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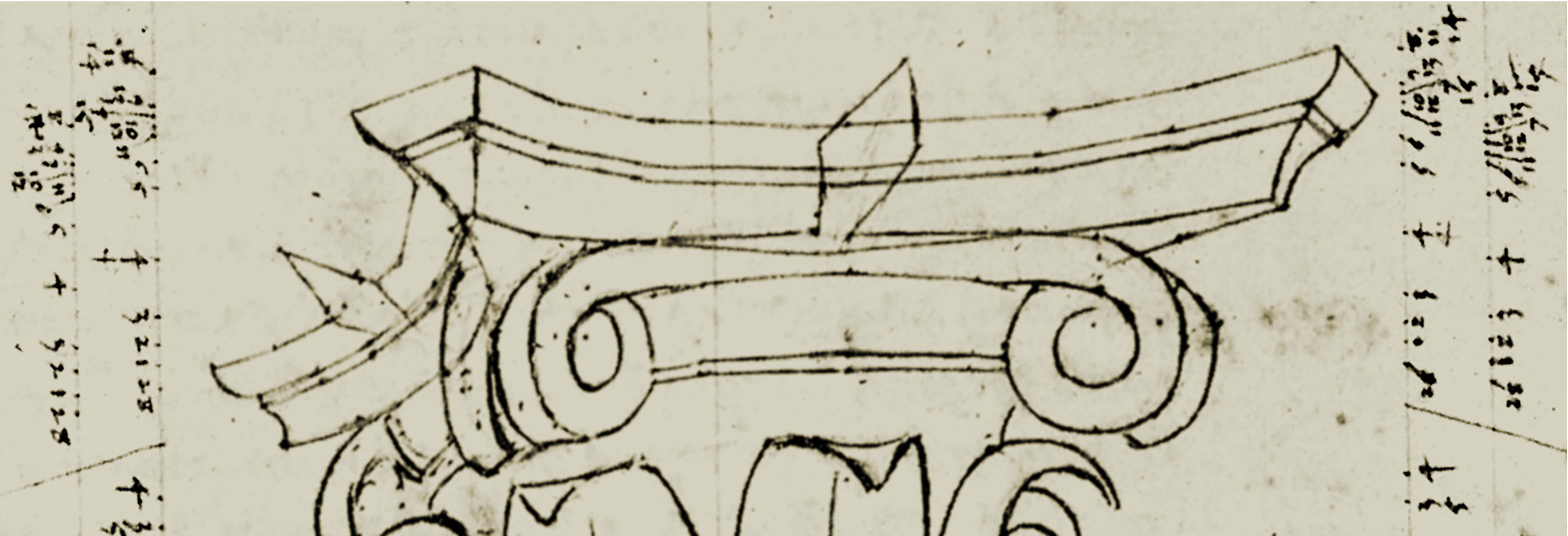

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HISTORY/HISTORIES OF REPRESENTATION

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Cover
Piero della Francesca, De prospectiva pingendi, codex 1576, Bilbioteca Palatina di Parma, foglio 55 r. [Piero della Francesca (1984). De prospectiva pingendi. Edizione a cura di G. Nicco-Fasola. Firenze: Casa Editrice Le Lettere. Tav. XXXV, Fig. LXII].

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. 3/2018, the evaluation of contributions has been entrusted to the following referees:
Salvatore Barba, Maria Teresa Bartoli, Marco Bini, Maura Boffito, Stefano Brusaporci, Massimiliano Campi, Eduardo Antonio Carazo Lefort, Laura de Carlo, Agostino De Rosa, Riccardo Florio, Fabrizio Gay, José Maria Gentil Baldrich, Paolo Giordano, Manuela Incerti, Emma Mandelli, Riccardo Migliari, Roberto Mingucci, Giuseppa Novello, Maurizio Unali, Graziano Mario Valenti, Chiara Vernizzi

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Editorial

Vito Cardone

In 2018, the 40th Conference of Teachers of Representation Disciplines took place in Milan: the first edition of these meetings was held on 3-4-5 May 1979 in Santa Margherita Ligure.
The Italian Union for Drawing (UID) will appropriately remember this recurrence, effectively kicking off a two-year celebration, considering that the 40th anniversary of the foundation of our scientific society (formally constituted on August 4, 1980) will fall in 2020.
The article by Mario Docci –who was one of the founders of the UID and today is its Honorary President– that opens this third issue of *diségno*, actually inaugurates this path, intended as an occasion for reflection on, as we say, "who we are, where we come from," but also on "where we are going" or rather: on where "we must go." It is no coincidence that Docci focuses mainly on the events of the last half century, with particular reference to our history –which is now an integral part of the more general history of graphic representation– and the teaching of Drawing in the Faculty of Architecture of Sapienza University of Rome, where he sees the birth of a "Roman school" starting, in Italy, "the creation of a new discipline: architectural representation." Docci concludes his contribution by expressing the hope that "young people will dedicate themselves to historical research in the field of representation, because although some studies have been tackled in the fields of survey and freehand drawing, the History of Representation is still largely to be written."

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It seemed therefore natural, more than appropriate, to dedicate the first thematic issue of the journal, i.e., the first not dedicated to the annual UID conference, to the history of representation.
This theme has been present since our first conferences and the UID has always supported its cultivation, considering history fundamental for the definition of the identity of the scientific-disciplinary sector. It is worth mentioning that at the end of the first (and at the time not yet "International") Conference of the Teachers of Representation Disciplines in the Faculties of Architecture and Engineering, it was decided that the following Conference would have as its theme *The history of drawing for a didactic method*.
In fact, in that second appointment, which took place from 29 to 31 May 1980, again at Villa Durazzo in Santa Margherita Ligure, things went much further. "The history of drawing, or of representation, (but I would be satisfied –since there's quite enough– with the history of drawing!) allows us to understand, rediscover, create and recreate drawing; history of the theories on art or architecture, history of the criticism of art and architecture and finally history or criticism of drawing, in the many variations of their forms, mean the gaining and the possession of a historical-critical spirit," Gaspare De Fiore stated in his *Introduction*. And the first paper, by Luigi Vagnetti, had the significant title: *Drawing and Representation. An invitation to history*.
That approach has meant that the attention to historical contextualization has always characterized the most qualified scientific research in the sector and, therefore, even the most significant contributions that have been recorded at our annual events. The eleventh edition of the Conference –held on 16-17-18 October 1989, at Villa Marigola in Lerici– had as its theme precisely *The History of Drawing*.
To inaugurate that edition of the Conference was Edoardo Benvenuto, Dean of the Faculty of Architecture of the University of Genoa, which organized these events. He opened with an erudite lecture entitled *Representation in the history of scientific thought*, which therefore went far beyond representation in the sphere of architecture and engineering. Thus, even if in broad terms, the scenarios that would later have fascinated some of us –at the time, young people at the beginning of their academic careers – leading us to be interested in the whole of visual representation, not only graphic, and therefore of all images, for any purpose they were produced: starting from those that fall within the area of science or the artistic field, thus no longer only those functional to architecture, design and engineering.
Furthermore, 2018 is a Mongean year, because it marks the bicentenary of the death of Gaspard Monge, the founder of descriptive geometry.
It is known that he did not invent, nor has he ever been credited with the paternity of the method of orthogonal projections, which later took his name, but limited himself to strictly codifying it. Monge, however, systematized the traditional empirical practices of graphic representation adopted at the time and concretized the intuitions of many artists, architects, engineers and surveyors who had preceded him –from Piero della Francesca to Albrecht Dürer, from Philibert de L'Orme to Girard Desargues, from Guarino Guarini to Amédée François Frézier– in complete and successful conceptions and formulations. He thus outlined a real scientific discipline, previously non-existent as such: having a solid coherent theoretical framework –based on abstractions, idealizations, identification of the only elements and laws essential to representing objects according to constant general rules– of practices of theoretical speculation and organized specific research, which is even dedicated to the development of teaching materials. The subsequent development of these studies, up to the current formulation in an organic disciplinary body, not only cannot disregard the founding principles of Monge, but is also incommensurable with his work.
This also because he not only dealt with theoretical questions, but also addressed –and this is perhaps one of the greatest expressions of the inseparable bonds between science and technique and between theory and practice that characterized all his scientific industriousness and his teaching– concrete applications and, therefore, extended his interests to the technique of representation. Thus, he consciously initiated the elaboration of a more general "theory and technique of graphic representation of a technical nature," based on a homogeneous and in many ways autonomous disciplinary body that goes beyond the boundaries of applied mathematics (into which, precisely following his initial approach, he repeatedly attempted to include it) and which revolutionized the approach to the drawing of all objects, not only of architectural artefacts, and the representation of the territory.
Dedicating an issue of our magazine to this master would have been inappropriate, especially considering that last

year, in anticipation of the anniversary, I myself wrote a new book on his incomparable scientific itinerary, as professor, politician and organizer of higher studies.
It was instead considered natural –given the very recent printing of the Italian edition– to dedicate the Readings/Rereadings section to Piero della Francesca's *De prospectiva pingendi*. Laura Carlevaris took on this task, with a significant essay that also constituted a careful reading of this monumental publication, in which the critical edition of the drawings was edited by Riccardo Migliari, with the involvement of some of his students.
Obviously, in line with the call, the articles selected for this issue of the journal, as well as those published upon invitation, deal with the history of representation and not with the history of the UID or the Conferences of the Teachers of Representation Disciplines: we will deal with these, as mentioned earlier, in a series of initiatives being organized by a specific UID work group, coordinated by Vice President Mario Centofanti, whose first product were prepared for the Conference in Milan.
As expected, most of the papers received as a result of the call were related to Geometry, descriptive and not, and to design drawing, naturally identified as the two main and fundamental lines of the discipline. Some proposals, especially those concerning design drawing, were rejected because related to realities –architectural or urban– or to minor or otherwise less significant figures within the rich and articulated history of representation. The papers selected after the double review process conducted on the abstracts as well as on the complete articles, therefore form the two thematic sections of this issue of the journal, introduced by two articles presented on invitation.
The introduction to the section on Geometry was entrusted to Fabrizio Gay, who focused on what he calls the "historical passage from Descriptive Geometry to Computational Geometry," which occurred in the second half of the last century, highlighting "continuity and discontinuity in the history of geometry for drawing" and mentioning the current conditions of this thematic area.
For the introduction to the section on design drawing, instead, a contribution was requested of Livio Sacchi, who dealt with the main transformations that have changed architectural drawing, which had "enjoyed extraordinary historical stability over time," with the exception of small innovations on the instrumental level. Among the main procedures of the more general infographic algorithms that have replaced the traditional (and exclusive) graphic algorithm of the design process, mainly parametric design, BIM, Big Data and artificial intelligence were examined: that is, the innovations that, for Sacchi, more than others "seem to summarize the changes underway." The article concludes with several interesting considerations on the further revolution that is approaching "in regard to the authorship, both of drawings and, of course, of projects."
Various proposals received dealt with digital drawing; but for the most part they had a descriptive approach and were rather poor in scientific content in line with our journal's approach, thus they were almost all rejected by the referees, usually during the evaluation of the abstracts. The only one selected is introduced here with an article by Alberto Sdegno, focusing mainly on the origins of the application of information technology to graphic representation: a crucial passage, not yet adequately and critically historicized by our scientific community in its full revolutionary potential. For this reason, a contribution on the same topic was also requested of Liss C. Werner, of the Tecnhische Universität Berlin, who has been investigating the same subject for some time, on which she held an interesting *ponencia* at the recent Congreso EGA in Alicante.
Few, and almost all not up to standards, were the proposals addressing other topics, confirming the fact that these –starting with survey– are considered above all as an expression of applied research activity, in which we essentially adopt innovation from other scientific areas, rather than producing it on our own. It was impossible, in any case, not to dedicate a reflection to Survey, whose manifestations over the centuries have had a substantial effect, if not on the definition of the methods of representation, certainly on the documents realized within them and on graphic techniques.
This reflection wad entrusted to Paolo Giandebiaggi who, with very linear reasoning, attempted to redeem Survey, shifting away from the idea that it is a simple technical practice. On the basis of the complexity of the present-day world, which requires a new and very articulate type of knowledge, he stresses the need for interdisciplinarity in survey, forced to "confront itself with cultures different from the traditional ones in the fields of architecture, urban planning, history and engineering." Giandebiaggi thus outlines a new and in many ways unprecedented scientific dignity for survey, even going so far as to speak of an autonomy of survey, considering it as an autonomous discipline. That proposed by Giandebiaggi is a wide-ranging

contribution, of which we felt the need, which can help us to go beyond the practical applications that characterize much of our commitment to survey, especially after the introduction of the most sophisticated procedures and methodologies.
With this issue of *diségno*, in the section of bibliographic references entitled "the UID library" there are the reviews of books considered particularly significant. This is a firm choice of position that –in the dangerous drift currently characterizing, especially in Italy, the evaluation of scientific publications, among which reviews are not considered– emphasizes instead the importance of this publishing product which, in other contexts, even the most experienced and established professors, not just young scholars, continue to deal with. I hope that the same thing can happen for us, that is, that significant proposals will be received and that the reviews of monographs will regain their due importance.
Instead, reviews of events on topics in our area are increasing. This shows, first of all, the great fervor that for the last few years has characterized the activity of colleagues in the sector in the various Italian universities, but also the fact that the UID has become a point of reference in the international field, with requests for patronage of initiatives held abroad, promoted by other organizations. The high participation of both our members and of external scholars in these events bears witness to the achievement of an exceptional goal.

The experience of this first thematic issue suggests a consideration useful for guiding future proposals for articles for our journal. The fact is that our journal is not –as are the proceedings of the conferences– a collection of writings without a numerical limit; it cannot therefore accept each and every article that responds to the theme of the call and is considered "acceptable" according to the standards used for the papers of the conferences.
This implies that the papers that are proposed in relation to the general theme of the issue should not only be contextualized, but must have an appropriate approach, be focused on persons and topics of adequate relevance for helping delineate a truly significant scenario in relation to the general theme proposed. It also means that the articles evaluated by referees will not be evaluated simply "acceptable," as just specified, but only those that –for originality of content, relevance, quality of the text, notes and images, correctness and relevance of bibliographic references, style and propriety of language, as indicated by the review form– can be considered at least of a "high" level, worthy of a necessarily selective scientific journal.
I hope that the proposals for the next thematic issue –Issue No. 5 of the journal, whose publication is scheduled for December 2019, dedicated to the representation of landscape, environment and territory– will take into consideration what is proposed here.

A Contribution to the History of Architectural and Environmental Representation

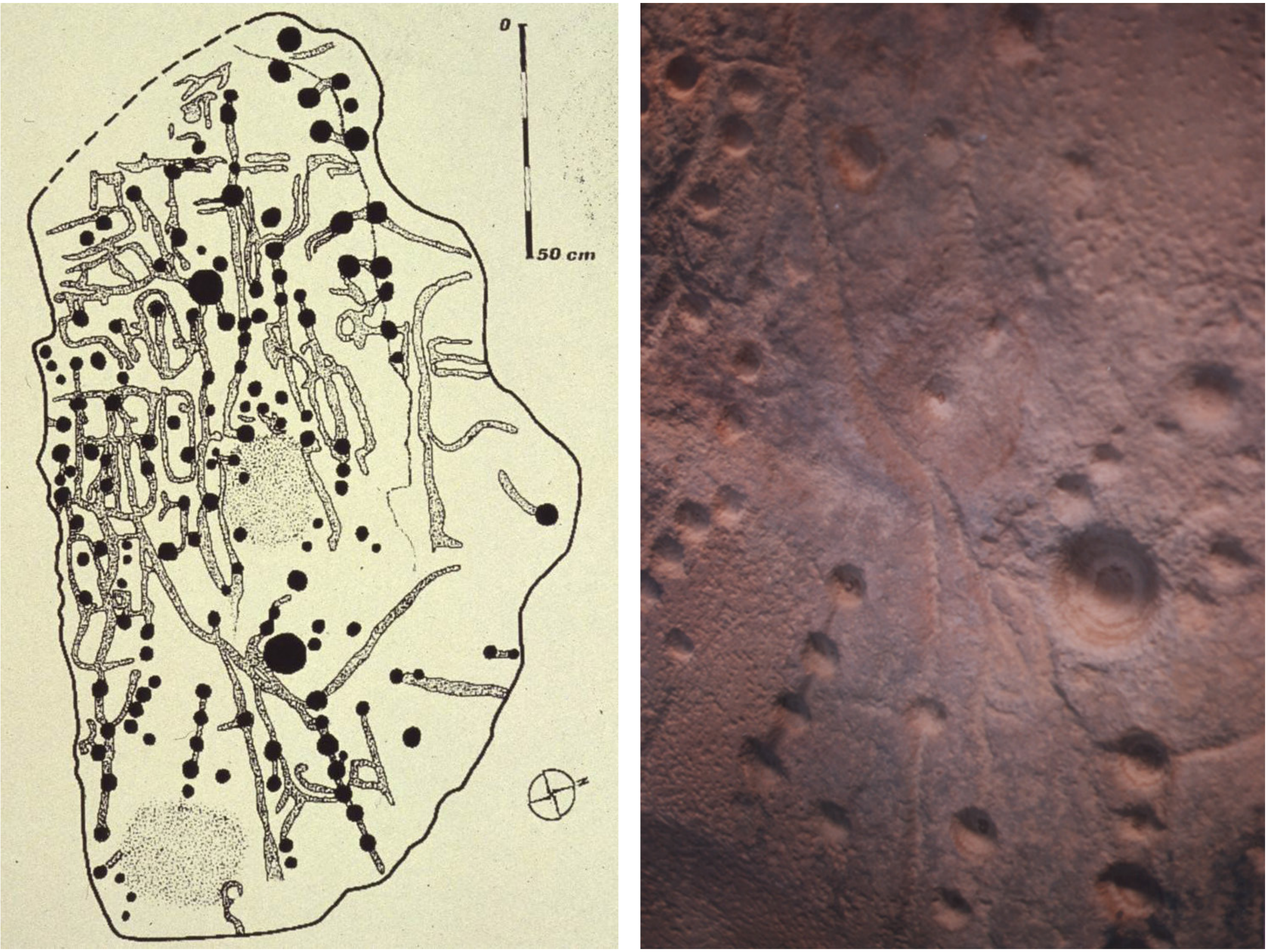
Mario Docci

Introduction

It is necessary to reflect on the meaning of the term 'Architectural Representation' before tackling the themes related to its history over the centuries; this denomination was fully accepted into technical language only in relatively recent times, starting from the middle of the last century, while previously other terms were used, such as 'drawing', 'architectural drawing', 'technical drawing', 'descriptive geometry', 'applications of descriptive geometry', 'methods of representation'.
Some Italian dictionaries define the term 'representation' as the operation of representing, with figures, signs and sensible symbols, or with various, even non-material processes, objects or aspects of reality, facts and abstract values. Representing is the operation of graphically reproducing an object, also a geographical region, etc. by projections, according to appropriate criteria, onto a plane surface.
Representation can be applied differently in various fields, ranging from philosophy to law, to mathematics, as well as to the field of architecture and engineering.
Specifically approaching the field of architecture, we can say that the activity of representing is as ancient as the world [1], but over the centuries it has taken on different connotations and denominations, as I wrote back in 1997: "Historical analysis has investigated in depth the role

This article was written upon invitation to frame the topic, not submitted to anonymous review, published under the editor-in-chief's responsability.

Fig. 1. On the left, Map of Abel Jamud (Wadi Rum) graphic transcription, Neolithic period 3000-3500 B.C. (graphic elaboration by the author); on the right, Map of Abel Jamud (Wadi Rum), in a detail (photo by the author). Engravings locating roads and round notches showing villages can be noted.



played by the methods of representation and in particular by perspective; in this respect, it is sufficient to recall the fundamental contributions of Erwin Panosky and Decio Gioseffi. While there have been many studies dedicated to the problem of the history of perspective, few have been dedicated to the more general history of representation and only very few, finally, are the studies that deal with the relationship between design drawing and architecture in its historical development: yet in this relationship lies the key to understanding the progressive development of methods of representation and, more generally, of solid, sites and descriptive geometry. To convince oneself of this it is enough to think of two emblematic cases, situated exactly at the beginning and at the end of the period in which the transformation of current knowledge took place: Vitruvius and Frézier. In Vitruvius the method of representation is clearly consistent in all respects with the design process: *ichnography*, that is, our projection onto a plane, precedes all the other representations of architecture, because it simulates, chronologically, even with drawing, the first operation carried out at a construction site, that related to tracing the plan of a building on the ground. The term that Vitruvius proposes to us, in fact, stands for 'drawing the footprint'; only after this operation can you proceed to erect walls and columns, whose graphic correspondence can be found in the term *orthography*. Finally, once the construction is complete, we have the *sciography*, that is, the 'overall view,' which by some is considered an elevation, perhaps a '*promenade architecturale', ante litteram* resolved thanks to the graphic simulation that provides an overall vision. It is interesting to observe how for the great Roman theoretician there exists a precise link between the graphic operations performed at the drawing board and those at the construction site; this allows us to also understand how some graphic constructions, for example, the division of a circumference into a certain number *n* of equal parts can be carried out with exactly the same rules, whether on a sheet of drawing paper or at the construction site. In fact, we know that to divide a circumference into four parts without performing complex calculations, it is enough to draw two straight orthogonal lines passing through its center; repeating the operation, we obtain divisions into eight, sixteen or thirty-two parts: that is why Sangallo's domes have sixteen or thirty-two spirals, and that is also why a wind rose has eight or sixteen winds. The same graphic procedure performed at the drawing board can be repeated on site. In this way, therefore, the part of geometry that is dedicated to the representation of three-dimensional objects by means of two-dimensional graphic models is closely linked to the project" [Docci 1997, pp. XII, XIII].

Essentially, we can say that for many centuries, until the end of the seventeenth century, to represent an object, a drawing was made reproducing, on a two-dimensional plane, the features of the object itself, without any strict correlation between its form and its representation. With the developments of mathematics and geometry, starting from eighteenth century, Projective Geometry [Amodeo 1939] was codified, whose principles are based on two fundamental operations: projection (construction of a projective ray passing through the center of projection and through a point of the object to be represented) and the section (intersection of the projective ray with the plane on which the representation is formed).

Going back to the aforementioned preface we can say that: "Taking a forward leap of twenty centuries, we reach Freziér who, as we know, represents the last author of treatises before the industrial revolution, mistakenly known among experts on geometry as the author of a stereometric treatise, while he should be known for an extensive work of

Fig. 2. Map of Nippur, engraving on clay tablet, 1500 B.C. On the right, the floor plan of the Royal Palace with indications of doorways can be noted: <https://pierrickauger.wordpress.com/2014/03/19/la-plus-ancienne-carte-du-monde/> (accessed 2018, June 10).

Fig. 3. Turin, Egyptian Museum. The so-called 'goldmine papyrus' with a map of Wadi Hammamat. Cyperus papyrus. New Kingdom, 20th Dynasty, reign of Ramses IV (1156-1150 B.C.). The representation of mining tunnels can be noted: <https://it.wikipedia.org/wiki/Papiro_delle_miniere_d%27oro#/media/File:TurinPapyrus1.jpg> (accessed 2018, June 10).

geometry, drawing and civil architecture, in which all the observations advanced up to now are admirably developed. He begins with a passionate defense of the theory, essentially, of geometric studies, as a prerequisite of architecture and ends with an exhibition of the five orders, well known to historians, in which he assigns to Vitruvian rationality the genuine origin of what in Architecture is authentic beauty" [Docci 1997, p. XIII].

Starting from these principles it has been possible to rigorously realize the representation of an object in space, by its projection onto a representation plane (picture plane) from a center of projection at a finite distance from the plane itself (central projection), or from an infinite distance from it (parallel projection). Thus, between the object and its representation, under specific condition is established, for which, given the representation, one can trace back to the object that determined it and vice versa. All this makes the representation scientifically objective and allows its use in physically constructing the object through a univocal process, on which all projects are based.

Starting from the principles of projection and section, various methods were developed which allow rigorous and objective operations of representation, designated by the term 'methods of representation', which are characterized in relation to the different type of center of projection (optical center) and its position with respect to the projection plane (picture plane) on which the projection is formed. Over the centuries the Method of perspective (or central) projection, the Method of double orthogonal projection (or Monge's Method), the Method of axonometric projection and the Method of topographic projection have been codified; each of them is distinguished by a different representation result. In particular, the methods that use a center of projection at a finite distance (proper center) construct a representation very similar to human vision (perspective) and therefore are used for realistic representations. The methods that use a center at infinity (improper center) realize, instead, more abstract representations (orthogonal projections, axonometric projections) but that have the great advantage of an immediate measurability, since the lines and points are not altered in the drawing; this type of representation is mainly used in the technical field and in design.

Fig. 4. Forma Urbis Romae (Severan Marble Plan), Severan period, fragments 11e, f, g, h [Docci, Maestri 1993, fig. 30, p. 25]. On the right there are three domus and an odeon, with indications of seats in the center and of the colonnade supporting the roof.

Finally, it should be remembered that the advent of computer science determined the birth of virtual representation, which is not a physical representation, but which could be, since it exists in the computer's memory and can be displayed on the screen; and therefore it can be used as the project of a work to be realized [2].

The Roman School and the first steps towards the creation of a new discipline: Architectural Representation

In the early 1960s, the Faculty of Architecture in Rome, like other Italian faculties, was besieged by a multitude of young students who wanted to become architects: enrolments had for a few years largely exceeded the number of three hundred and many courses were in crisis because they were too crowded. Due to these demands, the Faculty began to 'split' some courses and in the spring of 1962 it was decided that this procedure should also be applied to *Applications of Descriptive Geometry*; the new course was entrusted to a young professor, Gaspare De Fiore, who already taught *Drawing from Life*, in the hope that he would undertake a profound renewal of teaching; the other course of *Applications of Descriptive Geometry*, entrusted to professor Ing. Maria Luisa Ganassini, instead developed, more traditionally, the methods of Descriptive Geometry applied to the problems of architecture.

