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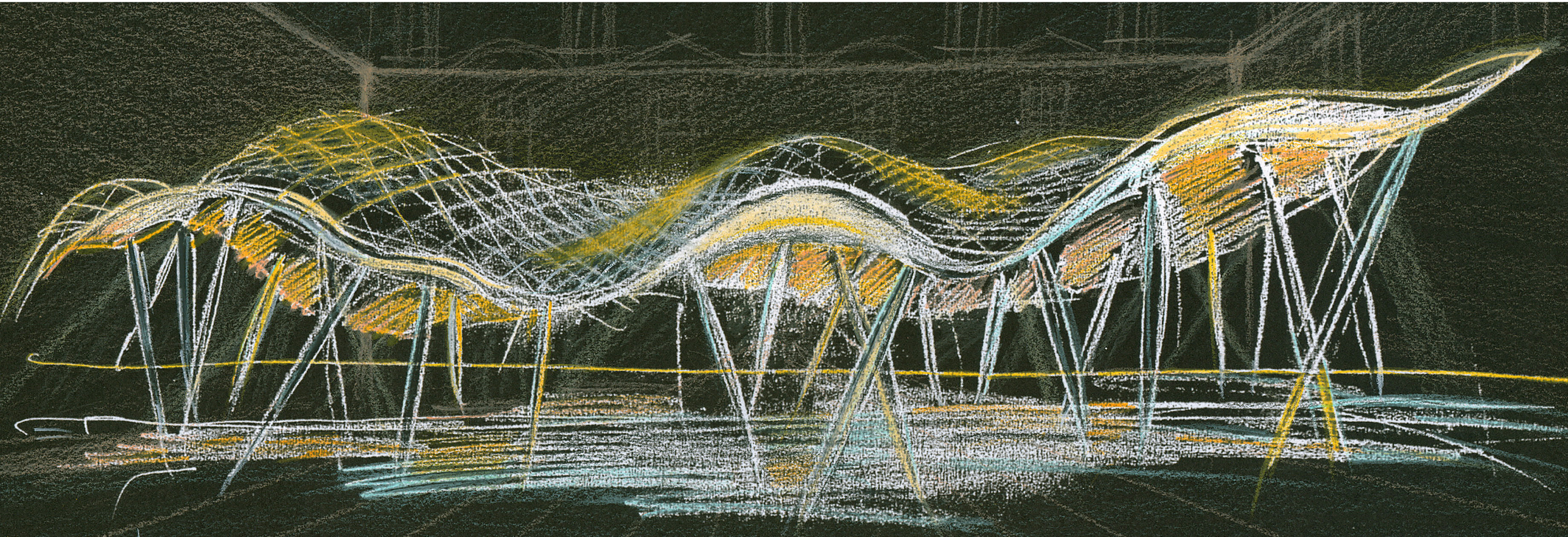

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DRAWING AS (IN)TANGIBLE REPRESENTATION

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Cover
Mario Bellini, Museum of Louvre, Department of Islamic Arts a Parigi (Francia), 2005-2012. Study sketch, detail.

The articles published have been subjected to double blind peer review, which entails selection by at least two international experts on specific topics.
For Issue No. 4/2019, the evaluation of contributions has been entrusted to the following referees:
Piero Albisinni, Marcello Balzani, Maria Teresa Bartoli, Cristiana Bedoni, Marco Bevilacqua, Marco Bini, Maura Boffito, Cecilia Bolognesi, Stefano Brusaporci, Adele Carla Buratti, Marco Canciani, Marco Carpiceci, Emanuela Chiavoni, Alessandra Cirafici, Laura De Carlo, Agostino De Rosa, Roberto de Rubertis, Antonella di Luggo, Paolo Giandebiaggi, Massimo Giovannini, Carlos Marcos, Emma Mandelli, Giuseppe Moglia, Roberto Mingucci, Leonardo Paris, José Ignacio Rojas Sola, Andrea Rolando, Livio Sacchi, Maurizio Unali.

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Editorial

Vito Cardone

The editorial team of Diségno opens the n. 4 of the journal with a dedication to Vito Cardone who left us prematurely on 17 April.
To him we owe the birth of Diségno and to him we, all the editorial team, owe the formulation of the magazine described in the editorial of n. 1.
Vito Cardone was a unique scholar, an engineer with a passion for reading and he knew how to combine this peculiarity with a rigorous method and great dynamism. His enthusiasm has infected all of us and not only because of the novelty of the project, but also because we were convinced of the need to equip a scientific society with a journal that was not a mere "institutional bulletin", but rather a place of exchange and scientific comparison on the founding themes of our discipline and on the less explored and unusual areas of research.
The N. 4, titled Drawing as (In)tangible Representation is dedicated to the in-depth studies of the XV Congress of the Unione Italiana per il Disegno and 40th International Conference of Representation Disciplines Teachers, held in Milan on 13, 14 and 15 September 2018, and was entirely followed in the main phases from Vito Cardone that only "an evil and bad fate" has prevented him from seeing it completed. For this reason we decided to leave to him the presentation, publishing a summary of his preface taken from the conference proceedings. Thanks to Vito, Diségno continues on its path, with the wish that it can go on for a long time in his memory.

F.F.

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The wish to open this *Preface* to the 40th Conference of Professors in Representation Disciplines –the most important of our yearly meetings, the first edition of which took place in May 3-4-5, 1979 in Santa Margherita Ligure– with some thinking about the path that led us here is strong. It also easy, though, to renounce, because UID's Technical-Scientific Committee decided to equately celebrate the anniversary, starting two years of celebrations and, most of all, reflections on "who are we", and "where we come from", or "where we are supposed to go", considering that 2020 there will be the anniversary of our scientific society foundation (formally founded August 4, 1980).
[…] I will therefore limit my words to some considerations regarding the Conference's participation and a paper's cross-reading, not by *Focus*, but trying to catch and highlight the macro-topics that seem to be cultivated. As UID President reading the accepted papers for the Acts publication, finalized to write the present *Preface*, is one of the most tiresome but in the meantime interesting and instructive experiences; it is necessary to realize the state of scientific activity carried out in our community. As a matter of fact the earliest results of underway research are offered to fellow's discussion and verification during the Conferences. much earlier than articles' formal publication or, in the case of broader topics, substantial monographs.
[…] The decrease is not due to a more strict review job, because the percentage of abstracts and papers gathered has been the same of last year. It should be noted that review have confirmed the limits highlighted by previous years' meetings, as well as the articles sent to magazines and for the reward evaluation, VQR type. Maybe this is the greatest cultural and political problem we must face today with specific initiatives beginning, for instance, with a specific seminar.
Nor the reduction in contribution is result of poor interest for the annual Conference by the UID associates and the Italian representation scientific community in general. It is due almost integrally to a contraction of foreign academics whom, compared to last year, are basically halved.
[…] It is without a doubt in counter-tendency with the great internationalization effort we are making, intensified this year by the commitment of the International Relations Commission presided over by Stefano Bertocci, whose work has been restarted on new basis and clear ideas with a consideration within the Italian community during the Symposium in Florence last June. We have now to understand the reason why this contraction took place and what to do to reclaim the positive trend of last two years. Certainly several factors affected; every year is full of international events in the area of representation, such as the *EGA* Congress, the *EGraFia* International Congress, The *Nexus* Conference in Pisa, the aforementioned ICGG in Milan. Maybe there has even been a less incisive specific promotion, lacking repeated solicitations, without the strong involvement of fellows with the most and strongest international relations, such as last year.
Most likely even the fact that in our Conference –in spite of what happens in the most important international events– the accepted papers are not all orally presented. This created more problems in the latest editions and, despite clearly written in the Conference's web-site, this year again some foreign fellows have complained because his/her paper was not accepted in the program.
Exactly for this reason, after the positive articulation in two parallel sessions, experimented in Florence and Naples, last year we noticed the exigency of increasing the number of oral expositions of about 50%, maybe even introducing a third session. This is what is going to happen here in Milan, allowing the exposition of 78 papers: practically 40% of the accepted, with a 1/3 increase compared to the 30% of last years' (67 papers).
[…] This year again, referring to macro-areas in which is possible to generally articulate the segment's specificities –geometry, visual perception, graphic semiology, project drawing, survey, environment and territory representation, history of representation– we have a great majority of survey topics, not only within the *Focus 2* in which they were explicitly expected, but in all the other ones as well. Survey is analyzed in all the declinations that came out in recent years […] with all the strength and weakness that I've been –unfortunately uselessly– pointing out.
Clearly the heart of the matter is more complex than it shows and requires a collective effort, that maybe we're not capable of facing yet.
[…] Very few –but the Conference's topic suggested this somehow– are the contributions in geometry and history of representation; the ones on project drawing are less than what could expect and, most of all, the ones on territorial and urban representation towards which attention to the non-material component is essential.
[…] Despite not treating smart cities, the only explicit contributions in that sense, come from Politecnico di Mi-

lano and Università della Campania Luigi Vanvitelli: those are the locations that about twenty years ago, together with Università di Salerno began to face this complex and fascinating topic.
I am referring, for instance, to Andrea Rolando and Alessandro Scandiffio's paper, *Nodes of tangible and intangible netweorks in the landscape between Torino and Milano* and to Nicola Pisacane, Alessandra Avella, Pasquale Argenziano, Carmine Maffei's *Enlarging the field of view of the territorial drawing, towards invisible data*. The other papers are written by foreigners, such as Hale Gonul and Fatma Sinem Ozgur, *Representing the intangible*, and Pablo Jeremías Juan Guitiérrez, *Use of layers as a tool to graph the movement in the territory*; this confirms what emerges in the last editions: some countries study more and more accurately territorial representation.
The majority of the few Italian contributions regarding non-material area is in the fields of communication and graphic semiology, which have a great and fundamental component linked to the representation of intangible. Anyhow, they are less than expected and, among them, specifically pointed out are the papers by Maria Linda Falcidieno and Elisabetta Ruggiero, *Social communication: the discipline of representation for the management on environmental emergency*, the one by Fabrizio Gay and Irene Cazzaro, *Materialism and image/writing: Otto Neurath towards a semiotic and rational stylisation*, and by Vincenzo Cirillo, *From the sign to the drawing of writing*, again on movement representation. Actually in some cases, the term "non-material" appears in the paper's title, but their content does not give much attention to the problem. This means that, from the macro-topic proposed for the Conference, only the "material" one was deeply treated.
Generally speaking, we can say that there is a confirmation of the tendencies recorded in the past years. Many papers focus on modeling, generally after surveys. Not few are centered on the reconstruction of architecture […] or non-built part of cities […] or destroyed buildings by bomb architectures and/or fragments.
Numerous contributions in term of virtual museums, amongst which notable were the papers by Francesca Fatta with a large group of fellows from her university, *Interactive virtual environments: a new concept of in-room entertainment*; the one Stefano Chiarenza's group, *Non-existent architecture: museums and virtuality across history, art, drawing and representation of knowledge*, and the one of the group led by Massimiliano Lo Turco and Paolo Piumatti, *B.A.C.K.TO T.H.E. F.U.T.U.RE. Informative Models & Virtual Museums*. Almost all of these contributions, divided between *Focus 1* and *Focus 2*, broadly use augmented reality, for which *Focus 2* was specifically dedicated.
Many have been the papers on BIM, which are two thirds of the whole *Focus 4*, but present in other *Focus* points as well. As occurred in other years, there have been some interventions on travel drawing, such as the paper by Ignacio Cabodevilla-Artieda, Aurelio Vallespín and Noelia Cervero Sánchez on Mediterranean classic and popular architectures, as seen by Fernando García Marcadal (International Style exponent for Spain) or the one by Maria Martone and Alessandra Marina Giugliani, *The design of urban spaces in the work of Paul Marie Letarouilly. The ancient port of Ripetta along the Tiber*. As every year, we saw some very original contributions. Alessandra Pagliano and Claudio Cammarota's, *Edward Hopper's unveiled spaces*…, on the review, with digital technologies, including augmented and virtual reality, of his work *Sun ligth in a Cafeteria* is one of these. I'd like to mention two unusual papers for us on the topic of tactile representation for blind: the one by the Ivana Passamani, Francesca Trotti and Andrea Schincariol group, T*ouch the slyline whit a finger. From the intangible skyline to the tactile silhouette*, and the one by Veronica Riavis and Paola Cochelli *Touching for seeing: understanding architectures through la tactile representation*. It is a really interesting topic, on which there has been some working, even in out-sourced projects, in several universities.
Some very significant papers even if not many, are those centered on teaching. To be highlighted amongst these especially the ones by Enrico Cicalò, *Graphic Languages for New Media of Digital Communication*, focused on learning new languages in Communication Science courses; Cristina Pellegatta's *A lesson by Vittorio Ugo: Reflections and applications in the teaching process*, important in order to historically reconstruct teaching in Italy also, topic we shall focus on; by Luca Rossato, Wilson Florio and Ana Tagliari, on an interesting international experience on survey, representation and analysis of modern architecture in Brazil; the aforementioned contributions by Hale Gonul and Fatma Sinem Ozgur and by Pablo Jeremías Juan Guitiérrez. Less than previous editions are papers related to some aspects of the masters' work in architecture and engineering, which however are not totally absent, from Leon Battista Alberti, topic of Graziano Mario Valenti and Jessica Romor, to Andrea Pozzo; from Guarino Guarini, in

Roberta Spallone's contribution, to Piranesi; from the aforementiones Nervi to Mies van der Rohe, around whom the study by Carlos Montes Serrano's group studies continue, to Le Corbusier, who's maybe the most focused on architects (this time by Alberto Sdegno to Victor Hugo Velásquez). Another decrease can be seen in the study of architectural perspectives, that in the past Conferences has been much frequent, maybe as a result of the important PRIN coordinated by Riccardo Migliari that involved several universities.
Extremely synthesizing, from all the contributions we notice that what Rossella said about *Focus 1* may be generalized, which is the emerging of an "articulated and promising experimentation towards integration of different representation techniques, starting from the now mature awareness that looks beyond the comparison between analog and digital". Particularly significant, to this regards, the paper by Salvatore Barba, Adriana Rossi and the young, compulsive sketcher Lucas Fabián Olivero, *"Cube-ME", a variation for an immaterial rebuilding*, regarding an interesting experimentation on a hybrid representation language, between analog and infographic.
This year again, I shall conclude the *Preface* pointing our deficiencies and negative aspects. First of all it is to be underlined that, once again, there are few general theory contributions.
[…] Also it is necessary to notice the lack of papers regarding basic or fundamental research and we can confirm that we are just simple users of new representation procedures and languages often.
[…] In some cases, furthermore, we have non-original works, nor anticipations of ongoing researches, but broadly treated researches which have been illustrated elsewhere, even by articles and monographs, and the papers received are a sort of synthesis, sometimes a partial.
[…] When these mistakes will disappear, we'll have leaped much forward to seriously be defined, non only self-defined, a proper scientific community.

Vito Cardone,
founder and first editor-in-chief of Diségno.
UID President, May 2014 - April 2019.

Architecture, Design and More

Mario Bellini

Text of the *Lectio Magistralis* delivered on the occasion of the 40th International Conference of Representation Disciplines Theachers and XV Congress of "Unione Italiana per il Disegno" titled *Representation Material/ Immaterial. Drawing as (in)tangible representation* held in Milano on 13, 14 e 15 Settembre 2018. The lecutre delivered at the Feltrinelli Foundation, on September 15th, 2018. Transcription by Camilla Casonato, Marco Muscogiuri and Domenico Jordy Pulerà, editing of the text by Alberto Sdegno.

I started drawing at the age of five, a time when I always had pieces of paper and pencils in my hands, and I used to draw the most bizarre, the funniest things that came to my mind. I remember that I used to enjoy making objects look like humans, such as, for example, small funnels that I added human legs and arms to; funnels that filled themselves with water from the top, making it come out at the bottom.
The examples I will go on to describe represent just a small selection of my major works, accompanied by various drawings and sketches made, precisely, during the design process. The aim, in fact, is that of showing how the creative idea takes shape, following the commission by a client or in relation to a competition, through a conceptual flow that starting from the mind reaches the hand, transforming itself into expression on a sheet of paper. In particular, one can draw well, or badly, but in general for an architect or a designer it is necessary to know how to draw well, that is,

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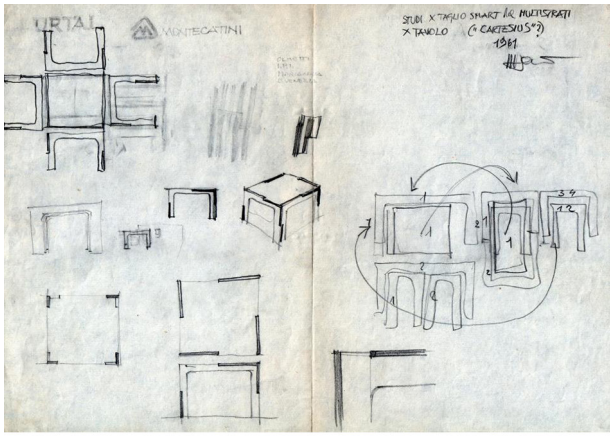


Fig. 1. M. Bellini, Cartesius table for Pedretti, 1960. Study sketches and photograph of the object.

to demonstrate a certain talent in the field of the figurative arts. When a young person shows up in my studio, the first thing I'm interested in seeing is how he draws; I'm not pleased if I see that he draws badly, because I understand that, in this case, there is a lack of correspondence between the graphic talent that he should have, and his ability to use it in the specific sector of project design.

I would like to start with my first significant project, the one for which I won the first *Golden Compass Award* of my life: it is the project for the *Cartesius* table designed for Pedretti in 1960 (fig. 1). I thought that the original drawings had been lost, but then fortunately they were found again, and they describe very well my way of proceeding in the conceptual phase. In particular, this strange table was made by cutting out all of its components from the same, single block of plywood and then assembling them together. Starting from this solution, several different versions were developed, that also differ for what regards the dimensional aspect.

Then there is a second table that I made a few years later, in 1976, strangely designed without first using the tools of drawing. The *La Corte table*, realized for Cassina, was designed directly, by making gestures with my hands, as I was sitting in the company's laboratory, without a real preliminary graphic elaboration. At a later time, I found myself observing the realized object, which is also in my own personal office, and I took a pencil and a piece of paper and did a 'portrait' of it (fig. 2).

For Cassina, in the following year, 1977, I designed another table that I called *La Rotonda* (fig. 3). Unlike the previous one, in this case the drawing permitted understanding the behavior of light and shadows, also generating in me a particular satisfaction/challenge dictated by a not so simple representation. I then made a different version of this object, very large, for the Chinese market. The Chinese, in fact, dine with many people seated around a round table, who rotate a central platform to serve themselves. Instead of ordering from a menu, they pick their food directly. The central part of my table is made of glass and is flush with the wood surface: it is possible, therefore, to rotate it with a finger, loading it with everything needed.

For B&B Italia I then created the *Bolt* table in 2017. Of this project, there are several variations of the same idea. I made a series of sketches, a series of drawings that you usually make when you are on the phone and your hand never stops moving. I wanted to make a table from the idea of interlocking, jointed wood, but using metal, with L-profiles of stainless steel or corten, that is, an iron alloy that, when it oxidizes, stops making rust, and bolts. The name *Bolt*, is

Fig. 2. M. Bellini, La Corte table for Cassina, 1976.
Sketch and photograph of the object

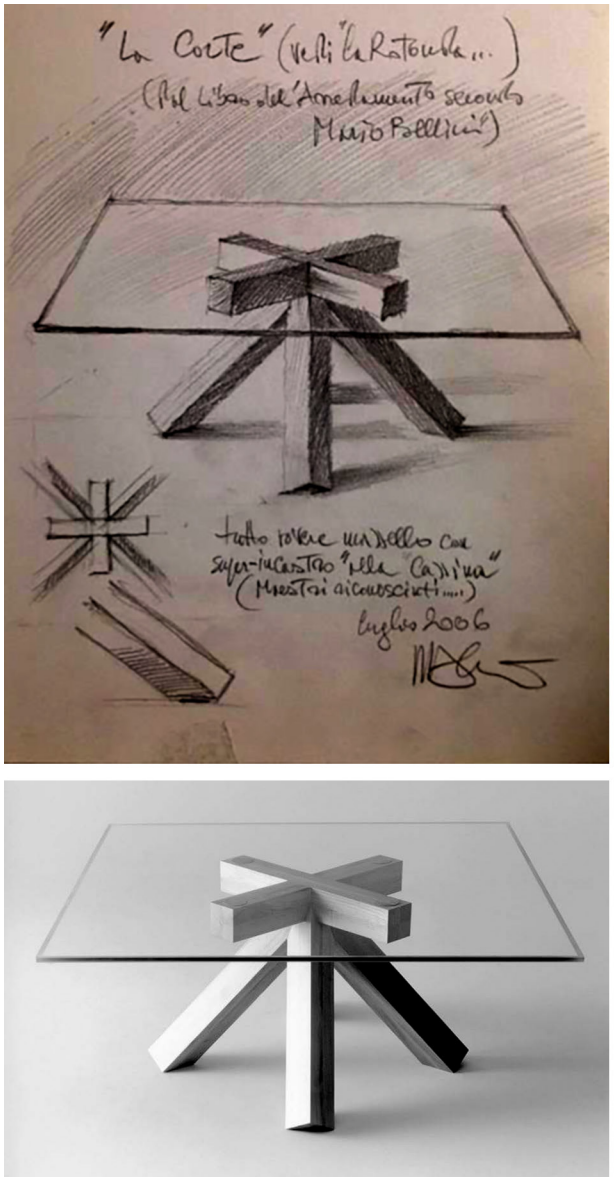


Fig. 3. M. Bellini, La Rotonda table for Cassina, 1977.
Sketch and photograph of the two solutions.

Fig. 4. M. Bellini, Opera table for Meritalia, 2014. Study sketches and photographs of the two solutions.

in reference to its characteristic double bolts. In this case, I had drawn it first, to see how it could work and then a T-profile variant was made. Usually my sketches are 'real' but it can also happen that I make simulated sketches. For example, when the Museum of Modern Art in New York dedicated a solo show to me in 1987, after having received the compliments for the works destined to the exhibition, they peremptorily asked me to also send their preparatory sketches. But I didn't have any sketches of those projects, because I had created them, each time, directly in the workshop. Since they kept on asking for them insistently, one Sunday I decided to take some large sheets of paper and I invented various beautiful "preparatory" sketches, claiming to have found them in the archive.

The 2015 *Cab Lounge* for Cassina, instead, is a long-chair with a footrest designed from many real research sketches, not 'portraits' gradually supported in an interactive way by the first prototype realizations.

In 2014, I created a fairly large round table for Meritalia, a medium-sized company where very talented people worked. It rests on just four spheres and is made of interlocking oak ribs, as in the carpentry framework of a boat's hull, of which there is a series of drawings I made during the conceptual phase, also drawing people around it (fig. 4). The table is called *Opera*, a name that makes you think of the under-works (*opera viva*) or the upper-works ("*opera morta*"), typical of boat hulls. I began by drawing an oval table, imagining the crisscrossed ribbing that supported a border on which to rest a large crystal table top, with an interlocking structure, later realized in many variations of essence and color.

Again for Meritalia, in the same year, I realized some sofas which I called *Freud*, in thinking of the direct relationship that there is between the sofa and Sigmund Freud's psychoanalysis. I imagined arms and backs folded back on themselves but opened as if they were human, revealing a different heart, a hidden intimacy of a different color and another type of finish. From opaque black, for example, they open revealing a shiny red of silk. From the initial drawing, the one the idea was born from, its realization was achieved. In some of my sketches, as we often see, I insert disturbing characters, with long devil ears, and enigmatic expressions.

From my innate passion for geometrically complex elements that twist and turn came the *Tango table* for the brand MGM (*Marmi Graniti Mariano*) (fig. 5), designed in stone or marble and realized in 2016, with a helical form that ends in a flared cup and pierced like a fountain plate, to support a crystal disk.

Also in this case there is a sketch from 2015, of a version marked by bold veining, from which in 2016 I created the *Torsion table* from a sketch made up of diagonal lines representing intense veining. Constructed with six twisted elements, like olive-wood rudders, that are connected in an invisible manner and bound together by this large, very heavy crystal table top which stabilizes the entire object with its weight. The table was produced by Natuzzi, which greatly appreciated the work itself, as well as its reference to the place where the company is located, the land of olive trees.

Fig. 5. M. Bellini, Tango table for MGM (Marmi Graniti Mariano), 2015-2016. Study sketches and photograph of the object.

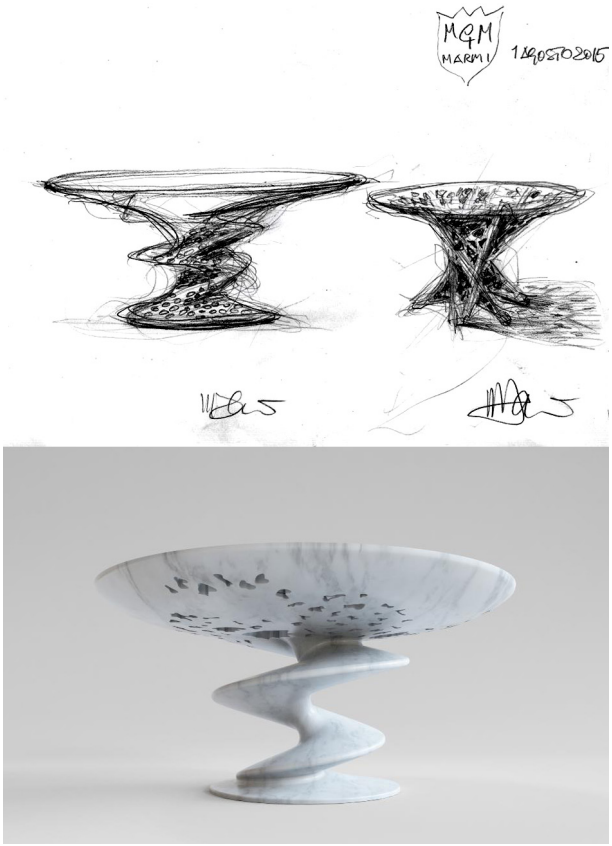


Fig. 6. M. Bellini, Teneride Torsion office chair for Cassina, 1970. Study sketches and photographs of the object.

As I have already said, I often make 'posthumous' sketches, under pressing demands, as in the aforementioned case of the Museum of Modern Art (MoMA), of which this sketch is an example (flanked by a series of small study sketches for details), unfortunately lost.
I now only have its digital scan. It is the *Teneride* office chair of 1970 (fig. 6), which only shortly later would go into production, when technology finally permitted doing so.
The Teneride office chair of 1970 in red leather has a reflective steel base and is completely covered with the same material which is sewn so that, when you sit down, "springs back" while it is free to turn around.
At the exhibition in New York there was also my stitched leather *Cab chair* (fig. 7) (always with its posthumous sketch), an object that is very popular all over the world. As many as 600-700,000 copies have already been produced worldwide and, even for this work, I never had any preparatory sketches. As you can understand, I would never have been able to imagine it without going through its practical realization by logical-inventive attempts in a workshop-laboratory. In fact it was a fortunate, long process of imagination. With this sketch I only pretended to have a drawing that revealed the construction details, and the proportions.
It is a chair with a welded steel skeleton, covered with a sort of stitched leather jacket, which slips on like boots, closed with zippers. A type of chair, one of this kind, had never been made, so many were inspired by it to generate imitations. If an object is imitated this means, in fact, that the idea was good, and for this I am more pleased than disturbed.
For the tea and coffee service produced by Cleto Munari in 1981 (fig. 8) I made a series of sketches that I found again despite the many relocations of the studio that I made over the years in Milan. Moving is often disastrous, because the dozens and hundreds of sketches that I make all the time cannot find always a precise arrangement, to the point that, as in this case, in fact they had been lost and have only recently been found. The idea behind this work lies in the desire to create a serving tray, as though it were a sixteenth-century courtyard, surrounded by columns, and in the middle the coffee pot, the creamer and other objects. Made of precious stones and sterling silver, I gave them the title of *The Ideal City*. I found an authentic one at an antique dealer's, with little pink quartz columns, complete with the creamer, coffee pot and sugar bowl.
The sketches I made while studying the plan, later realized, for the exhibition and conference spaces of Villa Erba in Cernobbio, inside the beautiful park, are obviously au-

thentic. This is the 1991 *Villa Erba International Exhibition and Congress Center* in Cernobbio (fig. 9). These are sketches showing the idea of a compositive center, around which three structures built as wings are organized, each one with a central corridor. Not far away there is the Visconti villa, owned by the Visconti family, that also owned the entire site. Again a series of sketches shows the large central pavilion, entirely openable, (having the same diameter of the Pantheon) at the intersection of the three adjacent solid bodies covered with marble, bodies that, with steel beams and rods, support the suspended roof at three points. The drawings that we realized were done with the best techniques of the time, axonometric and perspectives drawn with pens on tracing paper, on Radex, since at the time we didn't do renderings yet. We imagined, through drawing, how these large interior spaces would work, creating perspectives with vanishing points and horizon lines. I know projective and descriptive geometry very well, and very competent people worked with me to realize them, even down to the details of the vegetation, with leaves and pine needles drawn by hand with sepia ink. Some sketches can be compared with the photographs of the intervention realized: the interior space, the corridors. Opposite there is the view of Lake Como, the Visconti villa and the huge trees, including beautiful plane trees thirty-five meters tall.

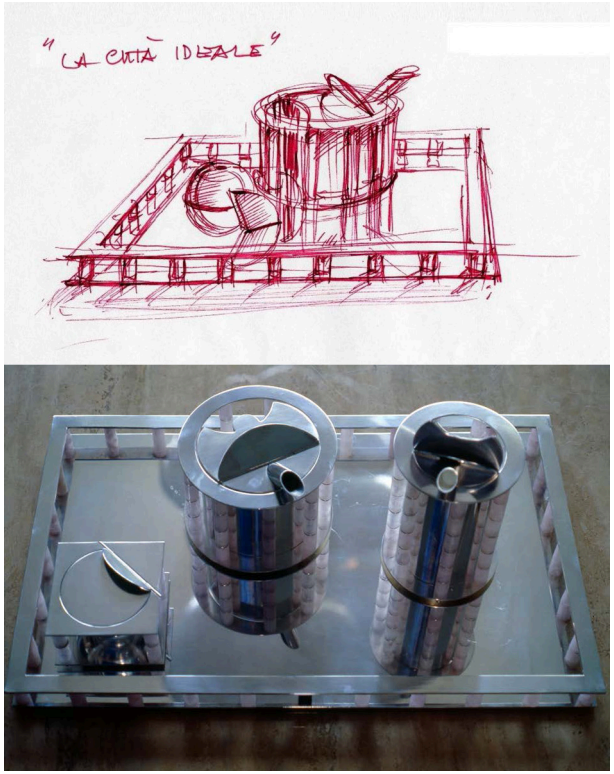
One day I received a phone call from a gentleman, whom I later met and became friends with, from a large Japanese firm, asking me to design a project on a large street, the Sakurada Dori, which leads to Tokyo's Gotanda Station. Some proposals had already been presented that had not convinced the client. They asked me if I felt like taking on this task right away. I asked for a day to think about it and then confirmed that I would do it, knowing immediately that I intended to do it. I started to make some sketches that then led to the creation of the *Tokyo Design Center* (1988-1992): a project near Shinto shrines. Precisely in Japan, a nation I knew and will know better and better, having been there one hundred and thirty times.

Between 1987 and 1997 I worked on a very interesting project: the *Milano International Trade Fair*, in the Portello district of Milan (1987-1997), where the former Fiera used to be (fig. 10). We made some drawings to help us imagine the new urban situation with this body almost 900 meters long, which was the prelude to the disposal of the area of the old fair, on which *City Life* will rise, the new complex with its skyscrapers. The building is eight hundred meters long and I had pointed this out to my studio staff, saying that we were

Fig. 7. M. Bellini, Cab 412 chair for Cassina, 1977. Drawing and photograph of the chair.

designing an object almost one kilometer long, like the walls of a city. I took a sheet of paper –I remember– and put it up on the wall and showed them that we were designing a piece of the city, not just a building. We also made a model, about nine meters long, on a 1:100 scale, in wood, realized with great care and of great scenic effect. The model was then stored in the warehouses of the Fondazione Fiera, but when I requested it for an exhibition they told me that they had burned it, because they needed space: that's incredible. Before the render era, for the same project, we had invented very effective photomontages, even revised now, superimposing the images of the model on photographs of context and playing withe shading, false skies and reflections, so that it looked like a plausible view of the city. I elaborated

Fig. 8. M. Bellini, La "Città Ideale" tea and coffee service for Cleto Munari, 1981. Study sketch and photograph of the object.



other drawings to imagine how this very long façade of the Portello fairgrounds in Milan could be realized, with a portico covered with greenery, and with the façade of the fair set further back. I also imagined, through my ink and colors sketches, to get the effect of reflections on the road, as if it were wet from the rain. Today there are 3D programs, such as *SketchUp*, very useful for quickly generating and modifying three-dimensional models, while you think of objects or entire architectural scenes, which unfortunately do not generate reflections.

I also participated in the international competition for the *National Gallery of Victoria* in Melbourne, Australia (1996-2003), and after the selection, restricted to only four competitors, I actually executed there, transferring a dedicated studio to Melbourne, the whole project (fig. 11). I made a series of sketches during many flights from Milan to Melbourne, which lasted about 24-25 hours, so there was plenty of time to think and draw. Once I arrived, very dazed by the flight (in which I lost track of time, day and night), I took part, at 8 am local time, in the meeting with with ministers and technical staff. The interior of the National Gallery is now realized in stainless steel mesh, which I have used many other times, such as for the Departmen of Islamic Arts at the Louvre in Paris. The building, now becomed a very popular museum, overlooks on the beuatuful *Queen Victoria Garden* with its central entrance.

I then designed and built, between 1996 and 1998, the Natuzzi Americas Headquarters in High Point, North Carolina. In this case, the clients wanted a building that would contain all the activities inside: from the offices to the showrooms. So I decided to propose a sort of ship's bow, starting from a sketch that immediately convinced me and my client. A sketch imagined during a mesmerizing world tour while at the same time I was forced to stop over in Singapore for other urgent projects, such as the Arsoa Headquarters (1996-1998), in Kobuchizawa (Japan). It was a matter of proposing a memorial in honor of one of the Japanese emperors, in particular the emperor who had reunified the nation. Japan, in fact, was divided for centuries into many small kingdoms. Following an international competition, my idea –also in the form of several sketches– will be realiized for another customer. I am convinced that certain successful projects or architectural works can find more lives and reincarnate in other contexts, in the face of the foolishness that says "form follows function."

I also participated in the international competition for designing a new *Cultural Center* in Turin in 2001, with the crea-

Fig. 9. M. Bellini, Villa Erba International Exhibition and Congress Center in Cernobbio, 1991. Study sketches and aerial view of the realization.

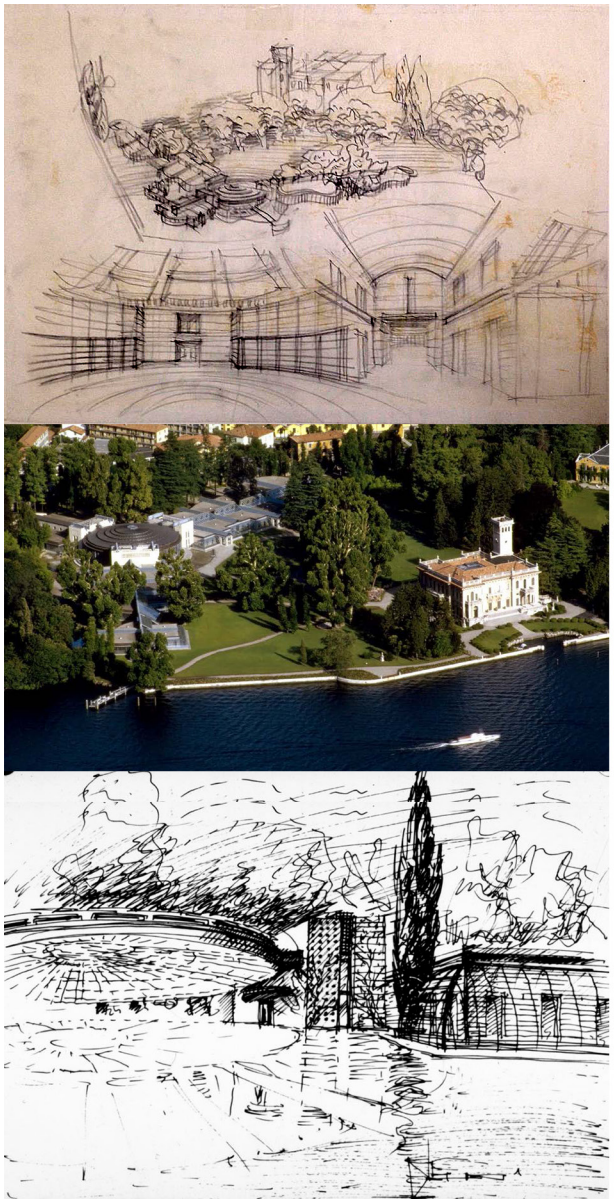
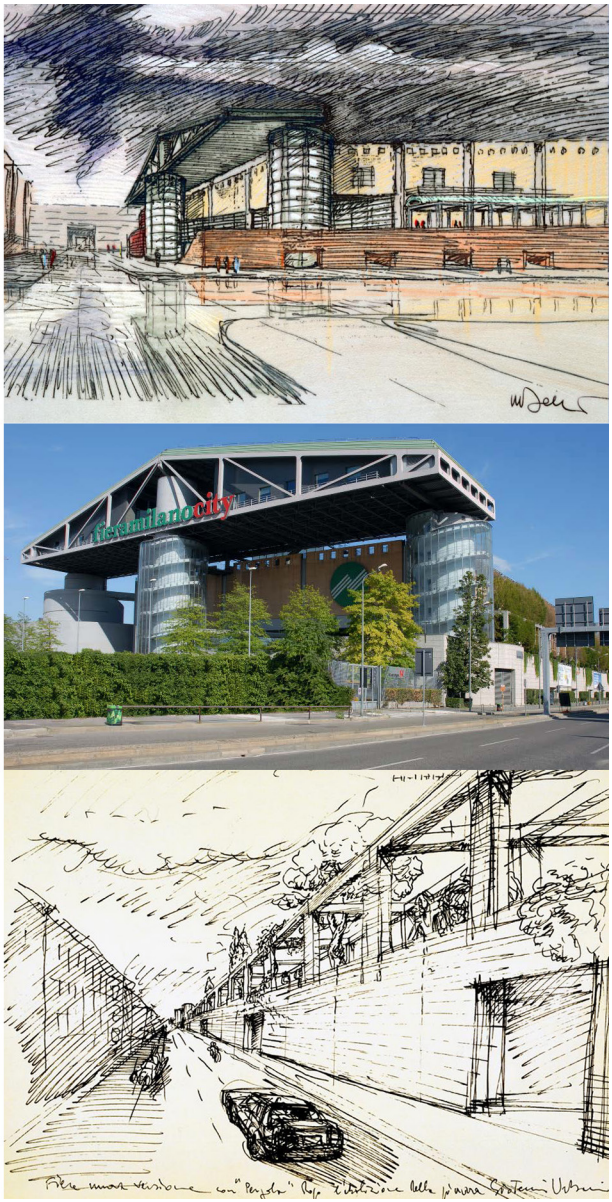
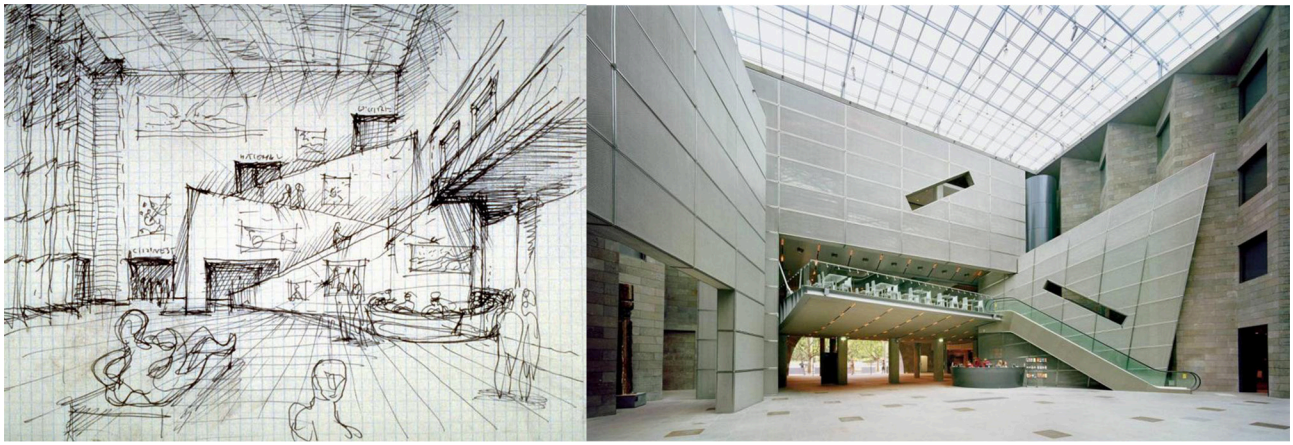


Fig. 10. M. Bellini, Milan International Trade Fair, Portello District in Milan, 1987-1997. Study sketches and view of the realized project.



tion of the new, large *Turin Civic Library*. My project was the winner, but then it was not realized, as often happens with the calls of Italian public administrations, despite the fact that the cost of the executive project had already been paid, as required by law, with a signed contract. In this case I had drawn a series of sketches on a small sheet of paper, and one, in particular, seemed to us to be the most significant, the source of the initial idea, which described the front of the project. The sketch was cleaned up, enlarged and became the symbol, the reference design that I have repeatedly reproduced and reinterpreted in various environmental moods, as well as being a guide to create a scale model.
For the *Department of Islamic Arts* inside the *Cour Visconti* of the Musée du Louvre in Paris (2005-2012) I created, in a design competition which I won, this kind of golden, flying sheet, supported by a series of 'dancing' tubes (fig. 12). A sketch in particular is quite effective, even if it is substantially posthumous (even here it was necessary to 'have' a sketch –for public relations– while in reality I had created the cloud by modeling with my hands a piece of metal mesh, then sampled digitally with a cloud of dots), that I often use as a reference, redrawing it with different colors and then giving it away, perhaps at charity auctions, with my signature. It is a kind of cloak that seems to be lifted from the ground, as though it were floating in the air, inside the *Cour Visconti*, one of the Louvre's eighteenth-century courtyards: a covering enclosed by invisible glass. The work continues inside a highly-frequented subterranean gallery, which can be reached by entering from the pyramid. This is another one of those cases where they wanted the sketch, which I drew afterwards, of course. On this occasion, several renderings were also done, because the managing director of the Louvre was very impressed with our project, and wanted to see the envisaged solution, with its extraordinary iridescent roof. The renderings, therefore, had to serve to show the final effect.
For this reason we have also produced some segments in real scale as example, trying to convince our client and, subsequently to carry out the project (very successfully). The structure is made up of triangles, which are able to make this surface 'flying' –almost 'dream-like'– from anodized stretched aluminum mesh, gold and silver in color, with an even more interesting effect under the light.
For MiCo, the *Milan International Congress Center* (2008-2012) in Milan, I designed a roof in the shape of a cloak, a canopy, later realized in a silvery, golden color. I often found myself having lunch in a restaurant in the Navigli, where I had my studio, and I used to draw in pencil on the butcher paper placemats. On those occasions I had invented this idea: a sort of canopy covering the terminal of the building of the former Portello Fiera, overlooking the city, facing towards the current *CityLife*. The voids and cuts in the roof must meet precise fire safety specifications: these spaces are escape routes, open at the top.

Fig. 11. M. Bellini, National Gallery of Victoria in Melbourne (Australia), 1996-2003. Study sketch and view of the inner courtyard.



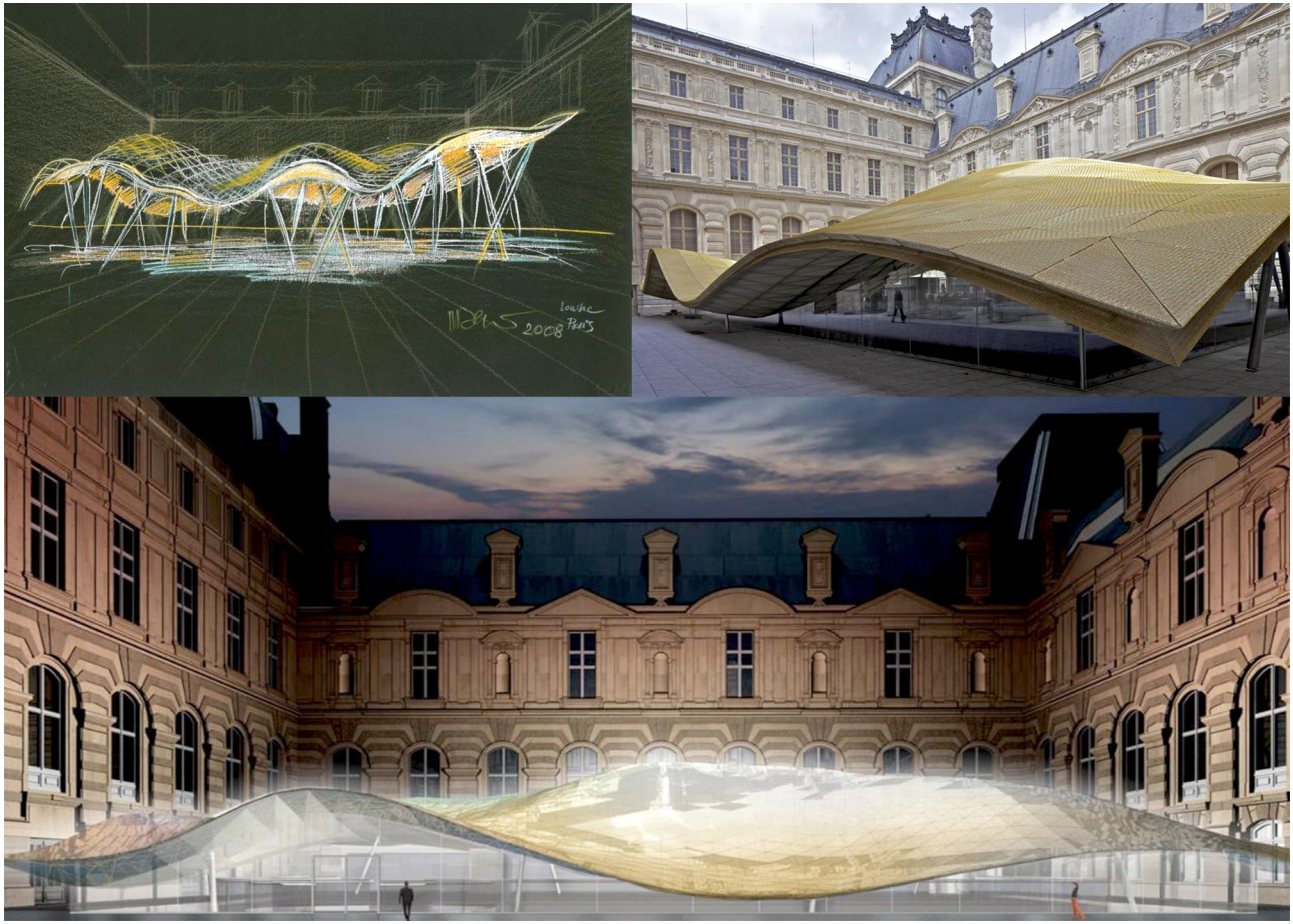
One of my most recent projects is the *Oasis Residential, Cultural and Sports Complex* (2012) in the Gulf Area, in Doha, Qatar. In this area, which will host the world football championships scheduled for 2022, I designed, on commission, elements flying in space, reproduced with renderings. I imagined the exterior of this huge system entirely terraced, and complete with equipment and structures. Thirty-two soccer fields, training fields and hotels for soccer teams were planned.

Author

Mario Bellini, Mario Bellini Architects, www.bellini.it

The text will shortly be published in *Mario Bellini. Il disegno del progetto* by Camilla Casonato and Marco Muscogiuri.

Fig. 12. M. Bellini, Louvre Museum, Department of Islamic Arts in Paris (France), 2005-2012. Study sketch, view of the realized project and rendering.



The *Map of Padua*

Giovanni Valle

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The *Map of Padua* by Giovanni Valle: Hypertext/Hyper-Representation *Ante Litteram*

Andrea Giordano

The city of Padua is surveyed by technicians coordinated by Giovanni Valle, who elaborates, draws and 'amends', under the direction of Simone Stratico –whose role has not yet been clarified [1]– a map that was engraved in Rome, within 1784, by Giovanni Volpato. For technical reasons the huge surface of the drawing is transfered on 20 copper plates of various sizes [Ghironi, Mazzi 1985] becoming, in its original edition, one of the most important and famous maps of the city. Realized according to precise criteria of geometric measurement, it can be considered, therefore, a punctual record of the urban condition of Padua in the 18th century [Zaggia 2009]. For this reason, the map plays a role of great historical importance since it crystallizes the *forma urbis* of Padua before the wide nineteenth and twentieth century transformations. The Padova map of Giovanni Valle is, therefore, at the top of a long cartographic tradition that precedes the concepts of Descriptive Geometry and the rigorous codification of Orthogonal Projections, formulated only a decade later by Gaspard Monge at the École Politecnique of Paris [Cardone 1996; Cardone 2017]. Indeed, starting from the Renaissance, the representation of the city abandoned its symbolic role, describing the tangible physical features of places and architecture, adopting measuring instruments and mathematical-geometric rules based on the principles of Euclid's *Optics* and *Elements* [Stroffolino 1999].

What is interesting about the work of Valle is its effective 'composition', that has, on both sides of the plan projection of the urban area, a set of perspective views depicting some specific 'main places' of the city [Mazzi 1985, pp 32, 33].

Like many cartographers of the eighteenth century, Valle chose to overcome the limits of space and time in a single document, combining more 'views' of the city with its plan shape, as if a user of the document could stay, at the same time, in several positions of observation. This operation can be interpreted as a sort of optical zoom on

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the most important places of Padua, a strategy of representation which, although performed on a scale of greater detail, from an urban and orographic point of view, sees in the Gallery of Geographical Maps, completed in the Vatican by Egnazio Danti among 1581 and 1583, his most illustrious precedent [Gauthiez 2006].
This composition is therefore not new: the history of cartography of urban realities includes analogous, previous and contemporary examples, among all the map of Rome by Nolli, that of Naples by the Duca di Noja [Bevilacqua 2010] and –referring to the Venetian area– the map of Venice by Ughi. In all these cases the composition is the similar: a plan projection, and a series of perspective views that offer the vision of precise urban places. Two distinct modes of representation of the city are overcome, integrating different strategy of outilining the places, both easily recognizable in the history of cartography: the perspective view and the plan projection [Nuti 1996]. In the case of the view, we have a clear reference to what today we would call '3D view' of a three-dimensional entity, with the intention of showing how it looks, from an observation in the space; in the case of the plan projection, its aim is to read and communicate metric/geometric data and specificaaly, in the case of a city, the representation is certainly addressed to understand the relationships, the concerns and the properties of the forma urbis. So, the map by Valle –as well as Ughi's one– anticipates a concept through the combination of several representations: a hypertext, in which it is possible to grasp multiple information simultaneously, also for the presence of captions and lists of roads, buildings and notable places [2].
Indeed, let us read this map precisely in terms of a hypertext. Or rather, this map can be considered as a hyper-representation and, as uch, it must manage data, organizes them and offers outcomes in terms of communication. As a hyper-representation, Valle's map is a useful tool not only for visualization but, above all, for knowledge and communication of the architecture and the city, simplifying the rapid and accurate analysis of complex and variable data. According with Jean Luc Nancy, the hyper-representation: "it does not consist only in the colossal and boundless character of the representation, demonstration or spectularization systems […] it consists above all in a representation whose object, whose intention or idea is integrally realized in a manifested presence […] The hyper-representation […] is a reversed revelation, a revelation that revealing does not portray the revealed, but on the contrary it exhibits, imposes and impregnates all the fibers of presence and that of the present" [Nancy 2007, pp. 90-91].
As we said, a huge number of data, managed by drawing procedures, can be found in such an output. Indeed, more generally, through the forms of representation that are a privileged tool for the study and the analysis of what we identify with the terms 'architecture', 'city' and 'landscape', knowledge acquires communicative power; for this reason it is important that the architectural, urban and landscape heritage are based on representation to be studied and disseminated. A map, like the one that Valle outlined, today as in the past, must be assumed as a privileged place of knowledge and communication: the contribution of representation as a communicative vehicle is therefore fundamental. Today, refined digital technologies are used for the realization of such elaborates, but an idea of 'virtual' set still prevails, it even has sometimes a scenographic, if not a playful or an entertainment nature. However, the data managed in such a map are an enormous quantity of information that identifies:
– physical-naturalistic quality (the shape, the conformation rules, the configuration and transformation of the architecture and of the settlement and infrastructural apparatuses);
– historical-cultural quality (history, traditions, cultural and environmental heritage in general);
– social and symbolic quality (social values, attitudes and knowledge, aesthetic values and forms of perception consolidated in the communities);
– functional quality (a symbol is associated with each represented location remarking its intended use).
The solution is the organization of a data network, that allows a greater contamination with different disciplinary areas, giving a deeper degree of accessibility to an ever wider number of users: indeed, the creation of a hypertext, and in our case of an hyper-representation, certainly refers to a condition of extreme combinatorial freedom. And if we consider the Augmented Reality experiments, a sector of computer research that combines the real world with computer-generated virtual data, we face an anticipation –in the specific case of architecture, city and landscape– of the goals, putting in relation (virtual) entities that have not only external connotations, of perceptive appearance (the perspective views), but also metric and geometric features (the plan projection).

At this point, it is important to describe the operational analogies on 'how to' map and reference precisely on the 3D object/model metric information (architectural, urban, landscape), analytical type (study of sources and documents), synthetic type (creation of the 3D model – now also interactive). The current technology, as in the past, aims to the localization or to the movement in space, in the same way aesthetic and geometric attributes (color, texture, opacity, shape etc.) become further information suitable for the effective definition of such a work, providing –formal, constructive or structural– processes, organizations, and systems that are not immediately understandable and often hidden or untold.
Yet, compared to the present, there are differences. Certainly in the contemporary era, the generation of CAD, GIS and BIM technologies, also known as Software Object Oriented, is certainly more versatile and suitable. An Object Oriented software program is structured in numerous high-level objects, each of them replicates one or more aspects of the problem that is solving and interacting with others, 'exchanging messages', but maintaining its own status and data. The term Object Oriented describes, therefore, a program in which data are not defined as lines and forms but as virtual objects that can be assembled into larger components. It is therefore a software technology particularly suited to architectural, structural, and urban representation. Indeed virtual objects, in an Object Oriented application, can be equipped with the attributes of the physical objects they represent, such as the geometry and the characteristics of the material as well as energy efficiency, costs, maintenance requirements, evaluation of useful life and so on; the Object-Oriented technology makes the creation of a virtual model easier and more efficient than a series of separate drawings, according to a mental scheme analogous to the way of conceiving an architectural project.
If we consider a hyper-representation as the design and experimentat of a coordinated and interactive system, that elaborates various data in a simple and immediate format, then a map organized like that of Valle manages, in particular, variable data in constant flow, proceeding, ante litteram, through the following operational steps: the design of 3D models/representations with not only geometric but also semantic and descriptive integrated contents (today we would say: according to the recent OGC standard –Open Geospacial Consortium– CityGML) [De Carlo 2014; Huffman Lanzoni, Giordano, Bruzelius 2018]; identification/testing/development of methods for populating these 3D models; experimentation with navigation and interrogation tools for these models, experimentation that, today, takes place via the Web.

Notes

[1] His contribution seems more a scientific direction than a direct intervention. See Mazzi 1987, pp. 30-37; Mazzi 2013, pp. 187-197.

[2] It is interesting to note how in the preparatory drawing Valle indicated the properties of the individual noble palaces.

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DRAWING AS (IN)TANGIBLE REPRESENTATION

Theories of Drawing and Digital Practices for the Project

Drawing for project innovation and product design
Drawing for modeling and fast prototyping
Drawing for "smart cities" design

The Drawn City. Architectural Graphic Art: Tradition and Modernity

Sergei Tchoban

I regard architectural drawing as not just a means of communication, but also an important way to study the contemporary urban setting. It helps me think about what architecture is today, in an age when the multivectoral nature of architecture's development has reached its apogee. Drawing is a path to oneself and to understanding what is happening around you and what you like in architecture. Here, of course, I cannot entirely separate my practice as a draughtsman from my main job: in terms of end result, drawing and architecture are very different from one another, but the two types of activity are based on reflections on one and the same subject – how to make cities interesting today, how to create *mises-en-scène* which in terms of quality and visual intrigue are a worthy match for the best examples offered by history.

I began drawing very early, at a secondary school specializing in art attached to the Academy of Arts in Leningrad. Almost immediately, I realized that my main interest in drawing was architecture. I found all these *mises-en-scène* involving cities –not just Leningrad, in which I grew up, but also the ancient Russian cities of Novgorod, Rostov Veliky, and Pskov– extremely exciting, and the genre of drawing with its special agility and incompleteness was the best way of translating those internal experiences into artistic imagery. And I have to admit that I have lived all my conscious life with this. To this day, I draw a great deal myself – from life, as well as fantasies that are reflections on the urban environment, and, of course, sketches for architectural projects. I have always been interested in drawings by other people – in outstanding examples in this field. Aleksandr Benoit wrote in his memoirs: "By their very essence, drawings are

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Fig. 1. Pietro di Gottardo Gonzaga, Set Design. Arcade with a flat roof on a town square, early 19th century, quill, dry brush and sepia, 448 x 552 mm (Tchoban Collection).

Fig. 2. Pierre-François-Léonard Fontaine, View of the Roman Forum, 1788, brush in grey tone, quill and Indian ink, 483 x 627 mm (Tchoban Collection).

of great value: they are a kind of confession by the artist; they allow us to look into the secret places in the artist's creative work" [1]; this is something with which I can only agree. I have always been very interested to see which particular architectural subjects specific architects and artists have chosen to set down and which techniques they have used in order to convey their impressions. As soon as I had the financial opportunity to create a collection, approximately 20 years ago, I set about doing so. The first work which I consciously acquired, realizing that it could be the beginning of a collection, was a drawing by Pietro di Gonzaga of scenery for the theatre. Subsequently, a part of this drawing became the basis for the pattern of one of the tiers of the façade of the Museum for Architectural Drawing, which was built to my design (in collaboration with Sergey Kuznetsov) in Berlin in 2013. At the same time, I was interested in Japanese engravings. I still, from time to time, acquire for my collection engravings by Utagwva Hiroshige from the first edition of his series '100 Views of Edo'. There was also a period when I collected Russian art; to this day I bow down before the achievements of Aleksandr Benoit (1870-1960) and Mstislav Dobuzhinsky (1875-1957). Later, it's true, I gave part of my collection relating to Russian art to the museum's endowment fund for subsequent sale to finance construction of the museum building. But the core of my collection is works by masters from the 18th and 19th centuries – that period which is justly known as the 'Golden Age' of architectural graphic art.

Architectural drawing came into being as an intermediate and ancillary genre, a way of depicting a future building on a plane. During the course of the 16th and even 17th centuries the emphasis was on the applied nature of this genre, with no opportunity for individual techniques and merits to be manifested to their full. Simultaneously, this period saw the development of the drawing depicting a view (*veduta*), a genre which, as the art critic Vladimir Sedov has noted, "was rather harsh and precise in the hands of architects and in the hands of artists gentle and rich in eye-catching effects, but often architecturally weak or inexact" [2]. As a genre, the drawing also had an applied, preparatory character, but by the late Renaissance had developed its own forms, media, and original style, and had also acquired its own circle of followers and connoisseurs. However, the drawing depicting a view, especially of a city or buildings, was a special case; it exhibited various different aims on the part of the artist – a tendency for either picturesqueness and freedom on the one hand or documentary precision on the other. It was the convergence of these different types of graphic art –the architectural drawing, the *veduta*, and the landscape drawing– that brought the onset of the Golden Age of

architectural graphic art. What these artists, draughtsmen, architects, and engravers all had in common was the desire to create works that were complex, virtuoso, and extremely difficult to execute. These synthetic works were not views or architectural sketches; they were fantasies on the subject of reality; they drew upon well-known or already sketched parts of buildings or entire buildings to create new compositions, allowing their authors to think up and invent new combinations of rhythms, new scales, and in the final analysis to reflect on what kind of city they liked. And it will come as no surprise that the principal city which exercised artists' minds was Rome. It was acquaintance with the Eternal City that was the most important starting point for many very different architects and artists, the key to their understanding of architectural spaces and details.

In the middle of the 18th century a truly unique situation obtained in Rome, which had become a gathering place for all important forces among architects, artists, decorators, and antiquarians. The alliance between Rome and France and the emphasis on studying antiquity were factors that underwrote the existence of the French Academy in Rome; the Academy was where the most notable artists and architects of the time lived and interacted with one another. The special stipendium which they received allowed French artists to spend several years at a time in the Eternal City, in untiring search of new angles for viewing well-known and famous buildings, while also taking part in excavations aimed at discovering new buildings, paintings, or statues. This active artistic life was responsible for the emergence of a special genre –the architectural drawing depicting Rome. Among these works we may identify several main subgenres– elegiac drawings with depictions of antique ruins, views of ruins with the addition of generic scenes (sometimes including diggers or collectors), and, finally, fantasies on the theme of ancient-Roman life and ancient-Roman architectural ensembles. All these genres were especially popular among the French artists and architects who gathered around the French Academy in Rome. It is sufficient to name artists such as Charles-Joseph Natoire (1700-1777), Hubert Robert (1733-1808), Jacques-Louis David (1748-1825), Charles-Louis Clérisseau (1721-1820), or architects such as Jean-Laurent Legeay (1710-1786), Charles Percier (1764-1838), Pierre-François-Léonard Fontaine (1762-1853), and Jean-François Thomas de Thomon (1759-1813). Romans who belonged to this circle included Giuseppe Valeriani (1708-1761), Canaletto (Giovanni Antonio Canal, 1697-1768),

Fig. 3. Giacomo Quarenghi, View of the Ponte Luciano near Tivoli, late 18th – early 19th century, pen and grey and brown wash, Indian ink, watercolours, 269x425 mm (Tchoban Collection).

and Giovanni Battista Piranesi (1720-1778), as well as Giacomo Quarenghi (1744-1817), who subsequently left Italy to go to Russia.

There are works by all the above authors in my collection; they constitute its core – Natoire with his early drawings in blue paper with semi-fantastical, but recognizable views of Rome, Davide with his realistic depictions of typical spots in the Eternal City, or, for instance, Thomas de Thomon with his painstaking, almost documentary, recording of architecture, an approach which is in fact a profoundly original vision of antiquity. Hubert Robert likewise sometimes recorded and sometimes unabashedly made up ruins, going on to dream up little scenes relating to the study of antiquity: think of his 'Interior of the Palace', where he takes the liberty of embellishing the vestibule of the Palazzo Barberini with ancient sculptures, or his 'Architectural fantasy with excavations of an ancient city', where he gathers together all the best-known statues in a kind of abstract archaeological dump. I would especially like to single out Fontaine's 'View of the Roman Forum', a work characterized not just by a realistic recording of particularities, but also by the desire to fertilize this realism with an unfamiliar angle, to impart emphatically heroic features to a familiar view. By and large, all works of this synthetic character are distinguished by the quest for new subjects and ever new discoveries in the field of graphic techniques, and this is why they continue to be so interesting and relevant for artists and architects today.

Fig. 4. Joseph Maria Olbrich, View of the Russian Chapel in Darmstadt, 1904, watercolour, pencil, grey paper, 311x269 (Tchoban Collection).

Giacomo Quarenghi, who came to fame in Rome as a Neoclassical architect before enjoying a brilliant career in Russia, possessed a unique manner of drawing. When creating architectural views, Quarenghi was an artist characterized by comparatively intimate pieces in a light manner of execution and with elements of fantasy. His 'View of Ponte Lucano near Tivoli', for instance, is a drawing in which precisely recreated architecture is placed in an imaginary Italian landscape with mountains, individual buildings, trees, and the silhouette of a town in the background. "Equally imaginary is the staffage incorporated in the game proposed by the architect: together with him, we 'recall' something created which in reality looks different, poorer, and simpler," notes Vladimir Sedov [3].
The gradual development of archaeology took architectural drawing down the path of excessive precision and detail. During the late-Classical age drawings were executed extremely precisely, in detail, correctly, and, consequently, with a kind of artistic dryness. A brilliant example of the graphic art of this period is a drawing by Leo von Klenze (1784-1864), the most important Bavarian Neoclassical architect. In his drawing depicting the forum in Rome the 'limits' of the graphic art of the time are more clearly visible: the delicate lines display craftsmanship, but a certain freedom or boldness is lacking.
There was also a gradual change in the face of the architecture of this time. In the 19th century, especially during its second half, architecture saw active quests for new forms and layout techniques, but architectural drawing continued to be an invaluable school of craftsmanship for architects. For instance, drawing served Eugène Viollet-le-Duc (1814-879), the founder of architectural restoration, as an important support in his practice. Just as active as a draughtsman was Charles Rennie Mackintosh (1868-1928), who used drawing to study the fundamental links between forms and elements and then re-told them in a completely different language. Or take, for instance, the Austrian architect Joseph Maria Olbrich (1867-1908), one of the founders of the Viennese Secession. Olbrich's graphic art is characterized by simplicity and structural clarity. Interestingly, he was equally fervent in drawing both historical and contemporary buildings. For instance, my collection contains his drawing of the Church of St Mary Magdalene in Darmstadt, which was built in 1903 to a design by Leonty Benoit (1856-1928).
Rome in its primeval beauty likewise did not lose its importance for artists and architects, remaining a desirable destination for artistic pilgrims – including for artists and architects from Russia. In his book *Moi vspominaniya* ['My memoirs'] Aleksandr Benoit described his stay in Rome as an extremely important landmark in his biography. Summing up this "artistic feast", he describes the very strong impression made upon him not so much by ancient-Roman or early-Christian monuments, as by masterpieces of the Baroque age and, in particular, St Peter's Basilica. "Where the entire Baroque system creates its miracles utterly freely and yet draws upon unsurpassable knowledge, techniques, and a feeling of architectural masses, there I felt an incomparable delight and fascination. Is this not divine architecture? Is this not artistic might at its peak?... It's a celebration enshrined for all time, an apotheosis built of stone and yet quivering with life" [4]. In a series of watercolour views of Rome created in 1903 Benoit makes this feeling visible to the viewer.

Fig. 5. Alexandre Benois, View of the Capitoline Hill in Rome, 1903, watercolour, pen in brown tone and whiting over a black chalk preparatory drawing, 233 x 335 mm (Tchoban Collection).

Fig. 6. Ivan Zholtovsky, Painting underneath the arcs of the main building and on the tower of Palazzo Vecchio in Florence, 1909–1912, watercolour, bronze, preparatory pencil drawing, 194x263 mm (Tchoban Collection).

The motif of Rome and Italy's elevated, even heroic beauty is characteristic of the entire circle of Russian Neoclassical-Revival architects. This felt 'heroic' quality made it possible for them not to concentrate on details, but to capture the whole, to capture it almost impressionistically, but always on a large scale. Such are the album drawings of Ivan Zholtovsky (1867-1959) and the sketches of Ivan Fomin (1872-1936). Of extreme interest is a drawing of the Baroque church of Santa Maria della Salute in Venice by Boris Iofan (1891-1976), the architect of the USSR pavilions at the world exhibitions in Paris 1937) and New York and of the never-realized Palace of the Soviets in Moscow: the subject chosen, the composition of this work, and the attention given to drawing the architectural details of the soaring cathedral are evidence of Iofan's lively and impartial interest in pyramidal compositions – an interest which he carried with him throughout his life, from his diploma project for a monument to 'Fallen Heroes' to the unrealized 416-metre-high Palace of the Soviets, which was intended to be the principal building of the Country of the Soviets. Le Corbusier (1887-1965), an innovator who substantially shaped the face of architecture in the 20th century, brought back from Soviet Russia in 1928 a drawing of the cathedrals of the Moscow Kremlin. And although the pioneer of Modernism might have been expected to renounce historical forms, it was in fact the latter especially that he documented with great care in his album.

As I have said above, I am convinced that drawing is vitally necessary to architects in order for them to feel and understand what they like in particular urban formations and forms. It is for this reason that in my own practice I spend so much time on drawing from life, using my pencil to record almost every city –large and small– which I have the fortune to visit. Over time I have put together quite an extensive selection of drawings of urban spaces of various types.

For me, getting to know a favourite city begins with visiting its central square. What is a square? It is a space which is shaped usually by mainly public buildings, some of which play the role of architectural landmarks while others are a frame for the latter buildings, a mounting which compels the precious stone to gleam in the most attractive light. I always find it extremely interesting to study the character and rhythm of this interaction and the conditions it creates for the pulse of the city's life. For instance, Piazza del Duomo in San Gimignano, the famous city of medieval skyscrapers in Italy, which used to be the centre of religious and economic life in the province of Sienna, is now a major tourist attraction. The western part of the square is occupied by the façade of the collegial church, while the northern part is formed by twin towers – the Torri dei Salvucci; together they form an extremely picturesque silhouette and dialogue of textures. If this is an example of a medieval square, then Piazza Navona in Rome is a similarly harmonious alliance of background and landmark buildings, but from the Baroque age. This square, which runs strictly north-south, is framed by eight palazzos, and its main embellishments are the church of St Agnese in Agone, whose magnificent Baroque façade was created by the architect Francesco Borromini, and three fountains (del Nettuno, dei Quattro Fiumi, del Moro) created by the architect Giovanni Lorenzo Bernini. An example of a square from the second half of the 20th century is Place Georges-Pompidou, which appeared on the map of Paris in the middle of the 1970s. The square was designed by the authors of the Centre Georges Pompidou, Renzo Piano and Richard Rogers, in 1971, at the same time as work was begun on construction of the museum complex; the architects understood very well that in order for their complex façade with its exposed utilities systems to be seen properly, there needed to be a large public space in front of the building. For the same reason the new square was placed slightly lower than the level of the surrounding urban blocks. The square is made

Fig. 7. S.Tchoban, Piazza Navona, Rome, 2017, pastels, charcoal, chalk, 402x602 mm.

distinctive by the enormous white ventilation shafts for the underground structures situated beneath it, and by a pronounced slope towards the museum, which allows the square to be used as an improvised amphitheatre where pedestrians can relax. Today this is a popular recreational place for citizens and, of course, tourists.

Development on the embankments of European cities is usually the same kind of multi-dimensional urban interaction of background buildings and individual architectural landmarks which together form an extremely picturesque river (or seaside) façade for their city. Here, of course, we should, above all, remember Venice, whose every embankment is as individual as a fingerprint and yet is harmoniously entwined into a uniform image of the city, whether this be the imposing façade of the Grand Canal opposite the Fish Market or a view of one of the numerous islands in the district of Castello. The embankments of many other historical cities –e.g. Ghent, Amsterdam, San Sebastián– took shape in a similar way. An important discovery for me in my travels to cities throughout the world was that the idea of interaction between landmarks and background buildings is extremely relevant for the non-European tradition of urban design as well. A good example is Suzhou, a Chinese city situated in the delta of the River Yangtze which is often called the 'Chinese Venice' due to its plethora of canals and bridges.

Fig. 8. S. Tchoban, Centre Georges-Pompidou in Paris, 2017, pastel, 395x575 mm.

And, of course, an extremely important element in the image of any city is its streets. Whether a street is pedestrian or mixed-use, what is crucial from the point of view of urban design is always the relation between the distance between the buildings, i.e. horizontals, and their height, i.e. verticals, a relation which forms a certain rhythm and mood. Thinking about the character of streets and especially about what kind they can and should be in new city districts, I usually show a drawing of a street in the historical centre of St Petersburg, the city where I was born and grew up and whose urban fabric largely shaped me as an architect. The traditional street in historical St Petersburg is relatively wide and densely built-up on both sides. Usually, the buildings which constitute its façades are not individually memorable, but together they nevertheless create a feeling of the traditional harmony of similarity. In these buildings designed by architects who are not known to us, buildings which are usually collectively known as 'Dostoevsky's St Petersburg', what is especially important for me is the level of detailing of their façade surfaces. The presence of the finest details creates a very dense fabric, one which is diverse in terms of tactile sensations. It is this which has

given me personally from childhood onwards an absolutely distinct impression of architecture as an organism which exists in time and which is capable of ageing beautifully and with dignity, gradually becoming covered with expressive patina. There are many such streets in Rome, Paris, and Brussels too. I have found it just as interesting to study the streets of old Delhi – streets which look more chaotically built-up than those in European cities, but which also in their own way withstand the effects of time, bearing the marks of ageing with dignity. Of course, it is impossible to ignore too streets in modern megalopolises built in accordance with the principles of Modernism – avenues in Tokyo or Hong Kong formed by the outlines of high-rise buildings and even the multi-level car junctions in whose endless rings it is so easy to get lost without the benefit of precise instructions from a navigator.

However technocratic the modern megalopolis is becoming, it fortunately always has space for vegetation, and, as someone who draws, I find it incredibly interesting to observe the union of nature and the manmade environment. Interaction between architecture and nature is always an interaction between regularity and irregularity. Its literally inhuman capabilities ensure that nature always surpasses any idea man might have of freedom of form, which is why architecture, even architecture of the most sculptural kind and of extreme intricacy in terms of surface decoration, is always more controlled than free-growing trees and grass. This can be clearly seen in idyllic views of cities such as Gras and Cannes in France and even in the look of the Angkor Wat temple complex in Cambodia (which, although entirely covered in intricate carving, cannot compare in terms of the complexity of its forms with the intertwining trunks of the trees which grow against the background of these buildings).

A central place among the themes which exercise me as a draughtsman is given over to so-called 'icons' or landmarks – buildings which clearly stand out against the background of their surroundings. As a rule, these are sculptural buildings whose emphatic individuality of form serves as an expression and direct consequence of the unique functions which they perform in the structure of the city. I follow their role in the urban context using the example of structures from various different ages – from monuments of antiquity (the Pantheon) and the Middle Ages (Santa Maria del Fiore) to the most modern buildings which create a visually unfamiliar effect (an effect which 100 years ago would have seemed impossible from the point of view

Fig. 9. S.Tchoban, Venice, view to the island San Pietro di Castello, 2012, sepia, watercolours, 370x535 mm.

of traditional harmony) of a contrast-rich mise-en-scène involving the historical surroundings or natural landscape. Such, for instance, are works by the Russian Constructivists (e.g. the Zuev Club built on Lesnaya ulitsa in Moscow in 1927-1929 to a design by architect Ilya Golosov (1883-1945)), and almost all buildings by the celebrated Oscar Niemeyer (1907-2012), including his National Congress building in Brasilia with its famous upward-pointing white bowls and the presidential Palácio da Alvorada with its distinctive plastically expressive colonnade. Incidentally, during the very short period in which the centre of Brasilia was constructed Niemeyer's architectural language invented and 'sang' the melodies for almost all the architectural hits with curving volumes of various kinds which are still in extensive use to this day [5]. Consider, for instance, the forms given to modern skyscrapers and to new museums of contemporary art, buildings which are very popular today and which every more or less wealthy city considers it its duty to acquire.

For every theme in drawing I always try to select the most appropriate medium, one which allows me to convey with maximal precision the feeling that arises from a particular architectural and urban-planning situation, whether this is the scorching sun and the contrasting shadows which the sun creates on the narrow streets of Rome or, on the contrary, the morning light of the sun tinting the dome and upper part of the façade of the Pantheon to a warmer shade.

Fig. 10. S. Tchoban, Kolokolnaya Street in Saint Petersburg, 1984, charcoal, 480x345 mm.

Fig. 11. S. Tchoban, Mumbai, India, clash of the epochs, 2018, sepia ink, watercolours, paper, 485x351 mm.

I usually merely name the colour without trying to document it scrupulously, merely indicating whether it belongs to the warm or, on the contrary, cold chromatic spectrum. I very often choose coloured paper, using it as an additional means of creating the atmosphere I need. For instance, for a nocturnal view of the cathedral of Santa Maria della Salute in Venice coloured paper proved indispensable: by using white and light-grey pastels on dark-grey paper, I was able, I hope, to convey the feeling of mirage which envelops you when you see this church at night, especially in late autumn when the city is often shrouded in mist. Coloured pencils and black paper were my irreplaceable companions on a journey through Japan; this is an ideal way to convey the texture of the wooden façades of the traditional two-storey little houses in old Kyoto. I am also very fond of using coloured paper of uneven texture coupled with white pencil, this makes it possible to recreate the tactile sensation of old plasterwork or a wall of white stone – for instance, the apparently modest façade of the church of San Marziale in the Cannaregio district of Venice, a façade which conceals rich interior decoration. I like recording the motifs of Baroque architecture with the help of dense calli-

Fig. 12. S. Tchoban, Niterói Contemporary Art Museum, 2012, Indian ink, watercolours, 308x408 mm.

graphic ornamentation and Niemeyer's floating forms with Sennelier Gris ink. The latter has a concentrated colour, but with the addition of water can become almost transparent, making it ideal for conveying the feeling of weightlessness characteristic of Modernist buildings. And although neon felt-tip pens, for instance, are not at all something you would find in my arsenal, I sometimes use them too, in order, for instance, to convey as closely as possible the character of advertising billboards and LED screens, things which are now an integral part of the look of the streets and high-rise buildings in many megalopolises.

In conclusion I would like to talk about one more theme which I have already touched upon indirectly and which is for me one of the main themes in my practice not just as a draughtsman, but also as an architect. This is the textures of the urban environment and how different materials are affected by the impact of time. There is no doubt that some materials –for instance, natural stone or brick– age with dignity and beauty while others have great difficulty in coping with time's onslaught. They enter into severe conflict with one another, and this conflict introduces into the appearance of our cities a perceptible visual discomfort. I have tried to record this situation in my drawing 'Collision of epochs', which I created in Mumbai: a Victorian building from the second half of the 19th century is shameless butted into by a building from the postcolonial period, a typical International-style structure made from concrete. This contrast-rich collision of two utterly different architectural structures and two artistic and plastic languages had a profoundly disturbing effect on me due to the way that they compete with one another, fighting instead of interacting. Is this how it should be? I am convinced that unions of this kind should be more gentle and harmonious. "We live in an age when the figurative element in architecture has disappeared – together with the Classical order, decoration, relief, and ornamentation. At its top now reside challenge and radical dialogue, while the outskirts are occupied by the faceless, pragmatic, and beauty-less ('beauty' is a forgotten word in respect to architecture!) form of Minimalism" [6]. This is a quotation from my book '30:70. Architecture as balance of forces', which I wrote together with the architecture critic Vladimir Sedov and which has been translated into English, German, and Chinese. The subject of the book is the direction in which today's contemporary architecture –especially background architecture, which accounts for the majority of residential and office buildings built today– can develop in order to serve as a visually rich and harmonious environment for particular outstanding buildings embodying the technological and artistic attainments of their age. And in the conclusions to which I come in this study I was undoubtedly helped by drawing. By studying the city with the help of pencil and paper, I can not only better understand the character and laws of formation of our contemporary urban environment, but also seek out for it particular solutions which I then realize as an architect – on the path, I hope, to a harmonious and comfortable city, one which is not drawn, but real.

Notes

[1] Benois, A.N. (1913). Drawings collection by S.P. Yaremich. In *Starye gody magazine*, november issue, 1913. Sankt-Petersburg, p. 13.

[2] See the 2010 exhibition catalogue: *The Golden Age of architectural graphic art. Drawings by European masters from the 18th-19th centuries from the collection of Sergei Tchoban*. Moscow: Iskusstvo-XXI vek, p. 09.

[3] See the 2014 exhibition catalogue: *Only Italy! Architectural graphic art from the 18th-21st centuries*. Moscow: Iskusstvo-XXI vek, p. 130.

[4] Benois, A.N. (1980). *Moi vospminaniya (v pyati knigakh)*. Moscow, p. 390.

[5] Tchoban, S., Sedov, V. (2017). *30:70, Architecture as a Balancing Act*, DOM publishers. p. 123.

[6] Tchoban, S., Sedov, V. (2017). *30:70, Architecture as a Balancing Act*, DOM publishers. p. 141.

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Perspective Trials in the Manipulation of Space. The Bramante's Fake Choir of *Santa Maria presso San Satiro* in Milan

Giorgio Buratti, Giampiero Mele, Michela Rossi

Abstract

The Milanese church Santa Maria presso San Satiro *documents an experimental integration between perspective and architecture in which the accelerated perspective of the choir simulates a distance comparable to that in the transept. The effectiveness of perspective deception demonstrates the quality of local perspective science and justifies the perspective variables examination, comparing the previous hypotheses in light of a proper survey of choir inserted in the real architecture.*
The research is based on the interior space three-dimensional reconstruction of the virtual architecture designed by Bramante. Starting from a survey campaign, which integrated direct methodologies with laser scanning, it was identified the privileged point of view, reconstructed through the illusory space digital simulation of Bramante's architecture. The mounting of 24 point clouds and the subsequent transformation in mesh surfaces allowed us to verify the construction accuracy and to individuate some unknown anomalies hidden by the ornamental apparatus which make difficult to set the point of view in a unambiguous location.
The virtual reconstruction highlights a theoretical point of view, different from those already hypothesized and explains the design that identifies the solid perspective of San Satiro as the first model of modern theatrical scenography.

Keywords: Bramante, Fake Choir, Solid Perspective, Architectural Perspective, Illusory Space.

Introduction

The church of *Santa Maria presso San Satiro* in Milan, attributed to Donato Bramante on a documentary basis, is famous for the solid perspective of its choir. It evokes a depth that is comparable to the transept with the aim to simulate a Latin cross space in the first, exceptional example of integration between perspective and architecture.
Bramante, already dubbed '*il Prospettivo*', would cement his fame with this wonderful spatial artifice, turning the perspective from a rational space representation into a perceptive deception. A wooden and stucco perspective apparatus, embedded in the back wall of the apse, transforms a small space into the illusion of a choir with a coffered barrel vault that extends the pictorial decoration of the nave. The Tau cross plan becomes a Latin cross as a prelude to the central plan. This application of the perspective with a new intent, which was extraneous to its primitive concept of mathematical 'measurement', opened the way to further applications in theatre and to the *quadratura* interior decoration.
Like many other Maria's churches of the Renaissance, mostly with a central plan, the construction is linked to a prodigious event [Lotz 1955], which took place near the shrine of San Satiro, Sant'Ambrogio's brother. The original building was erected before 879 by Ansperto, archbishop of Milan [Buratti 1992, pp. 9-24] and according to the tradition, in 1442 the image of the Madonna was profaned by a stab and bled. The place became a pilgrimage destination, then Ludovico Sforza approved the construction of a new

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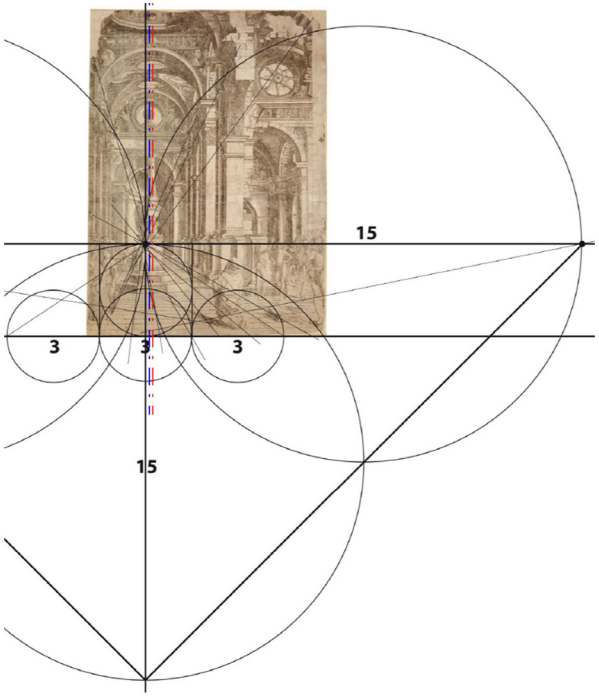
church, which was built between 1478 and 1482 [Dalai Emiliani 1980].
Due to lack of space, Bramante created the choir in a solid perspective. The image of the apse recalls the Masaccio's Trinity with an unprecedented interpretation that was named 'admirable artifice' by his contemporaries. He applied the Donatello's stiacciato in a full scale, visualizing a different space from the built one. The idea was new and it became a decisive model for the theatre, which was forced to contract the scene in the stage. The baroque scenography will define the theoretical principles later [Baglioni, Salvatore 2017].
This solution prompted many scholars to study the church and its perspective suggesting the point of view in different positions. The first hypothesis is that of Arnaldo Bruschi [Bruschi 1969, pp. 745-750], taken up by Filippo Camerota [Camerota 2006, pp. 247-248], which identifies the height of the point of view at 2.60 m and fixes the distance of the observer in golden ratio with the width of the picture plane, defined by the nave width.
This hypothesis seems to be based on an arbitrary graphical reconstruction of the choir geometry, because it does not correspond to existing surveys that are correct. The second is Eros Robbiani's one [Robbiani 1980], quoted by Rocco Sinisgalli [Sinisgalli 2001, p. 264], which establishes the main point at a height of 2.10 m with the observer on the edge of the first bay, about 13.90 m from the picture plane. Also in this case the published drawing does not overlap the surveys drawings.
The different height of the point of view is surprising. In fact it coincides with the point of concurrence of the straight lines that simulate the depth of the fake choir, which can be easy derived from the restitution of the choir previous surveys [1]. These overlap each other and respect the current survey. No hypothesis followed the geomatic survey published by Adele Buratti in 1992, which was focused on the church structure and elevation, more than to the articulation of the choir, only represented in cross-sectional drawing [2]. The other authors who studied the church did not made perspective investigations, with any references to other hypotheses.
Both theories fix the point of view at a higher level than the one described by the treatises, which Alberti measures in 3 Florentine arms, corresponding to about 1.75 m., comparable to eye level of a good size man. Robbiani justifies the excessive height with a detailed analysis of the analogies with the perspective in the Prevedari engraving [3], in which the horizon line is high if compared to the kneeling figure's eye, less to the others (fig. 1). The plate highlights a slight offset of the central vanishing point with respect to the church axis, underlined by a monument under the dome. As a consequence, the main centres of symmetry are not aligned with the perspective, as seems to happen also in the Milanese church because of the axis offset and the choir asymmetry that emerges in the survey.
The two hypotheses seem to be set on arbitrary restitutions, based on a perspective reconstruction that fixed the central point in the middle of the tabernacle because it was flawed by a symbolic prejudice or perhaps by a photograph from a higher point of view. It can be verified that it would raise the point of convergence of the coffers in the fake vault. No authors refers to a measured survey.

Fig. 1. Pattern of the Prevedari engraving: the offset in the point of view highlights the depth staggering the elements along the visual axis (grapfic elaboration by the authors).