Fig. 5. Map of Jerusalem, floor mosaic in the Church of Saint George at Madaba, second half of the 6th century A.D.: <https://en.wikipedia.org/wiki/Madaba_Map#/media/File:Madaba_map.jpg> (accessed 2018, June 10).

Gaspare De Fiore brought together some of his collaborators from the *Drawing* course and other young architects, such as myself, stating that he would accept the course if we committed ourselves to taking charge of it, under his coordination. So it was during the summer of 1962 when we organized many meetings with Gaspare De Fiore and other colleagues, such as Igino Pineschi, Achille Pascucci and Camillo Ianniccari –I believe that sometimes Franco Donato also took part– in it order to develop the program of a course that was not to be the duplicate of the one already initiated and that, above all, addressed with greater incisiveness the representation of architecture and, in particular, the realization of projects and the analysis of urban or territorial context; I would like to mention here that a project begins with the first concept sketches, followed by the definition of the project itself, up to its communication, and continuing towards the executive project.
It was from these debates that a distinction was made between the terms 'applications of Descriptive Geometry', which only refers to Monge's Method, or double orthogonal projection, and the term 'representation'; it was clear to us that in order to represent the project, an architect also needs other methods of representation, such as perspective, axonometry and topographic projection, bearing in mind that the modern world also proposes other techniques such as photography and scale models (models or maquettes). These were the main reasons for finding a new name for a course that intended to explore all aspects of Representation.
It should be remembered that an architect or a civil engineer should use Representation not only during the design and definition of a project but also in the phase of gathering information about the places in which the new work is planned to be builtand, similarly, for interventions on historical architecture and on cities; in fact, by using architectural surveying he needs, after having measured the characterizing points of a work, to represent the single building or the urban sector; he therefore needs to employ all the methods and tools of representation in a broader way than what the *Applications of Descriptive Geometry* could offer us at the time.
On that occasion we fully understood how architects had by then come to use systems of representation that in those years were already more complex than the classical ones which, although constituting the scientific foun-

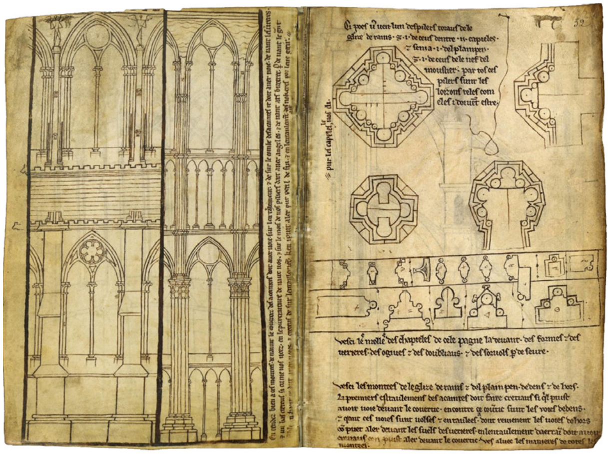


Fig. 6. Villard de Honnecourt, Sketchbook, folios 62 and 63, mid-13th century: <http://classes.bnf.fr/villard/feuillet/index.htm> (accessed 2018, June 10).

Fig. 7. Cristoforo Buondelmonti, Map of Constantinople, 1422, Liber insularum Archipelagi, 1824; Paris, Bibliothèque nationale de France: <http://gallica.bnf.fr/ark:/12148/btv1b55010482q/f79.item> (accessed 2018, June 10).

dations of Descriptive Geometry, needed to be expanded with other methodologies in order to meet all the needs of contemporary architects. Thus, the name of the course, while maintaining the official title of *Applications of Descriptive Geometry*, was completed with the subtitle: *Theory and Techniques of Representation*. It was conducted by our group, under the supervision of Gaspare de Fiore and, in particular, we, Pascucci and I, were very involved; unfortunately for our experimentation, starting from 1968 the course was passed on to another teaching professor because Gaspare De Fiore had in the meantime won the chair of *Architectural Composition* in Palermo.
Our experience thus ended, but the commitment of Gaspare De Fiore students did not cease; we devoted ourselves to further explore the themes of Representation, so much so that in 1965, I, on my part, published a monograph entitled *Theory of Representation*: nothing particularly significant, but we had now reached the full awareness that Representation was our disciplinary sector. Following Gaspare De Fiore advice, in 1966 I decided to participate in the competition for professorship and, again on his suggestion, I decided not to participate in the that for *Drawing* or *Applications of Descriptive Geometry*, but in that for a new discipline we were experimenting in Rome. In May 1967, I

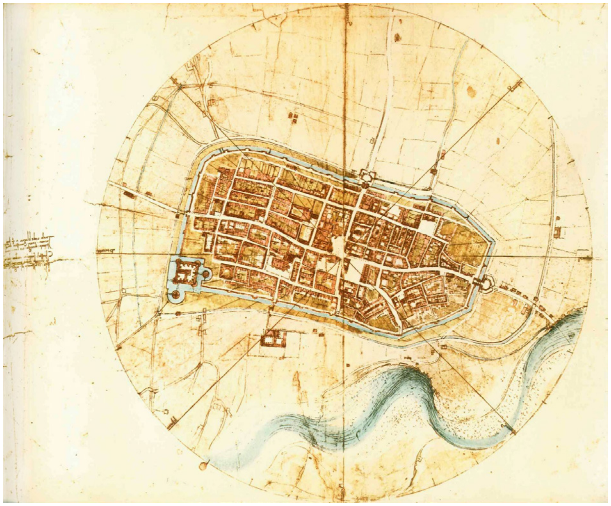
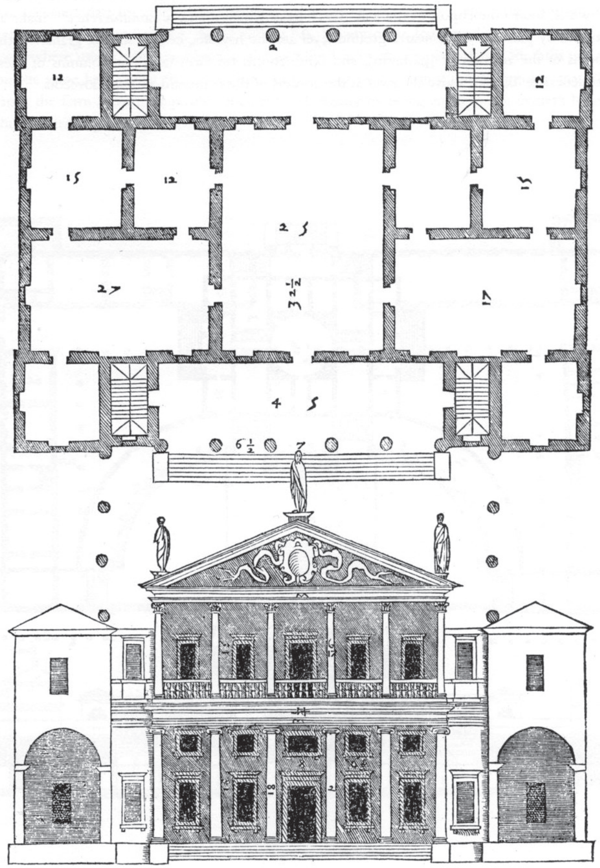
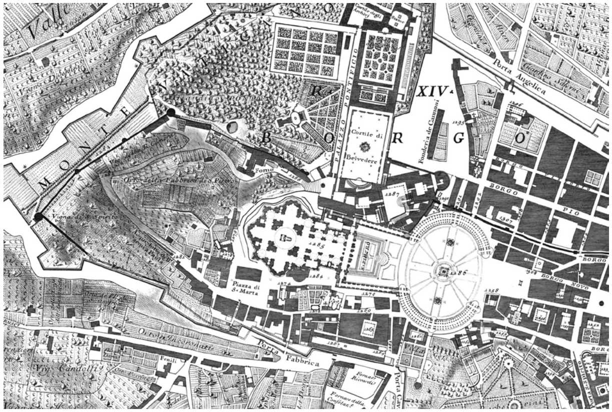


Fig. 8. Leonardo da Vinci, a plan of Imola, c.1502, Windsor Castle, Royal Library, no.12284. The representation of blocks and public buildings with their plans can be noted [Docci 1987, fig. 2, p. 182].

Fig. 9. Map of Baghdad, 1533. The plan of the city shows the buildings tilted away from the Tigris River; the walls are represented turned back at a 90-degree angle in order to show their elevations: <MuslimHeritage.com> (accessed 2018, June 10).

obtained, by unanimous decision of the examination board, the qualification as professor of *Theory of Architectural Representation*, a discipline that for the first time entered the Italian university world.
As known, in 1969 the new regulations of the Faculties of Architecture were published which profoundly reformed the previous one and heavily affected our disciplines, reducing them from six to two, namely, *Applications of Descriptive Geometry* and *Drawing and Survey*, completely eliminating the two courses of *Drawing from Life* and the two courses of *Survey of Monuments*. The teaching of *Applications of Descriptive Geometry*, having to deal with the scientific foundations and techniques of representation, took very different forms depending on the teacher's either limiting himself to providing the teaching of methods of representation or, otherwise, trying to make the course of *Science and Technique of Representation* come back to life. That's what happened for the course of *Applications* that was entrusted to me starting from the academic year 1970-1971 and that I kept up to the year 1974-1975, in which I again took up what I had already experimented with Gaspare De Fiore from 1962 to 1968.
In the 1970s, therefore, the experiment began again and continued for many years thanks to the contribution of





Achille Pascucci who took over my course, continuing to teach *Theory of Representation*. Maintaining this course not only meant facilitating the diffusion of knowledge in the field of representation, but also the development of research and scientific contributions unfolded over time, as I will explain below.

The birth in 1983 of departments at the Sapienza University and the creation of a department called 'Representation and Survey' –which included all the teachers of Drawing, about thirty, scattered throughout the Faculties of Architecture, Engineering and even in those of Mathematical, Physical and Natural Sciences– determined a considerable step forward for the activity of scientific research and also a greater diversification of scientific skills.

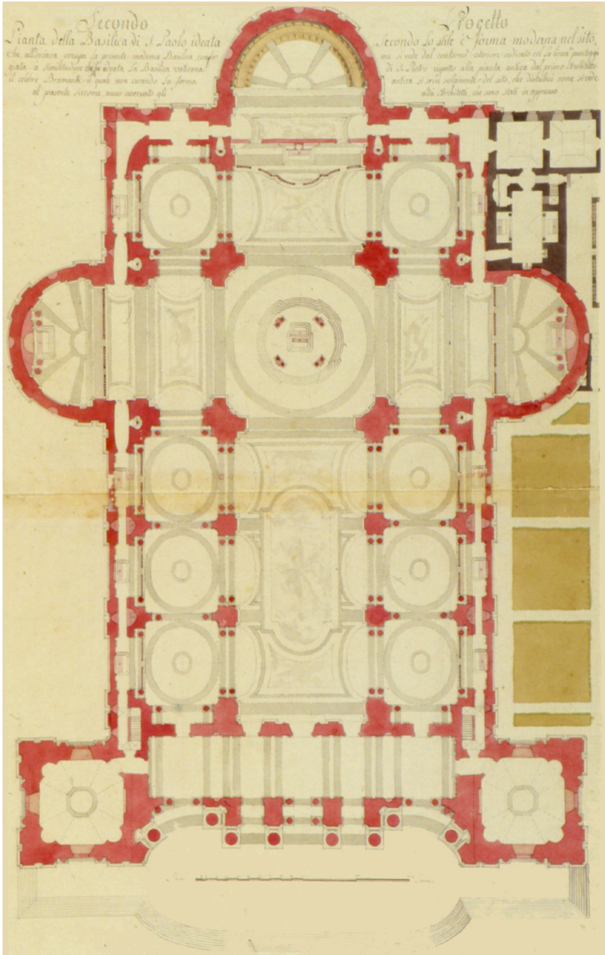
A great confrontation of ideas took place in those years concerning the issues related to representation in its various aspects. In 1986 a particular initiative was taken to organize an International Congress entitled "*I Fondamenti Scientifici della Rappresentazione*" (that is, *The Sicentific Fundamentals of Representation*), whose scientific directors were Roberto De Rubertis and myself. In order to address our topics from an interdisciplinary point of view, in addition to all Italian teachers of Drawing, the following teaching professors were invited: Decio Gioseffi, professor of History of Art at the University of Trieste; Richard Gregory, professor of Neuropsychology at the University of Bristol; Giuliano Maggiora, professor of Architectural Composition at the University of Florence; Corrado Maltese, professor of Art History at the Sapienza University

Fig. 10. Andrea Palladio, Villa Valmarana in Lisiera, Bolzano Vicentino, Vicenza. Engraving [Palladio 1570, libro I, p. 59].

Fig. 11. Giovanni Battista Nolli, Nuova Pianta di Roma, 1748. Detail of the area around Saint Peter's Basilica. The representation of the city is realized using a rigorous orthogonal projection; in addition, the public buildings are also represented with their interior spaces.

of Rome; Mario Rasetti, professor of Theoretical Physics at the Politecnico di Torino; Alessandro Polistena, professor of Computer Graphics at the Politecnico di Milano and René Taton, director of the *École des hautes études en sciences sociales* (School for Advanced Studies in the Social Sciences) in Paris. The proceedings of this congress constitute a definitive report on the state of the art of Representation and also of its history; at same time, I would refer to the lectures by Decio Gioseffi and René Taton, but I think that the interventions during the round tables should also be carefully analyzed by those who want to deal with the theme of the History of Representation [AA.VV. 1989]. The congress took place in the Palazzo della Cancelleria, a prestigious venue, as I said in the opening of the works: "As you may have intuited, the choice of this hall, wonderfully frescoed by Giorgio Vasari, where our Congress is being held, was not accidental; who better than the great Florentine draftsman could have said: 'drawing is not other than the visible expression and declaration of our inner conception and of that which others have imagined and given form to in their idea'?" [3].
Bearing in mind the results of this important Congress, the Department of Representation and Survey organized a new on April 1993, also closely linked to the topic of Representation, entitled *Il Disegno di Progetto. Dalle origini al XVIII secolo* (that is, *Drawing for Project. From Origins to VXIII century*) which traced the features of the History of Representation of architectural projects; the proceedings of the congress –particularly interesting, also taking into account submissions from various European schools– can be found in the book containing the most significant papers [Docci 1997].
After many years of discussion in 1993 the Faculty of Architecture decided to deal with the problem of revising its regulations, believing that they, dating back to 1969, were no longer able to satisfactorily address the education and training of young architects, also taking into account the European Community Directive relating to the profession. After a series of confrontations between the different faculties and the various disciplinary sectors, the new Table XXX was approved which called for considerable changes in the education and training of architects [4]. The new organization envisaged a three-cycle structure (2 years + 2 years + 1 year); in addition, for the first time, eleven disciplinary areas were introduced and the '*Area XI*' was called '*Area della Rappresentazione dell'Architettura*' e dello Spazio. This system, which remained in existence for about

Fig. 12. François Demesmay, Concorso Clementino, 1758, second class: 'Ridurre la Basilica di S. Paolo sulla via Ostiense a forma moderna'. Plan of the proposal for trasformation. Rome, Accademia di San Luca (Dis. Arch. 0564), [Docci 1997, fig. 4 p. 324].



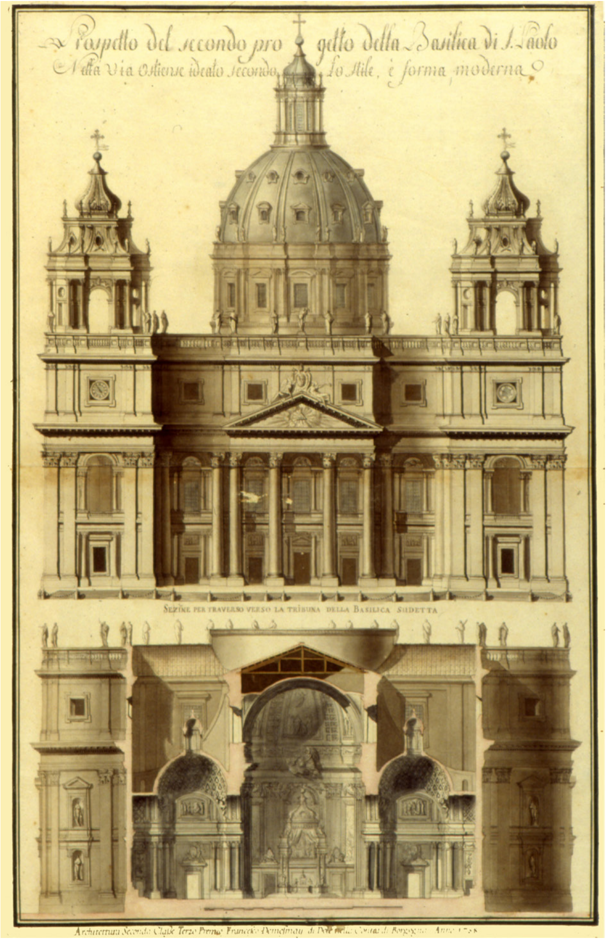


Fig. 13. François Demesmay, Concorso Clementino, 1758, second class: 'Ridurre la Basilica di S. Paolo sulla via Ostiense a forma moderna'. Elevation and section, third prize. Rome, Accademia di San Luca (Dis. Arch. 0565), [Docci 1997, fig. 5, p. 324]. The perfection of the representation, which follows the canons of the orthogonal double projection method, is evident.

ten years, has been taken as a model by many European schools and, in my opinion, should be analyzed with great care since it is still today a model of modern training and more effective than the system currently used [5].
These innovations did not go unnoticed by publishers at the national level; in 1995, in fact, the '*Nuova Italia Scientifica*' (NIS) publishing house asked me to compile a monograph on Representation including the knowledge of Descriptive Geometry as well as other methods of representation. I asked my colleague Riccardo Migliari to collaborate and together we addressed this topic. In the presentation of the book we had the opportunity to write: "It is known that the term 'descriptive geometry' (*géométrie descriptive*) was coined by Gaspard Monge to baptize the new science of which he declared himself the creator. It is written in the sources of this history that after the 'invention' of descriptive geometry it would be possible to solve, thanks to the latter, every problem first faced with the means of perspective, gnomonic perspective, stereometry and all the other sciences applied to representation of architecture and engineering, topography and geodesy, etc. It is also known that many 'ways of representing,' which at the time had not yet achieved the dignity of being called 'methods of representation,' found it in a more recent history, so much so that today the so-called Monge's Method has been joined by others, at least three, all with equal dignity as mathematical tools. It therefore seems absurd to continue to include under the aforementioned denomination such ancient, noble and complete sciences as double orthogonal projection (in the form of the architectural drawing illustrated in this book), perspective (or central projection, if you prefer), axonometry (completely ignored by Monge), or topographic projection, and studies that make better use of these other methods, rather than Monge's Method, such as the study of surfaces, that of vaults and the theory of shadows and chiaroscuro. Instead, it seems dutiful, in order to understand the teaching of history, to understand all these disciplines, together and alongside the geometry of Monge, under the new title that could be that of 'Science of Representation', a title that is proposed for this book" [Docci, Migliari 1996].
In those years, therefore, the need to historicize the Science of Representation was alive in all of us, as can be seen in the publication mentioned here, where each method of representation is preceded by a brief historical introduction which highlights its development and its codification.

The birth of the courses in Science of Representation

The new regulations of 1993, already mentioned earlier, started from the following academic year; in many faculties, within the Area of Representation, the subject was still taught for some years in courses that maintained the traditional names they had in the pre-existing disciplinary Area ICAR17 (ICAR was the acronym indicating Civil Engineering and Architecture), in many cases passing from two to three courses made mandatory by the new system. In the Faculty of Architecture at the Sapienza University of Rome, it became immediately clear that it was necessary to make an effort to try to overcome the old disciplines by finding broader terms to designate the different aspects of Representation, and Techniques of Representation, as well as Survey with all its methodologies, including scanner surveying, without neglecting Life Drawing, with its various techniques, such as watercolor. Regarding the name of the course, beginning with the academic year 2001-2002 it was decided to designate it with the name of *Science of Representation I, II, III*, although perhaps we could have more coherently called it *Science and Techniques of Representation*; simplicity, however, always pays. The problem of the contents of the three courses was solved through the commitment and coordination of the three professors, with diversified skills, of Architectural Drawing, Methods of Representation and Survey. In three years, however, knowledge is not acquired in a linear manner: for example, the first year is mainly devoted to free-hand and architectural drawing techniques, but the graphic analysis of architecture is dealt with as well; in the last year, in addition to the main Survey methodologies, the virtual modeling of architecture with the use of computers for constructing virtual 3D models is taught.

Topicality and complexity in the elaboration of the History of Architectural Representation

From what has been outlined above there emerges the current complexity of the forms that Representation assumed in the first twenty years of the 21st century, since not only the advent of computer science determined the birth

Fig. 14. Paul Letarouilly, Plan général del la place et des édifices du Capitole, 1860. It can be noted that the representation is not always objective but tends to interpret the forms [Letarouilly 1860, fig. 15]: <https://www.fulltable.com/vts/aoi/l/letr/15.jpg> (accessed 2018, June 10).

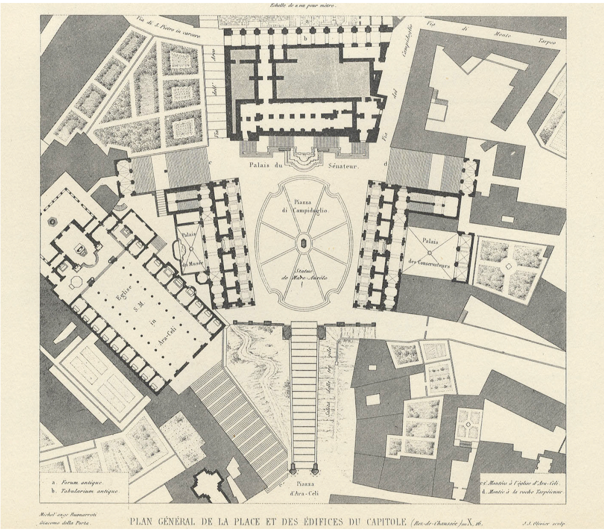
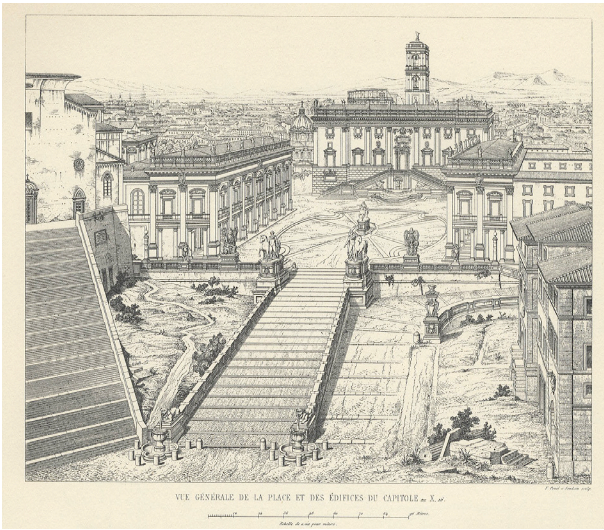


Fig. 15. Paul Letarouilly, Vue général del la place et des édifices du Capitole, 1860. It can be noted that the perspective representation is performed with great accuracy [Letarouilly 1860, fig. 16]: <https://www.fulltable.com/vts/aoi/l/letr/16.jpg> (accessed 2018, June 10).



of Virtual Representation [Docci 2007] but also because other representational methods such as three-dimensional models (scale models or maquettes) and Reverse Modeling, photography and film shooting became more and more relavant in our research field. Other aspects have to be considered, such as those of the three-dimensional representation of an object or an artifact, that is, the models generated by 3D printers managed by software and derived from three-dimensional scans with laser scanners and other methods such as photomodeling.
In addition, there are specific and autonomous sectors in the world of Architecture and Engineering, such as that of the representation of the territory, or cartography, which, while resting its scientific foundations on the method of topographic projection, in present a series of particular aspects regarding the symbology, the graphic signs and the thematisms, so much so that it can be defined territorial representation, and which in some cases becomes a real discipline: think, for example, of thematic Cartography.
Exactly defining which fields Architectural Representation embraces today is therefore a very complex task, also due to the continuous contributions of computer science and of the new technologies.
It is, therefore, perhaps the moment to propose a new definition, broader than the term 'representation', which I believe should take into account that Representation is the result of a process that has as its purpose the representation of a real or virtual object, on a representation plane or in 3 dimensions (physical model) following specific laws of correlation between the points of the real or virtual object, and the corresponding points represented, on a plane or belonging to a three-dimensional model.
The History of Representation, like other histories such as that of Architectural Survey, is none other than one of the many chapters of the History of Science [6], and therefore will have to follow the previously proven rules, developing along paths that cross all the periodizations that have been defined, from the origins to the present day.
In my opinion, there are three paths along which the History of Representation develops.
A first path is that of the scientific foundations of the subject, a history already largely written by mathematicians and philosophers who dealt first with Descriptive Geometry and later, with the Methods of Representation; I would mention, in this regard, Gino Loria [Loria 1919; 1924; 1931] and Luigi Vagnetti [Vagnetti 1965; 1978].
A second path is that of the methodologies of representation, including all aspects related to graphic conventions, from the symbologies to the nature of the graphic supports.
The third path is that concerning the instrumentations – from the simplest to the most complex– in the contemporary world, used in the process of representation, an aspect on which there is much work to be done.
In conclusion, it is hoped that young people will dedicate themselves to historical research in the field of Representation since, although some studies have been undertaken in the sectors of Survey and Freehand Drawing, the History of Representation is still largely to be written.

Notes

[1] The text is accompanied by a series of images, not directly mentioned in the paper, which illustrate the transformations of the methodologies of representation used during the course of centuries.

[2] On virtual representation see: Docci 2007.

[3] Mario Docci, Opening address. In AA.VV. 1989, p.11.

[4] The Italian Ministerial Decree relating to Table XXX for the Faculties of Architecture was published in the Italian Official Gazette No. 153 of 2 July 1993.

[5] For example, for the Area of Representation it is stated that the disciplines of the area are aimed at achieving the following objectives: to form the theoretical and practical knowledge necessary for the representation of architectural space, also through the analysis of their historical development; to practice all the graphic techniques, in order to achieve full control of the tools of representation, applying them to the analysis of architectural values, as well as to survey and to project design; to practice methods of direct and instrumental surveying as well as the consequent techniques of metric, morphological and thematic restitution; to form the ability to control the mental model of space, which is the premise of every design activity (see page 28 of the Italian Official Gazette No. 153).

[6] For more information on this type of path, see, for example, Docci, Maestri 1993.

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The *Bon Architecte*, the *Mauvais Architecte*

Philibert de L'Orme

The Double Allegory of the *Bon Architecte* and the *Mauvais Architecte* by Philibert De L'Orme

Francesca Fatta

Philibert De L'Orme was one of the leading exponents of the architectural culture of the Second Renaissance in France [Blunt 1958].
A double image has been chosen, one of the best-known of the sixteenth century, which takes up the idea of the good architect, as opposed to the bad one, in an allegorical key.
In the representation of the double allegory, a current, since eternal, concept emerges, intended to involve the reader in reflections that directly invest the social and political context of the practice of architecture.
These works are two woodcuts, placed at the end of the treatise *Le premier tome de l'Architecture* (1567) [1] which documents the competencies of the architect as designer, builder and decorator. They have the characteristic of presenting the human figure and the architectural and landscape settings in an articulated and explicit manner.
De L'Orme was a builder and theoretician of great prestige in France, under the reign of Francis I, and undoubtedly represented a strong and influential personality for the time. In these images, between similarities and differences, it is summarized the evolution of the figure of the designer and of the builder in the phase of transition between the Middle Ages and the Renaissance.
Known as antithetical images of positive and negative attitudes toward designing and building, they recall Ambrogio Lorenzetti and his frescoes on the effects of good and bad government [2].
The "*sage et docte Architecte*" (on the right) is represented in pleasant surroundings, enlivened by cultivated gardens and fountains that –in a play of perspectives– are surrounded by airy, spacious buildings with façades marked by well-designed and well-proportioned rounded arches. The exteriors and interiors interpenetrate each other, giving the impression that nature and architecture play agreeable, mutually respectful roles.
But it is above all the figure of the architect that attracts, amazes, despite its incredible physical alteration, without creating repulsion. His posture is hieratic and condescending, he turns compassionately towards the student and the two share gestures and looks.
A physical figure that we could call 'everted,' given the multiplication of the senses with which it is represented: four hands, three eyes, four ears, to amplify hearing into listening, the hands into the transmission of actions, and sight into grasping the signs of the past, the present and the future [3]. In addition, the feet are endowed with small wings, probably for resting on nature in a light and considerate way. The 'good architect' speaks to the student with a slightly-open mouth because his science must be transmitted in a calm and transparent way [4]. The scroll held in one of his hands represents Drawing that organizes the world.
The 'bad architect' (on the left) is represented according to a similar and opposing idea. The setting appears bleak and in disarray. Nature is desolate and barren, un-

This article was written upon invitation to comment on the image of Philibert de l'Orme, not submitted to anonymous review, published under the editor-in-chief's responsability.

related to a scene that has as a backdrop a dark, massive castle, providing a clear reference to an obsolete medieval culture. The house on the right is little more than a hut and the sky is menacing. Even the large tree in the center of the picture appears to have no connection with the landscape. At the center, a maimed figure moves clumsily, an architect without eyes and nose, his hands cut off, with disorderly garments that leave his bare legs uncovered, making the appearance of the "*mauvais Architecte*" even more fragile and exposed. Finally, his mouth is wide open, always for the idea of contrast with the reasoned speech of the "*bon Architecte*" [5].

This symmetrical juxtaposition between positivity and negativity, between amplification of the senses and mutilation, emphasizes the response from positive to negative in the art of building and in the ethical and representative figure of the architect. The importance of knowledge, of know-how and of knowing how to teach is emphasized. An allegory that, as already underlined, resumes the Ambrogio Lorenzetti's allegorical idea conceived about two centuries earlier. Even in that case, the frescoes rely on allegory to underline a clear didactic message. The allegory of the *Buon Governo* and that of the *Cattivo Governo* both use opposing visions of architectural and landscape order and harmony to inspire the conduct of rulers.

Notes

[1] The treatise of Philibert De L'Orme, published in 1567 and entitled *Le premier tome de l'Architecture* (*The First Volume of Architecture*), because a second one was planned, consists of nine *Livres*. The *premier tome de l'Architecture* closes with a *Conclusion* centered on the figure of the Architect and on "*certaines instructions sur l'entreprinse et faicts des bastiments*" which end with recapitulative advice on the knowledge that the "*sage et docte Architecte*" shares with his student so that he, too, will become a "*bon Architecte*" [de L'Orme 1567, pp. 281-283].

[2] Ambrogio Lorenzetti, *Allegoria del Buon Governo*, *Effetti del Buon Governo*, *Allegoria del Cattivo Governo*, 1338-1339. Siena, Palazzo Pubblico.

[3] De L'Orme states: "*la figure cy-apres descrite* […] *vous met devant les yeux un homme sage* […] *ayant trois yeux. L'un pour admirer et adorer la saincte divinité de Dieu, et contempler ses oeuvres tant admirables, et aussi pour remarquer le temps passé. L'autre pour observer et mesurer le temps present, et donner ordre à bien conduire et diriger ce qui se presente. Le troisieme pour prevoir le futur et temps à venir*" [de L'Orme 1567, p. 282].

[4] De L'Orme states: "*il fault beaucoup plus ouyr que parler*" [de L'Orme 1567, p. 282].

[5] In this case De L'Orme states: "*Il a seulement une bouche pour bien babiller et mesdire*" [de L'Orme 1567, p. 281].

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HISTORY/HISTORIES OF REPRESENTATION

Geometry

On the Genealogy of Geometry in Drawing for Design: Primitive Future of a Techno-aesthetic Issue

Fabrizio Gay

Introduction

The acquisition of this historical knowledge –according to the purpose of this issue of *diségno*– should help us to understand what we actually mean when we talk about 'Geometry' in the field of university researches especially applied to Design, Pedagogy and Arts schools. In this field, specifically, the history of geometry should not be mistaken for the histories of mathematics [Chasles, 1837, Loria, 1921], or with the history of art and ancient erudition: these general historiographical issues have other (authoritative) scientific and editorial references.

The 'geometry for the *design*' can be actually regarded as a single issue (topic) provided that at least two conditions are met: 1°) the presence of a common technical subject shared by studies of different disciplines, and 2°) common vocabulary and methods shared by the different points of view.

1°) 'Geometry for the *Design*' means an 'applied science' that studies the 'categories of the object shapes' (eidetic categories), as well as their projective and diagrammatic representations. The history of this 'practical geometry' gathers those studies that, although relying on different points of view, explicitly or implicitly include all the geometric-morphological aspects pertaining to the field of the history and anthropology of 'visual artefacts', especially of those 'visual artefacts' specifically 'designed to represent'. Therefore, the stories of visual artefacts investigate specific 'geometric-morphological issues.'

This article was written upon invitation to frame the topic, not submitted to anonymous review, published under the editor-in-chief's responsability.

Historical studies on 'geometry' intended as such take into account various disciplines –from the history of exemplary (artistic) visual artefacts, to essays or the current parametric modelling, thus offering a multi-faceted overview to be intended as a single thematic area, albeit transdisciplinary.
The 'geometry for the *design*' globally consists of 'paradigms', i.e. a collection of geometric models, a sort of (historical and current) synchronic plurality, which could be considered 'Descriptive Geometries' to point out a genealogy which precedes and still continues after the historical parabola of Descriptive Geometry.
Based on our assumptions, these 'Descriptive Geometries' share the same existence of the 'technical objects' described by Gilbert Simondon [1958; 1992; 2013] and, as such, according to the French philosopher, their specific technical-aesthetic dimension can be grasped.
2°) The unity of this 'collection of geometric models' is made up of two aspects: i) the mutual comparability (translatability) of the models and ii) their adequacy, namely their ability to describe the most significant aspects of the object shapes and their images. Precisely these two conditions –i) comparability of the models and ii) their explanatory adequacy define the thematic unity and the relevance of the historical studies on the 'geometric morphology of visual artefacts.'
This reasoning, however features some criticalities.
Any 'naïve realist' like me would wonder what the 'real explanatory adequacy' of the geometric models actually is. In order to adequation the geometric descriptions to the physical and anthropological (cultural) values that indicate the meaning to the object shapes, it is necessary to gain a historical awareness of the actual technical and aesthetic dimension of geometry.

From Descriptive to Computational Geometry

The internal combustion engine of modern cars still preserve something similar to the ancient steam engine. We realize this fact only if we trace the genealogy of the design of that type of engine, going back to Watt machine. However, the present cars are complex mechatronic artefacts so complex that it is no longer possible to figure out the calculations that a series of algorithms –in spite of us– performs in a fraction of a second, for example, to adapt the braking command to the four wheels according to their specific speed. The consistency of these algorithms –similar to those which control airplanes, the road traffic or even the secretion of hormones– goes well beyond the imagination of the same authors. This happens also with the operation of microprocessor networks in the objects around us, which relies on algorithms going exceeding the visual and object imagination of the ancient 'theatres of machines' and the technical drawing.
The steam engine and the *Géométrie Descriptive* (DG) are both technical objects belonging to the first industrial revolution at the end of the 18th century; while the current mechatronic artefacts, often provided with artificial perception, fall within the computational geometry (CG) and, like the latter, are the result of the third as well as of the incoming fourth industrial revolution.
Descriptive Geometry (DG) and Computational Geometry (CG), albeit in different periods, arise from the same historical development, i.e. the means of technical conception of the artefacts. The DG is associated with the '*l'art du trait*', stereotomy, to mechanical drawing and photogrammetry; while the CG is connected with the CAD and CAM systems, automatic photogrammetry and artificial vision. They are both designed as translation systems for geometric entities from a 'mathematical representation' to drawings, prototypes and models. They both result from the elaboration of new categories of curves and surfaces, intended as mathematical objects to be geometrically transformed and created in workshops. Together with the *Géométrie Descriptive* and the manufacture of cannons, Gaspard Monge, established the Differential Geometry where the 'constant slope surface' is still named after him. In line with the improvement of numerical control machines in the Renault factories, thus laying the foundations for CAD and CAM systems, Pierre Bézier created an *ante-litteram* CG thanks to the invention of 'polynomial curves and surfaces' which are performed still today based on the algorithms of Paul de Casteljau and are named after him.
DGs and CGs –surfaces of Monge and surfaces of Bezier– both result from the same two-century development of design and industrial manufacture, moreover they arise from the same thousand-year-old development of the science of vision.
The DG actually emerged some centuries before its establishment through the invention of the Renaissance theory of perspective –i.e. the development of geometric optics in the *perspectiva artificialis*– as well as with the first projective propositions of practical geometry. Conversely, the further progress of the Science of Vision towards the

computational models of the psychology of perception as well as towards artificial (robotics) vision has promoted the development and applications of the CG, as will be discussed in the conclusion.
Then –shifting from the scientific background to the technical practices– it is worth stressing that DG and CG both refer to the techniques of survey of the surfaces of real bodies in the space. The representation method of the DG par excellence is the 'bicentric projection', namely a kind of 'stereoscopic vision' arising from the ancient topographic assessment system based on 'forward intersection', a scheme similar to the geometric model of stereo-photogrammetry.
The CG can be also regarded as an enhanced development of photogrammetry which, however, leverages the technological evolution of digital sensors and their sensitivity to a wider range of radiations and vibrational phenomena. After the spread of digital imaging systems, thanks to the CG algorithms, the DG photogrammetric processes and, above all, Epipolar Geometry, are now fully available to everybody through software working on personal computers, with images provided by simple cameras or shared on the web. Moreover, the CG grew in the Eighties in line with the great success of 3D data optical acquisition systems –from 'active triangulation' to 'structured light'– by applying the constant invention of new sensors and scanning solutions of natural objects, artefacts, minerals or living subjects to the traditional topographic and photogrammetric schemes.
It is impossible to summarise the amazing technological development of the spatial geometric data collection systems over the last thirty years, together with their numerous applications in various fields –from biology to astronomy, from the manufacturing to the entertainment industry, from the medical image to the robotic vision– up to our everyday life through, e.g., smartphones and means of transport.
For example, the evolution of tomography –starting from the first machines of Godfrey Hounsfield to X-ray scanning devices– can help us understand how the CG has extended the DG applications to bodies and dimensions previously inaccessible to the human eye and imagination. From the molecular scale –for example in the study of protein vibration phenomena– to astronomy –in the study of the spongy form of matter in the cosmic space– the CG is fostering the development of different '*Descriptive Geometries*'. However, these new 'Computational

Fig. 1. Survey of double pendulum trajectories through long exposure photographs (graphic elaboration by E. Calore, F. Giordano, E. Pettenà, IUAV University of Venice, Course on 'Morphology of artefacts', prof. Fabrizio Gay, academic year. 2016-2017).

Descriptive Geometries' can investigate the object shape also through a reverse mechanism with respect to the traditional DG.
In the DG, as happens with the CAD modelling, the form is given '*a priori*' compared to the concrete representation. On the contrary, in the CG, the form is derived '*a posteriori*', and is implied as a geometric structure underlying a large amount of spatial data.
The CG is a morphological instrument which proposes to study patterns, stochastic regularities, dots, corrugations and un-dulations, the morphology of organic or geographic tissues, the tessellations of the *alveoli*, cracks, marbling, stripes, zebra patterns in animal and mineral pigmentations, ramifications, etc.
While the DG mainly acted as a representation instrument, the CG is a form of 'aesthesic' geometry. Today the CG helps to develop instruments for the perception and categorisation of bodies in the space as well as of image networks, reconstructing processes similar to those leading living beings to the recognition and aesthesic knowledge of the objects of the world.

The (historical) translation among geometries and the primordial concept of 'distance'

Computational Geometry is the title of the final dissertation of Michael Shamos dealing with "the Issues that arise in solving geometric problems by machine at high speed and the fact that such devices have only recently been built obliges us to consider aspects of geometric computation that simply do not occur in classical mathematics, and new methods are required." [Shamos, 1978, p. I]

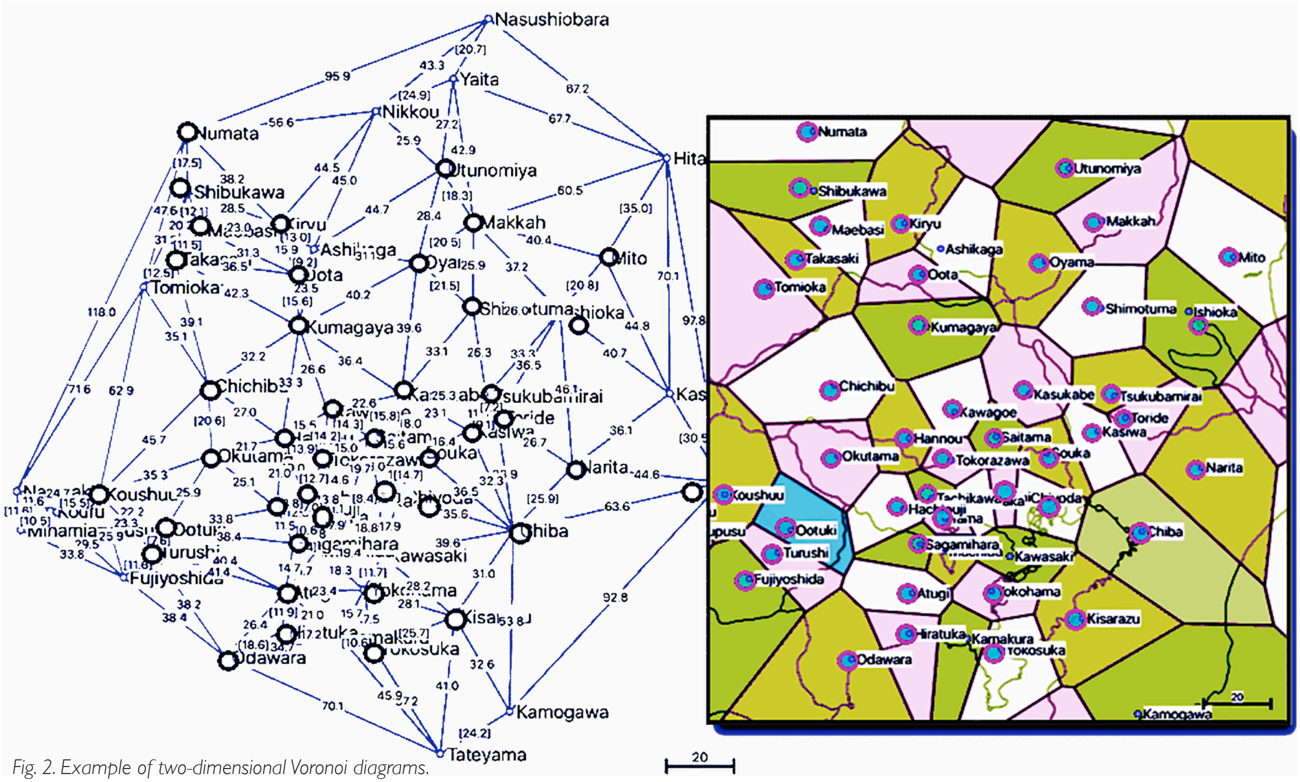


Fig. 2. Example of two-dimensional Voronoi diagrams.

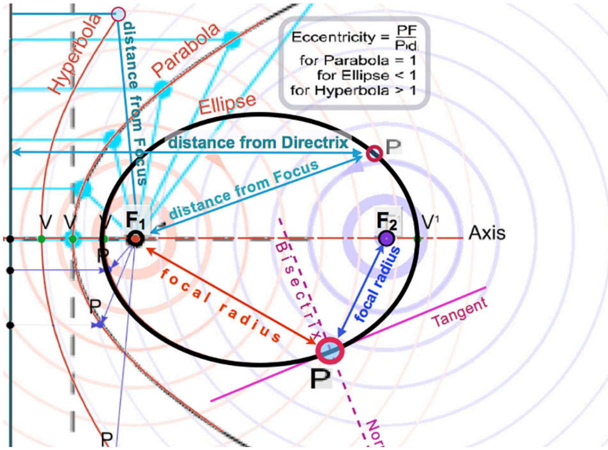


Fig. 3. Eccentricity and focal properties of conics.

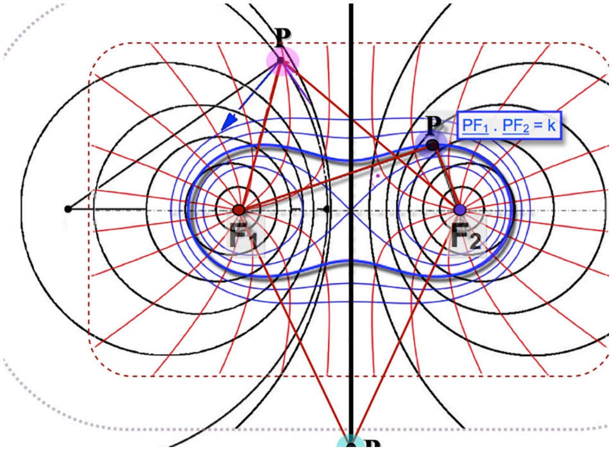


Fig. 4. Circles of Apollonius and lemniscates of Bernoulli with the hyperbolas, their orthogonal trajectories.

An example of these issues is the so-called "Closest-Pair problem", which requires the identification of the two closest points in a certain series of *n* points. What we are trying to roughly assess is, geometrically speaking, the result of an efficient calculation. However, if a machine measured the distance of each $m = n \cdot (n - 1) / 2$ pairs of the *n* points and then arranged and compared the distances, it would carry out a $O(n^2)$ computational complexity task. Conversely, the author [Shamos 1978, p. 163] suggests a recursive algorithm based on the *divide-et-impera* principle, which reduced complexity to $O(n \cdot \log n)$. Basically, the calculation time on set of ten million points drop from one week to one second.
The above-mentioned scattered sequence of *n* points can be considered by the CG only through discrete mathematical models and the figure which best expresses the discretisation of space is the Voronoi diagram. It consists (fig. 2) of the division of a certain space into distinct regions (called Voronoi cells) in such a way that each of them contains only the points closest to a given point (seed) referring to other points (seeds.) The boundaries of the Voronoi cells are places equidistant from two or more points (seeds.)
The qualitative meaning of 'distance between two points' redefines, in computational terms, the traditional categories of the geometric entities. Thus the 'distance' define not only the circle and the sphere –intended as a locus of points equidistant from the centre– but also the straight line and the plane, since they are a locus of points equidistant from two given points. Therefore, the straight line and the plane are the Voronoi diagram only for two points. The locus of points equidistant from a point and a straight line (or a plane) is obviously represented by a parabola (or a paraboloid of revolution.) In general, the metric definition of the conic sections proves that 'equidistance' is just a special case of the 'distances ratios' (= *1*). In fact, conics are defined by their 'eccentricity', i.e. as is a loci of all points *P* whose distances *PF* from a given point *F* (focus) and *Pd* from a given straight line *d* (directrix) have a constant ratio ($PF / Pd = k$). Obviously, the presence of an ellipse or hyperbole depends on whether *k* is bigger or smaller than one. After all, even circles or spheres can be regarded as loci of points *P* whose distances from two given points (F_1 and F_2) have a constant ratio ($PF_1 / PF_2 = k$). Actually they are the circles (and spheres) of Apollonius, which degenerates into a straight line (and in a plane) when $k = 1$. (fig. 4)
The metric property of the eccentricity ($PF/Pd = k$) defines all the conics and is directly reflected by their focal properties. (fig. 3) Based on their definitions, the ellipse and the hyperbole can be intended, respectively, as loci of the points of a plane whose distances from two other given points (focus F_1 and F_2) have an unchanged sum (the ellipse $PF_1 + PF_2 = k$) and unchanged difference (the hyperbole $PF_1 - PF_2 = k$). When *k* is equal to the F_1F_2 distance, the ellipse

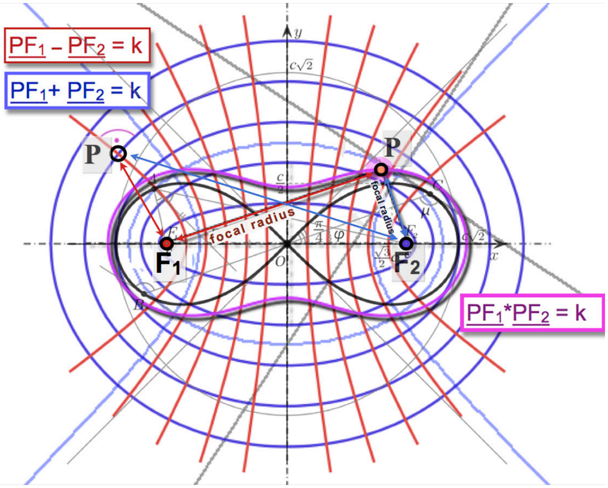


Fig. 5. Confocal Conics and Cassini ovals.