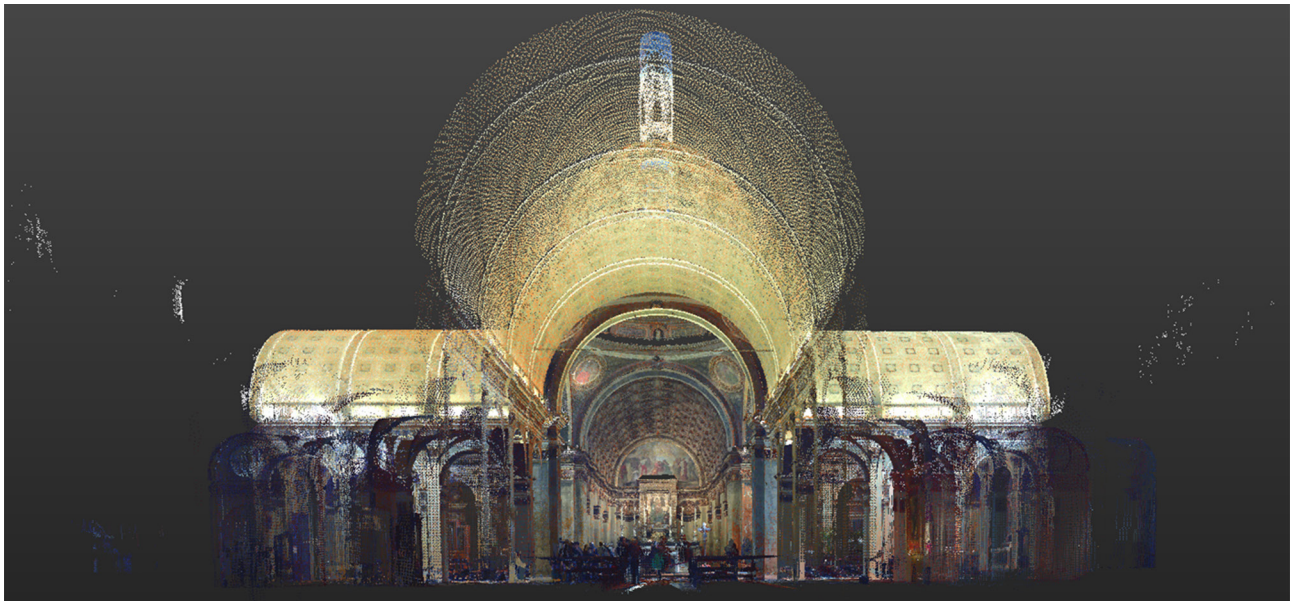


The importance of Bramante's example in the science development of perspective justifies therefore a new study. This is eventually based on an accurate architectural survey, adopting tools that are suitable to the object complexity to verify the position of the projection point of the fake choir.

Architecture, simulation and construction

The research pursued the privileged point of view identification starting from the virtual reconstruction of the consolidated design hypothesis, according to which the choir simulates the transept length. The digital reconstruction of Bramante's illusory space was derived from a reworking of a theoretical model assumed from the instrumental survey with laser technology [4] (fig. 2), as part of a national research project dedicated to architectural perspective [5].
The hypothesis was to reconstruct the virtual apse theoretical model using the scan of a transept arm to collimate the perspective conspicuous points of the choir, and to determine the point of view on the longitudinal axis identified by the false coffered vaults, looking for references that can be recognized directly on the mesh model.
Three-dimensional scans provide conspicuous and precise data, but point clouds do not constitute a three-dimensional model immediately available to the accelerated perspective geometric analysis, based on the collimation of fake real points of the choir with those of the ideal model. Therefore it was necessary to transform the point cloud into a mesh model [6], whose level of detail was a compromise between computational manageability and the precision required by the research, with a high polygonal density in the choir and less for the rest of the architecture (fig. 3). The superposition of photographic pixels, made available from the same scan, to the reworked mesh was fundamental to identify the conspicuous points to be collimated even where the density was lower.
In restitution it was decided to deprive the surfaces of the decorative paints, obtaining a 'neutral' model that would allow an objective and punctual reading of wall structures plastic articulation, to highlight and to facilitate the study of geometric characteristics and possible anomalies.

Fig. 2. The laser scanning point clouds (elaboration by Compagnia delle Misure).



Both the verification of previous hypotheses and the point of view research are based on data provided by an accurate digital survey, integrated by a direct survey of the main elements, capable to offer immediate and precise indications (fig. 4).
The main steps were:
- the integration of 24 points' clouds produced by the scans required for the church interior survey;
- the reworking of mesh model with the stitching of gaps in the shadow areas;
- the restitution of the direct survey and its overlap to horizontal section of the points' cloud with a check for possible model construction 'errors';
- verification of geometric correspondence with respect to the axes for the identification of constructional anomalies:
- identification of collimation points of the solid perspective with the virtual choir;
- identification of the main straight line [7];
- the construction of virtual choir with the length of the transept, according to the theoretical design model;
- the definition of intersection area of the collimation lines;
- verification and comparison with a reference grid based on the construction metric unit.
The direct survey has highlighted the metric regularity in the rhythmic scansion of central nave and transept, with a difference of 2 Milanese feet in their width and the consequent 'lengthening' of the cross vault, dominated by a dome resting on an oval cornice.
The instrumental survey has confirmed this basic construction precision, but also some important constructional anomalies hidden by the ornamental apparatus:
- the misalignment of the central nave compared to the choir;
- the different misalignment of the cross vault with respect to central nave and the choir due to the transept's slight deviation;
- a marked as much as inadvertent asymmetry of choir and pilasters that define the frame;
- the circular base of the dome, hemispherical, disguised by the oval cornice overhang inserted in the trapezoidal lay-out of the cross vault.
The greater transept width, already distinguishable in the point cloud due to the impossibility of collimating the depth lines of the nave with those of the choir, and the little deviation of its axis with respect to perpendicular to that of the nave are concealed by the different protrusion of the tambour cornice on the two axes and by the raising of one foot of the center point of arc and nave vault to keep the *cervello* element at the same height (fig. 5, fig. 6).
The false vault is divided into 10 coffered ceiling with the impost of the arch at the linear frame, which is lower than the diameter. Developed on a circumference the panels are 19, as a consequence of same arch elevation and of the choice of positioning the cornice in key place of the *patera*, as done by Alberti in Sant'Andrea in Mantua, unlike the pictorial examples on the model of Masaccio's Trinity.
This solution contradicts the constructive custom of coffered vault, but it allows to have the wooden choir in correspondence of false capitals, avoiding the lacunars cutting and to optimize prospective deception. On the contrary, the fake painted coffered ceiling that decorate the vault of the nave resumes the pictorial model, with an inversion of roles between reality and illusion. (fig. 7)
The laser survey also points out the choir asymmetry, whose vertical axis is displaced by 5 cm between the frame (taken on the advanced plane and the background) and the misalignment of the two arches of the cross vault equal to about 16 cm, which makes it difficult to uniquely determine the main distance between the two halves, while the different width does not allow the direct reconstruction of the virtual choir from the scan of the transept.
The choir asymmetry is revealed in the three-dimensional collimation of choir conspicuous points with its virtual ar-

Fig. 3. The mesh model of the church used in the reconstruction of the choir, after optimizing the point clouds (graphic elaboration by the authors).

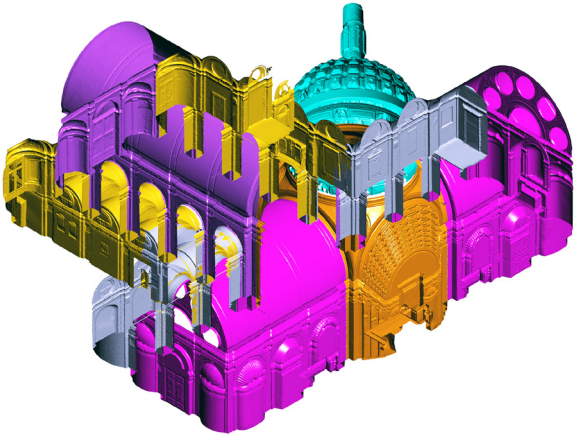
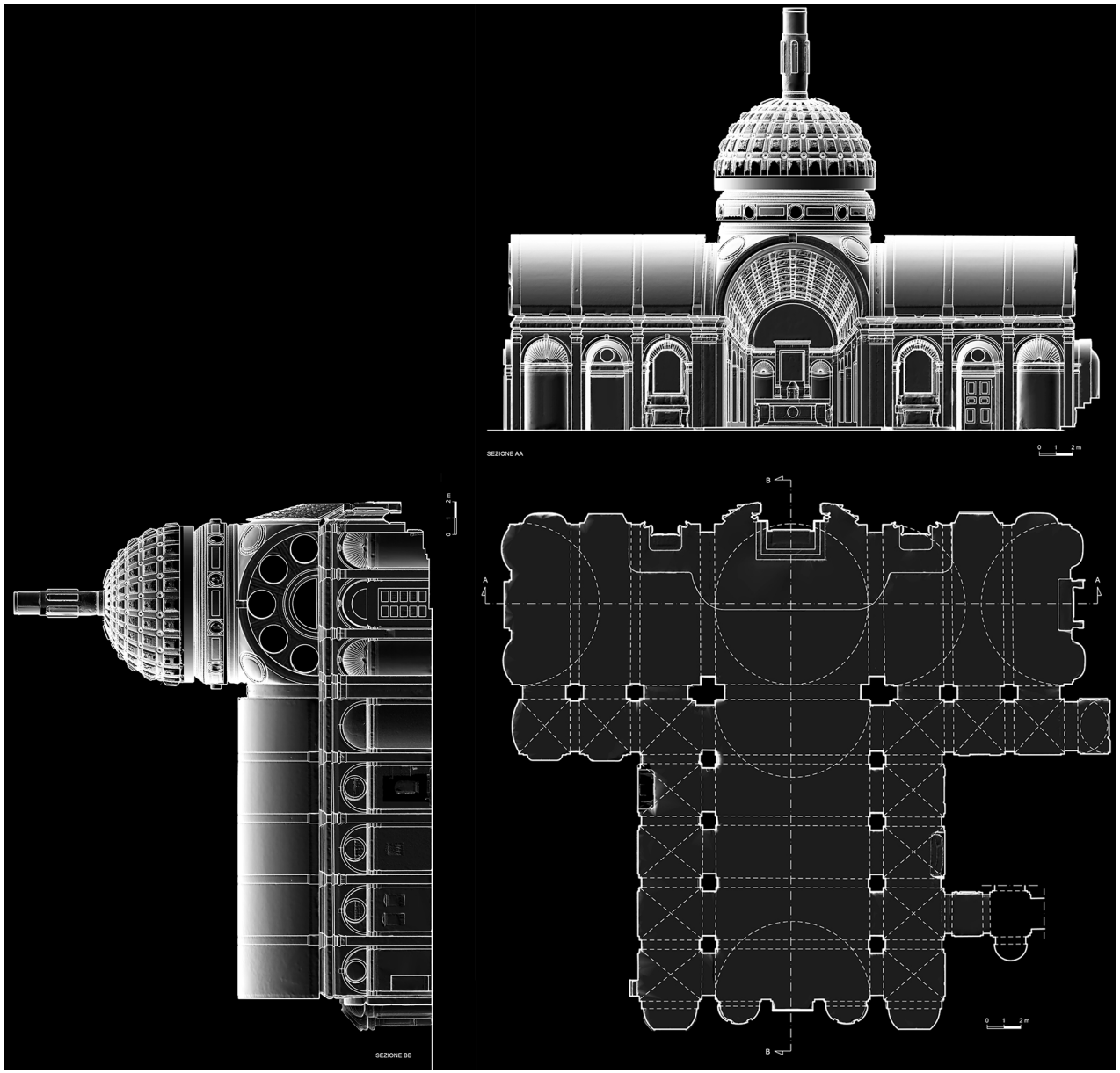


Fig. 4. Architectural survey of the church. Longitudinal and cross section (graphic elabortion by the authors).



chitecture, rebuilt starting from the nave for the different width of the transept, which highlighted the geometric irregularity in the different intersection of the visual rays with the axis of the nave in the two halves. The deviation to the left recalls in proportions the one of the Prevedari engraving, already underlined.
This asymmetry, due to a 2 degrees difference in the angle between the base that defines the two depth planes and the frame, shifts their intersection to the left in the point of view, making difficult to determine it.
The survey documents the current situation of a building on which various kinds of morphological-conservative interventions have followed [8], that may have altered the geometry of the perspective elements, so before proceeding with the analysis it was decided to verify the specificity of restoration in relation to the purpose of the research [Grecchi 2015]. In particular, the last restoration (1983-1992) found the original terracotta floor 17 cm lower than the current two-colored marble floor, created in 1531 by eng. Cristoforo Lombardi [Marrucci 1987, pp. 23-50]. Other interventions that have affected the apse have been done on the wall of via del Falcone, because of its very small thickness required a first consolidation in 1662 and again in 1937.
Also the wooden apparatus and the stucco of the choir have been restored several times, but do not seem to have undergone morphological changes, while the new floor has distorted the position of the observer's eye with respect to the original drawing, which had not foreseen the presence of the base of the pillars, as it can be seen in the articulation of the false choir. From the survey it does not seem that the wooden apparatus was moved upwards when the floor was raised, therefore the main point of the perspective does not seem altered. However, the double survey identifies with adequate precision the main point in line with the point of concurrence of the

Fig. 5. Geometric and building irregularities (grid of Milanese feet), (graphic elaboration by the authors).

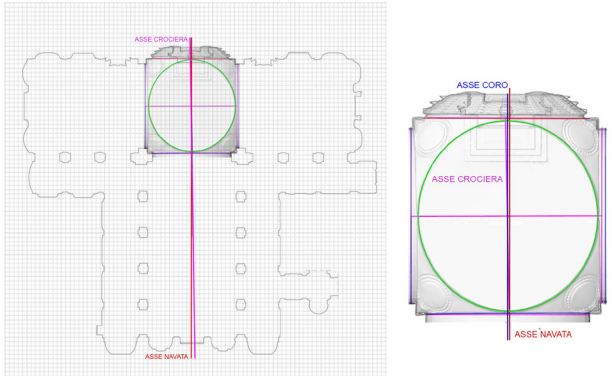
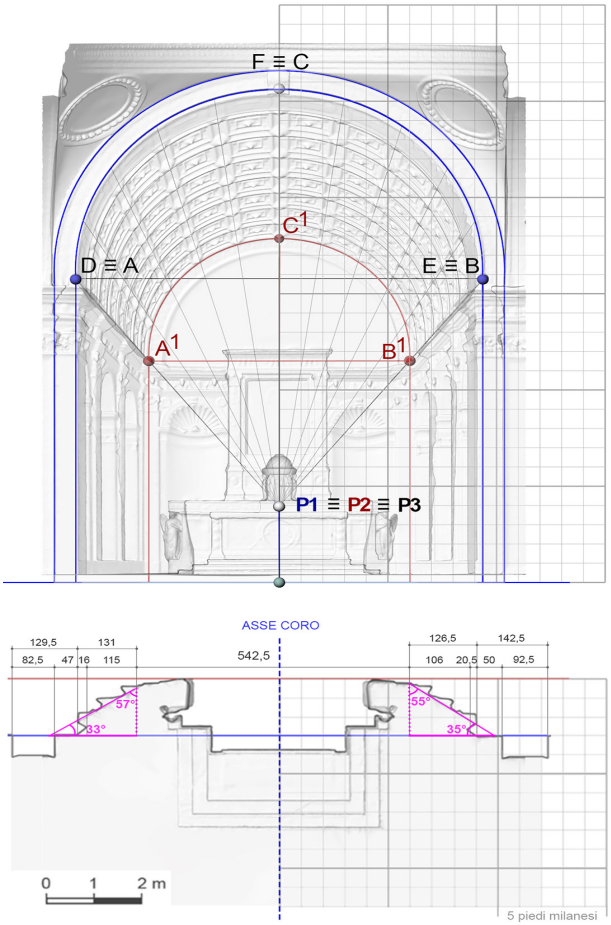


Fig. 6. Choir asymmetries: the angle in plan that compensates for the different width of the pillars keeps the altar in the middle (graphic elaboration by the authors).

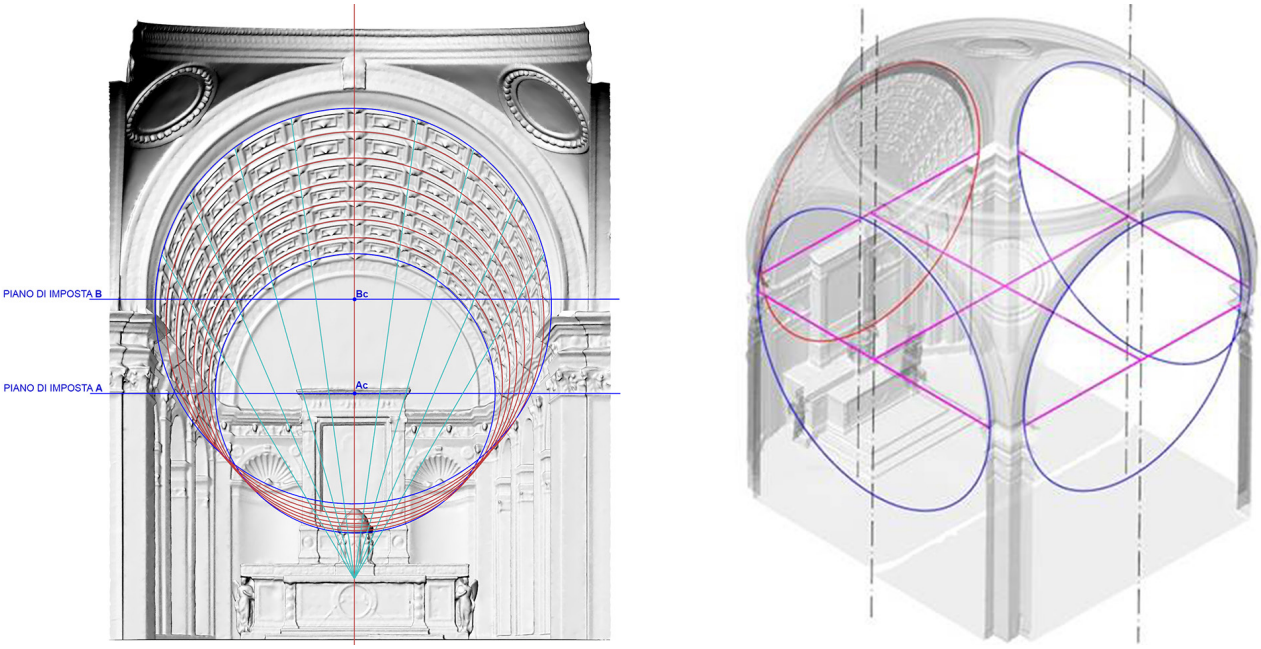


false vaults alignments, establishing the horizon at a height very close to the ideal value suggested by literature, verified taking into account the floor rising, invalidating consequently the previous hypotheses [9].
The point of view determination is more complex, placed on the horizontal axis at the height of the main point. In fact the possible alignments are not many and for the approximation of the fake choir plastic apparatus the perspective pilasters that simulate the pillars have significant dimensional variations. The maximum deviation can be found in the pilasters that delineate the choir and define the perspective framework, which differ by 10 cm (the left is 82.5 cm; the right is 92.5 cm) (fig. 8). Rather than constructive inaccuracies, this asymmetry is attributable to a series of compromising adaptations to the existing elements, aimed in finding the most effective solution and from which it is impossible to disregard the perspective reconstruction analysis for which there is no reference below the horizon level. In fact, as Robbiani pointed out, the choir floor is not in perspective, although it is beyond the frame and it's justified by the need to guarantee visual continuity between reality and illusion.

Design drawing, measurement and geometry

Retracing the hypothetical procedure of design drawing, the survey establishes the height of the main point P1 at 1.53 m from the current floor, that is 4 Milanese feet from the supposed level of the original floor, lower about 21 cm. The viewpoint is 16.97 m (equal to 39 feet from the frame and 42 from the background plane). The framework, beyond which the solid perspective of the virtual choir originates, is on the faces of the masonry pilasters that separate the architectural space from the perspective space and the distance of the point of view from the picture is therefore 1.5 times the presumed depth of the transept.
The analysis of the survey using a square grid in Milanese feet allows to overcome the uncertainties produced by construction irregularities and to formulate a reliable

Fig. 7. Geometric analysis of the fake vault. The bow is raised and the vault has a beam in the key ridge (graphic elaboration by the authors).



hypothesis on the design process. Alberti's perspective theory influences the construction of the accelerated perspective. The reading of *De Pictura* points off a series of axioms and rules that see a rigorous design method in measurement, squared grids and cubic space, that the writer refers empirically and his illustrator of the Lucca manuscript clarifies through a drawing that represents a schematic plane that can refer to a space punctuated by a cubic tessellation [Alberti 1518, f. 23*r*]. During the Renaissance the use of the 'cubic space' was the architectural design control method.

The illustration of procedure for putting in perspective a cube of known dimensions divided into square modules, with the frame on one of the faces and the point of view at distance and height in proportion with the measure of the edge, highlights relations and coincidences between the perspective variables. The representation of a cube in perspective exemplifies the possibility of 'measuring' an en-

Fig. 8. Search for the point of view in the solid perspective of the fake choir (graphic elaboration by the authors).

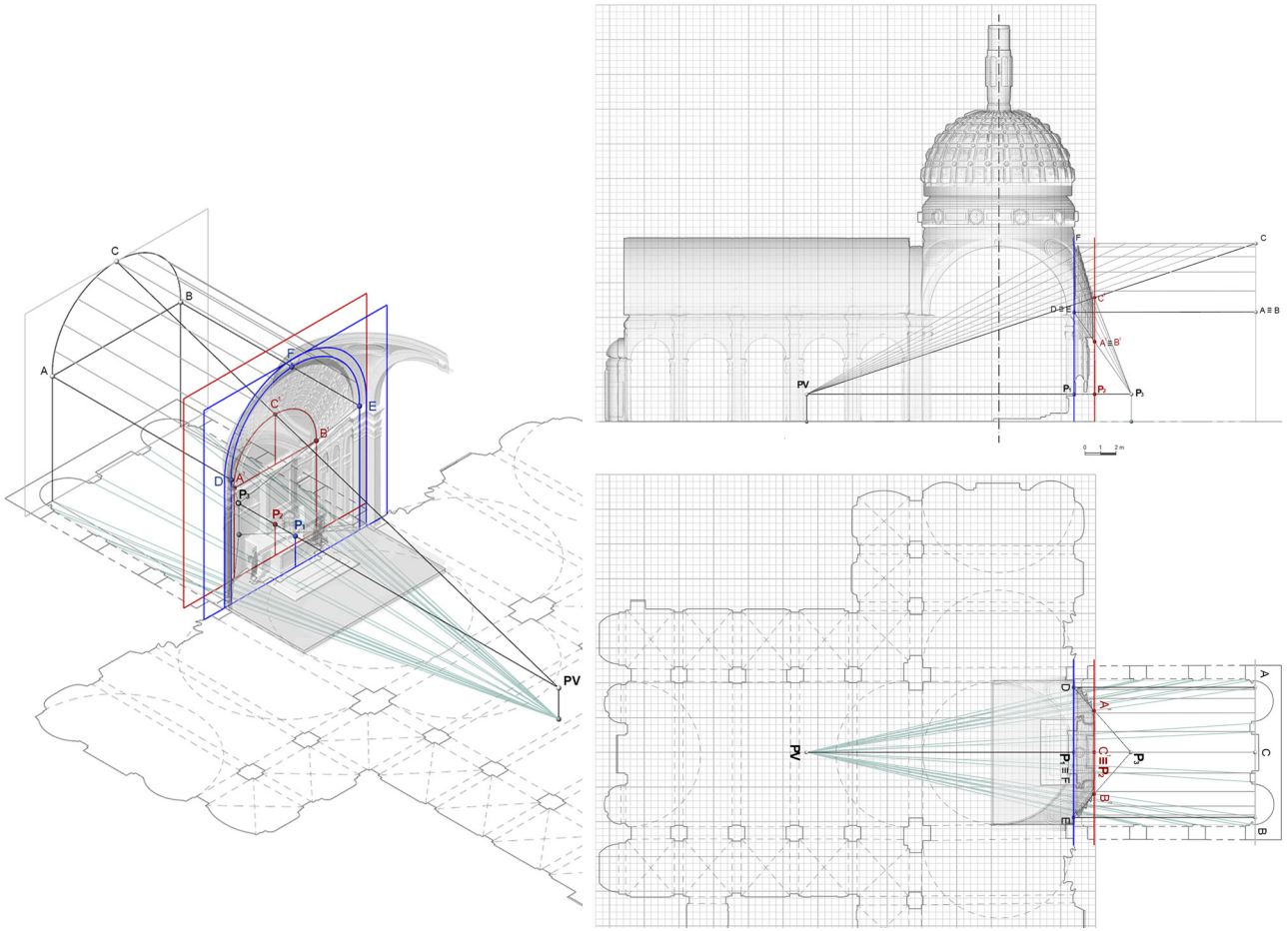


Fig. 9. Pattern of Albert's quadrangulus and geometric pattern in axonometric view. (graphic elaboration by the authors).

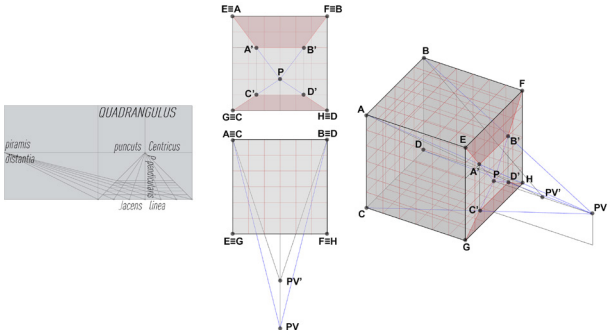
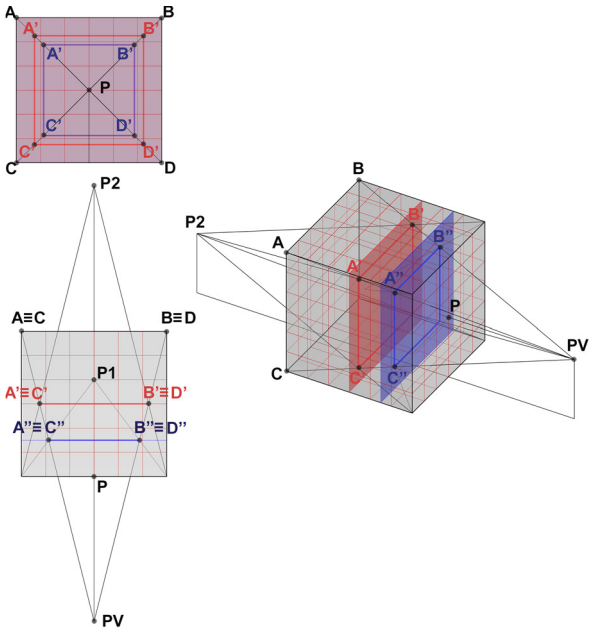
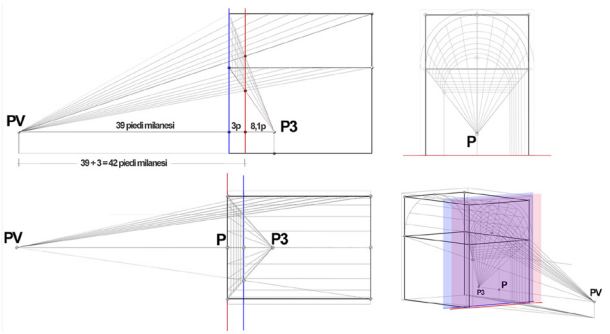


Fig. 10. Three-dimensional pattern of the three variables in the solid perspective: point of view, picture plan and background (graphic elaboration by the authors).



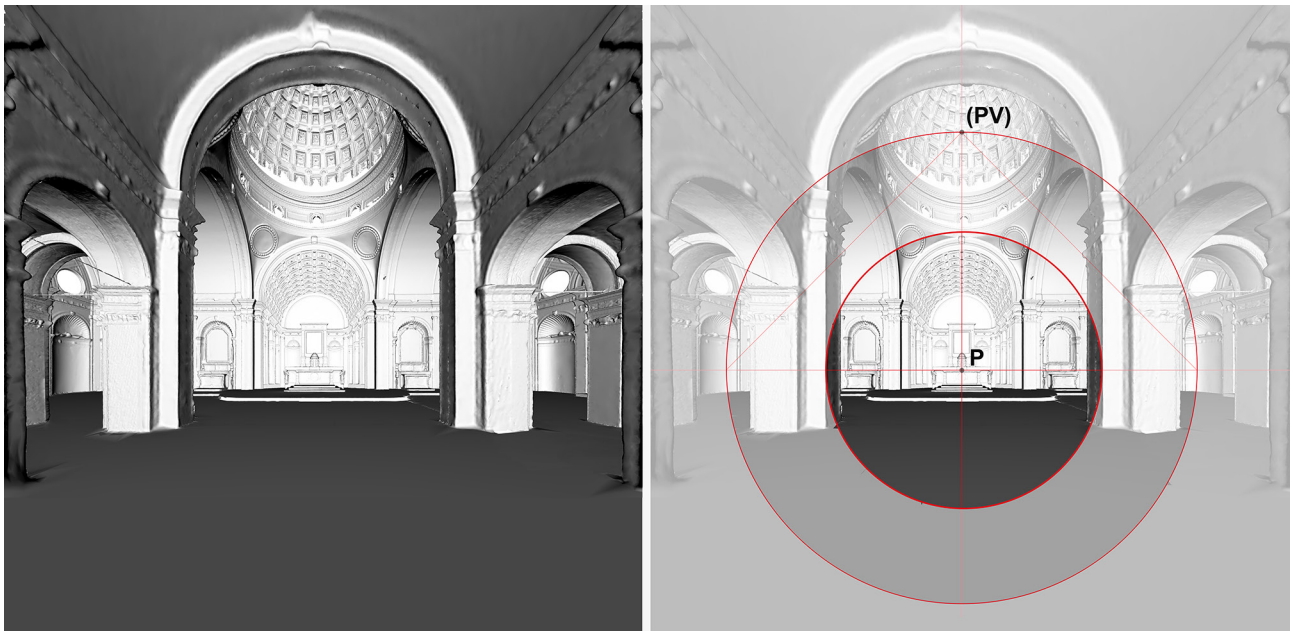
vironment in which the plan and elevation are contained in the same square matrix scheme: the grid belonging to the frame is a contemporary representation of the plan and the elevation of the cubic room. The idea of a cubic space and its plan drawing are therefore governed by the same modular scheme of the square grid, in which *ichnographia* and *orthographia* can be traced back to a scheme that associates number and measure also in perspective. Figure 9 explains the relationship between the surfaces projected on the frame and the grid placed on it. The edge is 6 modules and the faces are divided into 36 (6 x 6) smaller squares, for a total of 216 cubic units, like in the explanatory graph of Alberti's words. If you place the point of view A at a distance from one of the the faces of the cube [10] equal to the length of the corner (6 units) and at the height of 2 units, the projection on frame of the opposite upper edge face coincides with the second horizontal line from the top of the frame grid, while the corner projection opposite to the base cube framework corresponds to the first horizontal line of the same grid. If the distance of point of view is halved, the coincidence between perspective and grid occurs for edges opposite to the framework and orthogonal to the projection plane. With this matrix, if the point of view is placed at a distance from the picture equal to the edge of the cube and at a height equal to half, the problem of the *quadrangulus*, exhibited by Leon Battista Alberti in the *De Pictura* [Alberti 1518] and then taken up by Piero della Francesca in *De Perspectiva Pingendi* [11] *incipit*, is proposed again. The question became the paradigm for positioning the height of the point of view (3 Florentine arms = 4 Milanese feet), but here we can realize that the

Fig. 11. Perspective diagram of the variables of the solid perspective of the choir (graphic elaboration by the authors).



problem is of a completely different scope, since it explains the construction of the solid perspective, which no one before Bramante had dared to apply on a real scale.
This simulation allows us to hypothesize that Bramante applied an extreme simple process, derived from Alberti's perspective method, which lays the foundations for the conception of the Renaissance 'cubic space' [12] In San Satiro Bramante shows a knowledge that integrates architecture and painting in a single method attributable to the square grid. This tool allowed to think space as a function of shape, number and size, to project it on a plane (linear perspective) or to contract it between two planes (the perspective frame and the background plane), generating a solid perspective. To contract the space in a scenographic fiction it's necessary referring to the relationship between the variables of accelerated perspective: the relative position of the point of view, of the frame and of the 'background plan' π^1 parallel to the frame. The conceived architecture contraction depends on this plan position. If the depth to be contracted is known and the position of the π frame and the PV point of view is decided the second plane is fixed parallel to the frame at a distance of 3 feet (distance of the accelerated perspective of the fake choir) and the notable points A, B, C are connected with the point of view: the alignments intersect the plane π^1 parallel to π identifying the points A^1, B^1, C^1. Joining these points with the corresponding ones D, E, F on the frame, the segments A^1D, B^1E and C^1F are determined whose extensions intersect in P3, which is the point of convergence of parallels to the segments described by the contracted coffered ceiling of the vault. Once these four elements and the metric procedure that links them have been identified, it's easy to obtain all the points of the solid perspective. The constructive tracing of the wooden quarterdeck that keeps the floor horizontal may have been done in scale or in true dimension on the floor, reporting the fundamental elements of the perspective in plan and section (fig. 10). Once the tracing is prepared and the armour of the fake choir is built, one proceeds with the definition of the perspective position

Fig. 12. Virtual vision from the theoretical point of view: the central space unites nave/choir, transept and dome (graphic elaboration by the authors).



of the pillars, creating a simplified wooden structure on which to define the minor parts in stucco, and realizing the final painting.

Conclusions

This is the goal of the check carried out on the architectural survey, verifying the theoretical design hypothesis on an ideal model that was reconstructed coherently with the real architecture (fig. 12). The consolidated thesis of the design reference to a central plan suggested the search for the position of the point of view in the 'theoretical' plan with transept arms, choir and nave of the same dimension, aligning the fake chorus with the real transept width. In this case PV would advance towards the centre of the arm of the Greek cross, bringing the observer closer to the middle of the nave in the centre of the imaginary space, thus in a conceptually significant position. Once again the survey removes any doubt: the particular proportion that the longitudinal section shows between the distance of the point of view from the picture plane and the theoretical depth of the choir underlines the correctness of perspective reconstruction, deduced from the virtual model.
This theoretical point of view satisfies both the suppositions of Architecture scholars and the statement of contemporary treatises, but also the perceptive assumptions pointed off in Robbiani's study.
The Bramante's design mastery, manifested in the elegance of the relationship between the real architecture and the perspective apparatus, shows that once acquired the instruments for space measurement, the architect exploited the visual representative potential by applying the perspective to interior decoration, as an integration of the architecture itself.
The meaning of 'real measure', which was originally associated with perspective, was later extended to the space and turned into the theatrical game between reality and fiction suggested by Bramante's work. The same method that Alberti describes in the exercise of the *quadrangulus*, was applied inside the room to create a virtual space that, like the two Brunelleschi's plates, becomes 'real' because the image has the same measure of the reality.
The geometric identity between the object and its image is what makes the measured representation 'true'. Thus the perspective materializes the artifice through which the image interacts with the real space, creating a figurative room that extends the building without continuity solution. The key is the integration of the point of view of the *architectura picta* in the real room, with the application of some expedient devices to hid the critical points in the boundary between the real and the virtual space.
The geometric pattern deduced from the metrological reading of the survey reveals an idea of space functional to the scenic perception and its perspective representation, confirming the importance of geometry in the control of the visual space. The 'cubic lattice' solves the solid perspective problem with a simple pattern, through which the solid perspective of San Satiro became the first model of modern theatrical scenography. In this way Bramante fixed the empirical bases before Guidobaldo del Monte's coding [Del Monte 1600] and the further application to the baroque theatrical scenography, according to the practical indications of Nicola Sabbatini [Sabbatini 1638].
Thus, at the end of the fifteenth century, in Milan, the perspective becomes an useful element for the definition of the architectural space. After this Bramante's 'admirable artifice', the quadratura reworked its application to theatrical scenography.

Notes

[1] The known surveys that may have been at the base of two perspective reconstructions are those of F. Cassina (1840-62), E. Road (1884) and F. Manspero (1938).

[2] Performed by the G.M.S. from Milan.

[3] The image is attributed to Bramante on the basis of an inscription inserted in the engraving which indicates he is the author.

[4] The survey was carried out with a Faro laser scanner by the research group.

[5] PRIN 2010-11 National Research, principal investigator professor R. Migliari, with the participation of research unities of Rome, Milan, Turin, Venice, Napoli-Salerno, Florence-Bologna, titled *Architectural Perspectives: digital digital preservation, content access and analytics*.

[6] The mesh model was processed using Geomagic Studio 12 software.

[7] The main principal ray or observer's Optic axis is the line perpendicular to the pictorial plane, passing through the point of view; in this case it is a horizontal line and the only variable that we can determine exactly.

[8] Cfr. Cultural Heritage Information System of the Lombardy Region, Sheet OARL-1j560-00062.

[9] Leon Battista Alberti states 3 braccia fiorentine (*1 braccio* = 58,3626 cm) that correspond to 4 *piedi milanesi* (*1 piede* = 43,5185 cm).

[10] The cube side is the plane of representation.

[11] Piero della Francesca. (1476 ca). *De Perspectiva Pingendi*. Book I - XII, "*Da l'ochio dato nel termine posto il piano asignato degradare*" [Nicco Fasola 1984].

[12] The author explains the problem by placing a square on the geometric 6 x 6 Florentine arms lattice; the picture plane lays on a cube side and the point of view has the same distance of the cube side lenght (6 arms), the height is equal to the half of the cube edge (3 arms) [Alberti 1518, f. 23*r*].

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A Codification of the Cubic Projection to Generate Immersive Models

Lucas Fabián Olivero, Adriana Rossi, Salvatore Barba

Abstract

The results of this research aim to describe the representation system made with immersive visualizations. The main goal is to transfer techniques that characterizes immersive models from raster images to models generated with vector images. This way is passed over the boundary that supposes the simple substitution of the elementary geometrical entity, point (or pixel), with the line. In order to do it, the transformations from bi-dimensional views to the immersive panoramic will be codified. It is proposed an advancement for the state of the art, connecting the studies with the descriptive geometry field, opening the cone of vision to the whole space that surrounds the observer. The work considers, as a departure point, previous studies about hybrid immersive models using both equirectangular and cubical projections. But, while for the equirectangular projection there is a complete bibliography for both intuitive (trail-error) and mathematical methods, for cubical projection instead, the procedures are just approximated, without a necessary theoretical and complete framework. The used method previews, as a mandatory passage, the development of geometrical formulations that will constitute the base for the mathematical ones. Announcing future steps, the content here presented in graphical terms, will look to be synthesized in an algorithm with digital graphics output, written ad-hoc, looking to propose a new advanced technique of representation.

Keywords: cubical projection, cubemap, equirectangular projection, advanced representation techniques, VR panoramas.

Introduction: immersiveness and immersive model

"*Inmersividad, proviene del lat. immersus, part. pas. de immergĕre, sumergir. Hablar de nuevas tecnologías nos lleva al concepto de inmersivo, de inmersión y de proyectos inmersivos. El criterio utilizado es estar sumergido, o contenido por algo. Lo que nos hace suponer-imaginar que al estar sumergido o inmerso hablamos de un medio ambiente, de un macro ambiente, de una escenografía, de una construcción, o una arquitectura variable*" [Lolas 2014].
An immersive model is a set of communicative elements (for example graphics, texts, sounds, videos), connected to a virtual environment. It will be this environment to allow the interactivity of the user with the content.
Environment and content then can be connected in different ways: for instance, the content overlaps a virtual environment (Virtual Reality) or the content overlaps a part real and part virtual environment (Mixed Reality). There would be a third possibility where the content overlaps just a material (real) environment (Augmented Reality) but this possibility will be excluded from this article as our focus is precisely on the environment creation. As, in this case, the generation of the environment is not object of representation, the problem is reduced in a technical difficulty (the execution) and not to a theoretical question.
In *La geometria descrittiva: evoluzione di una teoria* is commented "*Ci si accorge, allora, che la rappresentazione matematica con le sue caratteristiche di continuità e accurato controllo metrico è affine al metodo di Monge,*

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mentre la rappresentazione numerica, discontinua e approssimata, ma agile nella visualizzazione foto realistica, è affine alla prospettiva" [Migliari 2012, p. 26]. Based on this, as we are focused on the representation regarding the environment itself, it is possible to study the sensitive perception produced by shapes in the space (as extension of classic perspective) or the mathematical model for its definition (as extension of Monge system). Thus, two clear objectives are defined: first, how to represent basic shapes in an immersive model, and second, the relation from the perceived image with its constructive definitions. Understand these two concepts results fundamental to comprehend the space when, for example, the immersive model is applied to architecture. This space will be defined with a extension of classical perspective and its methods, enlarging the technique and finding a fluid way to read objects in relationship with the architectural environment and this with the urban context.

As a consequence of a growth use of immersive techniques, must be pointed how important is to regulate the process to warranty a scientific procedure. It is in fact enough to see the exponential increasing of use and applications based on panoramic photography. On another hand, the construction of a generic environment involves both architects and engineers mainly because: first, the conception and materialization of the space constitutes their raw material; and second, because the state of art shows the autonomous existence of this representation system which lacks scientific discipline almost completely, being this slot where the article takes place.

The definition of the term 'virtual' here used, goes further the usual connection with the tools of execution of the drawings. It is proposed widely, in the terms expressed by Vito Cardone in his *Modelli grafici dell'architettura e del territorio*, that is "*con l'aggettivo inteso come ciò che è latente, ma soprattutto come ciò che possiede una potenzialità; ossia – secondo la categoria aristotelica – come ciò che è fondamentalmente potenziale inteso*" [Cardone 2015, p. 342].

We extend the definition to survey models (reconstructions) or models destined to architectural planning. As we will see, this opening will not link us to the used tool but to the communicational coherence of the representation, or, to the thought process for the construction of the scene.

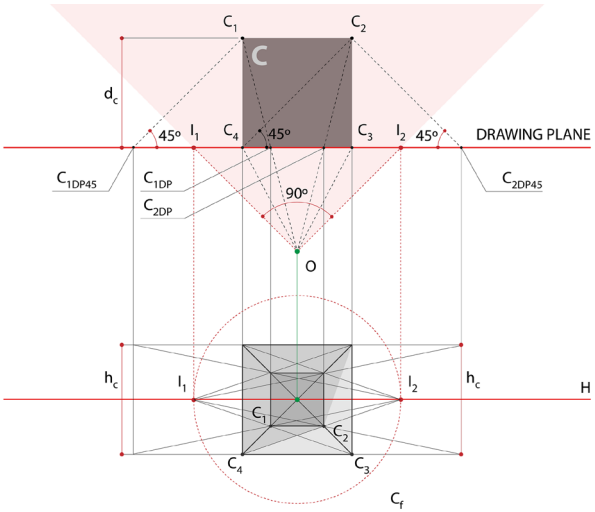

Fig. 1. Conical perspective solved using the 45° diagonals to find C_1 and C_2 (graphic elaboration by Lucas Fabián Olivero).

The context

The first steps of the current immersive models find origin in entire environments that we could refer as 'immersive installations'. Some examples are some *trompe l'œil*, the Sistine Chapel, the compositions of Andrea Pozzo, in St. Ignatius of Loyola at Rome etc.

In these cases, the room is a real space and the representation is based on one specific point of view. Following that point, the spectator can dive into epic scenes and study the symbolic content.

From here, maybe the first systematic attempts to create virtual environments with entertainment purposes were between the 18th and 19nd Century.

Then 360° painted scenes for the panoramic rotunda of Robert Baker and multiple projections of the Cinerama [Rossi 2018, pp. 1389, 1390; Cabezos Bernal, Cisneros Vivó, Soler Sanz 2014, p. 5] brought to the public the access to remote places or historic moments, such as the ruins of Pompeii or the Battle of Waterloo.

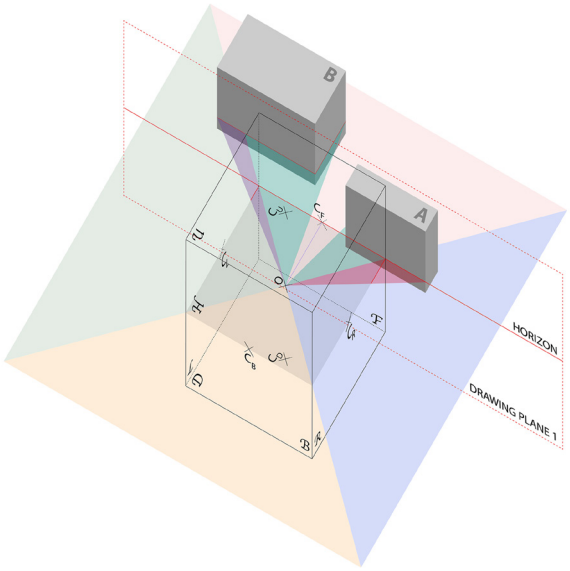

Fig. 2. Generic scene to be represented in cubical projection (graphic elaboration by Lucas Fabián Olivero).

Up to this point, an entire huge mechanism serves to create the illusion of the audience. Sometimes this device even tried to 'confuse' spectators passing them through installations designed for that purpose: "The building was designed to disorient people as they passed from the actual to the virtual world. Spectators had to walk down a long dark hallway and climb shadowy stairs before emerging onto the viewing platform" [Shannon 2016].
Finally, one nearest link is the panoramic photography, evolution of the first panoramic drawings. Nowadays, thanks to the Internet it is very easy to find whole or partial immersive panoramas from elsewhere. In fact, digital architectural navigation to countless places and urban exploration had become a daily habit thanks to billions of people that have a photographic machine in their mobile phones and the use of many applications able to capture single images and then compose the entire panorama through an instant stitching such as Google Street View.

Today, immersive models are used mainly to disseminate information but at the same time, it can be seen a strong growth for technical uses. For example, to visualize architectural and urban projects or as a basis for photogrammetric modelling [Barazzetti, Previtali, Roncoroni 2017].

Anamorphosis

At the base of all these productions and as a common denominator, we find anamorphoses. An anamorphosis is a way to reduce dimensions in the most literal sense of the word. For example, a real object that exists in three dimensions is reduced in one dimension when it is drawn in the plane, however and as is logical, the object and its representation are equivalents in meaning, but not in matter.
In order to appreciate the 'natural form' of an anamorphosis, there are two conditions: first, the observer must watch the scene from the exact point where the rays of the conic projection converge.
If not, the representation will look as 'deformed'. Indeed, Andrea Pozzo marked those points in the above-mentioned St. Ignatius for the best appreciation of the scenes in the main nave and in the false dome. Nevertheless, when the same representation is watched outside of the focus point, is not entirely correct to affirm that is deformed (as a synonym of erroneous, poorly performed). The representation is just correct for a single spatial point and for a specific field of view, such as pointed by the mathematician António Araújo in *Anamorphosis: Optical games with Perspective's Playful Parent* [Araújo 2017, pp. 73, 74].
There is also a condition to produce an anamorphosis: to have the knowledge of the surface where the rays are being projected. The distribution of the spatial points in the final representation will depend on the shape of that surface. As that surface must be flattened, without its knowledge is impossible to determinate the group of possible developments in the plane.
In particular, classical perspective itself is a special case of anamorphosis. Indeed, the surface is known (a plane) and the group of projected rays is reduced to those contained in the cone with a field of view of 90°. The result of following these two conventions, is a type of representation where the deformed outline of the objects can be overlapped to the reality, fooling our perception and giving the

sensation of something truth. In fact, "Perspective had been developed as a method representing space and spatial objects according to our seeing" [Leopold 2016, p. 409]. Thus, it has been popularized by its character by common agreement either for its reading or for its elaboration.
In the case of our immersive models, the used surface is no longer a plane but a spatial container. The surface now surrounds the observer, closes around it and defines a specific projection related to its intrinsic characteristics. The next step is defined as the flattening of the surface and the codification of the previously mentioned possible line developments. So, for example, the equirectangular projection is the flattened map of the projected points and lines in a sphere, while the cubical projection (or cubemap) is the resulting flattening when the used projection surface is a cube.

Digital and hybrid immersive model

During the history, the used tools to do a representation have switched from analogical to digital, giving as a result nowadays a big range of expressive possibilities. The choice can be done according to the technical-communicative needs defined by the object of the representation itself. In particular, the digital technology, that has started with the imitation of analogical techniques, has gradually become an independent language of representation.
The immersive models referred in this article are, in their final version, digital, or better said, assembled and visualized with digital technology. Effectively, in order to have the most complete fruition and interactivity degree, the content additions and the final visualization are carried out with computer support. Maybe the best-known example of a digital immersive model is the virtual tour where the used environments can be from 360° panoramic photographs to environments entirely created with modelling programs.
Passing over the rusty debate about the primacy of digital or analogical techniques, it is proposed a hybridization of digital models with analogical drawings. In this way, it is possible to recover some of the innumerable advantages that both techniques can offer separately strengthening mutually. We will call this Hybrid Immersive Model. The hybrid immersive model is generated with analogical techniques and mounted, navigated, enhanced and visualized with digital ones.

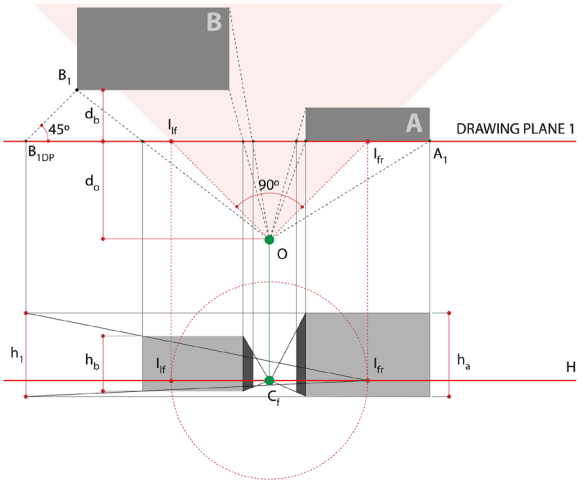

Fig. 3. Construction of the classical conical perspective of the scene (graphic elaboration by Lucas Fabián Olivero).

There are different kind of projections used in computer sciences that allow to synthesize the entire panorama around the observer. Most of them represent at least six vanishing points according with the x, y, z axes of the 3D euclidean space, however, this work will just refer the equirectangular and the cubical projections.

The state of the art

It has been studied a varied casuistry of immersive artworks cases. The presented selection bases on two criteria: first, the chosen surface for the creation of the virtual environment, and second, in the used drawing method.
For the first case, the chosen examples reach the two most used surfaces for VR navigation: the sphere and the cube. In particular, they refer the equirectangular projection (among the various spherical projections) and the cubical projection respectively.
For the second criteria, are referred two main methods used indistinctly for each projection: the intuitive (or trial-and-error) and the geometric / analytical / mathematical. The intuitive method considers the use of preformatted grids. Following the template, the users can 'create' immer-

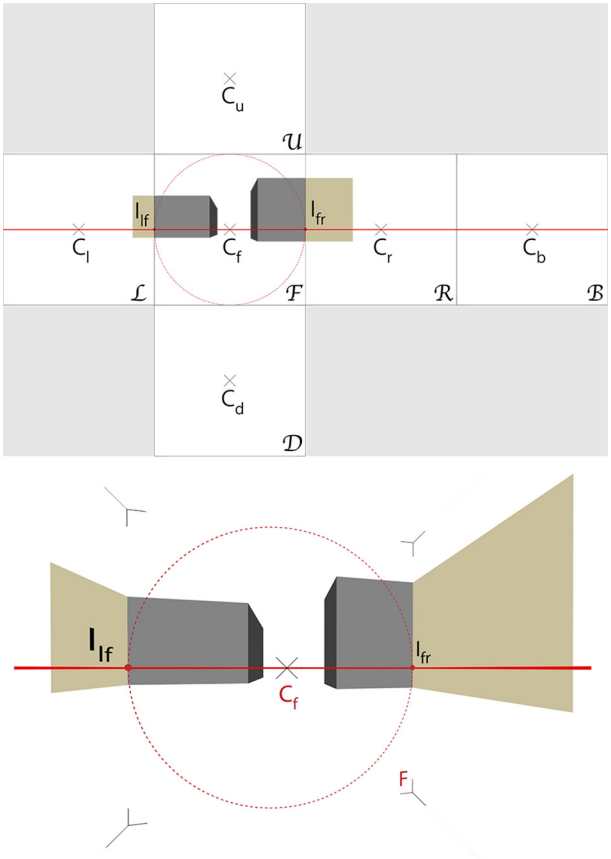

Fig. 4. The composed perspective placed into the cubemap and its immersive visualization (graphic elaboration by Lucas Fabián Olivero).

sive perspectives, although they are not necessarily really conscious of what are they doing. In fact, the depth effect of perspective can be also the result of guessing with approximative trial-and-error proves.
A geometric / analytical / mathematical method instead, aims to spread a deep knowledge: the reasoning to understand the whole projection in the space. This article is part of this second group.
Crossing the criteria, for spherical projections using intuitive methods, it is possible to find an increasing number of architects and artists using grids, such as Arno Hartmann (Germany), Sandnes Frode Eika (Norway) and Bruno Sucurado (Argentina). Here, the grid has been used either to produce imaginary virtual environments (project) or to re-produce synthesizing real environments (survey). Another use given to these templates is as a base for 360° raster drawing software, such as *Sketch 360* [1].
For spherical projections using geometrical-mathematical methods, works such as *Drawing Equirectangular VR Panoramas with Ruler, Compass, and Protractor, Constructing a Total Spherical Perspective* [Araújo 2018a; 2018b] and *La prospettiva e la costruzione dello spazio figurativo* [Masetti 2014], evolve or complement previous works such as *L'œil, au centre de la sphere visuelle* [Michel 2013] and *La perspective curviligne: de l'espace visuel à l'image construite* [Barre, Flocon, Bouligand 1967]. All these studies aim to the analytical development of perspective using spherical projections. The methods cover from partial field of views up to the whole 360x360°. In any case, there is a common *modus* breaking down of the whole system into the simple construction of partial elements like points, lines and planes. Only then is given a method that includes an integral solution. The result is an exhaustive base material in scientific terms. In particular, the intention to solve these systems is pointed to the use of simple instruments such as the ruler and compass or, as Migliari refers with the use of the classic geometry "*la geometria classica che impiega esclusivamente la retta e il cerchio*" [Migliari 2012, p. 27].
For cubical projection using intuitive methods, there are many blog entries as tutorials, such as *4 Steps to Create a 360 VR Illustration/Painting in Photoshop* of the Studio Behind 90 office [2] or *Draw Sketches for Virtual Reality Like a Pro* [Kurbatov 2017]. These publications try to solve the 'how-to' without mention the projection itself and its characteristics. In some cases, the problem is partially solved converting the equirectangular grid into the cubemap and then reverting to the equirectangular for-

mat again. There are more automated procedures also such as the Oniride plugin [3] created for Photoshop 2015.5. Furthermore, as described in the *How to create 360 Virtual Reality (VR) Illustration with Adobe Photoshop CC* from the previously mentioned Studio Behind 90, Adobe Photoshop includes by default a tool to switch between the equirectangular projection and a flattened vision. Finally, there is the Sketching in Space project [Habakuk, Zöllner, Müller 2010] that uses an interactive installation based on a cube and wireless tools designed ad-hoc.
For the cubical projection using geometrical-mathematical methods, the research gives a partial result with raster-based solutions, leaving a gap of disciplinary advancement for a vector-parametric answer. There are also methods that could be adapted to give partial solutions since the cube is used as the basic reference to draw spatial forms but always giving just incomplete solutions. Some examples are the *Prisma T-homólogo de un Cubo* method used in the *Homologías entre figuras de tercera categoría* [Fernández Rodríguez 2002, p. 2]; or the drawing of the cube in perspective that makes an "*aplicación de retícula con figuras en paredes laterales y localización en su interior*

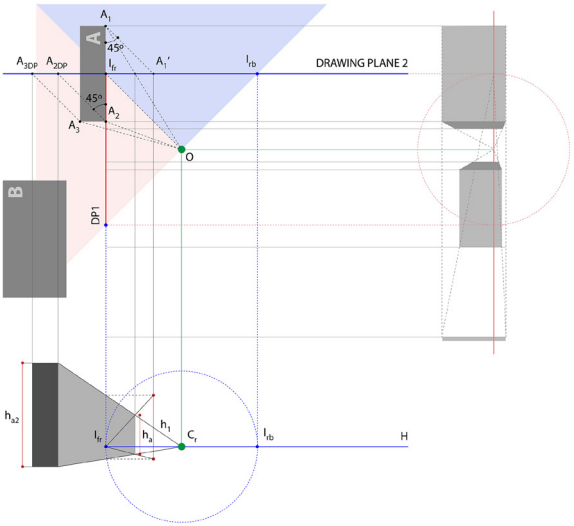

Fig. 5. Construction of the conical perspective rotating the observer 90° to its right (graphic elaboration by Lucas Fabián Olivero).

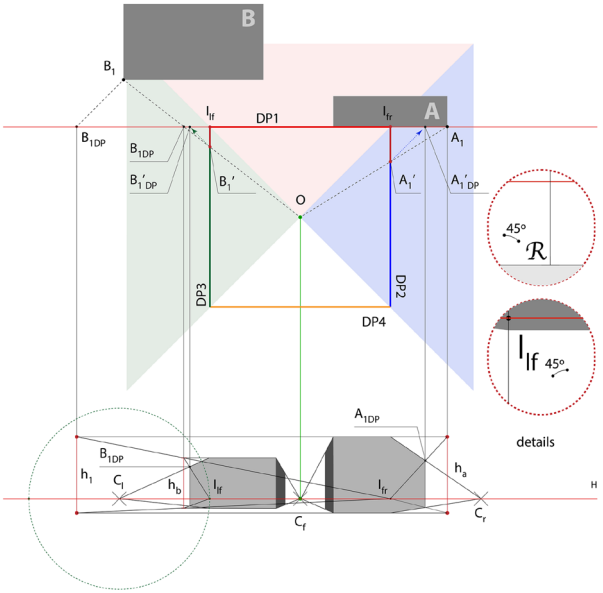

Fig. 6. Final composition of the scene solved with the use of conical projection (graphic elaboration by Lucas Fabián Olivero).

de dos estructuras poliédricas valiéndose de la retícula de las paredes y el suelo" [Hernández Falagán, Signes Orovay, Berdié Soriano 2015, pp. 10-12]. All these knowledges, undoubtedly valuable as a starting point, do not give a fully, systematized, organic and elegant solution to the immersive creation with cubical projection. In order to do it, a solution that includes the classification of lines and the elaboration of grids must be proposed as, for example, the complete immersive drawing method based on geodesics as used for the equirectangular projection [Araújo 2018a, p. 17].
Even if the current developments for cubical perspective are not exhaustive to solve the problem, as indicated in the first part of this work [Rossi & Olivero 2018, p. 36], a close approach is the comparative study of both surfaces in computer science for environmental mapping, such as Isocube: Exploiting the Cubemap Hardware [Wong, Wan, Leung 2007], Converting to/from cubemaps [Bourke 2016] or Environment Mapping and Other Applications of World Projections [Greene 1986]. However, as could

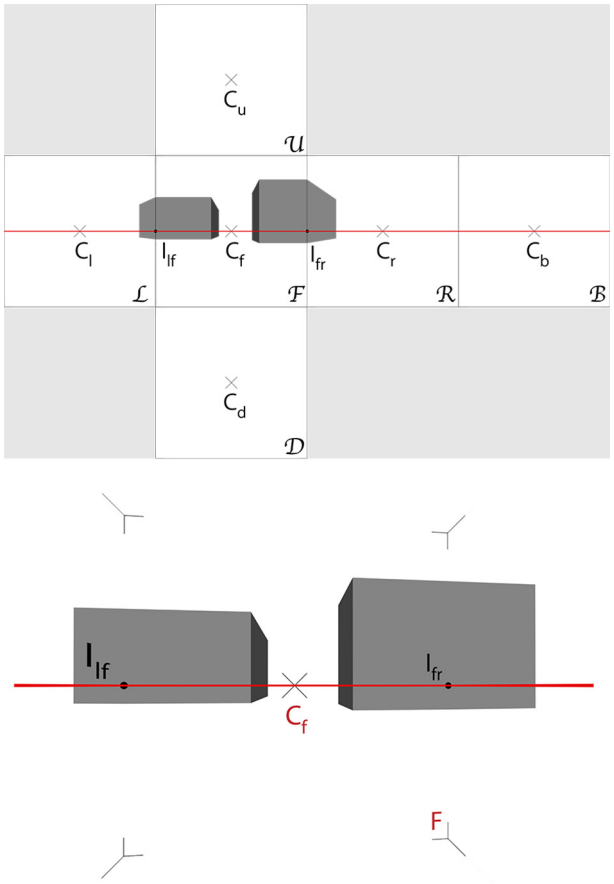

Fig. 7. Final construction placed into the cubemap and its immersive visualization (graphic elaboration by Lucas Fabián Olivero).

be natural for this area, the study is focused on the performance and efficiency in terms of resources for rendering, evaluating, for example, graphical benefits such as reflections and shadows for 3D modelling. In terms of texture, for example, each pixel of the sphere (inscribed or circumscribed in a cube), finds its correlation with a pixel of the texture of the cube. The result is just validated by a correct visual appreciation without a metric parameter.
As a result, the content collected for the cubic projection using geometric / mathematical methods does not complete a holistic solution. The empirical methods instead, manage to cover well the how-to procedure but leaving out of focus the scientific precision. So the current state of art shows a big presence of the trial and error method and as a consequence, the obtained result can be only for exhibition purposes mainly, which has, at least, a doubtful utility for scientific purposes.
This characteristic seems to be inherited from the historic conception and use of immersion. In fact, in those cases the goal was to increase the emotional impact of the users as pointed in Virtual Art: "Immersion can be an intellectually stimulating process; however […] in most cases immersion is […] a passage from one mental state to another. It is characterized by diminishing critical distance to what is shown and increasing emotional involvement in what is happening" [Grau 2003, p. 13]. Therefore, one risk is the propagation of a not normalized representation that could lead to a black box use [Araújo 2018a, p. 16]. As a result, those who make use of this representation system may not really possess the knowledge of what they are doing, rather they may be are mere virtuosos in the use of some software or tool. Nevertheless, the whole state of art testifies the growing interest in those techniques that join unify the analogical drawing with the VR technology.

Basic descriptive geometry in cubical projection

Hereinafter, a generic example of representation in cubical projection using a geometrical / mathematical method is presented. At the base of all the reasoning there is classical descriptive geometry. The objective is to find the correct projections for a projection that will result fragmented since it exceeds the normal 90° vision cone that each cube face contains. In order to clarify some concepts that will be used next, a conical perspective example with a central vanishing point is recall (fig. 1).

The used method suggests to find the correspondent position of each point in the perspective (bottom part of the figure) by defining rays from C_1 to C_4 to the observer O and intersecting the drawing plane (DP). In particular, C_3 and C_4 result in real dimension in H because they are in contact with DP.
The problem is how to find the depth of elements that are not in contact with DP such as C_1 and C_2.
In a first method, C_{1DP} and C_{2DP} are going to be used, which are the intersections of rays C_1O and C_2O with DP. Then C_3 and C_4 are projected toward the central point. The projections of C_1 and C_2 are in the intersection with the extensions of C_{1DP} and C_{2DP}.
Furthermore, there is also another possibility which suggests to project the searched point with an angle of 45° towards the drawing plane. What are we doing actually is to use known vanishing points (those corresponding to 45° lines). In the specific case of C_2, the diagonals intersect DP in C_{2DP45} and C_4. Applying the reasoning previously explained, the real height of the object h_c is positioned in H in the extension of C_{2DP45} or C_4. From there, C_{2DP45} is projected to the vanishing point I_1, or to I_2 if C_4 is being used. Any of the two diagonals give the same result, which can be graphically verified also for C_1.

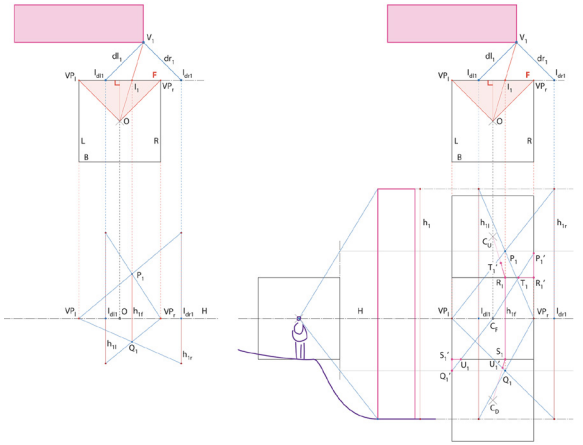

Fig. 8. General layout of the complete algorithm for horizontal and vertical lines parallel to the faces of the cube (graphic elaboration by Lucas Fabián Olivero).

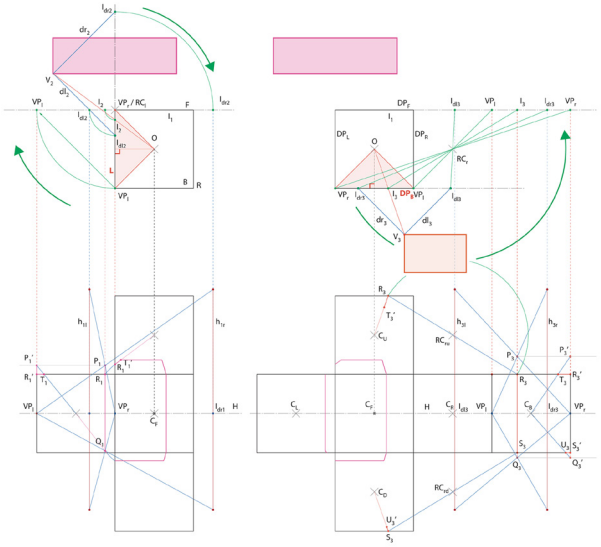

Fig. 9. Application of the algorithm to a practical exercise. Resolution of a line contained in one face (left) and of a line divided in three segments (right) (graphic elaboration by Lucas Fabián Olivero).

In conclusion, any of the three ways must verify that the projection of C_2 is at the intersection with C_{2DP}.
Let us now present the generic scene composed for two buildings A and B (fig. 2) to be represented in cubical projection. The perspective is a composition that uses one central vanishing point called C_f (fig. 3). Both buildings have the same height h_1. The facade of building A is parallel and coincides with DP1. Building B is also parallel to DP1 but it is located at a certain distance d_b. A generic observer O is defined located at a distance d from DP1 and perpendicular to it.
Now to construct the perspective, every vertex of buildings A and B are extended to O. Any intersections with DP1 is, at its time, extended to the bottom part until the horizon line H. Since A_1 is in contact with DP1, it results that $h_1 = h_a$. Then h_a can be translated to H in real dimension and positioned directly according to its relationship with the observer (or H). To find h_b instead, the previous method with the diagonals will be follow projecting, for example, B_1 at 45° towards DP1. As a result of this construction, the complete scene is obtained with zones that exceed a 90° field of view.

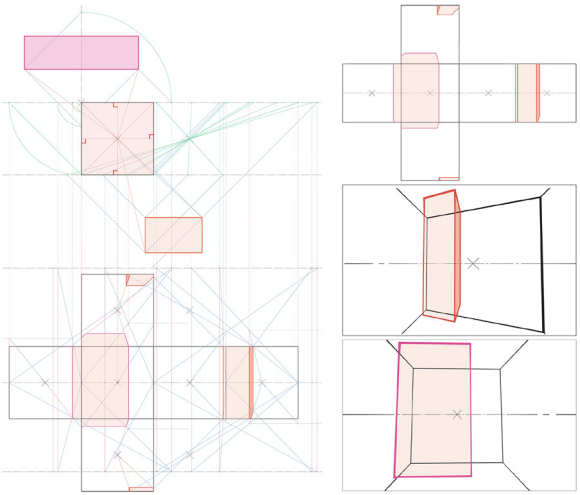

Fig. 10. Application of the algorithm to a vertex positioned in planes different than the frontal one: projection in L and R (left), projection in B (right) (graphic elaboration by Lucas Fabián Olivero).

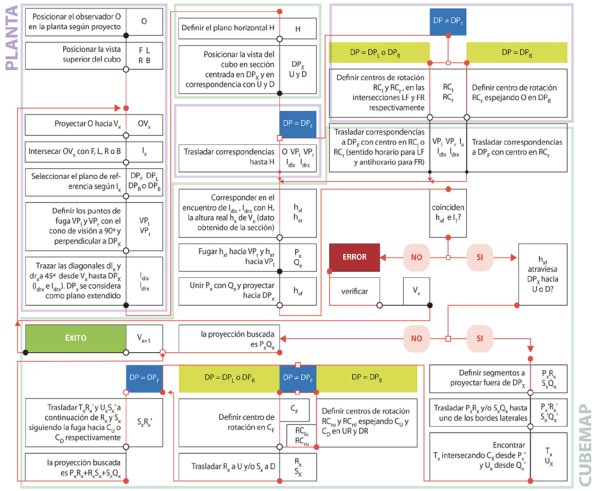

Fig. 11. Complete resolution of a practical exercise applying the algorithm (left). Final cubemap and VR visualization (right) (graphic elaboration by Lucas Fabián Olivero).

Next, the recently created scene is positioned in the open cube map and then proceeded to the immersive navigation. As each face of the cubemap contains a field of view of 90°, the outside zones are incorrectly visualized (fig. 4). Nevertheless, if the observer turns to its right, it is possible to reconstruct building A which is actually the only one in its visual field (fig. 5). In this case is used drawing plane DP2, perpendicular to DP1 and the vanishing point Cr.
The part ahead DP2 is solved in the same way at the beginning of this section, that is translating A_2 and A_3 with an angle of 45° to DP2. The real height of the building is in correspondence with point I_{fr} (intersection of A with DP2). Using I_{fr} and projecting from C_r, the searched heights are obtained in correspondence with A_{2DP} and A_{3DP}.
Placing this last content on the right face R of the cubemap centred on C_r, the immersive navigation results in a correct visualization (fig. 6). Thus, the use of a drawing plane orthogonal to the first scenario gives as a result the correct anamorphosis.
In order to complete the scene, it is now proposed a direct method. Coming back to the initial scene, we want to find the intersections without the cumbersome need to rotate every 90°. To this end, the projections in the four planes of drawing DP1 to DP4 located around the observer are studied (fig. 7).
A_1 is used to verify the new method with the already elaborated perspective. After established new drawing planes also new intersections have appeared, and therefore new projections. In the intersection of ray OA_1 with DP2 has now appeared A_1'. This point is in front of DP1, so, to find its correspondence is translated 45° towards the extension of DP1, which gives $A_1'_{DP}$. In perspective, $A_1'_{DP}$ effectively matches the intersection already built during the previous steps. Iterating the process for B_1 the effective end of building B is also found. Now joining all the constructions in the cubemap and using the immersive modality, the correct composition of the anamorphosis can be verified (fig. 8).
As last step, once a complete drawing has been done, digitalized and cut with the right proportions, it will be necessary to add some metadata trough digitally manipulation and do certain mandatory passages required to assemble the model using software such as Hugin or PanotourPro to recompose the cube. A first work-flow guideline for this part can be found in *"CubeME", a variation for an immaterial rebuilding* [Barba, Rossi, Olivero 2018].

The complete algorithm

"*A partir del estudio geométrico y algebraico de la homología entre figuras de tercera categoría podemos proporcionar a la Informática una serie de algoritmos que nos permitan explotar las posibilidades de esta transformación geométrica*" [Fernández Rodríguez 2002, p. 1]. As corollary of the applications, a first complete algorithm for drawing on the six faces of the cube is presented (fig. 8). The general workflow is defined through the use of the already presented 45° diagonals and the searched height is found in their encounter. Once got it the height, a double verification is made using the correspondence given by ray OP_x (fig. 9). As practical application is solved an example composed by two buildings with the same height located in the front and back of the observer (fig. 10) where is also includes the solution to represent fragmented heights, that is, contained in more than one face of the cube (figs. 9, 10). The correctness of the whole construction is verified with the proper anamorphosis in the immersive visualization (fig. 11).
Is still missing the resolution of lines or planes that do not have their vanishing points at the centres of the faces (or, lines that are neither horizontal nor verticals, parallels to the edges of the cube). It is also announced that this total resolution will be the object of future publications.

Conclusions

Cubical projection is presented as a complex representation that nourishes from the concepts of the classical perspective as a starting point. This new way of adaptation enhances undoubtedly immersive graphics. However, is still lacking to develop a complete classification of lines, the resulting projections from the intersection of planes with the cube, as well as a method to locate points from live survey.
Some innovative aspects of this kind of representation are synthesized in: first, the system seeks to enhance, define and organize in a technical way a geometrically defined immersive hybrid model, exclusive potential for the moment of the digital modeling. In fact, thanks to the scientific use of technology, the usefulness of immersive installations has been extended and made more complex, with the fundamental difference (regarding the historical panorama) that the user can interact and add content in real time.
Second, being at the base of these models the analogical drawing, the system constitutes an instrument to understand and manipulate the space. Can be seen that this upgrade of the traditional methods supports an extended application. In fact, since the support is not limited to 90° of visual field but open to the entire surrounding vision, can be meekly studied the relation of the object and its spatial insertion and the building in its urban context. The produced environment also gives (and at the same time) a base to upload interactive contents with the possibility of visualization in real scale (thanks to the use of VR glasses).
Third, although the huge visual field covered, thanks to the use of anamorphosis and digital technology, no bulky support is needed. In effect, technology comes to complete a universal and 'pocket' access through mobile devices and the use of Internet.
Finally, being the whole process in direct correlation with the technical definition of anamorphosis, perspective and descriptive geometry, as well as mathematics and computer sciences; we have a package of resources more than enough to follow the path of a possible and innovative system of representation.

Acknowledgments

With special and deeply dedication to Vito Cardone.

Notes

[1] See <https://www.microsoft.com/en-us/p/sketch-360/9p89s2qlh11t> (accessed 2018, February 17).

[2] See <https://www.studiobehind90.com> (accessed 2018, February 17).

[3] See <https://www.oniride.com/360art> (accessed 2018, February 17).

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Techniques for Analysis and (Re)Building of Heritage

Virtual reality and augmented reality for the reading and interpretation of past, present and future

Low Tech/High Tech: interactions between tradition and innovation

Knowledge: drawing to show and prove what doesn't exist (any longer)

The Democratization of Processes and the Use of Remotely Guided Acquisition Tools for Survey 2.0

Carlo Bianchini, Luca J. Senatore, Lorenzo Catena

Abstract

The technology that 'amplifies' the real world as well as the technological means of data capturing, are continuing to have a development difficult to control or predict. Projects of a certain interest are born, develop and die sometimes without producing significant results nevertheless becoming phases of a fluid and dynamic process, on which new software applications and hardware systems are built. At the same time, the role of the academy seems to be often overtaken by what is developed by the citizen science. Researchers no longer seem to exclusively explore the 'discovery' domain, but rather work at the setup of scientifically reliable protocols for technologies often used by different communities of citizens in a way that does not conform to the specifications for which they were originally designed.
*This paper focuses on these issues taking as its starting point two experiments with high innovative content that cover various stages of the process defined by the term Survey. They pertain on the one hand to a hw/sw system of data capturing, processing and communication developed for mobile devices (*Tango Project*) and on the other to a mixed ROV/UAV multisensor platform equipped with a LIDAR system and digital camera for data acquisition in inaccessible places (*Heritagebot Project*).*

Keyword: Google Tango, Heritagebot, Augmented Reality, UAV, Survey.

Introduction

In the last years, the Survey domain has been experiencing a season of rapid and in some ways extraordinary change that can be assimilated to an evolutionary leap or, more precisely, to numerous evolutionary leaps all tending towards a phase of consolidation that we could name as *Survey 2.0*. What is the real meaning of *Survey 2.0* is still hard to know, as it becomes immediately obsolete any attempt to define it. At the same time, the role of the academy seems to be often overtaken by what is developed by the so-called citizen science [1]. Researchers no longer seem to exclusively explore the 'discovery' domain, but rather work at the setup of scientifically reliable protocols for technologies often used by different communities of citizens in a way that does not conform to the specifications for which they were originally designed. Projects of a certain interest, are born, develop and die sometimes without producing significant results nevertheless becoming phases of a fluid and dynamic process during which new software applications and hardware systems are built.
This typical phenomenon of the so-called 'digital revolution' influences our interaction with the real world both in terms of capturing and 2D/3D modeling. New systems and digital applications that only 20 years ago were almost unconceivable, become commonplace and develop through the simplification of processes, the miniaturization of sensors, the change of paradig-

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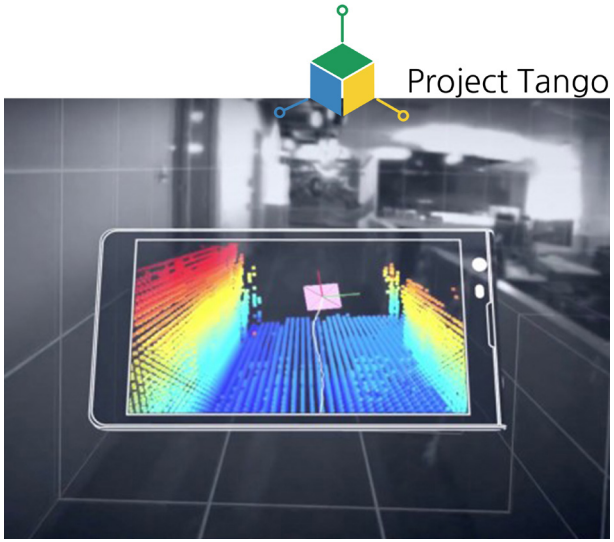
Fig. 1. Project Tango and Heritagebot prototype.



ms. As in the case of the massive 3D capturing that, since the appearance of LIDAR (*Laser Imaging Detection and Ranging*) scanners and, more recently, *Structure from Motion* (SfM) systems that generate point clouds directly from common digital images, has substantially changed the approach to the understanding of built artefacts (architectural and archaeological).
In fact, LIDAR or SfM 3D capturing systems have quickly become a sort of standard thanks to the reliability of the instruments, their extraordinary acquisition speed, a certain user-friendliness and overall economy of use (even if not always of cost).
In this context, mobile and low-cost systems are playing an increasingly relevant role, paving the way to the democratization of what was once the realm of few specialized technicians and high-end research or professional organizations. At the same time, the use of remote-controlled robotic systems is constantly and rapidly evolving, providing interesting perspectives also for the field of architecture and archaeology. Robotics in fact allows improving the methods for data capturing and knowledge enhancing of *Built Heritage* (BH) especially when accessibility of sites and exploration of artifacts is dangerous or impossible to human operators. Furthermore, the miniaturization of robotic platforms components combined with their reduced weight and consumption guarantee not only higher performances but also a minimization of impacts on the objects under study.
These processes have been (and still are) so tumultuous that in some cases the technology seems to have gone even too far, proposing an offer of innovative solutions for which there is not yet a real demand. In our opinion, the *Google Tango Project* and the *Heritagebot Project* discussed in this paper are two of these examples. Assuming as pilot cases the ancient church of Santa Maria delle Vigne in Pratica di Mare near Rome and the archaeological area of Cassino, our research has therefore focused on two main tracks. On one side, within the *Tango Project*, we tested characteristics, performance and reliability of a mobile device for real-time 3D capturing and Augmented, Mixed and Virtual Reality (AR/MR/VR) content development. On the other, we assessed the capabilities of a remote controlled robotic prototype developed within the *Heritagebot Project* and particularly its data capturing sensors (LIDAR and SfM) when used in not easily accessible contexts.

A *Google Tango/Google ArCore Project*

Tango is an experimental project developed by Google for Android smartphones and tablets that started in 2013 and ended in 2018 being presently replaced by *ARCore*.
The main objective of the project was to test the reliability, impact and interest of users in a hw/sw package that would allow for the creation of AR/MR/VR content only using their 'smart' devices. Both Lenovo and Asus producers joined this challenge and released innovative *Tango* devices with a special package of integrated hardware components (RGB camera; time of flight camera; infrared projector; fish-eye motion camera; accelerometer and gyroscope) and innovative software features. In summary, these devices can 'scan' the target scene in real time thanks to a mix of special inertial sensors that, without using any type of external signal, determine the position of the smartphone/tablet in space and generate point clouds and textured meshes.
The basic principles of *Tango* are the following:
- *Motion Tracking* - SLAM system (simultaneous localization and mapping);
- *Learning Area;*
- Perception of depth.

A. *Motion Tracking* - SLAM System
This function refers the movement of the device to the 3D space around it.
In this phase, in fact, *Tango* collects a large amount of data thanks to the fish-eye camera (about 60 black and white frames per second) and the inertial IMU (*Inertial Measuring Unit*) which includes accelerometers and gyroscope that update the position of the device up to 100 times per second. The processing of the images leads to the identification of the 'salient features' (feature tracking) of the explored scene mainly referring to the geometric discontinuities of the real environment. These in fact act as reliable elements that allow frame by frame an accurate feature tracking to which IMU readings are continuously coupled. From the combination of these two sets of data, the software identifies a 3D trajectory that represents the movement of the device in space.

B. *Learning Area*
This step causes the software to determine its position with respect to the surrounding environment. This pro-

Fig. 2. Sensors of Tango mobile devices: RGB camera; time of flight camera; infrared projector; fish-eye motion camera; accelerometer and gyroscope.

Fig. 3. Church Santa Maria delle Vigne in Pratica di Mare, Rome. Photo of the current state and point cloud obtained by a survey made with the Tango technology

cess develops in close combination with the previous one (*Motion Tracking*) and aims at accurately assessing the position of the device in space, a key function in both 3D capturing and AR/MR/VR applications. In brief, by visiting a previously acquired environment, the device compares new and old information by updating/refining its own calculated trajectory and automatically introducing corrections to the errors accumulated during the movement.

C. Perception of depth
The dynamic information acquired during the first two phases is finally placed into a three-dimensional metric grid generated thanks to the measurements of the infrared TOF (*Time of Flight*) sensor.
It is in this phase, in fact, that *Tango* creates the 3D model of the surrounding scene, an essential step to guarantee the required metric precision of the final dataset, which from now on will become the reference framework for 3D capturing and AR/MR/VR applications.

Tango Applications

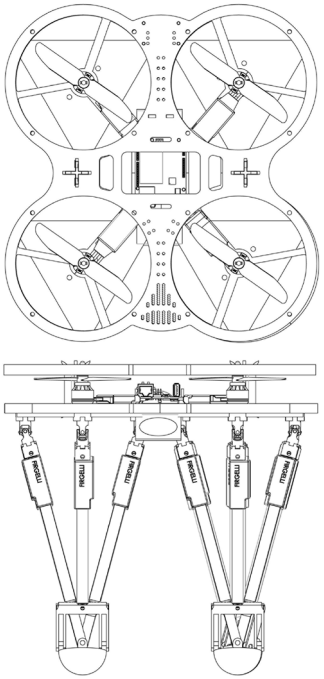
Using the combination of the integrated sensors described in the previous paragraph, *Tango* technology is able to correlate position information, RGB readings and data obtained from the infrared TOF sensor to generate a textured 3D mesh model of the 'scanned' areas. The acquisition process is particularly simplified and fully automated, requiring only the user to choose and complete his own trajectory within the area to be acquired. Our experimentation focused on the quality and possibilities offered by this technology, testing the systems on a small pilot case (the Church Santa Maria delle Vigne in Pratica di Mare, near Rome). Our activity involved the surveying (3D capture), the metric validation of the data and the creation of 3 models/contents developed respectively in AR, MR and VR environments. The results were rather encouraging especially about the acquisition and construction of communication models built almost exclusively with the consumer *Tango* device we used (Lenovo Phab Pro). However, we encountered some relevant problems during the acquisition phase mainly due to the poor performance of the hardware and its storage low capacities.
To overcome these bottlenecks, the capturing phase has

been divided into segments, each one carefully planned and optimized according to the capacity of the device. The acquired 3D numerical model (point clouds) was then processed to obtain the corresponding mesh surface. Once all the mesh surfaces were built, they were aligned by means of homologous points and validated with traditional mesh management software (in our case *Meshlab* and *Rhinoceros*) with respect to a reference model derived from an integrated topographic and SfM surveying campaign.
However, the *Tango project* was mainly conceived as a tool for 'enriching reality' in the form of AR/MR/VR content. In our experimentation the first two models (AR and MR) have been developed before and in some way in preparation of the VR model more oriented towards the use of the information content about the artefact. The AR and MR models provide in fact interactive information on the different historical phases of the building, merging its real appearance with three-dimensional reconstructions of missing parts or elements relevant for its stratigraphic reading. The mobile device, previously used for the development of content, has in this phase acted as a VR viewer ensuring the exploration of an immersive model with which the user can interact.
The expeditious survey conducted with the *Tango system* shows how the high-end technology integrated in the device allows a 3D survey of built artefacts accurate enough and at the same time easy to perform. The results are encouraging and sometimes even competitive with SfM technology. Many of the limitations found (hw performance, memory) are typical defects of an ongoing development. The hardware structure is not completely optimized for these 'survey/modelling' activities: first of all the limited RAM of the device forces users to perform multiple scans even for small constructions. Other problems concern a workflow not yet standardized or design choices that can be improved (for example, the integrated infrared sensor has a limited range of action and obviously cannot work properly in a too bright environment).
However, the advantages that the *Tango* suite offers to the entire field of surveying and representation of built structures are important: the low cost of the system (about 500 €), the ease of use, portability and, above all, the ability to operate in a real stand-alone condition. This last feature is particularly significant because the device does not need in every phase of the work

Fig. 4. Interface for accessing the contents of AR/MR/VR.

nothing but the power supplied by its own battery, regardless of any connection (i.e. internet, GPS).
In conclusion, we can affirm that *Tango*, although rudimentary, still represents an interesting innovative and 'democratic' tool offered to any surveyor or AR/MR/VR content developer. In particular, it allows the creation of new types of user experiences and content thanks to new functions (such as inland navigation and environmental recognition) that lead to a greater user involvement. Furthermore, the limitations that currently affect *Tango* in our opinion will be quickly overcome by the natural evolution of new products coming from what we might consider its heir, the *ArCore* suite.
With the closure of *Tango*, in fact, Google has started a new and more ambitious project called *ArCore*, initially presented as revolutionary because it would be compatible with all new Android devices and not only with some specific models as its predecessor *Tango*.
The idea was to extend the great potential of *Tango* technology (unfortunately not so great) to any smartphone with an Android version equal to or greater than 7.1 Nougat (in some cases recently corrected to 8.0 Oreo).
The substantial difference between *Tango* and *ArCore* lies in the removal from the process of the depth detection (TOF sensor data) and the motion tracking (fish-eye camera data), a choice that has certainly determined a reduction of costs and an increment of compatibility with the Android devices that meet the minimum requirements of *ArCore*.
Unfortunately, even if the cutting of important hardware components has given impulse to the development and adoption of *ArCore*, still there are significant critical issues in the software, mainly because of the additional 'calibration' operations entrusted to the IMU system (much more than it was for *Tango*), which require an exchange of information between the manufacturers of smartphones and those of the various sensors (accelerometers and gyroscope) at the moment not always adequate.
Moreover, *ArCore* does not seem to have yet overtaken *Tango* also because, despite the appreciable efforts of simplification (no specific hardware is required), the platform is not sufficiently supported and powerful. For example, it is not possible to perform (at least officially) neither 3D capture nor use the Area Learning function: this means that the device is not able to recognize a previously explored environment limiting in fact the creation of AR/MR/VR experiences.

Fig. 5. Heritagebot prototype design and technical specifications.