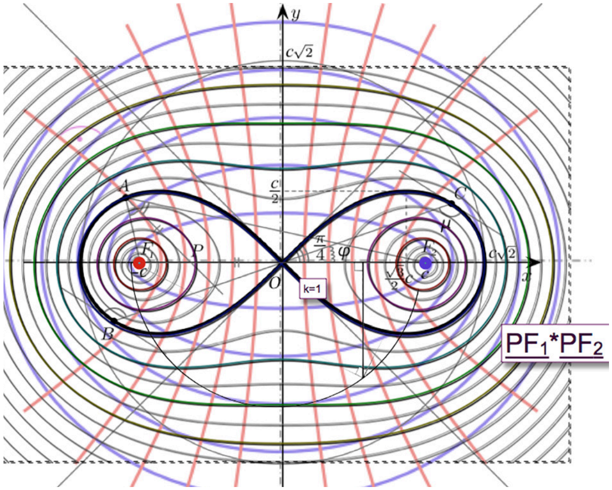
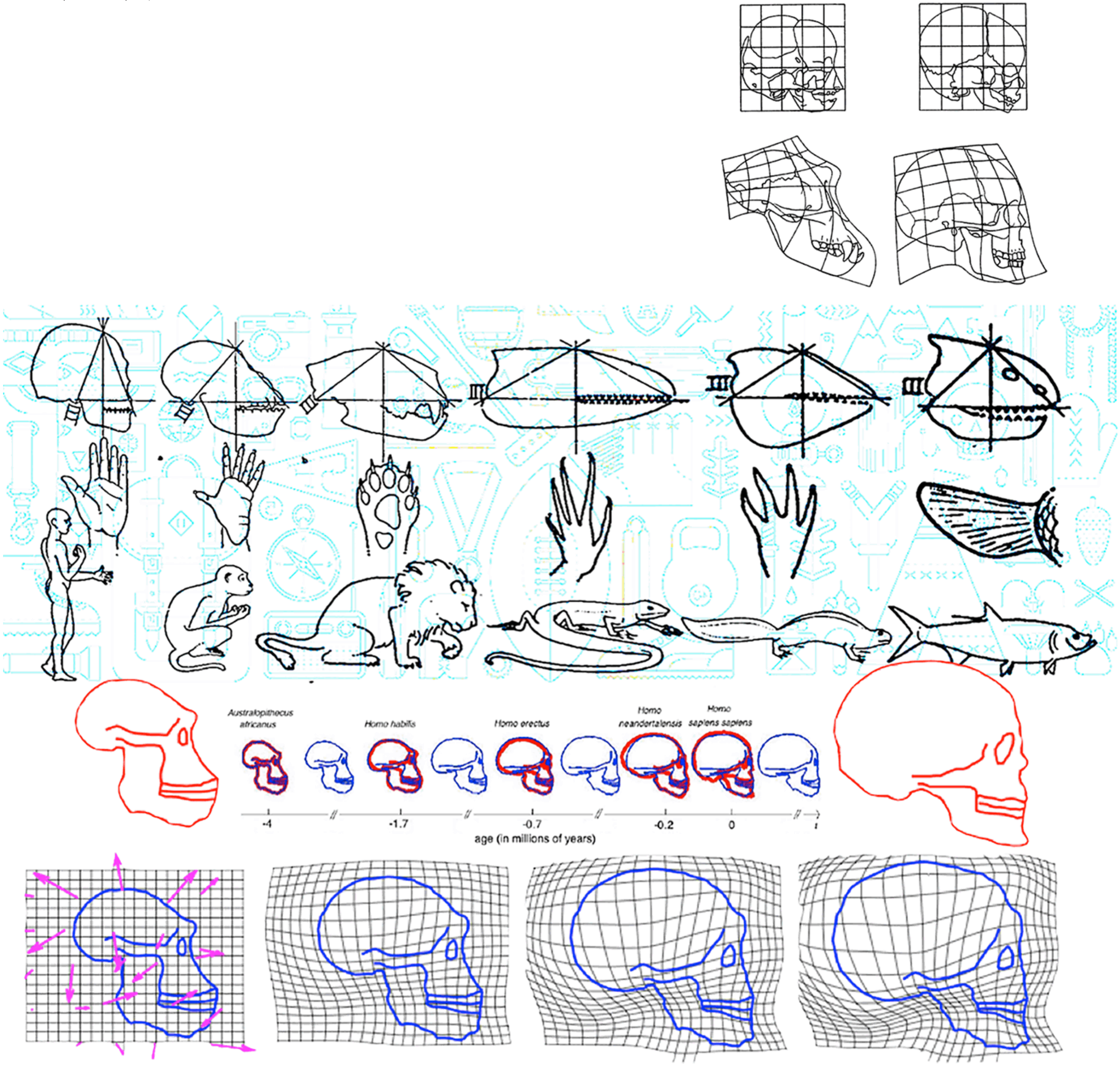


Fig. 6. Different shapes of confocal Cassini ovals.

degenerates into the finite F_1F_2 straight segment, while the hyperbola degenerates into the infinite F_2F_1 segment.
The eccentricity and focal properties of the conic sections, by analogy, help to define other curves and surfaces. For example, Conchoidal curve can be regarded as set of the points whose product of their distances from a given point and straight line is constant ($PF \cdot Pd = k$). Conversely, (fig.4) the lemniscate which Jakob Bernoulli defined in 1694 by hybridizing the construction of the ellipse and circle of Apollonius ($PF_1 / PF_2 = k$) (fig. 5), can be intended as a locus of points of the plane whose product of their distances from two focuses ($PF1 \cdot PF2 = k^2$) is constant ($= k^2$). The traditional eight-shaped lemniscate (fig. 6) result from $k = 1$; while when $k < 1$ the curve degenerates into two distinct branches, two quartic ovals, or, when $k > 1$, it takes on the various shapes of Cassini Ovals.
These examples prove that the emergence of new definitions of curves and surfaces over the history of geometry transforms the previous definitions. After the invention of the conic sections, even the circle, the straight line and the coplanar pair of straight lines have become special cases: 'degenerate conics'. The most important fact in the historical development of the theory of conics is that the new properties streamlined the previous ones and, above all, defined physical properties.

The word 'focus' is physically and historically connected with the renown optical properties of the conics. In fact, considering (fig. 3) that each pair of 'focal radii' meeting in one point of the ellipse is always such that: 1*) their bisecting line is the normal of the curve (orthogonal to the tangent), and 2*) their extensions have a constant sum, then these geometrical properties physically lead to the fact that all the radius originated by a focus are reflected in the other focus (due to 1*) at the same time (due to 2*.)
Therefore, the energetic interpretation of 'distance' is shared by physics and geometry. Actually the Archimedean line –the shortest among the lines that have the same extremes– and the Euclidean one –a line that lies equally between its points (a curve that coincides with every tangent)– were already defined *ab-antiquo* in 'energetic' terms, like the circle of Aristotle, intended as the form of perfect motion.
From the Burning mirrors of Archimedes to the development of mechanical and optical curves in the 17th century, up to the study of the patterns of electromagnetic fields in the 19th century, physics and geometry reflect a figurative conception of the science of extension.
Due to the imaginal nature of geometry there is not a single formalised way to categorize and figure out an entity or a geometric figure. The conceptualized and formalised 'eidetic categories' rarely have a hierarchical network. The

Fig. 7. Sequence of limbs and cranial vault of vertrebrates by Leroi-Gourhan [Leroi-Gourhan1986] and application of diffeomorphisms to statistical analysis of skull shapes and profiles.



fact that what we know about things is tied to what we know about other things also applies to geometry, although it is conceived as a self-referential, symbolic and axiomatic language.
Actually, we can paraphrase correctly, for example, the definition of 'sphere': locus of points equidistant from a given point. In terms of 'distance ratios' it can be regarded as:
1) locus of points whose ratio of their distances from two given points is constant (the above-mentioned sphere of Apollonius);
2) locus of the points *P* whose 'distance' *PX* from a given segment *AB* is always and only the square root of $AX \cdot (AB - AX)$;
3) two-axis ellipsoid with coincident focuses.
Recalling the right angle –or the isoptic curves– the sphere can be regarded as:
4) the locus of the vertices of all the right-angled triangles having the same hypotenuse *AB*; or, the set of the vertices of the right angles whose sides pass through two given points *A* and *B*; or the set of the points from which a given segment *AB* is always seen under a right angle.
From a differential point of view the sphere is:
5) the only surface of constant positive curvature;
6) the only surface with Geodesic curves all closed and congruent with one another;
7) the only surface (in addition to the plane) made up only of umbilical points.
Conversely, from the opposite 'integral' point of view, the sphere can be intended as:
8) the regular polyhedron with an infinite number of infinitesimal faces;
9) the envelope of the possible polygons whose apothems have the same extension and reach out to the same point;
Then there are many variants of the kinematic genesis of the sphere: surface of revolution of a circle around its diameter; for example:
10) surface 'of revolution' in infinite ways, in every point;
11) the only surface that a plane always intersects into circles;
12) the simplest surface with a constant width, whose parallel tangents are always equidistant.
Eventually, the sphere could be effectively intended as a soap bubble, according to the physical principle of the stress minimisation, namely as
13) the littlest surface that covers a given volume.
These definitions –which somehow recall Queneau's *Exercises in Style*– shape different concepts of the sphere. A bubble blown into a perfectly elastic membrane (def. 13) is very different from a ball produced with a lathe (def. 4 and 10) or shaped (def. 5, 10 and 12), or woven with interlocked rings (def. 6 and 11), or by stacking homothetic disks whose radius varies in consistency with the cosine of the spherical radius (paraphrase of def. 2.)
In order to mutually and geometrically reproduce these conceptualised images, it is necessary to apply the energetic notion of 'distance'. This notion is 'primitive' in three senses: logical, historical and psychological. It is logically preliminary to others and is older. It goes back to times when no distinction was made between physics and geometry, when the 'distance' ratios corresponded to the 'force' ratio and the simplest figures –straight line and plane, circle and sphere– were just the least probable elements among the 'disputed' spaces between opposite forces.
On the one hand, the notion of 'distance' recalls the sense of ancient arithmetic operations between segments traced with a ruler and compass. On the other hand, it refers to the phenomenal and cultural properties of the physical objects. In this sense, it deals with a 'figurative conception' which has always been intrinsic in the history of geometry, emerging especially in the psychological genesis of the axioms [Enriques 1906, pp. 174-201.] The idea that geometry is basically a figurative science –and not abstract– has been shared by the science of extension 'realist' school up to a project of a Semiophysics [Thom 1988.]

Conclusion: geometries and categorisation of the objects

The above-mentioned figurative conception of geometry leads her back to the field of the natural philosophy and the techniques [Thompson 1945.] It also helps better grasp the historical continuity and discontinuity of geometry for the Design in the shift between the DG and the CG. From this point of view, the DG and CG are episodes which both stand out along the composite genealogies of two important chapters of natural philosophy:
1) the 'Science of Form' which flourished especially in naturalistic morphology, from ancient comparative anatomy to the morphogenetic theories of the 19th and 20th century;
2) the 'Science of Vision', from the Euclidean optics to the Renaissance *perspectiva artificialis*, from the psychology of perception of the 19th-20th century up to the current computer and robotic vision.

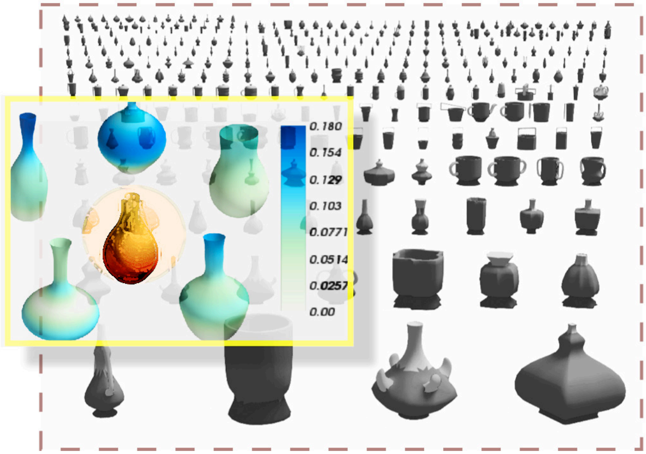


Fig. 8. Statistical shape analysis of the Karcher mean of vase shaped objects; The mean shape is displayed in the centre [Bauer, Bruveris, Michor 2014.]

The 'Science of Form' and the 'Science of Vision' are very different from each other, but they have often acted as the 'objective' and 'subjective' sides of analogous 'morphological questions'. They both share some problems and methods, some geometric and mathematical instruments that, after the third industrial revolution, were confronted with a quantum shift towards the techno-sciences and the current digital dimension of the world.
1) Obviously, from the second half of the 19th century, morphometric and statistical comparative methods were applied to the natural sciences. They helped develop typologies taken from comprehensive *corpora* of *exempla* –mainly consisting of samples, calques or graphical representations– categorised and parametrically arranged by degree of typicality. Starting from these corpora, each naturalistic typology has always been based on the correlation of analogous characters of homologous samples of different bodies. Therefore, every typology presupposes a measurable taxonomy, i.e. a paradigm shared by a comparative specimens, and a mathematical criterion for the measurement of their differences. From a technical point of view, the geometric, metric and differential properties –'distance' and continuity of curvatures in one point– are compared. These geometric transformations are called 'diffeomorphisms' – somewhere between differential geometry and topology – and were predicted in the famous *On Growth and Form* by D'Arcy Thompson [1945]. In his works the English naturalist [Thompson 1945, pp. 1026-1090] introduces the use of diagrams called 'transformation graphs': (fig. 7) graphs that describe the morphological variability of the bodies in terms of the 'deformation' of a reference grid made up of homologous lines in organisms and parts of different organisms represented at the same metric scale. Obviously, the 'transformation diagrams' can be performed only if there is a paradigm shared by the comparative bodies. In fact, they depend on the choice of the pairs of places (ontogenetically) homologous in different organisms. Therefore, this transformation network should have identified the closest parameter system to the 'real form line growth' (ontogenetic lines) as well as to those organism parts featuring (phylogenetic) speciation differences.
D'Arcy Thompson's 'science of form' –in the revolution towards the current digital world and techno-sciences– has turned in comparative Biometrics and morphometrics which –since the Sixties– have been accompanying the amazing development of morphogenetic models in the field of theoretical chemistry, physics and, above all, theoretical biology.
2) The geometric models which explain the emergence of forms from matter are extended also to neurosciences. Today, the *Neurogeometry* [Petitot 2008] studies the functional geometry of the perception system, with special reference to the low-level visual perception processes. It focuses on the translation of visual information from a 2D proximal (retinal) stimulus to the perceived form processed by the first visual cortex (V1). Obviously, these studies fall within the broader framework of the geometric models used in the study of the different stages of the visual perception process:
a) the extraction of the first morphological structures from the retinal image (positions, dimensions, directions, colours, contrasts, distances, motions),
b) the emergence of visual forms,
c) the extent of the articulation of surfaces in the environment,
d) the identification of regions and objects as 'things' of the actual environment,
e) the attribution of the size and position of things,
f) the perceptive segmentation of the 'things' into their 'parts',
g) the recognition of the objects,

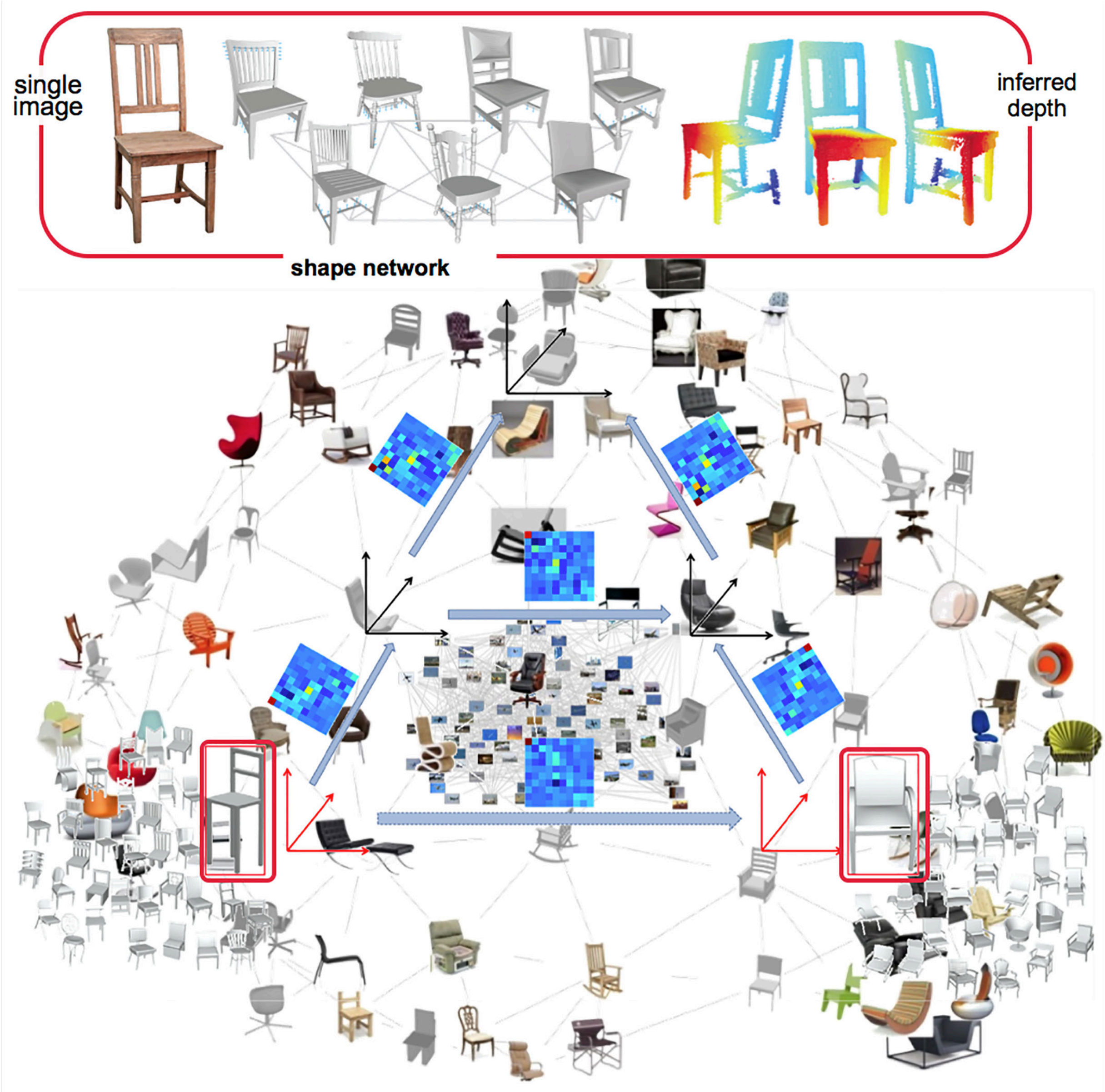


Fig. 9. Automatic recognition and categorization of an object through the inference of depth of a single image and the extraction of features from image repertoires [Yi et al. 2017].

h) the attribution of (functional and cultural) categories to the perceived objects and situations.
For example, with reference to the 'e' stage, vision is similar to a 'photogrammetric' and 'stereoscopic' restitution of the seen scene according to the so-called "inverse (representation) problem" developed by the DG.
As regards the 'c' stage, a differential geometry is used which describes the luministic behaviour of the surfaces [Palmer 1999, pp. 243-246.] The perceptual computation of the curvatures is supposed to depend on the isophote lines, intended as an variation index point by point of the normals to the surface.
Differential geometry is applied also to the 'f' stage. For example, based on the tendency [Hoffman 1998] to attribute 'names' only to the convex parts of the objects, all the perception curvature indices of a surface are decisive [Koenderink 1972.]
The search for geometric models able to explain the perceptive extraction of the most significant characteristics of the objects also involves the study of higher cognitive processes ('h' stage), although a perceptive categorisation already takes place in the early perception stages. According to the main assumption, vision is guided by categorisation through computational economics strategies, as happens with the perceptive organization criteria already theorised by the *Gestaltpsychologie* which identify psychology and geometry of the image-form (*Gestalt*).
The shift of the computational paradigm included both geometry and the psychology of perception [Marr 2010.] In fact, in the same years, they are fully incorporated in the neural networks theory developed by Minsky and Papert [1990.]
The history of this convergence is long and well known. But what does the geometry developed within the *design studies* have to do with the convergent genealogy in the computational model of the various 'morphologies' arising from natural sciences?
The first answer is historical. Since the second half of the 19th century, the morphological measurement of phylogenetics had involved also anthropology, then regarded as 'the natural history of men.' The comparative geometry of *naturalia* led to the *artificialia* ones, i.e. the diffeomorphism measurement method was also extended to the study of the historical and archaeological species of human artefacts, appropriately divided into model corpora and typologies. (fig. 8) Since then, methods similar to statistical biometrics have been applied to analytical archaeology [Clarke, Pinnock 1998] and today they have reached their fully accomplishment by working (on line) on digital model corpora deriving from the 3D scan of huge collections of findings.
The GC has significantly expanded the technical possibilities of the morphology of the findings and of the collections. In the era of big data, the CG allows for the extraction of geometries starting from various types of data –from physical bodies, measurements, image web collections [ex. Heath et al. 2010] and network models, … (fig. 9)– thus performing semiotic elaborations well beyond the human possibilities [Stiegler 2016.]. The algorithms of the GC exceed even the possibilities of human imagination, but not of their traceable history, where the technical and aesthetic genealogy cannot be separated.
As 'morphology' (science of form), Geometry is part of the aesthetic knowledge invested in the construction of objects; especially, the 'History of DG', the 'genealogy of the methods of projective representation' and the 'morphology of curves, surfaces and patterns' are relevant points of view in the study of the evolution of (artistic and technical) 'visual artefacts'; therefore these topics must refer to the thematic area of 'geometry in drawing for design': a field that, from a historical point of view, stands out against the background of the millennial mutual exchange between 'science of form' and 'science of perception'.
This thesis offers a unified –retrospective and prospective– vision of the historical events related to the 'Geometry for Design'. This is the thesis that we have shown, starting from the replacement –half a century ago– of DG with CG and indicating their continuity and discontinuity.
In retrospect, we have highlighted the discontinuity between the mechanical-projective paradigm and the computational-informational one, superimposed on the deep continuity of a geometry intended as a natural science: a kind of knowledge that is always negotiated between 'morphology' and 'theories of perception'.
In prospect, we have proved the thesis by recognizing that today's applications of CG are articulated following –step by step– the chapters of the psychology (and semiotics) of vision: from the elaboration of the proximal stimulus to the processes of perceptual, cognitive and cultural categorization.

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The Points of Concurrence Theory in Guidobaldo del Monte's Scenography

Leonardo Baglioni, Marta Salvatore

Abstract

Theatrical scenography was one of the privileged applications of perspective in the Renaissance. The court theater, characteristic of those years, is structured around a frontal perspective installation developed in depth. This particular perspective application makes the scenography a privileged place for experimenting the projective transformations at the origins of the relief perspective in which the real space contracts and transforms itself into the illusory space of the scene. This study regards the De scenis*, the sixth book of* Perspectivae libri sex*, written by Guidobaldo del Monte in 1600, entirely devoted to theatrical scenography. The treatise elaborates a scientific method of universal validity to construct scenes, based on the theory of the points of concurrence explained in the first book of this work, a theory that deeply influenced the history of perspective and descriptive geometry. In Guidobaldo's work, the problem of controlling the projective transformations of space is resolved by reducing the relief perspective to a set of flat perspectives in relation to each other and controlled through the theory of points of concurrence. Applied to the art of scenography, this theory reveals itself in all its generality, since it allows the representation of classes of lines generically oriented in space and, at the same time, resolves the problem of measuring angles and lengths with projective reasoning.*

Keywords: Perspective, Scenography, Guidobaldo del Monte, Relief perspective, Points of concurrence.

Introduction

During the sixteenth century scenography was one of the privileged applications of perspective. The theories of linear perspective, which had involved mathematicians and humanists in the late fifteenth century, became, during the Renaissance, the main form of representation of reality. This theory manifests itself in every form of art and finds, in scenography, a particularly fertile ground, capable of giving an unprecedented aspect of centuries-old art [Mancini 1966, p. 9].
In fact, court theater is structured around a frontal perspective installation where mainly urban models are represented, in relation to the work to be staged. Vasari recounts how this perspective model, first conceived flat, was extended to three-dimensional space thanks to the contributions of Baldassarre Peruzzi, who widened the depth of scenic space, [Mancini 1966, p. 25] introducing, as is defined today, relief perspective in scenography.
Thus, this art appears in the treatises of perspective, published in the sixteenth century, such as those of Serlio, Barbaro, Vignola-Danti and Sirigatti, where it is taught to contract the scenes from an operational point of view.
Guidobaldo's contribution is at the apex of the scenographic production for the court theater, written in years when mathematicians had begun to take an interest in perspective [1], at a time when so much in scenography had been experimented and so little theorized.
The *Perspectivae libri sex*, a monumental work written by Guidobaldo del Monte in 1600, is a fundamental text in the history of perspective since, as noted, it forms the

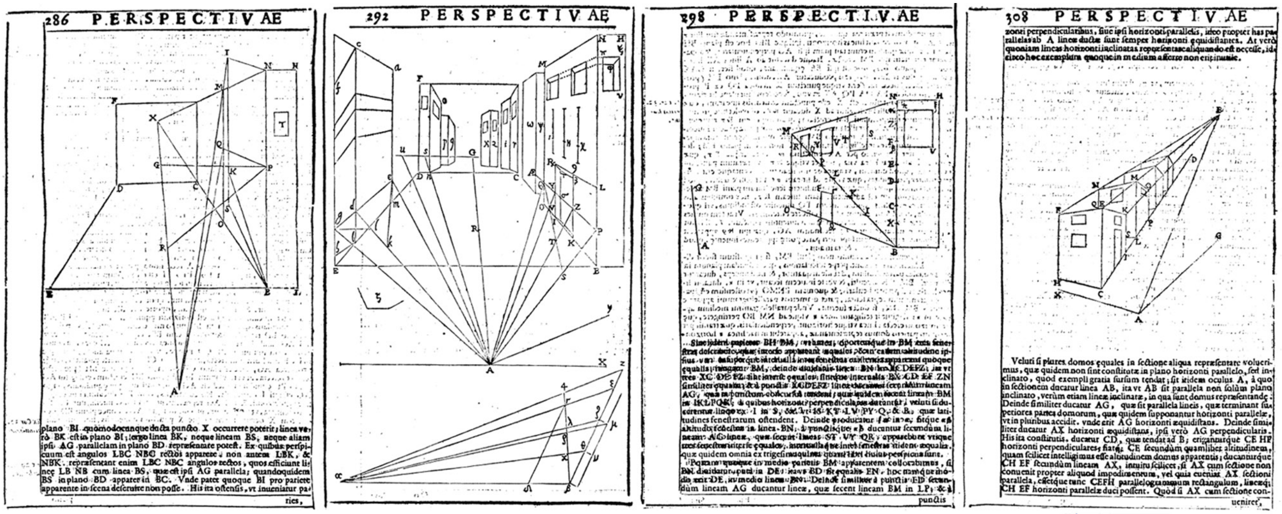


Fig. 1. Guidobaldo del Monte, Perspectivae Libri sex, illustrations of De scenis [Del Monte 1600].

projective foundations that will lead to the theorization of modern perspective. The sixth book, *De scenis*, is entirely devoted to theatrical scenography and focuses on the practical application of the theoretical principles explained in the previous volumes (fig. 1).
Guidobaldo's work was intended to bring the mathematical universe closer to pictorial practice, becoming an occasion for direct experimentation of apparently abstract theoretical principles. Scenography must be understood in this regard. In continuation of the perspective tradition of the Renaissance, scenography was considered a perspective laboratory in real scale in which to experiment procedures and validate results. Scenography is the place where projective transformations at the basis of relief perspective materialize, where real space contracts and transforms itself into the illusory space of the scene. The three-dimensionality of the constructions is also reflected in the images that illustrate the treatise, which describe the contraction of the scenic box in a sort of natural perspective that invites the reader to reason in three-dimensional space [Field 1997, p. 173].
Control of the projective transformations of the scene is resolved by Guidobaldo through repeated application of the theory of points of concurrence. This flawless reasoning allows the representation of entities in a generic position and is structured around two main moments:
- definition of the projective transformations of the scene;
- construction of perspective on the lateral wings.

Projective transformation of the scenic space

Construction of the scenic box was a direct consequence of stage floor declivity. In fact, to avoid this plane appearing particularly flat in the eyes of the observer, the stage undergoes a declivity of a few degrees, which is also useful for the actors allowing them to amplify the acting space. This change of position introduced into the stage space a perspective artifice. All the scenographic planes, namely the lateral wings, must be in relation to this artifice, giving the spectators the illusion of seeing a regular space or, at least, a plausible space with respect to those known in common visual experience [Baglioni, Salvatore 2017, pp. 1-12].
Consequently, Guidobaldo's treatise stems from the need to reduce the scenic space, demonstrated by *reductio ad absurdum* [2]. This reasoning considers the overall contraction of the scenic box a result of a set of projective transformations of all the planes that compose it, degraded one by one

through the application of the theory of points of concurrence. The desire to experiment the validity of this theory in perspective practice, animates our mathematician's interest in theatrical scenography. "Since the scenic apparatus seems to partially vindicate the analysis undertaken […], we will briefly mention a few things that also concern this topic; and we will illustrate in the following way […] that the procedure obtained, specific and universal in reproducing the Scenes, is a result of the principles that we have explained" [Del Monte 1600, p. 283; Sinisgalli 1984, p. 219].
Between the XXVIII and the XXXII propositions of the first book of this work, it is explained how to represent the perspective of a straight line oriented in a generic position in space, through construction of its points of concurrence, by means of a procedure still used today for the vanishing point construction of a given line (fig. 2). "The point on section, where a line is conducted from the eye equidistant to a set of other parallel lines, is a point of concurrence" [Del Monte 1600, p. 44; Sinisgalli 1984, p. 64].
Therefore, Guidobaldo considers the edges of the wings that define the scenic space one by one; he imagines that they are perpendicular to the front of the scene, as in reality, and projects them to the lateral wings, each intended as picture planes. Then, he obtains the point of concurrence of these straight lines, constructed by the intersection of the 'visual ray' with the respective picture planes, *sections* in the treatise, namely the planes of the wings. Since these edges are parallel to each other, the respective perspective images will share the same point of concurrence and because they will have to appear perpendicular to the front of the scene, this point will be given by the intersection of the perpendicular straight line to the front itself, with the planes of the wings, opportunely imagined, extended.
The final result is the relief perspective of a parallelepiped space, contracted in a pyramidal trunk, in which the actors must move (fig. 3).
In the contraction of the scenic box the relation between scenography and relief perspective is revealed. However, the principles on which this form of representation is based, are still far from the treatises of the nineteenth century, which will give theoretical foundation to the perspective transformations in the projective space. Indeed, Guidobaldo reduces the relief perspective to a set of flat cases, resolved by the reiterated application of the points of concurrence theory. The solution is legitimate but resolves a very special case, in which the object of the projective transformations is a portion of the space, namely, a container delimited by a series of flat surfaces that establish its boundaries. Thus, the relief perspective concerns the scenic box, affecting the architecture only with respect to the construction of the facade of the buildings and their moldings [3].
The definition of the point of concurrence of the lines perpendicular to the picture plane is exemplary in terms of theory and therefore legitimates the procedure in use. However, its construction is not easily applicable in the operational practice; this point was generally inaccessible due to the reduced court size. This obstacle is the starting point for the experimentation of refined projective procedures with an aim toward resolving the problem. In the treatise, this is preceded by a significant description of the operational practices for construction of the perspective intersections in use at that time.
All methods described in the text, both those practiced by Guidobaldo and others, operate on a plane, defined today as 'projecting plane', determined by the visual ray (projecting line) and by a chosen point on a lateral wing, through which the perspective will have to pass. The materialization of the visual ray, by means of a taut rope between the observer and the backdrop plane is common to all the described methods. Therefore, Guidobaldo describes how it was customary to construct the perspective of a straight line, *PQ* in figure, pass-

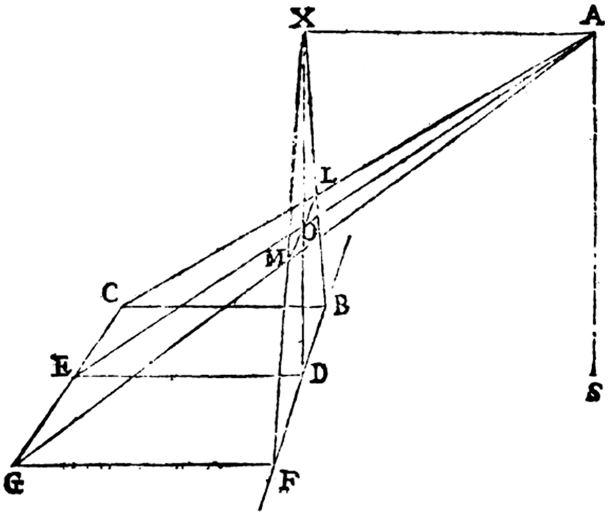


Fig. 2. Guidobaldo del Monte, Theorema propositio XXIX. One of the images that describes the theorization of the point of concurrence [Del Monte 1600].

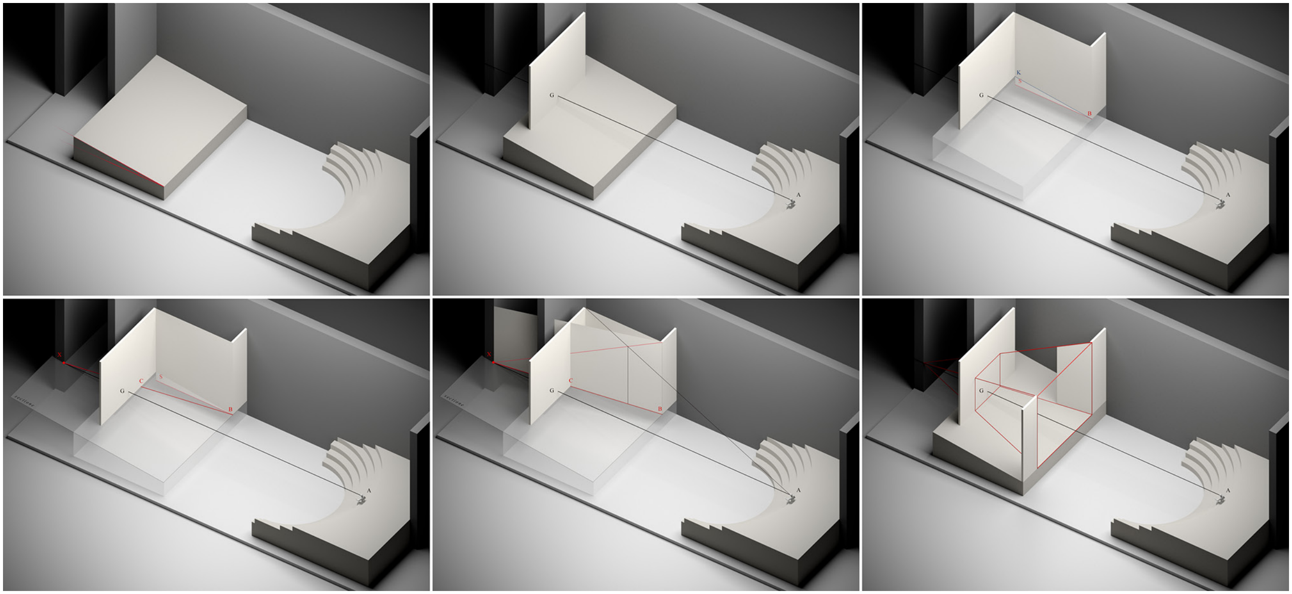


Fig. 3. Phases of projective transformations of the scenic space (graphic elaboration by the authors).

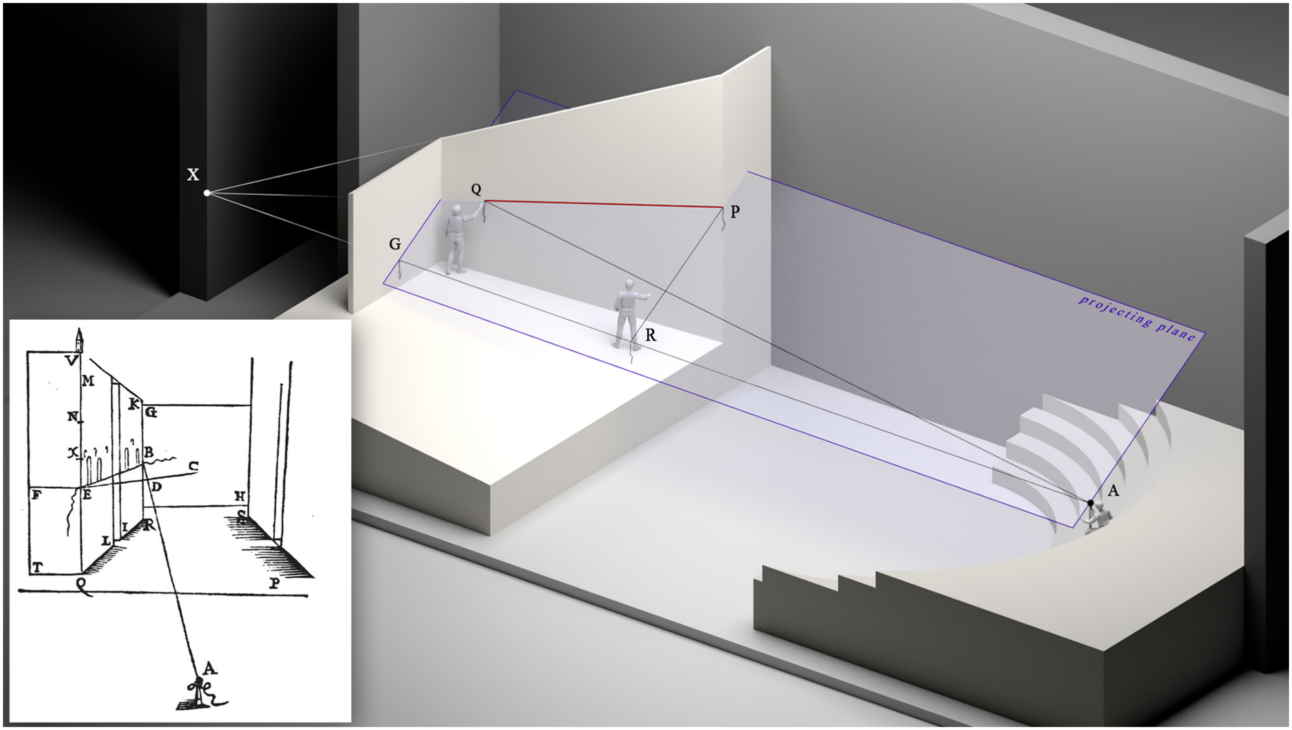
ing through an assigned point *P* on a lateral wing, with a series of taut ropes. Given the visual ray *AG*, a second taut rope was placed between point *P* and point *R*, chosen in a generic position on *AG* [4]. With a third rope, fixed this time in the eye *A* position, it was possible to project one of the infinite points of the straight line *PR* on the lateral wing, which is the picture plane in this construction, determining point *Q*, useful to construct the sought after perspective *PQ* (fig. 4). This procedure, similar to that described in the *Commentarii* by Egnazio Danti on *Due Regole della prospettiva pratica* di Vignola [Vignola Danti 1583, pp. 90-92], presupposes that the projective operations are performed on the projecting plane, because the perspective images of all lines that belong to this plane appear in its intersection with the picture plane. It was possible to reproduce this projective procedure with ropes and cords, or with light sources, generally mentioned in the form of candles in this and other perspective treatises of the time. These light sources represented the sought after perspective traces through the projected shadows of the taut ropes. If the problem with the use of the ropes consisted of their flexibility over long distances, the problem with the use of the torches was due to their feeble illumination capacity; in fact, at the same distances, they would hardly have been able to project a clear shadow.

Combining theoretical synthesis and procedural agility, the method proposed by Guidobaldo resolved this problem because it liberated the projective operations from the observer position, projecting straight lines that lie on the same projecting plane from any point of this plane, with the use of only one rope: the visual *AG* ray.

Having to represent the perspective *PQ* of a straight line that is perpendicular to the picture plane, as in the previous case, Guidobaldo imagines an observer, whom we define as an auxiliary, who is free to move in half of the scene. The visual *AG* ray and a *P* point on the wing are given. The auxiliary observer will have to move on the scene, observing the *AG* line and *P* point together, and going up or down until the two entities merge into a single image. If the perspective images overlap, the eyes of the auxiliary observer are placed on the projecting plane belonging to *P* and *AG*. It follows that the *PQ* perspective will be confused with the image seen by the auxiliary observer who, in that position, can easily recognize one of the infinite points of the perspective *PQ*,

so determined [5] (fig. 5). The construction could have been executed by replacing the auxiliary observer with a light source free to move on the projecting plane. Thus, this light could have been positioned with respect to the line to be projected and to the picture plane at convenient distances to ensure the projection of a sufficiently sharp shadow.
Once the method has been explained and the procedure illustrated, the problem is presented in marked operational terms. "In order not to make a serious error" [Del Monte 1600, pp. 289; Sinisgalli 1984, p. 222], the borders that delimit the stage floor and establish the entire contraction of the scenic box must be constructed before the others. Therefore, once the declivity is fixed, the design of the stage could be resolved using two different procedures, derived by two different constraint conditions. The first establishes the height of the observer, consequently obtaining the foreshortening of perspective; the second, on the contrary, fixes the foreshortening of perspective, given by the shape of the trapezium of the stage, thus obtaining the height of the observer.
The first procedure follows the construction previously described in the case of the perspective *PQ* of a straight line although, in this case, point *P* belongs to the stage plane. Using this procedure, it was impossible to plan the width of the stage *a priori*. It was only possible to foresee that the greater height of the observer would have caused greater width, due to the increase in the distance between the point of concurrence and the observer, and vice versa.
However, the control of the dimensions and the proportions of the scenic space was a priority parameter in the design of the stage space. Thus, Guidobaldo proposes a second procedure, which primarily establishes the dimension and the proportions of the trapezoid of the stage, i.e.

Fig. 4. Method used for the construction of perspective traces (graphic elaboration by the authors) and comparison with Egnatio Danti's method [Barozzi da Vignola 1583].



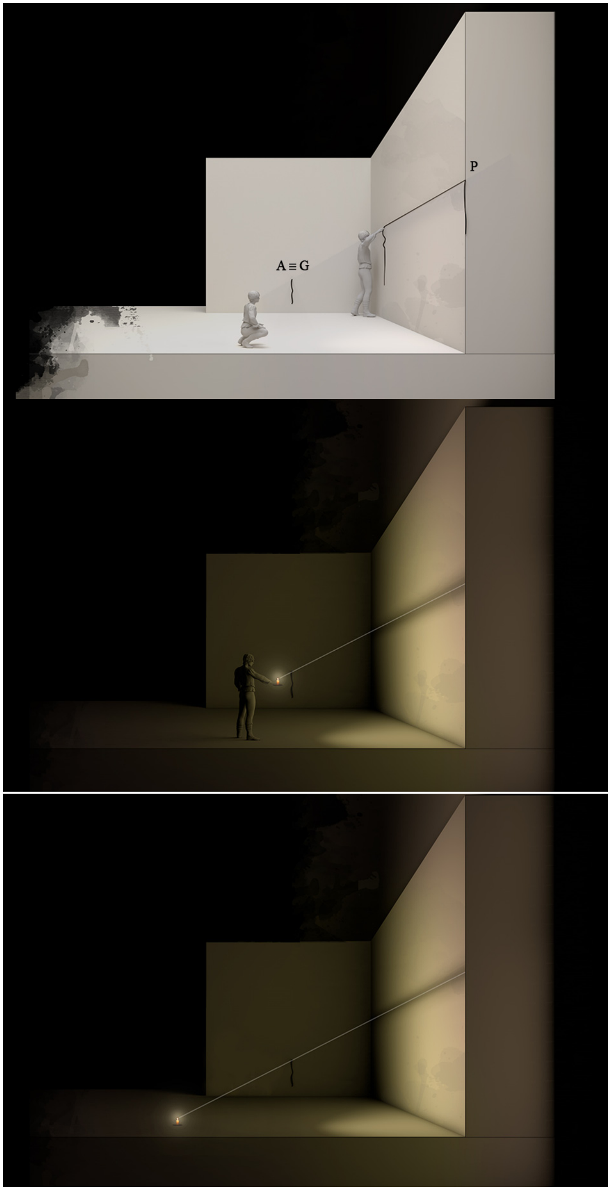


Fig. 5. Guidobaldo del Monte's projective method executed by the view and by the source of light (graphic elaboration by the authors).

the foreshortening of perspective. Although the operational relevance of this procedure is highlighted in the treatise, the passage is synthetic and cryptic, in fact it is not explained, contrary to what happens for the other constructions.
Once the trapezoid of the stage is traced: "the *AG* must be moved up or down, providing that it always occupies the center of the scene (as has been said) and that it is located equidistant from the horizon, until, once on the side of *ED*, we look at the *BD* line through the *AG* line, and the *AG* e *BC* lines appear in a single line [...]; and once the *AG* line is found, the *AG* must then be immobilized; and in this way the *A* eye position will be determined" [Del Monte 1600, p. 291; Sinisgalli 1984, pp. 222, 223].
In this type of construction there are two variables, the height of the auxiliary observer and that of the *AG* rope which we conveniently imagine this time as a rigid shaft. The simultaneous movement of the shaft and the observer cause the evident operational difficulties in the procedure, antithetical to the spirit with which Guidobaldo addresses the question.
It is possible to hypothesize the separation of the movements and order them according to a logical sequence that simplifies the problem (fig. 6).
We can imagine the AG shaft fixed in a point on the backdrop plane, placed at an arbitrary height from the stage floor. The auxiliary observer is free to move up and down anywhere on the stage and observe, with a single gaze, the *AG* shaft and the inclined *BC* edge, placed on the ground on a wing. Once a position is chosen, there is only one observer height in which the *AG* shaft and the *BC* edge appear parallel. When this height is established it is possible to vertically move the *AG* shaft until its image coincides with that of the *BC* edge and, consequently, find the height of the projection center. The proof is not given in the treatise, but it is possible to imagine that Guidobaldo reasoned again in perspective terms to resolve this particular geometric problem. In fact, the *BC* edge and the *AG* shaft are two skew lines. It is always possible to observe a pair of skew lines from a position that makes them appear parallel, a condition experimentally verifiable by turning one's gaze around a pair of wooden sticks.

Construction of perspectives in the scenic space

Once established the contraction of the stage box, Guidobaldo continues his dissertation with the construction of linear perspectives on side wings. This phase is particularly significant because it clarifies again –and in an even more

incisive way– the field of experimental application of the theoretical statements of the work, once again giving rise to the methodical and repeated application of the theory of points of concurrence.
Each wing of the scene, including the scenic stage with its declivity, constitutes a portion of a picture plane to be imagined infinitely extended, on which to draw the perspective of the illusory space that one intends to represent: "given that scene conformation is usually expressed through numerous objects reproduced in various sections appearing in front of one's eyes" [Del Monte 1600, p. 283; Sinisgalli 1984, p. 219].
Thus, the overall illusion of the setting of the scene was entrusted to the representation of perspectives painted on the wings, picture planes that delimit the contracted scenic box, all seen from the same projection center. These two-dimensional painted backdrops were able to be installed directly in the theater or to be used as a support for the construction of three-dimensional wooden units, such as those made by Vincenzo Scamozzi for the Teatro Olimpico in Vicenza.
In this perspective system, the observer recognizes the illusion by gathering together the multiplicity of the picture planes, as is done by observing the architectural perspectives painted in fresco on the walls of a single hall, on which perspective images that allude to the same illusory space are represented.
Then, Guidobaldo must resolve the problem of representing straight lines having a generic position in space on different picture planes so that the set of perspectives turns out to be coherent. The solution lies in the universal nature of the theory of points of concurrence, thanks to which it is possible to construct scientifically, that is, with a repetitive procedure, sets of straight lines in any direction and in whatever position. The treatise accompanies the reader through increasing levels of complexity that lead to the maximum generalization of the method. The classes of lines in question can be summarized in the following order:
- straight lines perpendicular to the front of the scene;
- horizontal lines parallel to the front of the scene;
- horizontal lines but oblique with respect to the front of the scene;
- straight lines in a generic position.
The first class to be examined concerns those that must appear perpendicular to the front of the scene. In the role of a Renaissance scenographer focused on representing, on a lateral wing, a regular building with openings on the facades, Guidobaldo observes that the perspectives of straight lines with this direction, such as window sills, converge towards the

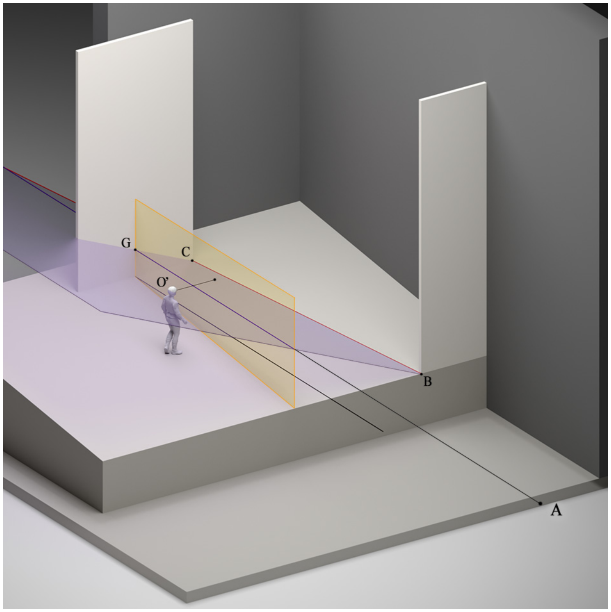


Fig. 6. Reconstructive hypothesis of the design process of the scene starting from a pair of skew lines (graphic elaboration by the authors).

point of concurrence already determined in the phase of contraction of the scenic box.
The problem is then the depth measurement of these lines by proposing two distinct procedures. The first, operative, performed directly in place to divide the lengths into proportional intervals; the second, graphical, which instead permitted the measurement of the line's lengths, represented on paper through the ichnography of the scene.
The first procedure leads to obtaining an opening placed at the center of the wall that appears perpendicular to the front of the scene, which is used to construct the *P'Q'* perspective of a horizontal *PQ* edge (fig. 7). From the *Q'* point, a straight line parallel to *PQ* was traced. This line is the edge of the actual building ideally positioned beyond the wing, which meets the visual *PA* ray in point *S*. Two points, *T* and *V*, were thus detached on the *Q'S* segment in such a way that the *ST* and *VQ'* the segments were the same length, representing a centrally arranged opening with respect to the facade. Finally, by means of the visual *AV* and *AT* rays, door width was estimated in proportional terms and reported on the *P'Q'* segment.