SPECIFICHE TECNICHE

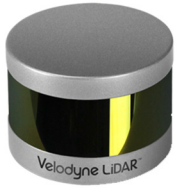
Dimensioni (overall size): cm 50x50x50
Peso (stimato): Kg. 5
Power supply: 12 V
Battery capacity: 5,2 A/h
Payload (max): 2 kg
Walking speed: 65 mm/sec = 234 m/h
Battery life (stimato): 16/32 min in small
flight 5 hours in static mode
2 hours video/sensor mode

Fig. 6. Sensors that can be applied to the Heritagebot prototype: Camera RGB, Death Camera, Lidar 3d, Lidar 2d.

Camera RGB

Death Camera

Lidar 3d - Velodyne



Lidar 2d - Rp Lidar

Despite all problems that afflict the newborn *ArCore*, expectations are still very high, and some signs suggest the implementation soon of new features to reduce the gap with the 'old' *Tango*.

The *Heritagebot Project*

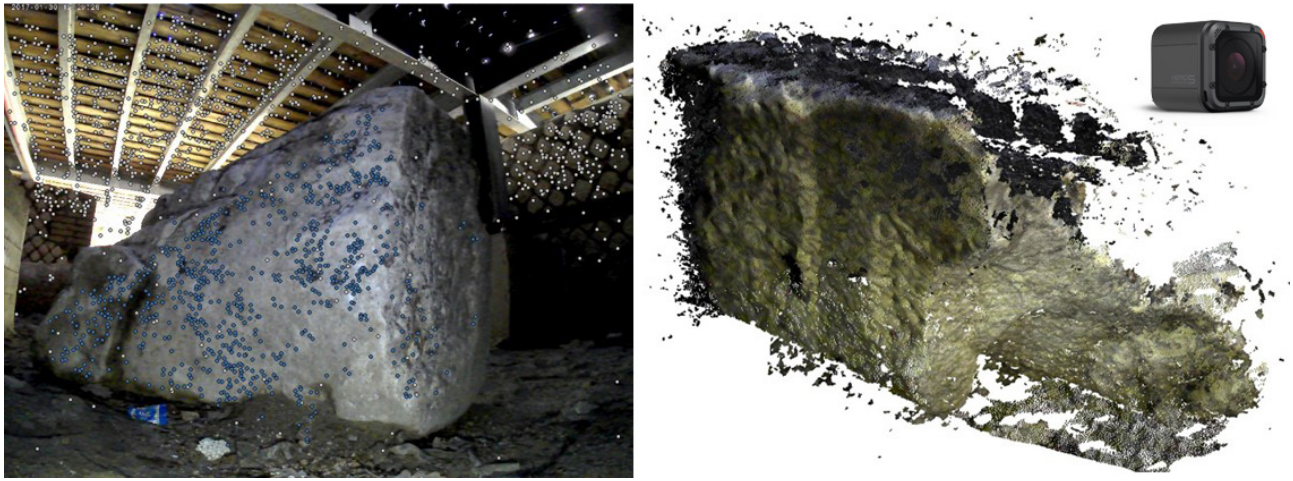
Robotics has so far provided relevant improvements to several fields (industrial, research, professional). More recently, though, it has increasingly influenced also recreational applications thanks to the availability of low cost equipment and the simplification of interfaces. This fact has triggered a virtuous helix of 'democratization' in which affordable remote-controlled platforms and lay users influence each other actually creating innovative products capable of exponentially enlarging the fields of application. This process deeply involves also the documentation and survey workflows of BH with a clear tendency to make capturing activities almost automatic, increasingly remote controlled and not affected by many of the logistic limitations we have experience so far.
Generally, robotic equipment tends to be bulky as the result of a coupled requirement: provide enough mobility and stability to the platform that hosts the sensors and ensure the energy needed to operate.
For this reason, these models seem not to be adequate to perform the activities connected with the documentation and survey of BH where instead a low impact often represents a mandatory constraint in order to preserve the object and its parts.
In this framework, we took up the challenge of developing a robotic platform providing an increased manoeuvrability, a wide range of sensors and, finally, enough energy to ensure an effective operability.
Together with the platform, 'sensors' cearly represent a crucial part of the problem for not only their mechanical or engineering implications but above all for the task they must perform in order to make the robotic station operative. Presently, we can already count on a variety of small size and low consuming devices that appear promising candidates for building up an interesting robotic platform in which different sensors could work together to perform a reliable capturing of BH. In addition, the data acquired by such a digital sensors' system can be integrated in a single work protocol ensuring both the control of the platform itself and the capturing of the studied artefact.

Quite apart from the design issues we have been briefly describing in the previous lines, we must underline how such a robotic system intends to join that challenging 'task force' of equipment aiming at making the documentation and surveying of BH as much as possible complete improving the accessibility to what until now is inaccessible for various reasons.
In fact, the layered nature of buildings that have grown over time, their physical response to years, centuries and millennia, or even the transformations produced by catastrophic events, are all pieces of information crucial to design a respectful and effective intervention on BH. The possibility of consciously making critical choices about the 'value' of an architectural or archaeological artefact often comes up against the objective limits imposed by the difficulty of exploring particular 'hostile' environments. What is accessible and visible is in fact already analysable in high detail, but often the objects of study have parts precluded to the conventional procedures of acquisition both for reasons of safety of the operator (collapse, toxicity etc.) and because they are too small for the instruments to physically access them.
Just to give an example, let us consider an artefact seriously at risk for collapse. Its documentation and survey would thus be precluded to human operators unless a complex system of consolidation structures would be setup. Nevertheless, many narrow spaces (such as subfloors or tunnels) would be excluded anyway due to practicability reasons. A robotic platform equipped with the 'right' sensors an a 'several degrees of freedom' movement capacity would be in this case the solution to overcome the mentioned above information gap.
The *Heritagebot Project* [2] was launched to meet these needs. It has aimed at constructing a remotely controlled mobile platform, highly innovative for its ability to acquire digital data autonomously and in locations otherwise inaccessible.

Applications using the *Heritagebot* remote control prototype

A major part of the *Heritagebot Project* has been devoted to the analysis of the state of the art of acquisition technologies and to what extent these technologies would support the creation of models for communication.
The first phase of the activities concerned the assessment of which sensors would fit at best the requirements of the prototype to be developed. The market proposes different solutions that can be classified ac-

Fig. 7. FSM procedure in inaccessible location: frame of the processing phase and point cloud.

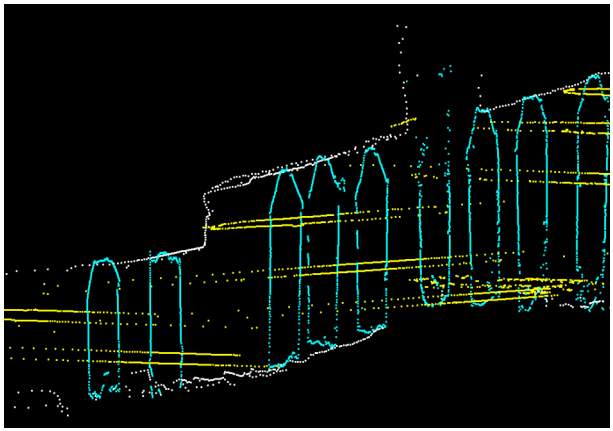


cording to their acquisition technology. In general, sensors can be divided essentially into two classes: LIDAR (2D or 3D) based on TOF laser technology and sensors capable of reacting at different electromagnetic wavelengths both in the visible section of the spectrum (the common photographic sensors) and in the non-visible ultraviolet and infrared section (the latter used by the so-called depth cameras including the one mounted on the *Tango* device mentioned in the first part). The two technologies acquire partial information from objects in the form of digital data that after processing can provide metric and/or perceptive information.
In order to evaluate the quality of the data acquired through the individual sensors, we used a comparative method using on the one side laboratory acquisitions of reference objects and on the other readings recorded in real contexts. Besides, the larger and bulkier technologies (3D laser scanning and topography) not easy to use in inaccessible environments but with certified metric quality, have represented the benchmark for the validation of the results acquired during the test of the sensors.
Furthermore, working according to specific sections or plans, we assessed not only the metric quality of data but also the performance of the sensors in terms of operational distance, the average deviation per unit of measurement considered, the ability to acquire RGB or infrared data with respect to the brightness or sensitivity of the detector (a key factor for modeling using SfM software).
The final comparison showed a comforting picture, even if not definitive. Although each sensor considered individually shows evident limits, however this problem was easily overcome by integrating different sensors. In conclusion, the most promising solution to obtain digital data useful for critical or descriptive processing is probably a single device equipped with several sensors all interlaced (e.g. referred to a common geometric matrix) and thus able to provide consistent digital data of the analysed object.

Procedure based on *Structure from Motion*

The capturing procedure implied to usage of SfM. We carried out two different tests in the Cassino archaeological area (the first outdoor and the second underground) using an action camera mounted on a *Parrot*

Fig. 8. Acquisition procedure with Lidar 2d sensor of inaccessible tunnel, point cloud used for comparison and sections obtained by Lidar 2d sensor.



Mini Drone remotely controlled.
The first test intended to capture a part of the cavea of the ancient theatre of Cassino. The flight was quite successful because the photos taken from the drone allowed the software to recognize a great number of points and eventually the creation of a dense point cloud.
After this first test, we performed a new micro capturing campaign with the same method (mini drone, action camera and SfM) but this time focussing on a structure positioned under the theatre scene where are located some archaeological finds. In this case, though, the photogrammetric software has recognized a much smaller number of points with direct negative influence on the quality of the final point cloud.
These tests gave us the opportunity to identify some bottlenecks of the process, e.g. the level of illumination that underground was beyond the operational limits of the sensor used. However, the test lead us to the easy (in this case) solution of this problem by integrating in the system a macro flash for the camera.

Second Test LIDAR

A further test on the potential of the prototype has been carried out with the use of a LIDAR sensor and combining the acquired data with those obtained with the SfM technique. This activity was carried out again in an inaccessible area in the Roman archaeological site of Cassino: the tunnel that passes from the centre of the amphitheatre under the outer wall to the southeast of the building, probably originally devoted to the drainage of water.
The choice of this site came from the need to test the instruments in a context showing many of the challenges that characterize an area with low accessibility: the spontaneous vegetation, the narrow space available, the unevenness of the ground and, more generally, of the entire surrounding surfaces. The testing environment was accurately mapped with 184 photos, taken not only inside the tunnel but also outside to allow the combination with other relevant data of the building. In the following phase, 183 photos were correctly aligned, obtaining a point cloud composed of more than 27 million points.
To simulate the actual operation of our prototype (able to move along the x,y,z axis and to make acquisitions both in flying and ground mode) the tests were carried out by making several scans on parallel planes to map the entire tunnel using the LIDAR sensor. The processing of the data necessary to convert the polar coordinates (the way in which the instrument acquires the data) in cartesian xyz (crucial to read the file as a point cloud) was used by an accelerometer installed on the acquisition platform in order to provide the relative movements. Considering that our LIDAR sensor was recording the coordinates only on a plane, the z coordinate has been set to zero for all scans and then the vertical sections have been rotated and aligned according to the zenith while the acquired plane has been left horizontal at different heights. The alignment processes were performed in a CAD environment thanks to the compatibility between Recap 360 (for the management of point clouds) and *AutoCad*.
The alignment process produced a satisfactory result, both for the density of the points acquired and for the metric uncertainty of the measurement. Moreover, unlike the photogrammetric process, the LIDAR does not suffer from the lack of light inside the tunnel and this allows an easier detection of those areas that, without additional light, would not be detectable with traditional cameras. From this data, numerous characteristic sections have been created: a longitudinal section that underlines the altimetric variations and different transversal sections in the key points where it is possible to notice the different solution used for the ceiling of the gallery.

Conclusions

The important activity aimed at creating models of manufactured products is certainly influenced directly by the systems used for the capturing with a clear preference for those easy to transport, highly automated, multisensor, as miniaturized as possible but still able to provide scientifically reliable data and results.
At the same time, the diffusion of intelligent devices allows us to offer users new ways of enriching knowledge by creating models able to outline a more involving and efficient user/reality interaction and, eventually, to reveal new forms of communication and diffusion of culture.
Augmented, Mixed and Virtual Reality applications have in fact massively rekindled the interest of users (and the experiential leverage has certainly been one of the key elements for their success) only after these technologies

have been incorporated into low-cost mobile devices. In fact, even if for years there have been systems able to simulate immersive or interactive effects, these were quite expensive and required dedicated installations.
The same phenomenon has concerned robotics until a number of experiences in the field of 3D printing and 'play' robotics have released, especially thanks to the internet, numerous examples to the wide public.
With the miniaturization of acquisition and visualization technologies, this scenario has radically changed, opening the way to the involvement of a wider audience, given the easy access to ready-to-use tools, simply by downloading a specific application and exploiting the potential of a smartphone.
Both *Tango*'s and *Heritagebot*'s experience show that the technology is now mature to change the global approach to data acquisition and AR/MR/VR content production. It is now a concrete and widespread option for acquiring geometric data, interacting with environments, even inaccessible ones, and designing a new way of perceiving reality with the help of intelligent devices.
A new leap, therefore, towards the democratization of

Notes

[1] *Citizen Science* is defined in different ways because it has multiple origins and derives from different concepts. The Oxford English Dictionary in 2014 defined it as "scientific activity conducted by members of the general public in collaboration with scientists or under the direction of professional scientists and scientific institutions". However, *Citizen Science*, as Bonney, Cooper and Ballard (Bonney et al. 2016, p. 1) point out, also refers to something else when it allows ordinary citizens to ask questions and provide answers on important scientific issues or to direct public attention to environmental issues, public health or natural resource management by fostering collaborations between community citizens and scientific institutions <https://it.wikipedia.org/wiki/Citizen_science> (accessed 2019, May 26).

[2] The contribution is part of the products of a FILAS Lazio Region research carried out by the Department of Economics of the University of Cassino and southern Lazio and involving researchers from the laboratories DART, LARM, IMPRENDILAB and FINLAB.

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The 'Architectural' Projects for the Church of St. Ignatius by Andrea Pozzo

Marco Fasolo, Matteo Flavio Mancini

Abstract

Andrea Pozzo –a painter, scenographer, and master of perspective– should always be fully recognized as an architect in the cultural panorama of the baroque period. This artist from Trento created his works in the church of St. Ignatius in Rome between 1685 and 1694, where he depicted St. Ignatius protector of afflicted people in the apse semi-dome (1685–1688), the Glory of St. Ignatius on the vault of the central nave (1687–1693), and the false dome (1685) to replace the one that had been designed but never built. For the works mentioned, Pozzo aimed to 'construct' a building that, while being illusory, did not exist in reality, lives amid the space of the physical architecture of the church.
The documentation, which evidences the various sequential phases of creation, was studied to recompose the design path he followed [Salviucci Insolera 2015]. The goal of this paper is therefore to define and verify the design process that Pozzo used to create these works. From the committee's request to the drafting of the first sketches, to the drawings that aim to represent the building as it is and as it appears. Everything can be found in his work and is supported by graphical and textual documents for the designs of the dome and vault. Finally, an analysis of the relationships between his three designs for the church of St. Ignatius poses further questions regarding the existence of an unifying intent formulated by Pozzo.

Keywords: Andrea Pozzo, church of St. Ignazius, architectural perspectives, project drawing, Perspectiva pictorum et architectorum.

Introduction

Very synthetically we define rhetoric, in the noble, ancient sense of the word, as the art of elegantly speaking and writing following precise codified rules. We also consider one of the more consolidated definitions of drawing that identifies it as a language used by architects to conceive and communicate their ideas based on universally recognized principles. By associating these two definitions we can therefore, by extension, also include drawing among the arts of rhetoric.
Well, considering that rhetoric was one of the classes that characterized the teaching of the Jesuits' scholastic tradition together with grammar, humanity, and philosophy, it is not a stretch to consider Andrea Pozzo, an able drawer and brother of the Society of Jesus, as an emblematic example of the finest and highest-ranking expression of the rhetoric of drawing.
Thus, the three essential qualities that Cicero, in his Orator [Scaffidi Abbate 2017], identifies in the figure of an orator –*docere* or *probare*, *delectare*, *movere* or *flectere*– can be found with suitable perspicacity in Pozzo's conduct.
The *docere* in Pozzo can be easily identified in his role as a teacher at the school-academy in a vast loft at the *Collegio del Gesù*: "in which, entering, you would have seen with utmost delight a variety of students from different nations: some of them studying architecture, some drawing, these engraving copper and those painting with oils and these with tempera; and others are intent on placing under the press those prints that were –and are still– seen in the

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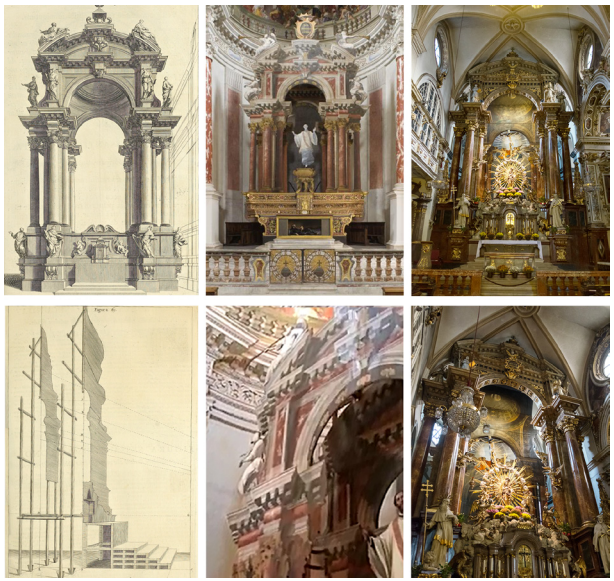
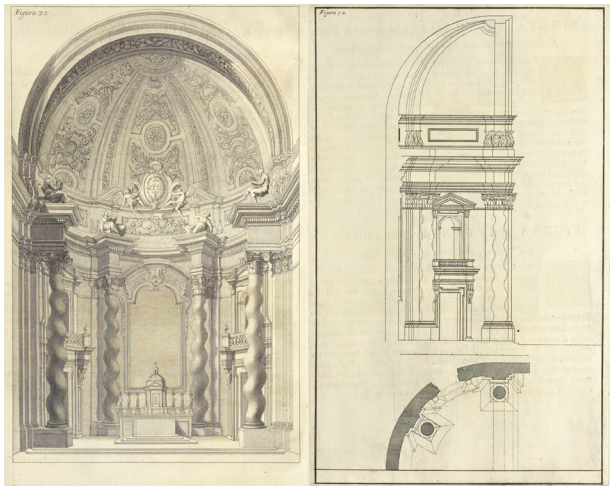
Fig. 1. Square construction, from the treatise, I, 64 (top left); Way of constructing the apparatus made up of multiple orders of panels, from the treatise, I, 61 (bottom left); church of St. Francis Xavier (centre); Franciscan church in Vienna (right).

Fig. 2. Main Altar for the Jesus in Rome, from the treatise, II, 71 and 72.





beautiful, rare books of his *Prospettiva*" [Baldinucci 1975, p. 333]. It is precisely his treatise that represents the epilogue and culmination of the transmission of his knowledge.
Thus, when Pozzo designs and constructs his works realized in many churches of his order, always intervening with his ability and sensibility as a painter, scenographer, and master of perspective, evoking positive emotions and feelings in the spectator, this way of working represents his *delectare* [Portoghesi 1966, p. 7].
In addition, with his perspective 'deceptions', Andrea Pozzo manages to *movere* the observer, to involve him or her emotionally in viewing a space or architectural elements that only apparently exist in three dimensions [Kemp 1999, pp. 105–123]. We recall, however, that in addition to the visitors of the churches, Pozzo also directs this gift of persuasion at his students, as Baldinucci reminds us: "the same scholars always increasingly and assiduously applied themselves to the study of the art that each of them wanted to profess; so much so that they usually said that the school of father Pozzo gave those who had neither the desire nor pleasure for studying and learning the joy of it" [Baldinucci, 1975, p. 333].
All of these qualities have, as we will see, a common denominator, a common thread that ties and connects each to the others. This connecting line is architecture.

Andrea Pozzo, architect designer

Andrea Pozzo (Trento 1642 – Vienna 1709) has been called a painter, scenographer, master of perspective, and architect, but while critics have written a lot regarding the first three professions, the last has often been overlooked, not fully recognizing his role in the architectural panorama of his time. In fact, after the timid hints about his importance as an artist made by Antonio Gurlitt [Gurlitt 1887, pp. 459–473] and Antonio Muñoz [Muñoz 1919, pp. 318, 393], it would only be with the first studies made by Nino Carboneri starting from 1961 [Carboneri 1961, Carboneri 1962] that Pozzo would begin to be recognized as an architect.
Through an analysis of his drawings, this study [1] instead aims to contribute in conferring on Pozzo the trait of architect that only in a recent past has become widely recognized.
It is also true that Pozzo approaches architecture by steps, his sacred theatres, his interventions for apses, altars, façades, and fresco cycles ooze with architecture, with his

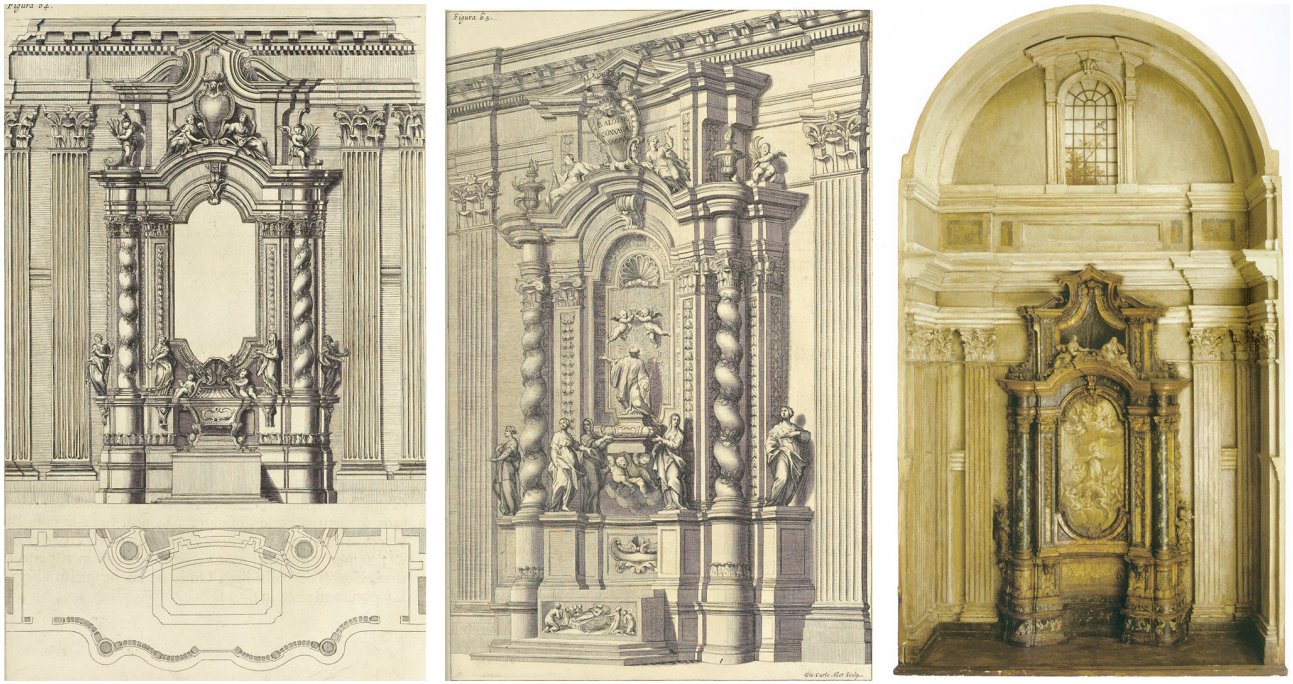


Fig. 3. Other Altar for the Blessed Luigi, with two columns, from the treatise, II, 64 (left); Another Altar for the same effect but changed enough, from the treatise, II, 65 (centre); Model in wood and wax for the altar of St. Luigi Gonzaga (right).

vision of architecture that he would express completely in his designs for works that were realized or only remained on paper.

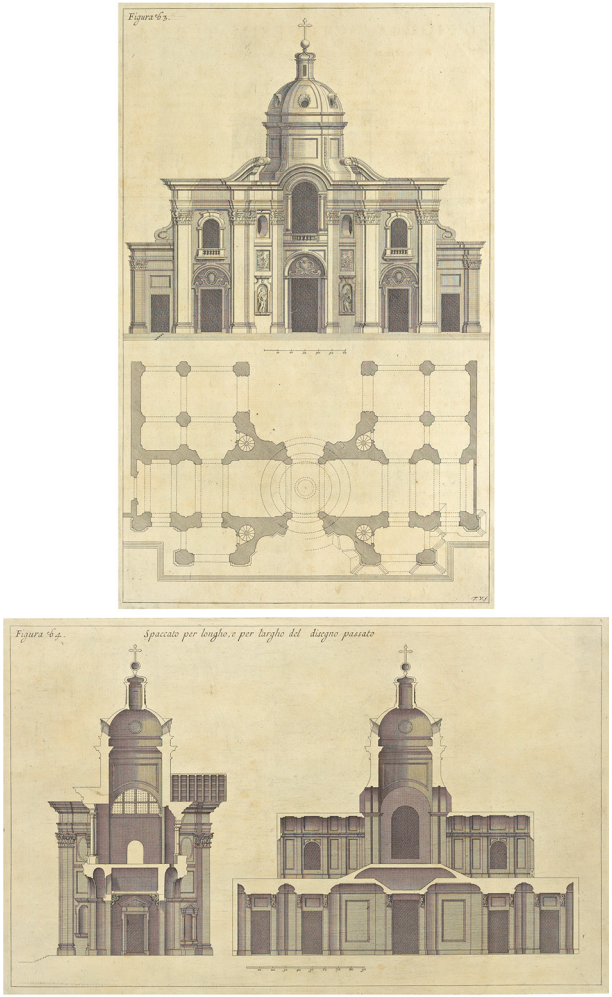
To understand Pozzo's architecture, one cannot help recalling, on the one hand, his belonging to the order of Jesuits, an order characterized by a severe, authoritarian environment; and on the other, the historical artistic moment in which baroque culture reached its apex. In his architectural thought, Pozzo basically had to satisfy these two orientations: "convention and experimentation, observance of tradition and ideational spontaneity constitute extreme opposites, within which he had to orient his view of sacred building and address the problem of typological choices on which his poetic discourse would be based" [Bösel, Salviucci Insolera 2010, p. 37].

Even if Pozzo began his artistic activities practicing figurative painting, especially his perspective paintings as well as his staging of ephemeral devices led him to quickly work on architecture. In addition to its recognition for its intent to teach: "the quickest way of putting all architecture drawings in perspective", his treatise *Perspectiva pictorum et architectorum* [2] [Pozzo 1693, Pozzo 1700] gathers drawings made by the author which show both his ideal designs and reference designs for his constructed works. But it also assumes another teaching value: that of being a repertoire of architectural ideas from which architects could draw inspiration to create their works.

In the pages of the treatise we find drawings related to the realization of sacred theatres then present in many churches where Pozzo worked. These constructions were based on the concept of scenography and were realized with "multiple orders of panels", as Pozzo himself illustrates in figure 61 in the first part of his treatise. An important example of one of Pozzo's sacred theatres can be found

in the Church of San Francesco Saverio in Mondovì, which the Jesuit brother made during his fruitful training in northern Italy. In addition to the frescoes painted on the vault and the intervention in the interior spaces, Pozzo created the altar apparatus composed of wooden frames to support painted canvases –the only remaining exemplar of these kind of compositions– which directly refers to the "square construction" presented in the treatise (fig. 1).
Similar in some way to this scenographic genre are the drawings provided in the treatise, which, as Pozzo himself explains, have two purposes: one to create the apparatus for the Devotion of Forty Hours and one as a model for the main altar, both destined for the church of the Gesù in Rome. The engravings illustrated in figures 71 and 72 represent the project through a straight-on perspective and half plan, with the related section rigorously associated between them (fig. 2). Within the apses, the Jesuit brother designed altars that are included in and conditioned by the apses in a relation that Pozzo always addressed with the due spatial attention and perspective sensitivity. One such example is the altar of the *Franziskanerkirche* in Vienna, which again recalls the project for a "square construction" present in the treatise: here Andrea Pozzo combines the real architecture of the altar with a painted altar that, with great refinement, creates a potent illusion of unitarity that is revealed only from an off-centre point of view as seen in figure 1.
We also recall the two proposals for the altar of Saint Aloysius de Gonzaga in the church of St. Ignatius, the first represented in plan and elevation, the second in perspective view (fig. 3). We also mention the altar of St. Ignatius in the church of the Gesù, described and shown in figure 60 through an angle perspective and in the following figure drawn in plan and elevation "with a simple contour". This project would be particularly important for Pozzo's fame in that it was also lauded by Carlo Fontana.
The Trento master's opportunity to deal with architecture as a whole came in 1699, when, appointed by Cardinal Benedetto Pamphili, he developed two projects for the façade of St. John Lateran in Rome. The projects, which are echoed in the pages of the treatise, once again testify Pozzo's complete graphical control in associating plan and perspective drawings, transverse and longitudinal sections, and a perspective view that is scenographic in its nature (fig. 4).
Unfortunately, little remains of the drawings Andrea Pozzo made for the design and construction of his mainly archi-

Fig. 4. Facades of St. John Lateran, from the treatise, II, 83.



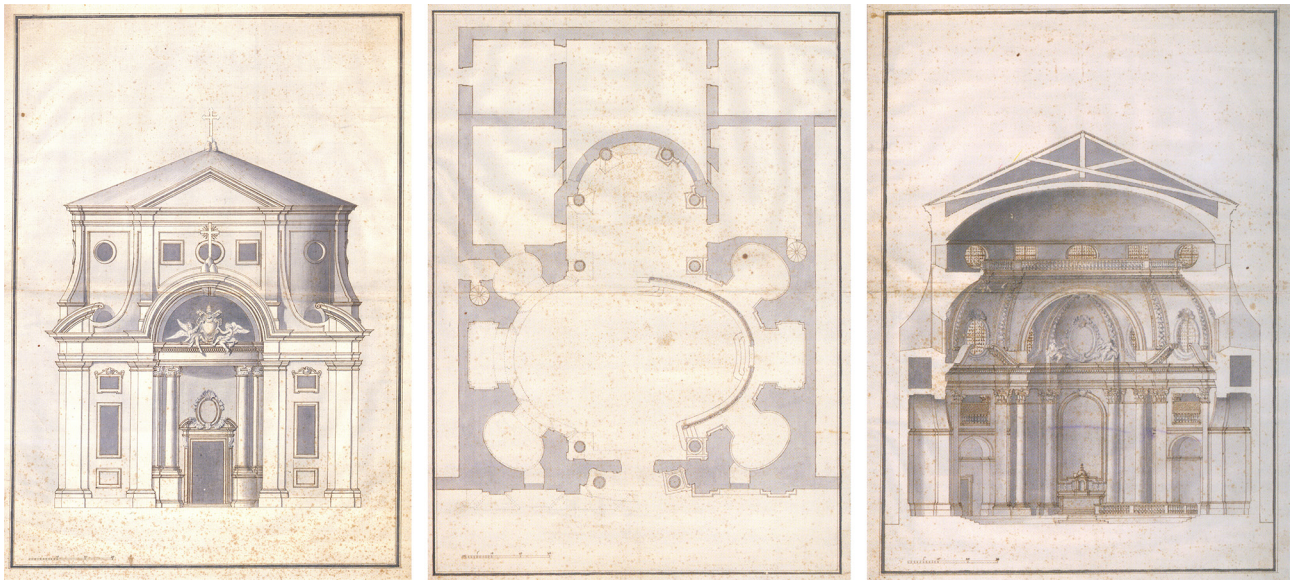


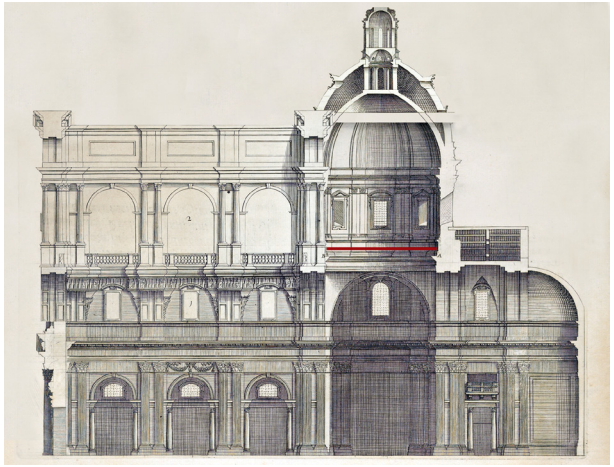
Fig. 5. Design for the churches of St. Thomas of Canterbury in Rome.

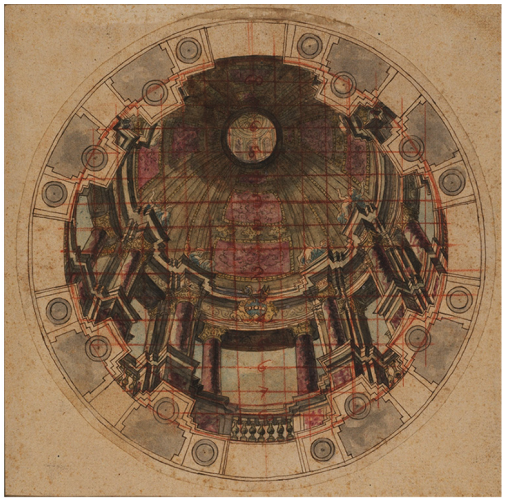
tectural works in Ragusa, Ljubljana, Trieste, Montepulciano, Belluno [Dal Mas 1992, p. 61], Trento and again Rome. The few drawings rediscovered and attributed to Pozzo include the ones he produces for the projects of the churches of St. Thomas of Canterbury in Rome, St. Ignatius in Ragusa (now Dubrovnik), and St. Apollinaris at the collegium Germanicum et Hungaricum in Rome.
The project for the church of St. Thomas of Canterbury in the English College in Rome possibly represents one of the most important works with Pozzo's stylistic hallmark. The church, presumably conceived between 1697 and 1702, was never realized, but three remarkable authentic drawings of it remain: an elevation, a transverse section, and a plan. The first two graphics were made by applying a light chiaroscuro that tends to highlight the sculptural quality of the construction. The plan communicates a twofold message simultaneously: on the right, the building is sectioned, using the rules of geometry, with a horizontal plane; the left instead shows the projection of the elements situated above the plane of the section. The graphical scale expressed in palms is shown in all three drawings at the lower left (fig. 5).

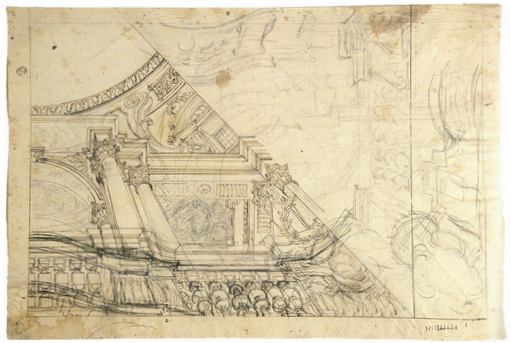
A particularly well done intervention from an architectural point of view is the work in the *Universitäskirche* in Vienna in which Pozzo shows his architectural maturity, transforming the simple, single nave and pouring into this project a large part of his architectural heritage composed of his experiences in sacred theatres. Here he inserts tribunes, transforms the chapel, choir, and the main altar and, bringing his mastery of perspective to his elevations, creates a false dome in the vault. The church thereby had a new vault, which Andrea Pozzo wanted to design and realize.
Therefore, in perspective, Pozzo, a man of art in painting, can and should also be recognized as an architect. The criticism in this respect cannot overlook Milizia, who stated referring to the Jesuit father's work: "who wants to be an architect in the inverse way have to study brother Pozzo's architecture" [Milizia 1781, p. 275]. Regarding his incapacity to do architecture, we recall how Pozzo himself responded: "never let this stupid argument come out your lips again: he is a painter and therefore cannot be a good architect; rather, infer the opposite: he is a good painter and good perspective drawer, therefore he will be a good architect" [3].

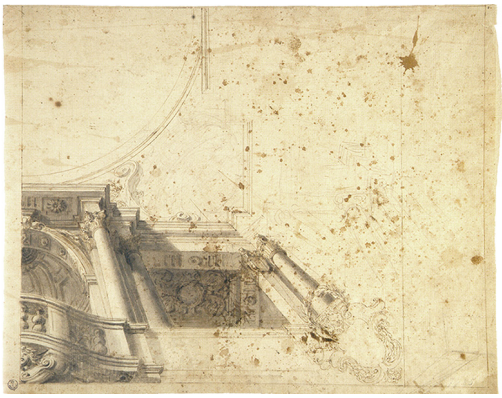
Fig. 6. A composition of figures 94 and 96 from the treatise, I. The image shows the relationship between real space and the space designed by Pozzo.

Fig. 7. Pencil sketch for the false dome (top). Two sketches attributed to the school of Andrea Pozzo (bottom).









It was with the spirit of an architect that Pozzo addressed the cycles of paintings that had brought him so much fame. We have purposefully omitted from this framework the many architectural perspectives that Pozzo created over the course of his activities, reserving for them a specific investigation into the works for the church of St. Ignatius in Rome: the vault, false dome, and apse.

The design process for the works for the church of St. Ignatius

Perspectiva pictorum et architectorum was for Pozzo both a tool to spread his techniques and an architectural tool. By reading the treatise, it is possible to identify both the references that inspired Pozzo and his architectural ideas. Particularly important is the case of the "square construction", whose design was used by Pozzo to create at least two works that still survive: the scenic apparatus of wooden frames for the apse of the church of St. Francis Xavier in Mondovì (1676–1677) and the altar of the *Franziskanerkirche* in Vienna that the author created as a com-

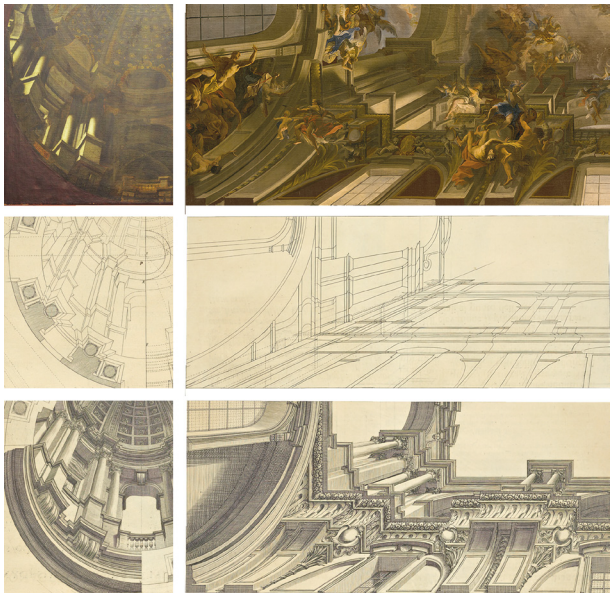


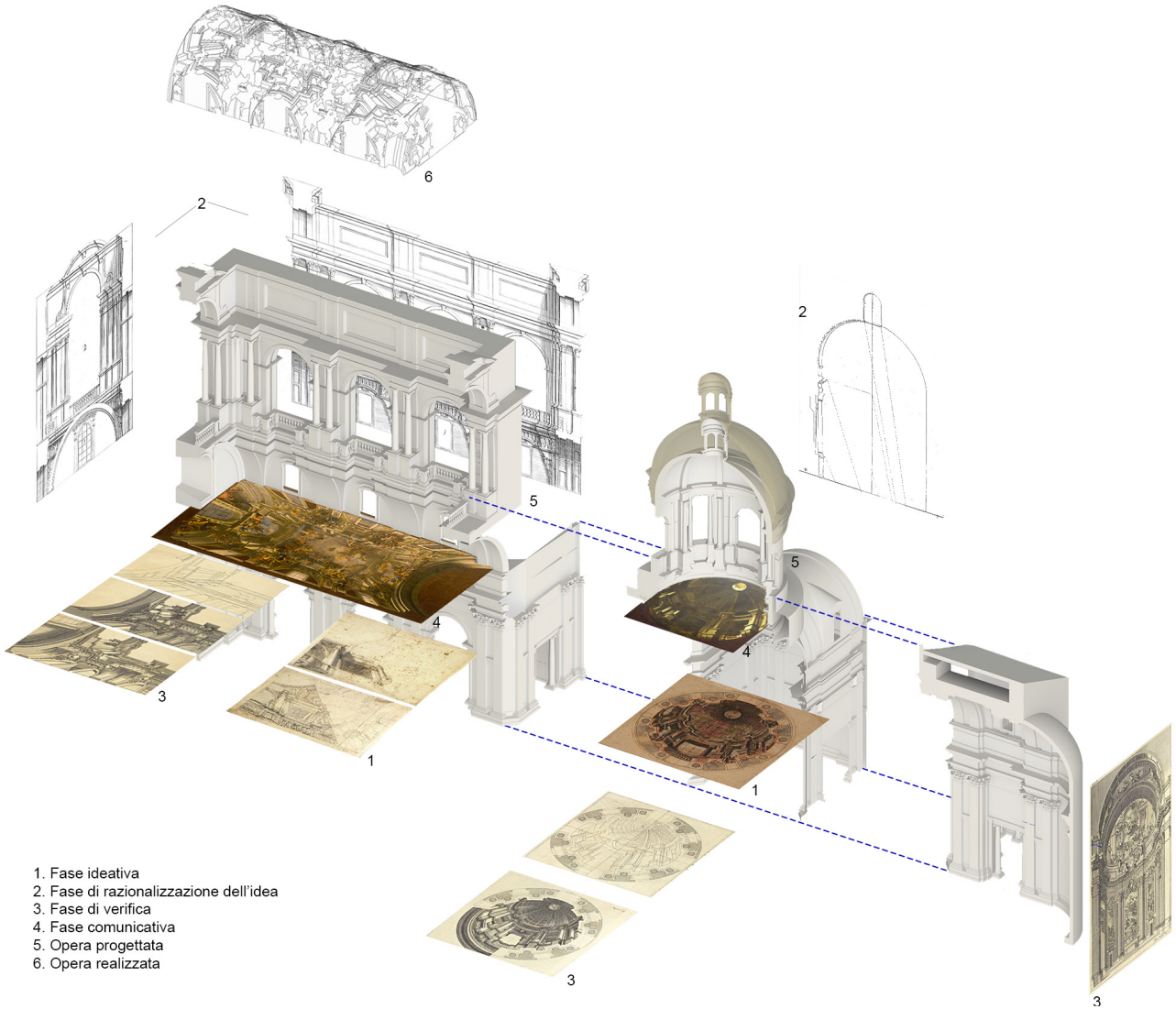
Fig. 8. Oil sketch for the dome and figures 90 and 91 from the treatise I (left). Oil sketch for the vault and figures 97-99 from the treatise I (right).

prehensive hybrid of parts and others in wooden frames (1706–1707). These two works are chronologically separated by about thirty years; the first preceded the publication of his celebrated treatise (1693), and the second was built few years after publication of the second part of the treatise (1700). In addition, in the text of figure 64 in the first part of the treatise, Pozzo himself states that he used the model to create some mechanisms for the Devotion of Forty Hours, structures in successively smaller wooden frames like the one in Mondovì, and he suggests to use it to construct the main altars like he would do years later in Vienna as the figure 1 shows. This case demonstrates how Pozzo conceived architectural projects that would accompany him throughout his career and how he was capable of activating them via different forms. Buildings, scenography, or perspective paintings are for Pozzo realizations of architectural ideas or, using the words of Vincenzo Fasolo: "every artistic idea for an architect painter (and also non-architects) is always architecture" [Fasolo 1969, p. 216]. We could therefore say that the cycle of works realized for the church of St. Ignatius in Rome is the activation of precise architectural ideas through which Pozzo intended to expand the real space by constructing various illusory spaces. While episodic, when combined with reality, they bestow new three-dimensional life on the church (fig. 6).

Pozzo worked in the church of St. Ignatius for about ten years, a long period in which he intervened several times on the surfaces of the central nave, the transept, and apse. The first work to be realized was the large canvas of the false dome (1685); the frescoes of the semi-dome of the apse and the vault of the presbytery were the next (1685–1688); and, at the end, the decorations of the vault of the central nave (1687–1693) and the corbels of the dome (1694) were realized. The entire cycle was opened to the public on 31 July 1694 at the presence of Pope Innocent XII. Andrea Pozzo's architectural work cannot be found only in the architectural models present in his treatise, but also reconstructing the steps that led him to the realization of the works themselves. In fact, historical documents and graphics testify almost every phase of the design process for the works in the church of St. Ignatius: from the assignment received from the committee to the first conceptual sketches, to the phase of rationalizing the form, to the drawings meant to communicate the work to committee and public, and to the techniques adopted to create the fresco of the vault.

Pozzo was called to create decorations for the large church, that, up to then had remained rather bare [Wittkower 1995, pp. 5–7, 23], and also to solve two real architectural problems: the impossibility of creating a masonry dome and the proportions of the vault of the central nave. With regard to the vault, in a document dated back to 1688 entitled *Points to consider regarding painting of the vault of the church of St.Ignatius* [4] [Bösel, Salviucci Insolera 2010, p. 77], the Superior Fathers of the order express the reasons for the work and entrust the assignment to father Pozzo. The document contains indications regarding the approval process, which would have passed through the public exposition of a draft of the work on canvas. The most interesting aspect of this document is a passage specifying the reason for which the work was commissioned. The superior fathers wanted Pozzo to solve: "the only defect in this church […] that is, the vault, which is too high and not arched enough" [Bösel, Salviucci Insolera 2010, p. 87]. This highlights the cultural refinement of the Jesuit committee and also explains Pozzo's compositional choice. In contrast to other interventions for vaults, here he makes a true op-

Fig. 9. Synthetic image that describes the relationship between the graphic works concerning the project for the vault and dome of the church of St. Ignatius.



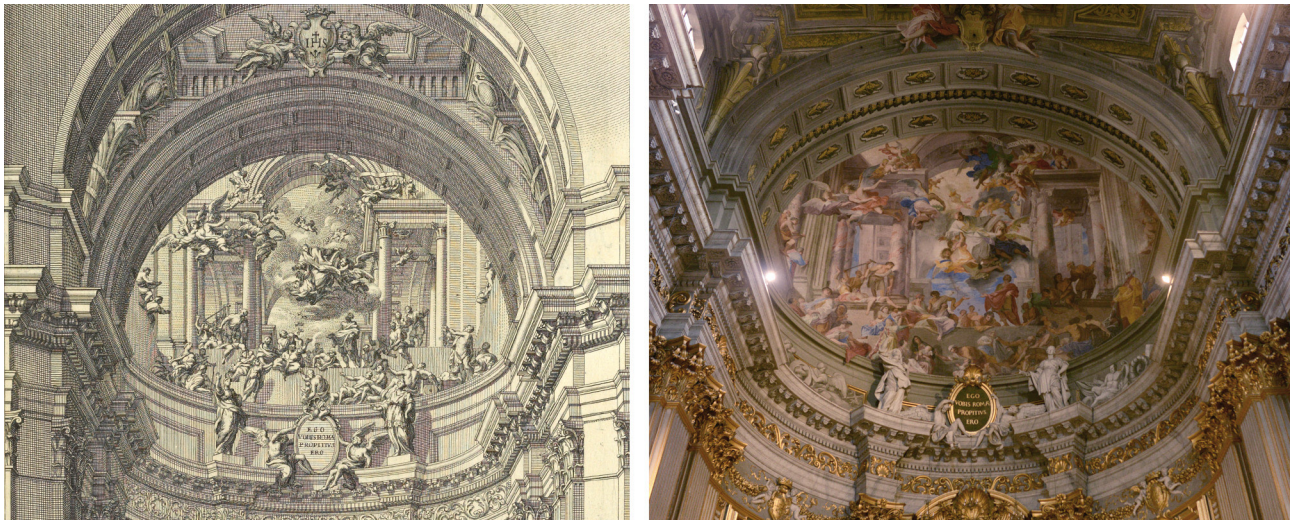


Fig. 10. Detail of the main altar for the church of St. Ignatius in the Roman Collegium, from the treatise, II, 81 (left), and photo of the frescoed basin of the aps (right).

eration to pierce the ceiling. In fact, the vault appears to be removed, slightly above the windows of the lunettes, and replaced by an imposing architecture.
The ideational moment of an architectural work cannot overlook the use of freehand sketches, drawings directly relate the designer's mind to the hand. This is presumably also true for Andrea Pozzo, as attested by a rough pencil sketch for the false dome [Baglioni, Salvatore 2018], of uncertain authorship, stored at the Courtauld Institute of Art in London, and some drawings referring to vaults in perspective from below attributed to his school and housed in Florence in the Department of Prints and Drawings at the Uffizi Galleries. The latter show two moments following the conceptual phase: a primordial one characterized by rethinking and marks that proceed by approximations to define the idea; and a more advanced one in which, in addition to a more definite idea, chiaroscuro is applied to better describe the three-dimensional nature of the forms (fig. 7). This phase was followed by the rationalization of the designed shape and the adoption of plan and elevation drawings through which the designer describes the form of the building as it is. This phase is well documented by the plates in *Perspectiva pictorum et architectorum* which, while following the works in Rome, demonstrate the need for this phase to define the architectural idea. Figures 49, 50 and 52 in the second part of the treatise referring to the dome and figures 95 and 96 in the first part related to the vault illustrate this phase of the design process [5]. From these drawings, it is possible to rebuild the three-dimensional digital model [6] of the designed building and to understand how these interact with the real architecture through the circumference of the dome impost and the horizontal slice of the crown of the vault.
Once he had defined the design idea of the architecture as it is, the designer returned to perspective representation for two reasons: it allowed the design to be verified perceptually and allowed him to communicate to the committee how the final work would have appeared. The graphical documents left by Pozzo demonstrate both aspects: plates 90 and 91 of the first part and 50, 51, 52 and 53 for the dome, figure 81 of the second part for the apse, and figures 97, 98, 99 and 100 of the first part for the vault [7], represent perceptual verification of the works, the designer's personal verification, and technical publication for other artists. The oil drafts stored at the National Gallery of Ancient Art in Barberini Palace, were instead requested by the committee to be able to judge and have the project judged before approval (fig. 8). The

Fig. 11. Comparison between the work carried out (fresco) and the designed work.

Fig. 12. Perspective section with the two designed works: vault and dome.

cogent relationship that ties all the graphical drawings into a single design process is well represented through a synthetic vision of the whole. In addition to the real space of the church of St. Ignatius reconstructed starting from the designs in plates 93 and 94 of the first part of the treatise, this also includes the three-dimensional surveys of the final works on the surfaces of the church of St. Ignatius and the graphical documents that attest the architectural design process followed by Andrea Pozzo for each intervention. This process can clearly be seen with regard to the design of the false dome and the vault, while it is only partially true with respect to the semi-dome of the apse (fig. 9).

Conclusions

The frescoes on the vault and semi-dome and the canvas of the dome are just one of the possible realizations of Pozzo's projects for the church in Rome and, as for each realization, his comparison with the design idea highlights some differences. In the case of the vault, a comparison between the design presented in the treatise and the fi-

nal work –the fresco– highlights a rethinking with regard to an attic plane decorated with rectangular panels that should have connected the two arches present on the short opposite sides of the composition. If realized, it would certainly have rendered a more rigid, static image of the architecture since it would have reduced its interaction with the sky. On the other hand, the perspective shortening adopted is entirely consistent in all perspective drawings with what is realized both in the rough oil sketch and the final fresco. With regard to the dome, a comparison between the drawings in the treatise and the final canvas highlights the adoption of a different perspective shortening while the morphology of the structural and decorative elements appears to be consistent. A comparison of the design and realization for the fresco in the semi-dome of the apse shows a clear consistency with regard to perspective shortening and the compositional choices. A notable compositional expedient can be seen in the fresco on the semi-dome of the apse: the illusory architecture, a temple with four arches, appears to be cut by the presence of the large arch of the presbytery of the real church, thereby creating an occlusion that accentuates the sense of three-dimensionality and interaction between real and illusory buildings (fig. 10). The late baroque plasticity of Pozzo's architecture and his efficacy in solving the problems raised by the committee are particularly perceptible when exploring the digital reconstruction of Pozzo's project for the vault. Here the expansion of the real space by piercing the ceiling and the addition of the illusory space creates the perception of an open space articulated by strong chiaroscuro (fig. 11).
Finally, the summary model based on the real space of the church of St. Ignatius, integrated with the illusory architecture of the vault and dome [8], allows us to formulate some considerations. The two architectures have a difficult coexistence in the space immediately above the large arch that separates the nave from the transept, but they have comparable proportions. A comparison between the interior dome designed by Pozzo and Grassi's dome (ochre in the model) presented in plate 94 of the first part of the treatise, shows how Pozzo's project does not seem to consider the original approved project and is characterized by the presence of protruding columns on corbels, a very criticized element at Pozzo's time [Pascoli 1736, p. 255]. On the other hand, it is worthy to underline that it is precisely the presence of these protruding columns that represent typological continuity with the architecture of the vault (fig. 12). These initial considerations can be investigated and completed following the rendering of the third and less documented episode of the entire cycle, i.e., the illusory architecture of the apse. Indeed, the reconstruction of the entire cycle will enable a comparison between the three projects that highlight the elements of continuity and discontinuity clarifying the existence of a unifying design attempt or the independence of the three episodes created by Pozzo for the church of St. Ignatius.

Notes

[1] While sharing the contents of the contribution as the fruit of common reflections, the *Introduction* and *Andrea Pozzo, architect designer* section are by Marco Fasolo, the *The design process for the works for the church of St Ignatius* section and *Conclusions* are by Matteo Flavio Mancini.

[2] *Perspectiva pictorum et architectorum*, subtitled *In qua docetur modus expeditissimus delineandi opticè omnia que pertinent ad Architecturam* is composed in two volumes, the first published in 1693 and the second in 1700, both written in Latin and Italian.

[3] *Perspectiva pictorum et architectorum*, text explaining figure 66 in the second part.

[4] The text of the document is reported in notes 33, 36, 37, 38 and 39 in the same essay, pp. 87-88.

[5] With reference to rationalizing the form, figure 9 shows plates 49, 50 and 52 of the second part of the treatise, in which a section of the dome is represented, and plates 95 and 96 of the first part of the treatise, which show the longitudinal and transverse sections of the frescoed architecture on the dome of the central nave of the Church of Sant'Ignazio.

[6] The digital models were developed in collaboration with Flavia Camagni.

[7] Referring to the design idea checking, figure 9 shows plates 90 and 91 of the first part of the treatise and plates 50, 51, 52, and 53 of the second part, in which the perspective of the dome is drawn with different levels of detail and graphical treatment; Figure 81 of the second part of the treatise with the perspective of the apse and Figures 97, 98, 99 and 100 of the first part, in which the perspective of the architecture of the vault is drawn with different levels of detail and graphical treatment.

[8] The model of the dome was realized by Leonardo Baglioni and Marta Salvatore, whom we thank for having allowed its use in this essay.

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Lunette Vaults in Guarini's Work. Digital Models between *Architettura Civile* and *Modo di Misurare le Fabriche*

Roberta Spallone

Abstract

In Guarini's systematization of vaulted systems based on geometric reasoning, the lunette vaults created by cutting main vaults of different geometric shape and inserting the groins take on a primary role. This operation increases the natural lighting of the rooms and ensures airiness and dynamism to atria and halls of Baroque palaces. In the Architettura Civile *(published posthumous in 1737) and the* Modo di misurare le fabriche *(1674), he describes the geometrical origin and the measurement of the vaults, respectively. In the first treatise, the lunette vaults emerge as a typology rich of shape variations and implementations in civil buildings, in the second the surfaces of the vaults are attributed to the geometric matrices of the single elements and present some novelties with respect to the* Architettura Civile*, having semi-ellipses, and arcs of circumference and ellipse, as directrices.*
In this work the significant relationships between these two Guarini's treatises, whose complementarity emerges in the continuous reference to the Geometry-Architecture binomial, are developed and deepened. The graphical analysis and digital modeling of surfaces allow not only the recognition of the geometric primitives underlying the structure of the vaulted systems and the verification of the measurement rules that Guarini largely attributes to himself, but also the comparison with the architectures realized in the period of the second expansion of Turin.

Keywords: graphical analysis, digital modeling, lunettes, lunette vaults, treatises, Guarini.

Introduction

Guarino Guarini (1624-1683), was an abbot of the Theatines order and a scholar with wide-ranging interests, mainly architecture, mathematics and philosophy. He worked in the century permeated by the *esprit de géométrie*, fueled by the discoveries and studies in the mathematical field and in particular of pure geometry. In this period a leading position of discipline within the philosophical method established, through the theories of Galileo, Bacon, Descartes, Malebranche, Desargues.
Guarini, after a series of journeys in Italy and France, during which he devoted himself to theoretical studies and architectural design, in 1666 settled in Turin. Here he published some of his most important treatises and created a series of religious and civil architectures, emblematic of the Baroque period.

Guarini was the first to develop a rigorous and systematic discussion of vaulted systems which is divided into three complementary treatises: *Architettura Civile* (published posthumously in 1737), *Euclides adauctus* (1671), and *Modo di misurare le fabriche* (1674), in which he illustrated the geometric origin, the stereotomy, and the measurement of the vaults, respectively.
Among them, the *Euclides adauctus* takes the role of theoretical reference based on the geometric discipline, with respect to the approach of the other two treatises constantly referred to the architectural works.
In this systematization, started in the *Architettura Civile* with the construction of a real vocabulary of shapes geometrically based, the lunette vaults, generated by cutting

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the main vaults of different geometric shapes and inserting the groins, take on a primary role. This operation increases the natural lighting of the rooms and ensures airiness and dynamism to the brickwork vaults that feature atria and halls in Baroque palaces. Indeed, from the time of the second expansion, begun in 1673, Turin is endowed with numerous palaces and noble houses of new construction and reshaping, in which the experimentation of unitary vaulted brick systems of considerable complexity is particularly lively.
The geometric nature of the vaults described in the *Architettura Civile* has been the subject of previous studies by the author [Spallone 2016; Spallone 2017, pp. 91-120]. Among these, the lunette vaults emerge as a typology rich of shape variations and implementations in civil buildings. Indeed, starting from the late Renaissance models having axial development, Guarini creates a new radiocentric system, on an oval plan, applied to the designs of the atria of the palaces Carignano and Provana di Collegno in Turin.
In the *Modo di misurare le fabriche*, the surfaces of the vaults are attributed to the geometric matrices of the single components. Among these, the lunettes, considered both as parts of cross vaults and as completion elements of main vaults, present some formal novelties with respect to the *Architettura Civile*. These shapes are recognizable in the lunette vaults both in the noble halls and in the service rooms in the palaces built in Piedmont between 17th and 18th centuries.
The brick lunette vaults, of Renaissance tradition, have an important precedent in the vault that Tibaldi had designed for the Sacristy of the church of the Santi Martiri in Turin (1592), while the great composed vault of the main hall of Reggia di Venaria (1667-68) seems to usher in a season of widespread attention for the vaults with cuts and lunettes in civil architecture [Piccoli 1999, p. 87; Scotti Tosini 2006, p. 95].

Working methodology

In this paper, the significant relationships between *Architettura Civile* and *Modo di misurare le fabriche* about the development of the theme are examined in depth, comparing theories and drawings, whose complementarity emerges in the continuous reference to the binomial Geometry-Architecture.
The graphical analysis and the digital modeling of the surfaces are realized starting from the drawings in the plates of the *Architettura Civile*, and the graphic diagrams printed with xilographic technique and inserted in the text of the *Modo di misurare le fabriche*. They allow not only the recognition of the geometric primitives underlying the shape of the lunette vaulted systems, and the verification of the measurement rules that Guarini largely ascribes to himself, but also the comparison with some built architectures.
The pseudo-axonometric diagrams, traced with some uncertainty, that describe the different models of lunettes, and the double orthographic projections (plan and section), that specify the spatial features and the proportions of the lunette vaults allow the control of the rigorous classification and ideation process followed by Guarini. This involves retracing the steps, applying the methods of graphical analysis and reconstructive digital modeling. For the purposes of this research all the lunettes and lunette vaults mentioned in the two treatises have been modeled, including their variants.
As regards to the *Architettura Civile*, the aims of modeling are the identification of Guarini's vocabulary of shapes, the control of consistence between the orthographic projections, and the reconstruction of the compositional logics underlying the proposal of *exempla* applicable to the construction of palaces. As regards to the *Modo di misurare le fabriche*, the aim is to complete the analysis, documented by the figures, up to the verification of the Guarinian calculation methods, which are extremely useful in estimating the quantities of materials needed for the construction and renewal of the buildings of the city during the Baroque age.

Lunettes and lunette vaults, terminological issues and convergences between the two treatises

In the *Modo di misurare le fabriche* the theme of the lunettes is developed in Chapter 3 of Part Two, devoted to the calculation of the surfaces of 'cloister and lunette vaults' on square or polygonal plans. From the chapter's title emerges that Guarini is dealing with vaults composed by portions of the first 'round body' classified in the *Architettura Civile* –the cylinder– which, appropriately cut, gives rise to those that today are called coves and groins.
While in the current architectural lexicon, by lunette is meant the portion of vertical wall between the arc of intersection of the wall with a groin and the impost plane, in

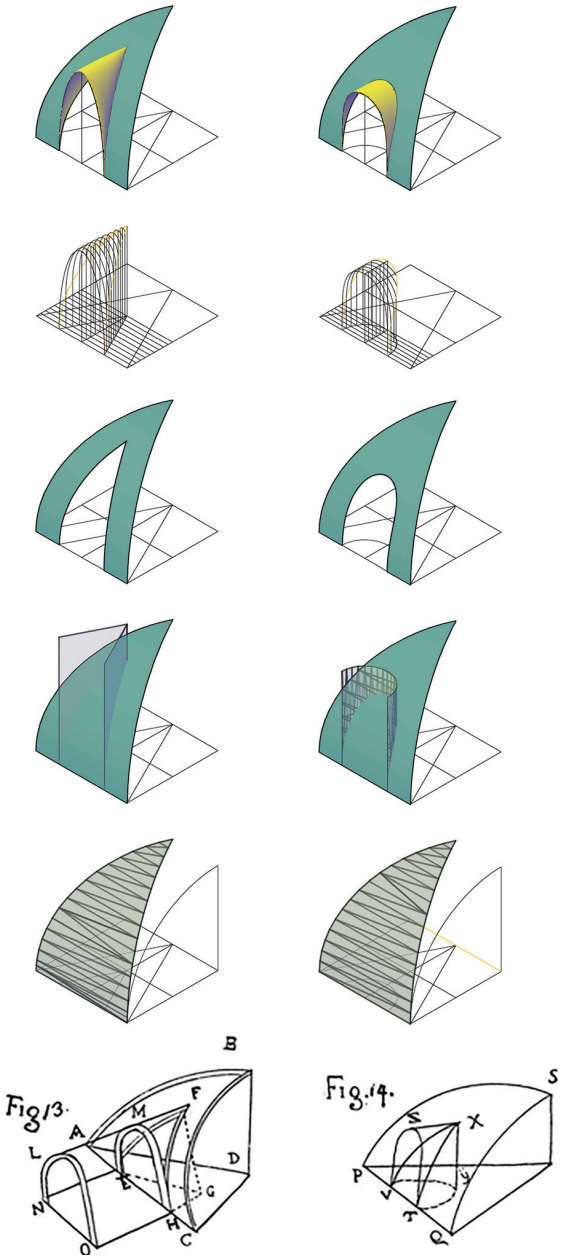


Fig. 1. Geometric shaping of lunette vaults. Image: Guarini 1737, Plate XIX; digital modelling: Roberta Spallone.

the *Modo di misurare le fabriche* the term 'lunette', or '*Luna*', is used both to indicate one of the four groins of a cross vault (propositions 14 and 23), and as a synonym of groin inserted in a main vault (proposition 16), and as a separate element (proposition 24).
In the *Architettura Civile* the lunette vaults are described in Treatise III, Chapter XXVI, entitled 'About the vaults, and various ways of making them', within Seventh Observation, which defines the geometric model of such vaults, and Octave Observation, which shows three examples applied to architecture. In this treatise the meaning of lunette vault is different: "if the vault of any kind will be intersected by many lunettes, it will be called lunette vault" [Guarini 1737, p. 187]. Thus, here is valid the definition of lunette vault as a cover composed of a main vault (barrel, cross, cloister, dome) cut and completed by groins, as the drawings in the XIX and XX plates confirm.
Beyond the terminological issues, the first part of the discourse concerning lunettes and lunette vaults has significant convergences between the two texts, also from the graphic point of view.
In the *Architettura Civile*, the deepening of lunette vaults follows the description of the elements shaping the vaults born from the 'six round bodies' – cylinder, cone, conoid, sphere, rotational ellipsoid (or oval), and scalene ellipsoid/oval. These primitives are considered as geometric matrices of the main simple vaults with single and double curvature (barrel, conical, conoidal, dome, sail) and composite (cross-shaped, cloister, 'gothic', lunette), after operations of cuts and compositions of parts.
The explanation of the lunette vaults concludes this typological repertoire. Indeed, they are composed vaults that can take as a main surface one of those previously described. Guarini specifies: "In all the aforementioned bodies, two kinds of cut can be made, one is triangular […] but does not arrive in the middle […] and then, is made another triangular cut on the other side, which reached up to the aforementioned […] and then that void is filled with a piece of cylinder cut triangularly with the same angle of the cut, and as high as the same cut" [Guarini 1737, p. 187]. In the drawing of such vaults, in figures 13 and 14 of plate XIX, groins with a triangular and circular plans are inserted into a cylindrical cove, while the groin having a square plan mentioned in the text does not appear.

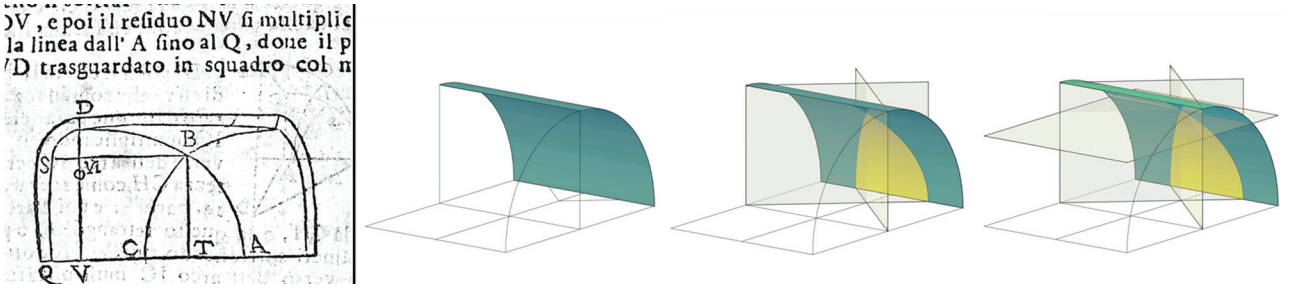


Fig. 2. Cut of a main vault aimed to inserting a groin. Image: Guarini 1674, Prop. 16; digital modelling: Roberta Spallone.

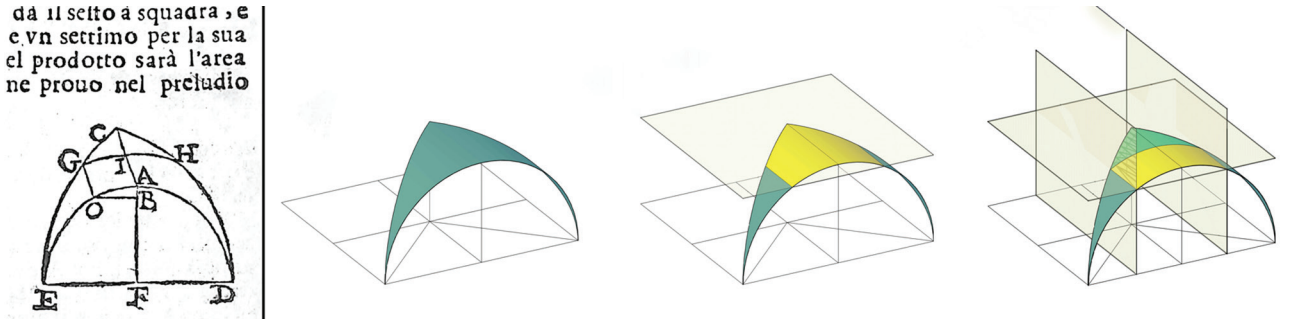


Fig. 3. Round-shaped lunette and its portions. Image: Guarini 1674, Prop. 14; digital modelling: Roberta Spallone.

As seen above, Guarini defines the surface of the groin as a portion of cylinder cut from the same planes that intersect the main surface but, as is well known, to guarantee the joint with the latter, this groin cannot be geometrically described as cylindrical, but it must be generated by parallel and variable sections (like arcs of circumference or ellipse) (fig. 1).
In the *Modo di misurare le fabriche*, the issue of the creation of lunette vaults can be read by relating two propositions. In Proposition 16, Guarini presents the problem of calculating the surface to be subtracted to the main surface consisting of a quarter of a cylinder, after cutting with vertical planes. The author explains the necessity of such a calculation to achieve a correct measurement of the lunette vaults: "As it is reasonable to measure the lunettes, that certainly make greater the surface of a vault, so it is convenient to remove that surface from the same vault, which occupies the space of the lunette" [Guarini 1674, p. 109].
This case establishes an undeniable relationship with the built architecture. Indeed, Guarini explains how to survey the position of some particular points and the horizontal plane tangent to the vertex of the groin, finalizing these operations to the calculation. The graphic diagram shows a doubling of the lines of the main vault to signify the wall thickness (fig. 2).
In Proposition 14 there is the ideal complement to the previous problem, namely "to find the surface of a lunette, or of a groin of a cross vault, whose directrix is a semicircle" [Guarini 1674, p. 107]. Indeed, here is illustrated the method for finding the surface of a groin with circular directrix, meant as part of a cross vault on a square plan. Following the beginning of Chapter 3, the reconstructive model hypothesizes a square plan for the whole vault,

therefore the horizontal projection of the groin results to be an isosceles triangle, rectangle at the vertex, with base equal to *a* and sides to √2*a*/2.
Finally, in the groin are made sections with two vertical planes parallel to the key line and with a plane parallel to the directrix. Therefore, Guarini starts from the case previously developed in the *Architettura Civile* and seen above, and extend it to extremely lowered lunettes whose section is an arc of circumference, very widespread to give light in low-pitched vaulted rooms, such as mezzanines and basements (fig. 3).

Diverging developments between architectural designs and surface calculation

In the two treatises, the Guarinian discourse continues in a divergent way: in the *Architettura Civile* developing three examples of lunette vaults, in the *Modo di misurare le fabriche* widening the casuistry of lunettes' shapes.
The first two examples in the *Architettura Civile* are based on late-Renaissance lunette vault models.
In the first case, a cloister vault cut with planes parallel to the intersections between the coves is hypothesized. The rampant groins, inserted for completing the cuts, are in equal numbers for each side and have different spans of the perimeter arches on each walls, which are, therefore, semicircular along two sides of the room and semi-elliptical along the others. The main vault on a rectangular plan has a ratio of 3:4 between the sides, and semi-elliptical directrices of the two semi-cylinders that generate the coves of the cloister vault. The rampant groins, having a triangular plan of different base along the two sides of the room are generated by sections (fig. 4). This model could refer to the drawing of the honor hall in the Guarinian design of Castello di Govone, present in another plate of the *Architettura Civile* (fig. 5).
In the second example, a rectangular room with a ratio of about 1:2 between the sides, is covered by a barrel vault with cloister heads. The lunettes, defined by cuts parallel to the intersections between the barrel and the coves, have the same shape and are in a different number on the sides. The compensation, necessary for the regularity of the system, is realized by setting a different distance between the lunettes along the sides. It should be noted that the Guarinian drawing of the section of the main vault is not geometrically consistent with the plan: the profile of the section is elliptical rather than plane in the central part and circular at the ends (fig. 6).
The vault described above could refer to a drawing of the section of the design for the central body of Castello di Racconigi, attributed to Francesco Lanfranchi and dating back around 1665 [Dardanello 2006, p. 435]. Guarini will succeed to him in the task of transforming the castle from 1677 (fig. 7).
The third case witnesses the passage from the late-Renaissance to the Baroque style, through Guarini's invention of a lunette vault set on the ovate plan that recalls, for its geometric layout, the vault of the atrium of Palazzo Carignano, even if the author does not explicitly refer to it. In the drawing shown in the plate XX the ratio between the axes of the oval plan is 4:3, while the section reveals that the main surface is generated by rotation of the oval around the major axis: the resulting rise is equal to the minor semi-axis. The horizontal projections of the groins, according to the indications of the text, have the sides of the same length and the vertex tangent to an internal oval equidistant from the main one. Guarini also shows a variant with different sides in plan for the diagonal groins.
In the reconstructive model, the rotational oval that shapes the main surface is cut with vertical planes drawn on the projection of the groins. In the section, these cuts generate vertices of the groins higher than in Guarini's drawing. The rampant groins, which originate from round arches, are modeled by parallel arcs with variable curvature along an oblique trajectory to the horizontal plane (fig. 8).
As said, the model in the treatise seems to be inspired by the ideation of the vault in the atrium of Palazzo Carignano, whose first drawings date back 1678-1679. The survey of the atrium of the palace showed remarkable measures of the central space to be covered with a single vault: in fact, the major axis measures about 14.65 m, the minor 10. The vault, consistently with the construction requirements, is rather lowered: the rise is about 2.20 m.
The comparison between the geometric diagram of the treatise and the realization in Palazzo Carignano reveals some morphological differences: in the atrium the main surface can be assimilated to a scalene ovaloid and the groins have triangular projections with different bases in plan. There are also some proportional differences: the ratio between the axes is between √2:1 and 3:2, while the rise is between a quarter and a fifth of the span as suggested by Guarini in a passage from the treatise [Guarini 1737, p. 188] (fig. 9).
In the *Modo di misurare le fabriche*, the link with architecture is less stringent: while acting as an aid to the architect's operational activity, the reasoning "is maintained on a the-

Fig. 4. Cloister vault with lunettes. Image: Guarini 1737, Plate XIX; digital modelling: Roberta Spallone.

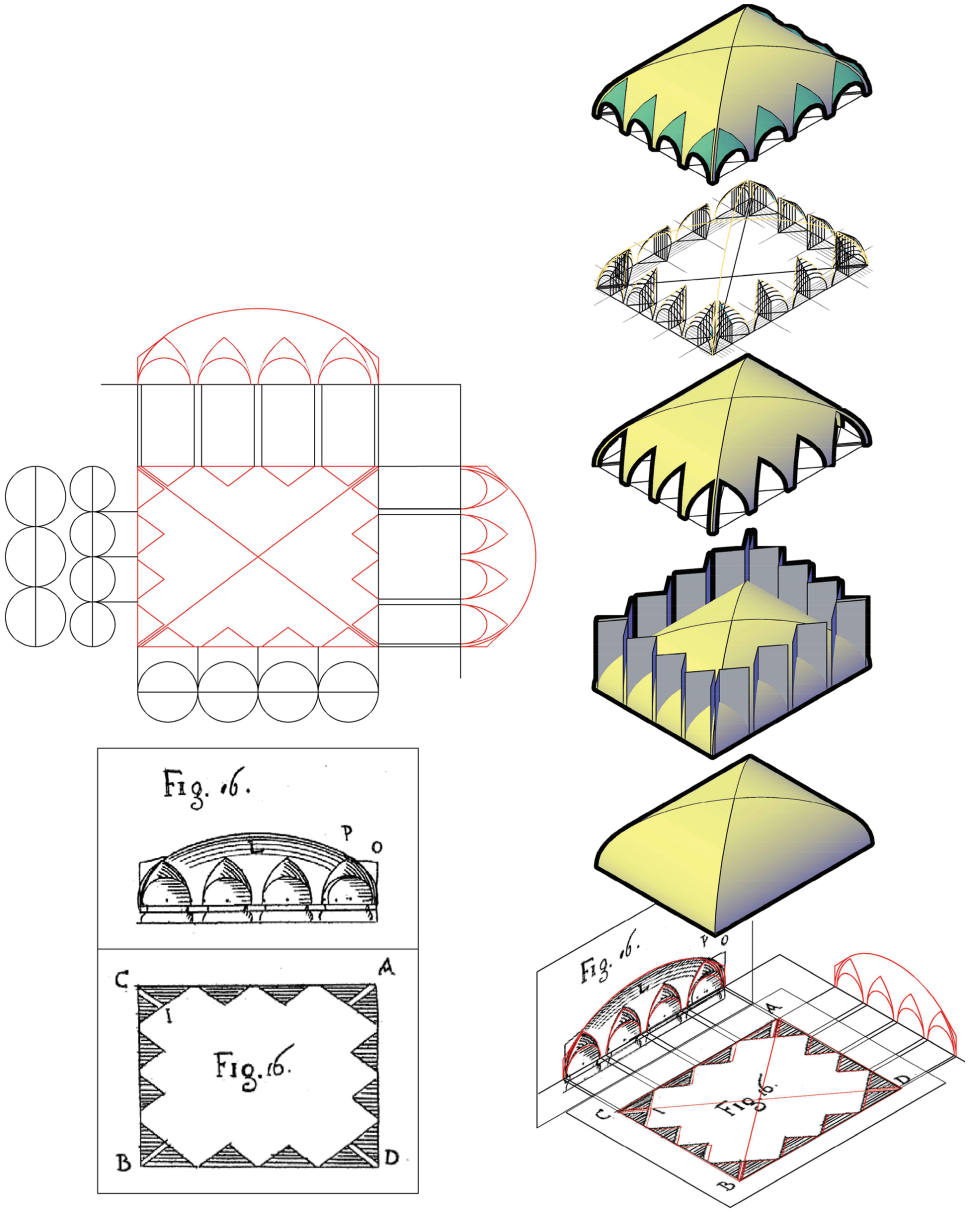
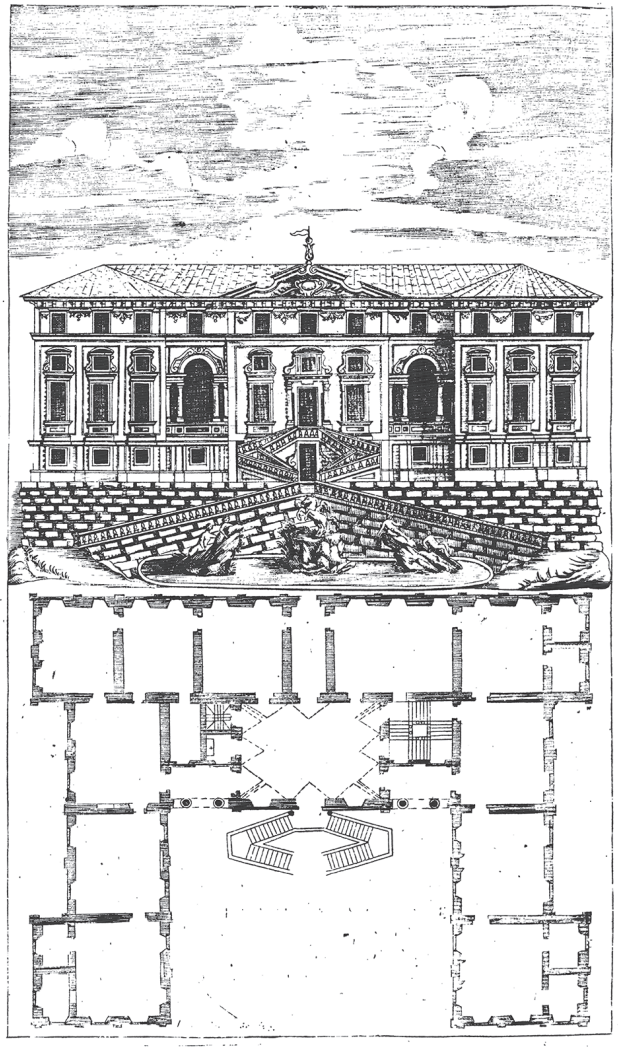
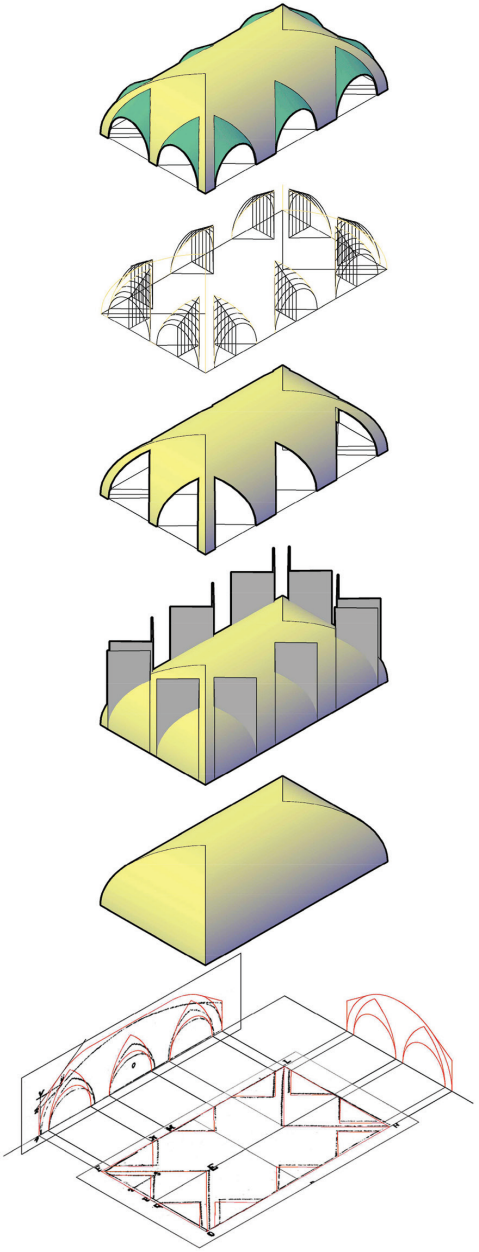


Fig. 5 Guarini, plan and elevation of Castello di Govone. Image: Guarini 1737.

Fig. 6. Barrel vault with cloister heads and lunettes. Image: Guarini 1737, Plate XX; digital modelling: Roberta Spallone.





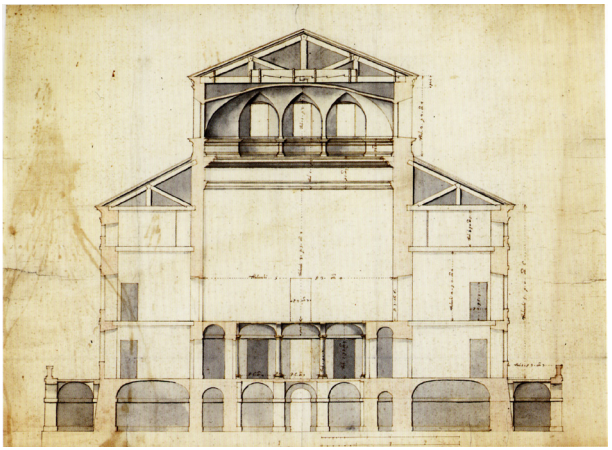


Fig. 7. Lanfranchi(?), cross section of Castello di Racconigi, c. 1655. Image: AST, Archivio Savoia-Carignano, cat. 95, mazzo 2, fasc. 124.

oretical level of absolute abstraction, in which the scientific and speculative mentality of the author decisively prevails" [Vagnetti 1970, p. 508].
The theme of the lunettes is carried out, in addition to the already commented propositions 14 and 16, in the propositions 23 and 24.
The description of the geometrical constructions of the lunettes is developed through the identification of different directrices, which give rise to lunettes round-shaped (semicircle), lowered arch (circumference arc), elliptic (semi-ellipse), lowered elliptic (arc of ellipse), archiacute (arcs of circumference), for a total of nine different shapes. The reference surfaces are semi-cylinders with different directrices or portions of them in the first four cases, and a semi-face of a pyramid, defined as 'concave' by the author, in the last. All the lunettes have triangular projections in plan.
In the book it seems evident Guarini's auspice, on the one hand, to assimilate the lunettes with geometric figures of which he can offer formulas for the calculation - exact or approximate -, on the other hand, to widen the spectrum of shapes.
Compared to the diagrams in the plate XIX of the *Architettura Civile* it is possible to note analogies in regard to the type of projection, and the use of dashed lines and letters but, in the plate, the lines are doubled in correspondence with arches, sections and intersections, aiming to simulate the future construction.

The modeling works are based on the recognition of: the geometric primitive, the directrix, and the horizontal projection of each lunette. This is followed by: the setting of horizontal and vertical cut planes that generate the variants, the automatic interrogation for the calculation of areas, and the comparison of the result with that obtained by applying Guarini's calculation methods. The latter are based on the four arithmetic operations and on the proportions with an unknown quantity, which he calls 'rule of thirds', while π is approximated with the fraction 22/7, according to the teachings of Archimedes.
Proposition 23 expands the series of lunettes to elliptical ones and their portions. Also these are designed as elements of a cross vault on a square plan, so their horizontal projection is identical to that of Propositione 14. In the graphic diagram the height of the lunette is given by the semi-major axis but the method is also valid for the minor one (fig. 10). Both are widespread in the built vaults, just think of the lunettes in the atrium and the vestibule of Palazzo Provana di Collegno designed by Guarini himself, in which elliptic lunettes with different impost spans alternate (fig. 11).
Proposition 24 concludes the discourse on the theme through an original construction, generated by the lateral half-faces of a 'concave' pyramid with a square base, or portions of them. The half-face, rotated 180°, can represent half of a pointed lunette whose plan is an isosceles rectangle triangle (fig. 12). This example is consistent with the reference to the Gothic vaults in Proposition 15 and in the *Architettura Civile* where a paragraph is devoted to them, and illustrated in plate XIX.

Conclusions

The parallel reading of the *Architettura Civile* and the *Modo di misurare le fabriche* about the theme of the lunette vaults is testimony of a production cycle of vaulted systems that goes from the ideation, to the construction, the calculation, and the verification of the quantities of materials during construction.
In the two treatises there is a further confirmation of Guarini's vision according to which architecture is dependent to mathematics and therefore must be traced back to its geometric matrices [Tavassi La Greca 1968, pp. 452-453; Vagnetti 1970, p. 509].
The lunette vaults appear in the *Architettura Civile* as the last element of the vocabulary of shapes established by

Fig. 8. Lunette vault on a ovate plan. Image: Guarini 1737, Plate XX; digital modelling: Roberta Spallone.