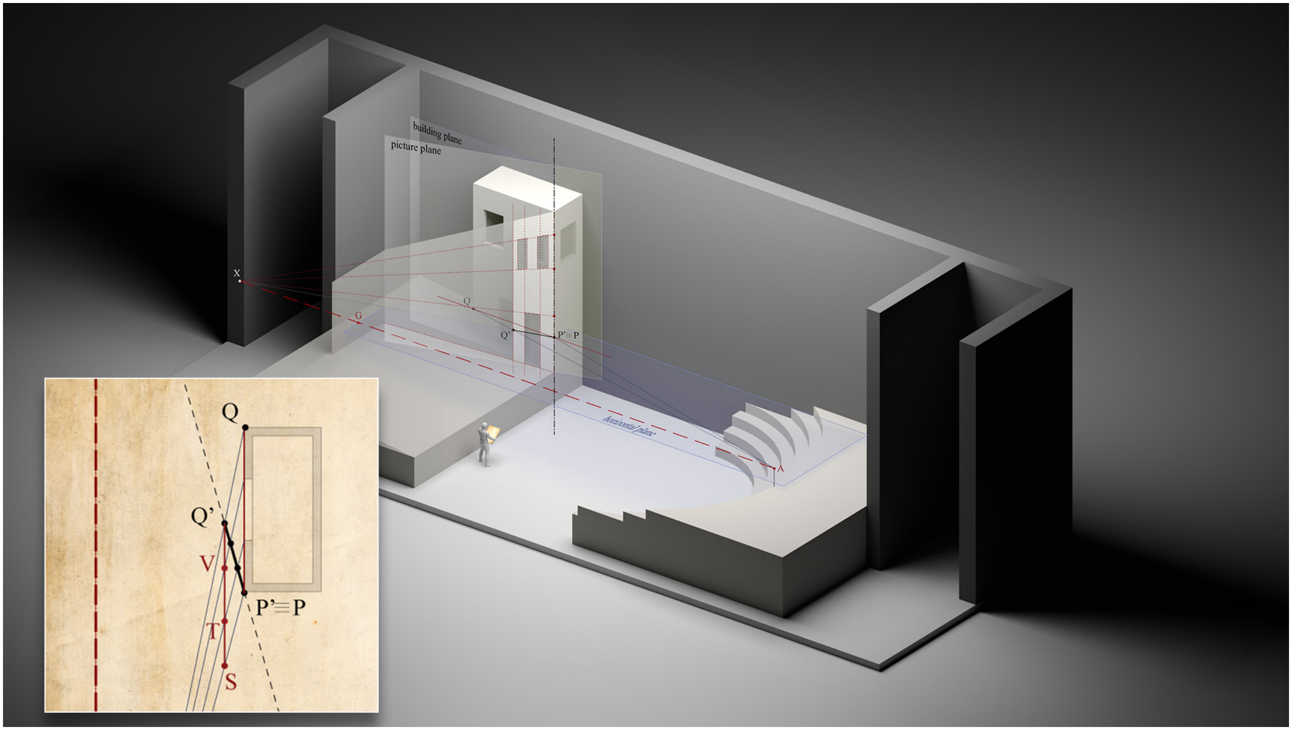
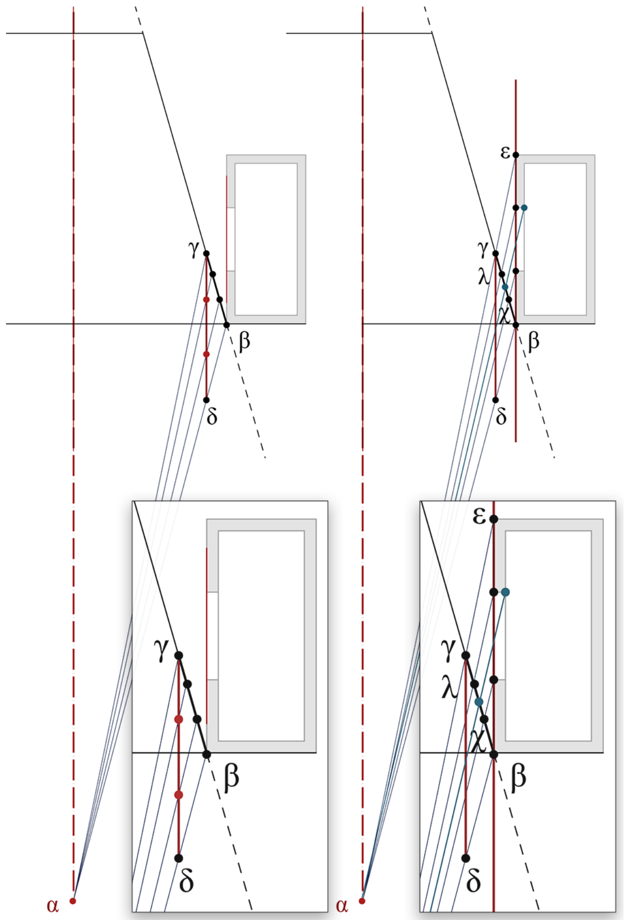


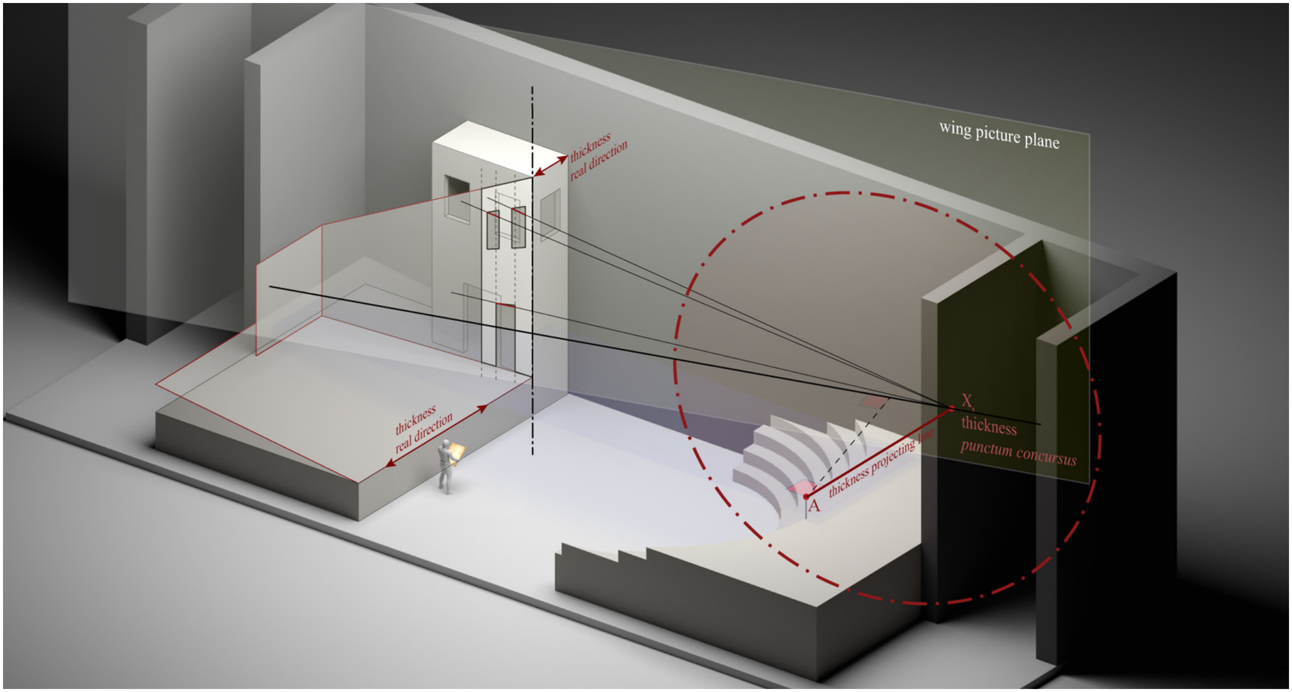
Fig. 7. Method of proportional division of lengths on lateral wings (graphic elaboration by the authors).

On the other hand, if a metric check were to be done in the subdivision of the same segment, the second method would be used. In Guidobaldo's time, perspective procedures based on the use of distance points had already dealt in perspective treatises [6]. However, the proposed method once again follows the logic of a purely projective nature operating directly in the scenographic space, appropriately reduced in scale on paper without resorting to the use of distance points (fig. 8). Thus, Guidobaldo projects the intervals on paper where, unlike the previous procedure, he obtains the measure in the true shape of the real edge. Then, dividing this edge according to measured lengths, the latter were projected onto the picture plane through the visual rays.
Once the representation of the straight lines perpendicular to the picture plane has been resolved and the position of the vertical edges of the buildings have been defined, the problem is complicated by the construction of a second class of straight lines: those horizontal and parallel to the front of the scene, whose perspective lies on the lateral wings. In particular, this is the representation of the wall thickness of doors and windows. This passage is especially significant in that it highlights Guidobaldo's *modus operandi*, which experiments the potential of the points of concurrence theory with surprising ease.
Consider the plan of the side wing on which we want to represent the thickness of the openings. The problem is resolved again with the determination of the point of concurrence of this class of straight lines, given by the intersection of the straight line projecting the real straight line, parallel to the front of the scene, with the *producto scilicet* picture plane (fig. 9). In this particular case, the linear perspective that is defined in the plane of the side wing, is generally characterized by a reduced principal distance; it follows that the

entities represented are arranged outside the circle of distance, giving rise to an anamorphic perspective that finds its correct vision only if it is brought back to the condition of restricted view (fig. 10). With this procedure, the construction of all the thicknesses of the walls of the scene is systematically resolved, by evaluating each time the direction of the real edge and the position of the picture plane.
The full control of the representation of straight lines perpendicular and parallel to the front of the scene allows Guidobaldo to increase the level of complexity, teaching us how to represent on a single wing two adjacent faces of the same building: one parallel to the front of the scene, the other perpendicular. The described constructions, where possible, were carried out away from the scene, moving the wing in a position that allowed the materialization of the points of concurrence through the nails to which the taut ropes were fixed. In the event that the wing was irremovable, the proportional division procedures, known at that time, were used to resolve the problem of inaccessible vanishing points [7]. Once the quadrilateral that defined the perspective image of a rectangle was determined, the opposite sides were divided into equal parts. The straight lines passing through the corresponding points of the partitions would therefore share the same point of concurrence.
The plane of the backdrop parallel to the front of the scene, is also a *section* on which to continue the graphic construction of buildings in line with those represented up to now. This representation is an opportunity to generalize the proposed method as it introduces the problem of the perspective of horizontal and oblique lines with respect to the picture plane (fig. 11).
The problem is resolved, as usual, with the construction of the points of concurrence. Guidobaldo represents rotated buildings of known angles with respect to the picture plane, resolving with surprising modernity the non-trivial problem of angular measurement in perspective. The reasoning always has a projective character. It resolves the question through the measurement in true form of the angle formed by the visual rays in the center of projection. The visual rays in question correspond to the pair of lines that form the given angle, of which the perspective is intended to be constructed. It is possible, with this method, to draw horizontal lines that form an angle with the picture plane as n-sided polygons to be used as reference structures for the envelope of curved lines such as circumferences.
Finally, the highest level of generalization is reached with the representation of inclined straight lines in a generic position, such as those of maximum declivity of a plane on which a building can be imagined placed. The reasoning is always the same and it is indispensable for the resolution of the problem in a condition of maximum obliquity, showing, in practice, the absolute generality of the points of concurrence theory: "Thus, it is possible to see how useful and advantageous the real knowledge of the points of concurrence theory is for perspective, which will certainly guarantee maximum facility for painters" [Del Monte 1600, p. 309; Sinisgalli 1984, p. 232].

Fig. 8. Method of measuring the lengths of segments on lateral wings (graphic elaboration by the authors).





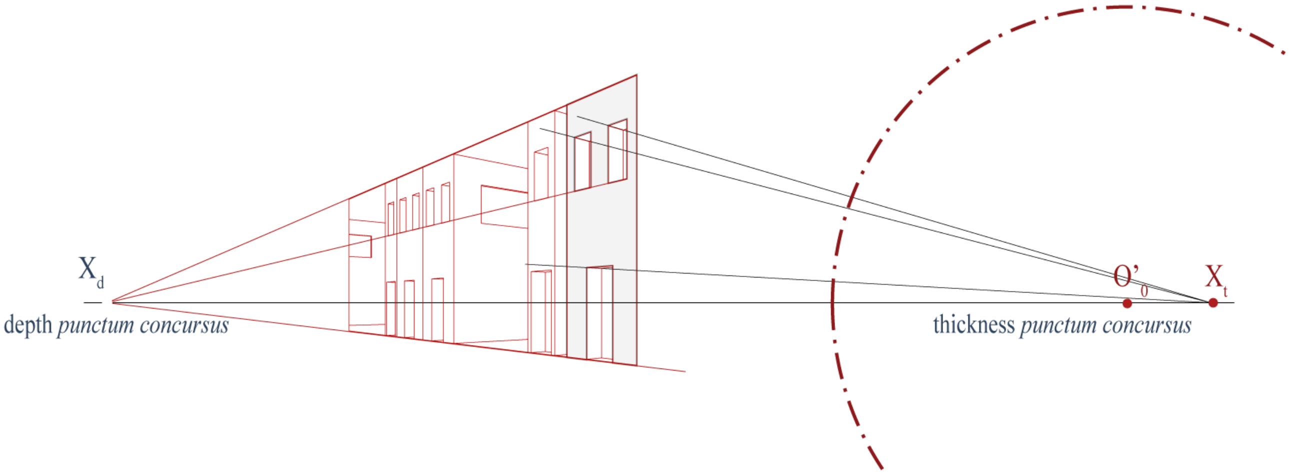
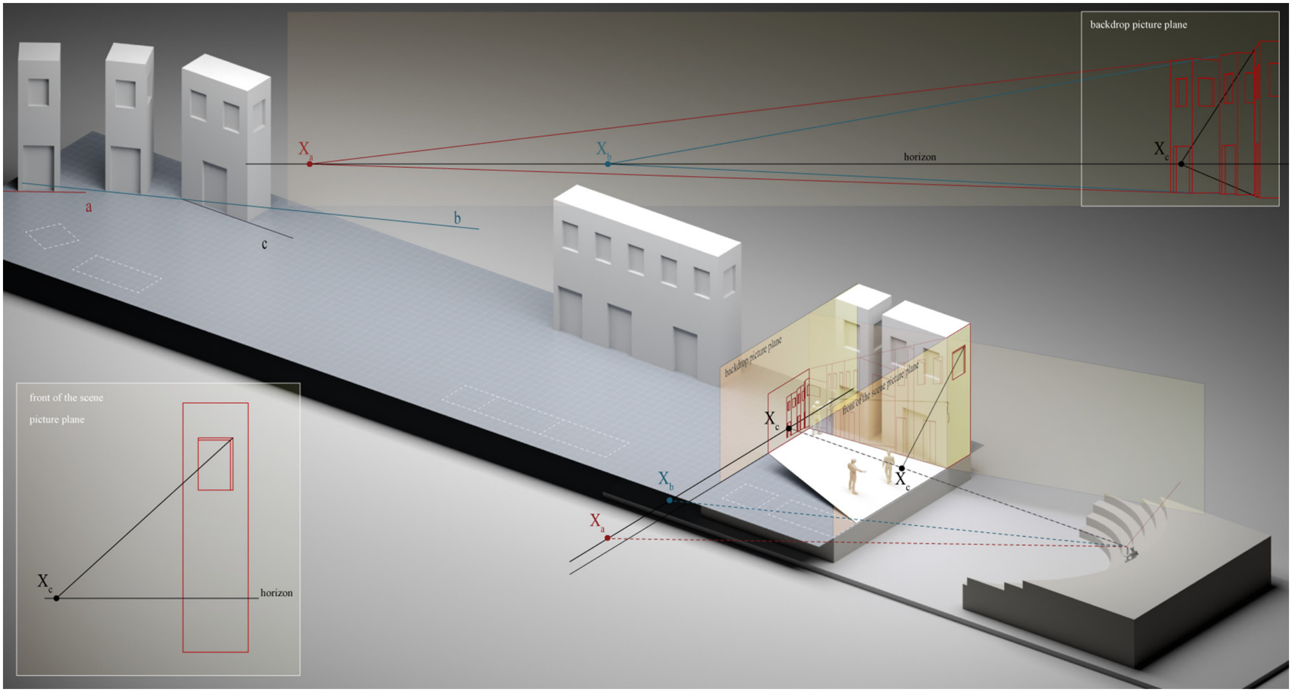


Fig. 9. Method of representation of horizontal lines parallel to the front of the scene with the theory of points of concurrence (graphic elaboration by the authors).
Fig. 10. Anamorphic perspective on the picture plane constituted by the lateral wing (graphic elaboration by the authors).

Conclusions

The points of concurrence theory, elaborated by Guidobaldo Del Monte, constitutes a focal point in the history of perspective. It shows, for the first time, how the perspective of a set of parallel lines is a family of intersecting straight lines, a circumstance which is established empirically, but which, until then, no one had ever even tried to demonstrate [Loria 1921, p. 16]. "Guidobaldo del Monte, using methods to represent three-dimensional figures on a plane reached such a high level, that very little remained to be added to reach the heights where they are today." [Loria 1950, p. 362].
In theatrical scenography, the points of concurrence theory reveals all its theoretical validity and its operative effectiveness, since it allows the representation of sets of straight lines however oriented in space and, at the same time, resolves, with projective reasoning, the problem of the measurement of angles and lengths. The protagonists of the constructions are the straight projecting lines, then called visible rays, to which, today, as then, the solution of every kind of perspective construction is entrusted.
Guidobaldo's scenography inaugurates, in the history of perspective, the treatment of the theoretical principles of a new applied science, or "relief perspective" [Loria 1921, p. 18], a form of immersive representation in which the projective procedures, which generally resolve linear perspective on paper, acquire physical form. In this artificially ephemeral place, between the real space and the projective space, all the operability of theoretical reasoning is revealed. This concretely reproduces, using ropes and candles physically present on stage or using sight only, refined projective reasoning through the reproduction of the visual rays, icon of the universality of the theories enunciated.
Guidobaldo is responsible for the development of a scientific method for practicing perspective, based on principles of projective character capable of conferring, through the strength of theory, the dignity of science to the scenographic practice at that time.

Fig. 11. Real space and projective space: set of perspective images painted on the wings of the scene (graphic elaboration by the authors).



Conceived to bring artists closer to the theoretical foundations of perspective, perhaps due to the difficulties of a Latin text or the excess of theoretical content that characterized it, *De scenis* did not immediately receive particular recognition from artists, as his theories were not very accessible to them [Andersen 2007, pp. 264].
Thus, the work by Guidobaldo, which was extraordinarily ambitious in scope with respect to the generalization of perspective theories up to that time, formed a solid foundation for subsequent advanced studies. This led, only a hundred years later, the English mathematician Brook Taylor to extend the concept of the point of concurrence, or vanishing point, to the wider definition of the vanishing line, refining theories that will bring perspective to appropriately reach the concept of infinity [Migliari 2012, pp.116, 117].

Notes

[1] Commandino and Benedetti gave significant contributions to the science of projections.

[2] The reasoning derives from the hypothesis that the scene has a parallelepiped shape and therefore the planes of the wings form ninety degree angles with the front of the scene. The declivity of the stage floor that must be perceived as horizontal by the observer causes the contraction of all the surfaces that delimit the scenic space, which otherwise would appear as an irregular prism [Del Monte 1600, pp. 283-289].

[3] In this regard, see the wooden scenes designed by Vincenzo Scamozzi for Andrea Palladio's Vicenza Olympic Theater in 1584.

[4] Point *R*, constructed in the text through the intersection between the line conducted from the *P* point perpendicular to the *AG* line, can assume a generic position along the *AG* rope.

[5] In the figure it has been hypothesized that in point *P* a second rope was fixed, which could easily be tautened according to the appropriate indications of the auxiliary observer.

[6] The use of the distance points recurs differently in *De Artificiali Perspectiva* by Jean Pelerin, in 1505, and in the *Commentarii* by Egnatio Danti in the *Due regole della prospettiva pratica di Jacomo Barozzi da Vignola*, published posthumously in 1583.

[7] Once some essential lengths were established, the partitions of the façades could be made using graphic constructions based on partitions in proportion to the sides of a quadrilateral with respect to its diagonal; methods of progressive division of the parts of a flat figure were in use in perspective of time, as demonstrated by some of the propositions of the first book of *De Prospectiva Pingendi* by Piero della Francesca (such as propositions IX, X, XI and XV).

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Theories and Methods for Development of Developable Ruled Surfaces and Approximate Flattening of Non-developable Surfaces

Mara Capone

Abstract

Geometric genesis of surfaces and knowledge of their properties are basis for solving many problems, both constructive and measurement. A developable surface can be manufactured starting from a flat "strip", using a flexible and non-deformable material. This is a very important feature of the surface. Geometry studies the properties that don't change and, therefore, the shape of the "strip" to obtain a certain configuration, after a series of rigid movements. The paper addresses different methods to define the development of developable surfaces and non-developable surface "flattening", or approximate development. The aim is to study the relationships between methods, illustrated in some treatises, and the applications that can derive from the use of parametric tools. We are going to create an overview of different approaches, that have defined the bases of differential calculus for the study of ruled surfaces properties, and of different methodologies that allow to determine their development. Starting from the first definition of surface by Aristotle in De Anima *(384-322 BC) and the ambiguous definitions by Amédée François Frézier (1682-1773), we analyzed the studies of Leonhard Euler (1707-1783) and Monge's main work on developable surfaces (1795).*

Keywords: Developable surfaces, Ruled surfaces, Double curvature surface, Parametric modeling.

Introduction

Geometric genesis of surfaces and knowledge of their properties is the basis for solving many problems, both constructive and measurement. A developable surface can be manufactured starting from a flat "strip", using a flexible and non-deformable material. Developability is a very important feature of a surface. Geometry studies the properties that don't change and, therefore, the shape of the "strip" to obtain a certain configuration, after a series of rigid movements, without stretching or tearing.

Theories

Differential classification of surfaces introduced by Leonhard Euler (1707-1783), and subsequently used by Monge, allows us to group surfaces according to the definition of curvature, which will be precisely defined by Carl Friedrich Gauss in 1902 [Gauss 1902, pp. 10-20], in four categories: surfaces with zero curvature, surfaces with positive curvature, surfaces with negative curvature, surfaces with variable curvature.
The curvature of a curve in P is k, where $k=1/r$ and r is the radius of the osculating circle of the curve, we can define as the main sections of a surface, the sections of the surface obtained with planes passing through the normal to the surface in P, with minimum and maximum curvature.

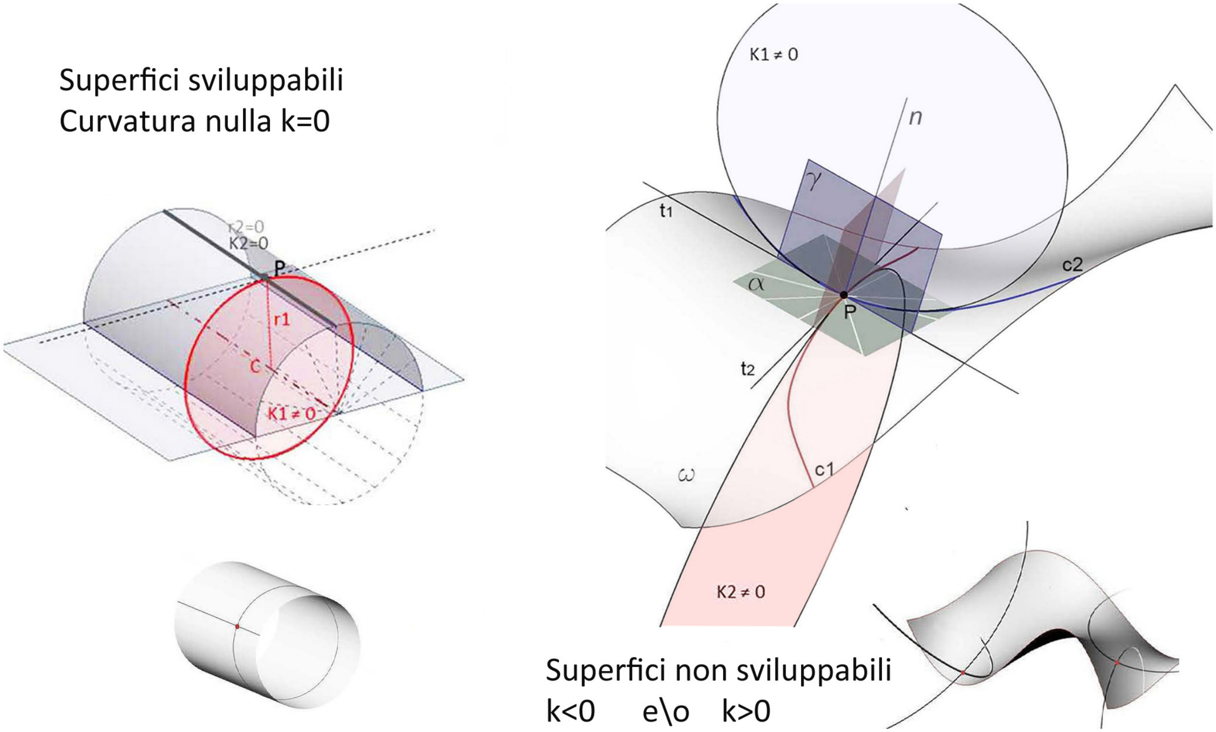


Fig. 1. Osculator circles and Gaussian curvature of a surface.

Leonhard Euler shows that the main sections of a surface belong to orthogonal planes.
Gaussian curvature is the product of the two main curvatures, so it can be positive, negative or equal to zero: it is positive when the osculating circles of the main sections are on the same side of the tangent plane, negative when they are on opposite sides, zero when one of the two main sections is a straight line.
The surfaces with zero curvature are some specific ruled surfaces, also called *developable* (fig. 1).
The Jean Pierre Nicholas Hachette's book is very important to study ruled surfaces. He classifies these surfaces into two categories: the developable surfaces, which are obviously ruled, and the ruled surface, which for the French scholar, are the non-developable ruled surfaces [Hachette 1828] [1].

On the other hand, Euler and Monge are the first to study systematically the ruled surfaces properties according to the principles of "differential geometry" [Snežana 2011, pp. 701-714]. Both propose a generalization of the question, even if they never explicitly refer to the concepts on which this classification is based, and never speak about an osculating circle or an osculating plane [2].
Euler explicitly poses the problem of surfaces development. In *De solidis quorum superficiem in planum explicare licet* he defines the geometric conditions of a surface so that it can be developed: "*Notissima est proprietas cylindri et coni, qua eorum superficiem in planum explicare licet atquea deo haec proprietas ad omnia corpora cylindrical et conica extenditur, quorum bases figuram habeant quamcunque; contra vero*

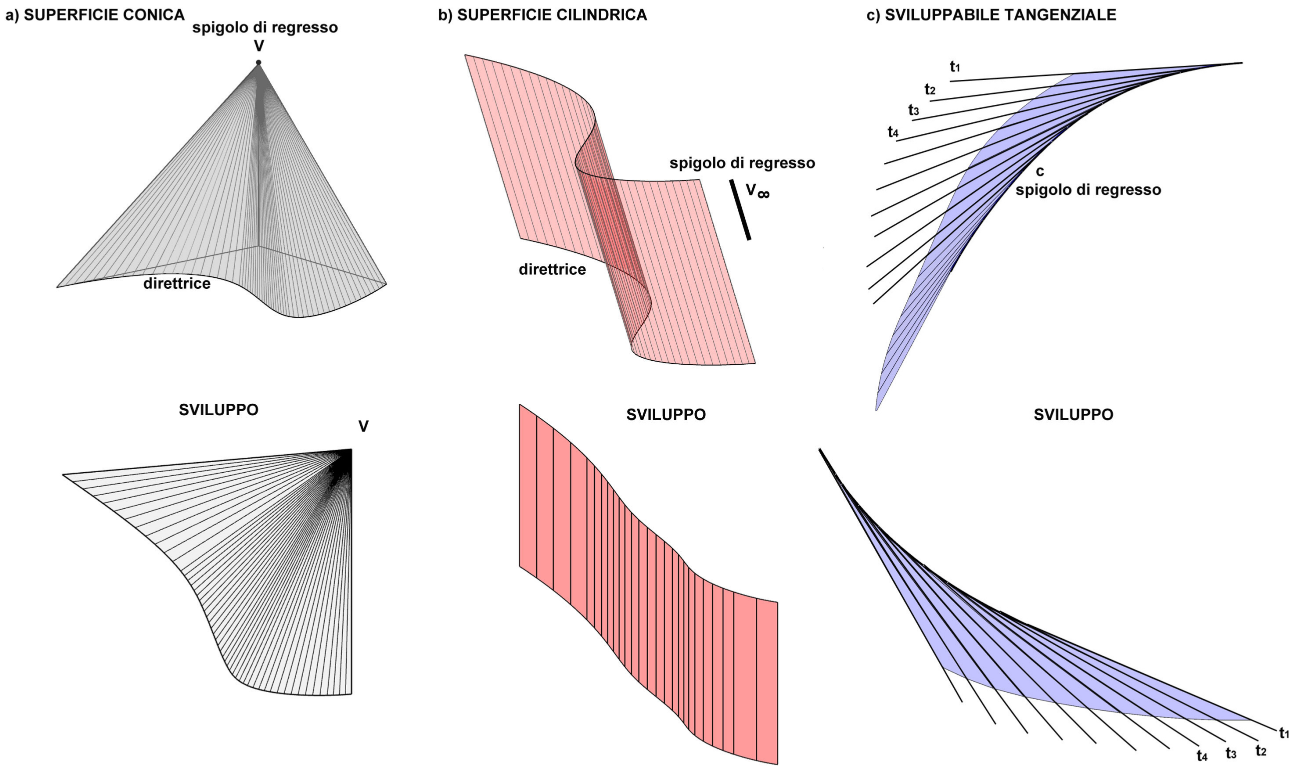


Fig. 2. Developable surfaces classification according to edge of regression. Determination of their developments.

sphaera hac proprietate destituitur, quumeius superficies nullo modo in planum explicari neque superficie plana obduciqueat; ex quo nascitur quaestio aeque curiosa ac notatu digna, utrum praeter conos et cylindros alia quoque corporum genera existant, quorum superficiem itidem in planum explicare liceat nec ne? Quam ob rem in hac dssertationes equens considerare constitui Problema: Invenirea equationem generalem pro omnibus solidis, quorum superficiem in planum explicare licet, cuius solutionem variis modis sum agressurus" [Euler 1772, p. 3] [3].
Starting from the research of the conditions that make a surface developable, Euler's main merit is to have clearly related the principles of analytic geometry and differential geometry.
Monge, who introduces a new family of developable surfaces, opened up questions that still today are the basis of the different approaches for construction of complex shapes [4]. However, who has introduced a new family of developable surfaces is Monge, dealing with questions that still today are the basis of the different approaches for the complex shapes fabrication. In fact, using the theorem that Monge illustrates in his lectures on Descriptive Geometry [Monge 1798] to demonstrate the domain of existence of a generic ruled surface, he defines a particular surface generated by a line that moves along a curve, tangent to the curve: this surface is called tangential developable [Monge 1795, p. 130] [5].
Therefore, based on the studies of Monge, Euler and Hachette, we arrive at a general definition of developable

Fig. 3. You can easily manufacture conical and cylindrical surfaces using a "flexible" but not "deformable" material (graphic elaboration by the author).