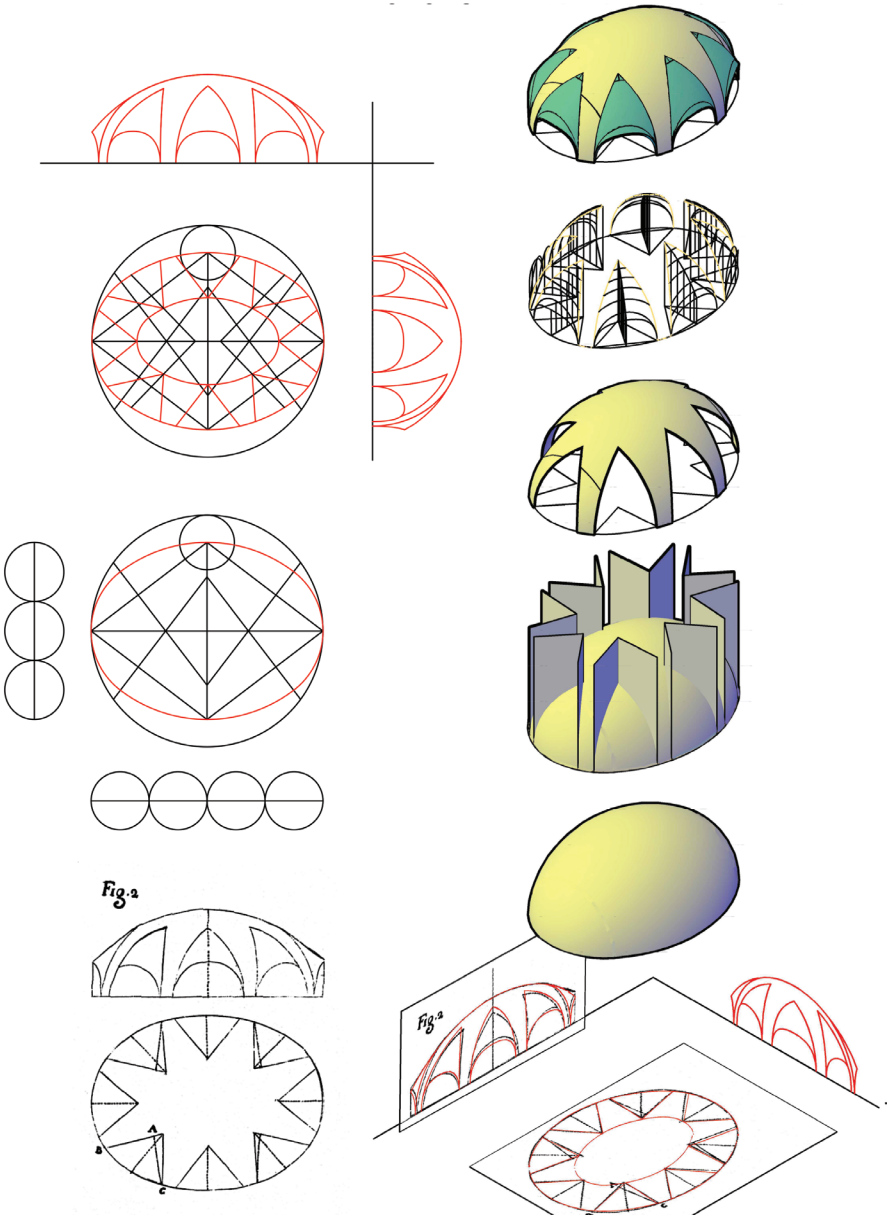
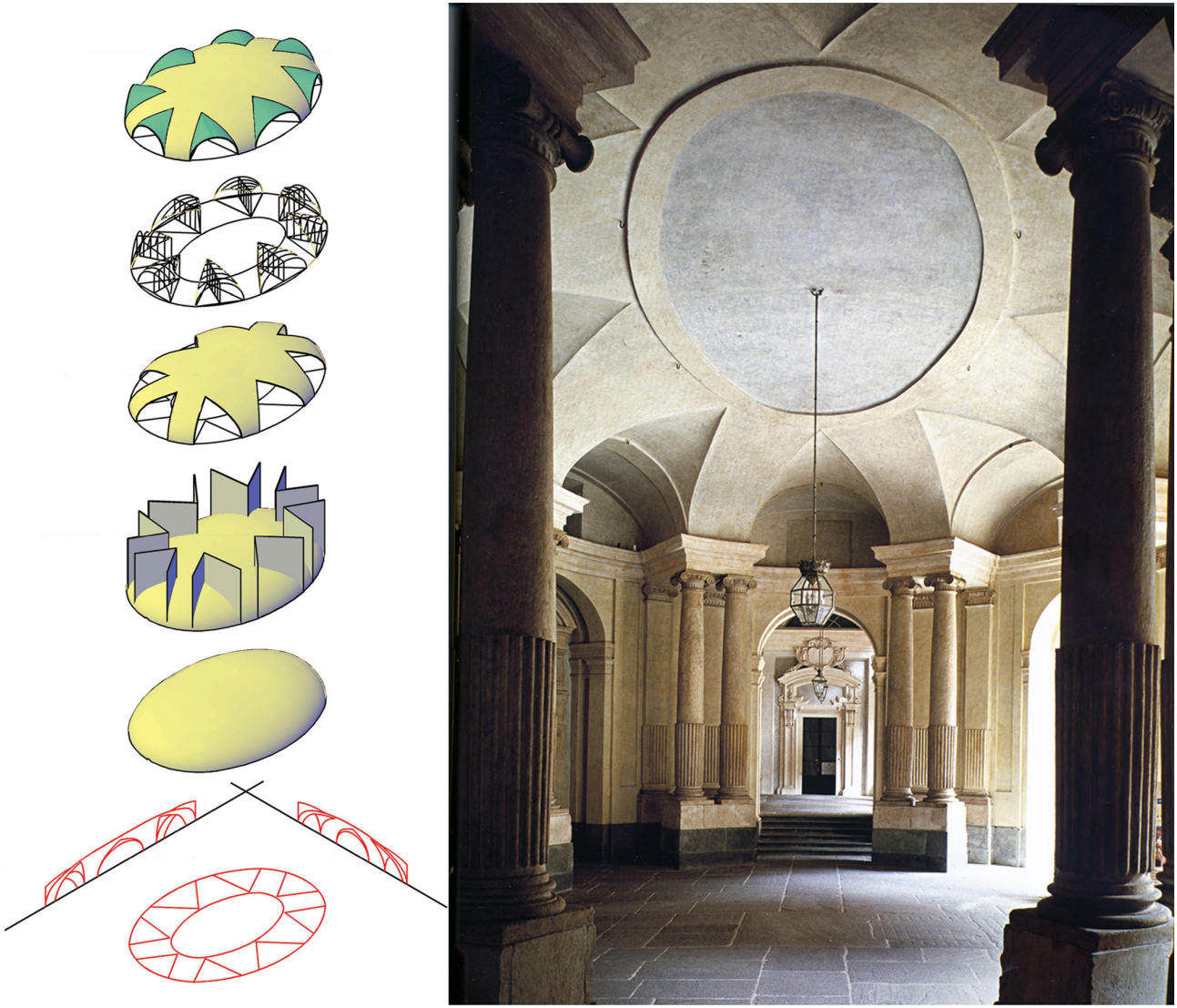


Fig. 9. Vault in the atrium of Palazzo Carignano. Digital modelling: Gabriele Piazzo and Lorenzo Valenzisi. Photo: Marco Vitali.



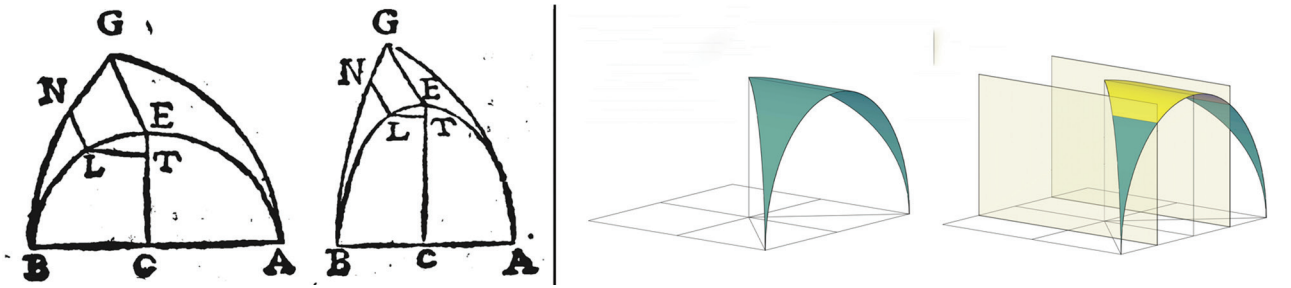


Fig. 10. Elliptic lunette and its portions. Image: Guarini 1674, Prop. 23; digital modelling: Roberta Spallone.

Fig. 11. Elliptic lunettes in the vaults of the atrium and vestibule of Palazzo Provana di Collegno. Photo: Marco Vitali.

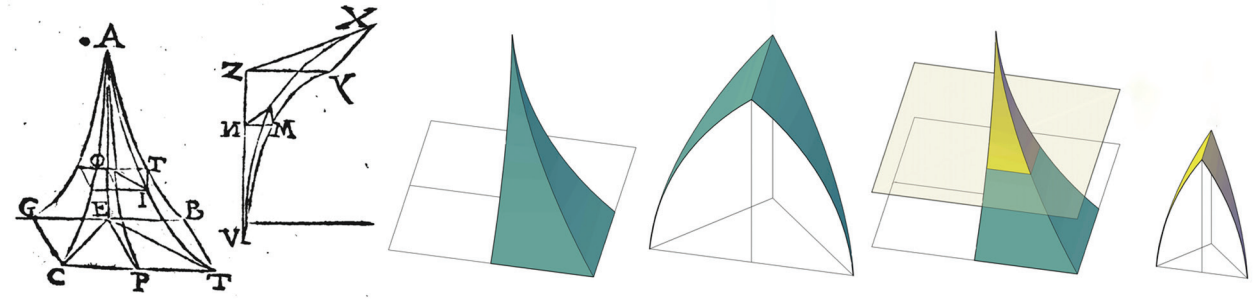


Fig. 12. Pointed lunette obtained from a 'concave' pyramid and its portions. Image: Guarini 1674, Prop. 24; digital modelling: Roberta Spallone.

Guarini for the solution of the issue of the vaulted coverage for the rooms in civil buildings. The combinability of the lunettes with simple and composed vaults of which he first treated, makes them a versatile element for the composition of multiple shapes, as Guarini demonstrates in the immediately following passage.
In the *Modo di misurare le fabriche*, the described shapes present some novelties with respect to the *Architettura Civile*: here the lunettes, all having a triangular projection, have directrices that extend to the arc of circle, ellipse and arc of ellipse, pointed arc, and its portion. The semi-elliptical lunettes are frequent in the vaults of large rooms between 17th and 18th centuries, allowing the creation of radiocentric or axial systems permeable to light even in presence of reduced rises. The lunettes having as a directrix round or elliptic arcs are widely used in the service rooms of reduced height.
The three-dimensional models allow not only to verify the geometrical and spatial consistence of Guarini's diagrams and drawings and the degree of precision of his calculation methods, but above all, to compare design tools and processes based on geometry, and enrich the discourse on lunette vaults with new examples. Therefore, the present research can constitute a new knowledge basis for the investigation on the Guarinian vaults and, in general, on the vaults in the Baroque civil architecture.

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Leon Battista Alberti and the Survey of the Walls of Rome

Graziano Mario Valenti, Jessica Romor

Abstract

The Descriptio Urbis Romae *by Leon Battista Alberti represents the result of the first scientific survey of the city of Rome, of which however the author does not provide any data, but only some operational indications. The aim of this contribution is therefore the advancement of knowledge on the Albertian survey project, through the collection of direct clues, coming in particular from the reading of the* Ludi mathematici*, and the analysis of some singularities that can be deduced in the restitution.*
The study focuses in particular on the survey of the walls of Rome, an element of great importance in the Descriptio *and which, due to its heterogeneity and territorial extension and the current persistence, is configured as a precious experimental opportunity. The restitution of the walls path, as it emerges from the graphic transcription of the numerical data present in the Alberti text, allows, compared with the current map, to produce new observations, crucial for the subsequent experiments, such as for example divergences of the walls and the coherence of the restitution for individual parts.*
By means of today's digital simulation tools, designed to retrace a critical selection of the relevant experimental data produced by Alberti with the instruments of the time, and guided precisely by the observation of singularities, the research helps provide valuable clues on the original survey project.

Keywords: Descriptio Urbis Romae*, urban survey, representation of the city, cartography, digital simulation.*

The *Descriptio Urbis Romae* by Leon Battista Alberti

The *Descriptio Urbis Romae* by Leon Battista Alberti [Alberti 2005] is a very important document in the field of urban survey and drawing: testimony of the configuration that Rome had taken towards the middle of the fifteenth century, it is among the first known attempts of topographic representation of the city and, together with what Alberti wrote in the *Ludi mathematici* [Alberti 1973], it defines the progress of knowledge in survey of city at that time. It consists of a short text that explains how to graphically reconstruct the map of the city –synthesized in some essential elements such as walls, doors, river path, Tiberina island limits and significant buildings– starting from the polar coordinates contained in the tables that follow the text itself (fig. 1). A graduated circle, the *horizon*, divided into 48 degrees, each subdivided into four minutes, and a line, the *radius*, split into 50 degrees, which are also subdivided into four minutes, are the only tools –described and illustrated in the codices [1] (fig. 2)– necessary to guide the reader in the execution of this drawing. Despite the drawing of the city is the main subject of the work, it does not appear in any of the codices that have survived, replaced in its entirety by its literal description, the *ekphrasis*: as usual in the period before the introduction of printed reproduction, it was used to protect the identity and fidelity of drawing, being its manual reproduction more susceptible to various mistakes if made by a copyist not necessarily expert on the subject.

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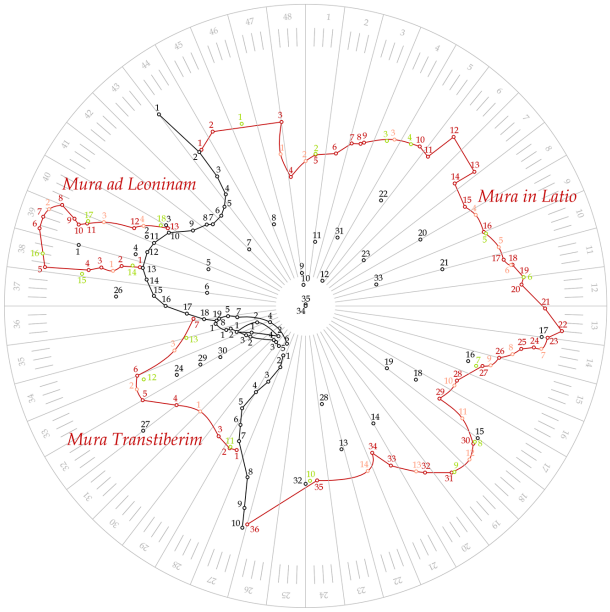
Fig. 1. Graphic restitution of the Descriptio Urbis Romae by Leon Battista Alberti.



When Leon Battista Alberti arrived in Rome for the first time, in 1432, the city showed signs of medieval decadence: ruined buildings, muddy roads, large areas within the walls uninhabited and used for cultivation and grazing, ruins of ancient buildings reused and surmounted by new buildings [Cantatore 2005; Fiore 2005]. In later years, it began to grow the interest of the curia in the study and enhancement of Roman antiquities in view of the renewal of the city, which was an increasingly important place of pilgrimage to the main buildings symbols of Christianity: Alberti himself, back again in Rome in 1443, began to study ancient and late ancient ruins and early Christian basilicas. It is in this period that he began to dedicate himself to the *Descriptio*, a work with which he implicitly manifested his interest in survey and representation of the city.
However, the *Descriptio* constitutes the conclusion of a far more complex path related to topographic survey, that is explicitly dealt, with a scientific approach, in another work, crucial for understand the genesis of the drawing of Rome evoked in the *Descriptio*: the *Ludi mathematici*. This work, written between 1450 and 1452 with pedagogical purposes, is among the first contributions in history to address issues related to the measurement of space and, as we shall see in particular, to the topographic survey. While in the *Descriptio* there are only the instructions that allow us to reproduce the map of the city by points, in the *Ludi* we find the description of the method and the tools with which Alberti detected these points.

For a study of the *Descriptio Urbis Romae*

Although this particular work by Alberti can be considered a significant evolution of knowledge in the scientific representation of the city, and –by extension– even of the data produced by the survey, the studies addressed to it are rare. The National Critical Edition of Jean-Yves Boriaud and Francesco Furlan, published in Florence in 2005 [Alberti 2005], constitutes a precious and indispensable contribution to the philological reconstruction of text and data and to the general framing of the work, and, as usual for this kind of publication, it is devoid of conjectural considerations about the survey operation that necessarily produced this result. On the contrary, the extensive analysis by Luigi Vagnetti, published between the 1960s and the 1970s [Vagnetti 1968; Vagnetti 1974], deals with the issue of restitution in depth –evaluating the discrepancies with respect to 20th century maps– and advances hypotheses on the choice of stations in the survey phase without resorting to experimental tests.
The *Descriptio* tells only how to reproduce the restitution of the city plan, while it does not deal with the method, the instruments and the procedure followed for the related essential survey activities, which are instead explained and illustrated from a theoretical point of view in the *Ludi Mathematici*. Starting from the suggestions collected in Vagnetti's text about the location of the stations and entrusting us to the philological reconstruction of data contained in the National Critical Edition, we started a complex and compelling retrospective investigation of the Albertian work aimed at formulating original considerations on the survey project that led to the definition of the city map. This complex investigation, in continuous evolution, aimed at the collection not only of the indications that Alberti,

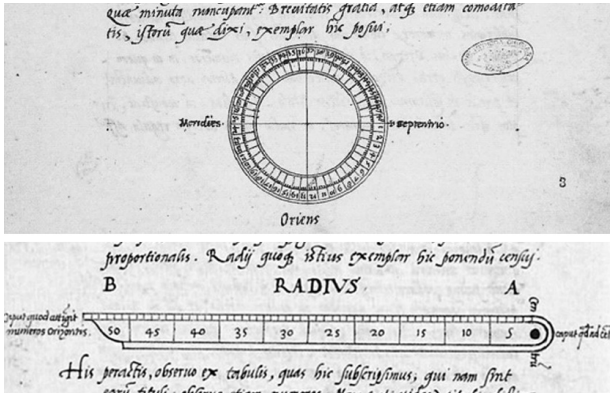


Fig. 2. Detail from Descriptio, codex Chig. M. VII 149, fol. 3r and 3v, Biblioteca Apostolica Vaticana.

Edifici e monumenti	*Stato*	*Stazione*	*Mira*
Basilica massima di San Pietro	alterato		
Piramide Tomba di Romolo	-		
Castel Sant'Angelo	originale	●●	●
Ospedale di S. Spirito (or Chiesa S. Maria in Sassia)	originale	●	●●
Torre di Parione	-		
Orologio in campo dei Fiori	-		
Rotonda del Pantheon	originale		●●
Colonna Antonina	alterato		
Casa Di Nerone, nei giardini Colonna	-		
Colonna di Adriano, Colona Traiana	originale		●●
Fastigio di Costantino (arco di Costantino)	-		
Torre delle Milizie	originale		●●
Chiesa di San Sabu	originale	●●	●●
Chiesa di Santa Balbina	originale		●
Chiesa di San Giovanni a Porta Latina	originale	●●	●●●
Basilica di San Giovanni in Laterano	alterato		
Chiesa di Santa Croce in Gerusalemme	originale	●	●●
Chiesa di Santo Stefano Rotondo	originale		●●●
Chiesa di Santi Giovanni e paolo	originale	●●	●●
Basilica di Santa Maria Maggiore	alterato	●●	●●●
Terminale dell'acquedotto (torri dei Capocci)	originale	●●●	●●
Terme (di Diocleziano)	originale		●
Chiesa di San Lorenzo in Panisperna	-		
Chiesa di San Pietro in Montorio	originale	●	●●●
Chiesa di San Giacomo al Gianicolo	-		
Chiesa di San Onofrio sul Colle	originale	●	●●
Chiesa di San Pancrazio	originale	●●	●●
Chiesa di Santa Prisca	originale	●	●●
Chiesa di Santa Maria in Trastevere	originale	●●	●●
Chiesa di San Crisogono	originale	●●	●●●
Chiesa di San Vitale	originale		●
Piramide di Paolo (Cestia)	originale		●●●
Chiesa di San Pietro in Vincoli	originale	●	●
Campidoglio	alterato		
Chiesa di Santa Maria in Ara Coeli	originale		
Porte	*Stato*	*Stazione*	*Mira*
Popolo	alterato		
Pinciana	originale	●	●
Salaria	demolito		
La donna (Nomentana)	demolito		
San Lorenzo (Tiburtina)	originale	●●	●
Maggiore	alterato		
Laterano (Asinaria)	originale	●	●
Latina	originale	●	●
Appia	originale	●●	●●
San Paolo	originale	●●	●●
Portuense	alterato		
San Pancrazio	alterato		
Gianicolense	-		
Santo Spirito al Gianicolo	originale	●	●
Posteriore sulla Valle (Torriona)	alterato		
Sul Colle (Pertusa)	originale	●	●
Palatina	-		
Castello	alterato		

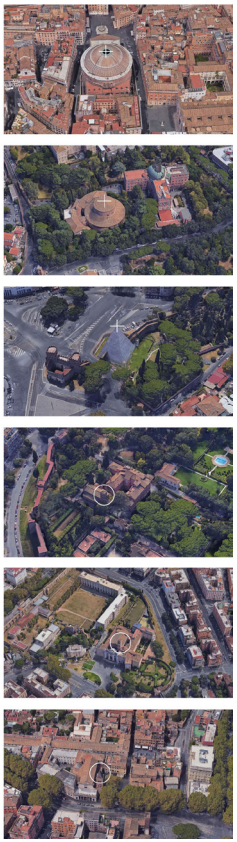


Fig. 3. Evaluation of buildings, monuments and gates considered in the Descriptio in relation to their possible role as targets (1-3) or stations (4-6).

more or less consciously, has left us, but also of those that originate from direct –through current experience and digital simulations– and indirect observation of the city – by means of its representations over the centuries.
A first chapter of this research concerned first of all, as in Vagnetti, the direct restitution of the map evoked in the *Descriptio*, in order to express some initial considerations on the placement of buildings and monuments considered by Alberti, through an automatic restitution process and digital simulations of uncertainty. This first phase allowed us to observe how the instrumental error –both in the measurement of the angles and in the orientation– is not sufficient to justify the deformations of the plan [Valenti, Romor 2016].
Furthermore, from a critical observation of the shape of the buildings, necessary to comprehend on which architectural element Alberti has focused attention in the measure phase, it is clearly evident that some of them constitute perfect targets, others can be ideal stations. In fact, the presence of some buildings among the others and their geographical position appear crucial for the survey, giving us important clues on the procedural nature of the survey itself.
In particular, we considered the buildings that were present at the time of Alberti, in the form we know them today, discarding those that no longer exist or whose identification is doubtful (fig. 3a). These buildings and monuments were subjected to a qualitative analysis to evaluate their capability to fulfill the role of stations and/or targets. Individual emerging elements, unique, unambiguous and relevant, have been considered good targets; towers or structures having high terraces, from which we can enjoy a full view of the surrounding panorama, have been considered as possible places for stations. Bell towers, excellent targets, have been considered less suitable for the placement of the stations, for two reasons: the difficulty of placing the instrumentation in the reduced space available; the limited possibility of sighting to the outside through the small openings that normally characterized this kind of structures.
The studies conducted so far on the *Descriptio* hypothesize that Alberti has established two or, most probably,

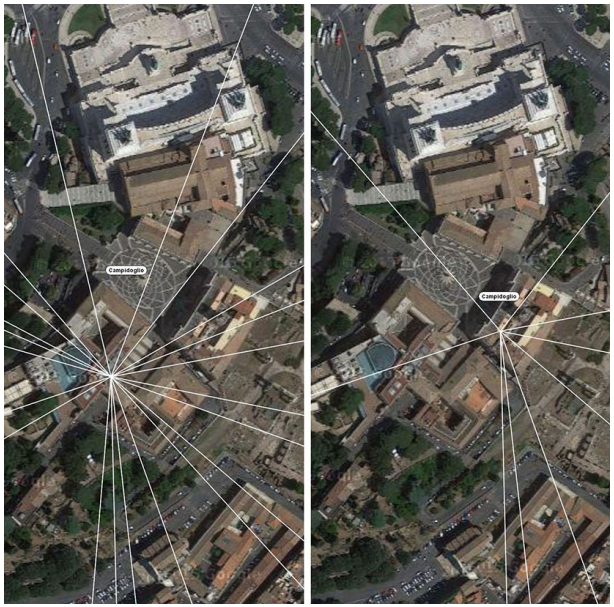


Fig. 4. Two solutions for identifying the station on the Capitol hill via a backward intersection.

three stations to make his survey [Vagnetti 1968; 1974]. The main goals we wanted to achieve at this stage were the identification of the station in the Campidoglio and the position of the secondary measurement stations. We proceeded along two different paths to identify possible solutions.
To locate the position of the most likely station on the Campidoglio, we proceeded with a resection. Firstly we identified the real coordinates of the points (IGM map), corresponding to the surveyed buildings that have an unequivocal target. Subsequently we defined a significant set of lines, having origin in an auxiliary and approximate center on the Campidoglio and passing through the identified points. Then we found the solution of the system that better approaches to the angular values measured by Alberti, by moving only the approximate central station, located on the Campidoglio.
The solution of the system, applied to the full set of the useful targets, identified the main station to the orographic point that, even today, we may consider the highest point of the hill (fig. 4a). We have also generated a different solution using a reasoned selection of the targets, so to eliminate those that introduced an excessive angular compensation. This solution identified a point placed near west side of the Palazzo Senatorio (fig. 4b).
This first phase allowed us to observe how the instrumental error –both in the measurement of the angles and in the orientation– is not sufficient to justify the deformations of the plan. In continuity with this first investigation, with this study we have set ourselves the goal of providing new answers to questions still open on the survey project carried out by Alberti, focusing attention on the walls, the first element to be cited in the introduction to the *Descriptio* and in the tables that show the lists of coordinates that define the interpolation points.

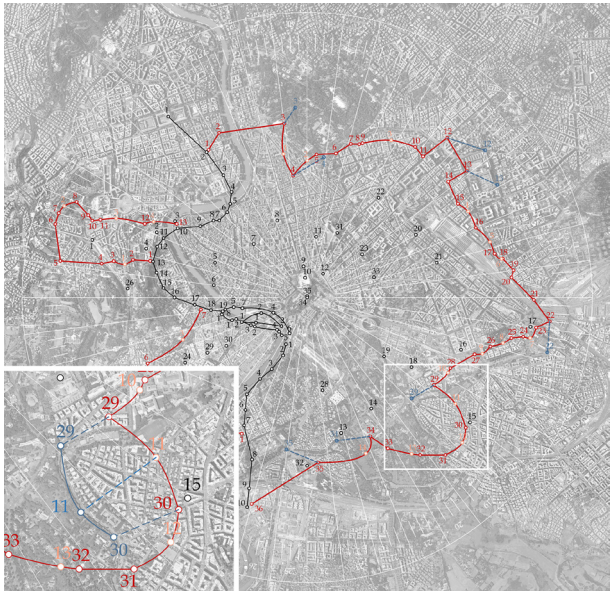
The city of Rome and the representation of its walls

To understand the originality of the Albertian contribution to Roman cartography history, before moving on to the next phase of analysis, it is better to make a brief investigation on the medieval representations of the city [Frutaz 1962], in which the walls appear as strong and preponderant signs, harbingers of allegorical meanings –as in the case of ancient Rome in the shape of a lion– or symbolic – considering the circular shape given to the walls in drawings contemporary to the *Descriptio* (fig. 5). In the maps designed by Paolo di Limburg and his brothers (fig. 5a) and by Taddeo di Bartolo (fig. 5b), the path of the walls appears circular and continuous, as well as, partially, in the drawings by Pietro del Massaio (fig. 5c) and Alessandro Strozzi (fig. 5d), where however the discontinuities between the wall sectors in correspondence of the river are respected. In all cases, even in other representations, the authors always tend to give a clear representation of the walls construction type, highlighting the tower and curtain system.
The drawing of the walls that derive from Alberti's instructions therefore appears to be opposed to this type of representation: a limited set of points that describes with geometrical rigor the layout of the walls in plan and does not linger on other types of information.
Reading again the aims expressed by Alberti and giving a value at the order in which they are listed, it is

Fig. 5. Maps of Rome by Paolo di Limburg and brothers (a), Taddeo di Bartolo (b), Pietro del Massaio (c) and Alessandro Strozzi (d).

evident the predominance of the geographical objective on the merely informational one: first, he considers the boundaries (the city walls); then, the river, the most emergent geographical element that complete the path of the walls; the roads, the entrances to the city and, only later, the main buildings and monuments; finally, the delimitation of the hills and of the inhabited areas.
The order in which the elements to detect are mentioned reveals a scientific approach oriented to survey the geographic and urban features of the place, from general to particular, from the boundaries (walls and rivers) to, finally, the monuments. The manifest intention of Alberti to proceed rigorously to the identification of the path of the walls, putting it as the primary objective and devising a system to differentiate the survey and the representation of vertices and curves, suggests that some of the buildings identified in the survey may have been selected for their strategic position in relation to the measure of the points selected on the walls, rather than for their importance and relevance in the city map.

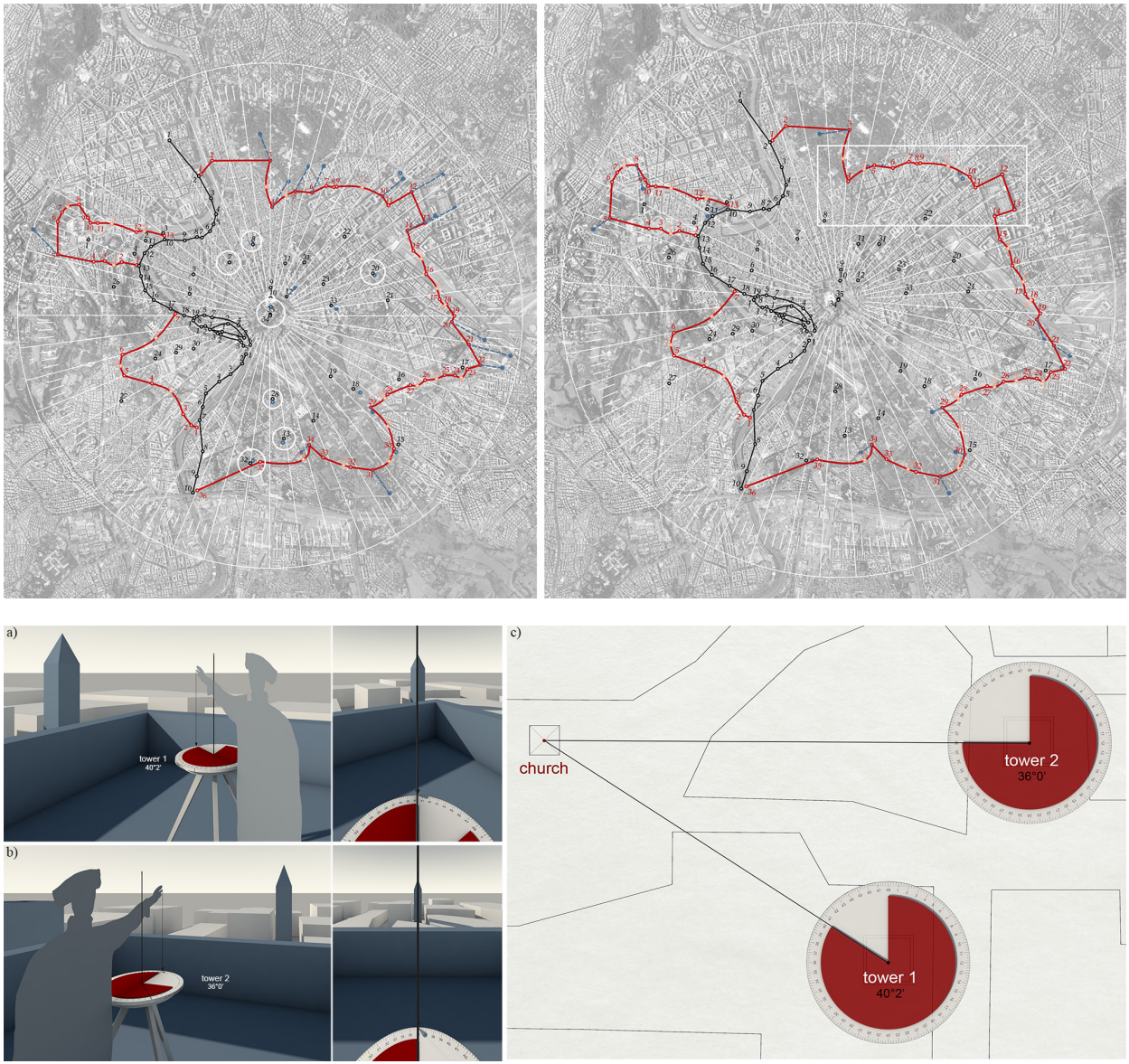
Fig. 6. Overlap between the drawing that emerges from the Descriptio and the Rome photomap.



So, let's see what the data provided by Alberti consist of. He considers three portions of walls (fig. 1): *in Latio*, coinciding with the vast eastern sector of the Aurelian walls, *Transtiberim*, the old Aurelian walls of Trastevere, and *ad Leoninam*, the fifteenth-century Vatican wall. Each sector is discretized through a given number of points, which refer to two elements of the walls: the first, the *anguli*, are attributed to vertices in which the walls change direction; the others, called *auges*, define points of greater projection/protuberance/protrusion of portions of walls that Alberti perceives as curves, even if we know that the layout/plan of the walls consists of a broken line. Then there are other points that belong to the route of the walls: they are listed elsewhere as doors or monuments (as in the case of the Pyramid of Cestius), that for now we do not consider. The walls so called *in Latio* are the most interesting from the point of view of comparative analysis, since almost completely preserved; in fact, *transtiberim* walls have almost completely disappeared in favor of the new Gianicolo's walls and the walls *ad Leoninam* have been incorporated into the successive structures and replaced in their function by the bastions of Sangallo. Moreover, the text does not consider the portions of walls along the river now absorbed by the banks, although still present at the time of Alberti, as shown by many maps coeve and immediately successive. Once the tracing of the walls in the three sectors has been carried out, and a first comparison is made with the current map, it is possible to make a series of observations, which will serve as an objective basis for the subsequent experiments. First of all we can see how, by aligning the drawing with the current photoplan according to the main buildings, the path of the walls does not coincide with the image of the walls on the map. Moreover, we can frequently record an inversion of the concavities/convexities of the walls where Alberti places the *auges* (fig. 6): this also happens for a building –the church of San Giovanni a Porta Latina– which, unlike reality, is located outside the walls in Alberti's drawing. This clue, in addition to highlighting critical aspects of the survey, can be useful to determine the degree of awareness that Alberti had of the urban space of Rome. Finally, if it is true that it is not possible to find an overlapping solution that simultaneously satisfies all the coincidence conditions relating to buildings and walls, it is possible to see how this happens for individual and more or less extensive portions of points (fig. 7).

Fig. 7. Local overlap of single parts of the drawing of the Descriptio to the map of the city.

Fig. 8. Digital simulation of the use of horizon.



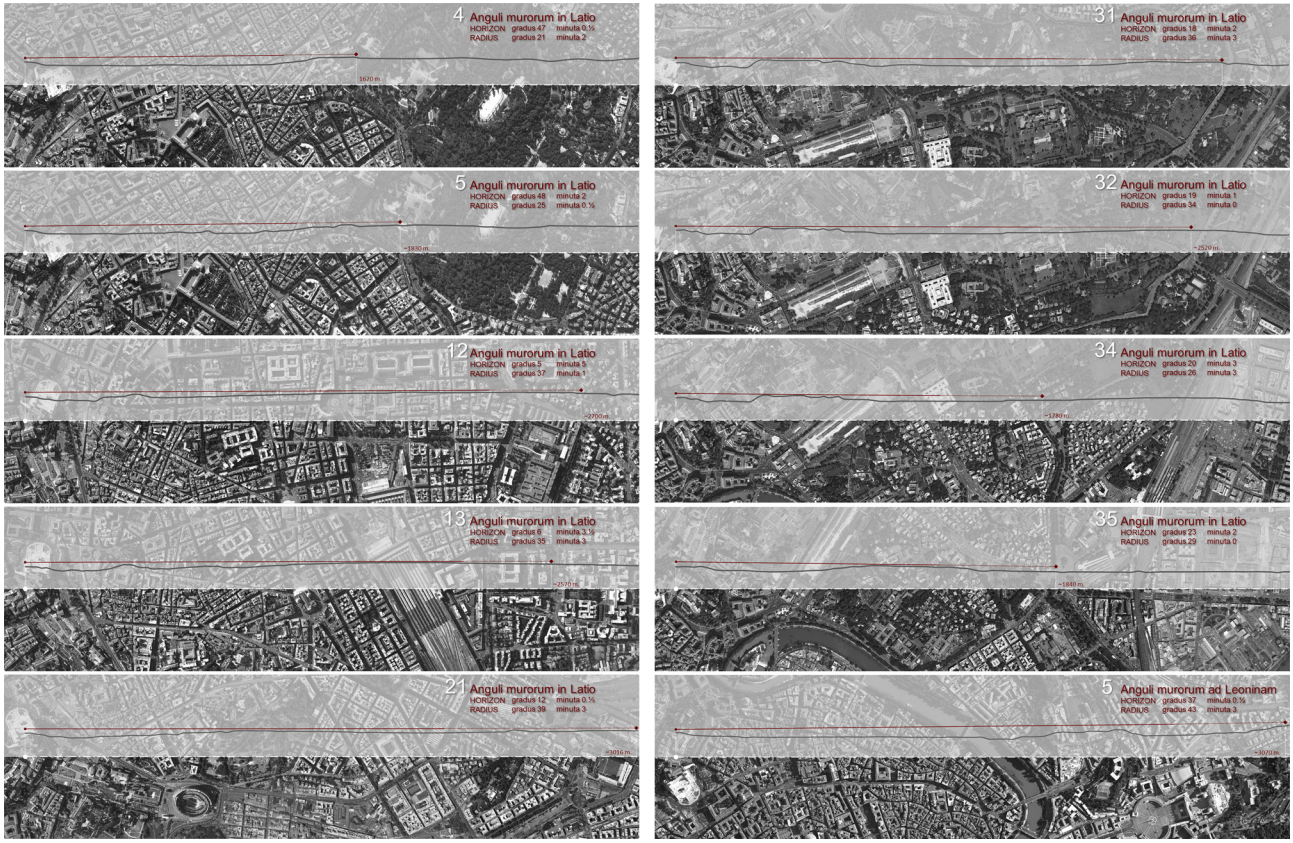


Fig. 9. Sections of the ground conducted for a station point located on the Capitol hill and some significant monuments, in order to verify their actual visibility from that station.

Understanding *Descriptio*: experiments

Considering these data and results only, since we do not have documents that clearly record the operative phases of the Albertian survey, we have collected useful clues to formulate hypotheses on the relative project.
To begin with, it is Alberti himself who provides explicit, though not exhaustive, clues. For survey operations, he uses a *horizon*, a graduated circle completely identical to that used in the *Descriptio* for reproducing the city plan, but larger (the diameter measures one arm); positioned the instrument in a first station, we can read on it the angle value of each targeted point thanks to a plumb line, held in hand by the operator, that aligns the eye, the center of the disc and the target (fig. 8a). Collected the angular values of the entities visible from the first station, we pass to the next, taking care to re-orient the horizon in the direction taken in the first station [2]: also in this case, we proceed to measure the angles of the same entities (fig. 8b). For each point to be detected it is necessary to note the value of the angle from two different stations, there-

fore the number of total stations will vary depending on location and visibility of the targets with respect to the stations themselves. Then, we move to the phase of restitution. We arbitrarily represent on a sheet the position of the first two stations, considering that the distance between them determines the scale of the drawing; thanks to *horizontes* of reduced dimensions placed in correspondence of the points that represent the stations, we determine by intersection the plan position of the various surveyed points (fig. 8c). Alberti says that the first point to drawn on the sheet, center of the reduced horizon with which we reported the angles of the measurements taken from the first station, coincides precisely with it and therefore, in our case, with the Capitoline Hill. Afterwards, he provides a method for measuring large distances between two points by exploiting proportionality with limited and known distances, directly measurable.

We then collected implicit clues: the nature and consistency of the deformations that emerge in the discrete representation of the walls –a more articulated element than the simple group of buildings and monuments indicated by single disconnected points– constitute further useful information for the formulation of hypotheses on the survey project.
Considering then the practical problems related to the survey, we can obtain valuable clues about the visibility of the mentioned subjects in relation to the places that could allow a panoramic viewing of the city. Here is therefore the importance of the visual experience, present and past: the first can be conducted today either by direct observation or by digital simulations able to derive significant sections of the urban territory (fig. 9 a, b); the second can be pursued through views of the fifteenth and early sixteenth centuries, which depict a still not too dissimilar Rome from the city surveyed by Alberti (fig. 10).

Fig. 10. Panoramas of Rome by Martino Van Heemskerk from Monte Caprino (Capitolin hill), 1534 (a, b). Panoramas of Rome by Antonio Van Den Wyngaerde from the Baths of Constantine, 1550 (c), and from Monte Mario, 1550 (d).

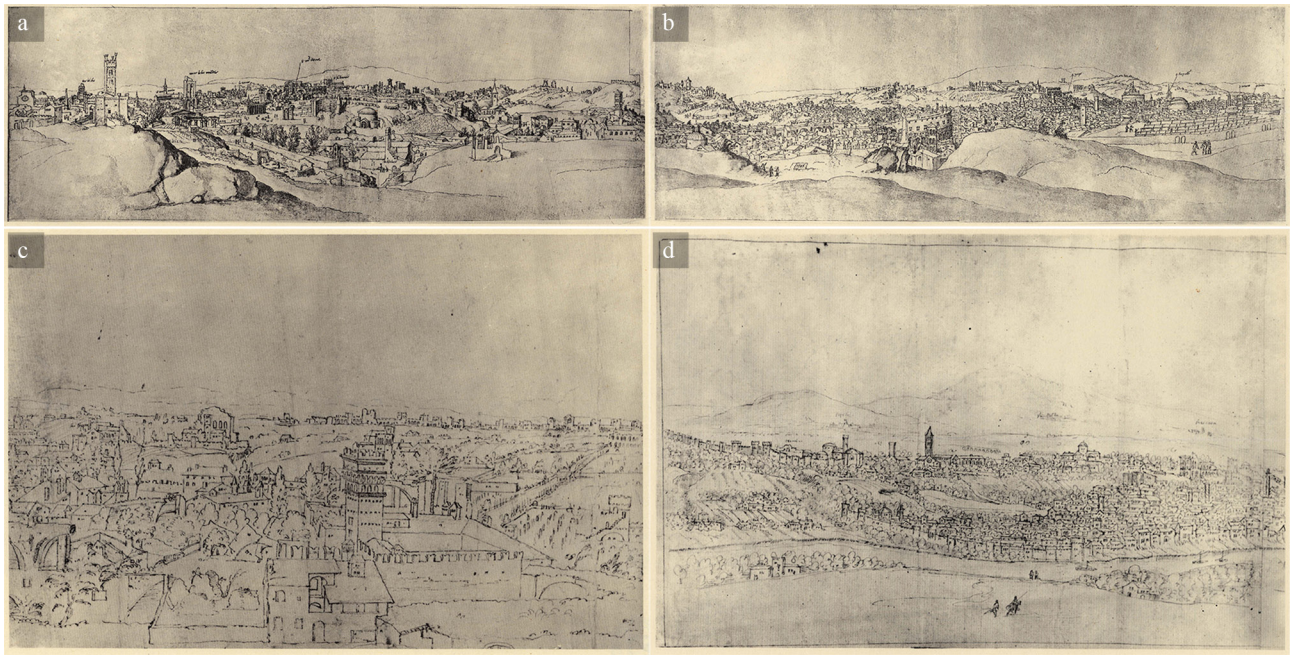
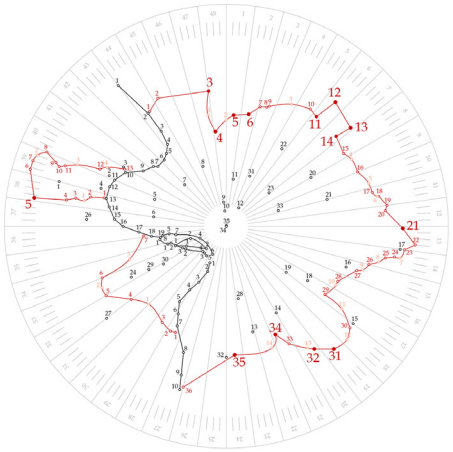


Fig. 11. Selection and evaluation of the points of the walls that are still present and recognizable and can therefore be taken into consideration for subsequent experiments.

Fig. 12. Two of the main maps taken into consideration for the historical analysis of the fiducial points selected on the walls: maps of Rome by Leonardo Bufalini, 1551 (a), and by Mario Cartaro, 1576 (b).



Anguli	G	V	R
Latio			
3	2	0	1
4	3	3	3
5	1	3	1
6	3	3	3
11	3	3	3
12	2	3	1
13	3	3	3
14	3	3	2
21	3	3	3
29	2	3	1
31	2	3	2
32	3	3	2
33	3	3	2
34	3	3	3
35	3	3	3
Leoninam			
5	3	3	3

Data and clues we have collected, even if significant, produce a too labile and undetermined investigation structure in order to formulate hypotheses about the survey project. Before beginning the subsequent critical analyzes, it was therefore necessary to set some axioms, based on the previous studies and the most accredited considerations. First of all, let's say that one of the stations (the first) coincides with the Capitoline Hill. Furthermore, to reduce the possibility of choice of stations, suppose that the surveyed points have all been detected from inside the walls.

Referring to the walls, we first looked for the correspondence between the surveyed points and the portions of walls currently visible and substantially identical to those present at the time of the *Descriptio*, in order to conduct subsequent investigations on a limited and reliable number of points. The research has produced a selection of points that have been evaluated, with varying degrees of reliability, in relation to their recognition in the survey phase and to our ability to identify the point on the walls today (fig. 11). The issue of recognizing points is very complex: if it is easy and immediate to identify a point in the plan on the theoretical level, instead falling into the practice of the surveyer and colliding with the physicality of the walls we wonder if that particular point refers to the internal or external side of the walls, which implies the assumption of stations not necessarily internal to the boundary. Each point has been subjected to the scrutiny of historical analysis, in order to evaluate its existence and consistency at the time of Alberti and nowadays. We therefore considered a series of maps and panoramic views –collected during the research– catalogued as direct sources, if they represent the city contemporary to themselves (fig. 12), or indirect sources, in the case of successive interpretations of ancient or medieval Rome. The restoration documents [Mancini 2001] also allowed us to evaluate the alterations of the walls over time and assess their relevance.

Given the data described and the preliminary observations, we therefore produced a series of considerations using a specially developed software that allowed to simulate different configurations of survey starting from the identified fiducial points and assuming pairs of possible stations in relation to the deformations that the map presents. The quality and quantity of deformations emerged with respect to the

current photo plan allowed to distinguish two categories of errors: instrumental/systematic, detected with the tools offered by new technologies, and material/operational, identified through philological reconstruction. The first ones derive from the reduced tolerance of the low-tech instruments used by Alberti and from the inaccuracies of orientation, reading and restitution, the others from critical aspects of the survey project. Let's focus now on this last aspect. The fact that the drawing of the city (as already noted for the buildings) overlaps the current map only for single portions leads us to believe that the Albertian map is actually a combination of more surveys, distinguished not only by type of elements detected (walls, buildings, river), but also within a single category, as it happens for the walls. The hypothesis of the multiplicity of surveys is also corroborated by the total lack of data relating to the survey of heights and inhabited center, promised by Alberti himself in the introduction to the *Descriptio*.

Descriptio Urbis Romae: the research continues

The observations and considerations that have emerged so far therefore lay the foundation for future investigations aimed not only at applying the same digital simulations to the remaining categories of surveyed elements (gates, river course and Tiber island), but also at testing new hypotheses on the survey project, starting from different assumptions, such as the possibility that Alberti used the towers of the walls as stations for his survey of the city.

Acknowledgments
Special thanks to: Professor Carlo Maccagni, for having gave us information on techniques and instruments of survey characteristic of the Renaissance; Professors Filippo Camerota and Francesco Paolo di Teodoro, for the valuable bibliographical references on topographic survey and, in particular, on the Alberti's 'Descriptio Urbis Romae'. We would like to thank Dr. Marina Marcelli from the Sovrintendenza di Roma Capitale, Department of Ancient Monuments, for supporting us in the consultation of the documentary material relating to the walls of Rome. We also thank Donatella Iacovacci and Valerio Sharani for the help in document selection.

Notes

[1] There are six known codices of the *Descriptio Urbis Romae*: Chicago, Newberry Library, ms. 102, end of XV century; Oxford, Bodleian Library, ms. Can. Misc. 172, 1487; Venezia, Biblioteca Marciana, cod. It. XI, 67, second half of XV century; Roma, Biblioteca Apostolica Vaticana, ms. Chig. M.VII.149, half of XVI century; Roma, Biblioteca Apostolica Vaticana, ms. Barb. Lat. 6525, XVII century; Milano, Biblioteca Ambrosiana, ms. O 80 sup., XVI century.

[2] As explained by Alberti, to properly orient the second station it is essential that it be surveyed from the first and that we note the relative angle on the *horizon*; later, we have to place the instrument in the next station and orient it by rotating the *horizon*, so that the opposite angle value of the first be toward the previous station.

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Means and Media of Representation and Visual Culture

Communication and enhancement of products and of material and immaterial goods
Drawing, graphics, communication and new media as strategies for didactics and communication
Signs, images, maps and visions oftTowns, lands and landscapes

Drawing and the Invisible

Laura Marcolini

In recent years, the Italian word *disegno* has expanded its range of meaning, embracing the influences of the English term design and thus involving the whole semantic field related to project conception and to the definition of spatial, sound and even behavioral configurations. This shift dialogues spontaneously with the attitude that has accompanied Studio Azzurro since its foundation, even though, precisely for this fact, it may prove potentially insidious.
Forty years ago, three friends, who had already converged their experiences for some time, decided to make a film together, exploring the language of video. Their previous experiences had been significantly linked to drawing: Paolo Rosa had published a few graphic novels in *Linus*, Leonardo Sangiorgi had dedicated himself to "one-step animations", both had trained at Artistic High Schools and then at the Brera Academy of Fine Arts; they were both excellent draftsmen, with a visionary inclination and a great ability to simulate space with a few strokes. Fabio Cirifino, instead, had trained as a photographer at Studio Ballo, coming into contact with architects and designers and absorbing an extraordinary mastery of the use of light. They were three people who imagined, who virtually drew, in their heads, every project they thought about.

Articolo a invito per inquadramento del tema del focus, non sottoposto a revisione anonima, pubblicato con responsabilità della direzione.

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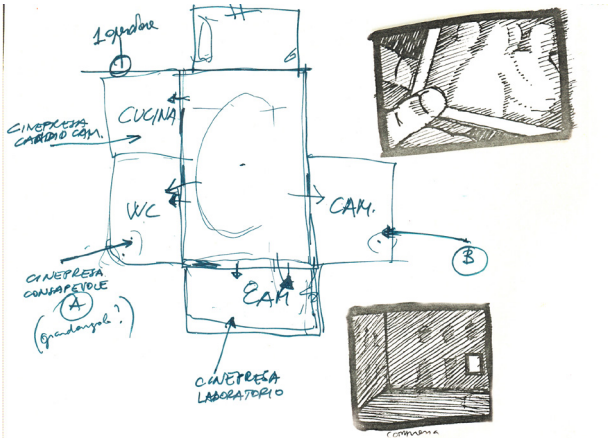


Fig. 1. Studio Azzurro, project drawing for the film Facce di festa, *16mm, 60 min., color, 1980.*

Fig. 2. Studio Azzurro, Il nuotatore (va troppo spesso ad Heidelberg), *video environment, Palazzo Fortuny, Venice, 1984.*

The film was preceded by a storyboard, by sketches and texts, and a rough diagram (fig. 1) of the position of a few fixed cameras (*Facce di festa,* film, 16mm, color, 1980). The place where it was filmed is quite particular: a private home where a party had been organized. That "parties were held every day", is true, but observed forty years later, the location appears decidedly programmatic. It was 1979, a moment of epochal passage recorded in an implacable and amused way on sets. In this work, several themes and attitudes that were to accompany the Studio for the next forty years were already consolidated.
On the one hand, by the intense planning that preceded each work, generated by a fruitful combination of study and free intuition, and on the other hand, by a tireless ability to adapt to the conditions encountered. The legacy of the previous experiences of contestation and metalanguage, carried out with a different group, the *Laboratorio di Comunicazione Militante* and with the first experiment in occupying an abandoned space (*La Fabbrica di Comunicazione* in the Church of San Carpoforo) supported both of these aspects and left its unmistakable mark in the ending of the film *Facce di festa*, in which considerations explicitly connected to the role of the artist/director/author and to the idea of collective work are ironically intertwined.
In the 1980s, Studio Azzurro took a different path, made a very decisive aesthetic turnabout, designed another project for its research, and launched itself with determination towards a new consideration of space and of its dialogue with the 'spectator'.
Space, objects, light and moving images–albeit two-dimensional–are components of an environment in which the spectator can move, approach what he prefers, enter and exit the light, relate to a condition that resembles a theatrical staging in which the actor, and even the screenwriter, is the spectator himself.
It is no longer a matter of facing a predefined vision, managed *a priori* by a director, in which the spectator participates standing still, with his own emotional involvement, certainly, but without being able to put himself, in the least way, in a voluntary relationship with the proposed imagery. Instead, it is a matter of moving within a world, which works similarly to the outside world, but which tells unexpected stories, soliciting equally unexpected responses from our complex perceptual system.

The first were deceptions

The first video environments realized in the early 1980s (*Luci d'inganni, Tempi d'inganni*) are places to explore in which almost everything is familiar and recognizable, yet something is unsettling because it breaks the rules of the

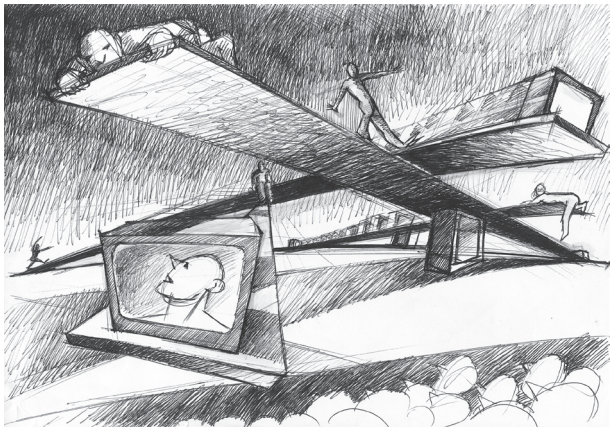


Fig. 3. Studio Azzurro, project drawing for the theatrical performance La Camera Astratta, *Documenta 8, Kassel, 1987.*

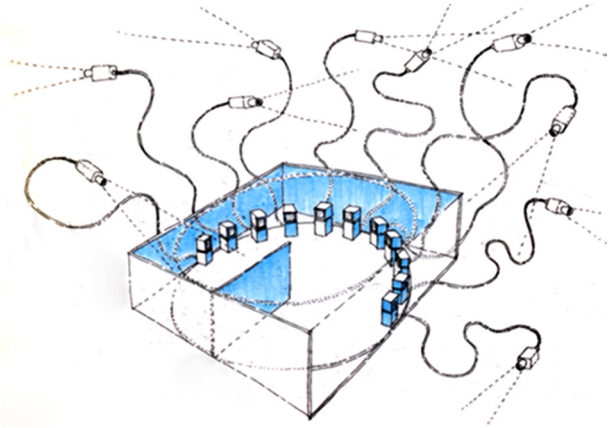


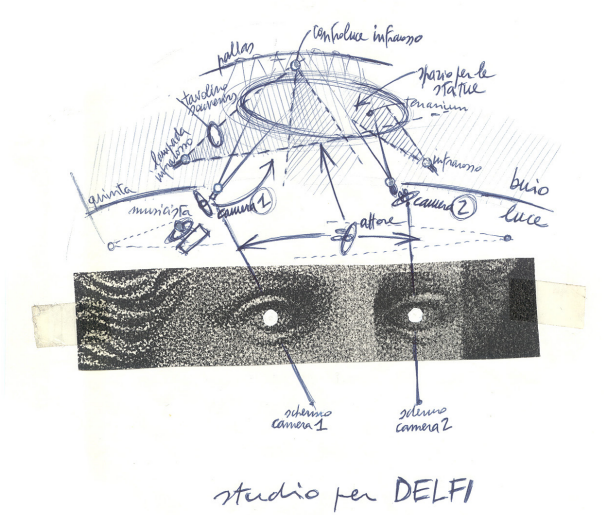
Fig. 4. Studio Azzurro, Vedute (quel tale non sta mai fermo)*, video environment, Palazzo Fortuny, Venice, 1985.*

relationships between the world of so-called reality and the world of electronic images. Often it is space and time that trigger a short circuit with images that appear inside the environment like subjects of an action set into a space and a time that the visitor is living inside, rather than outside, the world, as occurs in films. With *Il nuotatore (va troppo spesso ad Heidelberg)* (1984) the poetic gap becomes more evident, the environment is as plausible as it is impossible (fig. 2), its time is infinite and yet defined by the recognizability of human effort and of the unexpected. The aquatic light makes you hold your breath, and yet you can breathe, and if you move along the reconstructed swimming pool you see the swimmer also on the other side…
It is strange to think about these early works again, today, in the light of neuroscientific research, particularly Vittorio Gallese's most recent considerations on "embodied simulation" in relation to architectural space [Gallese 2017]. We now consider as being established concepts that were not then consolidated and that the Studio attempted to explore, disrupting the ways in which a work created using the language of video is planned. It is not a matter of objects, but of complex experiential systems set in a very plausible condition, which necessarily requires the active participation of the visitor.
Initially, this took place only in order to complete the exploration of space and its narrating subjects, but in the mid-1990s it became something much more disruptive, with the possibility of a significant and signifying, modifying action on the part of the visitor. As for planning, the design of the environments shifted from the amusing possibility of turning objects into narrative elements, to attention for the human gesture and for its potential relationship with the electronic image.
Before the opportunities opened up by technological interactivity, in the second half of the 1980s, research into this dimension became possible thanks to the constant collaboration with research theatre groups, and, in particular, with Giorgio Barberio Corsetti's '*Gaia Scienza*'. *Prologo a un diario segreto contraffatto* and *La Camera astratta* bring to the stage columns of stacked monitors presenting pre-recorded images and live images of the actors' bodies on a one-to-one scale… something otherwise impossible with the dimensional limits of a single monitor.
The medium of television–that unloads electromagnetic waves and moving images into family dining rooms and living rooms–is forced into a more complex design, and becomes the single element of a freer form, a piece of a mosaic in which the images regain a bit of the space reserved to visual works in the history of art.
Not only. In these two theatrical performances, the human figures presented in the columns of three superimposed monitors interact with the actors in flesh and bones, ac-

tively participating in the dramaturgy. It is precisely the drawing of the stage machinery (fig. 3) that makes the device evident: the arranged tracks and trolleys, transposition of the film cart, allow the actors to move the stacked monitors, or rather to move the images they contain. And a rocker arm, like a large seesaw, allows the monitors to move according to the weight exerted at a particular moment on the other side by the actor.
The text, which also stages a fragmentation similar to that of the body rendered electronically, is broken, alternating inner conversations with real dialogue, in a 'wild clarity' bordering on an explosion of speech. And the monitors tumble to the ground, making the cathode ray tube go wild, altering the behaviour of the electrons and with them the image that is generated. Behind the scenes, a complex set is prepared that trasmits live, in the monitors, actions moving back and forth from the scene for the audience to the hidden scene and vice versa. Thus, the invention of the 'double scene', which attempts to stretch the limits of what is visible for the audience.
Following this, between the collaborations with Barberio Corsetti and with Palazzo Fortuny (Venice), *Vedute, quel tale non sta mai fermo* (1985) permitted the investigation, in a visionary fashion, of the idea of the use of surveillance cameras and the narration of an imaginary story that (fig. 4) broke the hierarchy between live and recorded, reality and fiction, bringing the external space, the *calli* of Venice, and the imaginary space into the Palazzo. The most effective project drawing shows this operation as an organism combining architecture and technological innervations, with electronic, investigating eyes like hidden nerve endings, hidden, but focused on the world.

Returning to the invisible to find things again

Images pressed on the membrane of 'reality' from every side, they were everywhere, but imprisoned in the box of the monitor, in the frame of a photograph, in the borders of posters. And they were more and more realistic, more and more seductive in the lucid hedonistic magma of the late 1980s. Just like design objects.
It was at this very moment that Studio Azzurro began to capture a sort of 'lament of the images' and in 1990 created a theatrical performance with Moni Ovadia based on the prophetic text by Ghiannis Ritsos of 1961-1962, *Delphi*, about tourists who, in the archaeological site of Delphi,



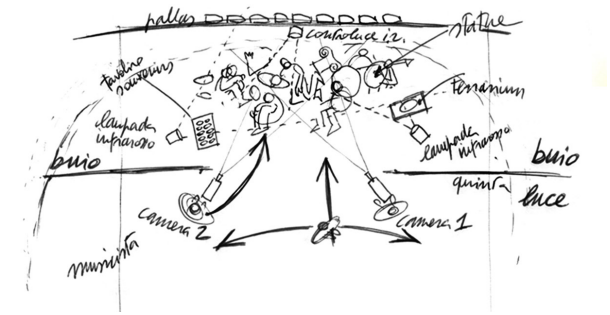


Fig. 5. Studio Azzurro, project drawings for the theatrical performance Delfi (studio per suono, voce, video e buio), *Festival Teatro 2, Parma, 1990. The statues' eyes become monitors and the study of the stage and of the positions of the hidden IR cameras.*

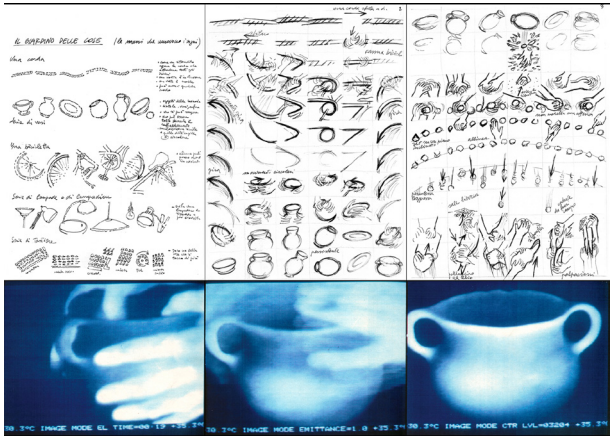


Fig. 6. Studio Azzurro, storyboard and detail of 3 monitors of Il Giardino delle cose*, video environment for infra-red images, Triennale, 13th International Exposition, Milan, 1992.*

Fig. 7. Studio Azzurro, Il viaggio*, video environment for X-ray images, Fondazione Mudima, Milan 1992.*

seat of the Oracle of Apollo, instead of observing, take pictures, taking photos on film. All they need to do is to point and click, without paying much attention, without the effort of making a drawing, which searches for and investigates forms. It recounts the generational passage between two tourist guides, and of a timeless time, where the statues alone are forced to continue observing, despite their millenary weariness. With respect to the text, at the time of the staging the tourists also captured images in movement, accumulating them in a growing distortion of the concept of memory. Something it would be necessary to deal with a few years later with the triumph of digital. In the project drawings for *Delfi (studio per suono, voce, video e buio)* there is a collage that centers expressively on the hollow eyes of the classical statues (fig. 5).

The stage is dark. From beginning to end. Two large monitors, huge eyes turned towards the spectators, and a few beams of light in which Moni Ovadia moves, seen and unseen. Two invisible operators film live, with infrared cameras, the plaster statues present on stage but hidden by the darkness. The shots appear, white and dazzling, in the two monitors. Only at the end, when the lights are turned on, do the spectators discover that they have had, right in front of their eyes, those same white objects, overloaded with history, without being able to see them. They had only seen their electronic images. Exactly what was happening to them, more and more, every day.

Experimentation with the non-human gaze continued in two other works that marked the definitive passage to a new chapter in research. In both works the image loses its photorealistic fidelity and approaches the simplification of a mark, in one case, and the essentiality of drawing in the other. These results were obtained by using cameras that 'see' frequencies invisible to the human eye, as in the case of *Delphi*. In one of these two works, *Il Giardino delle Cose* (1992) (fig. 6), the storyboard is significant to the point of becoming a device for the visual representation of the space-time narration that was to take place in the eighteen synchronized monitors. It is a fundamental projectual device for planning the shootings and for realizing the video editing. The shots, realized with thermal cameras, detect the heat of hands as they touch a series of simple everyday objects. The gesture that traces the shape of the object, redefines its form through heat. It redesigns it, finds it again, as though appearing to the eye for the first time, out of the darkness. In reaction to the impending consumerism and overexposure of the images, the care for the simplest and most useful objects restores form and life to them.

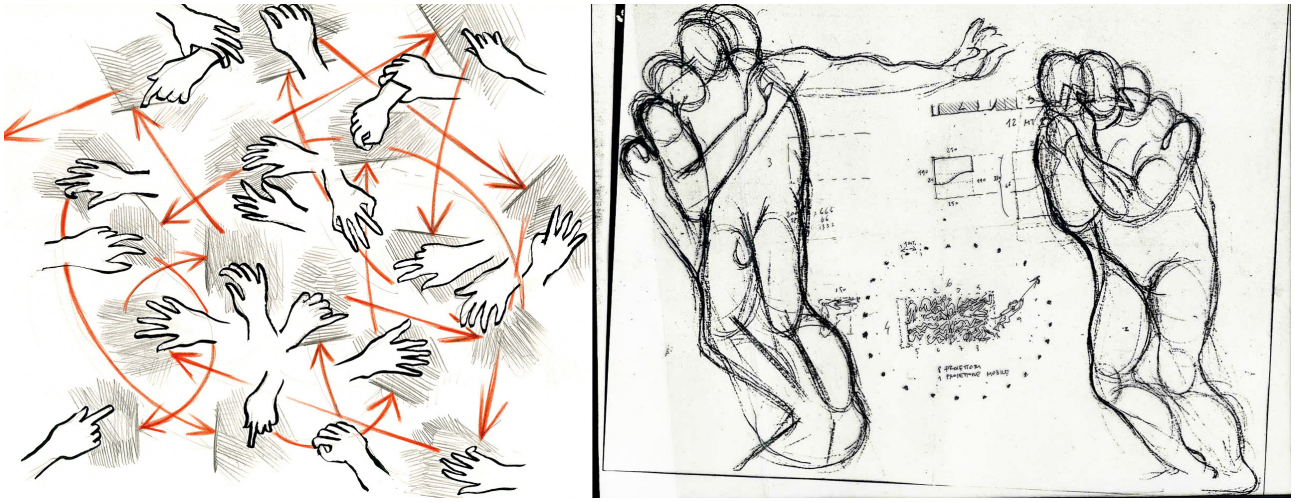


Fig. 8. Studio Azzurro, project drawing for Tavoli (perché queste mani mi toccano?) *and* Coro, *the first two sensitive environments realized in 1995, respectively in Milan at the Triennale and in Turin at the Mole Antonelliana in 1995.*

It is no coincidence that, in its edition most integrated with the environment, in Castellina in Chianti, *Il giardino delle cose* dialogued with a large mass of abandoned fragments of terracotta. The other work, *Il viaggio* (1992) (fig. 7), is the last video environment created by the Studio, a sort of affectionate farewell to the age of images in monitors. There are eight synchronized monitors in which X-ray images of suitcases, taken and then colored, flow across the screens. And one projection. The objects are perfectly recognizable but seem to come from a cargo of shared memory. They are almost like drawings deposited in those black boxes that accompanied us on our journey together in the first ten years of exploration with videos.

Images can be read

With the 1990s, the need to define a new path was felt. The idea of an environment designed for people in dialogue with moving images evolved precisely because those images could finally free themselves from the monitors, from their objective dimension, and their being in motion could involve space and whatever is present in it. Projections were introduced, and moving images could be deposited on any surface and at any height: even on glass, on a parachute, on sand, on salt, on the ground, on a ceiling, floating.
In 1995, this paradigm shift was joined by an even more disruptive one. The possibility for images to respond to the gestures and presence of people. It was a new world to invent. A world that would radically change the relationship not only with images but also with technology.
Three years of intense exploration followed. Video editing could be set anywhere in space and needed to be entirely rethought to make the viewer's involvement effective, but without losing the narrative potential, because the goal was still to tell stories, like in literature, like in cinema. But with the possibility of further amplifying the physical involvement of the spectator, of imagining synesthesias and sensory short-circuits allowing people to abandon their disbelief and follow the narrative, adding their own part of desire and creativity [1].
In this way, the need for fragmentation together with the organic nature of the project reappeared. This opened the fundamental theme–distinctive for Studio Azzurro–of collective interaction, because a new relationship with technology was already taking root, and it was a one-to-one relationship, pre-established in its canons by those who produced it.

The first interactive installations were a manifesto in defense of the choral nature of the interaction and of the possibility that an environment, if it is sensitive to a visitor's presence and gesture, can become an environment enhancing relationships between people and not just between people and machines [2].
Ultimately, it is a way to contrast 'behaviorial design', to divert it using the same instuments that carry that risk, manipulating them to allow man to not lose his natural sensitivity, to not lose the relationship with things, shapes and materials, with the correspondence between image, body and meaning.
Paradoxically, it is to make things and spaces become 'sensitive' so as not to expose technological man to the risk of forgetting that he is human, and therefore, sensitive.
Tavoli, perché queste mani mi toccano (1995), *Coro* (1995), *Totale della battaglia* (1996), *Il soffio sull'angelo (primo naufragio del pensiero)* (1997) were the first 'sensitive environments' [3], that is, created with projections that respond to the gestures of those who perform them: the touch of a hand on an ordinary wooden table, the trampling on the image of a body lying on the ground, asleep on a carpet (fig. 8), a breath on a feather, a call sent out to communicate with others in an ancient bastion… The natural interfaces [4] are the response to the new paradigm of the body in dialogue with machines and to the colonization of perception. The hand will always encounter a natural material, not an electronic appendix or a button, feet will step on carpets or sand, eyes will remain free to choose what to look at, the body will be able to move as it pleases within an enveloping environment, designed by light.
Light is another element in the design of an environment, which wrongly often goes unnoticed. From the first installation (*Luci d'inganni*, 1982), which staged design objects animated by haiku videos set in monitors, light, an element inherited from photographic sets, had an essential role in designing an environment where people feel like they are in a sort of dream. In this work the light hits mirrors and draws geometric spaces that re-trace the directions of a room immersed in a soft semi-darkness.
With projections, whose luminous intensity is less powerful than that of monitors, the environments become even more enveloping, the eye willingly gets used to the dim light and is guided by the presence of lights that underline a physical presence or a path. Thus the warm temperature of the light, in contrast with the bluer light of the projections, establishes a dialogue of great intensity with those who move in that space.

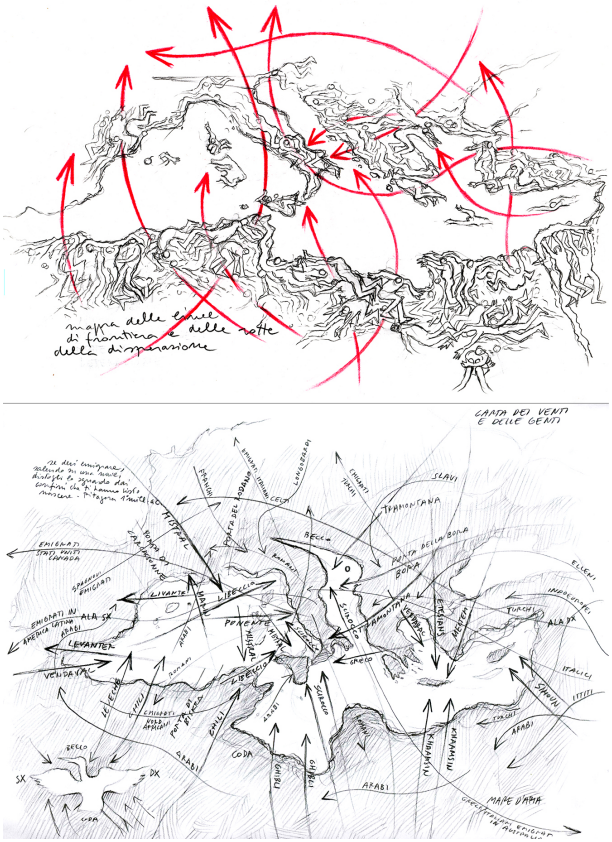


Fig. 9. Studio Azzurro, Meditazioni Mediterraneo, In viaggio attraverso cinque paesaggi instabili, *sensitive environment, Castel Sant'Elmo, Naples, 2002.*

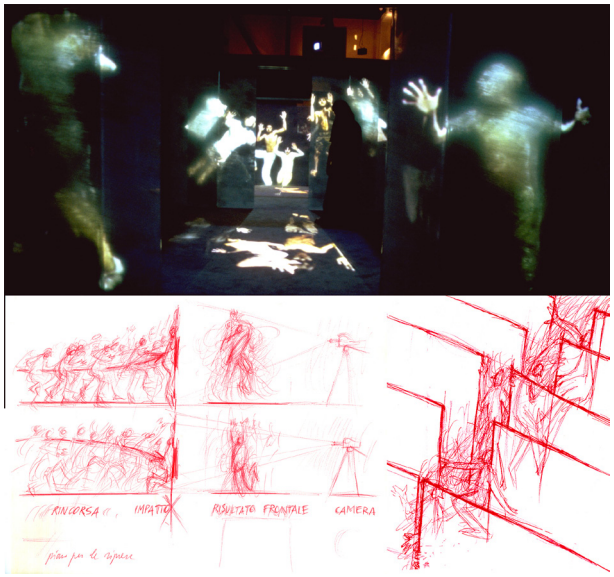


Fig. 10. Studio Azzurro, Dove va tutta 'sta gente, *sensitive environment, Vision Ruhr, Dortmund, 2000.*

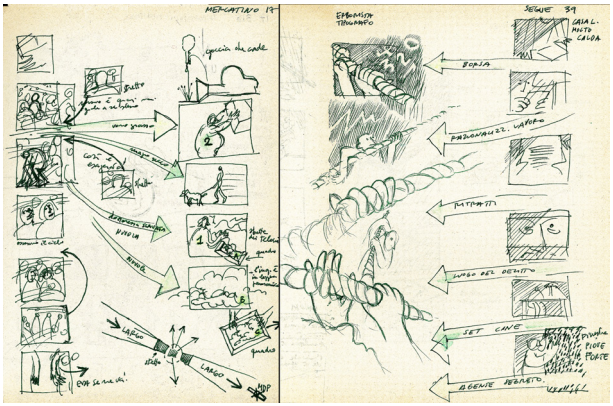


Fig. 11. Studio Azzurro, Il Mnemonista, *film, 35mm, color, 2000.*

The Mediterranean and memory

The 2000s marked a new step in Studio Azzurro's research and a return to cinema. With some unexpected commissions came the opportunity to deal with the outside world, not only to encounter and gather images for our stories, but also to collect stories for new images and for an evolution of the idea of the work. Precisely in the year 2000 an important proposal arrived and a parallel, autonomous work began, both about the Mediterranean Sea, with two approaches so apparently contrasting as to be complementary. On the one hand, *Meditazioni Mediterraneo* (2002), the work realized after having completed an almost complete circumnavigation of our sea to collect scenarios and craft traditions, touching on Italy, France, Greece, Libya and Morocco. Five installations dedicated to five unstable landscapes, threatened by strong anxieties whose outcome would be seen a few years later; five sumptuous landscapes full of natural and human history, five different interactive systems, designed for that specific content. A path that allowed everything that brings together, that unites the countries bordering the Mediterranean, to emerge clearly. On the other hand, *Dove va tutta 'sta gente* (2000), a single large installation that exhibited, in the heart of Europe, in Dortmund, the emerging phenomenon of the first migrations from Albania. A metaphorical work, anything but documentary, realized in our studio, staged without a background, like a universal phenomenon belonging to the whole human race, and that tells, in a different way, what was beginning to be seen in the news. Transparent, interactive sliding doors against which half-naked, defenceless bodies threw themselves, trying to cross this invisible border. When the doors open for the passage of a visitor, the bodies fall to the ground, unable to cross that threshold.
In the year 2000, a film was also realized, entitled *Il Mnemonista*, which drew inspiration from Alexander Luria's book on the clinical case of 'S.' (Solomon Shereshevsky), to narrate the theme of memory, which began to provoke reflection with the enormous accumulation of data of the digital era.
In all these works the component investigated and defined by drawing proved very important and is visually very significant because it reveals the function of drawing with respect to the design process. In the case of *Meditazioni Mediterraneo* it gives shape to the conceptual dimension: two visionary maps (fig. 9) transform the Mediterranean into a large bird carried by the winds, and into an uncertain coastline defined only by clusters of human bodies clinging on desperately; the cartouches with the poetic syntagma for each country, the representations linked to the material

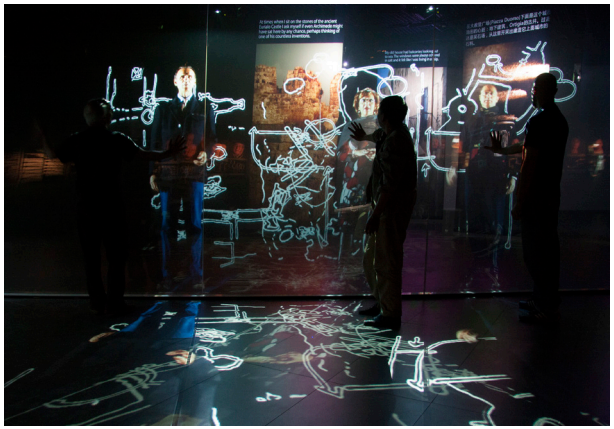


Fig. 12. Studio Azzurro, Sensitive City, *Italian Pavillion at the Universal Exposition in Shanghai, 2010.*

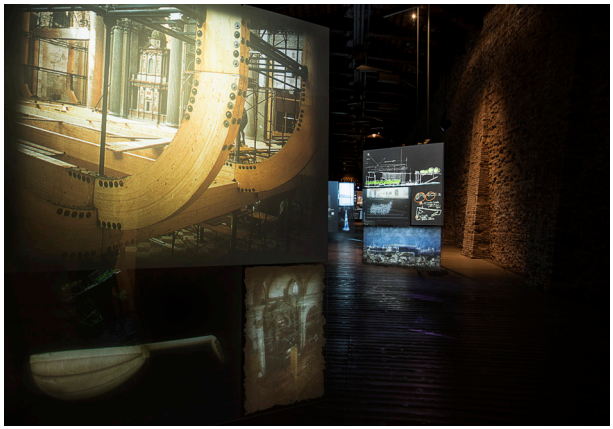


Fig. 13. Studio Azzurro, Renzo Piano. Progetti d'acqua, *video environment and sound, Magazzino del Sale, Fondazione Emilio e Annabianca Vedova, Venice, 2018.*

selected for each chosen place, such as salt for Greece, fire for the Phlegraean Fields, wind for Libya, weaving for Morocco, perfumes for Provence… (fig. 9).
In the case of *Dove va tutta 'sta gente*, instead, the drawing (fig. 10)–with its very tormented strokes–clearly shows the scenes imagined for the installation (fig. 10). It is no coincidence that the drawings are done with red ink, compressed into almost claustrophobic spaces, with swirling lines forming the volumes. Looking at them, you already see the installation, from points of view that are impossible for the human eye and very important for the project.
In the case of *Il Mnemonista*, the film, Paolo Rosa kept a workbook in which it is possible to see the development of the thought that generated the film, the writing of a storyboard (fig. 11) done with a very personal technique that expands in the pages, taking on free forms, and finally, it is also possible to find iconographic references, and even stylistic ones that intentionally recall the great Russians contemporary with Luria.

Fuori di sé

The experience of the encounter triggered by works related to the territory was consolidated in the 2000s and found an ideal dimension in a series of works that we have called *Portatori di Storie* ('Story-carriers'). They are complex sensitive environments, in which people appear projected at a slightly larger-than-life size, walking or facing the space while waiting for attention. If they don't receive any, they leave. If, on the other hand, visitors touch the figures and hold them in place with their gestures, they notice, pause, turn and begin to tell their stories. The gesture is very simple, like stopping a person to greet them by placing your hand on their arm or shoulder. They tell the story of places dear to them, reconstruct itineraries, remap a territory according to their own personal experiences, according to the memory of oral stories. *Sensitive City* was the most impressive project realized with this format, a large installation for the Shanghai Expo, dedicated to the livable Italian cities, small realities that preserve a shared history and strong traditions despite tourism and technological advancement. In this work the people encountered were asked to tell a story and then draw it by hand. All these traces reappear in the stratification of the projections, together with the scenarios, to redefine an imaginary world shared with anyone who accesses the installation (fig. 12).
The development we are working on for this format would offer the possibility for visitors to leave new testimonies, new traces that will remain together with those we have gathered. We realized an anticipation of this possibility in *Patine e accumuli* (2015) an environment totally without images until

someone visited it leaving their trace. It is one of the next objectives involving a further regression of the role of the director, who would definitively limit himself to creating the conditions for something to happen, that is freely generated by people around a theme, an object, a subject presented. After all, what we are trying to find and recreate in an environment is that ritual dimension shared through the artistic expression that man has been looking for and pursuing since he first conceived symbolic thought. A thought that was developed, first of all, through drawing.
That's why it was easy to work with this analogy in a recent project, which had drawing as its subject. In 2018 we were asked to tell the story of sixteen of Renzo Piano's projects and to present them in the wonderful spaces of the Magazzino del Sale of the Fondazione Vedova, in Venice. The result was a staging (fig. 13) for this evocative place, which resembles the bridge of a ship, a theater, the belly of a whale… a sequence of eight screens with different degrees of transparency, which held mainly line images, digitizations of original, partially animated drawings and 3D models, and which 'swam' in a mobile sound environment. A case in which interaction was triggered by the environment itself without any need for forms of technological interactivity. A demonstration of how a powerful space can suggest solutions that free us from technological superstructures by immersing us in an environment so saturated with narration that it asks only to be explored.

Notes

[1] Samuel Coleridge masterfully expressed this concept in relation to literature in 1817, calling it "that willing suspension of disbelief" [Coleridge 1817].

[2] Paolo Rosa, in his notes, later merged into *L'arte fuori di sé, un manifesto per l'età post tecnologica*, stated "We have come to say that the work that is being constructed is no longer the thing that is presented, but the one which is constituted in the moment it creates a profound and effective relationship with an interlocutor. That is when the work is constructed. The work is not what I propose. It is what results from this moment of interaction" [Balzola, Rosa 2011].

[3] 'Sensitive environment' is the definition used by Studio Azzurro to indicate environments in which technological interactivity is present, but in which its presence is not immediately perceptible rationally. It is the images, surfaces and objects that react, not sensors.

[4] 'Natural interfaces' is the expression used by Studio Azzurro to indicate forms of technological interaction that do not pass through graphic interfaces, but through the development of sensors that make it possible to completely hide the presence of devices that make everyday surfaces such as wood, metal, sand, fabric etc., 'sensitive', that is, interactive.

Credits

Photographs Studio Azzurro; Drawings Paolo Rosa (Studio Azzurro)

Author

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Dissemination Models for Communication of Cultural Heritage: '*di sotto in su*' Perspective Domes in Andrea Pozzo's Work

Leonardo Baglioni, Marta Salvatore

Abstract

This research deals with the communication and enhancement of cultural heritage through the construction of physical models that reproduce abstract theoretical processes making them accessible through visual interactive experience. This type of experimentation concerns perspective, in particular, the perspectives of fake hemispherical domes defined 'di sotto in su' *(from below) painted by Andrea Pozzo between the Seventeenth and Eighteenth centuries. The present essay explores the relationship between the true form of the dome and its perspective, with particular reference to the case of St. Ignatius, through the development of a theory that leads the different perspective images of the dome to a single ideal design model. This hypothesis has been analytically verified by measuring the invariance of the cross-ratio between the principal elements of the architectural order that articulate the tambour of the dome. This experimentation has been reproduced in an installation that relates the physical model of the true form of the dome with its perspective images and with the observer. The installation, which shows and demonstrates perspective through the perspective itself, has two distinct aims: the experimental validation of the formulated hypotheses and their subsequent sharing.*

Keywords: Andrea Pozzo, Perspective, Illusory Architectures, Fake Domes, Prototyping.

Introduction

Today, the communication of heritage is a central issue when it comes to the valorization of cultural assets. The concept of value loses its economic meaning to assume that of knowledge and its dissemination that, together, contribute to the enhancement of the asset. The flow of knowledge moves through two different levels of sharing: one relating to the dissemination of content within a scientific community in order to increase knowledge, the other relating to the sharing of content with the community, for explanatory purposes.
The term 'cultural asset' is generally understood to mean all the material and immaterial testimonies that have acquired a certain historical value over time. According to this broad meaning, cultural heritage can also include treatises and historical texts, witnesses of knowledge through the written communication of abstract principles and theories. The approach to an ancient text is generally reserved to the members of certain scientific communities, who are provided with the necessary tools to fully understand its meaning. This research aims to explain some of these theories, particularly those related to the projective principles underlying perspective representation, and to make them accessible through the tools of digital representation. The field of representation appears to be privileged in this sense, because it conveys theoretical content in visual form, through the construction of graphical, digital or physical models.
The interest in perspective is justified by the topicality of this method. Today, as in the past, the perspective transversally permeates a realistic representation of reality. This occurs

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Fig. 1. Three models of the dome of the Collegio Romano; from the left the painted canvas, the sketch and the treatise (graphic elaboration by the authors).

in its analogical, graphical or physical form, but also in its contemporary digital forms, ranging from the construction of a virtual image or a rendered sequence, to photography, immersive photography or to the most recent applications of virtual and augmented reality. But not only that. The projective theories at the basis of perspective generalize the totality of methods of representation. All the methods of representation can be ascribed to perspective, taken in its most general form, namely relief perspective, as the studies conducted by Fiedler [Fiedler 1874] around the middle of the Nineteenth century show and we believe that this generalization is still valid today.
In this experimentation, the explanation of the projective principles underlying the functioning of the perspective machine concerns the fake hemispherical domes in perspective '*di sotto in su*', painted by Andrea Pozzo between the Seventeenth and Eighteenth centuries, with particular reference to the Collegio Romano's dome.
The research was articulated in two main phases: a first phase of analysis of the graphical models of the domes in relation to the true form of the design model, which led to the development of a perspective theory at the basis of their realization; a second phase devoted to the dissemination of the results. During the first phase, the use of virtual models allowed the experimental verification and validation of the formulated hypotheses; instead, in the second phase, the same models were the subject of an installation with which to convey the results achieved through direct interaction with the perspective machine.