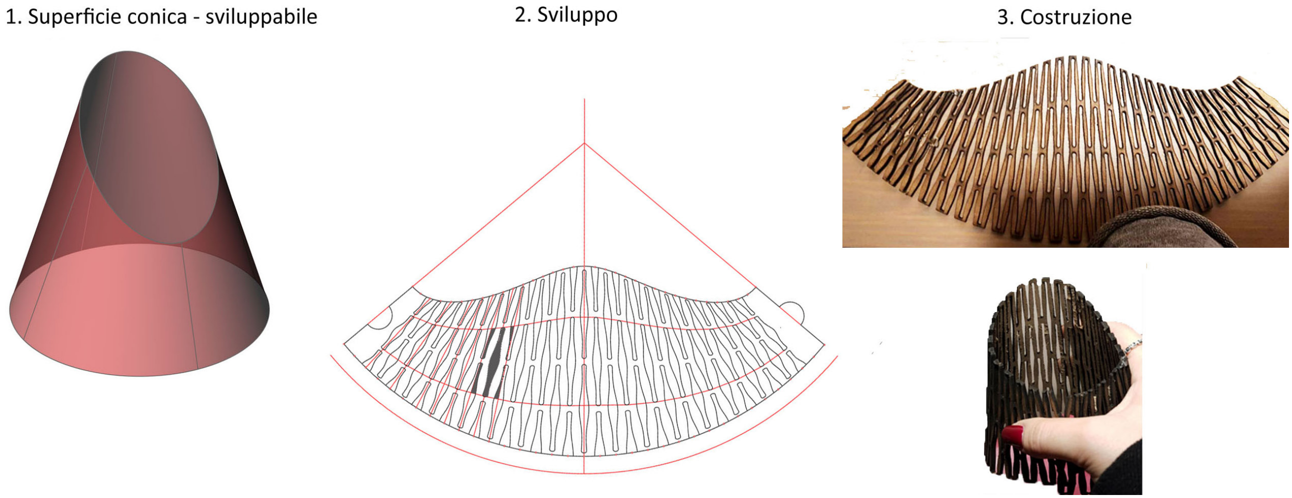


Fig. 4. Tangential developable. On the left: Antoine Pevsner, Developable Surface, 1938; on the right: Antoine Pevsner, Developable Column, 1942.

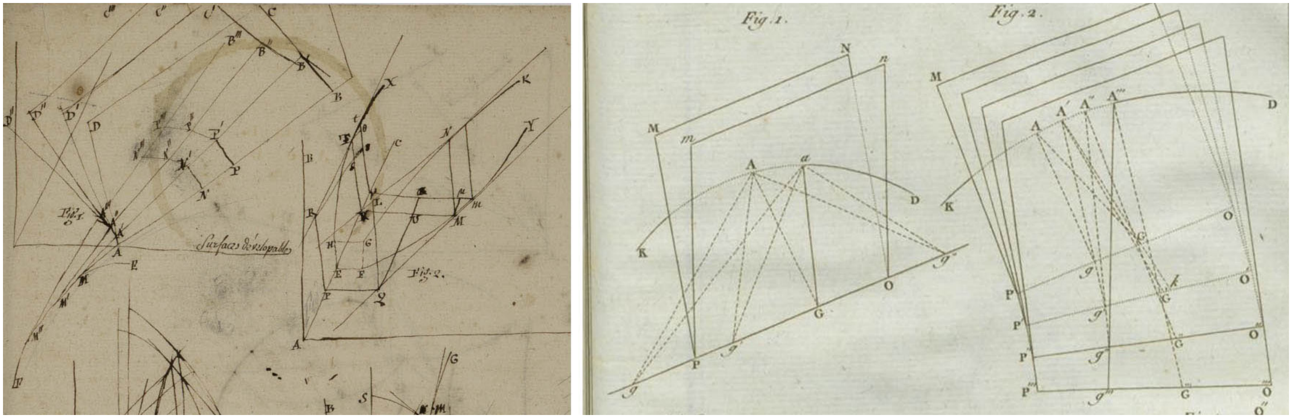


Fig. 5. On the left: Gaspard Monge, 1780 [Monge 1780]; on the right: Gaspard Monge, 1801 [Monge 1801].

surfaces, which are obviously all ruled surfaces, and they can be grouped into three families: tangential developables, conical surfaces and cylindrical surfaces. In a general discussion, the tangential developable can be considered the generic case, in which the directrix (edge of regression) is a generic space curve (fig. 2c). If the edge of regression is a point, we obtain a conical surface (fig. 2a), while if the regression edge is a point at infinity, we obtain a cylindrical surface (fig. 2b).
It is very important to define the concept of unrolling to study how to construct unrolled shapes. As we know, a surface can be unrolled if it can be put on a plane using an isometric transformation, without cuts or overlaps. We can immediately verify this property for the conical surfaces and the cylindrical surfaces (fig. 3), but this is more complex for a tangential developable (fig. 4), and it is complex to have its unrolled shape.
These attempts have been made to find a solution to the question posed by Euler, "*quorum superficiem itidem in planum explicare liceat nec ne?*", which surfaces can be unrolled on the plane and which cannot? In this way we define the geometric rule that will allow us to move from theory to practice: what can we unroll and how can we find the unrolled shape of a tangential developable? It is known that a ruled surfaces can be unrolled if two generatrices infinitely close intersect each other and they are therefore coplanar. This is clear for the conical surfaces in which all the generatrices pass through a fixed point, the vertex (fig. 2a), and for the cylindrical surfaces because all the generatrices are parallel and then intersect each others in a point at infinity (fig. 2b). In the case of the tangential developable we must use the principles of differential geometry and the concept of limit and derivative to demonstrate this concept. In fact, the tangent of a plane curve at *P* is the limit potion of *PQ* line when point *Q* approximates or tends to *P*. Defining the tangent at a point *P* to a plane curve, it is possible to prove that it is unique, so Leibniz introduced the concept of curvature and the definition of osculating circle [Migliari 2009, p. 103]. The osculating circle of a sufficiently smooth plane curve at a given point *P* on the curve has been traditionally defined as the circle passing through *P* and a pair of additional points on the curve close to *P*. The osculating plane to a space curve at a point *P* of that curve is the plane given by the tangent at *P* and a neighbour point on the curve. We can demonstrate that tangents of a space curve are intersections of consecutive osculating planes, so developable surfaces can also be defined as the envelope of the movement of osculating plane in space [Fallavolita 2008, p. 111].
Thus, summing up, from a theoretical point of view, the assumptions placed at the base of the experimentation, which is described here, can be summarized as follows:
- all developable surfaces are ruled surfaces;
- all developable surfaces are zero Gaussian curvature;

- developable surfaces can be generated by tangent line motion on a space curve;
- developable surfaces can be generated by osculating plane motion on a spatial curve;
- a surface is unrolled if two successive generatrices are always incidence.

All studies done in the past, whatever is the prevailing approach used (synthetic, analytical or differential geometrical) have historically been based on spatial intuitions that are often poorly represented or not represented at all, and therefore not very "visible". The aim of our research is also to use 3D modeling tools like a method to demonstrate (as well as to show) and to use the generative algorithmic modeling to compare different souls of Geometry: descriptive, analytical and differential.
Therefore, starting from these assumptions, our experimentation is based on hybridization of old principles and traditional methodologies with new generative modeling tools. We are trying to identify innovative research approaches in applied geometry, in which geometry knowledge is always foundation for the solution of complex construction problems.

Methods

Geometric construction of a conical or cylindrical surface does not present particular problems, assigned the directrix and the vertex *V* (also a point at infinity) we have to construct n generatrices that join the vertex *V* with the *n* points of the directrix. You can easily generate the surface using a 3D modeling software, extruding the curve in one direction or to a point (fig. 2). It's much more complex generating tangential developables. It's the same to find unrolled shape, it is very easy to find conical or cylindrical surfaces development using traditional methods or digital tools, on the contrary it is very difficult to find the unrolled shape of a tangential developable.

Tangential developable

In Descriptive Geometry a tangential developable is generated from a spatial, set as the surface swept out by the tangent lines to the curve. This particular group of ruled surfaces can be generated using only one directrix (the edge of regression) because the tangent in *P* is unique and it is always uniquely determined [Migliari 2009, p. 160].
A tangential developable specializes if the edge of regression is a cylindrical helix: the surface generated by the motion of a tangent line to a cylindrical helix is a developable helicoid.
It is difficult to construct a tangent line to a spatial curve with traditional graphic methods, for this reason, most of historical texts analyzed are without images that could be necessary to show the complex spatial reasonings. The advances in applied geometry derive from the use of digital tools that allow you to automatically construct a tangent line at a point in a spatial curve. To generate the surface, first we have to construct n tangents which, although automatically shown, must be determined one by one, and then the surface can be generated, considering the *n* generatrices represented. In this way the difference between the generated surface and the tangential development depends on the number of generatrices that you used.
Using the Gaussian curvature analysis tool *k*, you can verify if the surface thus obtained is developable (green, $k = 0$) or not (blue, $k < 0$) (fig. 6).
The case of the developable helicoid is the simplest, in fact, if the edge of regression is a cylindrical helix, in order to generate the surface it will be sufficient to construct the tangent at a point *P* and then make it move along the helix [6].
In this case, generative modeling is a powerful tool, useful not only for reiterating procedures but also for verifying theories. In fact, a tangential developable can be unrolled with some unavoidable approximations, as the two consecutive generatrices intersect each others on the edge of regression only in an infinitesimal neighborhood, with *n* tending to infinity. As part of our experimentation we have developed a definition, that follows geometrical principles, to construct developable ruled surfaces using a general spatial curve. This spatial curve can be imported by Rhino or parametrized in relation to specific needs. Dividing the assigned spatial curve (the edge of regression) in *n* parts, our algorithmic definition allows to generate the surface by constructing *n* lines (generatrix of the surface) passing through the *n* points and tangent to it. By modifying the length of the generatrix and the edge of regression it is possible to obtain infinite developable surfaces. This surface may be cut to define the edge, which is otherwise automatically generated as a function of the generatrix length (fig. 6).

Developable strip modeling using two directrices

Developable strips modeling using two directrices, *c* and *c'* is more usual than tangential developables.

Using the methods of Descriptive Geometry, we know how to model a developable surface using two spatial curves *c* and *c'* (directrices). We have to select a point *P* on the curve c and we have to construct the conical surface (vertex *P* and directrix *c'*): the generatrix of the developable surface, in point *P*, is the line obtained by considering the plane passing through *P* and tangent to the conical surface. Reiterating this process we can generate *n* generatrices of the surface. In this way we have shown that the tangent plane for a generatrix of a developable surface is only one [Migliari 2009, pp. 213-218]. This very important geometric property of the surfaces that can be developed has been fundamental to define the algorithm that allows us to construct a developable strip using two directrices.

However, it is not always possible to obtain a developable surface by arbitrarily assigning the two curves. In fact, it could be that the two curves, arbitrarily assigned, are not "extended" enough, or, vice versa, are too long. For this reason, it is not possible to determine the generatrix in

Fig. 6. Tangential, parametric model: approximation improves (k = 0) increasing the number of generatrices (definition by the author).

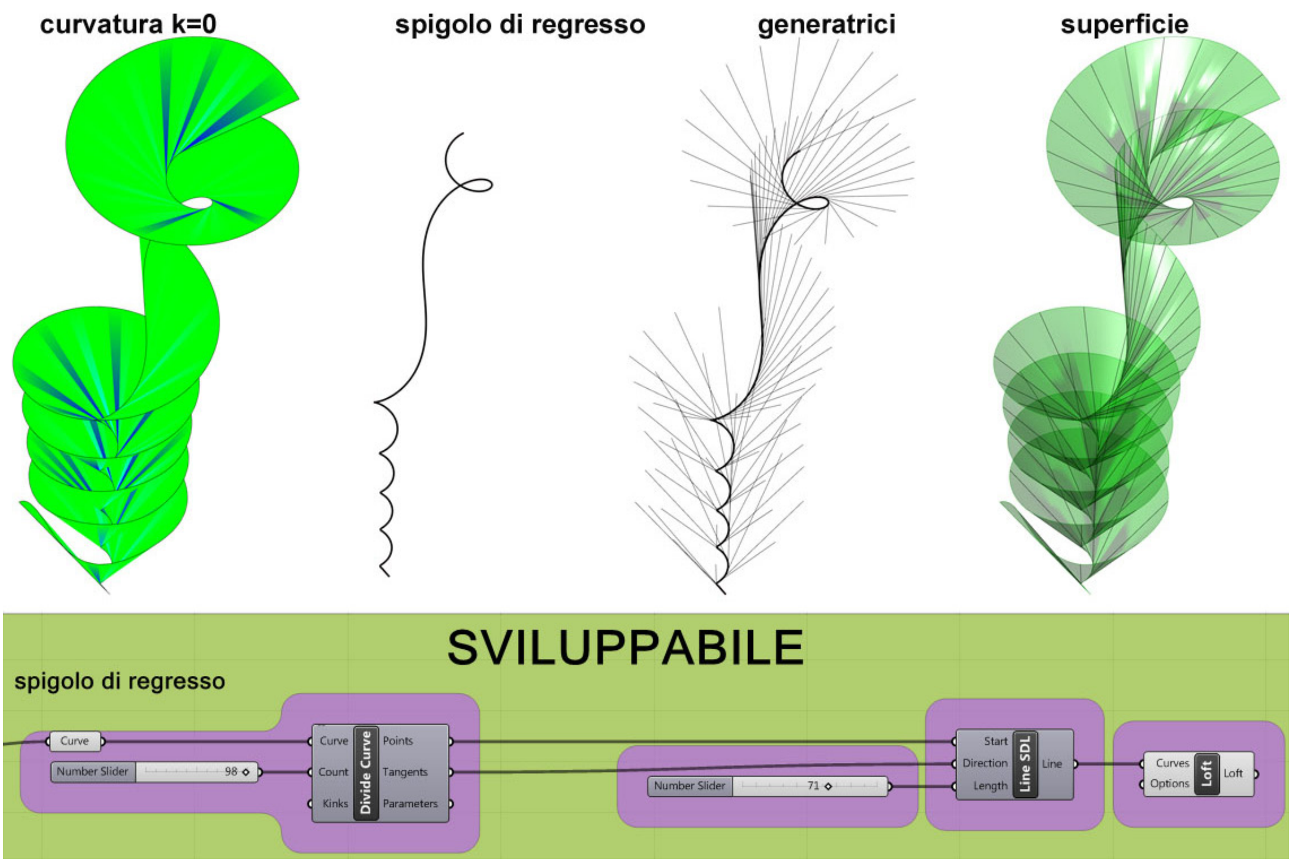
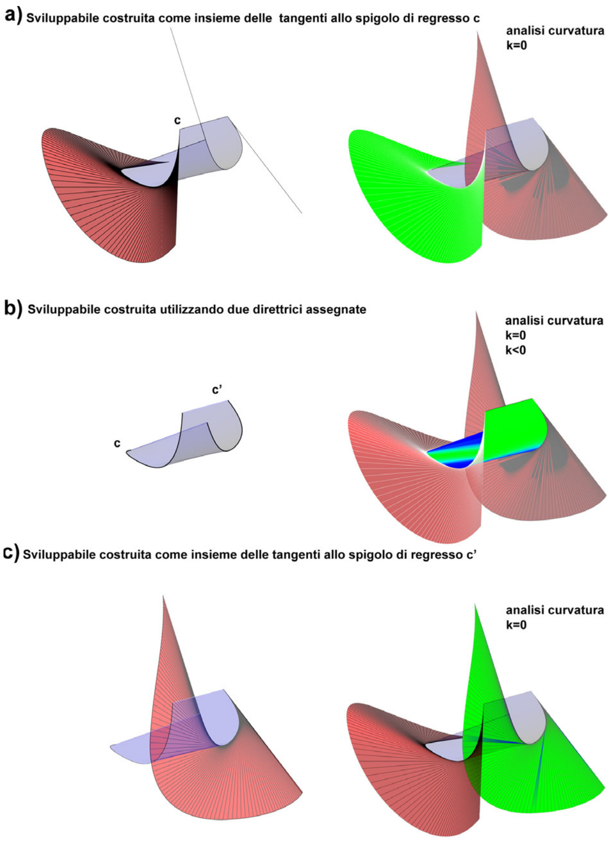


Fig. 7. Developable strips constructed using two spatial curves, c and c '. Definition of existence domain (graphic elaboration by the author).



some points. In this case it will be necessary to define the domain of existence of the surface (fig. 7).
The problem seems to be immediately solved using the 3D modeling tools, in fact, the *DevLoft* command of Rhino allows you to automatically generate a developable surface by two spatial curves. This surface has generally zero Gaussian curvature even if in some points it has negative Gaussian curvature (fig. 7), therefore, theoretically, we can't unroll it.
There are some different solutions to solve this problems, it depends on the specific application. One of the possible solutions is certainly to extend the curves and build the surface by analyzing the curvature. In this way, step by step, by correcting the curves to obtain surfaces with zero Gaussian curvature, you can modeling strips that can be developed, which can be cut according to need.
Through the algorithmic modeling, there are definitions that allow to modify the directices in order to guarantee the existence of the developable.
In our research, we have done the following tests using generative algorithm modeling:
- construction of a developable surface using two directrices, *c* and *c'* [7];
- determination of the the edge of regression by joining the consecutive generatrices;
- tangential developable modeling, using our definition;
- comparison of the two surfaces (fig. 8).
This procedure can be used to design a developable strip, because it is patch extracted from tangential developable, and to find the unrolled shape (fig. 9) [Lanzara 2015, pp. 199-203].

Unrolled shape of tangential developable
A surface, as we said, is developable if it can be unrolled on a plane with rigid movements (isometric transformation), without stretching or tearing: this is possible if two consecutive generatrices are coplanar.
We have analyzed principles and methods used to find the unrolled shape of a tangential developable. We have defined different approaches that allow us to determine the "approximate unrolled shape" of a non-developable surface. We have also considered materials and manufacturing techniques that can solve approximation problems connected to "smash", allowing the panel deformation thanks to "cuts", *kerfing*, or "overlapping", *bending*.
As we noted, developable surfaces have zero Gaussian curvature, consequently they can be manufactured, using a flexible and non-deformable material, starting from their unrolled shape, simply by shaping the cut out shape. This kind of surfaces are easy to manufacture and this has favored their diffusion.
In the case of cylindrical surfaces the edge of regression is a direction, so the generatrices are all incidents in one point at infinity. Using the traditional method introduced by Monge, in order to determine the development of the surface, the directrix is divided into *n* parts and a prismatic surface is obtained. This coincides with the conical surface when *n* to infinity. Cylindrical surface is

Fig. 8 Algorithmic modeling: comparison between strip obtained using two directrices and the tangential generating using the edge of regression.

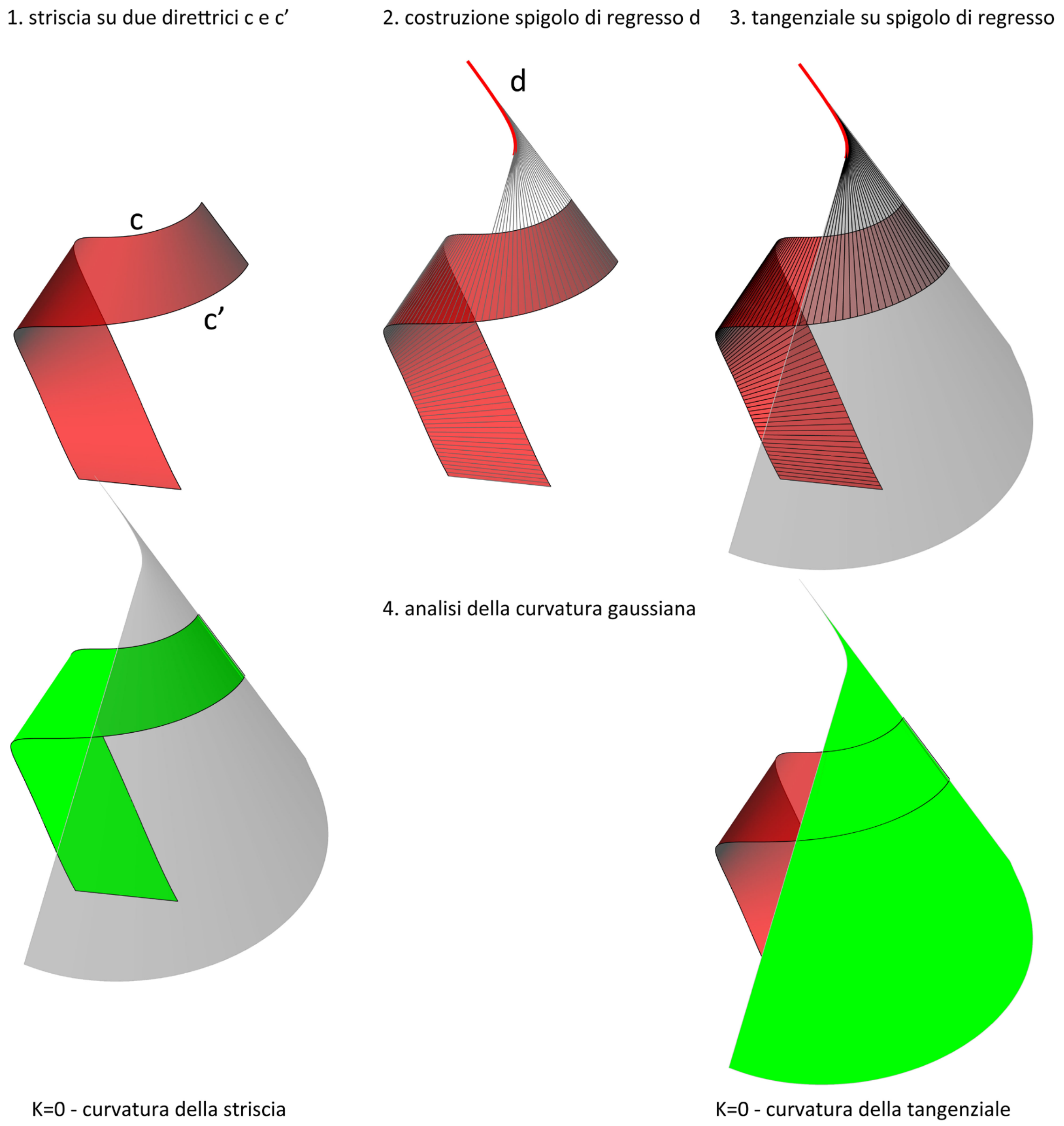
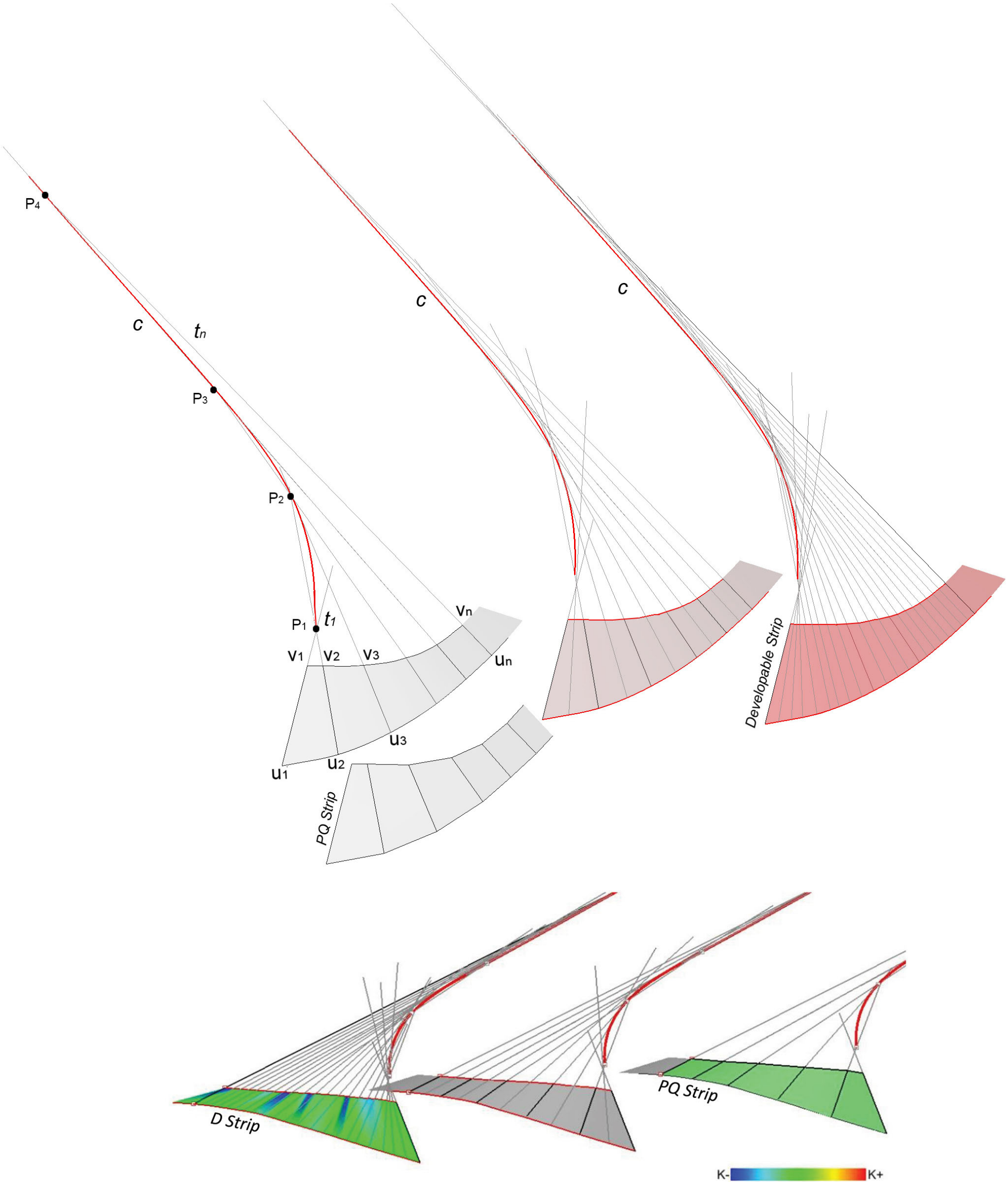