A design model for fake hemispherical domes

The idea of model has always permeated the activity of the designer for whom it is the instrument of control, analysis and communication of an ideal form. The model is therefore the representation of an idea, describing its specific part or aspect. Only as a whole and in their integration, the different models contribute to the definition of an ideal model, able to convey the overall idea of the form [Migliari 2004].
The theme of Andrea Pozzo's fake domes, which developed towards the end of his artistic activity and sanctioned his international success, highlights the transversal character of different forms of graphical and pictorial representation used by the artist in different phases of the design process. From the relationships that can be established between the different models it is possible, on the one hand, to explain Pozzo's *modus operandi* and, on the other hand, to demonstrate (by means of analytical tests) the convergence of representations towards the idea of a single architectural form.
In the case of the fake dome of the St. Ignatius Church in Rome, inaugurated in 1685 as a real prototype of the vast production of domes realized 'from below' in succeeding years, three models have come down to us, each of them for a

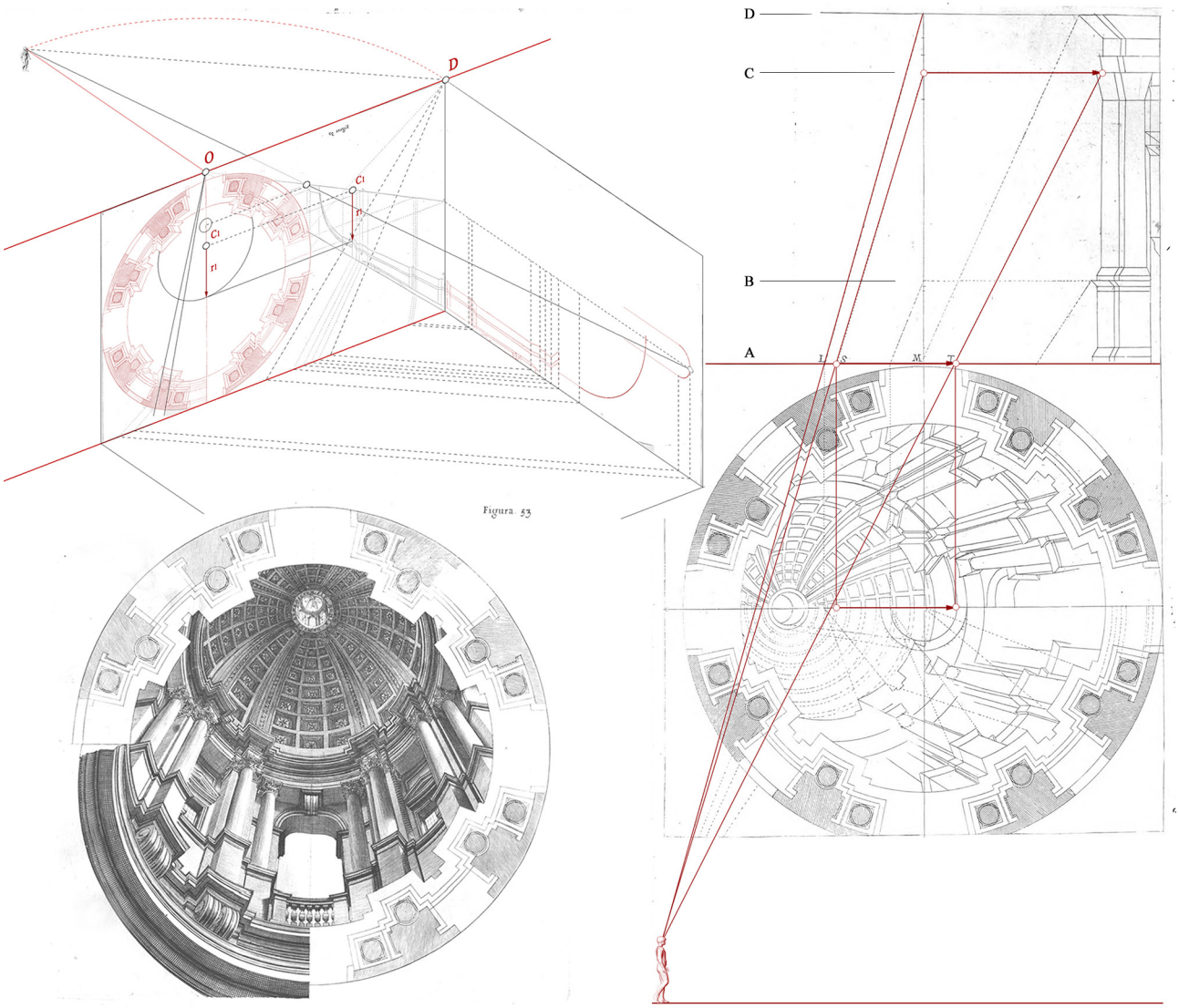
specific use: a sketch, which is preserved at the gallery of the Corsini Museum in Palazzo Barberini in Rome, the engravings of the graphic model of the dome that enrich the pages of the two volumes of the treatise on perspective and, finally, the painted canvas still visible today in the church of St. Ignatius [1]. The sketch is the first of the graphical models created by Pozzo. It is a square canvas measuring about 100 cm on each side and painted in oil that prefigures, presumably for the client, the perspective image of what will be the fake dome. The canvas, a faithful scale reproduction, which reduces the real size by about sixteen times, preserves, compared to the canvas in the church, the same perspective and a similar light and shade treatment. This is characterized by very dark tones, as if to simulate, or maybe amplify, the poorly illuminating effect of candles on the illusory intrados. The comparative analysis carried out on high-resolution photogrammetric surveys of the canvas and the sketch, reduced to the same size for means of comparison, shows the perspective coherence between these two models [2] (fig. 1) On the other hand, the main differences concern some morphological elements relating to the ornamental apparatus and the ceiling coffers in the dome. The sketch was followed by the realization of the canvas. The fake dome of St. Ignatius was an extraordinary success, which made this model a reference for several reproductions to follow, such as the church of Jesus in Frascati, the Abbey in Arezzo and the church of Jesus in Vienna, the only one to be painted on a surface with a double curvature, all made in the early Eighteenth century (fig. 2).

The importance of the St. Ignatius dome project led Pozzo to include its construction in both volumes of his treatise on perspective, to compare the effectiveness of the two perspective procedures that are therein respectively described [Pozzo 1693; Pozzo 1700]. In both volumes, the construction of the perspective passes through the representation in plan and elevation [3] (fig. 3). This *modus operandi*, common to all the case studies described in the treatise and therefore transversal, highlights the markedly design character of Pozzo's work, in which the perspective representation of the form derives from a precise architectural project which, as Pozzo himself observes, inevitably precedes it [Mancini, Fasolo 2018]. "whence you may perceive, that for designing things of this kind, the Painter ought to have no less skill in architecture, than is required for the execution of solid works" [Pozzo 1707, The Sixty-eight Figure].

The model published in the treatise is the most recent one. Although it explicitly reproduces the Collegio Romano's dome with the declared aim of preserving its future me-

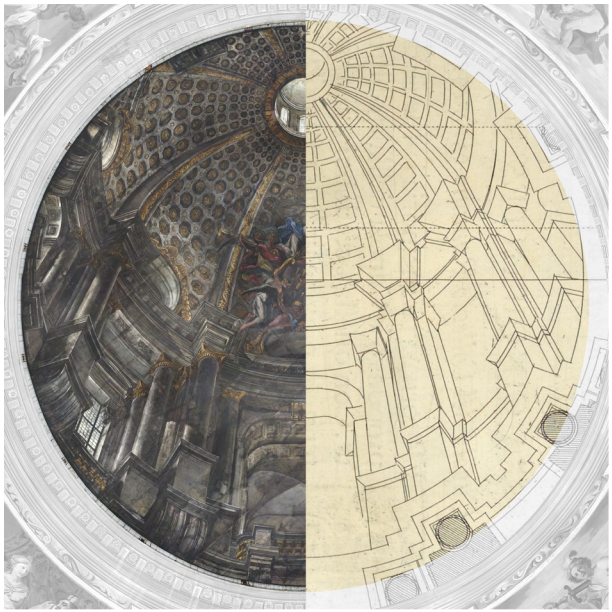
Fig. 2. Fake domes of the Abbey of SS. Flora and Lucilla in Arezzo (on the top) and of the Church of Jesus in Vienna (photographs by authors).

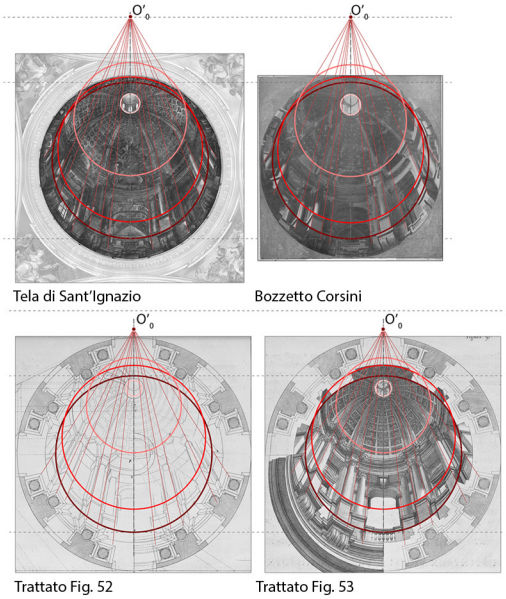
Fig. 3. Construction of the perspective of the dome with the rules of the treatise (graphic elaboration by the authors).



mory, it presents some differences with respect to the canvas and the Corsini sketch.
"The cupola in this plate will in all likelihood be of longer duration, than that which I painted on a very large table, for the flat ceiling of the church of S. Ignatius of the Roman College, anno 1685. For if that suffers by any accident, with the help of this its place may be supply'd by a better" [Pozzo 1707, The Ninety-first figure]
These differences especially refer to the position of the principal point and the depth of the tambour. In all the drawings the principal point is aligned according to the direction that the axis of the dome would have had if it had been represented in perspective. Therefore, in the treatise engravings, it is closer to the center of the impost circumference. Instead, the depth of the tambour is greater in the treatise engravings compared to the canvas and the sketch Corsini (fig. 4).
Considering the rigorous morphological coherence between the parts of the architectural order that structure the dome in all three graphic models, we wondered about the possible true form of the illusory space represented, researching a formal coherence between the theoretical model of design and the graphic models in question [4]. If perspective expands and contracts the same represented space, we ask ourselves what are the relationships that exist between the different models of perspective domes, and if it is possible to hypothesize the existence of a single architectural model to which all these perspective images allude. To this end, the true shape of the dome has been reconstructed, choosing the Corsini sketch from all the perspectives received, because it is authentic and because, as already mentioned, it is a prototype of the models to follow. Other reasons for choosing the sketch instead of the canvas are due to the various manipulations over time through much restoration [Pascoli 1736, pp. 245-276; Baldinucci 1975, pp. 315-326; Carta 1996].
The geometric restitution of a perspective requires the reverse reconstruction of the process that generated the perspective image and the spatial definition of the forms represented in it. It is an indeterminate problem that can find different solutions because of the hypotheses formulated on the basis of interpretations of an architectural nature.
In the general case of architectural perspectives, it is not always possible to return a plausible form to the represen-

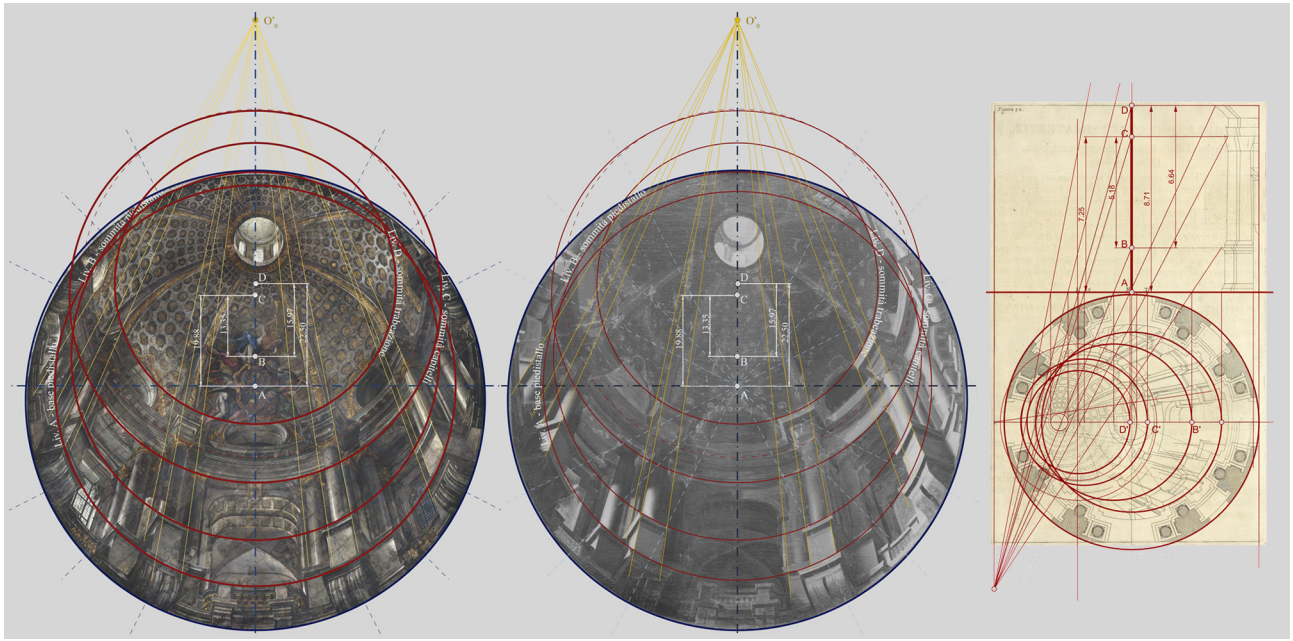
Fig. 4. Perspective analysis of the three models of the dome. At left the comparison between canvas and treatise (graphic elaboration by the authors).





ted space because often the pictorial work is conceived in a perspective and non-architectural key. Thus, the perspective restitution of the painted spaces often alters the proportions of the objects represented with results that are inconsistent with the physical reality expected [Baglioni, Fasolo, Migliari 2016]. In our opinion, however, the case of Pozzo goes beyond these considerations. The markedly projectural nature that strongly permeates the pages of the treatise legitimizes the venturing within the reconstructive hypotheses of true form, in search of the original design idea.
In a perspective from below, the picture plane is horizontal and perspective restitution becomes a complex problem because the elements that are normally used as a reference for the reconstruction of the distance points, such as the square bases of the columns, are missing. In the cases in question, the problem is amplified by the impossibility of reading the impost circumference of the vault, occluded, in all the perspective models, by the protruding frame of the projecting shelves.
In order to reconstruct the true shape of the dome, it is assumed that it would conform to the drawings of the elevation published in the treatise engravings. On these drawings, the proportions of the elements of the architectural order of the dome tambour, relating to the base, the column and the entablature, have been verified, with the intention of proving their invariance in the different perspective models. The verification can be executed because, in a perspective with a horizontal picture plane, it is possible to reconstruct the centers of the circles that remain in true form, on the perspective of the revolution axis at different heights corresponding to the elements of the architectural order.
There is a particular type of ratio between the lengths of three aligned segments that remain constant after one or more projective operations: the cross-ratio. The perspective of three aligned and contiguous segments, AB, BC and CD, alters the objective lengths and the relationships derived from the comparison of one segment with another. The cross-ratio, which is measured by the ratio between the simple ratios (AC/BC)/(AD/BD), is a projective invariance, therefore it remains constant regardless of the type and number of projective transformations that are applied. The invariance values of the cross-ratio, which measures about

Fig. 5. Calculation of the cross-ratio in perspectives of the canvas, the sketch and the treatise (graphic elaboration by the authors).



1,064 in the case of the Corsini sketch, 1,066 in the case of the treatise and finally 1,072 in the case of the canvas [5], have shown the same proportioning of the elements of the architectural order (fig. 5). The hypothesis according to which the architectural perspectives of the dome are the images of the same architectural model seen from different projection centers is therefore legitimate. Then, the difference is in the perspective view, namely in the position of the center of projection, determined by the principal point and the principal distance.
The analysis of the invariance of the cross-ratio was also applied to the case of the fake dome of the canvas in Arezzo, resulting in support of the expressed hypothesis. Based on projective invariance, the proposed method has general validity and can also be applied to cases of false domes on a polygonal plant or painted on surfaces with a double curvature, such as the dome of Jesus of Vienna [6].
The analytical verification of the invariance of the cross-ratio has therefore shown the existence of an ideal model of reference, proportionate according to the architectural order, consistent with the representations in true form of the treatise dome, to which the three models can be connected. With the intention of verifying this theory from a projective point of view, a virtual restitution of the perspective relationships that exist between the ideal model of the dome, its perspective representations and the position of the ob-

Fig. 6. Restitution of the ideal model of dome (graphic elaboration by the authors).

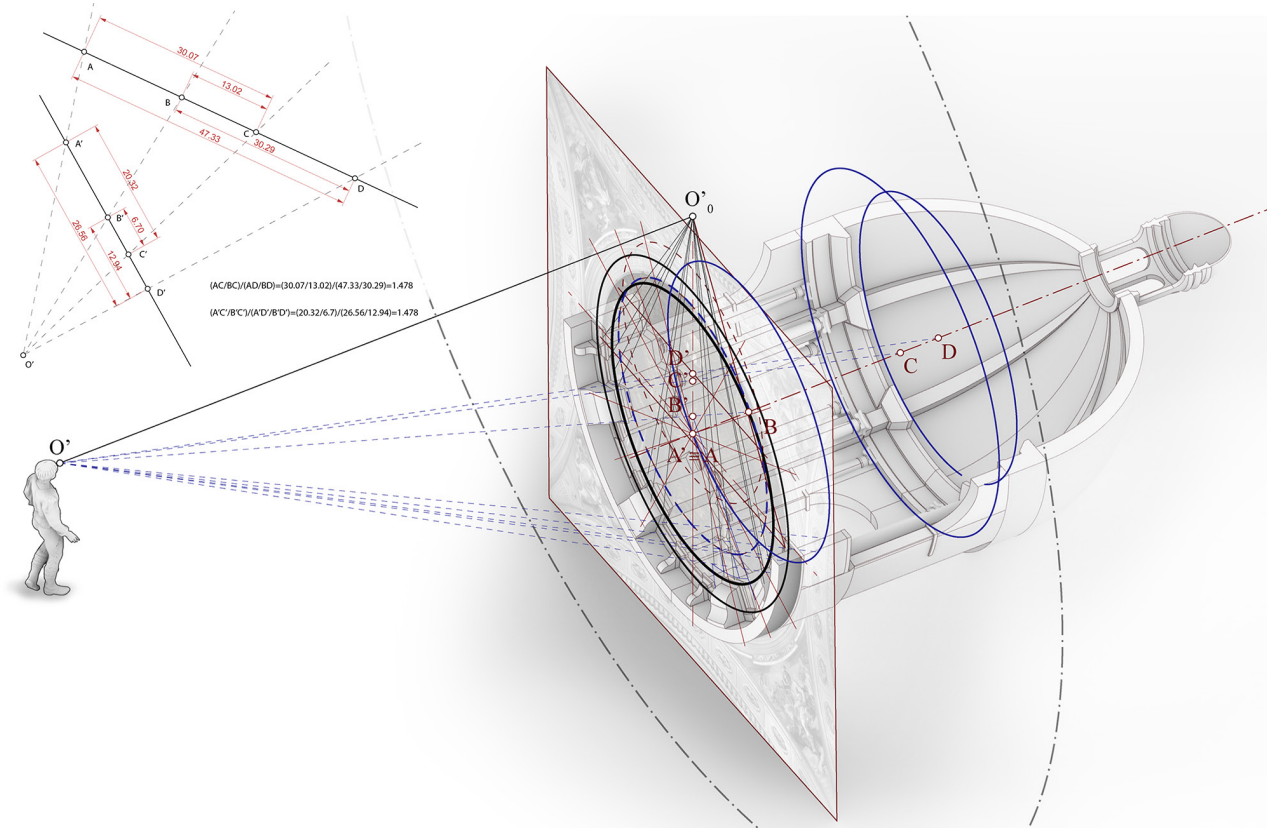
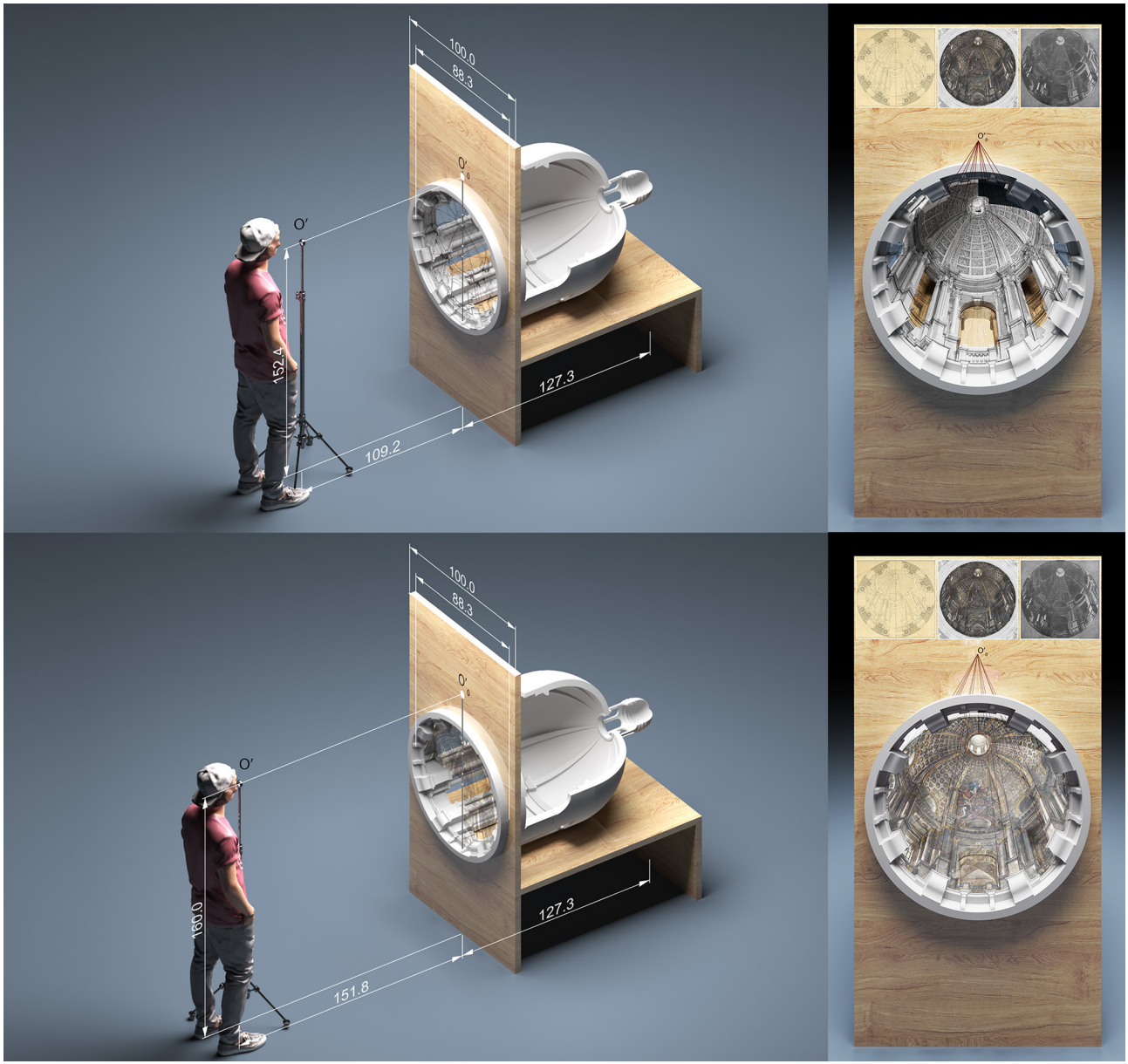


Fig. 7. Project for installation of the perspective machine (graphic elaboration by the authors).

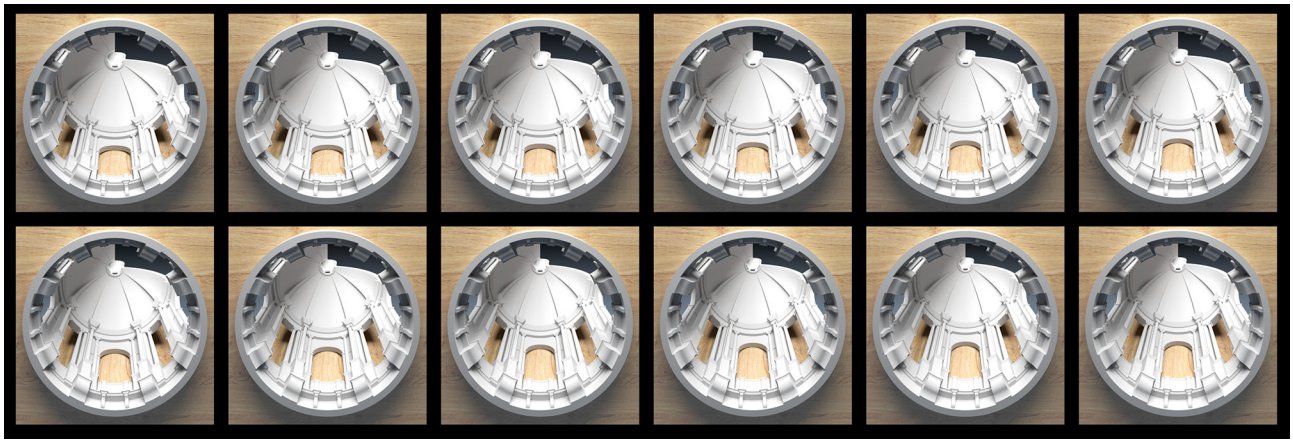


server has been carried out. The effectiveness of this simulation has led to the creation of an installation through which to experimentally validate this theory (fig. 6).

Exploration of the perspective machine

The model of the real form of the fake dome was the subject of a perspective installation conceived with two linked, but distinct, purposes. The first, devoted to validating and experimentally verifying the theory elaborated, was finalized to sharing the results within the scientific community; the second was aimed at communicating this theory to a wider and more inexperienced public, through an installation capable of describing the perspective through a physical model with which to interact in order to fully participate in the functioning of the perspective machine.
The installation reproduces the existing projective relationship between the theoretical design model of the ideal dome and the graphic models that constitute its different perspective images. Designed in large dimensions but, at the moment, realized with low-cost techniques of rapid prototyping, this installation reproduces the ideal model of dome design arranged horizontally so that it can be observed without necessarily having to look up. At the level of the dome impost plane, the perspectives of the graphical models of the painted domes, imprinted on interchangeable transparent discs, are arranged. Each of these images corresponds to a specific point of view. Observation from the relative projection center of the different graphical models, shows the persistence of the illusion. In fact, it is possible to verify every time the coherence of the graphical model with the perspective image that is naturally produced by observing, from the same projection center, the physical design model of the dome (fig. 7).
Understanding its more general meaning, which explores the functioning of the perspective machine, the installation expresses the relationship between the real space represented by the physical model, and the particular case of the linear perspective that corresponds to it. To understand the projective relations that exist between real space and its perspective, it is useful to observe the perspective machine from two different points of view: that of the observer, who is inside the perspective and who fully appreciates the illusion of perspective; that of an external spectator who understands the reasons for the illusion. This double mode of observation allows us to experiment the parameters that define the foreshortening in perspective and that depend, as illustrated, on the principal distance and the position of the projection center. An external observation reveals these variations, which can be appreciated by the physical movements of the observer, while an internal observation allows us to explore the perspective effects of contraction and dilation which are characteristic of the projective space. Moving away from the painting, in fact, the perspective space reduces its depth, the angle of field decreases, as if

Fig. 8. Perspective effects of contraction and dilation of the projective space (graphic elaboration by the authors).



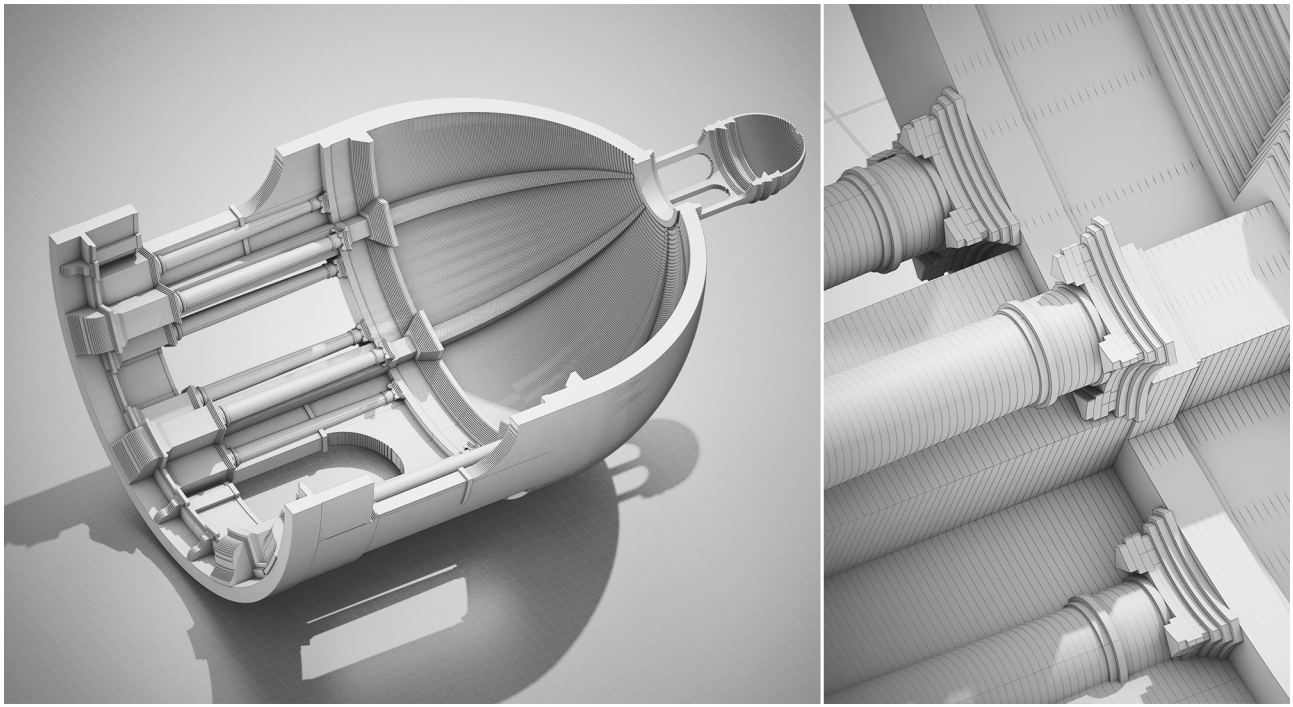


Fig. 9. Project for the prototyping model of the dome on a large scale with laser cutting techniques (graphic elaboration by the authors).

using a telephoto lens, making the perspective appear more flattened. One must imagine moving away until reaching an infinite distance from the picture plane, arriving at a limit condition in which the space projection becomes parallel. Impossible to reproduce in physical reality, this simulation is easily reflected in the dynamic virtual reproductions of the perspective machine (fig. 8).
In perspective, the larger the size of the installation, the more effective the interaction. For this reason, the project foresees its realization in dimensions that include the observer, thus amplifying the illusory power of perspective. To this purpose, the prototyping of the wooden model is currently in the design phase with laser cutting techniques that allow the construction of large models for the assembly of successive layers [7] (fig. 9). To measure the effects of the painted canvas in an optimal way, the model should be housed in the rooms of the church of St. Ignatius, in order to better appreciate, by comparison with the real painting, the effects produced by the variation of the foreshortening.
The prototype, made in small size, was tested in academic contexts, to support the verification of the proposed theory and was recently exhibited at the Maker Faire 2018 held in Rome (fig. 10), where it aroused special interest, stimulating a surprising curiosity and the active participation of a particularly young and heterogeneous audience.

Conclusions

The research aimed to propose a method of analysis and study of the domes '*di sotto in su*' based on the projective invariance of the cross-ratio to demonstrate the existence of a single design model with different architectural perspective images. The generality of the method allows its applica-

Fig. 10. Images from the recent Maker Faire 2018 in Rome (photographs by authors).

tion to other types of domes, currently under study, such as those on a polygonal plant or painted on surfaces with a double curvature.
The existence of an ideal model at the base of the domes viewed from below, reinforces the dual design character of Pozzo's theoretical and practical work. He imagines and describes the architectural models of the three-dimensional space through design drawings in plan and elevation, but at the same time designs in a scenic key, illusory architectures through perspective representations.
Characteristic of Pozzo's design activity, the idea of a model permeates the research in all its phases, from analysis to critical elaboration up to communication of the contents. This idea animates the definition of the geometries of the dome, in search of its ideal model starting from a critical reading of the relative graphic models. It characterizes the restitution phase by reproducing projective principles at the basis of the functioning of the perspective machine in a static and dynamic way. Finally, through the proposed installation, this idea expresses, in physical form, the relations that exist between the ideal model of the dome, its graphical model and the observer.
Today, digital representation allows us to operate with heterogeneous models, to relate them to each other, and to reproduce them continuously in their physical form. These different declinations of the ideal model show how this has been, and continues to be, a privileged tool for the transmission of knowledge, able to address even a heterogeneous public translating difficult to access projective theories into a simple and explicit language.
This is the main purpose of the proposed installation, aiming to demonstrate perspective through the language of perspective itself, proposing a fruition by an external spectator, who looks at the described procedures from the outside or by an internal observer, who is, instead, an integral part of the projective process.

Notes

[1] There is evidence of a second sketch, at present unavailable, about which Lina Montalto speaks in her studies on the subject and preserved for a long time in the sacristy of the S. Ignazio church [Montalto 1962].

[2] The painted canvas and the Corsini sketch were acquired through high-resolution photogrammetric panoramas, then straightened by means of control points acquired with topographic instruments.

[3] The first rule described by Pozzo teaches how to build perspective through the degradation of the plan and the elevation. These two images, degraded and associated in space on planes perpendicular to each other, allow the perspective construction by intersecting the lines passing through corresponding points. Instead, the second rule consists in projecting the plan and the elevation onto the picture plane, also represented in plan and elevation. For further information about the methods for perspective construction described by Pozzo, see a study by the authors entitled *Andrea Pozzo e la finta cupola di S. Ignazio in Roma* [Baglioni, Salvatore 2019].

[4] The three models of the dome of the Collegio Romano have the same articulation of the tambour, that are divided into eight parts, marked by twin columns interspersed with a column projecting on cantilevered shelves, framing a central arch and side windows that are different in each case.

[5] The uncertainty of the measurements is attributable to the different physical dimensions of the three models analyzed.

[6] In the case of the fake dome of the Church of Jesus in Vienna, the cross-ratio can be calculated directly from the perspective of the painting made by the projection center, using the centers of the ellipses to identify the segments aligned on the axis of revolution.

[7] This technique was used by Mario Botta in 1999, for the installation that reproduces in scale the church of San Carlo alle Quattro Fontane by Francesco Borromini on the shores of Lugano Lake, in Switzerland.

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Diachronic Analysis of some Urban Spaces in Valencia by Means of Rephotography

Martín Benlloch-Moya, Pedro M. Cabezos-Bernal, Juan J. Cisneros-Vivó

Abstract

The main objective of this research work is the application and study of a photographic technique called rephotography, which consists of taking a photograph from the same viewpoint as another picture that was taken in the past. This technique allows analyzing the evolution of the photographed scene over the time. To this end, a compilation of ancient photographs of different urban scenarios of the city of Valencia has been carried out. These photographs have been studied by means of a thorough graphic analysis, carried out by applying the laws of perspective, in order to accurately restitute the point of view of each picture. This process allows the accurate matching of the composition of current re-photographs to the older ones. After that, a comparative study between present and historical photographs was carried out in order to analyze the changes that these different urban scenarios have suffered throughout history. The graphic results of this research are intended to awaken the interest of the viewer, who can easily understand this evolution. This study also helps to recover the historical memory of places that have already disappeared or have undergone a profound transformation.

Keywords: Rephotography; perspective; photographic restitution; diachronic analysis.

Introduction

Re-photography is understood as the act of re-taking a photograph from the same viewpoint of another picture, taken previously, in order to reveal the transformations produced over the time. This is a great tool to analyze the evolution from a specific place, a building or a city. The challenge that arises has a double aspect. On one hand, the current photograph must achieve a viewpoint which matches exactly with the older one. On the other hand, the evolution process must be interpreted correctly and within its context. In order to fulfill the first condition, there are different techniques and studies that will be mentioned bellow. For the second, it is essential to know first-hand the reality that is being photographed, as well as having the necessary sensitivity to adequately compare both snapshots.

The adopted strategy has its foundations in the work of the North American photographer Mark Klett, after the publication of his book entitled *Second view*, a vast project that consisted of re-photographing the landscapes of the North American West from snapshots of the mid-nineteenth century [Klett 1984]. This work has greatly contributed to define the modern concept of rephotography, and the personal vision of the author has become a guide for the development of this research. Rephotography is meant to be a sensorial experience that goes beyond the simple comparison between images and the observer has to take an active position

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mixing his own experience and knowledge about the place in order to achieve a full experience [1].

The Historical Pictures

The first stage of the research process consisted of searching and selecting some old photographs that served as a starting point for the comparative study. The historical pictures that have been used in this work to analyze the evolution of the urban spaces of Valencia come from three different sources: the photographs by Jean Laurent, taken in 1870, and published by Huguet-Chanzà [Huguet-Chanzà 2003], those by Lèon et Lèvy of 1888, published by Huguet-Chanzà [Huguet-Chanzà 1996] and those belonging to the Diaz Prósper collection, published by Cancer-Matinero [Cancer-Matinero 2011]. Additionally, a study was carried out focusing on a lithograph bird's eye view of the city, executed in 1853 by the French lithographer and architect Alfred Guesdon that, despite not being a photograph, is an accurate perspective drawing.

The Viewpoint Restitution

In the process of rephotography, the photographic restitution of the main elements of the perspective acquires great importance. Since a photograph can be considered as a perspective, if the radial distortions are corrected, it would be possible to restitute the original point of view if we knew some geometric relationships in the scene such as orthogonality conditions and any dimension. In this way, we would obtain the camera position, the distance from the subject and the direction of the optical axis.
As previously mentioned, in order to equate a photograph to a perspective, it is necessary to do some corrections in order to eliminate certain geometric distortions caused by the photographic equipment. The main optical aberrations in modern photography are radial distortions, tangential distortions and chromatic aberrations. However, only radial distortions have a considerable impact on the restitution process [Cabezos-Bernal, Cisneros-Vivó 2013]. For this reason, it is mandatory to correct them using several computer software in order to obtain an accurate restitution.

Fig. 1. Viewpoint restitution in a vertical projection plane picture.

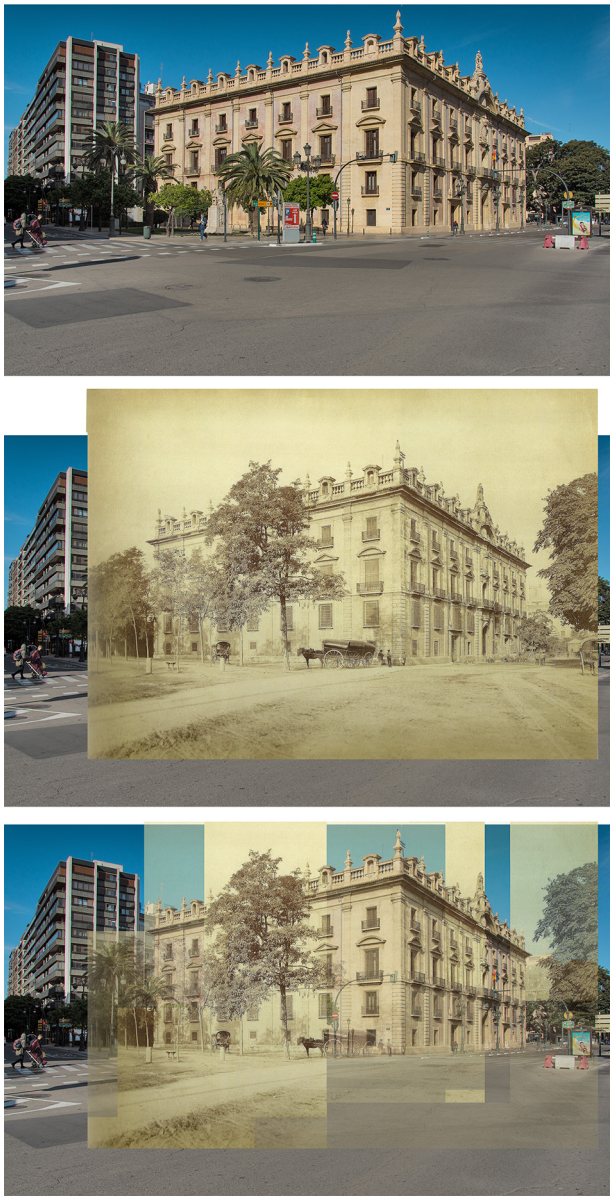
Nevertheless, in the case of historical images, the distortion is usually very low, as the majority of ancient cameras used the central zone of the lens to conform the image, producing a minimum radial distortion, so the viewpoint restitution would be quite accurate despite not making these corrections.
In this way, we can know exactly the point from where the original photograph was taken, place it on a map and proceed to take a new photograph with the same characteristics. We have carried out the viewpoint restitution of several ancient photographs, all of them with different characteristics so we have had to apply different procedures [2]. The graphic process used for the restitution of the point of view can be seen by analyzing the vanishing points corresponding to orthogonal edges of the scene in the case of a vertical projection plane picture (fig. 1) and in an oblique projection plane picture (fig. 2).

Urban evolution and diachronic analysis

This work shows some examples from the historic center of Valencia, in which, through the comparison between present and historical images, the evolution that these spaces have suffered over the time will be analyzed. The first scenario that we analyzed was the Superior Court of Justice of the Valencian Community. The building was built in the mid-eighteenth century, standing next to the old gate Puerta del Mar, on the inner boundary of the walls. It has a rectangular plan and contains two internal courtyards separated by a large imperial-type central staircase giving access to the first floor. The exterior façade, of an austere neoclassical style, shows a balustrade surrounding the top side of the building. The balconies of the main floor alternate straight and curved pediments and the large stone pilasters complete the façade together with a brick wall, which contains blocks of stone in its corners. By applying inverse perspective geometric procedures, it has been possible to accurately restore the viewpoint of an ancient photograph, belonging to the Diaz Prósper collection, which was taken by an anonymous author and dated in 1888 [Cancer-Matinero 2011]. Thus, the aspect of the building in the current photograph is almost identical to that of the original. In the collage that it was carried out (fig. 3), we intended to emphasize

Fig. 2. Viewpoint restitution in an oblique projection plane picture.

Fig. 3. Superior Court of Justice of the Valencian Community, 1888-2018.



this aspect. By superimposing both photographs, we have verified that the building has remained practically invariable for more than 120 years. The play with transparency bands and the fusion between pictures show that all the elements of the exterior façade matches perfectly, since the walls have not been modified during this lapse of time, except in some minor details.

Despite the invariability of the building, we can see a great change in the surrounding environment. In the left part of the ancient photograph, you can see a small road flanked by trees that corresponds, without any doubt, to the origins of Colón Street. The strategic position of the place, at the eastern entrance of the city and in direct relationship with the port, will turn it into a nodal point of communications. This space has evolved towards the present roundabout of Puerta del Mar, at the beginning of the first great circumvallation via the historic center of Valencia, which contains the main Streets Colón, Játiva and Guillén de Castro.

The evolution of this scenario has been analyzed, in turn, through another photograph, taken from a different point of view and in an intermediate moment between the previous two. It corresponds to an image extracted from Aleixandre [Aleixandre, Serra, Catal 1998], by an unknown author and date. We can estimate the date, by the stage and the clothing, to be in the decade of 1920. The building remains unchanged, being again the urban environment, which presents noticeable differences. The evolution of this space is already remarkable with respect to the year 1888: the street has already been asphalted, even defining the delimitation between the road and the sidewalk. It emphasizes the presence of people and different means of transport that, although in the previous image they were in second plane, in this case, they are the absolute protagonists. Among them, various tramlines around the building are gaining strength, showing the consolidated urban network of Valencia with buildings on the other side of Colón Street that remain nowadays. In the assembly made from these images (fig. 4), some transparencies have been used to highlight the most important aspects. On one hand, it can be seen that both the Court of Justice and the aforementioned buildings have remained unchanged. Nevertheless, the limits of the Park of *La Glorieta* has receded several meters, giving this space to the road, denoting that the arrival of the car to the cities causes them to adapt to their

Fig. 4. Superior Court of Justice of the Valencian Community, c.a 1920-2018.

needs. The streets ceased to be a space at the service of pedestrians to become a part of a system that gives priority to cars, giving them an important part of the valuable urban land, both for their circulation and for their parking, thus changing drastically the face of the modern city.

Another case study is the Plaza de la Almoina, located in the heart of the historic center, next to the Cathedral, the Basilica de la Virgen de los Desamparados and the Archbishop's Palace. In this place, we can discover the secrets of Valencia: its surface hides the mayor archaeological site of the city. Over 2000 years old, this is the oldest and most valuable spot about the city origins.

The image assembly (fig. 5) is intended to reflect the evolution of this place through the superposition of both photographs, which partially matches in the part corresponding to the cathedral. We also tried to take the current photograph at the same day hour to match the shadows. It can be seen that the buildings at the end of the scene have disappeared giving place to the current great square. It is understood that after the expansion of Valencia beyond its old walls, the historic center suffered some regenerations, because of the precarious conditions of health and hygiene and the high density reached. The opening of large public spaces, as in the case of the Plaza de la Reina, next to the Cathedral, gave a balloon of oxygen to the city center, promoting social life outdoors. Another aspect that is clearly noticed is the elevation of the ground level. Paying attention to the ground level in the cathedral wall, it can be seen that nowadays the stone blocks are about 35-45 cm above the pavement level 100 years ago. In 1985, the subway works discovered the remains of the Roman forum that engendered this city under the square. The subsequent excavation works and construction of the new museum located in this place are the cause of this elevation change.

Another monument that could not be missed in this journey through the city history is the Torres de Serranos and its surroundings. This building is one of the most representative monuments of Valencia. Its origin dates back to 1392, when its construction was initiated by the Valencian architect Pere Balaguer, who was inspired by other constructions of this typology, such as the Puerta Real of the monastery of Poblet or the Portal dels Boters (Lleida). However, the Torres de Serranos surpassed both of them, rising as one of the best examples

Fig. 5. Plaza de la Almoina, 1870-2018.

Fig. 6. Torres de Serranos, 1888-2018.

of Gothic defensive architecture throughout the Iberian Peninsula [Aleixandre, Serra, Catalá 1998].
The ancient picture taken in 1888 shows a sight of the towers from the Serranos bridge, with a lot of people, activities and movements that were concentrated in this place. Not in vain, thanks to its privileged location, constituted the main entrance to the city and that of which was used by monarchs, kings and other personalities when arriving in Valencia. In this case, the current image differs slightly from the ancient one (fig. 6). In the towers, only some modifications can be noticed, such as the elimination of certain openings on the walls present at that time when the monument was one of the prisons of the city. Also we can notice the restoration of the merlons. With regard to the urban environment, the figure of the Towers has been maintained as the protagonist of this urban scene, allowing its contemplation from the distance. Likewise, the recovery of the Serranos bridge as a pedestrian way, few years ago, is a success that recovers the historical memory of this place.
The great square known as Plaza de la Virgen has been for centuries the center of urban life in Valencia and contains also some of the city's main monuments, such as the Cathedral, that faces to this square with its lateral door, called Puerta de los Apóstoles. Beside this door, we can find the Lonja de los Canónigos with its Renaissance arcades. Next to the Cathedral, it also faces the square the Basilica de la Virgen de los Desamparados, which gives its name to the square. The ancient image by Lèon et Lèvy in 1888 offers a panorama of this square showing also, on the right margin, the original House of the Changing rooms, which today has turned into a municipal library and headquarter of the famous Water Tribunal of Valencia, as well as the old fountain that occupied the central space of the plaza. In the time of 100 years or more, which elapsed between the ancient photograph and the current one, the square has suffered innumerable modifications. However, the analyzed picture has remained almost the same. That is the idea that we wanted to transmit through the assembly in figure 7, showing that the only remarkable difference is the widening of Micalet Street, after the demolition of the buildings attached to the Cathedral previously known as houses of the Canons.
To finish the investigation, we carried out a study of the perspective on a lithograph by the French artist and architect Alfred Guesdon, a virtuous draftsman and litho-

Fig. 7. Plaza de la Virgen, 1870-2018.

grapher who specialized in the bird-eye representations of cities. Guesdon made aerial views of many European cities that were published in the form of lithography collections. The collection corresponding to the Spanish cities was entitled *L'Espagne à vol d'oiseau*, and it contains two views of the city of Valencia.
We took one of these views, the one corresponding to the view on the *San José* bridge that shows the old walled city and its gateways, just before its demolition, which begun in 1865 by order of the civil governor Cirilo Amorós. Only two of the gates of the old wall were saved from demolition; Portal de Quart and Portal de Serranos, since they served as prisons of the city at that time.
A thorough study of the perspective was necessary, we followed a methodology based on the study of vertical projecting planes for the restitution of the point of view [3], which was restored with enough precision. Given that the current legislation prohibits the use of a drone over urban spaces, we obtained the rephotography be means of Google Earth. We introduced the geographical coordinates of the restituted viewpoint. The image composition (fig.8) shows the comparison between the original lithography and the obtained rephotography that allows us to observe the configuration of the lost walled city, in front of the urban enlargement that the city has undergone through the different expansion plans.

Conclusions

The aforementioned relationship between image and architecture is one of the pillars sustaining this work, photography being the nexus between both. The comparison between photographs taken in the past and others taken nowadays has allowed us to analyze the evolution of many architectural and urban elements, the transformations that these have undergone and even the importance that has been conferred to them depending on the historical moment. However, it should be mentioned that the ancient photographic material determines this whole process, so its quality, its purpose and the conditions in which it was produced will significantly condition the conclusions that can be drawn from it.
The images produced from the analysis of the studied spaces in Valencia, enables us to be defenders of the

Fig. 8. Aerial view of Valencia: lithography by A. Guesdon (1853) and aerial view obtained from Google Earth.

utility of rephotography in various fields related to architecture. The meticulous work that is necessary for its production constitutes by itself an analysis of the architectural elements treated, in which even the smallest details have to be taken into account in order to obtain satisfactory results. In turn, all this work is based on an architectural basis, so a link is established between the two subjects, in which both are contributors, enriching mutually at the same time.
The visual power of the images obtained makes us think that, through them, it is possible to promote the interest of the general public, usually unfamiliar with the field of architecture and urbanism, expanding the range to whom this work can be addressed, and thus, improving the dissemination of these topics.
Architecture is a vestige of the passage of time, which is evident, but sometimes the architects do not give it too much importance. Throughout this work it is clear how some buildings endure over the centuries, while others disappear without leaving a trace of what they once were. They all together constitute a very important source of historical information and, from them, many kind of conclusions can be drawn: not only on past events, but also on how history influences our present and our future.

Notes

[1] For further information about rephotography, see Cabezos-Bernal, Formaglini, Giansanti 2015.

[2] For further information about the employed techniques, see Cabezos-Bernal, Cisneros-Vivó 2012, Cabezos-Bernal, Cisneros-Vivó 2013 and Villanueva-Bartrina 2001.

[3] For further information about the methodology employed in this restitution, see Cabezos-Bernal, Cisneros-Vivó 2018.

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Writing and Multimedia. Redesigning the Futuristic Experience

Vincenzo Cirillo

Abstract

This paper is part of the study of writing design (i.e. the graphic sign of writing) and of the concept of movement. It is placed within the context of historical references on the design of writing (as an archaic sign, pictogram, ideogram) and representation technologies (from calligraphy to typography). The relationship between graphic design (writing) and movement (animation) has been addressed in the digital environment through the design of video-graphic products analyzed on the basis of: visual theories of typographic composition; the figurative-generative languages of graphic signs, relational contexts (chromatic, dimensional, formal) along with the integration between image and photo-cinematography (where present); the duration of the audiovisual spot; of the sound component as a key to emotional reading functional to the visual narrative; of communication strategies. Kinetic typography, which integrates movement and writing, is therefore the object of study of this paper. In the field of graphic design and specifically of drawing discipline, two aspects will be evaluated: technological innovation, which made possible the video-graphic representation of the movement while physical time passes; audiovisual languages and compositional criteria for the figurative management of writing and multimedia communication. The realized projects are configured as short-term video-graphic ads and are developed in the context of audiovisual narrative in relation to the creative relationship between writing and: acting; sound; title design; heritage.

Keywords: kinetic typography, video graphics, multimedia communication.

Introduction

Due to its nature of 'graphic sign' attached to a surface through the use of devices, both analogue and digital form (from cuneiform signs engraved on a clay tablet to a writing tip on parchment and/or paper soaked by ink, up to the contemporary computer tools that trace signs on a screen), writing is one of the most powerful forms of human communication.
For over three millennia, the primordial and human communication purpose has not undergone any substantial changes. On the other hand, we have witnessed the constant experimentation and evolution of the 'putting into shape' of writing, intended as a graphic representational tool for the lasting transmission of information. Before writing was introduced, the elaboration and organization of an oral discourse required an active memory and thought. It can be assumed that from the beginning, communication originated primarily through sounds. Singing, acting, narrating were the only ways to communicate based on the degree of attention by the auditor. Consequently, "the strongest visual appeal of attention" [Arnheim 1962, p. 303] was manifested through the primitive meaning of 'movement' or the formal quality of body gestures which, together with the human voice, served in real time from a system for distribution of thoughts and ideas [Falcidieno 2006].
«We are living in a visual age. We are bombed by pictures from morning to night […]. We are entering a historical epoch in which the image will follow the written

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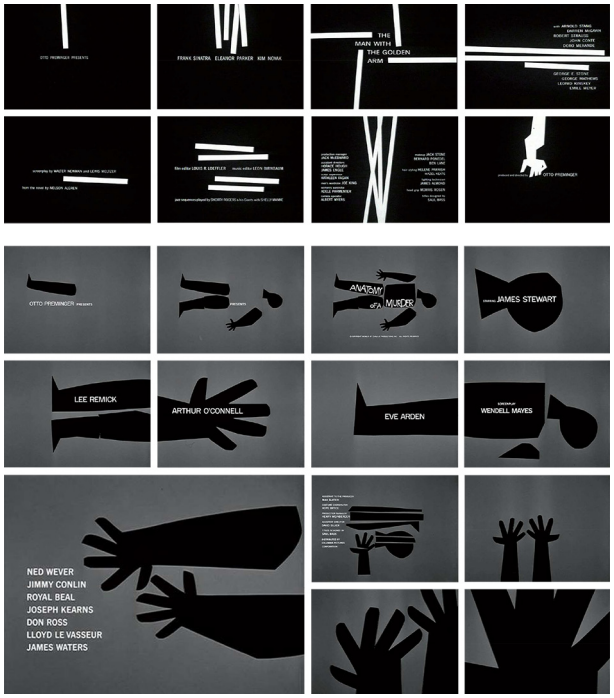


Fig. 1. Graphic signs and kinetic typography in the cinematographic work by Saul Bass. A - The Man with the Golden Arm (1950). B - Anatomy of a Murder (1959).

word» Gombrich says, referring to the only 'images' observed during a day [Gombrich 1982, p. 155]. However today, this possibility has increased. Thanks to the development of computing power available today (always in constant evolution), a new possibility is offered by the startup of forms of communication in which the original recording devices (eyes, ears, brain) are all perceptually involved. One of these new forms of communication is expressed using kinetic typography, which is the representation of information through words in motion over time. A form capable of evoking ideas and/or emotions through the dynamic visualization of writing [Lee, Forlizzi and Hudson 2002].
Thanks to the ability of transmitting emotion, kinetic typography reinforces the communicative properties of writing, becoming itself the promoter of some expressive powers. A pioneer of the use of this new form of expression was Saul Bass (1920-1996), who applied the technique of 'frame by frame' animation (fig. 1), a process capable of creating a sequence of images that viewers perceived as a single continuous movement. Most frame by frame animations were produced by horror filmmakers in the first half of the twentieth century for opening titles. These titles were a premise to the film's story, anticipating an emotional reaction in the audience to the cinema even before the plot is revealed [2011].
The director Norman McLaren (1914-1987) used not exclusively typographic graphic-matrix signs in his animated films (fig. 2). His work consisted mainly of the perfect coincidence between the 'sound' element and the movement of 'graphic signs' (conceptual or not): a sort of 'key of the instant', that is a synergy between the musical and visual forms, which is still today one of the operative methods of kinetic typography [Vallière 1982].
The current development, however, aims to create new forms of animation of typographic characters, as well as of text in general, since the constant evolution of technological tools influences the typographic characters design, giving the dynamic and animated text (motion graphics) a more and more seducing and amazing task [Zerlenga 2007].

Futurism. Speed, movement, time

The awareness that has given back to the artistic current of Futurism the right to take part in the cultural heritage despite its 'national-popular' nature, is a goal that the criticism of the last century has laboriously achieved with relative delay since the latter has not remained immune from ideological-political interpretative conditions. Official celebrations as well as public and private exhibitions held in Italy and in the rest of the world, starting from the centenary of the birth of Futurism (among the most recent, Naples 2018-19) [1] [Carpi, Villanti 2018], confirm that this Avant-garde movement is now recognized as one of the most fruitful artistic and cultural experiences arising within western civilization in the modern era. Futurism was a movement of cultural battle, which exhibited a set of ideas which, although oriented towards war ideals (indicators of a historical era at the turn of the two world wars), have represented many real needs of the time. The most noteworthy was the need for a renewal of man's identity, who wanted to break with the narrow and 'immovable' patterns of the nineteenth century. This

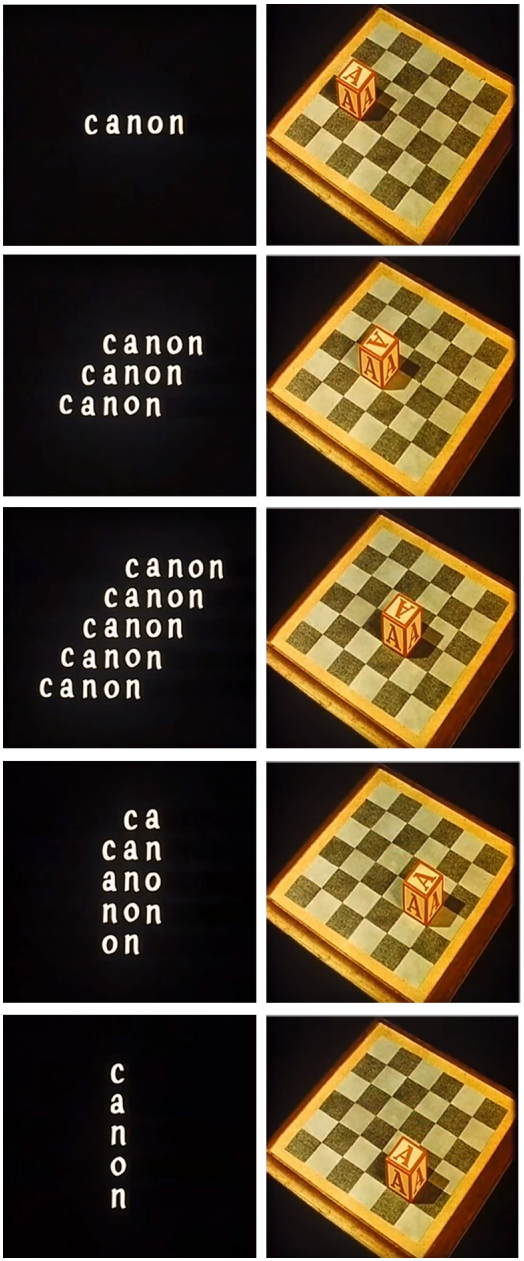
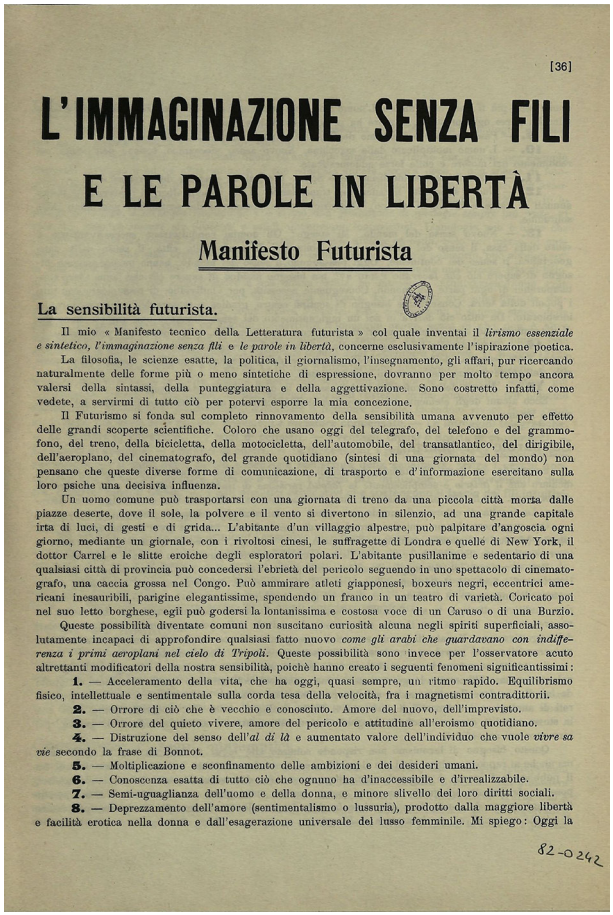


Fig. 2. Graphic signs and kinetic typography in the animated film Canon (1964) by Norman McLaren.

ideological position tended to: "grasp the truth of a life transformed by the age of technology […] and to consider man and technique on the same level" [De Micheli 1981, p. 246].
This way of thinking stimulated the cultural and creative themes of the futurist Avant-garde regarding new reflections such as the analysis of reality, investigated through visions offered by the phenomenon of 'speed' and 'movement', intended as the simultaneity and interpenetration of forms and emotions. Moreover, in its broader meaning, since the 'technique' is a functional component of the form, it actively participates in the determination of the modes of existence (real and material) of the model itself. Assuming the technique as a complex of rules, which governs the practical and functional exercise of art, for the Futurists, the technique participates in the definition of an idea of 'speed' intended more and more as a 'temporal movement'. With the ideological assumptions and artistic experiments carried out in recent years by the protagonists of the futurist Avant-garde, it can be said that this artistic current, more than any other, has represented and given value to 'time' through different expressive forms (writing, music, painting, sculpture, dance, etc.) in a totally new way: a time that is no longer 'slow', made of observation, reflection and meditation, but 'fast' and strongly integrated with the environment in which the movement of a body over time performs.
The conception of futuristic 'time' legitimizes, therefore, existence and is, at the same time, proof of the existence of matter. Without time, man does not exist, he does not move things, he does not live. This position finds its maximum expression in the artistic representations of Umberto Boccioni. In his works, both pictorial and sculptural, the representation of the material, that moves displaced in the space by the motion of a body, allows the observer to perceive the simultaneous relationship with the environment 'from the inside' [De Micheli 1981, p. 256].
Time, therefore, is the key of the moment. The art privileged by Futurism was sculpture because it lives in time, is usable over time, is composed over time. Nevertheless, in the graphic production of futurism made of images on a two-dimensional support, time is represented through graphic signs that allude to movement, evidently lacking

the physical-temporal 'space' in which the real movement is accomplished. However, the graphic allusion to the movement was not new, even if new was the experimentation of unusual depth indicators through the adoption of geometric lines of force which alluded to speed (for example, to the movement of a train in a race or a motorcyclist hurtling along the road). Futurist artistic thought is therefore: "based on the complete renewal of human sensibility that took place due to the great scientific discoveries. Those who today use the telegraph, the telephone, […] the cinema, the great newspaper (summary of a day in the world) do not think that these different forms of communication, transport and information exert a decisive influence on their psyche" since today there is an: "acceleration of life, which has, almost always, a rapid rhythm" [Marinetti 1913, p. 1].
Compared to all the artistic avant-gardes, since its appearance, Futurism has come up with an aesthetic vision that embraces all fields of art, particularly revolutionizing that of typographic production. The traditional layout of the 'page' is revolutionized by the simultaneous use of characters (different sizes) according to many geometric shapes such as to link the logical expression and the meaning of the words to a singular visual communication. This type of 'page' is defined as *parolibera*, a graphic composition that arouses in the reader the allusive visual perception of a movement corresponding to the events that the text narrates. This compositional method is used for the graphic design of covers as well as a page 'style' in numerous books.
In *L'immaginazione senza fili* e *le parole in libertà*, ideological manifesto conceived by Filippo Tommaso Marinetti in 1913 (fig. 3), the Futurists start a profound innovation in the compositional and graphic structure of the book, which is illustrated as follows: "Instead of humanizing animals, plants, minerals (a system that is by now outdated) we can animalize, vegetate, mineralize, electrify or liquefy the style, making it live in a certain way in the same life of the material. We will have condensed metaphors. - Telegraphic images. - The sums of vibrations. - The knots of thoughts. - The closed or open fans of movements. - The glimpses of analogies. - Color balances. - The dimensions, weights, measurements and speed of sensations. - The plunge of the essential word into the water of sensitivity, without the concentric circles that the word produces around itself. - The rest of intuition. - Movements with two, three, four, five times. - The explanatory analytical piles that support the bundle of intuitive wires" [Marinetti 1913, p. 3].
For the Futurists, typographic characters are therefore an opportunity to express their ideals of dynamism, declaring how up to then the literature had exalted: "thoughtful immobility, ecstasy and sleep. We want to enhance the aggressive movement […]. We affirm that the magnificence of the world has been enriched

Fig. 3. Futurist manifesto of Filippo Tommaso Marinetti, L'immaginazione senza fili e parole in libertà (1913).



[36]

L'IMMAGINAZIONE SENZA FILI
E LE PAROLE IN LIBERTÀ

Manifesto Futurista

La sensibilità futurista.

Il mio « Manifesto tecnico della Letteratura futurista » col quale inventai il *lirismo essenziale e sintetico, l'immaginazione senza fili* e *le parole in libertà*, concerne esclusivamente l'ispirazione poetica.

La filosofia, le scienze esatte, la politica, il giornalismo, l'insegnamento, gli affari, pur ricercando naturalmente delle forme più o meno sintetiche di espressione, dovranno per molto tempo ancora valersi della sintassi, della punteggiatura e della aggettivazione. Sono costretto infatti, come vedete, a servirmi di tutto ciò per potervi esporre la mia concezione.

Il Futurismo si fonda sul completo rinnovamento della sensibilità umana avvenuto per effetto delle grandi scoperte scientifiche. Coloro che usano oggi del telegrafo, del telefono e del grammofono, del treno, della bicicletta, della motocicletta, dell'automobile, del transatlantico, del dirigibile, dell'aeroplano, del cinematografo, del grande quotidiano (sintesi di una giornata del mondo) non pensano che queste diverse forme di comunicazione, di trasporto e d'informazione esercitano sulla loro psiche una decisiva influenza.

Un uomo comune può trasportarsi con una giornata di treno da una piccola città morta dalle piazze deserte, dove il sole, la polvere e il vento si divertono in silenzio, ad una grande capitale irta di luci, di gesti e di grida... L'abitante d'un villaggio alpestre, può palpitare d'angoscia ogni giorno, mediante un giornale, con i rivoltosi cinesi, le suffragette di Londra e quelle di New York, il dottor Carrel e le slitte eroiche degli esploratori polari. L'abitante pusillanime e sedentario di una qualsiasi città di provincia può concedersi l'ebrietà del pericolo seguendo in uno spettacolo di cinematografo, una caccia grossa nel Congo. Può ammirare atleti giapponesi, boxeurs negri, eccentrici americani inesauribili, parigine elegantissime, spendendo un franco in un teatro di varietà. Coricato poi nel suo letto borghese, egli può godersi la lontanissima e costosa voce di un Caruso o di una Burzio.

Queste possibilità diventate comuni non suscitano curiosità alcuna negli spiriti superficiali, assolutamente incapaci di approfondire qualsiasi fatto nuovo *come gli arabi che guardavano con indifferenza i primi aeroplani nel cielo di Tripoli*. Queste possibilità sono invece per l'osservatore acuto altrettanti modificatori della nostra sensibilità, poichè hanno creato i seguenti fenomeni significantissimi:

1. — Acceleramento della vita, che ha oggi, quasi sempre, un ritmo rapido. Equilibrismo fisico, intellettuale e sentimentale sulla corda tesa della velocità, fra i magnetismi contraddittorii.

2. — Orrore di ciò che è vecchio e conosciuto. Amore del nuovo, dell'imprevisto.

3. — Orrore del quieto vivere, amore del pericolo e attitudine all'eroismo quotidiano.

4. — Distruzione del senso dell'*al di là* e aumentato valore dell'individuo che vuole *vivre sa vie* secondo la frase di Bonnot.

5. — Moltiplicazione e sconfinamento delle ambizioni e dei desideri umani.

6. — Conoscenza esatta di tutto ciò che ognuno ha d'inaccessibile e d'irrealizzabile.

7. — Semi-uguaglianza dell'uomo e della donna, e minore slivello dei loro diritti sociali.

8. — Deprezzamento dell'amore (sentimentalismo o lussuria), prodotto dalla maggiore libertà e facilità erotica nella donna e dall'esagerazione universale del lusso femminile. Mi spiego: Oggi la

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with a new beauty: the beauty of speed […]. Time and space died yesterday. We already live in the absolute" [Marinetti 1909, p. 3] (fig. 4). The consequence of this assumption was that the Futurists used on the same page: "three or four different colours of ink, and even 20 different typefaces" [Marinetti 1913, p. 4], for example: "italics for a series of similar or fast sensations, bold round for violent onomatopoeias, etc." [Marinetti 1913, p. 4].

Fig. 4. Filippo Tommaso Marinetti, Fondazione e Manifesto del Futurismo, published by Le Figaro, 20 February 1909.

[3]

FONDAZIONE E MANIFESTO

DEL

FUTURISMO

(Pubblicato dal «FIGARO» di Parigi il 20 Febbraio 1909).

Avevamo vegliato tutta la notte — i miei amici ed io — sotto lampade di moschea dalle cupole di ottone traforato, stellate come le nostre anime, perchè come queste irradiate dal chiuso fulgòre di un cuore elettrico. Avevamo lungamente calpestata su opulenti tappeti orientali la nostra atavica accidia, discutendo davanti ai confini estremi della logica ed annerendo molta carta di frenetiche scritture.

Un immenso orgoglio gonfiava i nostri petti, poichè ci sentivamo soli, in quell'ora, ad esser desti e ritti, come fari superbi e come sentinelle avanzate, di fronte all'esercito delle stelle nemiche, occhieggianti dai loro celesti accampamenti. Soli coi fuochisti che s'agitano davanti ai forni infernali delle grandi navi, soli coi neri fantasmi che frugano nelle pance arroventate delle locomotive lanciate a pazza corsa, soli cogli ubbriachi annaspanti, con un incerto batter d'ali, lungo i muri della città.

Sussultammo ad un tratto, all'udire il rumore formidabile degli enormi tramvai a due piani, che passano sobbalzando, risplendenti di luci multicolori, come i villaggi in festa che il Po straripato squassa e sràdica d'improvviso, per trascinarli fino al mare, sulle cascate e attraverso i gorghi di un diluvio.

Poi, il silenzio divenne più cupo. Ma mentre ascoltavamo l'estenuato borbottìo di preghiere del vecchio canale e lo scricchiolar dell'ossa dei palazzi moribondi sulle loro barbe di umida verdura, noi udimmo subitamente ruggire sotto le finestre gli automobili famelici.

— Andiamo, diss'io; andiamo, amici! Partiamo! Finalmente, la mitologia e l'ideale mistico sono superati. Noi stiamo per assistere alla nascita del Centauro e presto vedremo volare i primi Angeli!... Bisognerà scuotere le porte della vita per provarne i cardini e i chiavistelli!... Partiamo! Ecco, sulla terra, la primissima aurora! Non v'è cosa che agguagli lo splendore della rossa spada del sole, che schermeggia per la prima volta nelle nostre tenebre millenarie!... —

82-0203

Parolibere: analysis of graphic signs and digital animation experiences

The first methodological-design experience carried out as a case study in the typographic art of Futurism aims at the graphic analysis and subsequent animation with the technique of kinetic typography of the cover of the book *ZANG TUMB TUMB* (1914) and the Filippo Tommaso Marinetti futurist manifest, *L'immaginazione senza fili, parole in libertà* (11 maggio 1913) (figs. 5,6).

The graphic analysis of the documents shows how both the aforesaid projects exhibit the use of words belonging to different types of fonts which, with different dimensions, are configured according to differently inclined directions and not parallel to each other. The use of bold is intended for words to which we want to associate a greater visual appeal, especially in the case of those with an onomatopoeic sound. Moreover, the latter often appear also deformed to give a greater expressive effectiveness to the meaning of the terms. In addition to the use of letters and words, there is also that of arithmetic symbols. Finally, for the most part, the directions have a rectilinear shape since, due to its geometric nature, the curvilinear appears visually softer and more sinuous, lending itself little to the aggressive language of Futurism. On these two 'tables' a subsequent design experience was accomplished. After having redesigned the 'tables' in vectorial graphics, the signs were animated by associating different dynamic effects to them [Bellantoni, Woolman 2001]. Moreover, on the graphic animation of the onomatopoeic words, corresponding sounds were associated, while the whole dynamic was accompanied by the musical composition *Macchina Tipografica* of the futurist composer Luigi Russolo (1885-1947). Signatory of the manifesto *L'arte dei rumori* (11 March 1913) (fig. 7), Russolo theorized the use of noise to arrive at composing passages consisting of pure noises instead of harmonic sounds. These disharmonious sounds were produced through a series of instruments designed by Russolo and called *intonarumori* (fig. 8) with which he started innovative musical compositions, immediately called 'futurist music'.

With reference to this poetic and taking up the methodological-design experience conducted with the technique of kinetic typography on the graphic composition of the cover of the book *ZANG TUMB TUMB* and the futurist manifesto of Filippo Tommaso Marinetti, *L'immaginazione senza fili e le parole in libertà*, in order to transform futuristic 'static' manifestos into 'kinetic', both a palette of sounds evocative of

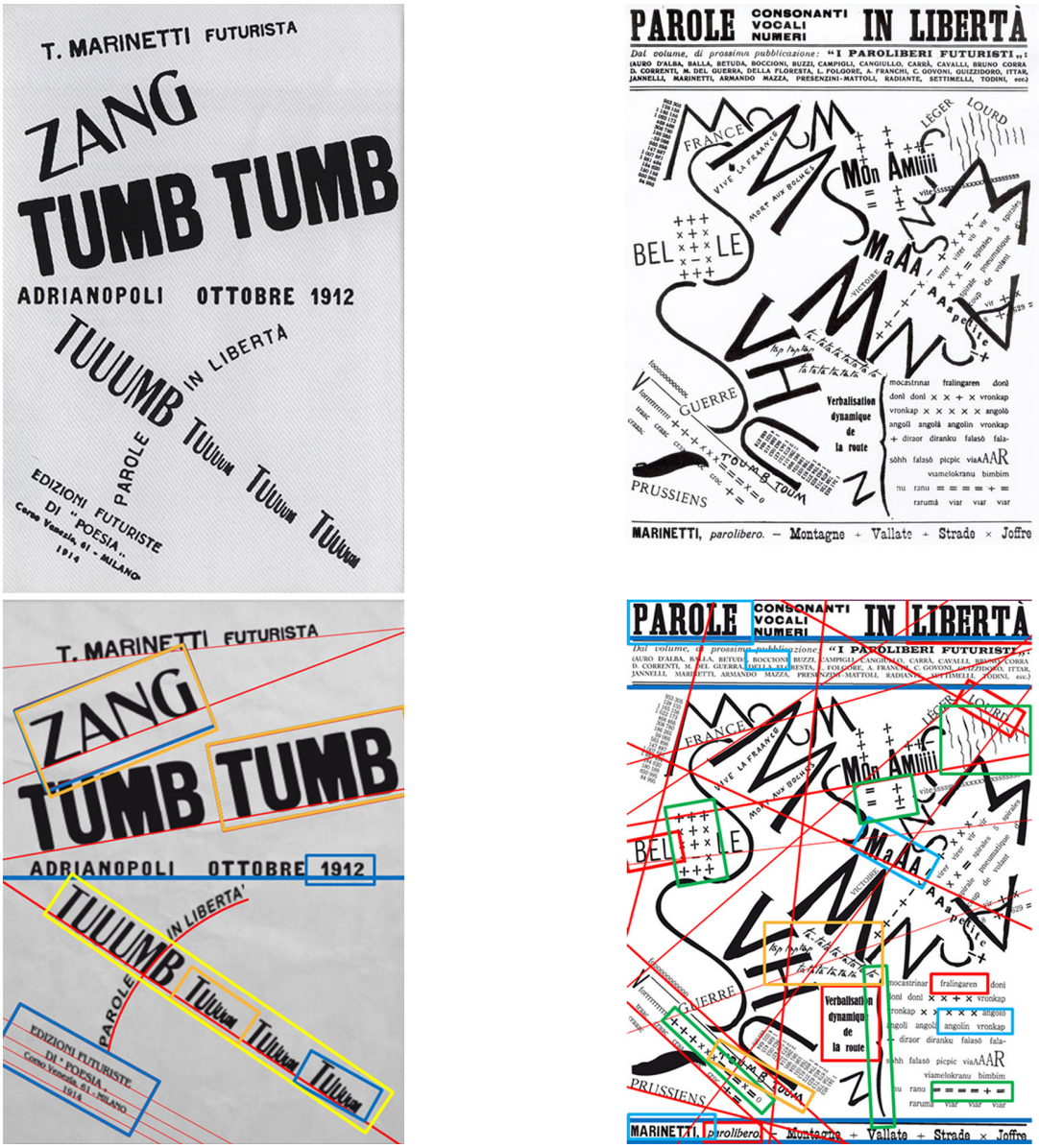

Fig. 5. A. Graphic analysis of the book cover ZANG TUMB TUMB (1914). B. Graphic analysis of the Futurist manifesto by Filippo Tommaso Marinetti, L'immaginazione senza fili e parole in libertà (1913).

noises to which the words and static graphic signs used in futurist posters allude, such as the sounds of chains, locomotives, rustlings, hands of watches, etc., as well as animated digital effects, such as appearance, rotation, falling, etc. were used. In addition, the use of Marinetti's voice which, with a heavy and serious tone, shouts 'parole in libertà' (free words) and the use of innovative media have further expanded the Futurist typographic context, passing from the use of static graphic signs, which visually allude to movement, to the use of digital contexts that allow the visual perception of graphic signs that transform or move in real time (fig. 9).

[32]

L'ARTE DEI RUMORI

Manifesto futurista

Caro Balilla Pratella, grande musicista futurista,

A Roma, nel Teatro Costanzi affollatissimo, mentre coi miei amici futuristi Marinetti, Boccioni, Carrà, Balla, Soffici, Papini, Cavacchioli, ascoltavo l'esecuzione orchestrale della tua travolgente **Musica futurista,** mi apparve alla mente una nuova arte che tu solo puoi creare: l'Arte dei Rumori, logica conseguenza delle tue meravigliose innovazioni.

La vita antica fu tutta silenzio. Nel diciannovesimo secolo, coll'invenzione delle macchine, nacque il Rumore. Oggi, il Rumore trionfa e domina sovrano sulla sensibilità degli uomini. Per molti secoli la vita si svolse in silenzio, o, per lo più, in sordina. I rumori più forti che interrompevano questo silenzio non erano nè intensi, nè prolungati, nè variati. Poichè, se trascuriamo gli eccezionali movimenti telluríci, gli uragani, le tempeste, le valanghe e le cascate, la natura è silenziosa.

In questa scarsità di *rumori*, i primi *suoni* che l'uomo potè trarre da una canna forata o da una corda tesa, stupirono come cose nuove e mirabili. Il *suono* fu dai popoli primitivi attribuito agli dèi, considerato come sacro e riservato ai sacerdoti, che se ne servirono per arricchire di mistero i loro riti. Nacque così la concezione del suono come cosa a sè, diversa e indipendente dalla vita, e ne risultò la musica, mondo fantastico sovrapposto al reale, mondo inviolabile e sacro. Si comprende facilmente come una simile concezione della musica dovesse necessariamente rallentarne il progresso, a paragone delle altre arti. I Greci stessi, con la loro teoria musicale matematicamente sistemata da Pitagora, e in base alla quale era ammesso soltanto l'uso di pochi intervalli consonanti, hanno molto limitato il campo della musica, rendendo così impossibile l'armonia, che ignoravano.

Il Medio Evo, con gli sviluppi e le modificazioni del sistema greco del tetracordo, col canto gregoriano e coi canti popolari, arricchì l'arte musicale, ma continuò a considerare il suono *nel suo svolgersi nel tempo*, concezione ristretta che durò per parecchi secoli e che ritroviamo ancora nelle più complicate polifonie dei contrappuntisti fiamminghi. Non esisteva *l'accordo;* lo sviluppo delle parti diverse non era subordinato all'accordo che queste parti potevano produrre nel loro insieme: la concezione, infine, di queste parti era orizzontale, non verticale. Il desiderio, la ricerca e il gusto per l'unione simultanea dei diversi suoni, cioè per *l'accordo* (suono complesso) si manifestarono gradatamente, passando dall'accordo perfetto assonante e con poche dissonanze di passaggio, alle complicate e persistenti dissonanze che caratterizzano la musica contemporanea.

L'arte musicale ricercò ed ottenne dapprima la purezza, la limpidezza e la dolcezza del suono, indi amalgamò suoni diversi, preoccupandosi però di accarezzare l'orecchio con soavi armonie. Oggi l'arte musicale, complicandosi sempre più, ricerca gli amalgami di suoni più dissonanti, più strani e più aspri per l'orecchio. Ci avviciniamo così sempre più al *suono-rumore*.

Questa evoluzione della musica è parallela al moltiplicarsi delle macchine, che collaborano dovunque coll'uomo. Non soltanto nelle atmosfere fragorose delle grandi città, ma anche nelle campagne, che furono fino a ieri normalmente silenziose, la macchina ha oggi creato tanta varietà e concorrenza di rumori, che il suono puro, nella sua esiguità e monotonia, non suscita più emozione.

Per eccitare ed esaltare la nostra sensibilità, la musica andò sviluppandosi verso la più complessa polifonia e verso la maggior varietà di timbri o coloriti strumentali, ricercando le più complicate successioni di accordi dissonanti e preparando vagamente la creazione del **rumore musicale.** Questa evoluzione verso il « suono - rumore » non era possibile prima d'ora. L'orecchio di un

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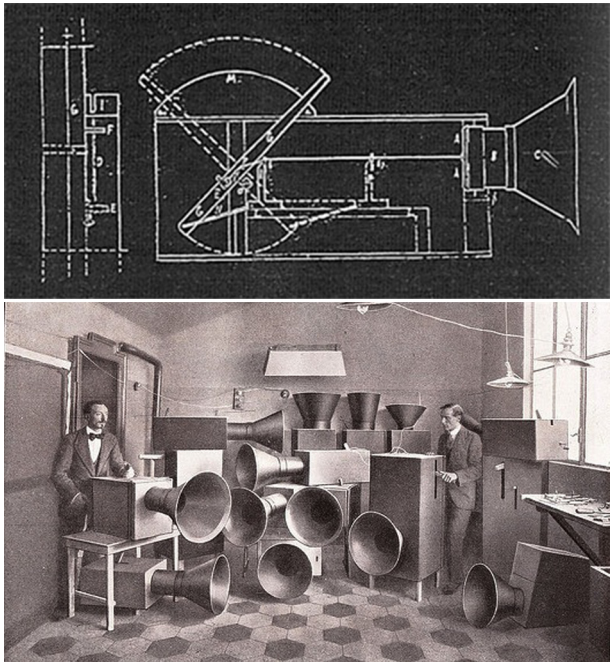
The Futurist manifesto. From the visual sign to the integration with the sound

In terms of the relationship between writing and multimedia, the second redesign experience was carried out on the cultural manifesto of Futurism, published in the French magazine *Le Figaro* in 1909 and entitled *Manifeste du Futurisme*. In this case, the experiment made use of the kinetic typography applied to writing through the technique of video-graphic and auditory implementation [Castellano, Falcidieno 2012].

Fig. 6. Luigi Russolo, L'Arte dei rumori, Futurist manifesto published on 11 March 1913.

Fig. 7. Luigi Russolo and the Intonarumori.



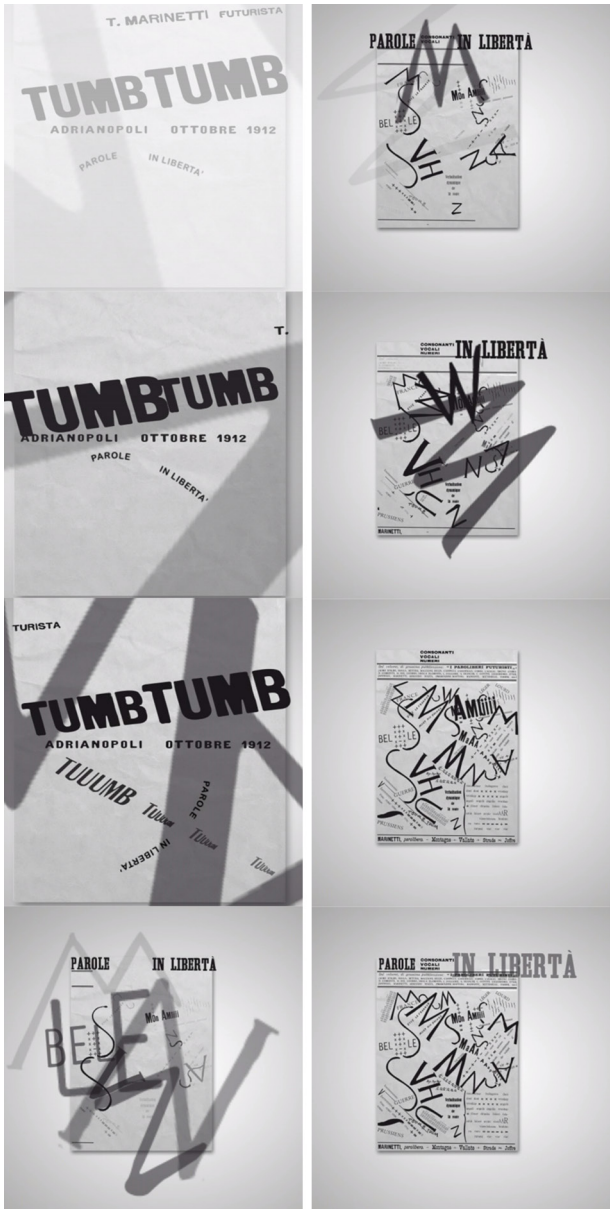


Fig. 8. Animation of Futurist posters with the kinetic typography technique.

Until the 1990s, music in the cinema was the background to the opening and closing credits as a soundtrack not synchronized with the graphic elements (writing or figures), already elaborated in kinetic typography. Only a few decades ago, the need arose to create a synchronization between the audio and visual content of the animations and, in this regard, the video clips of the early 2000s were the first examples of design in which the scenes are assembled according to the effects of kinetic typography (fig. 10).
In this direction, an ulterior experiment was carried out (an art advert) that combines the written sign with the sound. It uses a passage in visual writing of the text of the *manifesto futurista* integrated with the recital of the actor Carmelo Bene (1937-2002).
The union between these two forms of narration has been achieved using kinetic typography. The audio-video graphic project is based on the cultural awareness of Marinetti's statements which affirm that the: "punctuation must be deleted" [Marinetti 1912, p. 1] as well as they consider it necessary to produce a 'lively style': "without the absurd stops of the commas and full-stops" [Marinetti 1912, p. 1] and make «the noise, the weight and smell of objects" [Marinetti 1912, p. 3].
Sharing the opinion that an audio-visual advert made in kinetic typography is an effective communicative purpose if one of the main features is the simplicity of the visual, during the meta-project phase, the choice of the color palette was considered carefully (in relation to the content of the narration) along with a single font (to be used for the entire duration of the advert) (fig. 11).
The selected track was divided into several scenes, corresponding to a series of three colors (except the last one consisting of two). The colors of each palette were chosen starting from the first (primary or secondary) according to the chromatic variations of contrast and/or saturation. In general, the first color was attributed to the background of the scene; the remaining two, used for writing; the third as a background of the next scene. The symbolic use of colors dedicated to the written text is a function of the emphasis of the word, whose greater or lesser tonal variation corresponds to an emphasizing effect. Further graphic effects derive both from the reading of the piece as well as from the poetics of Futurism: a sense of static, speed and dynamism of words; use of mathematical signs; presence of onomatopoeias; theories of the new typographic harmony (fig 12). Returning to the use of the font, the choice fell on

Fig. 9. Music video-clip realized with the kinetic typography technique: Prince, Kiss (1988); Madonna, Music (2000); Neyo, Closer (2009); Måns Zelmerlöw, Heroes (2015).

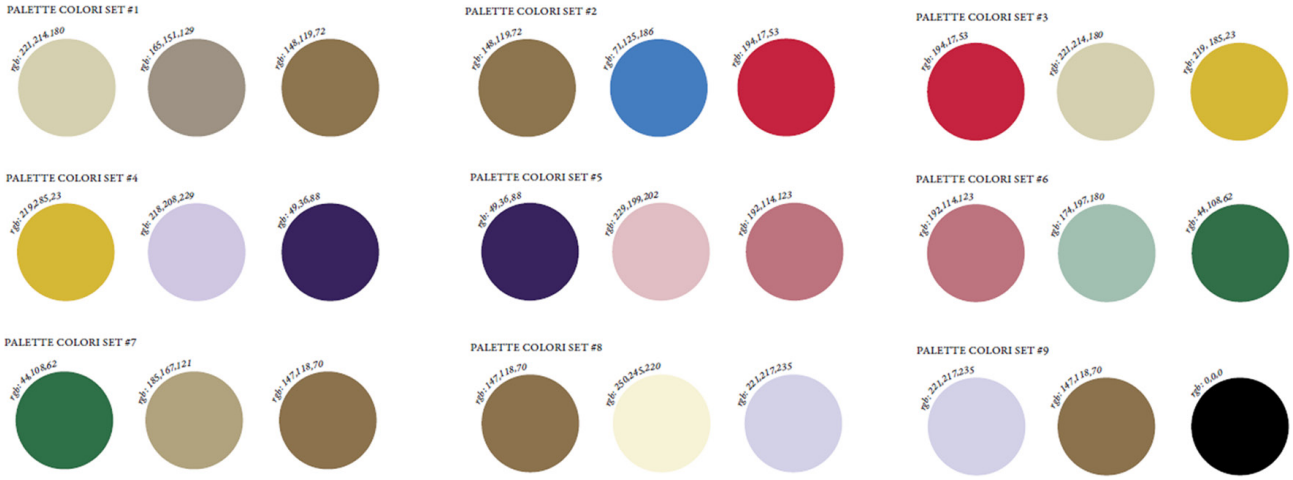


Fig. 10. Palette of colors used for the design of the futuristic manifesto spot.

an impacting font, which reflects the aggressive canons of Futurism, the *Impact* font for the note (designed in 1965) with a thick body.
Subsequently, from the recital of Carmelo Bene's Futurism manifesto, some modalities of variation of the voice used during the monologue were selected in relation to the sense of communication: babbling, whispering, slurred speech, amplification, warbling, stridency. They were also associated with different graphic effects to attract the attention of the user through the simultaneous use of different languages, techniques and methods: a sense of static, speed and dynamism of words; use of mathematical signs; presence of onomatopoeias; typographical compositions of some pieces of text according to axonometric or perspective installations; graphic allusive signs of depth. Similarly, the visual direction for the changes of the periods (in the performance) or of the words/phrases to which emphasis was given in respect of communication was carefully evaluated (fig. 13).

Conclusion

The sources mentioned and the experiments carried out are witness to the strong value of the design: its ability to communicate through forms (static or dynamic; analogical or digital; etc.) but, at the same time, its potential to be interpreted by the viewer [Falcidieno 2008]. The design alludes to the 'other' interpretation because the drawing is above all a cultural expression and, the more it can allude, the more cultured is the culture of the observer. The sources mentioned belong to a specific historical-cultural context. A context that justifies their use as artistic manifestos, creative tools for ideological positions of thought. In all this, design has assumed a crucial role: a never neutral role of intermediary, a medium that alludes to and which, at the same time, denotes.
The physical 'movement' that a body performs in space integrating itself with time, can be drawn statically (and, then, the drawing 'alludes' in the eyes of one who stretches to movement) or can be dynamically designed thanks to animation. The animated drawing no longer alludes to the visual perception of the movement, it is itself physical movement, real movement. The video-graphic products proposed through the two experiments are translated into animated drawings based on the creative relationship between field, writing, acting, sound, memory, etc., and, in this sense, 'communication' increases, which becomes multimedia expanding even more the already usual allusive power of drawing.
On these assumptions, the experimental theme of audio-visual communication using the kinetic typography technique was developed in laboratory form through univer-

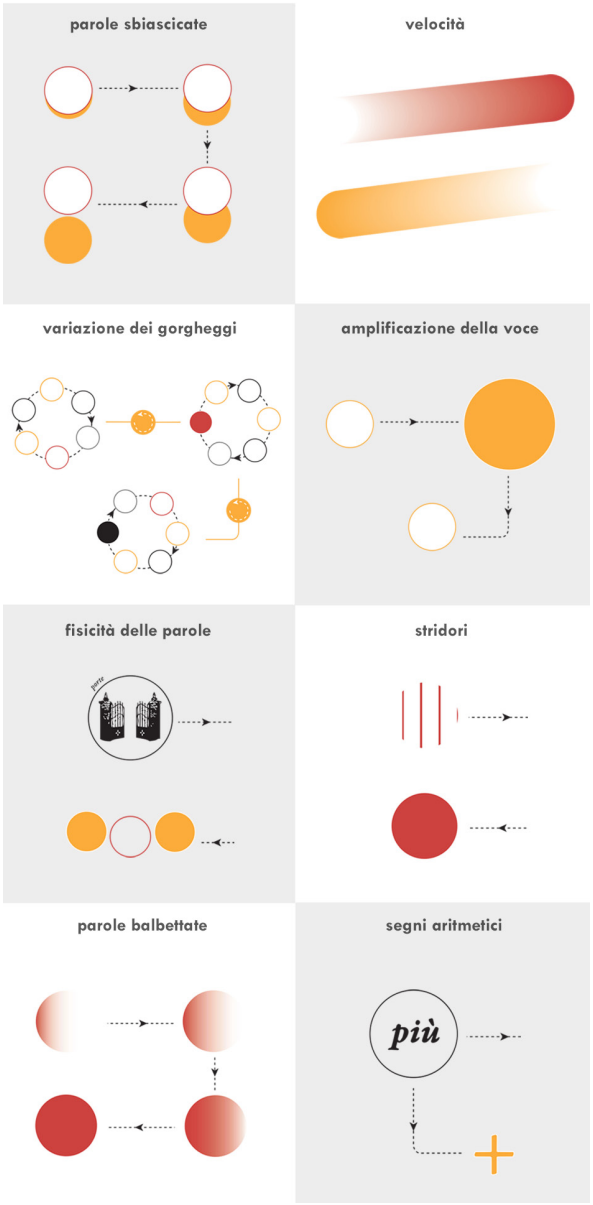


Fig. 11. Advert on the Futurist manifesto: acting effect, graphic effect.

Fig. 12. Advert of the Futuristic kinetic manifesto: kinetic typography frames.

sity-level didactic training and on the full awareness of the theoretical-scientific foundations of representation. The projects realized were configured as short-term videographic adverts and are part of the audiovisual narrative in relation to the creative relationship between visual writing, acting, sound, title design, heritage [2].
However, they are the outcomes of historical-cultural results (the artistic avant-gardes, here the Futurism), scientific-disciplinary foundations and technological contextualization. The reflection on the technological contribution to the methods and choices of the project deserves a separate reflection as technology has always been identified as an opportunity, a potential in continuous transformation and always more innovative than the previous one. The design experiences proposed here based on the current technological outcome could already allude to immersive virtual reality, suggesting the setting up of multi-sensory journeys (also for the senses of smell and touch [3]) within the manifestos proposed both in the form of design and written text and, tomorrow, forms of communication and experiences that are unimaginable today even though our body and mind is the first multimedia device.

Notes

[1] The exhibition entitled *Il Futurismo – Anni '10 – Anni '20. Boccioni, Balla, Carrà, Depero, Sant'Elia, Severini, Sironi, Prampolini* was set up in Naples from 19 October to 17 February 2019 in the *Museo Civico of Castel Nuovo*.

[2] An experiment on Futurist manifestos was conducted in team within the Graphic Design laboratory (scientifically coordinated by Ornella Zerlenga, Department of Architecture and Industrial Design of the University of Campania "Luigi Vanvitelli") with Antonella Marzano (figs. 5, 8) and Riccardo Onorato (figs. 10-12) and subsequently reworked and contextualized.

[3] An example of research in this field was carried out by Laura Marcolini with *Studio Azzurro*.

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Houses, Objects and Architects. Architectural Drawing in Children's Literature

Alessandro Luigini

Abstract

The research, presented here in summary form, investigates the contributions of architectural drawing in children's books and literature. The role of drawing in aesthetic education, in education for the understanding of space and in the introduction of young readers to the world of 20th century architecture is of primary importance and the research aims to underline as case studies are only simple examples for readers who are cognitively less trained than adults, but describe a precise educational strategy that cannot be derogated from other means.
The historical-critical investigation has its scope of observation the strict contemporaneity and aims to organize taxonomically the works collected and observed, proposing a textual analysis (in a graphic sense) of categories identified through the description and exegesis of some emblematic cases.

Keywords: Illustration, Architecture, Education, Visual Storytelling, Picture Book.

Introduction

The awareness of the need for a specific training in the understanding of space and the figures that compose it from the first years of life, is acquired since the first half of the twentieth century in pedagogical, psychological and artistic field [Dewey 1934; Piaget 1947; Klee 1925]. Specific techniques, methods and methodologies have been developed and applied in the educational field, at every age of life, starting from primary education (3-6/7-11 years old) in which the education process we refer to tends to construct the cognition of one's own proximal space and of the geometrical and chromatic nature of the objects that manifest themselves in it. In addition to this widely acquired objective, in recent years specific attention has rapidly developed to heritage education, both tangible and intangible, with multiple implications: from aesthetic one to education to the value of the history of our civilization, from education to arts as an expression of individual creativity to education to the quality of architectural spaces to stimulate a shared need and not only elitist [1].
One of the preferred tools, according to our thesis, is representation in all its forms, from the graphic sign to photography, passing through multi-material and digital elaborations. Literature on the subject is boundless and it is difficult even to select a limited number of studies that have focused on the ways in which representation can be related to education in space, the city and architecture as a form of artistic expression. For this reason,

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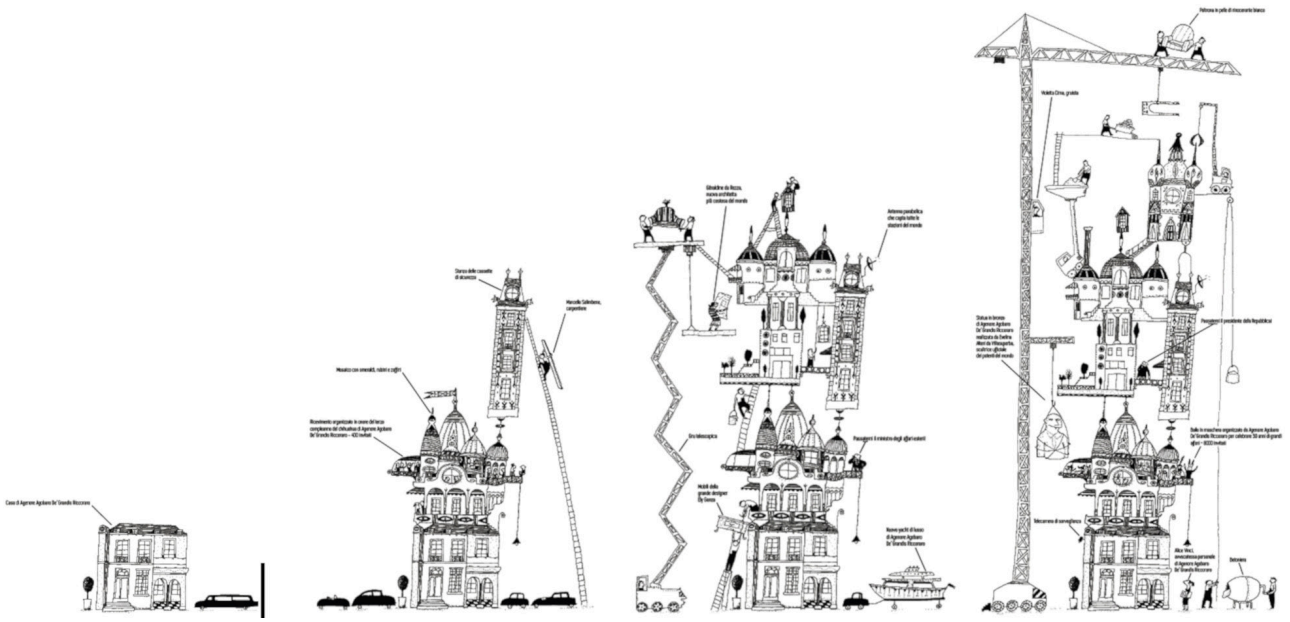


Fig. 1. Four phases of the elevation of the house of Agenone Agobaro De' Grandis Riccoraro, one of the two billionaire protagonists of Skyscrapers by Germano Zullo.

we will mention only a few texts to whose bibliographies we refer for a more extensive treatment: in the field of graphic sciences we point out *Intelligenza grafic*a [Cicalò 2016], in the pedagogical field *Arti visive nella didattic*a [Panciroli 2012] and in the psychological field *Il significato del disegno infantile* [Oliverio Ferraris 2012].
The research presented here is a summary of a historical-comparative investigation, in which a specific medium – the illustrated children's books – is identified as a support for the process of heritage education and whose specific system of representation is the design of architecture.
The books examined are mainly analysed from the iconographic and iconological point of view, and later from the pedagogical point of view, and the result of which, in essence, is revealed by the definition of a taxonomic organization and by the exegesis of some case studies that can be 'read' (literally or metaphorically) according to a semantic stratification of great depth [Luigini, 2018b].

Signs and drawings

The case studies collected are diversified by origin, technique and target, but have in common the leading role of architecture (or design) both in its authorial and anonymous form, always with a characterization useful to the process of cognitive transfer that in the young reader allows the formation of that spatial and figurative competence that we referred earlier.
Moreover, in the interest of underlining how these illustrated books [2] currently hold the educational potential for architecture that we have already anticipated, we have used their current presence in the catalogues of their respective publishers as a further criterion for the selection of volumes [3].
In the taxonomic organization we have identified some categories that we will describe in detail below.
The categories identified are:
- stories set in invented architectures;
- stories containing authorial architectures;

- travel books;
- non-fiction books;
- books published by architects;
- architectural monographs.

It is clear that these categories can sometimes be interconnected and some books can be counted in either category. For example, some architectural monographs, as well as travel books, do not in themselves aim to tell a story, so it would be possible to include them in the non-fiction category. Like some books that tell stories containing authorial architectures, they are actually monographs of architecture or design [4]. Or the category of books published by architects, which we previously considered as a subcategory of non-fiction books [Luigini 2018b] because in almost all cases they share the basic non-narrative approach, but as the collection of texts belonging to this category increases, it was possible to verify how certain peculiarities –which we will present below– made it a *de facto* autonomous category.

The description of the books that will accompany the various taxonomic categories, here, is operated with criteria of innovation with respect to the literary tradition and graphic and representative quality.

Invented architectures

In the story told in Germano Zullo's book *Grattacieli* [Zullo 2018] (fig. 1), two eccentric billionaires compete in the construction of the most eccentric, sumptuous and bizarre dwelling, starting from two buildings on which, page after page, through the work of architects with unlikely names (Arthur J. Sciacallo or Géraldine du Rezza), are configured with the addition of new rooms and new functions: from the most reasonable 'ultra-modern kitchen' and 'mosaic of emeralds, rubies and sapphires' to the 'cinema', the 'walk-in closet with 6,000 seats' and the 'pool with wave generator'. A senseless rivalry, where the epilogue seems to be already written in the shaky structures designed with a dry style –almost in memory of the building site executives– full of details that become expedients for the narrative. The page of the book also assumes its own role and, strengthened by the adoption of a Mongian projection, the limits of the sheet become a visual field whose line of land remains unchanged throughout the book and whose void at the top of the first pages seems to virtually contain the space of the

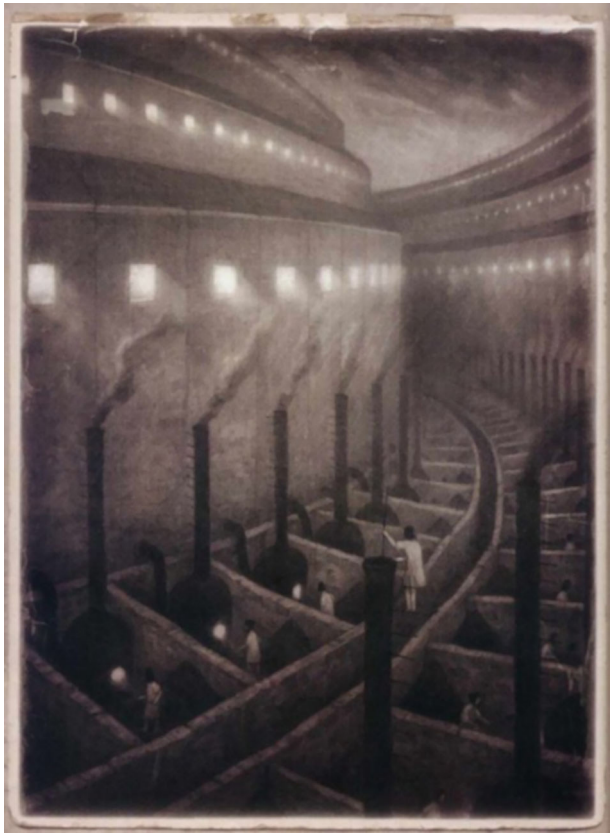


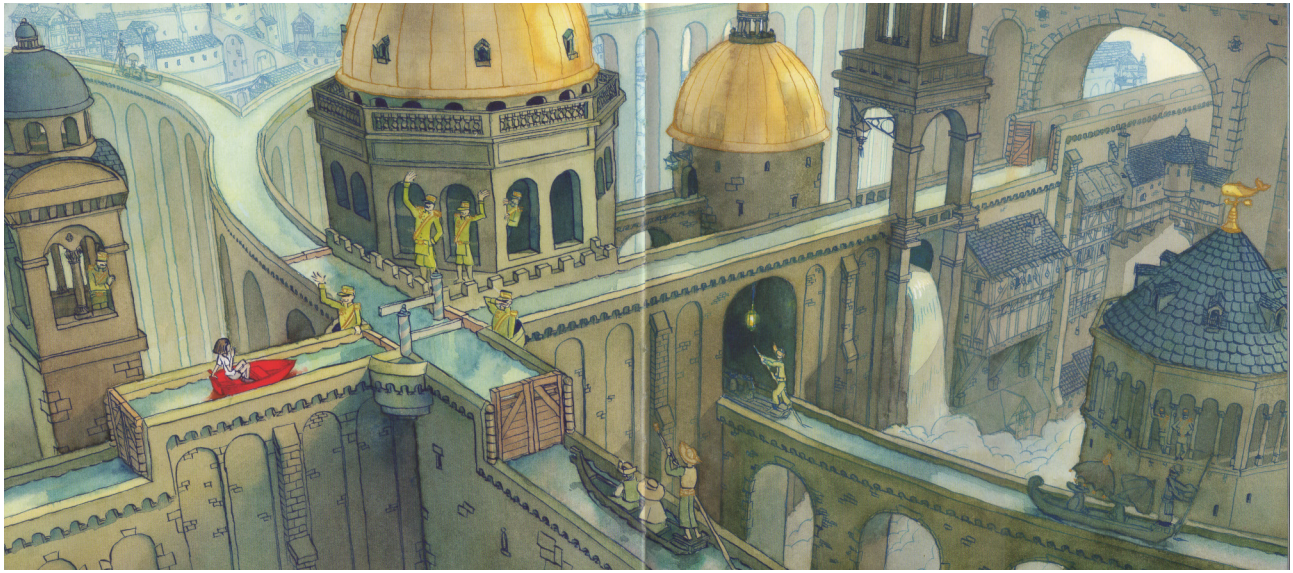
Fig. 2. Illustration taken from The Arrival by Schaun Tan with the perspective openly inspired by the famous engraving by Gustav Dorè Over London by rail (1872).

imagination of that continuous figurative invention that the story will prove [5].
Distant from the carefree and ironic nature of the two books just mentioned –but also distant for the stylistic choice that perhaps shows the widest audience compared to the previous ones– Schuan Tan's *The arrival* [Tan 2016] (fig. 2) is a silentbook that has received well-deserved international fame for the elegance of its settings, the refined graphic technique and above all for the narrative capacity of a theme so controversial such as emigration. The protagonist leaves his place and his affections to find his fortune elsewhere, but this 'elsewhere' reveals itself very quickly as a place to interpret, where everything is different from his previous experience. The beauty of the settings designed by Tan is such that, also in dramatic moments of the narrative, the eye is attracted by the bird's-eye perspectives, or by others with an ant's-eye perspectives, to run from building to building a multitude of architectural inventions that in many cases declare their debt to direct references, never hidden: this is the case for a church that seems to recall the Cathedral of Siena or for the large hall where the emigrants arrive, designed on the model of the hall where the emigrants actually arrived on Ellis Island, but above all for the perspective of the terraced houses taken up, by the same admission of the author, from the famous engraving by Gustav Dorè *Over London* by rail contained in *London. A pilgrimage*, published in 1872.
Aaron Becker has published a successful trilogy of silent books consisting of *Journey, Discovery and Return* (fig. 3). These are three stories of a little girl who, like a modern Alice, enters a fantasy world through a small door, but the surprising invention, probably autobiographical, lies in the way this door materializes in the book: the little girl, in fact, finds a red chalk on the ground in her grey room and it is with this one that she draws on the wall the door through which the story comes to life. In this case, the drawing becomes the place of the imagination, the place of the project of fantastic architectures, and through the drawing the protagonist becomes free.

Authorial architectures

When a reader without specific competence approaches a book belonging to this category, he may not distinguish it from those belonging to the previous category, interpre-

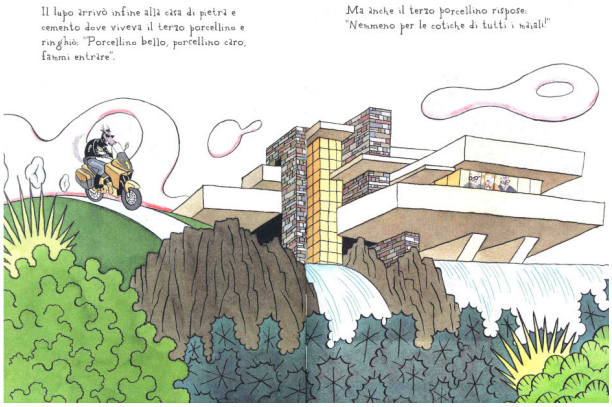
Fig. 3. Table taken from Journey by Aaron Becker, that predents an updated version of Alice in Wonderland.



ting as 'extravagant' or mere 'curiosity' the formal and spatial solutions of the buildings and objects he encounters in the narrative. Only in a few cases, and specifically in those where historical buildings are dealt with, could it be possible to recognize values that elevate the subjects of these illustrations to real monuments.
The case of the crossroads of characters named 'Frank' in Young Frank, architect [Viva 2013] an architect illustrated by Frank Viva, is different. It tells the story of the young Frank, who feels like an architect and builds bizarre tangles of objects, and the elderly Frank, his grandfather, an architect too, who reprimands his grandson for the lack of rules in the composition of his projects. Because of this distance of approach and for a moment of demotivation of little Frank decide to visit the MoMA in New York, where the two ones know the works, among others, of two other 'Frank' –Frank Gehry and Frank Lloyd Wright– realizing that grandfather Frank had lost the enthusiasm for discovery, for the excitement of architecture. The book, for its refined settings, is full of cultured quotations of twentieth-century design objects, and this makes it even more a valid tool for education about heritage and architecture.
Another exemplary album is the interpretation by American illustrator Steve Guarnaccia of the classic children's literature *I tre porcellini* [Guarnaccia 2009], in which he first of all characterizes the three protagonists –who are known to 'build houses'– such as the three most important North American architects of the twentieth century, or Frank Lloyd Wright, Philip Johnson and Frank Owen Gehry, and then studded the narrative environment of architectural masterpieces of the last century, from the villas of Greene & Greene to Glass House by Johnson, from the Einstein Tower by Mendelssohn to the Fallingwater by Wright (fig. 4), from the Gehry House to the Pyramid of Louvre. Every single environment in which history takes place and every single object in history –with the exception of a curious polka dotted concrete mixer– is taken from the history of architecture and design of the twentieth century. But Guarnaccia's innovation with respect to other similar texts is manifested in the guard and counter-guard of the volume where, far from being a decorative expedient, he re-proposes all the drawings of the works contained in the volume, indicating their title, author and year. Guarnaccia builds a 'map' with which to navigate the masterpieces designed by him but not only: it allows the adult who reads the story to the child –the fairy tale is suitable from about 2 to 5 years old

Fig. 4. The Fallingwater by Frank Lloyd Wright taken from The Three Little Pigs by Steven Guarnaccia.

Fig. 5. Illustration depicting the Trevi Fountain taken from This is Rome by Miroslav Šašek.



so the reading of the text component must necessarily be mediated by an adult– to be able to find himself the multitude of stories that lie behind each drawing [Luigini, 2017]. From the architecture of Gehry and Deconstructivism to Johnson and all the styles he mastered, from Ian Ming Pei to Piacentini, from Neoplasticism to Mies van der Rohe, from Buckmister Fuller to Achille Castiglioni: everything becomes accessible thanks to the illustration of Guarnaccia.
In 2018, Mario Bellini, to whom the Unione Italiana per il Disegno gave the gold plate the same year, edited *Il design spiegato ai bambini* [Bellini 2018], with illustrations by Erika Pittis, in which he describes his projects and the principles that inspired them, starting from his childhood. A journey through the history of Italian design through the work of the author who aims to transfer not so much the value of the architect's projects, but the autobiographical path fueled by passion, curiosity and the need to express an emotional creativity.

Travel

Travel has always been a recurring theme in children's literature, and if in many cases it acquires the meaning of a journey in search of inner growth, happiness or discovery of the world (from the epic Herculean vicissitudes to *Cappuccetto Rosso*, through Johnatan Swift's *Gulliver's travels* and many more recent ones, such as Tan's *The arrival* and Aaron Backer's trilogy), it should be noted that in recent decades there has been a proliferation of children's travel books dedicated to real tourism. And why not, even if imagined, but still set in real places.
Individual cities or entire continents, told to children by illustrators, are presented as a kaleidoscope of new, heterodox, often simplified but never naive points of view on architecture and monuments.
Miroslav Šašek, born in the nascent Czechoslovakia in 1916, after having studied architecture and found himself exiled from his native land, illustrates the famous *This is*

Fig. 6. Some pages taken from Opposites with Frank Lloyd Wright.

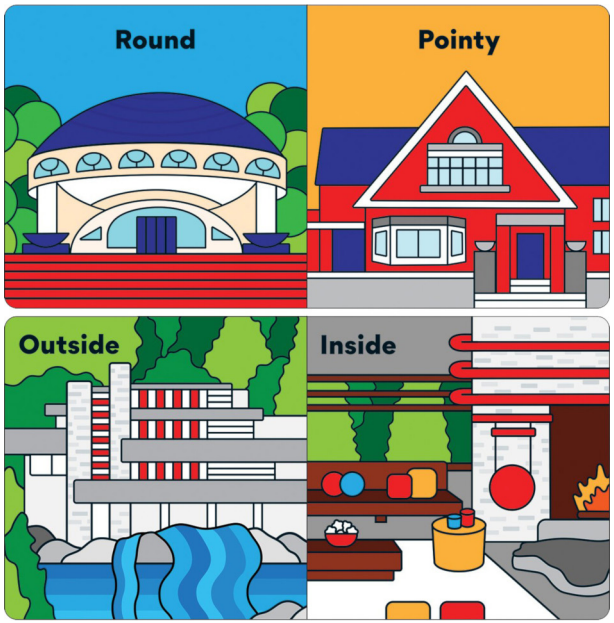


Fig. 7. Pages dedicated to Berlin from Metropolis by Benoit Tardif.

Paris in 1959, subsequently replicating his approach and editorial proposal for dozens of other cities, including, in 1960, Rome [Šašek 1960].
This is Rome (fig. 5) is made up of 27 watercolour plates measuring 46x31.2 cm, composed of about 100 drawings and texts by the same author, of which at least 30 are architectural drawings or urban views. In some cases a mixed technique is used, which consists in inserting black and white photos of some sculptural works in his drawings [6]. The general approach, recounted by Šašek himself, is that of an extraordinary draughtsman-traveller, who roams like a voluntary shipwreck in the amazing richness of the cities he visits: he tells us that he liked to get lost in the streets and squares carrying with him a notebook to draw, starting with the visit to the main monuments and then continuing until he discovers some substantial but sometimes hidden features of the different urban realities he went through. In real life, he drew numerous sketches –a urban sketcher *ante litteram*– which he subsequently re-elaborated and laid out, often composing more than one sketch in a single table. His fast, clear and never usual line, combined with a direct and often ironic narration, has made his illustrated books true masterpieces still today, at the threshold of sixty years from the first edition, regularly exhibited in bookshops all over the world. The predilection, then, for the central perspective, and a rarer application of the accidental perspective, is an indication of a stylistic approach that allows a clear and in-depth reading of both the proportional schemes – for example, the Trevi Fountain or the staircase of Trinità dei Monti – and the decorative parties, sometimes represented with a detail that would not be expected in an illustrated book for children.
Metropolis by Benoit Tardif [Tardif 2017] (fig. 7) is a visual guide to 32 major cities around the world, dedicated also but not exclusively to children. The book has a setting that recalls, rather than a paper album of photographs and clippings, a collection of shots taken with the smartphone and displayed in the form of thumbnails, where the text is reduced to the indications of the subject of each drawing and where the visual story captures the full attention of the reader. The drawings are very schematic, coloured with flat and saturated colours and an economy of details of the individual buildings that seems to give way to the need for direct experience: it will be useful to understand their value, taking into account the fact that these books were designed and produced in an age of visual overexposure and that the high-definition images of each single work are within anyone's reach and can be reached with a few clicks. Drawing, therefore, is free to express other values at the expense of verisimilitude, promising – rather than revealing – the beauty of the visit to the cities it tells.

Non-fiction

In the years of the abuse of the term 'storytelling', we probably felt the need to define as a unit that heterogeneous set of books that have no narrative content, that do not tell stories. Also in the children's publishing offer, the distinction –not always so clear– between books that follow a plot and books that present contents with alternative intentions, is becoming increasingly necessary. The particular character of this category requires more specification in the subcategories that we introduce below.

Concept books

Some books introduce children to elementary concepts and notions that in exemplary cases use works of architecture or design to pursue their own purpose, even if apparently alien to the creative context.
Two small illustrated books, for example, use what we might call the 'graphemes [Luigini 2018] of Frank Lloyd Wright's architectural language to introduce children –pro-

Fig. 8. Illustration depicting Uncle Oscar sitting at one of his 26 chairs of author taken from Uncle Oscar's chair. From A to Z. by Magnus Englund and Daniel Frost

Fig. 9. Table of the book Le nostre città ieri e oggi. The image above reproduces the book as seen with the naked eye, while the three images below simulate the vision of the book through the three red, green and blue colored lenses.

bably aged 2-4 years– to geometric forms and 'opposites'. *My first Shapes with Frank Lloyd Wright* [Ortiz 2017] and *Opposites with Frank Lloyd Wright* [Ortiz 2018] (fig. 6) are two small volumes that, through architectural drawings, teach the classification of geometric forms, the first, and the distinction of opposing concepts (hot/cold, inside/outside, day/night etc.), the second. In this case, through the skillful graphic elaboration of the illustrator, Frank Lloyd Wright's architectures become geometric forms poised between a figurative syntax and an abstract grammar, without betraying the original sign and keeping all the works perfectly recognizable.

ABC

Adding a narrative component [7], *Uncle Oscar's Chairs. From A to Z* by Magnus Englund and Daniel Frost [Englund, Frost 2018] (fig. 8) is the chronicle of two children visiting their uncle and asking him to tell them about the 26 chairs he keeps around a large table, each one with a name that starts with a different letter of the alphabet. At the sight of the incredible shapes of their uncle Oscar's chairs, little Jack and Molly are unable to restrain their curiosity, and so a journey through the masterpieces of twentieth-century design starts, in an exchange of questions and answers between the protagonists that intertwines history, design and imagination. As a demonstration of the anthological intent, the authors indicate the name of the chair, the author and the year of production on the top right of each table.

Reference books and atlases

Among the non-fiction books a certain number is dedicated to the presentation of information on the most diverse themes, from history to science, from nature to the biographies of historical figures, and are usually organized according to chronological or thematic criteria. In this varied landscape you can often find books that deal in some way with the theme of architecture and the themes surrounding it (the city, design etc.).

The book *Case nel mondo* [Pesce, Tonello 2018] (fig. 10) published by Electa Kids, with texts by Maria Paola Pesce and illustrations by Martina Tonello, takes us on an imaginary journey through different and distant places, located all over the world and characterized by different climates and cultures. The narration is only a device to introduce the double-page illustrations –4.4x37 cm– in which the houses are immersed in their environments (urban or rural) and of which you can observe in detail the destinations of the environments that compose them but also the furniture and objects that together with discreet characters, inhabit it. These are illustrations that speak of everyday domestic life, and that introduce the reader to an understanding of the relationships between spaces and their functions.

Of great interest, the editorial series '*libri lente*' by the Italian publisher Sassi junior, is composed of four volumes of which three on scientific topics (human body, animals and nature) and one on historical-architectural issues. The last one, titled *Our Cities Yesterday and Today*, shows thirteen major cities and capitals from around the world (Paris, New York, London, Rome, Berlin, Dubai, Tokyo etc.) through drawings of urban views whose protagonists are famous

Fig. 10. Two houses from the book Case nel mondo. by Maria Paola Pesce and Martina Tonello.

architectural monuments, with the addition of an urban plan in the background. But the aspect of primary interest is the device of representation used: a 'mask' through which to look at the book, has three colored lenses (red, blue and green) each of which inhibits the feeling-perception of the traits of the figure drawn in the same color, thus revealing, or rather making visible, from time to time a different part of the illustration (fig. 9). The red lens shows us the view of the city and the monument *as it was yesterday*, the green lens *as it is today*, and the blue lens shows us the plan with the indication of the position of the monument, or *where it is*. The reader can thus recognize the great monuments now in a state of ruin (Parthenon and Colosseum) and see them as they were at the time of their construction, or the great modern and contemporary monuments (Eiffel Tower, Burj Khalifa, Empire State Building or the crossroad of Shibuya in Tokyo) to see them as they were under construction or as the cities were before their construction. All of that contextualized with characters and means of transport, terrestrial or air, of the time.

Architects editors

Many of the books listed in the entire taxonomy are written or illustrated by architects, but some of them –specifically those listed in this category– are different at least in one peculiarity: the editorial proposals presented here –talking about 'books' seems to us to be a semantic limit– have to do, as individual titles or as entire editorial activities, with 'doing design' rather than with the history of architecture. They are experience books, for the visual or spatial design of architectural or urban configurations. In some cases they invite the reader to interpret architecture and urban views, in others to graphically describe their daily experience.

The independent publishing house Tower Block Books [http://towerblockbooks.com/] was founded by a designer and an architect and the books they publish generally have as their theme the relationship between architecture and imagination, especially, but not only, childish. In their *The Big Letter Hunt* [Amandine, Nieto Ferreira 2014; Amandine, Nieto Ferreira 2016], the discovery of the city becomes a game of references between photography and typography, with which to discover the alphabets hidden in the architectural views that follow one another in the urban experience. A game of forms and points of view in a changing perspective, which promotes an attitude of observation capable of combining reality and abstraction, volumetric vision and two-dimensional projection.

All the titles of Tower Block Books concern architecture, or rather, as they explicitly state on their company website, they concern 'places': cities, streets, domestic environments, but still significant spaces. As in the case of *My bedroom* [Nieto Ferreira, Bowers 2017] or *What did Alex see?* [Nieto Ferreira, Vigrass 2017], and a publication on public buildings is being prepared that looks interesting because it follows a call for drawing in which more than 250 illustrators from over 45 countries participated.

French architect and illustrator Fanny Millard has published several books for children, all of them somehow focused on the theme of the elaboration of spatial configurations. Some, perhaps closer to architectural monographs but with a fundamental experiential component, are books presenting Parisian or French monuments to be redrawn by connecting a series of numbered points. Even less narrative than others, based entirely on the construction of

Fig. 11. Organic Space. Le livre maquette pour découvrir le paysage by Fanny Millard. Experiential books can be freely configured and combined with others to build a myriad of imaginary landscapes.

experiences of spatialization in which body, space and book become indispensable parts of a significant whole, Basic Space. Le premier livre maquette [Millard 2016] and *Organic Space. Le livre maquette pour découvrir le paysage* [Millard 2017] (fig. 11) are experience-books, useful for elaborating and exploring multiple configurations starting from a single object-book or from several object-books combined with each other.
Like Fanny Millard's books, other authors have also developed editorial projects that make experience a way of training creativity and problem solving. It will be useful to remember Studio Roof kits such as *Archiville* or the series of world capitals (from Barcelona to London, from New York to Tokyo) that constitute a selection of monuments of ancient, modern and contemporary architecture capable of identifying symbolic elements of individual cities.
Finally, there is the *Stampville* kit [Débat 2017] (fig. 12), a set of stamps containing the basic elements of an architectural grammar that can be adapted both to traditional contexts and, freely composed, to more refined, innovative and contemporary contexts.

Monographs

This taxonomic category is certainly one of those that most attracts our attention because of the direct relationship between children's illustration and authorial architecture, but also because the pedagogical objective of these volumes is, in particular, to bring young readers closer to modern and contemporary architecture.
In recent years, volumes of this kind have multiplied, and on the basis of narrative methods similar to travel books, it is possible to tell directly, and without further filters or mediators, the work of great architects, from Antoni Gaudì to Zaha Hadid, passing through significant works such as the Fallingwater by Frank Lloyd Wright.
As Janette Winter tells us, the gestation of the book *The World Is Not a Rectangle: A Portrait of Architect Zaha Hadid* [Winter 2017] (fig. 13) lasted a few years because from the moment she was struck by Hadid's architecture she first tried to get to know the designer through architecture books, according to the author too specialized and impenetrable to non-experts, and then tried to understand it by following lectures and interviews on Youtube to hear from her speakerphone descriptions of the projects and the design process. This direct approach to Hadid's words

Fig. 12. Kit Stampville to build architecture and city images starting from the basic elements of the individual stamps.

Fig. 13. Table taken from The World Is Not a Rectangle: A Portrait of Architect Zaha Hadid by Janette Winter in which we see a Zaha Hadid intent on drawing.

allowed Winter to figure out her own illustrations as representations of memories or dreams of the Anglo-Iraqi archistar, leading the reader to an intimate and profound knowledge of the character and his approach to the project.
The books in the *Who Build That?* series by Didier Cornille [Cornille 2014a; Cornille 2014b; Cornille 2016] (fig. 14), on the other hand, are probably dedicated to a public of a higher age group, because they are organized as didactic atlases and the projects are presented starting from a brief biography of the author and then continuing with a description of the work and then the drawings, almost always more than one. Cornille's drawings are unmistakable: his minimal, detailed and precise coloured strokes refer to the canonical projective models, passing from time to time from an ant's eye perspective to an oblique axonometry or to a central perspective with some passages with an exploded axonometric. Cornille's imagery is an imagery that is closely linked to the world of architecture and design: after graduating from the Ecole de Beaux-Arts in Lille after his meeting with Ettore Sottsass, he himself worked as a designer. From these experiences, the French illustrator derived his autograph trait, so familiar to those involved in architectural design that it makes us think that the recipients of his books are not only primary school children but, probably, also adults. In any case, these volumes remain poised between specialist monographs and narrative, bringing architecture into children's readings but through stories inspired by reality or stories of invention. In this case, as we will explain in more detail in the conclusions, the design of architecture mediates between the complexity of the work and the cognitive level of the reader, allowing in fact a perception that would not be possible even in the presence of the original work.

Conclusions

Our work consisted, as it is clear from the brief descriptions given, in the taxonomic cataloguing and analysis of each volume according to four different codes: a) the *iconic code*, b) the *graphic* and *type-graphic code*, c) the *mediation code* and d) the *pedagogical code*.
The *iconic code*, clearly, concerns the representative qualities of the illustrations, their character, their level of modelling with respect to the real subject, their projective system and other characteristics similar to these. The *graphic* and *type-graphic code* concerns the way in which the illustrations are presented to the reader, the relationship with the text, the choice of materials and format. The *mediation code* concerns the way in which illustration makes possible not only the 'recognition' of a given subject (in this case remarkable architectures and design objects) but above all its ability to set in motion the cognitive transference and, subsequently,

Fig. 14. Drawing depicting the Brooklyn Bridge taken from a book in the Who Built That? series by Didier Cornille.

to develop in memory that imaginary that makes the reading experience a truly formative experience. Finally, the *pedagogical code*, partly integrated with the previous one, concerns the specific training objective, which can be the development of creativity (*Iggy Peck Architect* or *Stampville*), spatial cognition (Fanny Millard's books or those of the Tower Brick Books), the construction of a specialized imaginary (*I tre porcellini* by Guarnaccia or *Baby's first Eames*) or the formation of a metaphorical idea of personal growth (*Journey by Aaron Becker*) but also others.
However, what results from the study of these volumes is that our initial hypothesis seems to be valid in any case: the representation of architecture, in this specific context, is the optimal medium for carrying out the processes necessary to achieve the pedagogical objectives we have listed. This happens for some reasons, the main one probably being the mediation that the drawing allows between the complexity of the work in reality and the reader, on average a child aged between two and eleven years. The drawing, the result of the discretization of reality carried out by the illustrator, finally makes a complex artistic expression such as architecture accessible to an otherwise impermeable public. But the illustrator's drawing is not the only drawing that enters into these processes: without dwelling on the pedagogical role of redrawing, which we give as an acquired fact, it is evident how this discretization (and if we want, as an example) makes the work of architecture accessible not only to the child's gaze, but also to his hands, to his graphic abilities. So in the didactic field, as we are already experimenting, it is possible to structure didactic units that contain phases of drawing of the child, taking as a model the illustrations of the books. Drawing, therefore, what they would not be able to draw from life or from a photographic image.
Drawing, in these cases even more, represents, 'makes present' architecture in a way that children can 'read' it –with their eyes and with their own drawing– and in so doing it makes concrete an art that, otherwise, would remain invisible to the eyes of children. It is, therefore, through drawing that children can be educated in heritage and know, more or less in depth but increasingly from more points of view– figurative, plastic, spatial, historical, experiential, imaginative, etc.– architecture and its possible declinations.

Notes

[1] Directive MIUR 107/2016 recognizes the educational role of cultural heritage, and is followed the next year by the *National Plan for Cultural Heritage Education*. In fact, although the dissemination of these policies is rather encouraged, the activities are still in the development phase, and a comprehensive validation phase is still missing.
A parallel could be suggested with similar French policies, which have been promoted for some time and whose references can be found in Casonato 2017, notes 1-3.

[2] In specialized scientific literature, the term illustrated register is preferred to illustrated book, because in the case of children's literature the texts are mainly illustrated, the relationship between images and texts is diametrically opposed to that of an illustrated book where the images illustrate the text that would be readable autonomously and sometimes the text is completely missing –in this case we speak of a *silent book*– such as the numbering of pages, which is normally absent. The size and physical characteristics of the book also make it easier for children to handle it, but also for the illustrations to be reproduced in greater detail. For a complete discussion of the subject, see: Faeti 1972; Farnè 2002; Beseghi 2006; Beseghi, Grilli 2011; Terrusi 2012.

[3] The research was developed from the end of 2016 to the present day and the integration of new titles takes place at such a rate that it would seem that the production of these illustrated books is following a growing trend. Suffice it to say that in the six months between September 2018 and February 2019 more than twenty titles were taxed.

[4] This is the case for the edition of Steven Guarnaccia of *I tre porcellini* e *Riccioli d'oro* e *i tre orsi*, and some others.

[5] Marcella Terrusi speaks of the gap that is created in the empty space between the text and the images, and that "presupposes the active presence of an 'implicit reader', that is, a reader capable of venturing into those empty spaces to build his interpretation of the text, his understanding and personal imagination, in the active mechanism of reading and discovering the text" [Terrusi 2012, p. 99].

[6] Technique that he will later develop in the ironic *Questa non è una pietra* [Šašek 2018], recently reissued by Quodlibet, where, following his stay in Rome, some classical and Renaissance statues are reinterpreted in unlikely and irreverent situations: so the Moses of Michelangelo finds himself traveling on a Vespa, the Medusa of Bernini goes to the coiffeur and Marcus Aurelius dispenses coffees in a bar.

[7] As already mentioned, some texts go beyond the limits of a taxonomic classification and contain components attributable to several categories. In this case the volume could have been catalogued in the same way as *Il design spiegato ai bambini* by Mario Bellini, but we preferred to highlight the methodological character typical of ABC books.

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Practices and Models of Information and Management

Innovation transfer and new technologies skills

Professional and industrial applications of drawing and survey

Drawing in contemporary design between interoperability and construction management

A Living Architecture for the Digital Era

Carlo Ratti

The history of architecture has been punctuated by transformations sparked by sudden technological leaps. During the mid-1400s, into the context of a craft-based architectural tradition, Leon Battista Alberti introduced a mathematical approach to graphic representation. In doing so, he paved the way for Renaissance classicism: architecture focused on precision and representation through drafting rather than approximate construction by artisans. Four centuries later, steel and glass enabled engineers like Isambard Kingdom Brunel, Sir Joseph Paxton, and Gustav Eiffel to design daring and innovative structures that shattered the limits of what could be constructed. Soaring feats of technological prowess became a new aesthetic at the nexus of architecture and engineering. A generation later, at the crest of the mechanical era, Le Corbusier appropriated the tools and forms of mass production, and concluded that the house is a machine for living in. Architecture was optimized not only from the standpoints of design and structural engineering but also from those of mass production and social function.

Technological upheavals are the lurching steps of architectural progress, its driving force. Le Corbusier dreamt of "realiz[ing], harmonically, the city that is an expression of our machinist civilization." Yet our civilization today has transitioned from mechanization to computation. The digital revolution–the convergence of bits and atoms–is poised to be the most radically disruptive change that has ever recast the design, construction, and operation of our built environment. Just as machines brought standardization and high output, digital tools can bring dynamism, variation, and responsiveness. The question now becomes, how will architecture evolve in the digital era?

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Fig. 1. Digital Water Pavilion (image credits: Claudio Bonicco). The Digital Water Pavilion, made for the 2008 World Expo in Zaragoza, Spain. The design teams at the MIT Senseable City Lab and Carlo Ratti Associati (CRA) created a reconfigurable space, with walls composed of digitally-controlled water droplets.

Fig. 2. Future Food District: (image credits: Delfino Sisto Legnani). A 7,000 sq. m. thematic pavilion exploring how digital technologies can change the way that people interact with food for the 2015 World Expo in Milano, by CRA and supermarket chain COOP Italia.

Initial attempts to address this question–to create dynamic architecture for the digital age–were form-based. Designers created evocative architectural sculptures that shout distinctive visual identities: Frank Gehry's iconic Guggenheim Museum Bilbao, for example, and the similar projects he has scattered around the world. These have ushered in a new aesthetic regime of irregular and organic buildings, often called "blobby" architecture. This new formal language was enabled in large part by parametric design software: digital tools that allow the architect to script an internal logic, input data values (objective contextual factors, zoning, or functionality requirements), and run an algorithm to negotiate those constraints and produce formal, often extraordinarily complex artifacts. Rather than detailing intricate specificities by hand, the architect writes parameters, and the computer churns out highly elaborate results.
Parametric software opened a new arena where designers could radically question inherited formal assumptions about architecture. They explored the boundaries of possibility eagerly and productively, assuming that–given an opposition between rational and organic–non-gridded and complex forms have a more vibrant quality. Early theorists of parametric architecture characterized a new sensibility that aimed for "maximal emphasis on conspicuous differentiation" [Schumacher 2008].
The highly visible 2004 Venice Biennale of Architecture, titled Metamorph, explored the "fundamental changes under way in contemporary architecture, both in the theoretical and practical design field, and in the use of new building technologies." The event brought together architects, academics, researchers, and critics at the forefront of computational design. Individualism and experimentation defined the collective rhetoric, but a more cynical view of the menagerie of projects found the differentiation to be superficial. "The computer has finally made possible forms that are different, at the same cost as the standard forms of old. A newness of very similar forms though, more sculptural than radical, buildings and structures with sensual folded, twisted and curving surfaces. It looks more like an international computer art festival […] and the most important theme to come out of the biennale was the question of redundancy." Under the guise of novelty, the common denominator that emerged was predictable manipulations of complex geometry rather than meaningful dynamism.
Parametric tools have granted architects an unprecedented power to generate space using algorithmic functions and to appropriate a rhetoric of vibrancy. As the trend

Fig. 3. Vertical Plotter (at Future Food District) (image credits: Delfino Sisto Legnani). The Vertical Plotter was the world's largest plotter, which painted on the facade of the Future Food District, a project by CRA and COOP Italia at the 2015 World Expo in Milano in 2015.

has developed since Metamorph, however, architects have been hard pressed to find meaningful data to feed into algorithmic design processes. A cruise ship terminal in Japan, for example, was informed by the geometry of waves in traditional paintings, specifically "the Hokusai Wave." The designers were inspired by "a drawing from a local painter that we had been toying with while we indulged in geometric manipulations and construction hypotheses during the design phase of the competition entry" [Zaera-Polo 2005, p. 80].
Furthermore, the application of parametric software, in many cases, goes no deeper than the skin of a building. Algorithms can compute thousands of unique elements to compose a dazzling facade on an otherwise standard structure. Parametric design promises a certain novelty, whether it is driven by geospatial data or by complex matrices of associations.
The virtual dimension that now blankets physical space is burgeoning with data, some of it appropriated by designers to plug into scripts as they seek "to grow or evolve new formal configurations in response to specific forces and constraints: structural, climatic, or programmatic. While this has produced compelling formal results, there are conceptual and procedural limits. The design techniques used to generate these new buildings may be dynamic, but the buildings themselves are static" [Allen 2011]. Architects can generate an almost infinite number of formal solutions in a given situation, but complexity and magnitude are not inherently meaningful or living. "The forms generated may resemble nature, but they retain little of the performative or adaptive complexity of life itself."
Algorithmically generated architecture is a static visualization of larger complexities. To evoke the fluidity of digital space in an inert physical object is to freeze a dynamic process, as if pressing Pause to find a single frame in an action sequence. Even the climax of energy and vibrancy, caught in a still frame, will convey only a shadow of the dynamic whole.

Fig. 4. Patrick Henry Commune (image credits: CRA graphic team). The Patrick Henry Commune is a project by CRA for a center for co-living, co-working and co-making in a former American military village on the outskirts of Heidelberg, Germany.

Fig. 5. Agnelli Foundation HQ (image credits: Beppe Giardino). For the redesign of the Agnelli Foundation headquarters, CRA equipped the century-old edifice with hundreds of sensors that monitor different sets of data, transforming it into a co-working space for the Office 3.0.

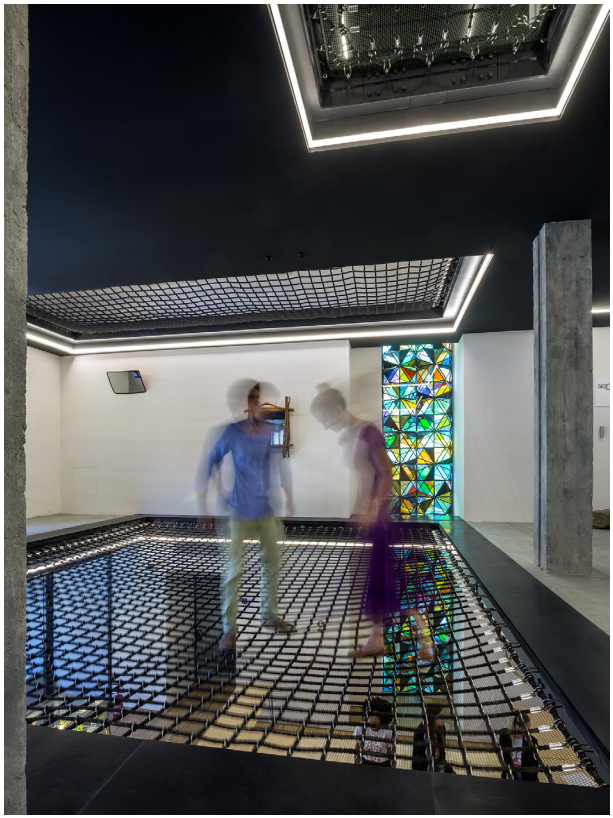

Fig. 6. Agnelli Foundation HQ (image credits: Beppe Giardino). CRA's intervention also added elements to open the building up to the city, and to make it a more light-filled and fun space.

Visual complexity can be computed, but can it deliver anything more than curb appeal?
And is that even desirable? The digital age has already suffused our world with innumerable flows and layers and intricacies, and formal plasticity only adds visual chaos to the ambient complexity. Could digital tools be integrated with architecture, beyond veneer or gloss? How, then, to integrate digital systems to achieve true dynamism? "Being digital is not primarily about using a computer in the design process, nor about making this use visually conspicuous. It is an everyday state that goes in hand with gestures as simple as being called on a cell phone or listening to an mp3 player" [Picon 2006]. That is, architecture should become an integral and responsive part of human life. Architecture must do more than just look like a living organism: it should perform as a living system.
The earliest glimmers of this possibility date back to experimentation with moveable structures in the mid-twentieth century. A group of young Japanese designers, the Metabolists, imagined living architecture for the growing population of postwar Japan. Buildings, they proposed, could be shaped dynamically by the pushes and pulls of socio-dynamic forces. Metabolist structures used biological models, attempting dynamism through, for example, spine-and-branch arrangements or cellularly subdivided megaforms. The architect would establish a master program (or "DNA") that could propagate itself according to a patterned structural system. Few of their structures were ever built. One notable exception–Kisho Kurokawa's Nakagin Capsule Tower, located in central Tokyo–is a paradigmatic example of Metabolist theory. It is conceived as a central spine, onto which individual housing pods can be attached and rearranged. In theory, infinite combinations of pods and connections between them allow residents to create larger or smaller spaces in response to different families, budgets, or changes in housing demand over time. Yet the Capsule Tower reveals a deep conceptual flaw: since the building's completion in 1972, not a single pod has been shifted or combined.

Fig. 7. MIND (image credits: CRA graphic team). MIND is a master plan to reimagine the former site of Milan World Expo 2015, designed by CRA in collaboration with Australian real estate group Lendlease. It features a one-mile long linear park and the world's first neighborhood planned for self-driving cars.

The twentieth century is dotted with similar attempts at mutable architecture–from Gerrit Rietveld's Schröder House to Archigram's Plug-In City–but they invariably fall into stasis or remain unbuilt. An entirely flexible structure still requires inspired occupants to take agency. In practice, mutable buildings go largely unchanged.
Flexible structures may not spark active participation, but it is here that digital technologies reenter the playing field, enabling a more gentle, intuitive, and responsive interaction between humans and the built environment. Far outside the discipline of architecture, pioneering computer scientists and mathematicians of the mid-twentieth century started developing a theory of cybernetics. The emergent discipline sought to explore networks, focusing on communication and connections between interdependent actors in a system.
Cybernetics, according to Gordon Pask, the academic responsible for popularizing it among architects, is "how systems regulate themselves, reproduce themselves, evolve and learn. Its high spot is the question of how they organize themselves." This conceptual framework could be productively applied to architecture. As a

practical design strategy, cybernetics is about negotiating a set of interrelated factors such that they function as a dynamic system. "The design goal is nearly always underspecified and the 'controller' is no longer the authoritarian apparatus which this purely technical name commonly brings to mind. In contrast the controller is an odd mixture of catalyst, crutch, memory and arbiter. These, I believe… are the qualities [the designer] should embed in the systems (control systems) which he designs." The architect becomes a choreographer of dynamic and adaptive forces rather than scripting outcomes in a deterministic way.

Around the same time, architects at the fringe of the discipline took the idea of interactivity and sensationalized it. Architecture became loud, fun, hip, and constantly evolving. Buildings were thought of as venues for action and interaction, as dynamic scenes that could incite events and connections and evoke delight. The Generator Project, by the architect-provocateur Cedric Price, was a clear example of this new attitude. An unbuilt concept for a retreat and activity center, the project consisted of a system of 150 prefabricated cubes, each twelve feet per side, that could be shifted and reconfigured–much like the pods in the Nakagin Capsule Tower–but, crucially, would also interact in a dynamic way. A primitive digital software detected inactivity, and if the building remained static for too long, the software automatically executed "The Boredom Program" to reconfigure its own structure and incite (or perturb) users. The architecture itself took an active role as provocateur, with the aim of enhancing human experience. This was a system for dialogue and mutual reaction, beyond the Metabolists' linear user-changes-building idea. In many ways, this work was an application of cybernetic ideas to the field of architecture: it created systems that would dynamically self-organize in response to inputs and actions.

If the first industrial revolution was concerned with creating machines optimized for a specific task, cybernetics, in contrast, was concerned with a new kind of (perhaps nonmechanical) "machine" that could satisfy an evolving program. "We are concerned with brain-like artifacts, with evolution, growth and development; with the process of thinking and getting to know about the world. Wearing the hat of applied science, we aim to create […] the instruments of a new industrial revolution–control mechanisms that lay their own plans" [Pask 1969]. Translated into architecture, cybernetics means buildings

Fig. 8. Scribit (Image credits: Avocado studio). Scribit is a small write&erase robot that can safely draw, cancel and re-draw content on almost any vertical surface, developed by CRA in 2018.

that function as adaptive learning entities living in a kind of dialogue with their inhabitants.

Active and networked architecture is starkly opposed to recent form-focused attempts at dynamism and may illuminate an alternative path forward. "Today, many designers have turned several late twentieth-century infatuations on their heads, for instance with speed, dematerialization, miniaturization, and a romantic and exaggerated formal expression of complexity. After all, there is a limit beyond which […] complexity simply becomes too overwhelming" [Antonelli 2008]. Rather than using digital tools to mathematically calculate complexity for the visual sense, interactive spaces can use digital tools to generate a new form of complexity: experiential complexity. A shift away from elaborate structures and toward structural dynamics entails buildings that perform as (rather than appear to be) living organisms.

Computation will not be used only to define intricate shapes according to parameters but will also become an integral part of the building, interacting with users according to a program. This interface functionality points to embedded rather than generative technology. In addition to plans and sections, architects in this future will be free to specify a system of interrelated sensors, operations, and actions–loops that bring architecture to life, based on a dynamic set of experiential and functional requirements. Grounded in communication and learning systems,

Fig. 9. The Dynamic Street (image credits: David Pike). In collaboration with Alphabet's Sidewalk Labs, CRA developed The Dynamic Street, a prototype of a modular and reconfigurable paving system hinting at the possibility of the future streetscape seamlessly adapting to people's needs.

Fig. 10. CapitaSpring (image credits: BIG). CapitaSpring will be a 280m tall high-rise on 88 Market Street, Singapore, jointly designed by CRA and BIG-Bjarke Ingels Group. The tower will be one of the tallest in Singapore, blending urban life with tropical nature.

sensor networks can transform buildings into intelligent agents with the capacity to learn from and coexist with their occupants. The dream of dynamic spaces can finally be fulfilled as buildings weave together humans, environment, infrastructure, and personal devices.
Just as mobility networks are taking advantage of ubiquitous sensors (as with crowdsourced maps or pothole detection), so too will buildings take advantage of the human flows running through them. We will shift from living in a home to living with a home. Architecture becomes a form of interface, playing an active role in the human environment, both digital and physical. "The goal is to facilitate as seamless a movement as possible from fast to slow, virtual to physical, cerebral to sensual, automatic to manual, dynamic to static, mass to niche, global to local, organic to inorganic, and proprietary to common, to mention just a few extreme couplings" [Antonelli 2008]. Integrating digital elements will allow the built environment to become a connective tissue between the distinct but coexisting realities of bits and atoms–an interface that enables spatial cybernetics.
The built environment is becoming a physically habitable Internet, a Hertzian space–one that is inextricably intermeshed with digital devices. "Hertzian space is […] a way of linking things, of sending information and content, etc. But [architecture] is an environment that can be inhabited, enjoyed, and explored" [Dunne, Raby 2013]. In the newly interactive, digitally laced architecture, detail and dynamism and complexity (formerly the ambition of parametric scripting) are the experiential consequence of design, not the justification.
Architecture takes on life through response–it becomes shocking or vibrant in time rather than in its external visual character.
Just as smartphones are a portal to larger systems, architecture can function as a mediator between daily, human-scale functions and vast, humanity-scale networks. "For millennia architects have been concer-

Fig. 11. CapitaSpring (image credits: BIG). The indoor space of the CapitaSpring tower will be characterized by an array of hi-tech solutions, including sensors, Internet-of-Things (IoT), and artificial intelligence, as well as a tropical forest at the core of the building and greenery throughout.

ned with the skin-bounded body and its immediate sensory environment […] Now they must contemplate electronically augmented, reconfigurable, virtual bodies that can sense and act at a distance but that also remain partially anchored in their immediate surroundings" [Mitchell 1996]. Pre-digital humans navigated their immediate physical surroundings, but today's cyborg (with prosthetic smartphone) inhabits space in profoundly different ways. Scales and contexts are blurred as we slip elastically between them. At any given moment, we may be standing in a room with three other people, but now the digital-spatial network can also reveal two close friends in a restaurant next door or a potential love interest only a block away. People and physical space are still a central anchor, but the upper and lower bounds of human reality have exploded outward, and architecture must encompass this breadth of spaces–in all of their active dynamics–while still relating to humans. Picon sets forth the question. How should the designer cope with an electronic and informational reality that seems to possess a dynamism and an expressive quality? The advent of the digital represents an even greater challenge for design than what the early stages of mechanization had meant for modern architecture. For the first time perhaps, architecture has to confront itself with a profoundly non-tectonic reality. Given these premises, how can the designer be in deep accordance with the invisible flows of information that constitute the bones and flesh of the digital world?

The very process of creating architecture could become an iterative chain rather than a directly linear process. Today, design, documentation, construction, and inhabitation are distinct phases in the life of a building, each carried out by a different specialist using different tools. As each step of the architectural production chain transitions to digital systems, the whole process will be unified. Integration will happen in-

Fig. 12. Science for Citizens (University of Milan's Scientific Campus) (Image credits: CRA graphic team). CRA is collaborating with Lendlease to develop the schematic design for the University of Milan's new Science Campus, Science for Citizens, which will include robotically-assembled brick facades.

crementally, by streamlining information, enabling the different phases to inform one another, structuring a codependent feedback system and, ultimately, a full merger. Initial steps have been taken in this direction–for example, with project-specific smartphone apps that organize the fabrication, shipping, and installation of complex facades with tens of thousands of unique components. Implicating inhabitants in all stages of the design, construction, and operation chain will graft the development and inhabitation of architecture together into a single experience. The Internet of Bodies and active architecture will be symbiotic. "All evolution is co-evolution; individual species and their environments change and evolve on parallel courses, constantly exchanging information" [Allen 2011]. What was formerly defined by a clear separation between mind, body, population, and environment is now entangled, "supplanted by a more complex and non-linear pattern of urban development in response to the spread of new information technologies" [Gandy 2005]. Each choice we make has ramifications in digital space that, in turn, shape our physical environment. The Internet of Bodies, grounded in our cyborg condition, may ultimately realize the concept of the built environment as a social and relational process.

The most important implication of radically integrating digital systems into architecture will be to refocus technology and the built environment on humans. A living, cybernetic program in spaces of dynamic interaction

Fig. 13. The Circular Garden (Image credits: Marco Beck Peccoz). For Fuorisalone 2019, a part of Milan Design Week, CRA, in partnership with global energy company Eni, developed an architectural structure made of mycelium, the fibrous root of mushroom.

will make architecture more like an extension of the body–and it is cyborg "tools" that enable the environment to respond. Augmented or "living" architecture is the large-scale hardware that digital-physical cyborgs create, plug into, and interact with. Active buildings are at once an environmental life support, a social catalyst, and a dynamic set of experiences. While congenital digital systems integrate seamlessly with human biology, the same prosthetic devices interface with the digitally augmented environment through real-time information flows. The Internet of spaces and the Internet of Bodies enable and co-create each other–each is the interface to the other.

Ultimately, technology recedes into the background, and interaction is brought to the fore. Buildings can be simple–rather than voluptuous and shocking–but even more integrally vibrant and living.

The result of digital networks, and more bottom-up processes, can ultimately lead to what we can call open source architecture. Open source architecture relies on all interested parties being involved in the design process. In the past (for instance, in the case of Gothic cathedrals) this emerged naturally in local communities. In this sense, open source architecture is really a re-visitation of a timeless way of building, of forms of production that yielded anonymous or vernacular architecture. The idea of bottom-up, locally-adapted, copied typologies, produced by citizens using their social capital as well as their financial capital, is the opposite of new. In many ways it is bringing tech-

nology to pre-open source industrial "barn-raising" approaches. Open source architecture is presented as an innovation, but it is really just the vernacular with an Internet connection.
The challenge is looming, goals are clear and technologies for achieving them exist. The task, then, is to reflect on the potential implications that "future vernacular" will have on economic development, social justice, resource scarcity, labor economies, planning systems, and the role of professionals. The discipline cannot remain hermetically sealed forever – there is a critical mass of people, ready and willing to work in a bottom-up way.

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The Modelization of Built Heritage. Comparing BIM Processes for Architectural Types

Martina Attenni, Maria Laura Rossi

Abstract

The study of an historical architecture and the heterogeneous set of information linked to has important repercussions in many areas: from documentation, to the planning of interventions, to the management of cultural heritage. The goal of total data integration is now pursued by the BIM processes; their application for the historical buildings involves methodological and technical implications both in the survey field and in the representation, linking the modeling operations to the massive data acquisition. These activities are very complex because of the use of libraries of standardized elements, in conflict with the uniqueness and complexity of the historical form. Two different case studies for eras and construction techniques are analyzed. For both the standardization process of the building process is evident, such as the presence of serial elements with easily recognizable geometries, handcrafted in the first case, industrially in the second. The parametric approach to the modeling describes, through creation of nidified elements with hierarchical structure, the logical process of decomposing the form.

Keywords: HBIM, architectural typo, standard, modeling, database.

Introduction

The evolution of digital technologies for the representation of architecture has allowed the achievement of objectives previously unthinkable for the survey, knowledge and communication of the built heritage. BIM processes –Building Information Modeling– promise new scenarios for storing and managing large amounts of information for the knowledge of Cultural Heritage [Messaoudia, Halin, De Luca 2018] by integrating 3D modeling and parametric tools.
This research aims to show the potentialities and the critical issues related to the introduction of BIM processes in the field of knowledge, transformation and management of the built heritage. These themes are closely related to the technological development of the last 20 years, which has brought an important change in acquisition and sharing knowledge. This is due to the almost exclusively digital methods used to build models as complete, heterogeneous, implementable and sharable databases. Furthermore, the increasing need for preventive and conservative interventions on existing artifacts imposes to have methods and tools to collect, store, compare, share and manage information on their past, present and future status. This is the context of the BIM (Building Information Modeling) and HBIM (Heritage Building Information Modeling) processes. The former, whose fundamental characteristic lies in the standardization of construction and architectural components, are now a fundamental reference for new buildings. However, it is still not completely adequate for for historical buildings, in which consist the majority of

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our architectural heritage. Obviously, the construction of architecture requires the production of construction elements in favor of a greater economy and a simplification of processes and operations. BIM models for historical heritage, and therefore the parameterization of realities characterized by infinite possible variations, presents considerable degrees of complexity.
Furthermore, it's not always obvious the geometrical knowledge of space. The necessity to have systematic readings of historical buildings is closely linked to identifying an information system defined on the basis of macro-elements, to which data can be associated capable of documenting the specific material, historical and technological features. Therefore, it is necessary to keep in mind not only the link between the documentation of the history of the buildings and the changes that over time have undergone, but also the knowledge of the current state, inextricably linked to surveying and survey activities [Chiabrando, Sammartano, Spanò 2016; Costa, Madrazo 2015]. To fixed the model construction process, this research highlightis the issue on the themes of knowledge, modeling and interaction between heterogeneous data (3D/2D models, numerical models, mesh models, photographic images, information bibliographic etc.). This interaction arises from the overlap between parametric models and survey data, which must necessarily be referred to the study and analysis of existing buildings. This involves into the construction of 3D informative models starting from the massive acquisition of data and defined on the geometric and semantic level. First of all, the study and analysis of numerical models, allows to break down the historical artifacts into the elements that characterize them. Then, the parametric modeling, implements the metric and geometric characteristics with information that is constituted as a basis for the knowledge of the object analyzed. The overlap between the discrete model (numerical model) and the continuous model (parametric model) allows the reading of the discontinuities that linked with the degradation of the architectural elements, of the design intentions of space and shape management, and, through their comparison, the changes that architecture has undergone over time.
In the complex transition from a numerical model to a geometric one of the real elements, after the necessary preliminary reflections for a conscious approach to the

Fig. 1. Botany Institute at Sapienza University, Rome.

Fig. 2. Camuccini Palace in Cantalupo in Sabina, Rieti.

Fig. 3. Botany Institute, numerical model.

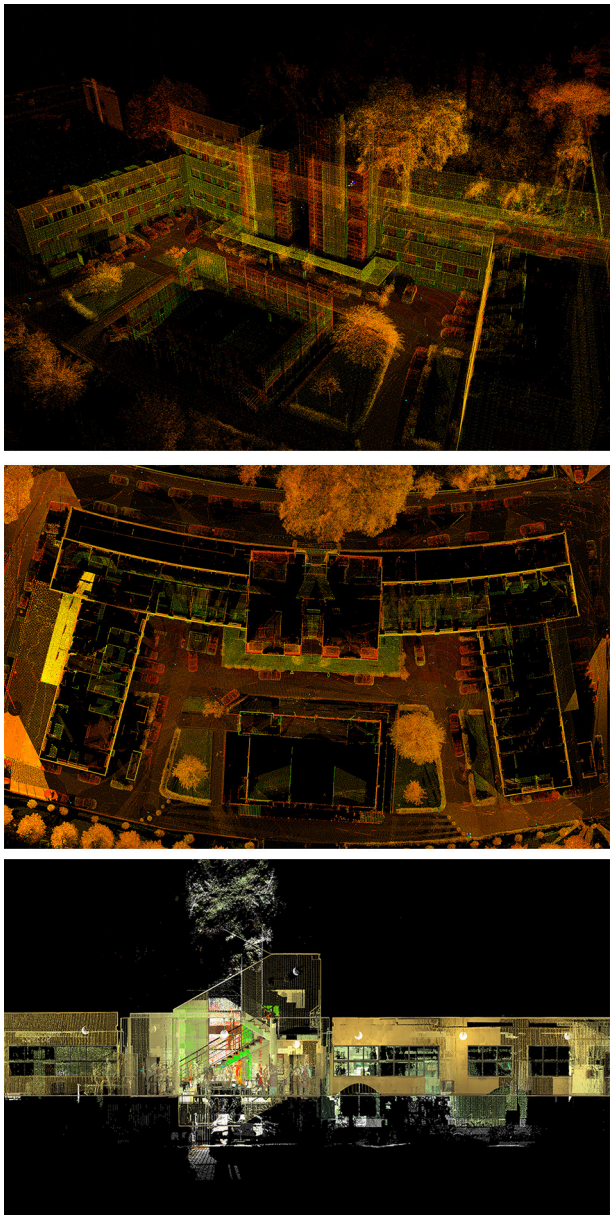


Fig. 4. Camuccini Palace, numerical model.

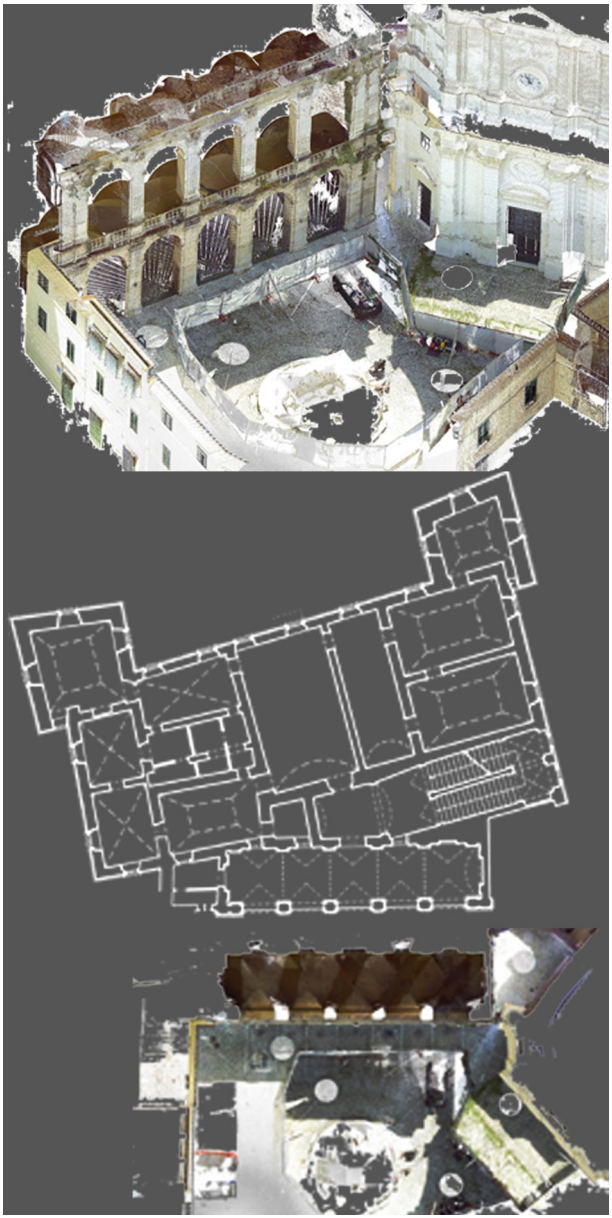
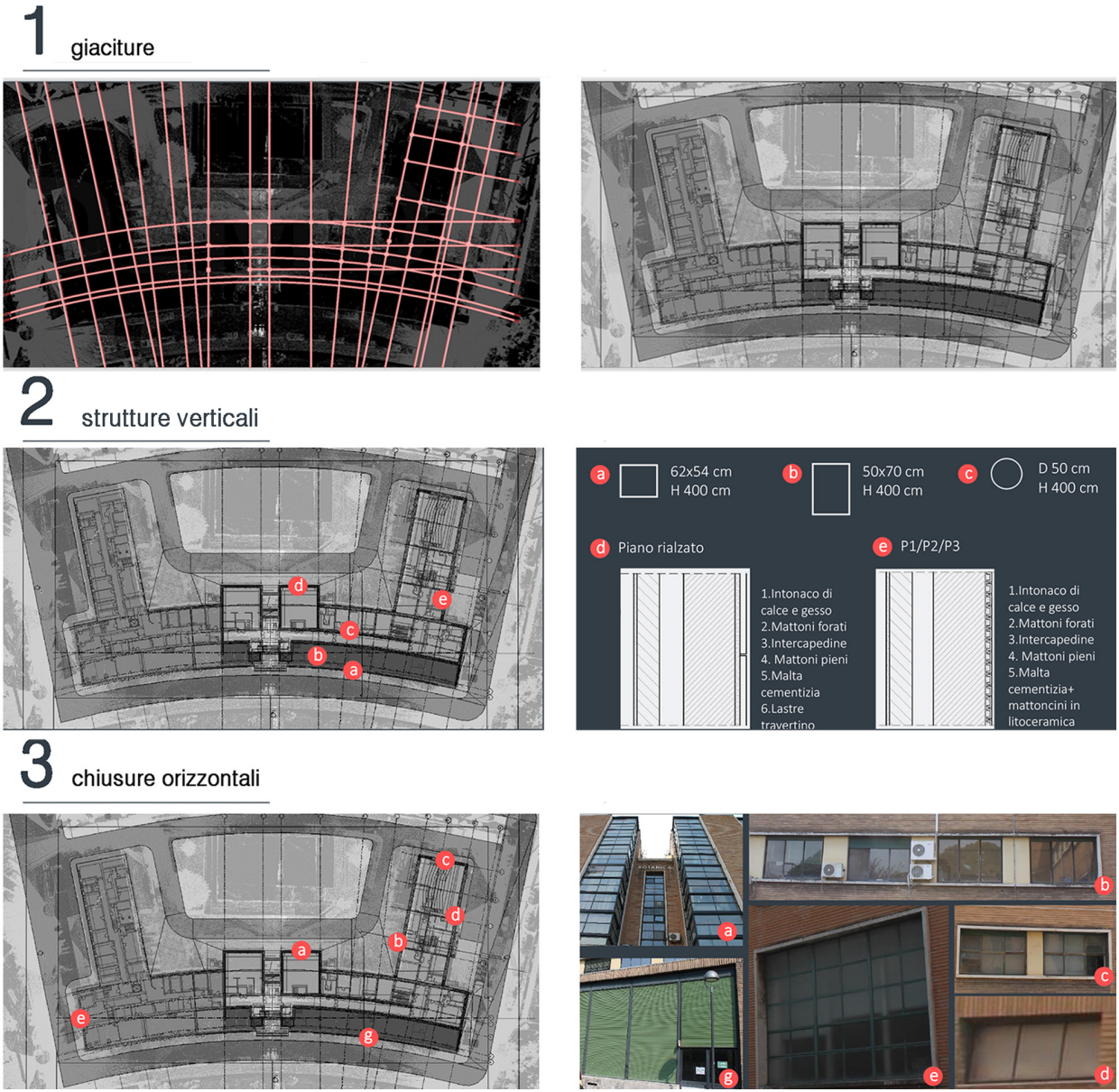


Fig. 5. Model of the Botany Institute. Scomposition and reconstruction of rationalist architecture: the constructive elements.



so-called HBIM, the discussion will focus on two case studies in the field of architectural heritage, representative of different historical periods and emblematic of interesting architectural types.
This theme is still at the center of experimentation by scholars of representation, historians, restorers, and figures involved in the field of cultural heritage. The research aim at outlining an operational protocol linked to the possibilities of managing the built architectural heritage, implementing the possibilities of HBIM in the consolidated integrated survey process [Simeone et al. 2014; Quattrini et al. 2017; Quattrini et al. 2015].
This study compares the process of HBIM by analyzing two case studies: the Institute of Botany at Sapienza university (Rome) and the Palazzo Camuccini in Cantalupo in Sabina (Rieti) (fig. 1, fig. 2). The first is a rationalist building, built between 1932 and 1935, which lends itself well to being studied through BIM processes for its typological, geometric-morphological characteristics, and for the presence of recurring and standardized elements. The second, built between 1566 and 1579, is an example of an intervention on a pre-existing structure: the originally military form of the entire complex was subsequently enriched by a graft on the façade, which is articulated on two levels with a portico and a loggia, designed to make it more suitable for a noble residence [Dal Mas 2015].
The choice of this architectures is not at all accidental. Modern architecture, of which the Institute of Botany is particularly representative, constitutes a substantial part of the set of public buildings in Italy. The orderly composition of regular geometries, the rigor of spatial solutions, the repetition of compositional elements and architectural details, make it particularly suitable for the application of knowledge and modeling methods that characterize HBIM processes. The loggia of Palazzo Camuccini, on the other hand, has its roots in Renaissance treatises, a collection of rules and geometric and proportional codes that express the intellectual activity of the architect of the sixteenth century, proposing typological solutions uprooted from any context.
On the basis of a typological representativeness in which unstable aspects coexist –linked to the uniqueness of the components– and stable aspects –linked to the recognition of the geometric matrix– it is possible to compare the modeling [1] of the elements within HBIM. The parametric approach to modeling for built heritage can be effective because, through the creation of nested elements with a hierarchical structure, it is possible to describe the logical process of decomposition of an architecture. The interaction between the discrete model (the point cloud) representative of the actual state (fig. 3, fig. 4), and the orderly logic of the operations for the construction of the parametric model, records the evolution of the form and the changes that the project originally suffered. The typological elements of the libraries are detailed through the parametric variations, obtained from the survey data, constituting a database of heterogeneous information, necessary for the archiving and transmission of architectural data of the past.

Fig. 6. Model of the Botany Institute. Analysis of the compositional elements.

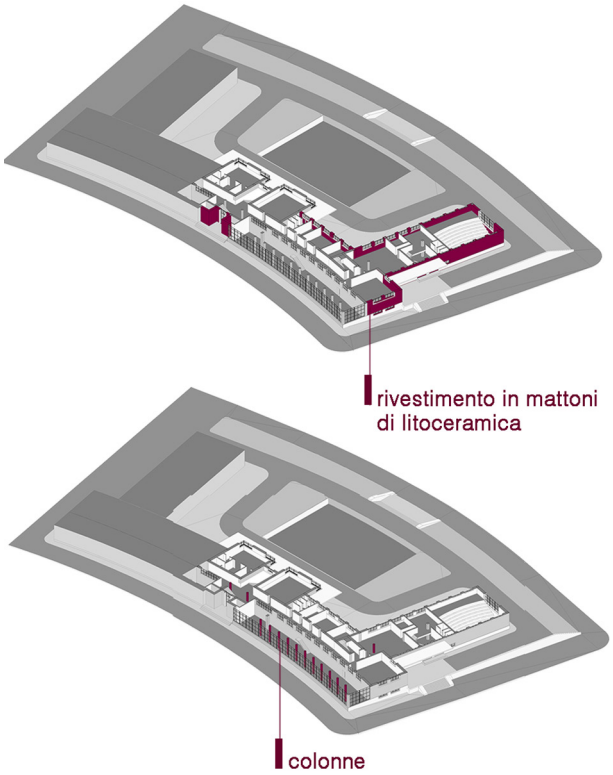
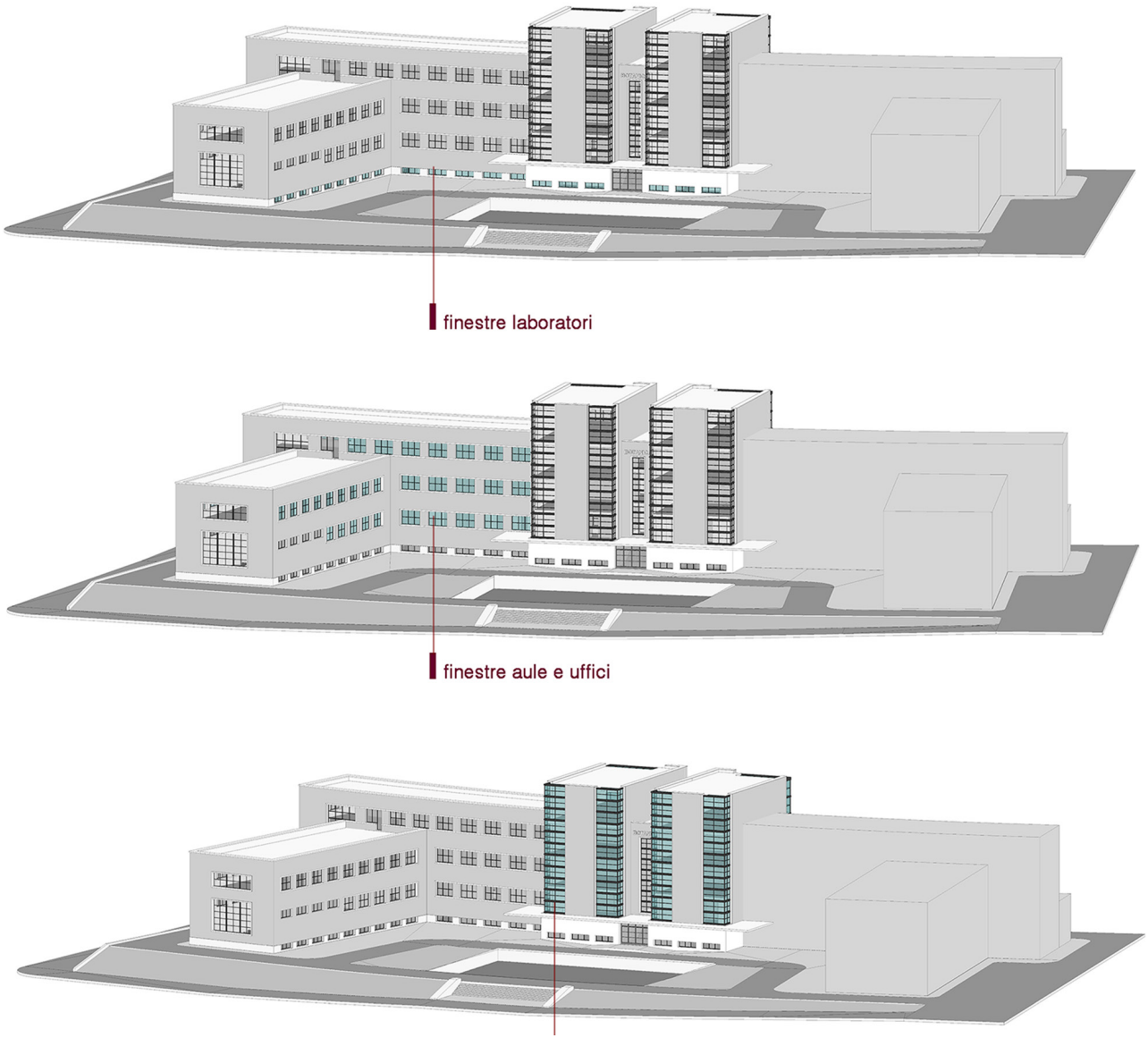


Fig. 7. Model of the Botany Institute. The transparent vertical elements.



The parametrization of rationalist architecture

The modeling of the Botany Institute reach the representation of the constructive equipment, oriented according to the architectural components: structural elements (frames or masonry systems), infills, fixtures, finishes etc. A careful survey of the relevant data has allowed us to extract information on the geometrical and the spatial articulation of the building, identifying the positions, then the bearing elements and the relative structural axes, then the infill walls, the horizontal and vertical closures, openings and connecting elements, external finishing materials, interior cladding, and technological systems. The objective of modeling the different components according to a process that seeks the most complete knowledge has required the use of a methodology that does not proceed from the general to the particular (fig. 5). The issue is related to the knowledge and the recognize of the element not only from the geometrical-morphological point of view, but in its constitution in terms of dimensions, materials, typology and methods of use in the more general context of the project analyzed, highlighting the parallelism between the BIM processes and construction site practices. For these operations all the informative, textual, graphic and photographic material, provided by the Sapienza Technical Office found in the documentation phase, was fundamental, because it describes in detail also the position of plants and ducts, and painting.
The symmetrical structure of the building, its geometric recognizability and the repetition of the elements, represented the starting point in the approach followed. Grids, fixed wires and levels constitute the geometric rules for the elements, so bound by parametric relations. The structure of the model starting from these components therefore involves a discretization and an adjustment of the geometries that define the elements of the project, placing itself in a manner consistent with the state of affairs, documented by the survey. The seriality of the elements, found both on the facades and in the internal solutions, was managed inside the modeler both for the supporting structure, which alternates pillars with different geometries, and for the vertical, opaque and transparent closures, both for the bricks and the travertine slabs that make up the external facings (fig. 6). The starting point for modeling architectural elements is editing operations of the loadable families: walls, internal partitions, inter-floor and roof slabs were built with the aim of achieving the maximum level of detail. The cross-analysis between the survey data and the archive sources made it possible to define some parameters and starting attributes of the digital object, such as the thickness of the walls, the type of support layer, the type of external cladding in slabs of travertine or lithoceramic bricks, and the type of internal plaster coating. The elements with the most particular configuration, such as the wall with the base and the canopy of the raised floor, have been modeled starting from the definition of the profile, traced from the survey data, subsequently extruded. A separate discussion was made for the external cladding and for the transparent closures. The first was structured as a modification of the curtain wall, defined through geometric matrices that regulate the number of elements and the step between the axes that make up a grid. The glass windows of the towers were modeled as curtain walls, while the windows, of which five types were repeated several times within the project, were built through the modification of dimensional parameters of windows and doors associating them to a single type, greatly speeding up the modeling process (fig. 7).
The operations carried out allow to evaluate the process followed, highlighting some considerations. The first concerns the criterion used for the decomposition of the building and the choices made during the modeling phase that clearly reflect the rational logic that characterized the design of the building. The second concerns the actual correspondence between the real object, the numerical model and the parametric one. Although the starting point consists of a highly detailed relief, which highlights the peculiarities of the building in its general appearance and architectural details, the standardization of the elements has prevailed over the differences that can be found between different elements of the same category. The repetition of architectural components shows variations in the order of centimeters, so it was possible to make simplifications, considering these variations linked to the practical installation operations, which are never free from inaccuracies.

The protoparametrization of Renaissance architecture

The second part of this study aims to interpret and restore, in a digital parametric environment, the project logic underlying the Renaissance intervention of the double

Fig. 8. Palazzo Camuccini: from the analysis of the Renaissance treaty to the parametric model.

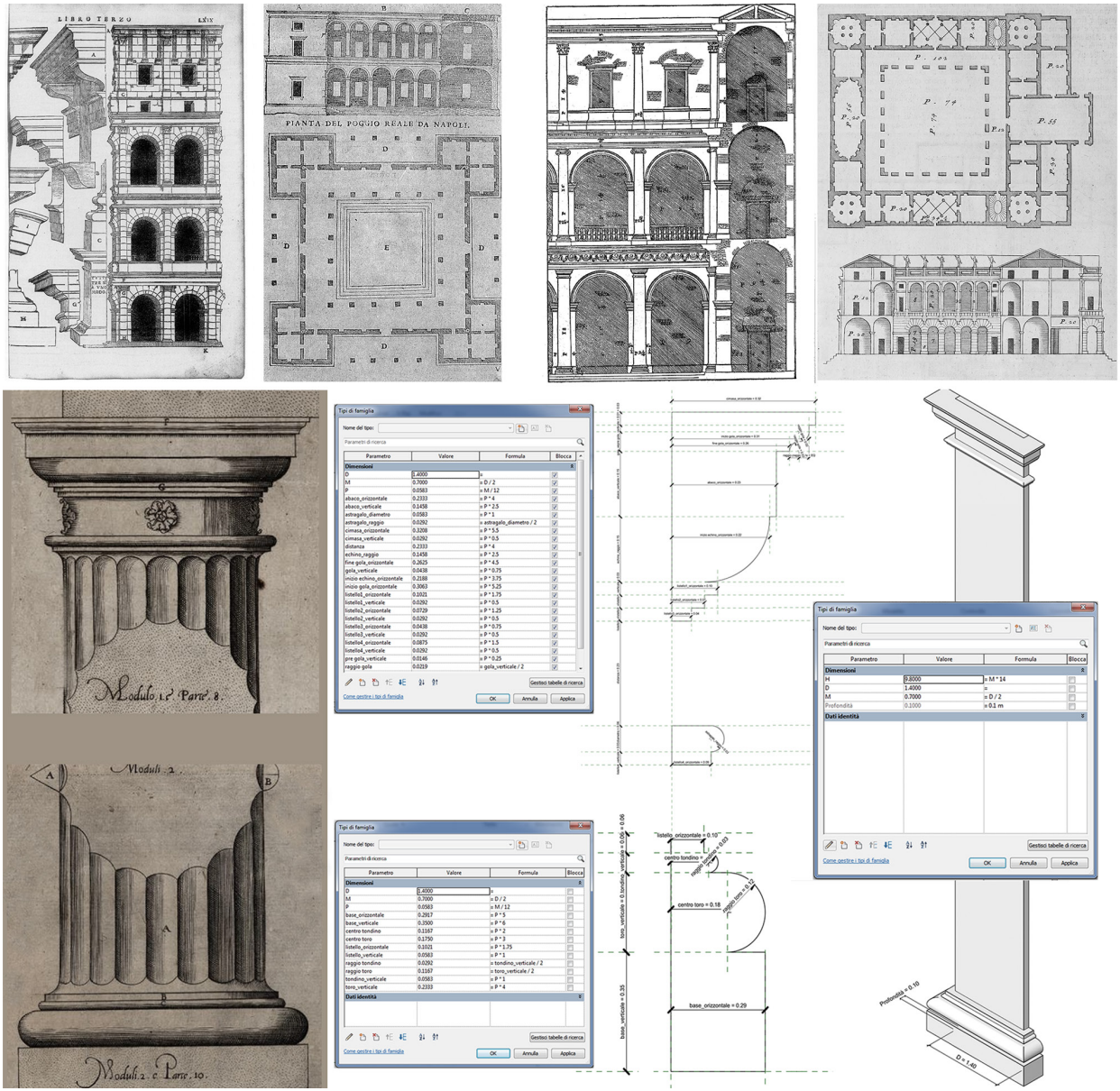
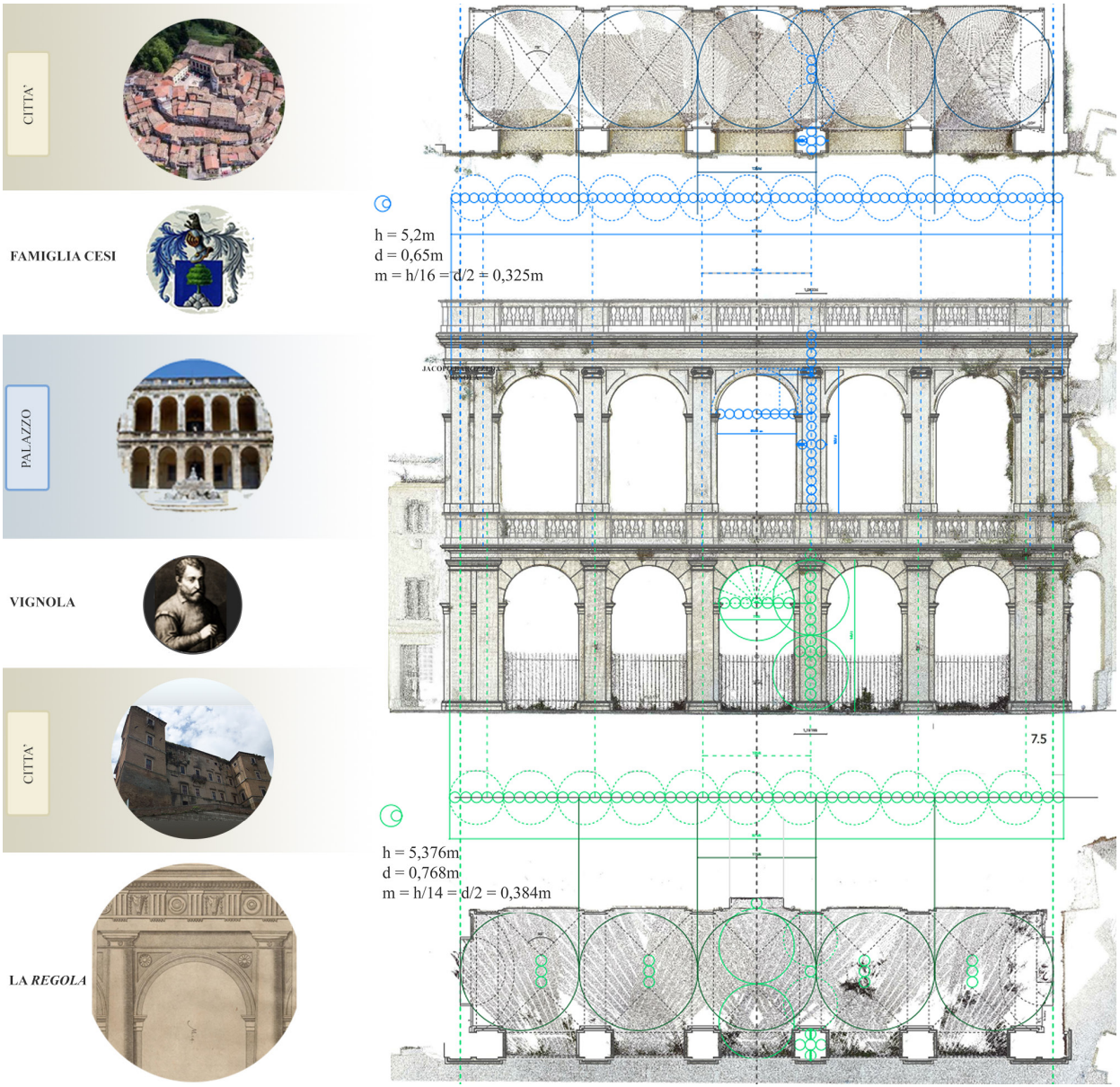


Fig. 9. Palazzo Camuccini: from the analysis of the Renaissance treaty to the parametric model.



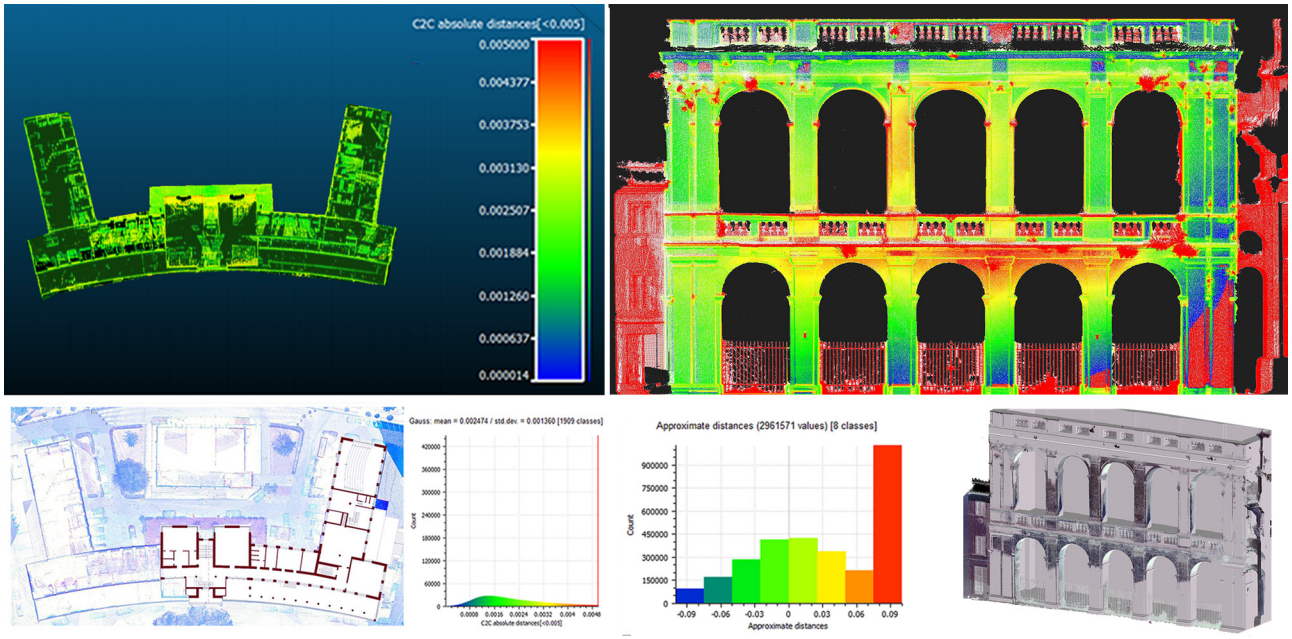
loggia on the pre-existing medieval fortress of Cantalupo in Sabina. The graft, carried out in compliance with the application of compositional rules shared at the time, is modulated according to a real space strongly conditioned by pre-existing buildings. The example considered is particularly representative of the cultural attitude that distinguishes the history of most architectural treatises of the time. Their huge widespread, also due to the invention of printing, began to remove the need for direct experience of architecture to exalt its virtual value, thanks to a great availability of two-dimensional models based on systems of rules. This makes the intellectual activity of the 16th century architect, expressed in terms of graphic models, geometric rules and proportional relationships between the parties, the proto-parametric reference for the construction of the digital model.
Palazzo Camuccini represents the union between the standards contained in the sixteenth century treatises and the specificity of particular solutions, adapting to the constraints imposed by the context and, therefore, separated by a purely typological study independent of the case in question. However, in order to define general and at the same time modular composition rules, it is necessary to follow a theoretical reference model (fig. 8).
The date of the intervention and the geographical position of the building, the wealth of similar examples in the same area, the client and the workers in service, brought together the theoretical model of the sixteenth-century double loggia of the building in question, with that described by Jacopo Barozzi from Vignola in the *Rule of Five Orders of Architecture* [Barozzi 1562]. The choice of Vignola's *Rule* as a theoretical reference in the construction of the parametric model of the loggia is determined in the first place by a 'geographical' reason, linked to the treatiser and the places he frequented in those years: as architect for the Farnese, the Vignola has a consistent following of workers in his employ. Secondly, from a 'temporal' reason linked to the treaty: the years of construction of the case study (1566-1579) are in fact immediately following the year of publication of the treaty (1562), which we can imagine as the expression of a know-how presumably already rooted in the local area.
Furthermore, this type of intervention is to be contextualised in a historical and cultural moment in which the concept of a city, large or small, is reinterpreted in an ancient key, understood as a place for social meeting, political organization and economic planning. This idea of civil life linked to the urban form is found in the will of the first citizens, bishops and nobles to renew the ancient splendor of medieval castles in favor of airy palaces.
Following the construction of the model based on the identified compositional, geometric and proportional rules, the overlap with the numerical model shows how the overall picture appears to be coherent with the Vignola's treatise only in part. By identifying both for the Doric order of the first level and for the ionic order of the second level, the module equal to the semidiameter of the column, it can be seen how, in the construction of the parametric model, the overall height of the building was forcibly reduced proportioning each order with respect to the order that precedes it in the rule (the Doric arcade is proportioned with the rules of the Tuscan order, the level of the Ionic order with those of the Doric order). Instead, the relations between the components of the sculptural apparatuses of the columns follow slavishly the treaty (fig. 9).
The model of Camuccini Palace, therefore, turns out to be representative of an ideal state, or rather of the design idea underlying the construction, and not of the current configuration. However, this model, when compared with the discrete model obtained from the survey operations, allows us to deduce further considerations. The difference between the two models, evaluated with respect to the deviation, in addition to giving information about the metric accuracy of the parametric model, offers the reading of the transformations that the building has undergone over the years (fig. 10).

Conclusions

This study is based on the search for a method based on a general procedure applied to particular cases. Following the recognition of serial and repeatable elements and their rules (geometric, dimensional etc.) it was possible to translate the relations between the parts into a digital parametric logic, valid both cases. The processes followed for the analyzed case studies contribute to the definition of ideal models; however, some substantial differences emerged during the modeling phase. In the case of the Botany Institute, the parameterization within the software used [2] allows the actual configuration of the real elements to be reproposed, designed according to a rational logic that involved mass production. The standardization of the

elements has prevailed over the differences that can be found between different elements of the same category. The repetition of architectural components shows variations about some centimeters, so it was possible to make simplifications considering these variations linked to the practical installation operations, often inaccuracies. This simplification, however, does not correspond to a metric and geometric approximation in the description of the forms, and makes the parametric model coincident with the 'as built'.
In the architectural orders that define the facade of Palazzo Camuccini, it is not possible to find the same concept of standardization that insists on the Botany Institute, starting from the project until its realization. Although it is possible to transfer to the digital model the design intention of the repetition of some architectural components (bases, capitals, moldings), it is necessary to consider that they consists of elements made by craftsmen, and their deformation and changing over time.
The construction of the model then follows the modulating design activity of the standard at the base of the structure of the Renaissance building, which involved repeating the elements while being aware of the peculiar characteristics of each of them. In the first case, therefore, the standardization of the components does not correspond to an approximation in their modeling, while in the second case the operations of geometric simplification were necessary for the construction of the ideal model.
The parametric modeling of architectural heritage components –and their possible variants– offered by a complex information system such as the HBIM, allows an acceleration in the construction of 3D models that must however take into account the architectural quality of each unique element of its kind.

Fig. 10. Botany Institute and Camuccini Palace. Comparison between the numerical model and the parametric model expressed through the standard deviation.



Notes

[1] Activity of construction of the digital model intended not as the sum of three-dimensional objects but as a cognitive process of creation of the forms that constitute it [Marotta, Lo Turco 2014. p. 55].

[2] Revit architecture 2017.

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Urban Regeneretion: a Multidisciplinary Approach

Giulia Pettoello, Luigi Stendardo

Abstract

The main objective of the DATA –Developing Abandoned Transurban Areas– research project, hosted by the University of Padua and financed by the Veneto Region, is to design innovative strategies to recover, regenerate, and enhance abandoned areas located on the margins of the consolidated city. Abandoned urban areas around Padua, the case study of the project, are a particularly important example in consideration of the fact that northern Italy contains the highest increase in land consumption in the country (8.4% in 2013; ISPRA 2015) and, in particular, the city is first in the region for the percentage of land used (49% in 2013; ARPA Veneto 2015). The objective is therefore to build transformation scenarios for development and economic rebirth in reference to sustainable living in compromised urban areas awaiting regeneration. The multidisciplinary structure of the project is organized into six distinct, complementary areas: web GIS; BIM and land information modelling; pilot scenario design; urban planning and feasibility studies; waste recycling; and data management and ICT. (G.P., L.S.).

Keywords: city, periphery, complexity, neglect, ICT.

Introduction

The main goal of the DATA research project [1] is to produce sustainable strategies for the development and economic rebirth of compromised urban areas awaiting regeneration, using the potential of efficient collection, processing, and dissemination of the related data. The project involves different sectors, including data management, ICT, and the division of urban and building transformations, considering environmental, economic, social, and cultural aspects. DATA –developed at ReLOAD, the Research Lab of ArchitectURban Design, and other partner laboratories in the Department of Civil, Environmental, and Architectural Engineering at the University of Padua and other partner companies in the project– is therefore designed as a complex project in which the capacity to produce visions is particularly important. (L.P.)

Designing urban transformation scenarios

Producing visions is a complex operation that, as a focus in all phases of the project, is at once theoretical and methodological foundation, a knowledge and communication tool, and formal result. In fact, visualization not only represents the final output of the project, but also constitutes a structured, complex language. It is therefore a form of thought through which reasoning is constructed and scientific argumentation is organized.

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Visualization regards not only the physical forms and existing and designed spaces –as immediately expected– but also other immaterial objects that are fundamental for building the transformation scenarios that constitute the goal of the project, i.e., the data, in their complexity and variety, and the processes through which they are managed and reprocessed.
Visualization of the existing space therefore constitutes a necessary tool for knowledge and the description of reality, which is not limited to representing the visible surface of the physical buildings, but makes all material and immaterial layers that cross the complex urban space respond, in a vision that never coalesces into a final image, but extends outwards in many dimensions. As well as along the two dimensions of the scene –which in the contemporary space tends to lose the limits of a traditional frame– the vision is stratified and moves continually in its depths, also intersecting with the clouds of immaterial information that progressively thicken or rarefy, pervading the physical space. It is therefore necessary to visualize not only three-dimensional, static spaces as they are traditionally understood, but complex, multi-oriented and dynamic fields.
To appropriately address the task of representing this complex project, the technical and formal language of the visualization had to make suitably different techniques and procedures interact: sketches, digital geometrical modelling, mapping, BIM modelling, definition of the graphical interface to manage and consult the databases, BIM models and GIS systems, and virtual, augmented, and immersive reality for the informed use of the existing space and design scenarios.
The techniques used to build and visualize the design scenarios therefore lead to a variable, nonuniform representation that is always changing, sensitive to user interaction, and capable of continuously remodelling the existing space and the viewing of possible future spaces. (L.S.)

Analysis through drawing of Padua's peripheral areas

In the present research, the city is considered not as a coherent whole, but as the juxtaposition of different realities. Through graphical layers, the different urban entities were identified, the first of which was the historical skyline, followed by the industrial one, which, when overlapped, generated a new, multi-form, and more articulated skyline (fig. 1). With the drawing, quick sketches, and visual notes, this analysis was very useful for focusing attention on extremely widespread problems in the areas around Padua. In fact, a specific graphical mode was identified to document and report the critical state of the reality being observed. For this purpose, with regard to the graphical aspect, the choice was made to use a 'strong' sign to highlight the industrial city, which contrasts with the light, slight trace used for the historical city (fig. 2). The objective was to enhance the 'transurban' areas and visually superimpose them on the historical urban areas to design a representation capable of making apparently contrasting places coexist. This is not a simple representation of the city, but rather the identification of connections to reach new interpretational meanings. In other images instead, attention was focused exclusively on abandoned areas such as, for example, the Ex Foro Boario area, where the neglect and marginality of the building was highlighted (fig. 3). The goal was to represent the strong caesura created by the untended vegetation with respect to the abandoned industrial buildings. For all the images produced, a common element was the use of representation as a tool for critical analysis and reporting. (G.P.)

State of the art (ICT)

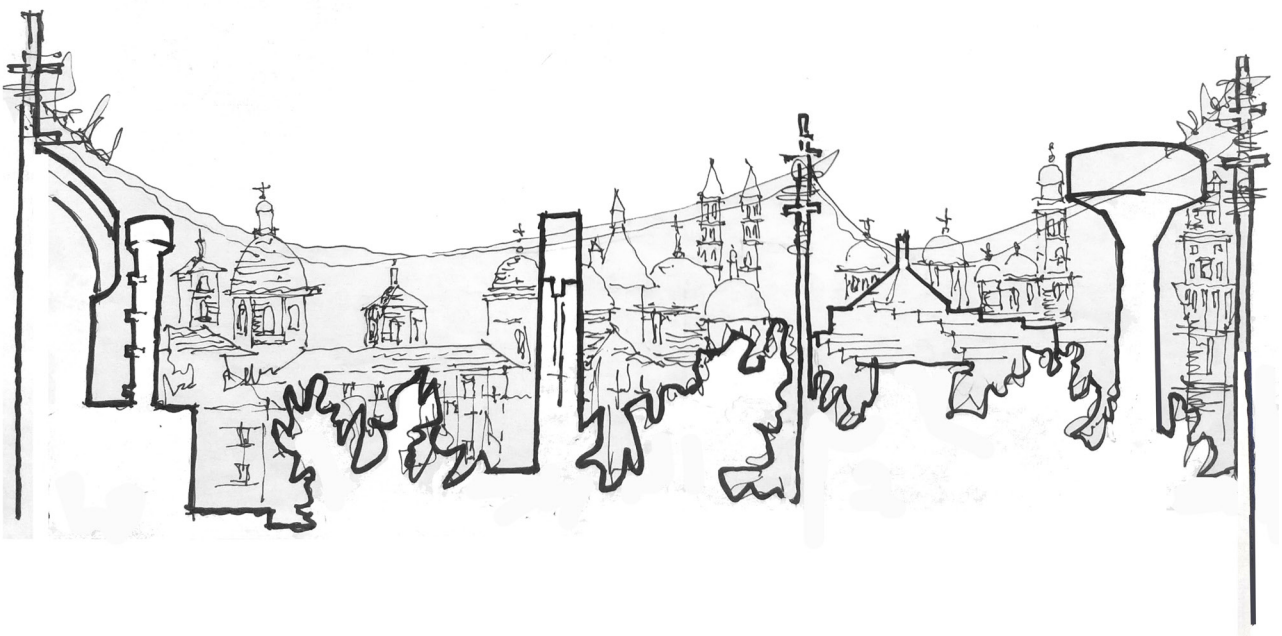
An essential aspect of the work presented was the analysis of multiple case studies pertaining to the vast sector of the enhancement of cultural, architectural, and urban goods using digital supports. In the present study of the state of the art, two different but related areas are considered: i) the management and dissemination of data and ii) visualization, communication, and Information and Communication Technology (ICT). With regard to the former, among numerous existing case studies, those presented during the INU Study Day, held in Naples in 2017 in the *New computer technologies for the territory* session were analysed [2]. During the meeting, the most up-to-date research regarding urban regeneration was examined, particularly the communication of complex realities by constructing specific interactive GIS and web GIS platforms. The various studies demonstrated the need to create such integrated systems since "it is estimated that by 2050, 6.4 billion people will live in cities, with significant consequences regarding resources and services. It is therefore necessary to investigate the complexity of the

urban phenomenon in an integrated way, considering the city as an open, malleable, and complex system that evolves over time and in space" [Mangialardi 2017, p. 606].
With regard to the second topic related to communication and ICT, only some of the many case studies [Allen, Lupo 2012] investigated are presented, in particular those characterized by an interactive relationship between the user and cultural good. The following cases are examined. The *Culture Clic* project (Paris 2011) is an application that aims to promote cultural goods in France. High-resolution data, visible in augmented reality with an iPhone, bring up sites of cultural interest as they were in the past. The *You Are Not Here* project (New York and Tel Aviv 2006-2007) allows participants to become 'meta-tourists' and highlights the strong relationships between the two cities. Participants can activate audio descriptions simply by calling a dedicated phone number and inserting the code they find on stickers located throughout the city. The *AMNH explorer* project (New York 2011) is an application that provides detailed information regarding the American Museum of Natural History. Via the app, visitors can create a personal virtual tour. Finally, the *Street Art View* project (Mountain View 2011) is a collection of sites characterized by works of street art drawn from *Google Street View*. Users can select and share their favourite works, helping to build the 'world's largest' art collection. For all cases examined, a common element is the desire to make the user the main character, becoming the focus of the designed cultural experience. (G.P.)

Abandoned urban areas and ICT

The multidisciplinary structure of the project is organized into six distinct, complementary areas: web GIS; BIM and land information modelling; pilot scenario design; urban planning and feasibility studies; waste recycling; and data management and ICT. The *Data Management and ICT*

Fig. 1. Graphical representation of the historical and industrial skylines of the city of Padua. Freehand drawing (pilot pen and felt-tip pen).



area is the focus of the present article. ICT plays a central role in cognitive, research, and dissemination processes, as well as in design processes, where it acts as an interface between different technical skills. These technologies have experienced significant development in the area of cultural heritage, in which they perform particularly complex tasks such as communication and popularization in extra-disciplinary fields.
With regard to ICT, two projects were developed in the present research: the first, *Extensive Project*, regarded the creation of a web platform; the second, *Focal Project*, regarded the creation of two technological 'applications' meant to investigate and interactively communicate the new design scenarios created over the course of the research. Among the many decommissioned areas present around Padua, attention was focused mainly on the Ex Caserma Romagnoli and Ex Foro Boario zones (fig. 4).
As mentioned above, the *Extensive Project*, consists in creating a web platform designed to organize the data collected and to make its use possible by any type of user, from everyday citizens to professionals. In order to facilitate the use of the web platform, it was built into a website containing all the data deriving from the six areas of research. With the platform, which is based on the MySQL database, it is possible to connect directly to the GIS 'container' built using Geonode (a web-based application and platform for developing geospatial information systems). Geonode is based on the Postgres database and enables access to the multiple interactive maps created (fig. 5). The objective of the system is twofold: to create

Fig. 2. Graphical representation of the historical and industrial skylines of the city of Padua. View of the Cathedral dome. Freehand drawing (pilot pen and felt-tip pen).

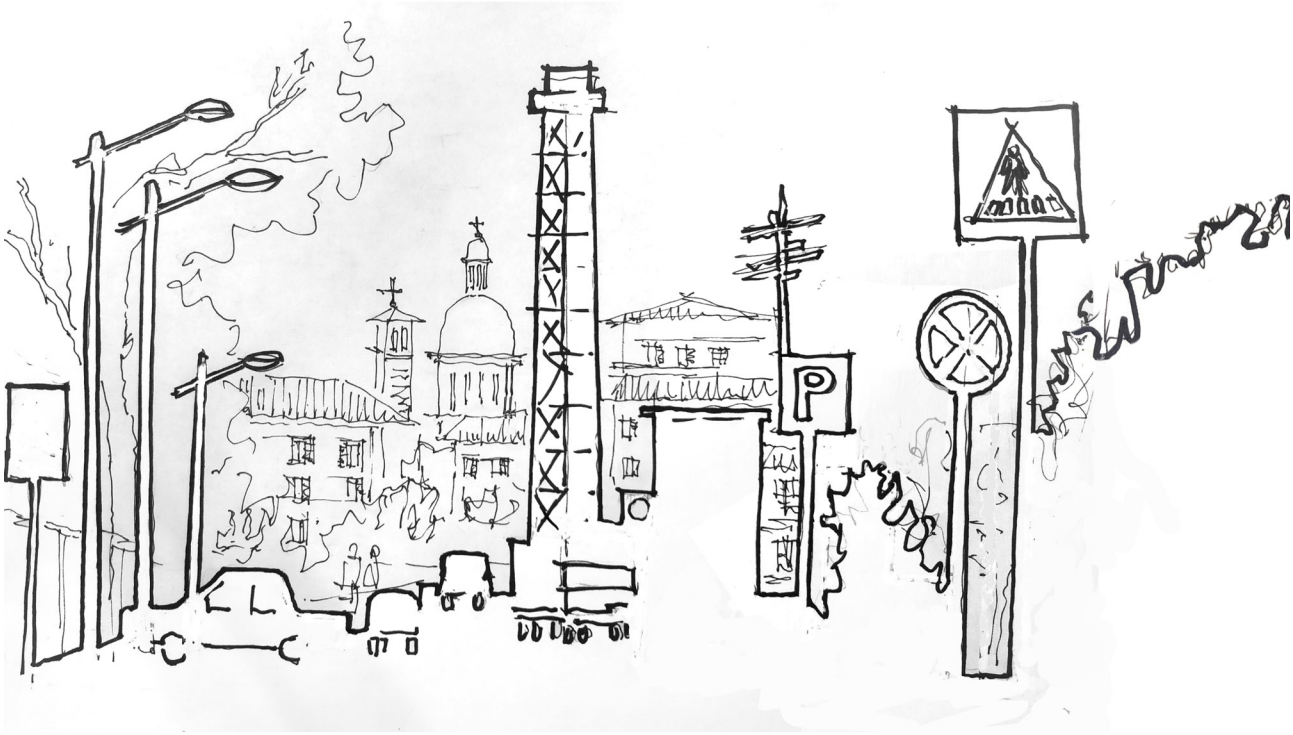
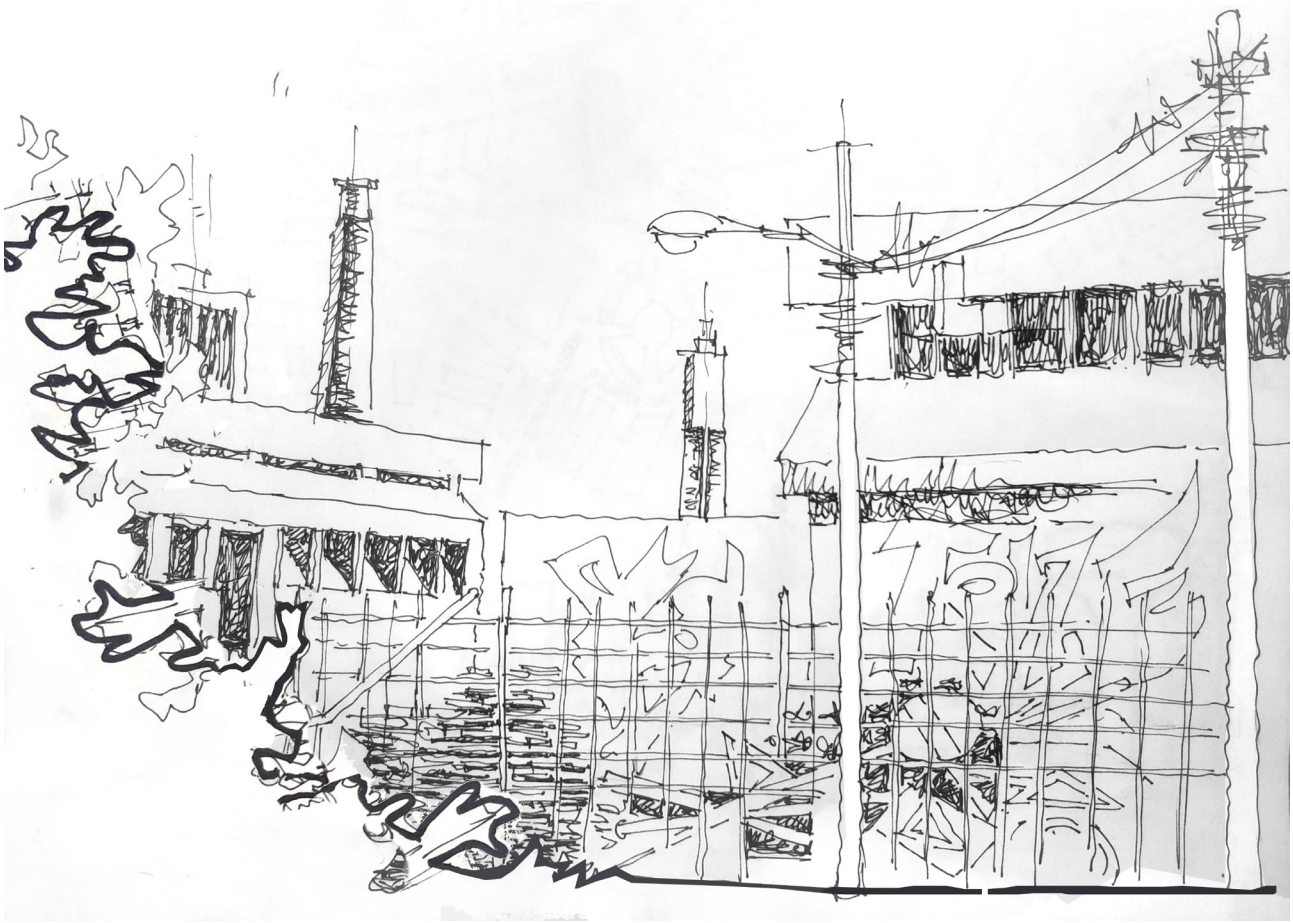


Fig. 3. Representation of a portion of the Ex Foro Boario in Padua. Freehand drawing (pilot pen and felt-tip pen).



an ordered archive of the data and an easy-to-use interrogation mode to rapidly explore and use any content present in the database. The web platform is therefore of fundamental importance in that it makes the various data processed during the research interoperable, facilitating its constant and continuous updating.
As mentioned above, the *Focal Project* consists in creating two digital 'applications' designed to communicate the regeneration project for the periphery. The first application regards the urban scale and the design of a 'virtual observatory'. With this tool in fact, it is possible to visualize the transformation of specific degraded extra-urban areas. With use of the 3D visor (a 3D smart visor in particular) and by activating hot spots, users have real-time 'access' to future scenarios of the city thanks to a 360° panoramic view. With the creation of a 3D model, it was possible to reconstruct a large part of the areas surrounding Padua. The reconstructed scene was then equipped with interactive tags. The functioning of the hot spots was made particularly intuitive. Indeed, simply by observing these points for an extended time (about 2 seconds), it is possible to activate and thus visualize the design scenario.

Fig. 4. Model made during research carried out in ReLOAD (Research Lab of Architect URban Design). Coordinator: L. Stendardo.

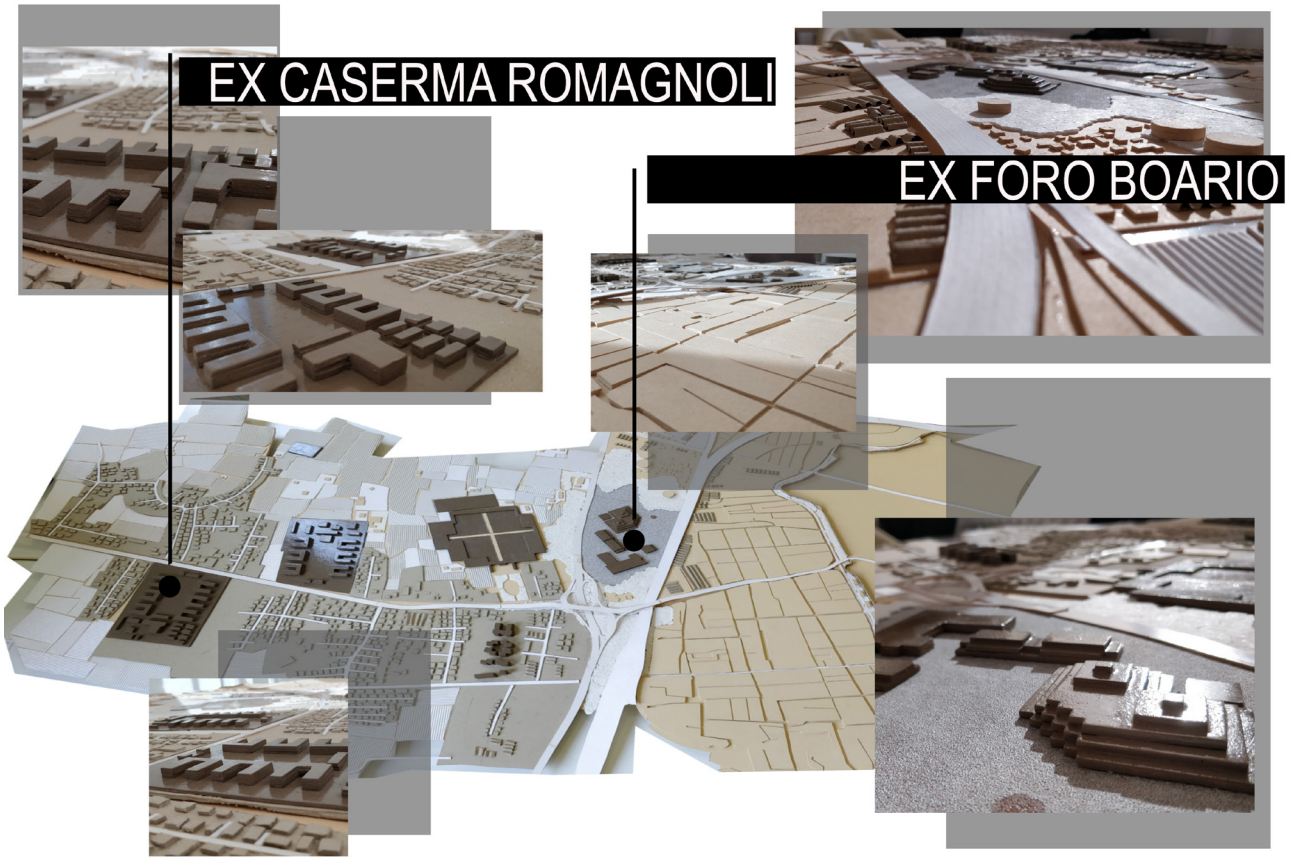


Fig. 5 Representation of the Web GIS Database searchable and available for consultation with the web site. Selection and analysis of different layers. Maps' realization: G. Pristeri, E. Redetti.

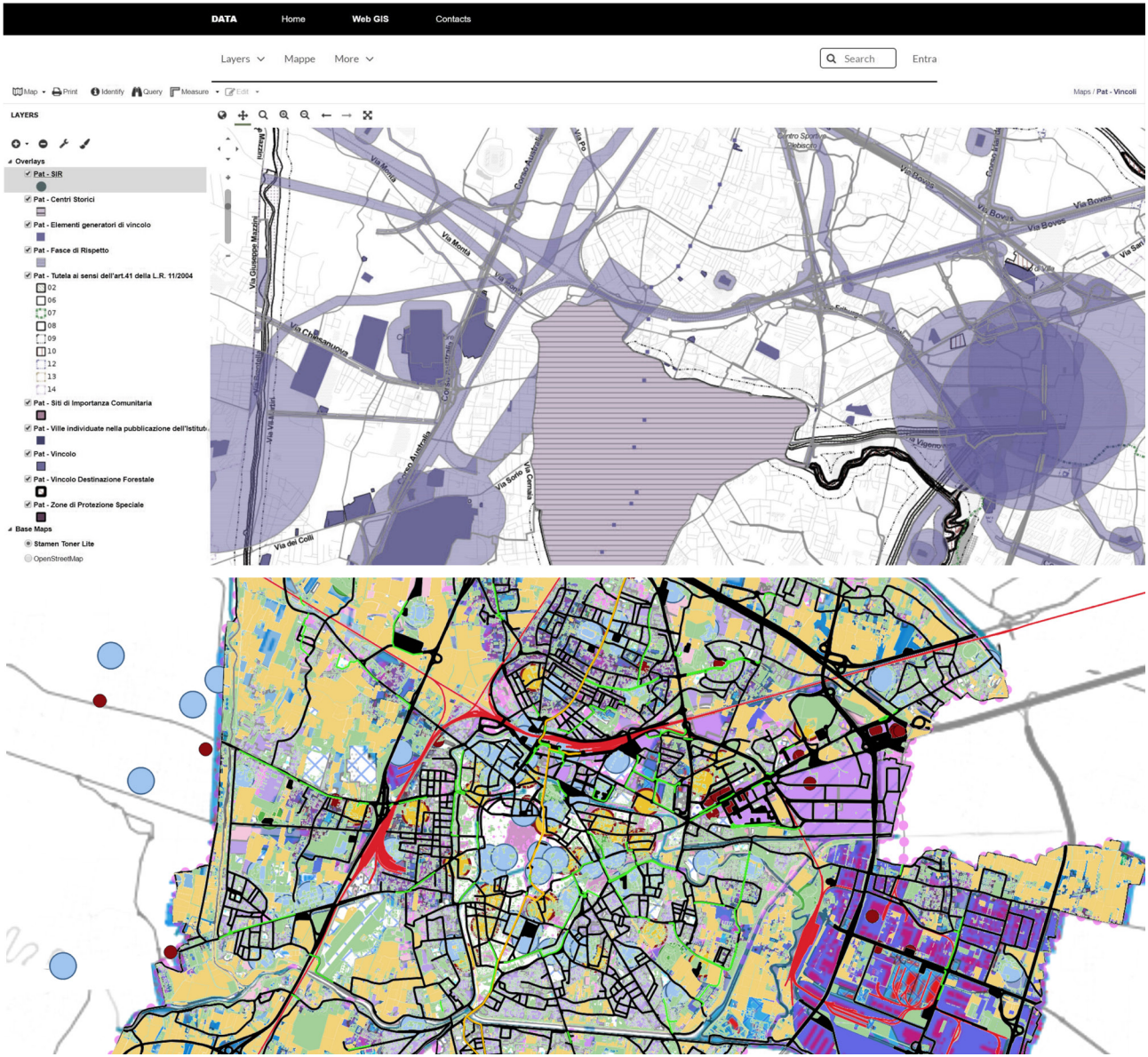


Fig. 6. Realization of digital application: G.Pettoello. 3D volumetric representation of the periphery of Padua: D. Barbato. Rendering image credits: Ex Foro Boario Padova. Serena Vianello, Mix and Match. Transformation scenarios for the Ex Foro Boario area, Corso Australia, Laurea thesis in Building and Architectural Engineering, University of Padua, 2014. Instructor: L. Stendardo. Rendering image credits: Workshop 'The Canal of Babel'. Instructors: L. Stendardo, L. Siviero, S. Antoniadis. Students: M. Barison, A. Quijada-Garcìa, G. Pozzato, S. Reverenna. Location: Idrovia Padova-Venezia.

The real-time transformation of the observed portion of city makes communication of the architectural renovation project particularly dynamic and involving. With regard to the technological aspect, the program *Revit* was used to create the 3D model; *3D studio Max* was used for the rendering. To create the user-interactive interface (responsive hot spots), specific scripts were created and then applied to the points of interest in the 3D environment. From the 'volumetric' 3D representation of the city, it is therefore possible to immerse oneself within the 360° reconstructed panorama. The following image shows, in particular, the work related to the Ex Foro Boario area (fig. 6).
The second application regards the architectural scale. In this case as well, the object of study regarded the Ex Foro Boario area; however, the degree of user involvement was increased. In fact, with the 3D visor, not only is 360° immersion within the scene possible, users can also explore the reconstructed environment personally in real time by virtually walking through it (fig. 7). Three-dimensional modelling was also used in this case to construct the portion of the city under study, and with specially designed scripts, users can move among the various points of interest situated within the scene. An audio recording of city sounds was inserted in the application in order to involve the sense of hearing as well, to make the experience even more involving. In both digital applications described, the user becomes the main character and plays an active role within the reconstructed virtual environment.
The DATA project addressed not only the fields of communicating cultural goods and user involvement, but also and more specifically the theme of urban regeneration of marginal areas. ICT was therefore called to face a different, even more difficult challenge through the use of multiple layers of communication. The role and challenge that ICT is called to support is of reconverting stored 'waste'. (G.P.)

Conclusion

Within the overall DATA project, the segment of research related to visualization –intended as structuring data and complex structures that are not only spatial and described in the project as data management and ICT– is continually addressed. This is true on multiple planes simultaneously with all the other segments (*WebGIS*, *Data mining, Building and Land Information modeling*, *Pilot scenarios design*, *Urban planning, Feasibility studies*, *Urban mining*), constituting a fundamental structure of relationships which allows all active skills in the project to interact in a complex way.
The synergy among the different actions that have assumed a visible form through data management and ICT has given rise to different research products. Starting with the point clouds obtained by laser scanner and photogrammetric surveys, integrated with thermal camera images taken both from land and on drones, and through SCAN to BIM processes, BIM were produced that were then interfaced with web GIS built based on data mining. Through synergy with the segment of pilot scenarios design, visualizations of the design scenarios were produced by developing virtual, augmented, and immersive realities.
In sum, the different forms of visualization produced different output. In particular, the following were developed: a database that organizes the information gathered; a web GIS platform [3] that can be updated and integrated with new content; interoperable BIM models for some decommissioned areas and design scenarios; pilot scenarios on the architectural and urban scales; design strategies on the territorial, urban, and local scales; a collection of environmental data as well as a quantity and quality assessment of waste produced in relation to possible scenarios of intervention; high-tech multimedia ICT products [4] including software interfaces for mobile devices that use virtual and augmented reality; and a website [5] (fig.8) to disseminate on the Internet the results that integrate the web GIS platform. (L.S.)

Notes

[1] DATA *Developing Abandoned Transurban Areas* is a research project in the Department of Civil, Environmental, and Archietctural Engineering at the University of Padua. Duration 12 months (26 June 2017–25 June 2018). Financed through competitive call under ROP Veneto – Social European Fund 2014-2020 (Regional Council Decision. no. 2216 13/12/2016), and cofinanced with FESR funds. The scientific committee of the project includes: L. Stendardo, *Principal Investigator* (*Pilot Scenarios Design*, *Data Management* e *ICT)*; M. De Marchi (*WebGIS* e *Data Mining)*; A. Giordano (*Building and Land Information Modeling*); M.C. Lavagnolo (*Urban Mining)*; M. Savino (*Urban Planning* e *Feasibility Studies*). The research team consist of: G. Pristeri (*WebGIS* e *Data Mining)*; D. Barbato (*Building and Land Information Modeling)*; S. Antoniadis (*Pilot Scenarios*

Fig. 7. Virtual-reality view of the city with a 3D visor. Real-time exploration of the future scenario. Creation of digital application: G. Pettoello.

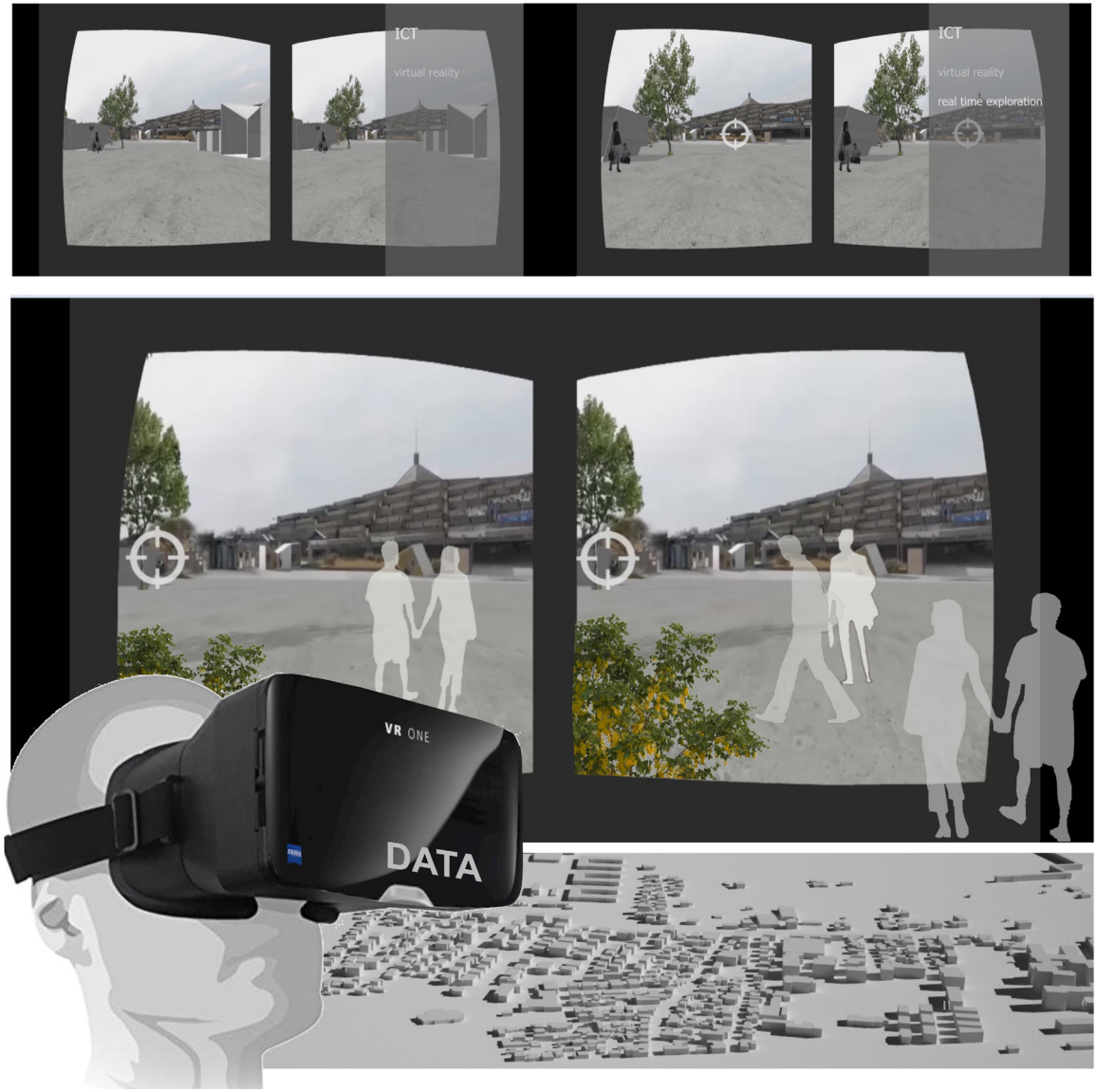
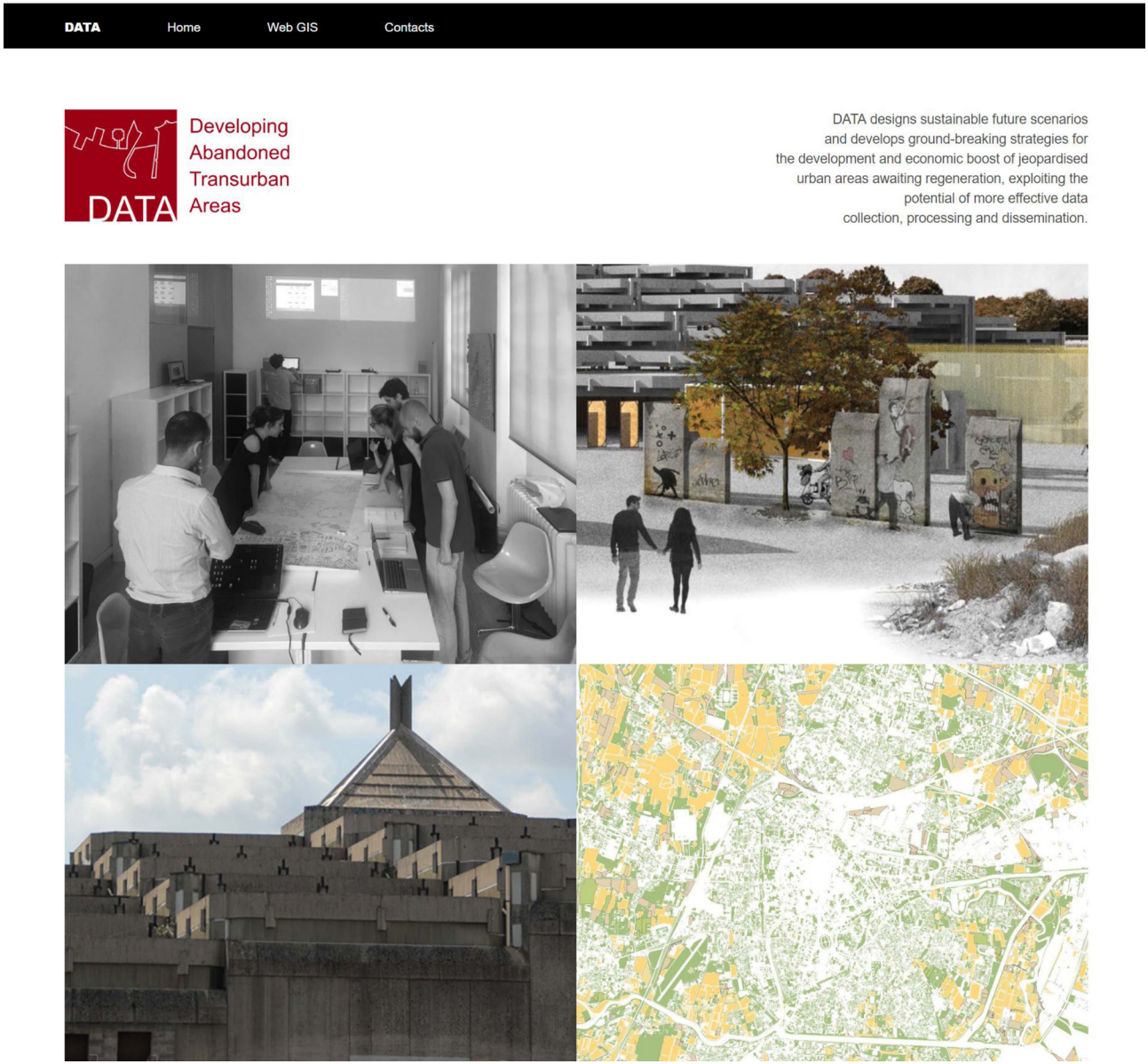


Fig. 8. Home page of the web site realized by the team during the year of activity. The web site shows the synthesis of the whole DATA project.



Design); E. Redetti (*Urban Planning e Feasibility Studies*); R. Malesani (*Urban Mining*); G. Pettoello (*Data Management e ICT*). The following entities participated in the project as network partners: Confindustria Padova, Centro Studi USINE e Fòrema, in qualità di *partner* di rete. The project also included the participation of the following operational partners: Archetipo s.r.l. (*Data Mining* e *Survey Implementation*); F. Gianoli (*Data Mining* e *Survey Implementation*); LTS s.r.l. (*Building and Land Information Modeling*); Orienta+Trium s.r.l. (*Building and Land Information Modeling*); CZ Studio (*Pilot Scenarios Design*); Favaro1 s.r.l. (*Pilot Scenarios Design*); Duff & Phelps S.p.A. (*Urban Planning e Feasibility Studies*); Impresa Costruzioni Edili Ing. Garbo (*Urban Planning e Feasibility Studies*); ACMO S.p.A. (*Urban Mining*); Ravagnan S.p.A. (*Urban Mining*); Advertendo s.r.l. (*Data Management* e ICT); Pallino & Co. s.r.l. (*Data Management e ICT*).

[2] X° INU Study Day, titled *Crisis and rebirth of cities* held in Napoli on 15 December 2017.

[3] <http://geodata.dicea.unipd.it/maps/?limit=100&offset=0> (accessed 2019, May 25).

[4] <https://youtu.be/u7cJUUVfDwI> (accessed 2019, May 25).

[5] <http://data.dicea.unipd.it/> (accessed 2019, May 25).

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LOD for Architectural Heritage: BIM Modelling for the Solimene Factory

Adriana Rossi, Umberto Palmieri

Abstract

The authors created a BIM model of a significant portion of the Solimene ceramic factory (Vietri, Salerno) based on an unstructured model obtained with phase-shift 3D laser scanning. The components, referred to standardized levels of development (LOD), are placed at the origin of a shared and interoperable workflow, suitable for comparing documents and models for design purposes and dissemination of architectural heritage.

Keywords: H-BIM, LOD, 3D Survey Technologies, Parametric Modelling, Points Cloud, Interoperability.

Introduction

The development of instrumental surveying techniques with 3D laser scanners and photographic datasets has introduced new methods to manage the complexity of the data acquired with high precision and quickness, also and above all for large architectures. The connected processes have profoundly modified the typical work of the surveyor: a professional once dedicated to the description and critical analysis of architectural/engineering works, today intensely involved not only as an expert in digital techniques but as the creator and administrator of the communication process of the project. In fact, the numerical model obtained from the data acquisition phases with active sensors is objectively representative of reality: rigorous measures can be taken from it and the quality of the survey products can be controlled, verifying –even afterwards– meticulous details. However, despite the certified precision, this model cannot be manipulated within a virtual space generated by a computer. To scale volumes and modify surfaces, or to enter geometric information of non-visible elements, the point cloud must be transcribed into continuous mathematically governable forms [Migliari 2004].
The techniques, the most common to implement this conversion, are based on algorithms that implement the triangulation of Delaunay: building grids of polygonal meshes with the vertices on selected points of the cloud, forms that establish relationships of connection and morphological identification are generated. The derived models are therefore suitable to support other types of operations

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and information, indispensable for professionals interested in adapting their modus operandi to technological development. Overcoming the resistance of the most traditionalists in the field of design, the law on public tenders commits, by decree, to manage the workflow with BIM platform. Overcoming the resistance of the most traditionalists in the field of design, the law [1] on public tenders commits, by decree, to manage the workflow with BIM platform.
This paper offers a good opportunity to verify the applicability of the method to historical buildings (H-BIM), to discuss the virtues and vices of the workflow based on the survey model, to support teamwork for the analysis of the possibilities of implementation and executive transcription of ideas.

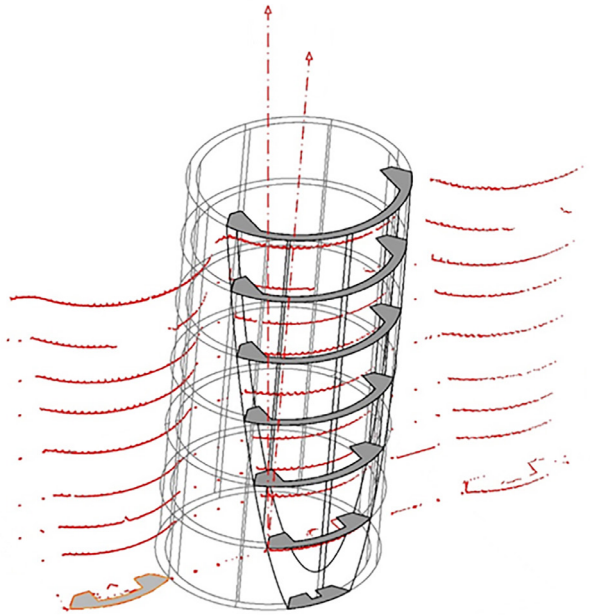
The case study

Unique in its conception, ambiguous in its form, irregular in its realization and incisively marked by time, is the Solimene ceramic factory, a work bound by LD 42/2004 and built between 1950 and 1955 in Vietri sul Mare (Salerno, Italy). The volume of the factory stands in the middle of

Fig. 1. South front of the Solimene factory (photo by the authors).

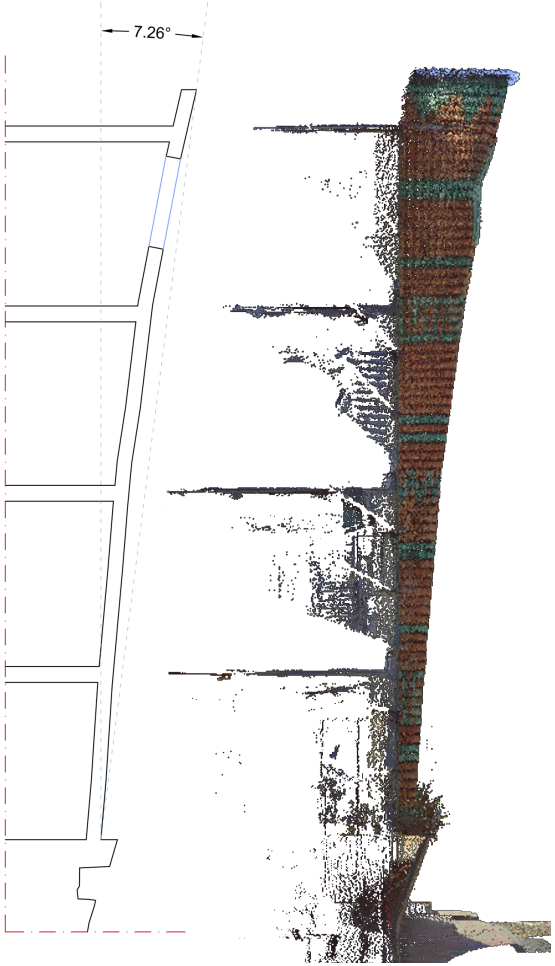
the Amalfi coast cliff overlooking the Gulf of Salerno, it is clearly visible from the sea with its characteristic front consisting of towering bodies and trapezoidal windows enclosing the deep cavity in which is produced and sold terracotta pottery decorated in local style.
The façade is dotted with bright green majolica and raw reddish terracotta (fig. 1): not a simple covering as it might appear from afar, but bottoms of thousands of 'bottles' set in the wall (about 16,000). A technique and a language resulting from experience, handed down and renewed preserving, also in this case, the indissoluble link between function, structure and aesthetics: by studying the static-dynamic behaviour of the building, the wall of bottles has proved to be a valuable solution for construction purposes as well as thermal and acoustic [Rossi 1995].
As the author, the architect Paolo Soleri (1919-2013), says, the design configuration is 'frugal' [Abbate, Spina, Zevi 2010] for its functional 'sustainability', respectful of the tradition of which it is a manifesto.

Fig. 2. The intersection between the oblique cylinder and the plane set on the pillars surface.



Soleri, applying the teaching of Frank Lloyd Wright, proposes an inexhaustible source of theoretical exercise: the abstraction necessary to interpret its formal structure generates mental elaborations that can still reconfigure the compositional aspect [Monteleone 2013].
Apparently, the high towers look like truncated cones erected like gigantic vases supporting the roof garden [Rossi 1995]. An idea confirmed by observing the perspectives painted in watercolour [2] by Soleri himself but clarified thanks to the critical survey [Rossi 2017]. Their real geometric configuration, in fact, has been explained by mathematical studies derived from the survey with total station (Trimble S6 Vision): these volumes are slightly oblique cylinders with the axis inclined by about six centesimal degrees respect to the horizontal reference plane.
From this, it follows that:
- the edge of each level the protruding floors is an arc of ellipse (not very pronounced because of the slight slope of the cylinder axis) (fig. 2);
- the intersection between the oblique cylinder and the surface of the pillars is a branch of ellipse not entirely on the oscillating pillar surface.
It seems likely that the vertical profile irregularities, evident as bottlenecks in the middle of the cylinders (fig. 3), rather than a bad execution, were a mandatory choice during the construction [Rossi, Palmieri 2018].
In order to answer the remaining questions, a new survey was carried out with a terrestrial laser scanner and photographic datasets. The technology and the device used, the Faro Focus 130 HDR [3], return an experimental certified model. The informative reliability of the method is derived from the remote sensing of millions of points, which indicates the distance from zero of all solid parts reached by the laser light [Rossi, Palmieri 2019].
This system is suitable for almost-Lambertian diffusive surfaces [Guidi, Russo, Beraldin 2010] but less reliable for reflective glass surfaces [Benedetti, Gaiani, Remondino 2011]. However, the acquired data are sufficient to address the descriptive reliability since the analysis is addressed to the description of the infill walls [4].
So, we did 10 outdoor (every 30 m) and 2 indoor scans. The targets allowed the instrument software (Faro Scene) to place 'hierarchically' the scans, the chronological steps of the operations and the photographic datasets. Final data were organized with RiScan Pro. To speed up the calculation, spherical targets along the road and flat squa-

Fig. 3. Schematic profile of large vase-shaped towering volumes.



res on the façade were used during the acquisition phase (fig. 4). We proceeded to filter the point cloud from outlier points. The final output was an 'unstructured' model made of points (XYZ-RGB-i), then transformed into triangulated surfaces (meshes) on which textures were applied. In order to study the façade volumes morphology, it was necessary to transform the experimental (discontinuous) data into vector models that were ideally continuous. This transcription does not exempt from interpretation, even though it is methodologically well-founded. This model, explorable in three dimensions, allows both the measurement of distances and the connection to iconographic or alphanumeric documents.

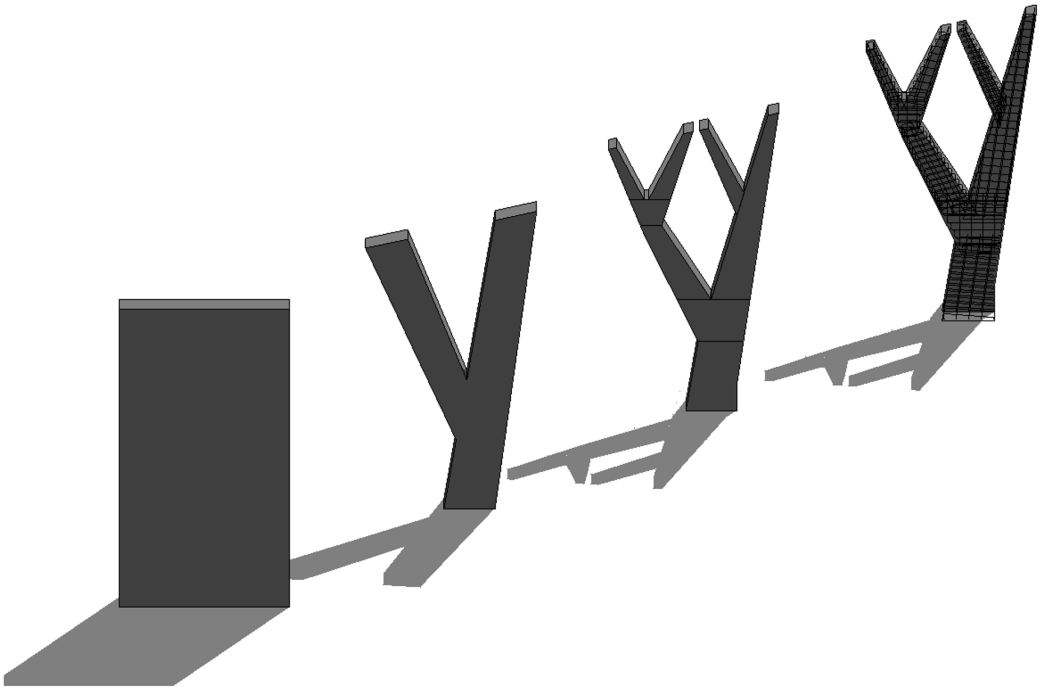
The three-dimensional modelling of the levels, processed in the same descriptive context, was guided by the tools offered by the modelling software.

There are specialized environments suitable for BIM that boast the ability to assist the production of many –if not all– specialized sectors (structures, plants, security, costs etc.). These, however, have been programmed to handle

Fig. 4. Location of targets and survey station points.

forms and techniques currently used in both engineering and architectural design: parts of buildings generally made up of serial and essential shaped elements are modelled quite quickly and effectively with those software products. The modelling of the Solimene factory appears to be anything but rapid in our case.
Therefore, an advanced 3D graphics software (Rhinoceros) was preferred to rebuild the surfaces and, then, a BIM software to continue modelling and implementing the necessary information [Tang et al. 2010].
The application of BIM processes to historical buildings (H-BIM) represents a challenge: if the effectiveness of the BIM method is in the use of standardized database of objects, the digital re-construction, due to the atypical nature of the historical construction, starts from the necessary creation of components with an adequate level of accuracy in relation to the objectives.
The survey of the current situation, that is, the model created from objective data acquired with certified tools and techniques, is at the beginning of the workflow made shared and interoperable thanks to the use of oriented objects. In fact, each project presupposes a survey of the current situation [Banfi 2016] which, for historical artefacts, must even consider diachronic transformations. Putting a certified document at the origin of the shared chain offers the advantage of working with the same software both for the creation of components and for the engineering study related to their correct sizing. Therefore, the phases of acquisition and post-processing of the collected data are decisive in directing the organization of the BIM workflow.

Fig. 5. Development of the family of structural pillars.



Certified levels of development

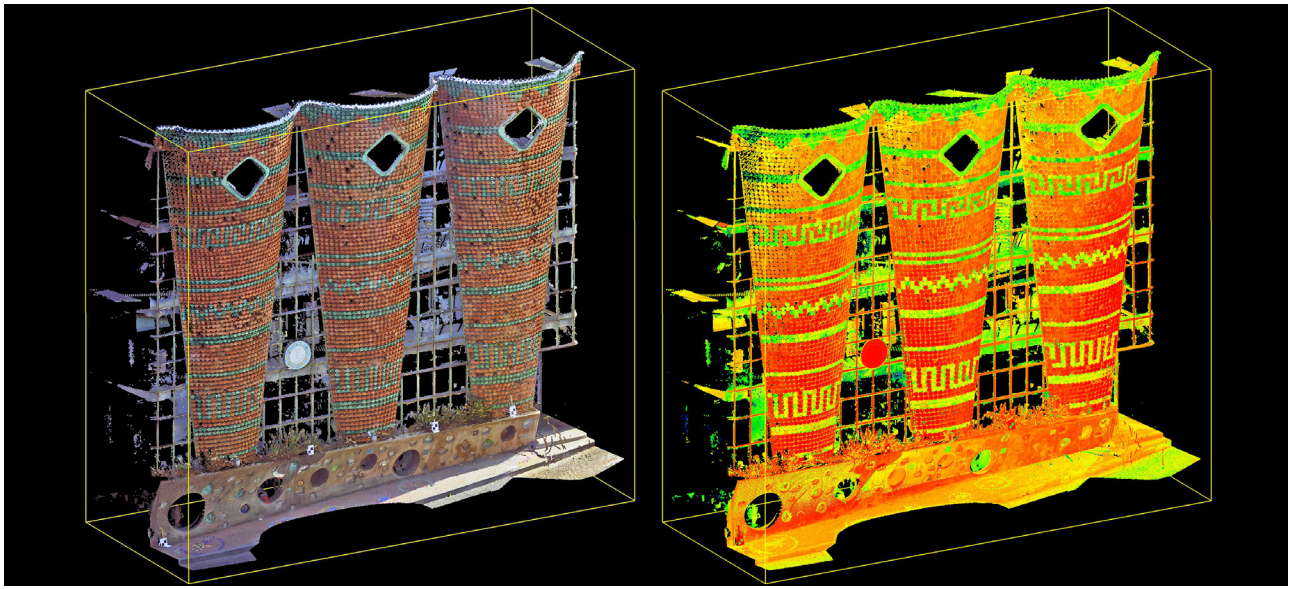
Information modelling, if addressed to historical buildings (H-BIM), can only be carried out starting from the construction elements definition derived from the survey. The true form and size of buildings and the environment in which they are located are catalysts for the elaboration of navigable models, aggregative cores of historical-documental information, diachronic analyses of changes, studies on materials and technologies and the necessary multidisciplinary comparisons. What in the past was configured as an aggregative core of symbolic alphanumeric and iconic data, today, if placed at the origin of a shared and interoperable chain of work, transforms the photo-realistic model, descriptor of the underlying information system, into a real digital construction [Gaiani, Benedetti, Apollonio 2011]. In this perspective, the scientific nature of the acquisition procedures is crucial both for the creation of the parts database and for the development of projects aimed at restoration and maintenance.
Coding the investigation process according to the agreed and signed knowledge level of analysis is the main action to be taken [5]. The standards, in fact, establish the geometric characteristics that objects must ensure (LOG, Level of Geometry) according to the related information aspects (LOI, Level of Information) in order to make

Fig. 6. Detail of the indoor pillars of the factory.

reliable the Level of Development (LOD) required by the project BIM oriented [6]. The same standards, however, show that graphic detail is a separate and independent issue [7]. However, it is desirable to have a sort of 'tolerance' of the detail in order to facilitate the transition between adjacent levels [Historic England 2017], satisfying the necessary precision. The level (LOG, LOD or LOI), obviously, does not coincide with the potential of modelling offered by the authoring BIM software, nor does it interfere with the quality of the certified survey, or with the deepening of the details modelled to create objects oriented in the sense explained above.
The uniqueness of the Solimene factory gives priority to the parametric construction of its components, pre-establishing their level of complexity. For this purpose, it is not always advisable to 'snap' directly to the point cloud [8]. In the absence of specific archives, form and geometry have oriented the primary decomposition for the recognition of serial characteristics, classifiable into cascade categories organized taxonomically.

The example shown in figure 5 clarifies a development by levels applied to the modelling of a pillar, element of original shape (fig. 6) and certainly not elementary (as could happen for new buildings). The operative practice foresees a development at different speeds of information and therefore of different geometries. If we look at the previous example, the tree-shaped pillar, we can see the unique LOD sequence that cannot be confused with the purely graphic detail: the element in Revit becomes a real vertical structure.
Modern BIM authoring software can model construction elements with different graphical abstractions, with detail according to the agreed LOD. They range, therefore, from a schematic visualization to a particularly high degree of detail [9].
Once the object has been created, it is possible to combine non-geometric information with it to make it uniquely identifiable: it can be named according to a classification system, to a position, possibly geo-referenced, and therefore correctly stored within the data model.

Fig. 7. Significant sample of the façade taken from the point cloud.



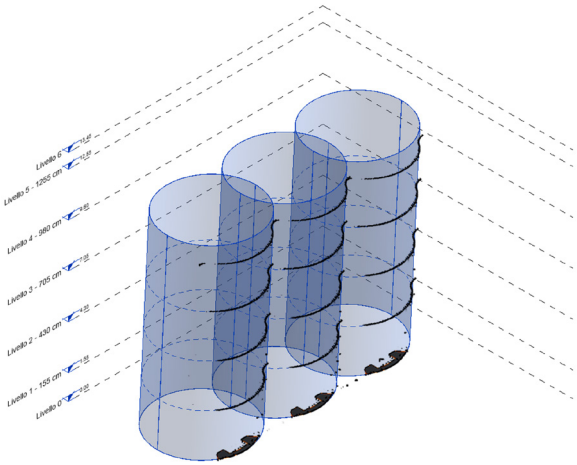
To define a parametric family, with objects aware of their characteristics, it is not enough to follow the logic of 3D vector graphics, but it is necessary to show and calculate (or describe mathematically) the geometric-constructive configuration of each component so as to make it 'intelligent', that is, accompanied by everything that fully documents what has been found on the subject.
From the very first phase, it is necessary to associate attributes to the 3D model that describe the nature of the objects present in the BIM model. Specifically, it is the creation of semantically defined geometries (walls, windows, doors) based on a typical architectural organizational structure referring to standardized levels of detail. This activity provides the taxonomic logic to develop the entire database made up of intelligent, questionable and interoperable objects for different purposes.

Building the information model

The absence of standardized BIM libraries [Arayici 2009] directly usable to assemble the components [Eastman 2008] has made it necessary to structure the elements of the case study specifically modelled and derived from the instrumental survey, in order to populate a database of parametric and interactive objects, formally homogeneous and always questionable for checks and inspections.
The construction of the model presented the difficulty of having to verify its geometric configuration before proceeding. The point cloud acquired with a 3D terrestrial laser scanner was the certified data for the (discontinuous) numerical model [Karmazyn 2017]. The file, processed and indexed after the survey phase, was placed in a BIM and georeferenced environment.
The point cloud connected to the project provided an extremely accurate visual and operational reference of the existing condition of the building, to be used as a guide for BIM data production operations.
In fact, each point detected is measurable, selectable and allows snaps for modelling. The cloud, once optimized and purged from useless information, allowed us to directly start the definition of the parametric elements, limiting the inaccuracies.
Having already discarded all non-functional points at the entry, the digital (re)construction of the Solimene factory was much faster. What was rendered in BIM is a significant sample of the facade (fig. 7) consisting of 3 of the 11 'towers' that mark the wonderful front. Each building element distinguished by name, number and position was associated with a type, therefore, correctly filed within the data model with a corresponding parametric family. The types prepared for the model were as follows:
- infill walls;
- external wall layer;
- glass walls;
- structural floors;
- structural pillars.

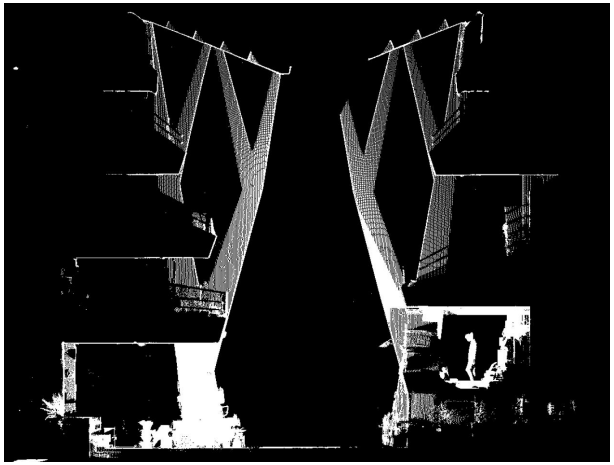
For this study the model was based on the symbolic aspect of its architectural elements, referring it to the standardised levels of development and referring to subsequent developments the possibility of reproducing also all the iconic beauty of the factory.
The principle was to use two languages in parallel: the first, technical, typical of architectural design and the second, informative, developed with alphanumeric data.
The components of the sample have been deconstructed in generic solids, only defined by their size corresponding to the volumes detected, thus matching the level LOD300.
The progress of the modelling, however, was also related to the quantity and quality of information collected and actually transferred to the model: accurate descriptions

Fig. 8. Constructive references for the creation of parametric families.



and historical information associated with the various geometric types allowed us to increase the level of information (LOI), increasing the level of reliability (LOR) of the work.
The modelling phases were distinguished according to the construction logic, hoping that the (re)construction simulated in digital could also reveal the accidents that arose during fabrication.
First, the following reference elements were derived from the point cloud: the heights corresponding to each floor, the plane on which the glass walls are placed and the circumferences representing the intersection of the inclined cylinders with each floor. Subsequently, these cylinders were modelled to be used as intrados of the infill walls (fig. 8).
At this point it was possible to create the floors, the structural pillars, the infill walls and the large glass walls.
The floors modelling was made easily applying the 'floor' family at the desired level, having already the reference heights. The pillars of the facade, partly hidden in the curtain wall, were modelled by examining old photos of the construction, while the tree-shaped pillars were derived from the internal scan (fig. 9).
Infill walls were modelled from the surfaces of the cylinders and then detailed by inserting the rhomboidal windows and a texture depicting the distinctive red and green terracotta bottoms. The glass walls, lying on the vertical plane, were quickly created with the specific 'curtain wall' family, remodelling the profile to give it a trapezoidal shape. At this point, the components were correctly sized and positioned with respect to each other, in perfect coherence with the results of the 3D laser scanner survey (fig. 10).
The possibility of extending the multidimensional model with additional information has encouraged the use of specific features of the BIM software, such as collaboration tools. In practice, the project was shared with professionals able to develop the structure of the factory. By creating a specific workset, reinforcements were added to the splendid branched pillars (fig. 11).

Fig. 9. Orthophoto of the point cloud derived from the factory's internal scan.



Objectives pursued and achieved

The case study provided an opportunity to test strengths and weaknesses of the H-BIM method at the basis of a workflow aimed at:
- integrate a plurality of professionals to support the analytical investigation: the 3D model (as a whole and in its components) becomes an exhaustive descriptor of the underlying articulated database, going beyond the character of a mere graphic interpretation tool;
- verify that the levels of development considered are suitable for the typical documentation requirements of tender specifications, up to the creation of the prototype that should constitute the entire data environment of the project.
In conclusion, it should be noted that processing the digitisation of project representation and documentation offers many further research developments:
- to digitally verify the construction hypotheses, to measure the differences between the numerical model and the ideal model, to reveal the reasons for unexpected events during the work;
- to subject the conformative hypotheses to inductive verification;
- use the information system and inter-operational models to allow inter and trans-disciplinary contributions to present the results in an impartial, logical and critical manner;
- to organize a process that converges towards the idea of the project, guaranteeing to future memory the detailed and truthful documentation of the as built;
- share all the data of the analytical survey.

Notes

[1] The public tender code (d.Lgs. 50/2016).

[2] In the Municipality of Vietri are kept the signed copies, signed with Eng. Immormino who verified the static calculation necessary to obtain the building permit, issued in 1954, as a variation of the project already approved [Zampino 1995].

[3] Phase-shift terrestrial 3D laser scanner, accuracy: ±2 mm; Range 0-130 m; Built-in high-definition metric camera (> 6 MP); Built-in GPS antenna; High acquisition speed: min. 976,000 pti/sec; Scanning angles: 360° horizontal - 300° vertical.

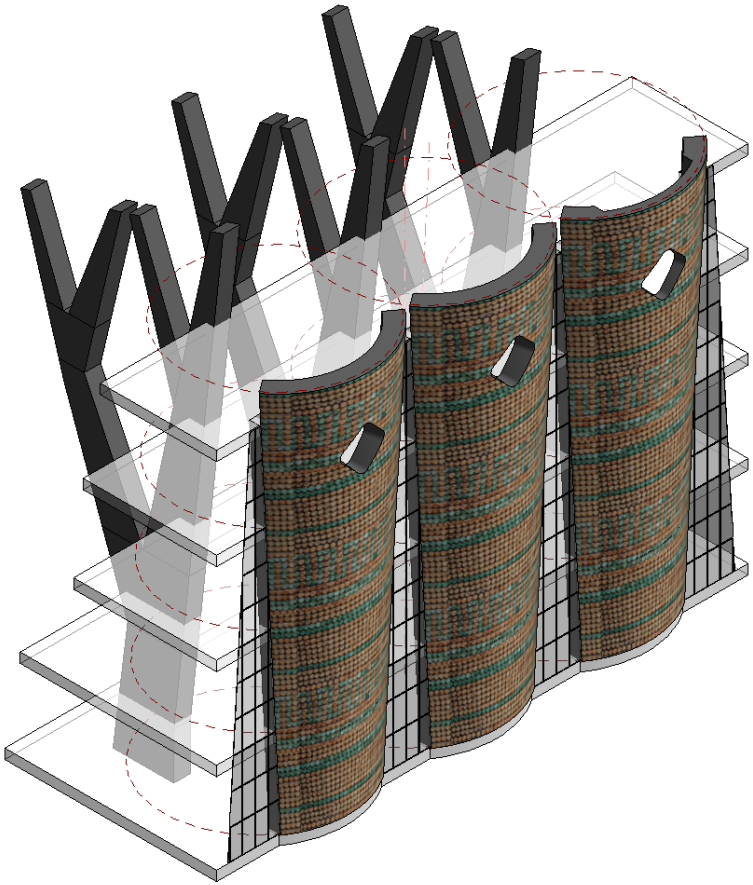
[4] The difference in signal return times allows the software to interpret the values as "peaks" and "valleys" of the surfaces and then convert them into points or polygons. The same is not true of reflective and transparent surfaces, for which acquisition is much more complex.

[5] BIM Execution Plan [BEP - PAS 1192-2:2013].

[6] UNI 11337:2017-4; AIA E202-2008: B.I.M. Protocol Exhibit.

[7] In particular, UNI 11337:2017-4.

Fig. 10. BIM model at LOD350.



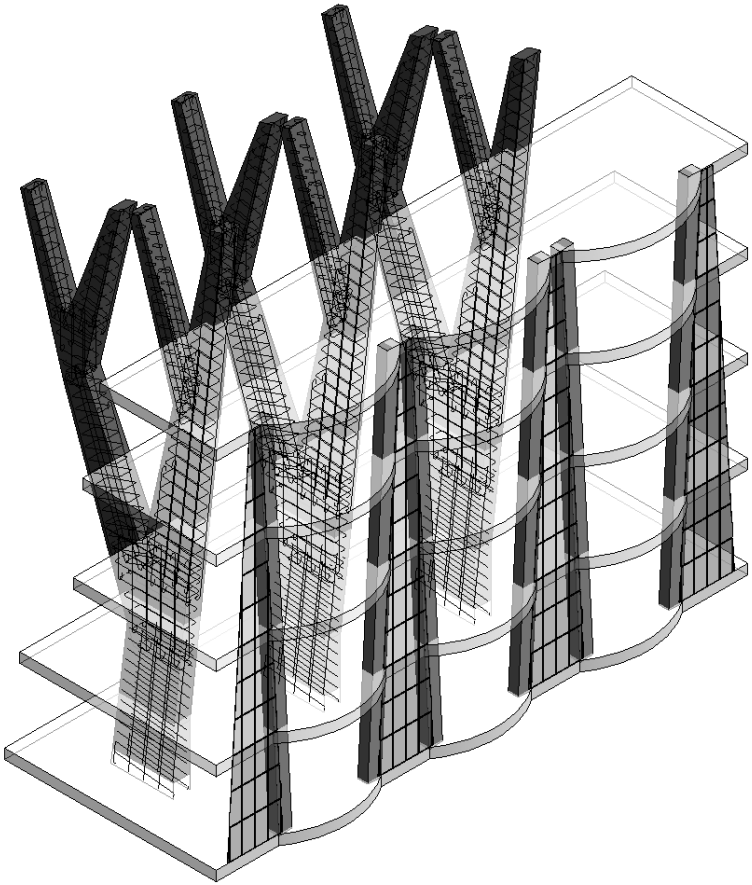
[8] Since 2008, "AIA E202-2008: Building Information Modeling Protocol Exhibit"), a guide containing the contents of the main design elements according to the design phase they describe, has been periodically updated and published online.

[9] AEC (UK) BIM protocols.

Acknowledgments

The unpublished and original results of this research would have been impossible to achieve without the survey and analysis developed by Halyna Karmazyn, then scholar of extraordinary diligence, today environmental and civil engineer. His will and honesty are, for all the fortunate who deepened her acquaintance, an occasion of a profound critical revision of the way of understanding and wanting life.

Fig. 11. BIM model at LOD400.



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Information Models to Manage Complexity for an Integrated Knowledge Project

Raissa Garozzo, Massimiliano Lo Turco, Cettina Santagati

Abstract

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

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

Introduction

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

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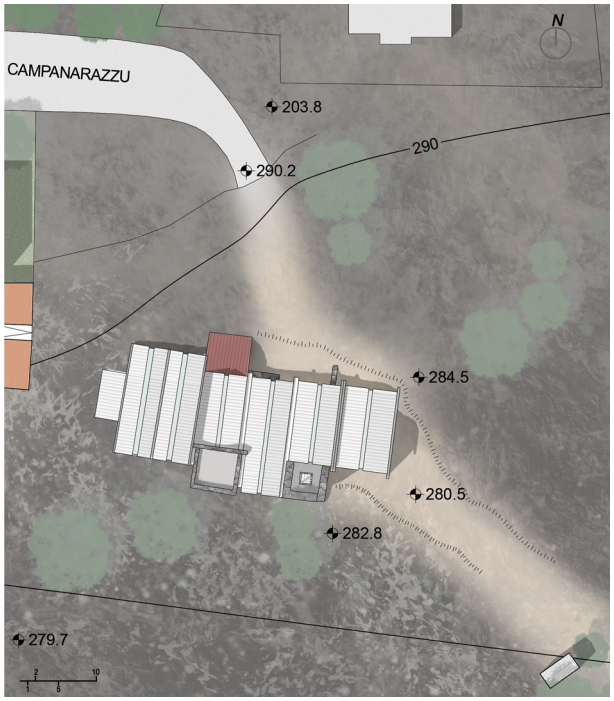


Fig. 1. General plan (graphic elaboration: R.G.)

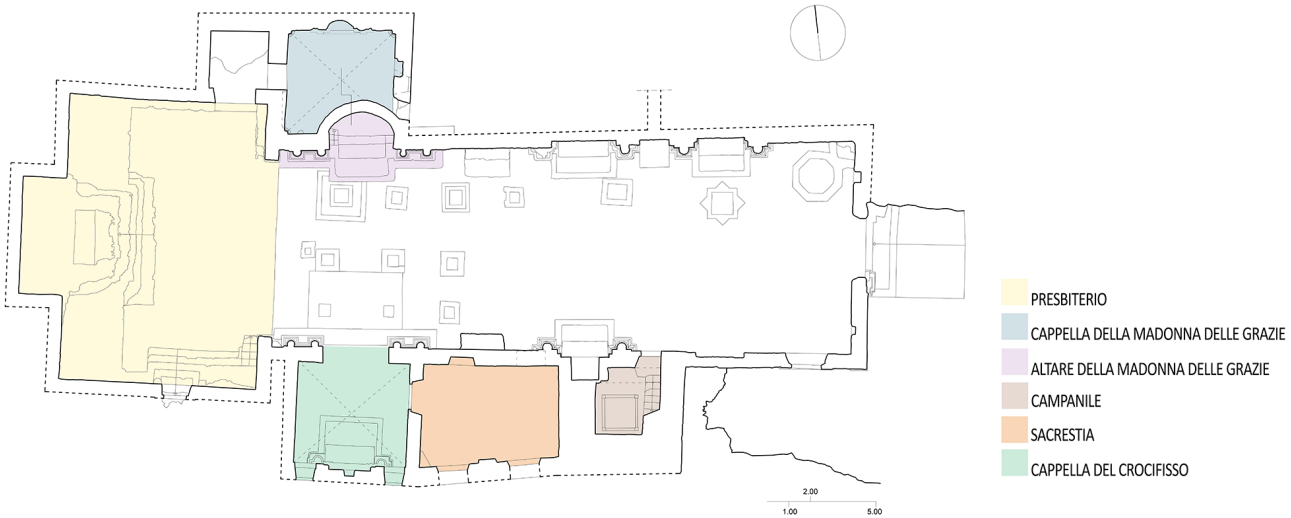
topic is still a frontier issue: the presence of irregular surfaces and complex decorative apparatus as well as the definition of very unique attributes, leads to time consuming activities in the setting-up of the model, due to difficulties which are not easy to solve and that shall be considered as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

Related works

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

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

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



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

The Church of Santa Maria delle Grazie in the ancient Misterbianco

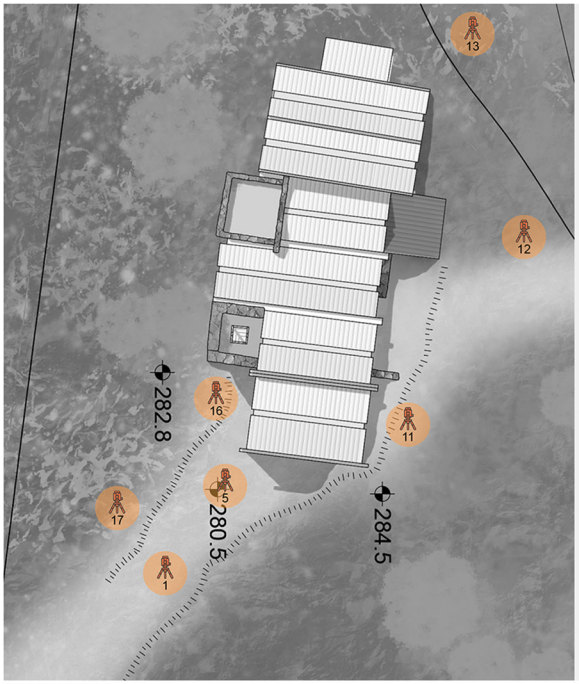
The following study refers to the Mother Church of the ancient Misterbianco (Catania), identified as a very interesting case study due to its unique state of preservation (unleaded walls, deformed flooring, original wall texture overlaid by today's integrations). Located 5 km north-east of the current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

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

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

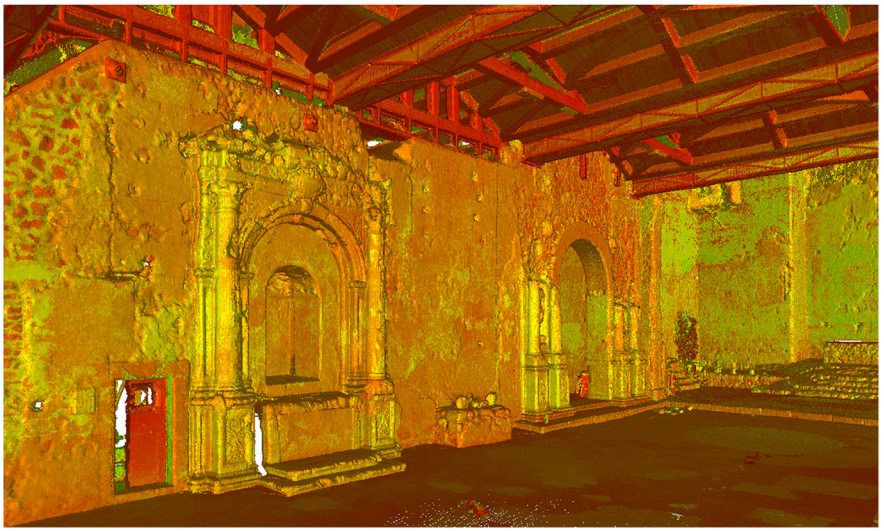
On the southern front there is the access to the bell tower and the chapel of the Holy Crucifix, a quadrangular vaulted room connected to a room probably used as a sacristy. On the northern wall, concealed by the niche of the imposing altarpiece that housed the marble statue of the *Madonna delle Grazie*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

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



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

Leica HDS 3000



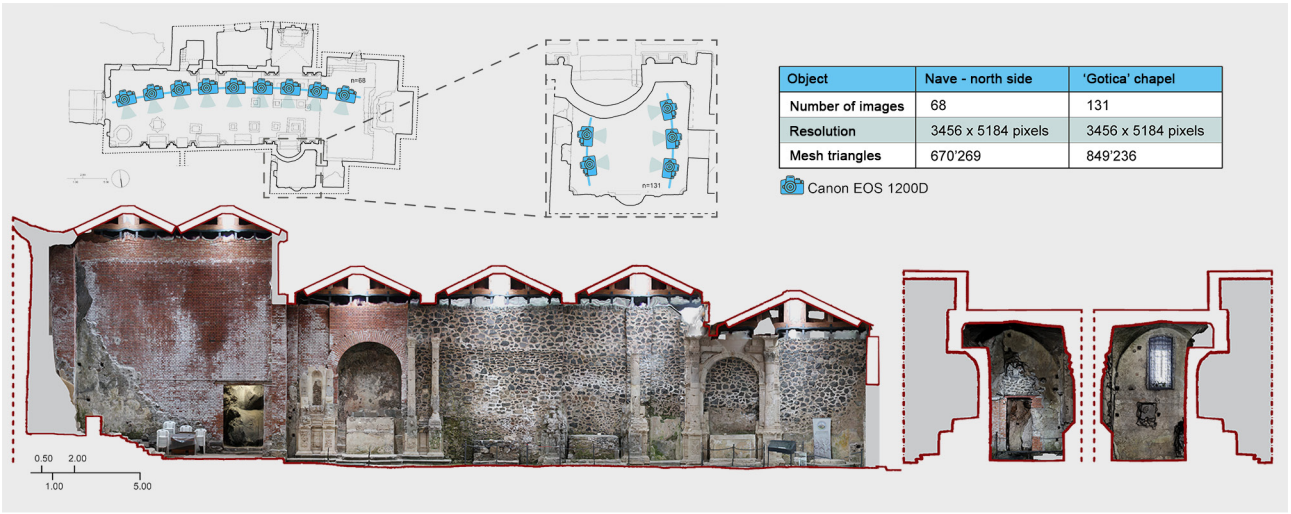
From survey to infographic representation: between interpretation and interoperability

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

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

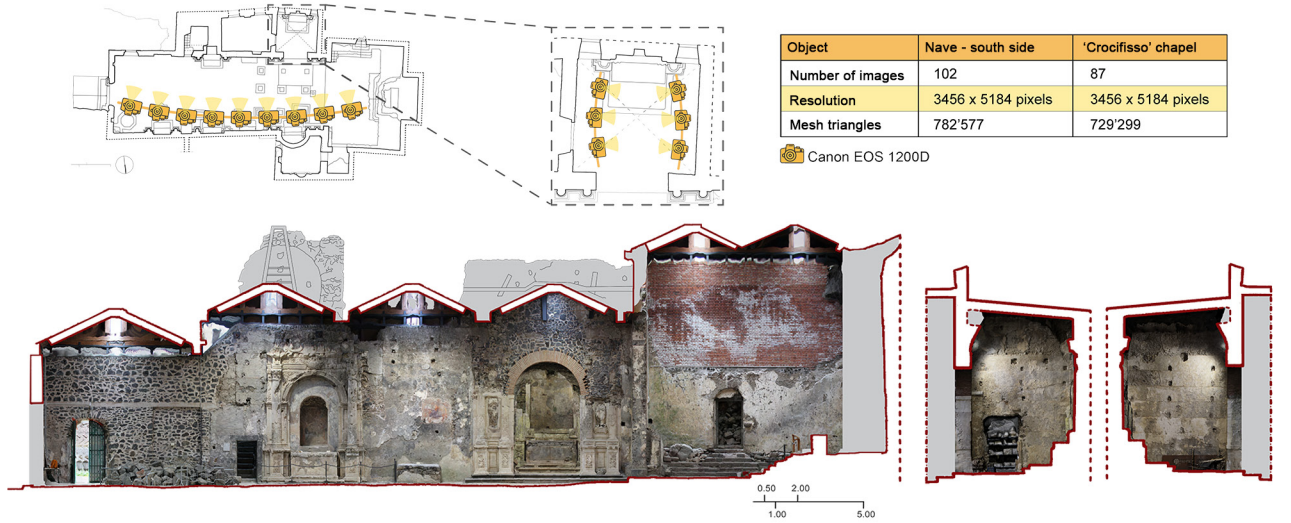
An integrated survey implies a double control, by providing to relate the definition of the level of geometric accuracy, obtained in the phase of graphic restitution, with the modeling of the attributes, semantically related to the digital artifact and its components. Moreover, as mentioned above, the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

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



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

Canon EOS 1200D

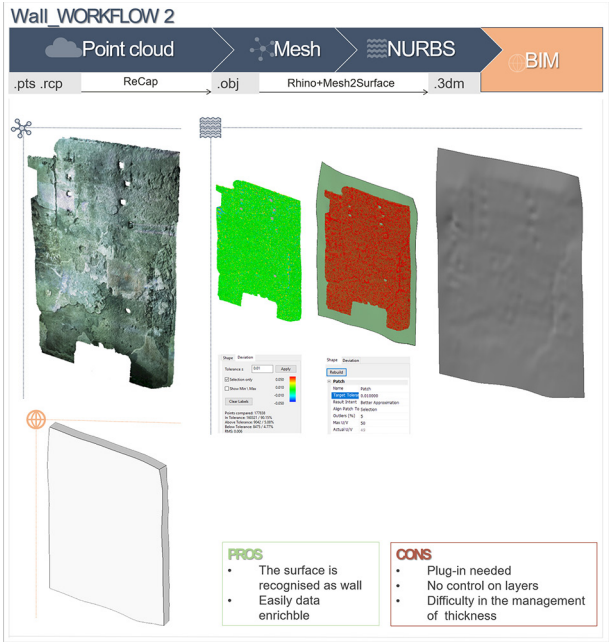


Object	Nave - south side	'Crocifisso' chapel
Number of images	102	87
Resolution	3456 x 5184 pixels	3456 x 5184 pixels
Mesh triangles	782'577	729'299

Canon EOS 1200D

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

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



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

Conclusions

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

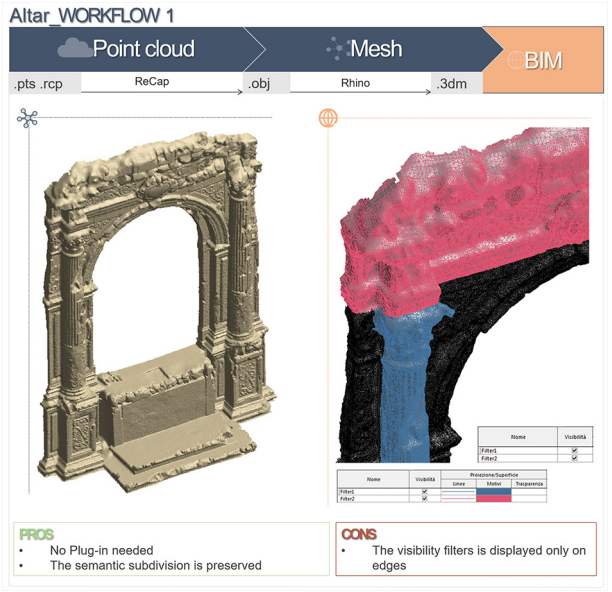


Fig. 9. Experimentation on the altar (graphic elaboration: R.G.)

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

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

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RUBRICS

Readings/Rereadings

Readings/Rereadings

Drawing is a Miracle! Aldo Rossi's *A Scientific Autobiography*

Paolo Belardi

First published under the title *A Scientific Autobiography* [Rossi 1981a], as part of the *Oppositions Books* series by the prestigious editors, Peter Eisenman and Kenneth Frampton, translated with great lyrical sensitivity by Lawrence Venuti and commented upon with extraordinary critical acuity by Vincent Scully (author of a memorable afterword entitled *Ideology in Form*), Aldo Rossi's *A Scientific Autobiography* (a story in a personal key to the relationship with architecture and the profession of architect) is an absolutely atypical book, because it manifests itself as a diary, a notebook and a memoir, all at once. But, on closer inspection, it is much more than that. This is evident from the start: it is one of the most engaging and, in some ways, most moving pieces of Italian literature in recent decades. Perhaps because it was written by an architect-poet who has never hidden his sense of awe, in the stories of his "dear architectures" [Posocco, Radicchio, Rakowitz 1998], suspended between mobility and immobility, or in his own personal story, suspended "between here and an elsewhere on the border between life and death" [Rossi V. 2009, p. 11].

"I began these notes about ten years ago, and I am trying to conclude them now so that they do no turn into memories. From a certain point in my life, I considered craft or art to be a description of things and of ourselves; for this reason, I have always admired Dante's Commedia, which begins when the poet is around thirty years old. By thirty, one ought to have completed or begun something definitive, and come to terms with one's own formation. All my drawings and writings have seemed to me definitive in two ways: first, they concluded my experience, and second, I then had nothing more to say. Every summer seemed to me my last summer, and this sense of stasis without evolution may explain many of my projects. Nonetheless, to understand or explain my architecture, I must again run through things and impressions, must again describe them, or find a way to do so" [Rossi 1981a, p. 1].

A Scientific Autobiography has certainly been (and still is) a fortunate book, having been re-edited many times and translated into many languages (from Spanish to Japanese; from German to French). But it is also a book that has, in certain respects, been misunderstood. At least, it was, initially, since it was published in Italy by the Pratiche Editrice of Parma publishing house only in 1990 [Rossi 1990], almost ten years after the first American edition. Published, moreover, in an austere editorial guise, which highlights many differences with respect to the original, both in its physical dimensions and in its collection of images: presum-

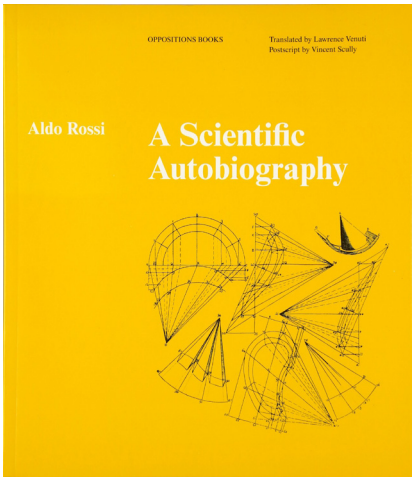

Fig. 1. Cover of the first edition [Rossi 1981a].

https://doi.org/10.26375/disegno.4.2019.22

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ably by choice of the same Rossi, who has never loved publishing magnificence. "I will not talk about my projects, because I do not think this is the occasion and the place: I will only say that I like their publication in a continuous and bare form and so different from the fashions we are used to, where are redundant color and format and comment [Rossi 1981b, p. 7]"
In fact, whilst the American edition comes in the form of an album (22x24 cm), flaunting a hardback cover signed by Massimo Vignelli and displaying a representative masterpiece taken from Guarino Guarini's *Civil Architecture*, and is accompanied, in the appendix, by a selected body of twelve autographed drawings entitled *Drawings, Summer 1980*, the first Italian edition comes in a pocket format (12x20 cm), with a paperback cover framing a detail of the photograph *Palm tree by the lake* taken by Gianni Braghieri, and is almost bereft of images, except for a portrait of the author, leaning against a railing overlooking the backdrop of a lake and lovingly embracing his daughter, Vera. And yet, despite its editorial austerity (the book is devoid of any devices: no colophon, no index, no preface, no notes and no bibliography), even in Italy *A Scientific Autobiography* has soon risen to cult status: it is the object, not only of passionate critical reviews and learned academic dissertations, but, also, of continual re-interpretations. One was conducted with rigorous methodology by Giovanni Poletti in a doctoral thesis discussed in 2009 [Poletti 2009] and published in 2011 after a minimal revision [Poletti 2011].
"From the study and the charm of the great courtyards of his country, of his homeland, Rossi arrives – following the routes of a landscape that is also, and above all, symptomatic of the existential motions of being – at other buildings of the cities of Galicia and of Andalusia, revealing his intimate premonitions, the *correspondances* (Baudelaire) between people, "things" and these buildings that, whilst belonging to their own time, evoke the memory of 'other' things. Rossi thus explores the role of memory and places:

Fig. 2. Cover of the first Italian edition [Rossi 1990].

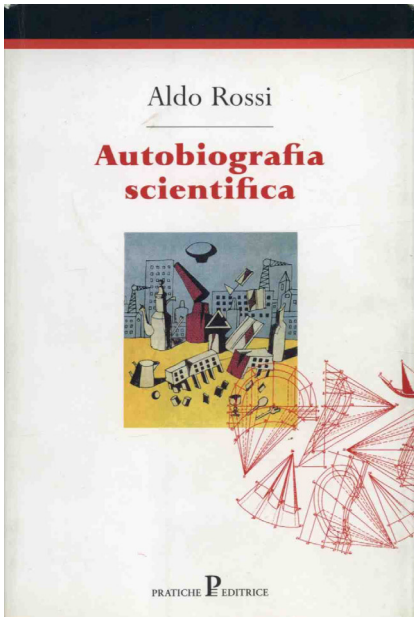

Fig. 3. Cover of the second Italian edition [Rossi 1999].

Fig. 4. Cover of the third Italian edition [Rossi 2009].

the *corral* typology evokes, in the present, other courtyards already seen and experienced in the houses of old Milan, but also in the farms of the Lombardy countryside, and from these landscape-places, through the gallery closely linked to the courtyard –through a sort of archetypal space-time continuum– he returns to the Sevillian *corrales*, with architectural structures continually orbiting, pursuing and identifying each other, beyond time and space. [Poletti 2011, p. 3]"

Whilst explicitly citing Max Planck's *Wissenschaftliche Autobiographie* and yet implicitly pre-empting the self-monograph *S, M, L, XL* by Rem Koolhaas, *A Scientific Autobiography*, precisely because it was conceived at the end of the Seventies, within the context of the rampant proliferation of visual messages, presents itself as a precious opportunity to rediscover an inverse relationship between text and image. The text, punctuated by personal reminiscences (the Sirena hotel; the Magdalene inn; the Odessa hospital) and fond memories (the San Carlone in Arona; the Filarete column in Venice; the buttresses of the cathedral in Milan), as well as by precise iconographic references (above all, the paper by Opicino De Canistris), emulates the evocative tone of the old serial novels, where insights and visualisations were left to the imagination and culture of the reader. This is betrayed by the title, *A Scientific Autobiography*, which Rossi chose, having long considered another, very different title, *Destroying architecture* [Leoni 2004, p. 124]. *A Scientific Autobiography* is, in fact, an oxymoronic title that "connects two different and usually distinct narrative modes: one is overtly intended to portray a mirror image of life, whilst the other is scientifically dedicated to mapping the relevant instruments of a discipline (field of work; art) for architecture" [Marini 2017].

"Certainly a very important point of reference is Max Planck's *Scientific Autobiography*. In this book, Planck returns to the discoveries of modern physics, recapturing the impression made on him by the enunciation of the principle of the conservation of energy; he always recalled this principle in connection with his schoolmaster Mueller's story about a mason who with great effort heaved a block of stone up on the roof of a house. The mason was struck by the fact that expended energy does not get lost; it remains stored for many years, never diminished, latent in the block of stone, until one day it happens that the block slides off the roof and falls on the head of a passerby, killing him. It may seems strange that Planck and Dante associate their scientific and autobiographical search with death, but it is a death that is in some sense a continuation of energy. Actually, the principle of the conservation of energy is mingled in every artist or technician with the search for happiness and death. In architecture this search is also undoubtedly bound up with the material and with energy; and if one fails to take note of this, it is not possible to comprehend any building, either from a technical point of view or from a compositional one. In the use of every material there must be an anticipation of the construction of a place and its transformation" [Rossi 1981a, p. 1].

A Scientific Autobiography is an elusive book, open and closed at the same time. It is an open book because, although it departs from a pre-determined point, it does not arrive at a pre-defined destination, developing freely within a setting that enmeshes places that are very distant, geographically (Belo Horizonte, Berlin, Cordoba, Galveston, Granada, Milan, New York, Sintra, Seville, Zurich), and as part of a screenplay that entwines characters who are even more distant, historically (Leon Battista Alberti, Dante Alighieri, Rosso Fiorentino, Ernest Hemingway, Edward Hopper, William Shakespeare), or even epic personalities (Alceo, Hamlet, Melville). But *A Scientific Autobiography* is also a book which closes in on itself because, retracing the salient stages of ten long years of project activity by the author (punctuated by absolute masterpieces such as the expansion of the town cemetery in Modena, the design competition projects for a student house in Chieti and for a new business centre in Florence, the theatre of the World in Venice and the monument of the Resistance in Cuneo), it loses itself in a circular *ad lib* trend. In the pursuit of happiness.

"As I continue these autobiographical notes, I should speak of several projects which characterize certain moments in my life; they are well-known projects which I have always avoided discussing directly. The first is the project for the cemetery at Modena, the second the project for student housing at Chieti. I believe that the first, by its very theme, expresses the end both of adolescence and of an interest in death, while the second signifies a search for happiness as a condition of maturity. In neither project I have renunced the liturgical sense of architecture, meaning that I have not done much more than has already been established by convention, even thought the results are quite singular. The first project is strongly bound up with certain experiences and with the conclusion of the search for fragments in the skeletal form. The second has to do with a state of happiness; it is like Christmas and, in another way, like Sunday. The quest for happiness is identified with the happy time of a holiday – especially because at such times, when things come to a halt, it seems impossible to withstand the force of happiness" [Rossi 1981a, p. 8].

"In the project for the municipal center at Florence, I imagined restored statues in the piazzas, like the alabaster Davide destined for tourists, thinking all the while that the copy is never entirely dissociated from the original, that in the plastic paintings of Venice with their ever-present lightbulb, hung in poor but decent kitchens among the family portraits, the mistery of the theater, whose performance is so important for us, is evoked again. We abhor directors who tamper with the text and ignore the period in which it was written; the ritual and hence the moment in which actions are performed constitute one of the fundamental rules of architecture and the theater. The rule applies equally to the places of the city. I thought about all these things during the Venetian autumn, when I was observing the construction and birth of 'the theater of the world'. This unique building made me feel quite happy; in it I rediscovered the oldest threads of my experience and the more recent ones of my own history. Perhaps I also saw rising from the water my projects from Modena and Cuneo which so resemble the cube-like theater, but as I have said, stasis had become a condition of my development. The compulsion to repeat many manifest a lack of hope, but it seems to me that to continue to make the same thing over and over in order to arrive at different results is more than an exercise; it is the unique freedom to discover. In this light, ought I now to view my projects as a succession of unfinished and abandoned undertaking, or as a pursuit of the unexpected appearance of some new event? It seems to me that the event constitutes the novelty of a thing, and it is in this context that I have spoken of a competition, a particular place, a monument" [Rossi 1981a, p. 54].

But above all, *A Scientific Autobiography* is a book on drawing, interpreted in its Albertian form of thought. Nor could it have been otherwise, given that, in the works of a controversial master like Aldo Rossi (who shared with Robert Venturi the prize for being the architect who was most detested yet, at the same time, most loved by his contemporaries), writing, drawing and construction co-exist in a tumultuous fashion [Dal Co, 1999], creating a triangle which may become equilateral, or isosceles, or scalene, according to the circumstances. But it still remains a triangle or a geometrical figure typical of the building site, where it allows the establishment of orthogonality and the mapping of buildings.

"I have always associated a rather complex meaning with the wooden yardstick used by bricklayers. Without this yardstick there is no architecture; it is both an instrument and an apparatus, the most precise apparatus in architecture. This sense of measurement and distances made me especially fond of the investigation of topography made by Professor Golinelli at the Politecnico in Milan. We use to spend entire mornings measuring the Piazza Leonardo da Vinci, perhaps the ugliest piazza in the world, but certainly the one most measured by generations of Milanese architects and engineers. Now it would happen that because the spring measurements were taking place with a certain laziness, and for a thousand other reasons which were not figured into the probabilities of inexactness, our triangulations often failed to close. The final form of the piazza became something absolutely original, and I found in this inability to close the triangulations not only our incompetency and indolence (of course) but also something mythical, like a further spatial dimension. Perhaps from these experiences my early projects for the bridge at the Triennale and the monument at Segrate were born. The unsuccessful attempt to close the triangle was an affirmation of a more complex geometry, which, however, proved to be inexpressible and could demonstrate only the most elementary facts" [Rossi 1981a, pp. 49-50].

Paradoxically, *A Scientific Autobiography* is a book on drawing, precisely because, although it is not illustrated by drawings, it invites one to reflect on the biunivocality of relationships which, through the practice of drawing, bind together past and future, survey and project, knowledge and design. Even if Rossi, relying on interest for the reconstruction of fragments and proceeding with feed-back between order and disorder, does not list the graphic instruments in the form of a manual and does not describe the representative techniques in the form of a compendium, but re-interprets the foundations of 'D Factor' in the form of a poem.

"Professor Sabbioni, whom I particularly admired, discouraged me from making architecture, saying that my drawings looked like those of bricklayer or a rural contractor who threw a stone to indicate approximately where a window was to be placed. This observation, which made my friends laugh, filled me with joy, and today I try to recover that felicity of drawing which was confused with inexperience and stupidity, and which has subsequently characterized my work. In other words, a great part of the meaning and evolution of time escaped me and still does so today, as if time were a material which I observe only from the outside. The lack of evolution in my work has been the source of some misunderstanding, but it also brings me joy" [Rossi 1981a, p. 39].

"Drawing was, for a long time, the only concrete way for Aldo to create architecture, and not only in terms of planning, but also in the sense that he would nurture the fruits of his imagination as if they were small objects to be displayed on a table; they were endowed with a certain

substance and vitality, often manifested through colour, a colour at times swirling with dense shadows, at times piercing and absolute like the blue of the sky that appears in the drawings for the cemetery of Modena. […] As far back as the Seventies, the method of drawing reveals a connection with certain aspects of modern painting: Sironi, above all, but also cubism, metaphysics and tonal painting. In particular, the collage technique allows him to introduce, in a drawing from as early as 1970, the decontextualised historical reference that will only later be transmitted into the architecture designed and built" [Portoghesi 1999, p. 7].

A Scientific Autobiography speaks mainly of project drawing but, on closer inspection, it also speaks of survey drawing. Challenging the concepts of measure and dimensions, as interpreted from the technical manuals, or celebrating the fertility of metric imprecision. And of the invisible distances (but also insurmountable distances) between thought and communication, between past and present.

"How does one establish the dimensions of these things, and indeed, what dimensions do they have? In this summer of 1977 I was staying at the Osteria della Maddalena when I came upon an architectural definition in the course of a conversation that was otherwise not very memorable. I have transcribed it: 'There was a sheer drop of ten meters from the highest point of the room.' I do not know the context that this sentence refers to, but I find that a new dimension was established: is it possible to live in rooms which drop off so suddenly and precipitously? Does the possibility exist of inventing such a project, a representation which lies beyond memory and experience? It is useless for me to declare that I have tried in vain to draw this project or this room: I could do it if it were not for the fact that the drawing always stops at a void which cannot be represented. For many reasons this void is both happiness and its absence" [Rossi 1981a, p. 24].

"When I write about architecture, I seem to be able to encompass these things in a general design, and I don't know to what extent this concerns only my architecture. Now it seems to me that that something, perhaps a nothing, that always existed between thought and communication, between past and present, ever more persistently disappeared. So when I wrote: 'It is strange how I resemble myself', it seems I still did not know how to consider that something that defines the differences, or certain differences, between the things we do" [Rossi 1989, p. 244].

"But it is this love for collecting that underlines the separation, the fragmentation of things without any further possibility for relationships, where distances become insurmountable" [Moschini 1979, p. 8].

Not only. *A Scientific Autobiography*, in developing themes already addressed by Rossi in other writings, also speaks implicitly of survey drawing, electing it as the medium of a renewed synergistic relationship between the new and the ancient.

"Finally, any statement of the relationship between new buildings and the pre-existing configuration of the town and its architecture is more than a mere correlation between different qualities and quantities. (The attempt to discover that relationship in external facts stems from a mechanical point of view). Any such statement to be capable of affording a solution to more general problems, must be generated from within the project according to the limits of the theme developed" [Rossi 1976].

On the other hand, "how can one measure buildings, if an amphitheater can become a city, and a theater a house?" [Rossi 1981a, p. 77]. And, above all, how can one measure time?

"The double meaning of the italian word *tempo*, which signifies both atmosphere and chronology, is a principle that presides over every construction; this is the double meaning of energy that I now see clearly in architecture, as well as in other technics or arts. In my first book, *The Architecture of the City*, I identified this precise problem with the relation between form and function: form persists and comes to preside over a built work in a world where functions continually become modified; and in form, material is modified. The material of a bell is transformed into a cannon ball; the form of an amphitheater into that of a city; the form of a city into a palace. [Rossi 1976, p. 1]"

"I have always known that architecture was determined by the hour and the event; and it was this hour that I sought in vain, confusing it with nostalgia, the countryside, summer: it was an hour of suspension, the mythical *cinco de la tarde* of Seville, but also the hour of the railroad timetable, of the end of the lesson, of dawn. I loved the railroad timetable, and one of the books I have read most attentively is the timetable for the Swiss railroads. This is a volume written entirely in small, precious characters, where the world intersects the black typography, where trains, buses, steamers, and ferries carry us from east to west, and where a few pages, the most mysterious ones, contain places and distances shaded pale rose. Thus they brought me again to the idea of analogy, which I have always regarded as the realm of probability, of definitions that approximated the object through a kind of cross-referencing. They intersected like train switches. [Rossi 1976, pp. 80-81]"

Reading the pages of *A Scientific Autobiography*, many questions emerge. One wonders, for example, how it is possible that a book bound so closely to personal experience is still loved and devoured by such distant cultures. Just as one wonders how it is possible that, in a world dominated by

digital manipulation and automated heuristics, this small book, which places the theme of handmade drawing at its core, can still be of interest. I certainly don't know. Or perhaps I do. Because, having established a good interpersonal relationship with Aldo Rossi at the time of the construction of Piazza Nuova in Perugia, I know he had a great love for the cinema. In particular, I know that he loved the opening sequence of the film *Good Morning Babylon*, directed by the Taviani brothers, in which the old contractor Bonanno, at the end of the restoration work on the cathedral of Santa Maria Assunta in Pisa, sits solemnly on a chair and, contemplating the façade together with his workers, exclaims, enraptured: "It's a miracle!". Which is what many of us think when admiring the writings, drawings and, above all, drawings-writings bequeathed to us by Aldo Rossi: "a human vision of the city, […] that today dissolves in the daring architectural visions of Dubai" [Scully 2009, p. 13]. Perhaps because, at a time when research is suffocated by the addiction to the parametric modeling exhibitionism, we need to return to breathe the poetic freedom of handmade drawing.

"I have thought of using this book to analyze my projects and writings in a continuous narrative sequence –understanding, explaining, and simultaneously redesigning them. Yet I have seen how, in writing all this down, one creates another project, which in itself contains something unforeseeable and unforeseen. I said that I have always liked things that were brought to a conclusion, and that every experience has always seemed conclusive to me: I have always felt that I was making something that would permanently exhaust my creativity. But always this possibility of conclusion has escaped me, even thought an autobiography or an ordering of one's work might well be such a decisive occasion. Other memories, other motives have come into view, modifying the original project which is still very dear to me. Thus, this book is perhaps simply the history of a project, and like every project, it must be conclusive in some way, even if only so that it can be repeated with slight variations or displacements, or assimilated into new projects, new places, and new techniques –other forms of which we always catch a glimpse in life [Rossi 1981a, p. 84].

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Reviews

Reviews

Carlos L. Marcos, Ángel Allepuz Pedreño (eds.)

Alberto Campo Baeza. El bisturí en la linea

Alicante, Universitat de Alicante
2018
pp. 168
ISBN 978-84-16724-98-7

El Bisturí en la línea was presented as part of the XVII Congress of Architectural Graphic Expression, celebrated in July 2018 at the University of Alicante. This book was introduced as a complement to the drawings and models exhibition of Alberto Campo Baeza, Professor at the School of Architecture of Madrid.

I had the great privilege of enjoying the magnificent conference prior to the presentation of the book and exhibition. The first words of Campo Baeza (p. 15) were dedicated to the "most beautiful work in the world", a profession that the architect, born in Valladolid, defends passionately.

However, throughout his extensive work, that passion was always allied with rational research process on the elements that one day would materialize his projects.

For the Master, "the drawings are like a research": his graphic tools seek architecture concepts with the precision of a scalpel ("Bisturí" in Spanish). Campo Baeza confirms it in the precious metaphor at the introduction of the book: "What is a drawing but the shadow of an idea after being illuminated by the light of knowledge?".

The drawings presented in this publication are thus germs of projects, assuming themselves as "signs of the language of architecture", according to the magnificent prologue by María Elia Gutiérrez-Mozo and Andrés Martínez-Medina (pp. 9-13).

These are mostly schematic drawings that, without seeking graphic virtuosity, manage to explore, fix, and communicate ideas. The editors Carlos L. Marcos and Ángel Allepuz Pedreño carefully organized these drawings in 10 chapters, where by each includes an interesting theoretical introduction that contextualizes the illustrations.

In addition, a suggestive 'taxonomic table' (pp. 42-43) is presented which, according to the editors, "allows the material to be exhibited to be grouped according to criteria", inspired by similar works by Peter Eisenman and Alejandro Zaera Polo (Foreign Office Architects).

The sketches and diagrams of Baeza remind me, due to their synthetic expressive line, those of other masters such as Álvaro Siza Vieira or Oscar Niemeyer. They are, however, more pragmatic drawings than those done by the Portuguese architect (where horses or angels often coexist among project ideas). Obviously, they are less organic than the ones which Niemeyer used to do in his Copacabana office; naturally drawings are always a reflection of the work of each architect, or vice versa.

Other sketches in this book evoke the architect Peter Zumthor. His drawings are like powerful stains that generate gaps or negative spaces to generate living spaces. Although the Swiss architect normally uses materials that directly define the stain, re-

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nouncing the outline, while the Spanish master rarely abdicates the line as the limit of the shadows, both seek, with these drawings, the 'stereotomy of architecture'. This concept is very clearly explained by Baeza in his text *From the cave to the hut* and the editors of this book also dedicate several pages to it.

Over the years Baeza produced thousands of drawings (the architect wrote that he had made 7,777, but we know that there are many more). Only a small sample is displayed in *El Bisturí en la línea* where plans, axonometries, sections, and conical perspectives cohabit. These are mostly central perspectives (one vanishing point) and the vast majority from a 'human' view point, which makes us imagine the spaces that one day will eventually be transformed from 2 to 3 dimensions. I would like to highlight some hybrid representations like the perspective sections. In this type of representation, the American architect Paul Rudolph is always a reference, however, his most popular drawings are always representational illustrations, while Baeza uses them to think: 'think with hands'.

Fernando Pessoa, paraphrasing the Roman general Pompey, wrote: "Navigating is necessary, living is not necessary". In *El Bisturí en la línea* we can preview the process of how Alberto Campo Baeza 'navigates' his ideas through drawings.

Surely this book, well laid out and treated with an exquisite methodological rigor, will be enjoyed by lovers of drawing and architecture.

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Reviews

Andrea Casale

Forme della percezione dal pensiero all'immagine

Franco Angeli, Milano 2018
pp. 264
ISBN 978-88-917-7076

"To perceive a visual image implies the beholder's participation in a process of organization. The experience of an image is thus a creative act of integration" (Kepes 1971, p. 17). Thus wrote Gyorgy Kepes in the introduction to his fundamental *Language of Vision*, to which the fine essay by Andrea Casale, that we present here, certainly owes the clarity of the approach used to examine the theme of the image, not in itself, but as a process, as an act of a discipline of organization of which vision, perception and memory are the protagonists. The urgency to reflect on the way of understanding visual language as an aid to "thinking in terms of form" permeates the pages of Casale's book. In glancing through its chapters, one perceives a certain anxiety in dealing with the need to reclaim vision as a primary tool for orientation, and thus for measuring and organizing spatial events, and the approach to this theme is novel. Those of the *Language of Vision* were years in which enthusiasm for the revisiting of the Bauhaus model proposed by the School of Ulm still animated the Schools of Architecture throughout the world, in a lively dialectic that had also intensely involved the theoretical foundations of geometry and representation. What happened shortly afterwards is a well-known story. Investigation into the concept of perception and visual thought ended up by being relegated to architectural training courses; its preparatory function for the project of an education of vision, which instead underlies the exercise of control over form and the idea of space, was underestimated and in some way abdicated. And thus a large and fascinating area of investigation into visual thought long escaped consideration in the field of representation, while a flood of images, both pervasive and invisible, began to invade the experience of everyday life. The first merit of Andrea Casale's essay is, therefore, that of recognizing, above all, the need to restore importance and centrality to the theme of education of vision, that would be capable of redefining emotional horizons and categorical tools useful, today more than ever, for acting with awareness in the varied scenario of the new media. In a memorable page of *Lezioni americane* (Calvino 1993, p. 103), Calvino had warned of the risk of losing the faculty of *thinking* in images and had invoked the need for a "pedagogy of vision." It is not an exaggeration to say that with his essay Andrea Casale basically attempts to give an answer to that concern by posing a few fundamental questions: what really happens when we look at something? what is an image? what are we doing when we use images? how do we learn when we learn through images? And Andrea Casale does so with particular attention to setting his reflections in a wide context in which the psychology of perception, traditionally used to explain visual-perceptive phenomena, allows itself to be con-

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taminated and enriched by different areas, from the physiology of the eye to the neurosciences, from philosophy to art, in a series of references that reveal the author's belonging to the category of researcher and, at the same time, to the category of artist.
But let us proceed in order. The essay opens with a chapter, *Occhio e mente*, devoted to the fundamental relationship between eye and mind, a key element of that process which from sensory information leads to awareness, that is, to the definition of forms endowed with a meaning. The critical horizon introduces the inevitable reference to the Gestalt paradigm into a broader range of reflections that define its limits and comparisons with contemporary and subsequent theories –from behaviorists to cognitivists– that, without denying its role in the evolution of visual thought, contextualize its meaning within the area of contemporary thought. Thus the argumentations of the following chapter, *Dalla matita alla matita*, are based on a well-defined critical reference and clearly develop the broad disciplinary and methodological issue of perception seen as a "complex and sophisticated [cognitive process] of interpretation of environmental stimuli, dynamically and actively modified by the mind in the continuous exploration of the environment" (p. 33). The notions of sensation and perception return, each one inserted, for its own specificity, in the process of recognition in which the role of memory –be it declarative or procedural– is clarified in a progressive awareness of the phenomena that appear to us under the visual aspect to which the entire chapter is devoted. The clear definition of the idea of perception of the "visual fact" as the result of the dynamic interaction between signals coming from the external world and information stored in memory introduces the role of imagination in the construction of the process of recognition of objects and of the space around us. A process in which the contents of the following chapters (*Lo spazio e il tempo and Rappresentazione mentale, rappresentazione iconografica*) provide further specifications and qualifications of meaning. The way of "what" and that of "how" we perceive are set into the spatio-temporal dimension understood, in a contemporary sense, as a "mental construction that, starting from specific information received by the senses, leads to deduce the reciprocal position of objects and the environment and of ourselves in relation to them" (p. 87), at the same time activating mental structures, "schemes" that categorize and group objects in abstract representations in which the general knowledge of phenomena takes shape. "Our brain, rather than processing images, constructs, through the active management of neuronal impulses, especially internal ones, together with the little information coming from the external world, complex conceptual and symbolic conditions that we could define as spatial mental models" (p. 100). The language with which these mental models communicate toward the external, but especially toward the internal world during our actions occupies the author's reflections on the thread of the relationship between mental image and iconographic image and in the subtle relationship that binds one to the other. The reference to Nelson Goodman's writings helps to define, in this context, the concept of similarity, and perhaps it would have been useful to refer to those "degrees of iconicity" in which Abraham Moles summarizes the entire linguistic space of the possible representations of an object in placing at its extremities the real object and its abstract counterpart, the word.
The tone of the argumentations in this first part of the book, in which complex themes are often touched upon, is on the whole pleasantly discursive, but never banal. The intention is clearly to build a clear and agile document on the themes of perception, seen as a "mental solution" to a problem posed by the senses, and on the relationship between thought and image. The examples and visual experiments proposed are useful in explaining the concepts. The bibliographical references, ranging over a significant period of time that reaches the contemporary period, are sufficient, and render the theoretical framework solid by enriching it with transversal contributions.
For now, "drawing" remains in the background, ready to come into play in the following chapters in which it is, instead, the great protagonist. In *Il bambino e il disegno* the author outlines the need that each of us has to communicate with the graphic sign, from scribbles to graphic expression, proposing as the key to interpreting this process the subtle line of development that goes from random realism to lost realism, up to intellectual realism and *Verismo* realism, underlining the cultural aspects and contexts. But it is above all in the next chapter, *Lo strano fenomeno della prospettiva*, that the author, an expert in geometry, finds his sincerest tone as a 'representer', proposing an interesting and not at all commonplace approach to that 'diabolical', more than 'symbolic', instrument, as Vittorio Ugo puts it, which is perspective. Casale enters into the *querelle* that has always seen the juxtaposition of those who accuse perspective of betraying reality with its

'symbolic form' and those who emphasize its value as a geometric-mathematical model' of space, radically changing, indeed, the point of view! The clear distinction between the author and the observer of the perspective image, "since the former constructs the image through what he knows and therefore from the mental model of the object, [while the latter] constructs his own mental model recognizing, in the representation, the characters deduced from his perceptive experience" (p. 159), defines the contours of this approach favoring the observer's gaze, and allows Andrea Casale to link the hypotheses for understanding perspective space to the whole context of previous reflections. The geometric relationship that is generated between object, observer and picture is at the same time the origin and the outcome of a process aimed at generating, on the one hand, the illusion of reality, and on the other hand, the representation of a truth, and both concepts of truth and illusion are interpreted by Casale as distinct tracks on which the observer's experience moves in his investigation of perspective space and its meaning, at the same time perceptual and cognitive. Once again the description of the cultural and methodological contexts is clear and captivating and allows the author to underline, through exemplary cases, the conversational tone of the image both in its relationship with the artist and then in its relationship with the observer until it becomes "a system of transmission between mind and mind" (p. 19) and therefore a system of communication. *Arte da vedere* and *Il bello del disegno* are the two final chapters in which this attempt to shift the reflection on the image for its fundamental role of communication, into the context of artistic production or architectural design, finds its clearest form of expression. Perhaps slightly less convincing in terms of approach and solidity of the theoretical framework, these two chapters are, instead, the clear and courageous attempt to bring the whole path of reflection back into the context of the production of images in which the artist and the architect (and Andrea Casale interprets both roles) are engaged in their daily work, thus completing the itinerary of reflection on the process that from thought leads to the image with a strong reference to the role that visual thought has in the dimension of the project and, more generally, of the creative process.

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Reviews

Livio Sacchi

Metropoli
il disegno delle città 2

Gangemi Editore International,
Roma 2018
pp. 239
ISBN 9788849283419

After the interest in the themes of the city was reduced at the end of the twentieth century, while at least until the end of the '70s they were so popular, with the new millennium these issues exploded again and today the mutual relationship between *urbs* and *cives*, the physical and the relational reality, the infrastructures and the people are very relevant.
In this era everyone is back to talk about the city, not only for its technical and specialized aspects, but also as the site of the survival of humans, therefore a priority. In fact, since the first decade of 2000, for the first time in history, on the planet most men live in the cities than being spread in the territory. Statistics say that by mid-century at least 75% of men will inhabit cities, and their number will rise to almost 10 billion. Probably cities will represent (and perhaps even now they represent) the only 'place' where you can 'live' in a contemporary sense.
In the second half of the 20th century, often the city had the problem of not representing the best in quality of life (large population density, complex mobility, noise levels and air quality far from being desirable etc.). But, since the beginning of the digital age, to live in a connected place, equipped with cultural and communication infrastructures, with networks and education, is synonymous with wellness and welfare.
Contrary to what one might imagine twenty or thirty years ago, statistics also say that larger cities grow more than smaller. Metropolises, megalopolises, megacities will become the privileged (or perhaps the indispensable) place for a good part of humanity. It is not hard to see why, even if the reasons are many and intersecting each other and they are readable only through the complexity that seems to characterize the current phase of the planet's life (Edgar Morin *docet*). Except for a few cases where there is a decline, mainly the big cities of the world are characterized by a growth that seems unstoppable. The shape of the metropolis continuously changes in appearance and substance: the aggregative principles of the new suburbs, the relationship with the centre/centres, the regeneration of compromised parts, the densification of aberrated portions.
Only those who ignore the architecture and its urban role may think that the substance of a constructive mutation does not become an image. Even if these phenomena seem to be globalized and they tend to look alike to each latitude and longitude, in reality European cities differ from Asian ones in their development and those of North America differ from Latin American or Asian ones. This difference draw a dissimilar design in each megacity, not only derived from the morphological matrix, the original system, the morphology of the territory on which it grew, but very much it derives from endogenous paradigms: culture, religion, customs and traditions, that holds different identity settings even in a contemporary and maximized city.
After the first volume named *Metropoli.*

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Il disegno delle città, in which Livio Sacchi led us to the main European cities (Amsterdam, Copenhagen, Berlin, Istanbul, Rotterdam, Turin, London, Madrid, Milan, Paris), this second volume takes us to 23 other megacities equally spread around the world: again Europe (Hamburg, Barcelona, Dublin, Helsinki, Lyon, Manchester, Munich, Moscow, Oslo and Stockholm), but also Asia (Dubai, Hong Kong, New Delhi, Beijing, Riyadh, Shanghai), North America (San Francisco and Los Angeles), South America (Bogotá and San Paolo) and Africa (Cairo, Nairobi and Cape Town). For each city, the information is always accompanied by very explanatory graphs and diagrams and provides a clear dimensioning of the planimetric extension of the conurbation, its shape, the number of its inhabitants, and as a result it give the urban information (density in particular) aimed at immediately give a first idea of the specificities and similarities between the different cases.

Almost always there are diagrams to understand the evolution over time of the urban dimension and shape. Generally, the topography of the territory and the presence of the main geographical features (orography, sea, rivers etc.) are compared. Districts, neighbourhoods and number of residents, often divided by ethnicity or origin, immediately show the heterogeneity of these cities, as authentic symbols of the contemporary, made of both globalization and a characteristic uniqueness. Diagrams, illustrations and data are joint with images, renderings and photos of the architectural projects that characterize the last years of development and those that are planned and/or under development and which currently the metropolis is still debating.

All these images also provide a possible representation of the city in terms of communication and image. Much attention is given to transport infrastructures, such as airports, stations, subways, as distinctive features of a large city, which is identified and recognizable by the structures that define its level of efficiency and international context. From the documentation reproduced on the latest urban masterplans, the immediate future is clear as imagined by the communities in terms of urbanization and land consumption. These are the answers that the single cities give to the theme of regeneration and urban organization between concentric or polycentric growths, including organization in dependent or autonomous suburbs. The relationships between urban and population growth, through planned interventions aimed at governing the mere growth in size, tend to improve quality rather than to manage quantity. Very often, specific projects are reported: they aim to combat pollution, or to reduce the risks deriving from rising seas, especially for coastal cities (San Francisco *in primis*). From the comparison between the metropolises, the importance of the demographic flows can be understood, particularly in Arab, African and Asian countries. There, the dimension is 'mega', and the growth influences the sociological aspects due to multi-culture and multi-faith.

Therefore, the city evoked in the book is not ideal, but a plural recognition that highlights the multidirectional tension, even in a globalized world, towards an identity of places as an essential element of a rediscovered urban 'superiority'. The *2030 Agenda*, whose 17 goals have been signed by 193 countries belonging to the United Nations, defines the objectives that the whole planet and in particular the cities must quickly reach. Thanks to the data collected about environmental aspects of quality of life in the metropolis (air, water, CO2 etc.), we can understand how urban ecology is becoming the 'place' of strategic importance for the political and institutional success of a community that looks to the well-being of its own future.

In conclusion, although the research was carried out on historical even if recent data, a perceptible sense of future transpire from the analysis, making visible the different approaches of the single cities, now in competition with each other, and the upcoming opportunities of their inhabitants. You glimpse their future design: the drawing of cities. Each one is different, each is deeply rooted to their origins, but all are equally moving towards a constant modification: this remains the most challenging thing that cities will have to immediately respond. Only the metropolis that will be able to change, despite the immanence of the structures of which they are made (buildings, networks, infrastructures), and to remain constantly attractive and inspiring, they will be able to compete on the international scene, under penalty of dissipation of the skills brought into play. The countless representations and data presented show that the real challenge will shift from material to intangible relationships, from the physical to relational values, in terms of people's health, opportunities and quality of life.

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Reviews

Silvia Masserano

Le prospettive architettoniche di Paolo Veronese. Analisi grafica e restituzione di alcuni teleri

EUT - Edizioni Università di Trieste, Trieste 2018
pp. 298
ISBN 978-88-8303-968-3 (printed)
ISBN 978-88-8303-969-0 (online)

This book is the final development of a scientific research work that began some years ago when Silvia Masserano, author of this volume and involved in teaching activity at the University of Trieste, carried out her PhD Thesis, entitled *Prospettive architettoniche dei teleri di Paolo Caliari, detto il Veronese*. Analisi, comparazione e restituzione. The thesis was recently awarded with two prizes: the *Menzione Gaspare De Fiore 2017*, by the Unione Italiana per il Disegno, and the *Premio tesi di Dottorato EUT*, by Edizioni Università di Trieste. The last award has allowed her to publish this book with the funding and institutional support of her University.

This work contains the essence of all the previous research that she devoted to the analysis of perspective in the paintings of Paolo Caliari, better known as Paolo Veronese or, simply, 'il Veronese', which is, undoubtedly, one of the best exponents of Venetian painting of the Italian 'Cinquecento'. Veronese worked on the pictorial decoration of several buildings by Andrea Palladio, who refers to him in the second book of his treatise [Palladio 1570, p. 8] as "*Messer Paolo Veronese Pittore eccellentissimo*", as is pointed out by Alberto Sdegno, supervisor of the thesis and author of the preface of this volume.

The book is divided into three parts, the first of which is introductory, and includes the biography of Veronese and an interesting analysis about the social and cultural environment surrounding the artist and the architectural influences that forged the character of his scenographic settings. Silvia Masserano explains how these influences were acquired from architects such as Michele Sanmicheli, Jacopo Sansovino and from the collaboration with Palladio himself. The essential support of his brother Benedetto and other disciples in the works of Paolo Veronese are also highlighted in this part, as well as the working methodology, which was used in the workshop of the artist. This section concludes with an interesting compilation of many preceding and contemporary treatises from which Veronese could have acquired his knowledge about applying the perspective rules to represent his pictorial scenes.

The main contents of the research are exposed after the introductory part and derive from the thorough study of the perspective in some of the artist's paintings. This work, without any doubt, is very unusual in its specificity, because analyzes in a very rigorous way, the use of perspective in the study of a work of art, and was made possible thanks to the financial support of the Italian Education, University and Research Ministry with the project titled *Architectural Perspectives, digital preservation, content access and analytics*, coordinated at national level by Riccardo Migliari of the Sapienza

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Università di Roma (PRIN 2010). The results of this vast research project were published in two books [Valenti 2014, Valenti 2016].
In the second part, the author exposes an excellent study of the evolution of the methodology used by the artist in his perspectives, through the analysis of the vanishing points of the central projection in many of his works. Initially, Veronese followed with rigorousness the rules of the genuine perspective as found in the treatises, for instance in his *Cena a casa di Simone*, painted in 1556, in which a single vanishing point is used. However, this method does not seem to satisfy the artist, since it caused excessive distortions in the objects represented on the upper side of the canvas. This issue was mainly due to the great height of the picture and the low position of the observer that forced the painter to establish the horizon line at the same level. For this reason, the author justifies the migration of the artist towards a much more flexible, multifocal, representative method that consisted in using several vanishing points, which were located on a single vertical axis, giving a more natural look to his large-scale works, such as *Nozze di Cana*, of 1563, or *Cena in casa di Simone*, painted around 1570.
The author also deals with some examples, which were painted on the ceilings in horizontal position. In Italian, these kinds of paintings were called "*prospettiva di sotto in su*", because they were seen by the observer from underneath and looking upwards. This different spatial relationship between the viewer and the painting led the artist to use another methodology, which, according to the author, was based on the mirror method, attributed to Giulio Romano and described by Cristoforo Sorte. This methodology consisted in constructing an architectural scale model that was placed onto a mirror with a grid that helped to transfer the reflection of the model to a preparatory drawing. Although this method may seem like a mere natural drawing, Masserano argues that it is necessary to have scientific preparation and to know the basics of perspective in order to establish the proper point of observation from which the copy of the reflection is taken. The reason for this is that it has to proportionally match the real observation conditions of the final painting, when placed on the ceiling, to achieve a convincing illusory effect.
The last part contains two case studies in which the author demonstrates her great knowledge of the inverse perspective; she carries on with the three-dimensional reconstruction of the architectural scenography represented in two important works of Veronese: *Il convito in casa di Levi*, painted in 1573, and a "*sotto in su*" perspective, placed on a ceiling of the Ducal Palace of Venice, known as *L'Apoteosi di Venezia*, which was executed in 1582.
The first case study represents a scene with a loggia and a staircase whose perspective contains different vanishing points, in consonance with the method used by the artist to avoid marginal distortions. This multifocal approach makes the restitution process more difficult, so the author begins to restore the digital model by studying the lower part of the lodge represented on the canvas. This projection can be considered a rigorous perspective, since those lines, which are orthogonal to the picture plane, converge in a unique vanishing point. This allows the author to restore the viewpoint of the perspective and proceed with the reconstruction of the model plan, taking as a reference the true dimensions of a fragment of the represented pavement. The elevation of the model is constructed using the true proportions conserved on the frontal parts and confronting the represented classical architectural repertoire with the proportions described in the classical orders treatises.
So it is easily possible to understand the virtual reconstruction process, thanks to the expositive clarity and the profusion of elaborate analytical images describing the whole process, which is very rigorous and precise. The final result consists of a very detailed three-dimensional model that is represented in an elegant and realistic way, since the author does an additional analysis to restore the light direction of the original work and even the surrounding space in which the painting was originally located.
In the second case study, the author proceeds analogously to the restoration of the facade with Solomonic columns and a central arcade represented in the *Apoteosi di Venezia*. It is a monofocal perspective obtained by means of the mirror method, used by the author in his perspectives located on the ceilings, as previously mentioned. Masserano explains this methodology in an exemplary manner using a considerable number of figures. The result is a digital model very accurate and detailed.
The volume concludes with an interesting appendix, in which the author exposes an innovative dissemination methodology, using procedures of Augmented Reality, which is used for the interactive diffusion of the model of the loggia, developed in the first case study. This Augmented Reality model can be visualized through

any mobile device or a computer equipped with a webcam, from any viewpoint. This example is a very significant contribution to introduce the latest virtual musealization techniques for dissemination.
The appendix also describes the methodology used for the complex photographic acquisition of the paintings located on the ceiling of the Ducal Palace of Venice, which are taken using the latest techniques in automated photogrammetry, based on SfM (Structure from Motion), to obtain a high resolution orthophoto. So, for its rigorousness and its clarity, the book could be suggested to anybody interested in the perspective applied to artworks. Its reading will not disappoint scholars of perspective and art history, who will surely be delighted with the contents and the flawless figures illustrating the volume, that is available in open access [1].

Pedro M. Cabezos-Bernal

Notes

[1] The link to download the book is: <http://hdl.handle.net/10077/22465> (accessed 2019, 10 May).

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Events

Events

UID PhD Summer School
Cultural Heritage Survey and Inclusive Representation

Giuseppe Amoruso

The University of Trieste hosted, from 24 to 28 September 2018 at the Gorizia University Pole, the first PhD Summer School of the *Unione Italiana per il Disegno* on survey of cultural heritage and inclusive representation dedicated to advanced doctoral training in the disciplines of representation [1].
The Summer School introduced participants to the practice of the most advanced tools and methodologies for the analysis, documentation and communication of cultural heritage. In addition, the participants were able to apply digital representation workflows in the field of scientific knowledge and dissemination, with particular attention to accessibility of collections and their effective and universal fruition.
As evidenced by the initiative's subtitle, *advanced communication and tactile representation of cultural heritage for museum accessibility*, activities had to face the resolution of operational problems related to the historical and artistic heritage survey exhibited in the museum spaces; the workflow has to be oriented to an overall strategy for relevant datasets exploitation, in terms of communication and visual diffusion through digital systems and of accessibility and experience for people with reduced sensory capacity. The use of new three-dimensional technologies, advanced computational applications, rapid prototyping and use through haptic interfaces is today a methodology that requires the development of specific skills.
For museum systems, digital technologies are renovating values and knowledge for dissemination of their heritage and collections, no more exclusively intended for scholars or exhibited as an extensive collection of items, that reduces the possibility of interaction and the real learning engagement by visitors.
The *UID PhD Summer School Programme* was inaugurated by an open conference at the National Archaeological Museum of Aquileia, entitled *Cultural Heritage Survey and Inclusive Representation for Museum Accessibility*. The Vice-President of the Unione Italiana per il Disegno, Mario Centofanti, explained, according to the Society policy, the reasons for a choice and the investment in training and applied research through the education of young graduate students from several universities. Mario Docci, Sapienza Università di Roma, introduced different topics according to the initiative contents and presented a lecture on the role of 3D virtual models for conservation and enhancement of architectural and archaeological heritage. Giuseppe Amoruso, Politecnico di Milano, presented the digital reconstruction hypothesis of the Roman amphitheatre in Milan, a process of geometric modeling that uses generative techniques starting from the survey of the survived foundation *septa* to simulate the geometric and architectural construction of the building. An innovative, procedural technique applied for the first time to the archaeological heritage representation and which opens the way for future applications of an experiential nature to be integrated with direct communication on the site.
Numerous case studies were also presented by experts in the field such as Marta Novello, director of the National Archaeological Museum of Aquileia, for accessibility in the renovated museum layout which exhibits the antiquities of the ancient Roman city and the archaeological area, inscribed to the *World Heritage of Humanity* (Unesco) since 1998. In particular the exhibition highlights the sculptures of the Julian-Claudian imperial cycle as well as the numerous portraits of the ancient inhabitants, which ideally introduce visitors to discover the ancient city.

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Fig. 1. Flyer of the event.

Ilaria Garofolo, University of Trieste, pointed out issues on the regeneration quality of places, landscape or architecture on inclusive design for accessibility and cultural heritage. A contribution to address the solutions that improve the fruition of culture in a universal way, through formal and technological devices for the elimination and mitigation of physical and perceptive constraints.
Elisa Perego, University of Trieste, presented some best practices on the role of audio-visual translation to improve the usability of art works, an area of accessibility and research of audio-visual translation quite neglected, in order to identify the critical features of copywriting and relate them to current literature and guidelines.
The research of Ivana Passamani, University of Brescia, from optical communication to haptic communication, described how communication of information on landscape and architecture for visually impaired users has not yet had an effective procedural and graphic systemization; for this reason a 'code system' is needed both for three-dimensional and two-dimensional templates, for which methodologies and crafting techniques must be identified.
Aldo Grassini, director of the National Tactile Museum *Omero* of Ancona, brought his decades of experience on the discovery of tactility values to promote the integration of people with visual impairment. The museum offers technical and scientific support to public institutions, charities and private people and designs installations and accessible temporary exhibitions with dedicates aids for the blind and visually impaired. Grassini reminded that art needs senses and all the world around to transform it into an authentic aesthetic experience. Touch, the most ill-treated among the senses but also the less known, hides unimaginable resources if one begins to consider it without prejudice and to seriously test its potential.
Even Loretta Secchi, from the Tactile Museum *Anteros* of Bologna, has directed her contribution towards the mysterious and yet so natural universe of touching with the eyes and seeing with the hands. In particular Secchi highlighted how important the cognitive and cognitive functions of aesthetic education are to reach the goal of multi-sensoriality.
Christina Conti, University of Udine, presented the experience applied to the National Archaeological Museum of Aquileia aimed at transforming the conventional visit and learning from the exhibition into multisensory, educational and pedagogical experiences that involve and make all visitors participating actively regardless of age, from the cultural education and physical and sense-perceptive skills.
In the field of virtual reconstructions for the use of the archaeological areas of Aquileia, Cristiano Tiussi of the Aquileia Foundation, presented the *Aquileia 3D* project: all the reconstructions of the urban settlement of the ancient Aquileia are accessible through an application that contains the animations of its symbolic places and landmarks (forum, river port, markets, amphitheatre, republican walls etc.), the interactive exploration of all archaeological areas, in-depth information sheets and 60 static virtual reconstructions.

Fig. 2. Open conference of the Summer School.

Pedro Manuel Cabezos Bernal, from Universitat Politècnica de València, presented a current digital museum application for the enhancement of cultural heritage. *Structure-from-Motion* photogrammetry makes it possible to document the heritage through 3D models that can be shared on repository platforms and explored through different visualization modes. This implies a great advancement for the enhancement of the heritage through a virtual museum, as in the case of the Romanesque capitals of the cloister of the monastery of San Cugat, where the study of their symbolic forms highlighted the relationship between form, artistic solution and the possible theories related to sacred music. The contribution of Silvia Grion, member of Italia Nostra, addressed the issue of accessibility to cultural heritage; coordinator of the *Gorizia conTATTO* project, for a more accessible cultural heritage to the blind and visually impaired, illustrated the ongoing projects in collaboration with the Department of Engineering and Architecture of the University of Trieste: the design of a tactile map of the Castle of Gorizia with table in Braille characters (by Paola Cochelli) and the installation of a tactile map at the Church of Sant'Ignazio (by Veronica Riavis).

The seminar was concluded with the presentation of Alberto Sdegno, promoter and coordinator of the initiative, on the tactile replica perception of sculptures with new technologies. In collaboration with the Coronini Foundation of Gorizia and Italia Nostra, the 3D printing of the two Franz Xaver Messerschmidt heads kept at the Foundation was created. The research showed the surprising images of the acquisition phases of the sculptural heads and then in detail the prototyping and printing process. Participants and professors of the PhD summer school continued to develop field applications at the Archaeological Museum of Aquileia and at the University of Trieste labs in Gorizia [2]. Several survey sessions have been carried out with the use of structured light laser scanning systems, the latest generation precision scanners and photographic sampling for SfM photogrammetry applications (*Agisoft Photoscan* and *3DF Zephyr* softwares). In particular, the 3D scanning and photomodeling tests were carried out on Roman sculptures and then developed with dedicated applications. At the end of prototypes production and reconstruction phase, some tests were operated and the 3D prints validated the geometric accuracy and the quality of the digital models and process outcomes.

Particular attention has therefore been paid, more generally, to issues relating universal design and accessibility, fruition by users with reduced sensory capacity and new visualization technologies.

Notes

[1] The summer school was promoted by the Unione Italiana per il Disegno, the University of Trieste, Department of Engineering and Architecture and by the PhD Programme in Civil-Environmental Engineering and Architecture between the Universities of Trieste and Udine and also in collaboration with the National Archaeological Museum of Aquileia. It was patroned by the Ordine degli Architetti, Pianificatori, Paesaggisti e Conservatori of the Province of Udine and it was realized as part of the *UID–Survey and Representation Days–Specialistic seminars in the disciplines of Drawing for PhD students.*

[2] Teachers: Giuseppe Amoruso (Politecnico di Milano), Pedro Manuel Cabezos Bernal (Polytechnic University of València), Alberto Sdegno (University of Trieste)– coordinator. Tutor: Silvia Masserano. Steering committee: Barbara Chiarelli, Paola Cochelli, Silvia Masserano, Veronica Riavis. PhD students: Antonio Camassa (University of Roma Tre), Barbara Chiarelli (University of Trieste), Paola Cochelli (University of Trieste), Sara Eriche (University of Genoa), Francesca Guadagnoli (Sapienza University of Rome), Andrea Improta (University of Campania 'Vanvitelli'), Gianluca Manna (University of Campania 'Vanvitelli'), Sofia Menconero (Sapienza University of Rome), Sandra Mikolajewska (University of Parma), Carla Mottola (University of Campania 'Vanvitelli'), Margherita Pulcrano (University of Naples 'Federico II'), Veronica Riavis (University of Trieste), Pablo Angel Ruffino (Politecnico di Torino).

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Events

FORTMED 2018

Stefano Brusaporci

The "International Conference on Modern Age Fortification of the Mediterranean Coast FORTMED, organized by Anna Marotta and Roberta Spallone, took place on October 18th, 19th and 20th 2018 at the Department of Architecture and Design (DAD) of Politecnico di Torino, in the marvelous location of Valentino Castle. Focuses of the conference were researches on modern fortifications in the Mediterranean area. The initiative favored the exchanging of knowledge and experiences in order to foster a better understanding and enhancement of cultural and architectural heritage developed in the Mediterranean countries (in particular Spain, France, Italy, Malta, Tunisia, Cyprus, Greece, Albania, Algeria, Morocco), and also in other regions, such as in central and southern America, characterized by similar historical dynamics (e.g. Cuba, Puerto Rico, Philippines, Panama etc.). Over 200 scholars of different disciplines, coming from many countries, participated to the three days of the conference, with presentations organized in four parallel sessions.

Papers were presented in four parallel sessions, regarding the following topics: problems of historical themes, also in the field cartography and building techniques; military engineering and defence systems, with particular reference to modern way to defence; research on architectural built heritage of castles, towers and fortifications and interventions of maintenance and conservation; the study of construction materials and alteration processes, with proposals for restoration interventions; the digital survey (Digital Heritage) with the use of 3D acquisition instruments, such as laser scanners and photogrammetry, and advanced modeling, with the study of the evolution of representation in the forms of Virtual Reality and Augmented Reality; the management and enhancement of the fortified heritage and cultural tourism. Finally, further experiences were

Fig. 1. Poster of the event.

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presented in a section that did not include the previous topics, but which also dealt with general topics, though still pertinent to the main theme of the conference.
354 scholars from 19 countries joined the conference call, submitting 235 abstracts. After the review by members of the scientific committee, 190 contributions were accepted and published in the proceedings by over 310 authors from the following countries: Italy, Spain, Albania, Algeria, Cyprus, Croatia, France, Germany, Greece, Israel, Morocco, Malta, Poland, Portugal, Romania, Sweden, Turkey, United Kingdom, Venezuela. The volumes of the proceedings [1], published in the editorial series that collects the results of the previous FORTMED conferences, were published in open access through a dedicated platform [2].
During the event, a number of speakers were awarded in three specific categories: Best Full Paper, Best Short Paper and Best Student Prize. These prizes were awarded to Marco Carpiceci and Fabio Colonnese (Best Full Paper), for the lecture entitled *Labyrinth as passive defense system: an analysis of Renaissance treatise of Francesco di Giorgio Martini*, *ex-aequo* with Antonio Bravo-Nieto and Sergio Ramírez-González for *Arquitectura religious en fortificaciones de Orán y Mazalquivir en el siglo XVI: varias obras de Jacome Palearo Fratín y Juan Bautista Antonelli*; the Best Short Paper was awarded to Marco Giamello, Andrea Scala, Sonia Mugnaini and Stefano Columbu for the intervention entitled *Analisi composizionale comparativa delle malte di allettamento delle Fortezze del Peruzzi e dei Medici prima e dopo la caduta dello Stato di Siena*; and finally the Best Student Paper was won by Vito Antonio Di Leo and Nicola Vulpio with *Il castello di Serracapriola: rilievo e analisi per una lettura dell'architettura fortificata*.
The conference was organized as part of the project entitled *Surveillance and Defense Towers of the Valencian Coast. Metadata generation and 3D models for interpretation and effective enhancement* with the scientific coordination (principal investigator) of Prof. Pablo Rodríguez-Navarro [3].
The Turin event represents the fourth edition of the FORTMED conference, whose precedents were held at the University Institute of Restoration of the Heritage of the Universitat Politècnica de València (2015), at the Department of Architecture of the University of Florence (2016) and at the Escuela Técnica Superior de Arquitectura de la Universitat de Alacant (2017).
The next edition of the FORTMED conference will be held in Granada from 26 to 28 March 2020, and will be organized by the Laboratorio de Arqueología y Arquitectura de la Ciudad, of the Escuela de Estudios Árabes (CSIC) [4].
FORTMED conferences are organized within the activities of the *International Association for Mediterranean Fortifications FORTMED*, which has the objective of studying, safeguarding and enhancing the culture and heritage developed on the Mediterranean coast [5].
Without any doubt, we can say that the FORTMED conference series has now come to constitute a reference for the international scientific community. Particular point of relevance is represented not only by themes of specific interest, but also by the involvement of high-level academic and professional figures, coming from various fields, including those of architecture, engineering, archeology, history, restoration,

Fig. 2. Work session at the FORTMED 2018 Conference.

geography, cartography and communication.
Wanting to outline a summary of the three days of work in Turin, it can be said that the FORTMED 2018 conference was characterized by high-value contributions, favoring the meeting of scholars from different sectors and the exchange of experiences of particular interest. A more than positive outcome, made possible also by the punctual and very careful organization of the hosts.

Notes

[1] The acts consist of the book of abstracts: Marotta, A., Spallone, R. (eds.). *FORTMED2018 Torino Book of Abstracts*. Torino: Politecnico di Torino; and from the three volumes: Marotta, A., Spallone, R. (eds.). *Proceedings of the International Conference on Modern Age Fortification of the Mediterranean Coast. FORTMED 2018*. Voll. 7, 8, 9. Torino: Politecnico di Torino.

[2] See the site <https://fortmed2018.blog/> (accessed 2019, May 10).

[3] Project reference code HAR2013-41859-P, funded by the National Program for Fostering Excellence in Scientific and Technical Research, National Sub-Program for Knowledge Generation, Ministry of Economy and Competitiveness (Government of Spain).

[4] Information on the 2020 edition is available at: <https://fortmed2020.wordpress.com/>(accessed 2019, May 10).

[5] The association is chaired by Pablo Rodríguez-Navarro of the Universitat Politècnica de València, with vice-president Giorgio Verdiani of the University of Florence and secretary Teresa Gil-Piqueras of the Universitat Politècnica de València. More information on the association is available at the site <https://fortmed.blogs.upv.es/it/> (accessed 2019, May 10), where it is also possible to find the proceedings of previous conferences.

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Events

EGraFia Congress, Argentina 2018

Emanuela Chiavoni

After the previous successful Congress held in Argentina in 2012, the Faculty of Architecture and Urban Planning (National University of La Plata) was again chosen as the venue for the International Congress of Graphic Expression (VII International Congress of Engineering, Architecture and associated careers) jointly organised with EGraFia (XV National Congress of Engineering, Architecture and associated careers). The Congress was held on 4-5 October 2018.

The Congress, held annually, was entitled *Campos, thresholds and poetics of drawing*. Many interesting presentations regarding research, training and professional activities were delivered during the meeting. The expositions, conferences and exhibitions organised during the Congress focused on projects, drawings and graphic elaborations, including work executed during the *Caravana Grafica*, an itinerant tour of important buildings in La Plata. Thanks to the enormous appeal of the topical issues on the agenda, the meeting was a domestic and international success triggering considerable interest amongst teachers from several Universities as well as local professionals.

The topics discussed during the two-day event were divided into four groups: research, teaching, transmitting culture to society, and profession.

In the section on research participants tackled problems regarding analogical and digital graphics; they examined new tools and the potential of different, increasingly sophisticated graphic systems. They also focused on the role of graphic expression, as a cultural manifesto, in the various disciplines of drawing as well as regards its future.

Teaching was given a broader palette so that participants could discuss the role of graphic expression in careers linked to the disciplines of drawing as well as the role of public education and new pedagogical teaching techniques, also compared to the reference guidelines of sectoral curricula.

The group discussing the transmission of culture to society assessed the relationship between society and education regarding graphic expression, its extra-disciplinary dissemination and the participation of the public in all ensuing experiences.

Finally, for the last topic (our profession) participants presented their own professional experience regarding graphic expression and the problems they faced in transferring their academic training to profession. They discussed the interaction between Universities and the Professional Categories, the relationship between social demand and professional supply, as well as what the future has in store for Latin American professionals.

Fig. 1. Poster of the event.

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Last year the EGraFia association celebrated its 20th anniversary. During this period, it has become an important, undisputed reference point in the field of architectural graphic expression in Argentina.
Established in 1998, one its major objectives is to promote the field of graphic expression in various disciplines such as engineering, architecture, drawing, natural sciences, astronomy, computer science and all their associated disciplines taught in Universities and schools in the Republic of Argentina. Its union and multidisciplinary nature always encourage and enrich coordination activities by promoting teaching, study, scientific research and the dissemination of graphic expression in the field of science and technique with a focus on the social needs of the population. In addition, cooperation agreements encourage teachers and students to participate in exchanges with national and international experts.
One of the speakers reviewed the work done by the EGraFia association in the last twenty years; he listed all the places where the congresses have been held and the topics tackled each year. He emphasised the objectives, strategies and work methods as well as some of the less positive aspects, especially the fact it was sometimes difficult to reach several of the congress venues. From Cuba, Rio Quarto, Catamarca, Rosario, Salta, Olavarria, Tucuman and General Pico, and then back to La Plata in 2018.
Drawing as the ultimate primary form of expression has always been the major protagonist of all the congresses and a key player in all cultural events. It is not only a tool used in numerous disciplines, but also a discipline in its own right; it carefully records reality and the built structures, either in a manual or tactile manner; it is supported by practical skills, but also plays a strong role in experiments on the potential of digital and integrated representation.
A significant number of students attended the Congress. Like the load-bearing columns of University life, they took part in the various activities together with professors, researchers and technicians: conferences, poster presentations, film projections, guided visits to important buildings in La Plata, and the now consolidated *Caravana Gráfica* event.
Another graphic tour was also organised during this Congress; it involved the use of drawing to interpret several buildings close to the faculty in downtown (including the Partenón and the National College of La Plata). During the analytical process drawing was used to capture the relationships between the buildings, their architectural consistency and state of conservation. It was a way to visually interpret and understand their visible material aspects as well as an attempt to interpret the immaterial values inspired by direct analysis. The last stop on the tour was the famous Curutchet House; the Argentine architect Amancio William built the house based on a design received by mail from the French architect Charles-Édouard Jeanneret-Gris, Le Corbusier.
As in the past, the tour lasted throughout the congress and was a crucial moment of aggregation for the group, especially the younger participants. Everyone, who took part in the graphic

Fig. 2. Freehand drawings made by the participants in the graphic Caravan in the city of La Plata.

rally, used sheets of paper pinned together like an accordion; they used different tools to draw consecutively on these sheets so as to, also, probably, highlight the links between the buildings and the urban landscape.
The participants' work was presented and commented during the meeting.

The numerous contributions to the proceedings (e.g. the presentations delivered during the two-days meeting) provided an in-depth, multifaceted review of the congress topics. Each in their own way, the presentations highlighted the multiple options of how to narrate our cultural heritage by documenting and conveying its history.
Several visits to important places in the city of La Plata also took place during the Congress. They included: the Planetarium, the Museum of Natural Sciences, the Teatro Argentino and the Cathedral.

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Events

EARTH2018 – International and Interdisciplinary Conference

Alessandra Meschini

As one of the various events patronized by the *Unione Italiana per il Disegno* (UID), the International and Interdisciplinary Conference on Digital Environments for Education, Arts and Heritage (EARTH2018) was held on the 5th and 6th of July, 2018, at the Brixen campus of the Faculty of Education of the Free University of Bozen-Bolzano. The event, which was also patronized by the Ministry of Cultural Heritage and Activities (MIBAC), the Italian Society for Research on Medial Education (SIREM) and the Autonomous Province of Bozen-Bolzano, was organized by Alessandro Luigini with the contribution of other scholars who are members of the program committee.
In October 2017, again in Brixen, Alessandro Luigini, together with Chiara Panciroli (Department of Education Sciences, Alma Mater Studiorum, University of Bologna), had in fact already curated a first interdisciplinary meeting focused on research in the field of Digital Humanities. This first event, albeit of a lesser order and on a national level (a one-day Open Conference based on invitational lectures) was in some way the prelude to the intention of realizing a more articulated and broader initiative such as EARTH2018.
Internationality and interdisciplinarity can be considered, over and above more specific and specialized terms, the two key words on which the conference was based. As a consequence, it aimed to promote the encounter of different disciplinary areas of study (primarily representation, education and psychology) on the theme of digital environments, for investigating their mutual complementarity more deeply, namely to encourage a systematization of experiences based on divergent approaches from which a reciprocal stimulus could be drawn. In Luigini's own words, the aim was "to find a point of convergence between art history, digital representation, pedagogy, psychology and the economy of culture, in order to understand how our heritage can be, even more than before, an important element in the construction of a better society, also through the conscious use of immersive technologies" [1].
With these intentions, and therefore aspiring to intercept a wider response in terms of plurality of innovative experiments, points of view and methodological reflections on the subject, the conference's call for papers was structured to propose 14 topics. This diversified articulation of the topics demonstrated widespread awareness of how, in the current context, there are increasingly complex relationships between media and environments, in respect to which virtual museums, multimedia installations, interactive technological platforms, serious games and immersive realities are just a few of the possible forms of digital environment suitable for the adoption of innovative methods of heritage education. The response received obviously sustained the plurality of visions and voices on which the conference was based. More than 100 papers were received, 80 of which were selected for oral communication by more than 50 scholars involved in the role of referees, while the scientific committee counted the participation of 34 members.
The conference was organized into two working days in which different registers of communication were alternated. After the usual institutional greetings of Rector Paolo Lugli and Vice Dean Michael Gaidoschik, aimed at underlining how the objectives (of interdisciplinarity and internationality) of EARTH2018 are also those of the Free University of Bozen-Bolzano, the first day opened with the two important introductory speeches of Vito Cardone and Pier Giuseppe Rossi, respectively President of the UID and of SIREM. The first highlighted how the topic of the conference is "one of those border issues" that a scientific association like UID must absolutely cultivate. He then

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Fig. 1. International and Interdisciplinary Conference #EARTH2018 – Digital Environments for Education, Arts and Heritage (from the event's website).

noted how the new, younger, smaller realities such as that of Brixen are the most favorable to "operate as avant-garde," and reiterated the importance of cultivating transversal, multidisciplinary and "transdisciplinary" relations, in an attempt to transcend the boundaries of the scientific-disciplinary sector and to understand the specificities and reasons of others. The second defined the event as an interesting "intricate and intriguing plot" in which the interweaving of different disciplinary paths can find fertile ground for sharing practices and processes of interpretation around the themes of media, education and digital technologies, contributing to the development of new interpretative keys useful for operating profitably in the current socio-cultural context.

The early afternoon was dedicated to a session of keynote speeches with several important guests: The Director-General of museums at MIBAC, Antonio Lampis, who underlined the extreme importance of the theme in relation to the objective of the creation of the national museum system; Eugene Ch'ng, Director of the NVIDIA Joint-Lab on Mixed Reality, University of Nottingham Ningbo China who, using a 360-degree video camera, showed various researches and projects of his laboratory focused on the combination of virtual reality and augmented reality (mixed reality) underlining how the sharing of cultural heritage can allow us to preserve roots, identity, social values and to transmit memory, knowledge and culture [2]; Stefano Mastrandrea (Department of Education, Roma Tre University), who presented a study on the relationships between the experience of visiting museums in different types of museums and the consequent educational aspects and benefits for the health of the visitor; Mona Hess (University of Bamberg – Germany) who presented the contents and objectives of the Master course in "Digital Technologies in Heritage Conservation" activated at her University since 2017.

Four parallel thematic sessions respectively entitled Visual Heritage, Communication, Digital Heritage and Education opened the works of the second half of the afternoon. The 23 contributions reported in these first sessions had already shown the variety of the panorama of research carried out, or currently in progress, focused on topics such as, for example, intermediality and the relationship between art and science (Gay, Cazzaro), transmediality (Moretti, Camillini), online

platforms (Caffio), videogames and learning (Feriozzi, Olivieri), applications for Universal Design (Yurdakul, Costa, M.Rossi, Buratti), digital archives (Palestini), automatic image recognition (Menendez Giglio, Todisco, Zerlenga), videomapping on 3D printed models for the interpretation of history (Fatta, Fischnaller), virtual museums (Cardaci, Versaci, Azzollo and Parrinello, Picchio, Dell'Amico), web apps for cultural itineraries (Vecchiattini, Battini), digital education (Poli, Zuccoli), educational innovation (Panciroli, Parricchi).
The second day proposed an intensive program consisting of seven parallel sessions distributed between morning and afternoon dedicated to seven variations of the theme of the conference: Augmented Reality, Digital Heritage, Museum Ideas, Immersive, Territory and maps, Archeology and Museum Life. The 47 scientific papers presented further confirmed the complexity and heterogeneity of the experiences as well as the different ways of approaching themes, such as, just to name a few: experiments with virtual tours in augmented reality (Brusaporci, Maiezza, Tata), immersive-interactive navigation at different scales (Meschini, Feriozzi), spatial augmented reality for children (D. Rossi), HBIM and museum digitalization (Lo Turco, Calvano), multimodal artifacts for cultural education (Dalai, Martini, Perondi), educational reflections for digital work (Cervellini), museum education and inclusive memory (Poce, Re), spaces, environments, places and communication models for the contemporary museum (Ippoliti, Guadagnoli, Casale), democratization of heritage (Valentin), social impact of museums (Viganò), psychology of perception and education through digital media (Peressini), simulation and immersive environments (Basso, Saracini and Cirillo, Conte), multidimensional virtual reality (Fanini, Demetrescu), immersive experience of parks, sites and archaeological heritage (Empler, Agnello, Garofalo) digital tools for knowledge and modeling of the territory (Dutto, Dighero and Inzerillo, Roberts), social media (Villa).
The different parallel sessions were interspersed by another moment dedicated to the lectures of several keynote speakers: Andrea Giordano (University of Padua) who, in presenting the inter-university and international research project "Visualizing Cities," showed how the development of appropriate interactive and interoperable digital models permits the communication and sharing of spatial-temporal knowledge on the transformations of historical cities, not only in architectural terms; Pier Giuseppe Rossi and Chiara Panciroli, who presented the objectives and meanings of the MOdE (Museo Officina dell'Educazione) project for the education and expression of users; Pierluigi Sacco (IULM of Milan) who, speaking of the work that the European Commission is doing in relation to cultural heritage, stressed the importance of the "New European Agenda for Culture" as a strategic document for the coming years; Franz Fischnaller (Albertina Academy of Fine Arts of Turin), who presented the design of the exhibit entitled "Virtual Journey through the History of Fort Saint Jean" (Marseille) as an example of transdisciplinary and multidisciplinary approach based on the combination of mixed digital environments.
The Scientific Committee, which followed and evaluated all the parallel sessions, conferred three Best Paper Awards. For the Senior section, to Fabrizio Gay and Irene Cazzaro (IUAV University of Venice), for the intervention entitled "Venetian Perspective Boxes: When the Images Become Environments. Low-Tech, High-Knowledge Media for Teaching the Historical Heritage of the Interior/Exterior Environments"; for the Junior section, to Ramona Feriozzi and Alessandro Olivieri (University of Camerino) for the intervention "Video Games for Learning Projective Geometry: Analysis of Virtual Spaces through the Disciplines of Representation" and to Silvia Calegari and Matteo Dominoni (Bicocca University of Milan) for the intervention "The Pollicina Project. A Collaborative and Educational Social Suite to Build Cultural Itineraries."
As a whole, the papers presented documented a wide variety of top-

Fig. 2. Cover of the published Proceedings.

ics addressed, high quality of research, fruitful cooperation between universities (including foreign ones) and with public institutions or productive activities, thus confirming how various scientific and cultural contexts are involved in the digital field, considered a support to the definition of new processes. The lively participation shown in the discussions after each presentation also confirmed a widespread and strong interest in wanting to investigate the lines of future development, thus expressing the transversal conviction of the significant contribution that research can afford to the offer and to the educational experience of art and heritage.

The Proceedings of the EARTH2018 Conference, which include the invitational lectures and all the peer-reviewed scientific papers presented, have been recently published in Volume 919 of "Advances in Intelligent Systems and Computing" by the prestigious international publisher Springer [3] and will be indexed in Scopus.

Notes

[1] <https://www.unibz.it/it/news/128935-earth2018-convegno-internazionale-sull-uso-dei-media-digitali-nell-educazione-all-arte> (accessed 2019, April 10).

[2] The 360° video of Eugene Ch'ng's Keynote Lecture is available at: <https://youtu.be/HXEC3MXXxBQ> (accessed 2019, April 10).

[3] <https://www.springer.com/it/book/9783030122393> (accessed 2019, April 10).

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