Fig. 9. Local optimization approaches to design a developable strip (graphic elaboration by Emanuela Lanzara).



developed by unrolling the *n* quadrilateral faces in sequence on a plane.
Furthermore, conical surfaces can be considered developable surfaces in which the edge of regression is a point, so two consecutive generatrices are always intersecting lines. To define the unrolled surface, we divide the directrix into n parts and transform the continuous surface into a discrete surface: a pyramid. using 3D modeling, there is a command that is able to automatically unroll both conical surfaces and cylindrical surfaces [8].
The method for finding the unrolled shape of a tangential developable is more complex, in this case differential geometry application is evident. Monge uses the principles of differential calculus to study the properties of the developables surfaces [Migliari 2009, pp. 106-108]. Each developable surface can be flattened onto a plane without distortion and, in a limited region, without overlapping. The unrolled shape of the surface generated by the infinite tangents to a space curve is obtained by considering n generatrices and flattening onto plane the surfaces included between two consecutive generatrices. If we consider two consecutive tangents $t_1 t_2$ (fig. 10), in theory incidents, they identify a plane, so if we rotate $t_2 t_3$ around t_2 and repeat the operation for the subsequent tangents we find the unrolled surface. The unrolled surface depends on the edge of regression. It may happen that the configuration of the surface is such that portions of unrolled surface overlap with the others [Fallavolita 2008, p. 113], in these cases, it is necessary to divide the design surface into parts in order to manufacturing it.
Development is therefore easy with regard to conical and cylindrical surfaces, in this regard the Sereni says: "*il metodo rigoroso non può che desumersi dal calcolo ed i metodi approssimativi sono essi medesimi soverchiamente lunghi,* e *di sì raro uso nelle arti che no meritano d'arrestarci davvantaggio… in ultima analisi tutti si ridurrebbero a costruire lo sviluppo di una superficie poliedrica…* e *quanto minore fossero gli angoli tanto più il lavoro si accosterebbe alla precisione*" [Sereni 1826, p. 49] [9].
Interesting is the approach of Leroy that highlights the importance of result knowledge to distribute errors. The scholar addresses the issue of unrolled shape of tangential developable, in particular of the developable helicoid, in the same way for a conical or cylindrical surface, he says: "*dividendo una curva piana situata sulla superficie in piccoli archi sensibilmente confusi con le loro corde: allora i settori elementari proiettati potranno essere considerati come triangoli di maniera che, se si costruiscono questi triangoli sopra uno stesso piano ed allato gli uni degli altri, il loro insieme rappresenterà lo sviluppo della superficie in questione*" [Leroy 1826, p. 289] (fig. 10). Leroy underlines that the need to approximate a continuous surface into polyhedric surface results in an accumulation of errors that could be avoided if we could know the unrolled shape of the curve. We know that helixes on developable helicoid turn in concentric circles, for this reason the edge of regression will turn into a circle whose radius depends on the radius of curvature of the helix (O_2A_2) and it can be determined by using the differential calculation or graphically. To draw the unrolled shape of the developable helicoid, it will be sufficient to fix the length of the assigned generatrix (for example A_2W_2) on the helix development and draw a concentric circle with radius O_2W_2 (fig.10).
We have defined a method that allows to find the unrolled shape of any developable tangential using the algorithmic modeling. If we divide the edge of regression into *n* parts and we consider *n* tangents (generatrices of ruled surface) we have that two consecutive tangents intersect on the edge of regression. This is true only in a small, infinitesimal neighborhood. In fact, if we divide the edge of regression into n parts and consider two successive tangents, t_1 and t_2, led respectively by points *1* and *2* (fig. 10), we define the non-flat quadrilateral *A12B*. When point *2* goes to point *1*, points *1*, *2* and *B* can be considered aligned, it follows that, approximately, it will always be possible to define a flat triangular face and then unroll the surface composed by *n* triangular faces. The approximation of the unrolled surface obviously depends on *n*.
We have done two tests in our research and we have analyzed the results to evaluate which of the two methods allows to obtain the unrolled shape that best approximates the real surface. In the first case we have divided the surface using the *n* tangents and we have defined a surface composed by ruled surfaces obtained by using the consecutive tangents, *A1*, *B2*, *C3*… (fig. 10). These ruled surfaces are modeled by using the no-flat quadrilater *A12B*, therefore, as we have previously said, they cannot be unrolled. Therefore, they have been "flattened" using the *smash* tool, which, using Rhino, allows us to determine the approximate development of

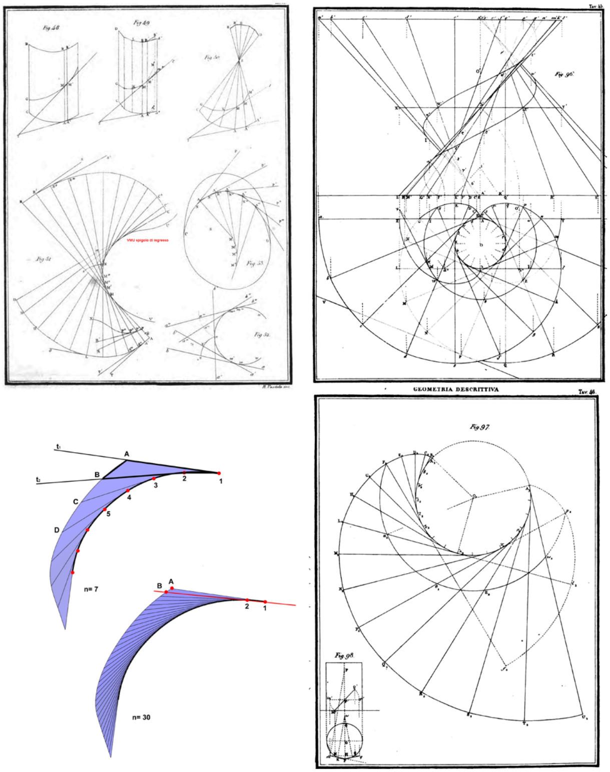


Fig. 10. Charles François Antoine Leroy: generic developable, developable helicoid, development of helicoid. Division in twisted quadrilateral or in triangular elements.

a non-developable surface. We have determined the unrolled shape of the surface by sequentially unrolling the quadrilaterals onto plane [10].
In the second case, we have supposed that the points *1*, *2*, *B*, and *2*, *3*, *C* are aligned and we have split the surface into triangles *AB1*, *BC2*, *CD3*… and we have determined the unrolled shape of the surface by unrolling the triangles onto plane. Comparing the metric values of the 3D surface, namely the length of the edges and the area, with the unrolled shapes that we have constructed, it results that, in the first case, the unrolled surface is larger than the real one, while in the second case it is smaller. For this reason, in order to construct exactly the 3D shape, using the unrolled shape that we have determined, in the first case overlaps (bending) must be provided, in the second case we have to cut (kerfing) and the material must be "deformable".

Approximate flattened shape of double curvature surface
There is no doubt about the advantages offered by using developable surfaces to manufacture objects that can be fabricate using a flat panel. To do that you need to know the unrolled shape in order to draw the exact contour of the surface to be cut out on the plane. We can find approximate but sufficiently precise unrolled shape of non-developable surfaces useful for certain applications.
We have identified in our research the following most significant approaches to construct a double curved surface using flat elements:
1. to approximate the complex surface splitting it into strips that can be developed, then identifying some remarkable lines on the surface in order to optimize the construction process;
2. to design the surface using strips that can be developed [Liu et al. 2006];
3. to use processes that make the panel flexible and deformable (kerfing or bending) to manufacture the shape designed from a flat element.
We have studied non-developable surfaces and in particular the case of hyperbolic paraboloid, to highlight some of the problems and to define some possible approaches to transform a non-developable surface into a flat surface that, with better approximation, is able to preserve the characteristics of the 3D surface.
Main research goal is to highlight, through the applications, how these approaches can influence the figurative outcome and the manufacturing process.
The hyperbolic paraboloid is a ruled surface that may be generated by a moving line that is parallel to a fixed plane, it is a not developable surface because two consecutive generatrices are always skew lines and Gaussian curvature is always negative.
There are several tools that allow you to automatically obtain the approximate unrolled shape of a non-developable surface: using Rhino the command *smash* and the command *squish* (fig. 12). The critical analysis of the results obtained using a 3D modeling software is part of our experimentation. Using the *smash* command we can automatically generate an approximate unrolled shape for a double curved surface, but using this flat shape we can reconstruct the real 3D shape only if we use a deformable

Fig. 11. Procedural modeling: tests for developable helicoid fabrication (graphic elaboration by the author).

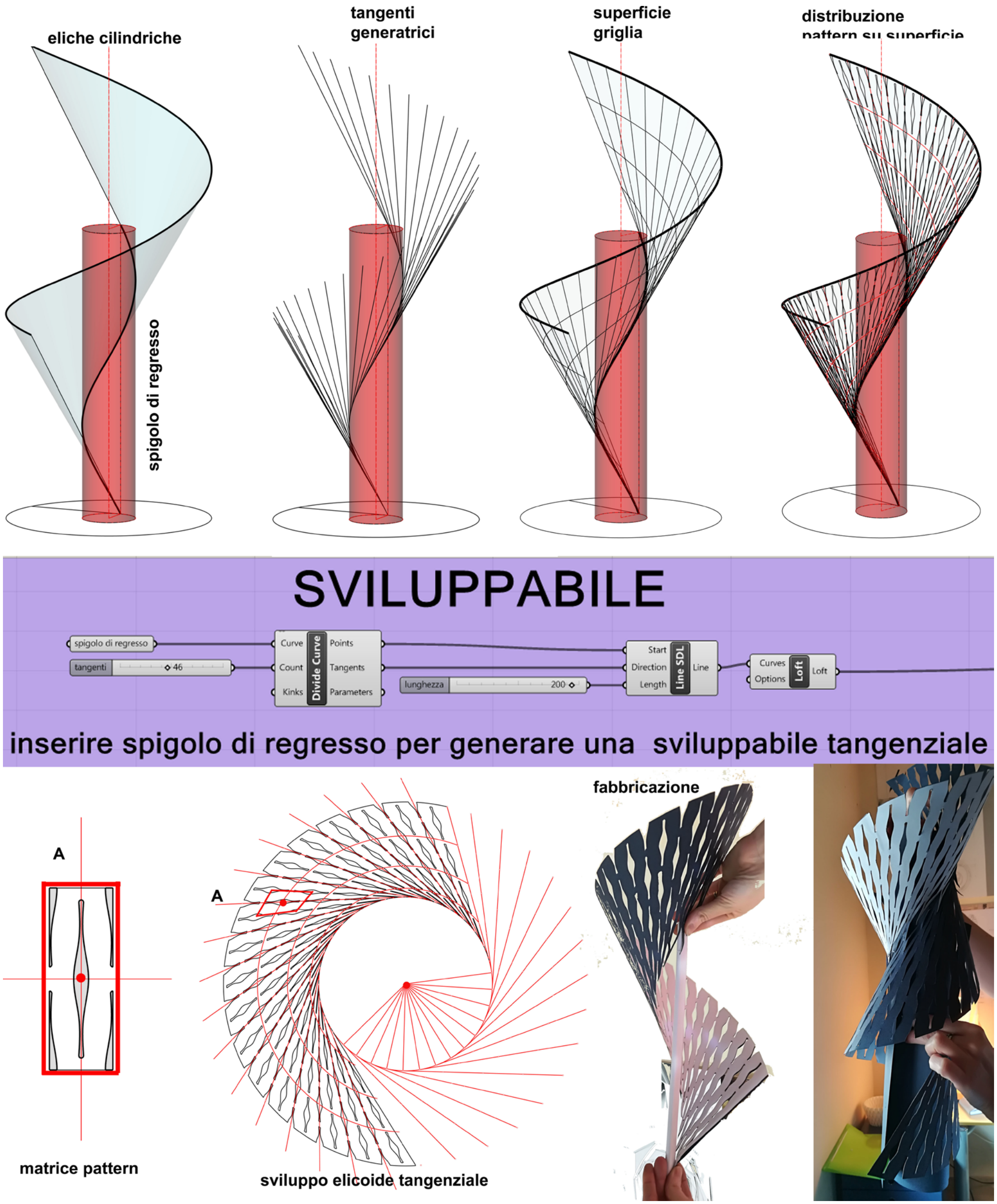
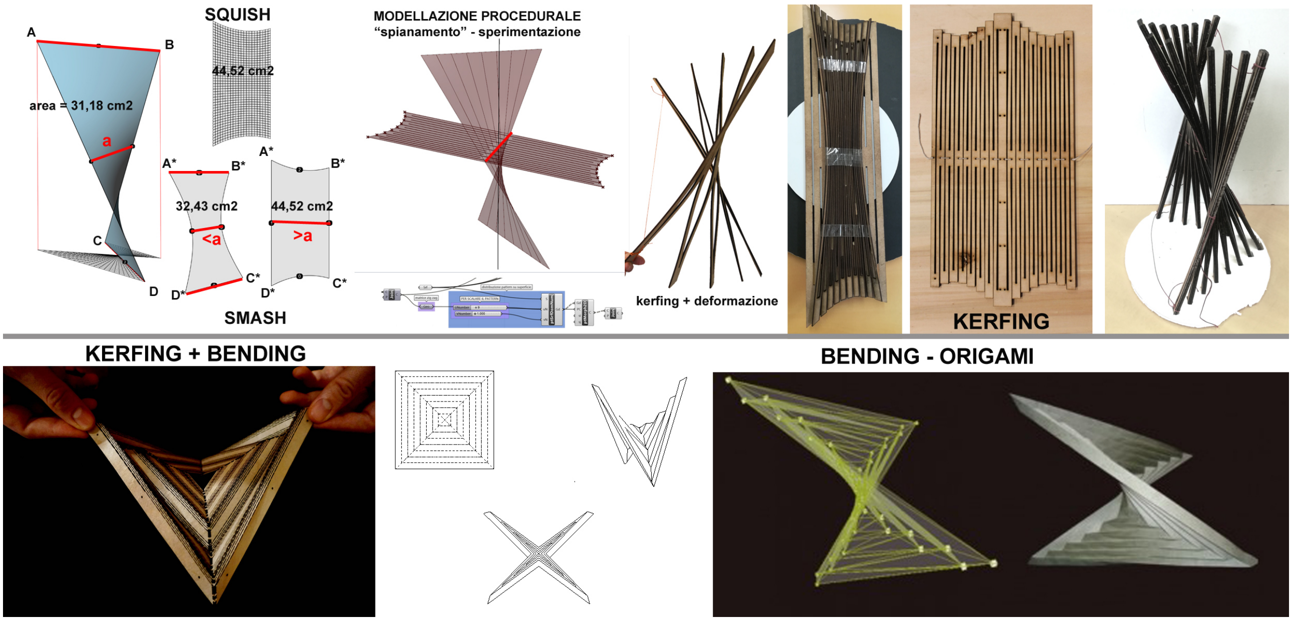


Fig. 12. Prototypes in wood and cardboard for a lamp manufacture: portions of developable helicoids. Design by Mara Capone.

Fig. 13. Tests for hyperbolic paraboloid manufacture: kerfing and bending experiments.



material. The *squish* command uses a different algorithm, performs the smoothing of meshes or 3D NURBS surfaces, modifying the starting area, allowing the display and control of the local compression and stretching zones.
Applying the *smash* and *squish* commands to the hyperbolic paraboloid piece, used in our tests, we obtained different shape (fig 12). We have done these observations based on results: the area changes with respect to the real one and the generatrices of one of the two groups deform themselves, it follows that to transform the flatten shape into 3D designed shape it will necessarily be breakings and/or overlaps. In fact, if the generatrix *AD* becomes curve, it turns into the curved edge *A'D*, this must be deformable, therefore the cuts must be made to allow the curve *A'D'* to assume the configuration straight of the designed shape. Similarly, if the generatrix *AB* is deformed, it will be necessary to allow that the curve *A'B* is able to be transformed into the straight segment *AB* (fig. 12).
Using generative modeling we tested different methodologies to simulate the deformation according to the cuts made. Our goal is to identify processes and to develop tools to define the approximate flatten shape of a double curvature based on the knowledge of geometric properties.

Conclusions and future research developments

The topic of fabricating 3D complex surface shape using a flat surface has been historically addressed and it is the basis of search for optimized solutions based on applied geometry. The use of parametric modeling tools allows us to address this very complex problem, opening new fields of experimentation and research based on ancient principles whose verification is always better supported by diffusion of digital manufacturing techniques.
Our research starts from the study of geometry and algorithmic modeling tools and, by hybridizing different methodologies, tends to develop general solutions that can be used in different fields.

Notes

[1] Hachette proposes a classification of surfaces in three groups: developable surfaces, surfaces of revolution and ruled surfaces "*de surfaces qu'onvient de définir et qui sont désignées par le noms de surfaces developables, surfaces de révolution, surfaces réglées*" [Hachette 1828, p. 30].

[2] We know that the *osculating circle* is the circle that approaches the curve most tightly in an infinitesimal interval. The curvature at one point *P* is the inverse of the radius of the osculating circle $k=1/r$. The osculating plane in a point *P* of a space curve, is the limit position taken by the plane passing through the tangent in *P* to the curve and for another point *Q* of the curve, to the tendency of *Q* to *P*. If we consider a point *P* of a skewed curve, the osculating plane is the plane identified by the tangent vector *t* in *P* and by the normal vector *n*.

[3] "*Notissima est proprietas cylindri et coni, qua eorum superficiem in planum explicare licet atque ad eo haec proprietas ad omnia corpora cylindrical et conica extenditur, quorum bases figuram habeant quamcunque; contra vero sphaera hac proprietate destituitur, quum eius superficies nullo modo in planum explicari neque superficie plana obduciqueat; ex quo nascitur quaestio aeque curiosa acnotatudigna, utrum praeterconos et cylindros alia quoque corporum genera existant, quorum superficiem itidem in planum explicare liceat nec ne? Quamob rem in hac dsisertationes equens considerare constitui Problema: Invenire aequationem generalem pro omnibus solidis, quorum superficiem in planum explicare licet, cuius solutionem variis modis sum agressurus*", Euler 1772.

[4] The most advanced researches in complex surfaces manufacture take place in the field of applied geometry. One of the possible solutions is to divide the surface into parts that can be made by approximation using strips that can be developed. This process is very advantageous for surface manufacture that can be built using flat elements to be put into shape.

[5] In his first lessons of Descriptive Geometry, Gaspard Monge teaches an elegant "existential demonstration" of ruled surfaces, generated by the motion of a straight line that is supported by three generic spatial curves assumed as direcrices. [Migliari 2009, p. 154].

[6] For example, using Rhinoceros, you can use *sweep one rail*.

[7] We used *Tapeworm script by Mårten Nettelbladt* to generate a developable strip. The tool allows to modify two directrices in order to guarantee the existence of the developable.

[8] Using Unroll, Rhinoceros allows to determinate the development of developable surface. We can automatically unroll conical and cylindrical surfaces. There are some problems to determine development of a tangential surface, even if it is developable.

[9] Sereni is a supporter of analytical method, in fact, he states that "the approximate methods are themselves overwhelmingly long, and so rarely used in the arts that they do not deserve to be arrested, they would ultimately […] reduce to building" [Sereni 1826, p. 49].

[10] Using generative algorithms the development of the tangential ruled surface was determined by dividing into n parts (variables) the regression edge and building the tangents to the curve passing through the n points so determined. In this way, the surface generated by the subsequent tangents was determined.

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The Spread of Descriptive Geometry in Great Britain Between the XVIII and XIX Century

Stefano Chiarenza

Abstract

Between the Eighteenth and Nineteenth Centuries the diffusion of the Monge's Descriptive Geometry in Europe determines, with different times and outcomes in the various countries, a radical change in the field of representation. It modifies not only the approach to design but also, and substantially, professional education. In Britain, however, the new science, for both political and cultural reasons, officially arrives very late.
Its circulation among professionals, craftsmen and designers, though well attested before, sees it grafted onto a series of independent research experiences, also fueling the attempts by British theoreticians to define a universal system of graphic communication.
The present study, through a research review on the history of representation related to this era, and the collection of documentary sources, intends to offer a systematic reconstruction of the diffusion of Descriptive Geometry in Great Britain, contextualizing it in the socio-political climate of the time and intertwining new instances of the Monge's method with the original research conducted across the Channel in those years.

Keywords: Geometrical Drawing, England, porjections, Monge, Nicholson.

Introduction

At the end of the Eighteenth Century the definition of Monge's Descriptive Geometry system represented the beginning of a profound cultural revolution in the field of technical sciences. The new discipline, was able to bring together in an organic corpus the vast existing empirical production and delineated the traits of a Science of Representation, until then never existed, or, at least, never formalized in such a unitary way.
With the Monge's geometry a radical process of transformation of the education system also began; the training in the technical-engineering field found in the new scientific method of representation an indispensable study tool for young engineers, connecting theoretical and mathematical subjects with applicative ones, in an educational path that involved a multiplicity of disciplines often heterogeneous. France was certainly the fulcrum of this change, but the theoretical refinement of the Monge's method and its different fields of application attracted, in a few years from its public dissemination, the entire European scientific community.
In the various countries the impact of the new discipline on studies gradually initiated significant processes of change in the educational pathways, grafting onto existing models or interacting in various ways with them. If in Spain, Italy and Germany the Descriptive Geometry was quickly accepted and reacted in an osmotic manner with the scientific knowledge hitherto matured, in other countries it did not find the same success.

Political factors and social reasons of the delay in the diffusion of the Monge's method in England

In particular, in England the Monge's method is transposed with delay due to a combination of both political and cultural factors [Mason 1971; Lawrence 2003]. From the political point of view, as it has been noted, "The lack of interest shown upon the translation of the technique into English is partly due to its having been translated during the period between the Napoleonic wars, so the technique itself was regarded as the invention of one of the most prominent republican educationalists. The competition between the two nations–English and French–in matters not only of war but of prosperity and industry during the intervals of peace is an important element to be considered. The lack of a suitable translation and instruction into the technique by one of the 'original' students was another result of the wars in which the French and English were engaged in at the time" [Lawrence 2003, p. 1271].
Indeed, the political events following the Revolution, coinciding with the years of Descriptive Geometry spreading beyond the French borders, are characterized by a period of peace between the two nations–intervened after the 1802 Treaty of Amiens and ceased already in 1803–but this appeared to be linked to contingent needs rather than to the search for a cultural unity.
Actually, England was moved to peace, among other things, by the interest of re-establishing trade relations with France to exchange its industrial surpluses [Bignon 1840, p. 270]. Such relations, however, never took off because of the evident French protectionism aimed at limiting British economic hegemony. The political contrasts and industrial competition between the two states therefore remained essentially constant and this, independently of the war, did not facilitate the scientific diffusion of Monge's work on the Island. The continuous state of tension and competition also prevented that French scientists could transfer knowledge of the Method to Great Britain, contrary to what happened instead in the United States of America, both on a practical and theoretical level, thanks to Marc-Isambard Brunel, Claude Crozet and Simon Bernard [Cardone 2017, p. 150].
From a cultural point of view, the slow expansion of the Monge's science in the uses of professional practice and in British technical training seems to depend, instead, on some profound differences between two national identities, the French one, and the English one; the first oriented towards theory, the second towards practice. And it is not a mere cliché, even though it may appear in the words of Hyppolite Taine when, in his *Notes sur l'Angleterre*, he writes "*le Français demande à tout écrit et à toute chose la forme agréable; l'Anglais peut se contenter du fonds utile. Le Français aime les idées en elles-mêmes et pour elles-mêmes; l'Anglais les prend commes des instruments de menémotechnie ou de prévision. […] En général, le Français comprend au moyen de classifications et par des méthodes déductives, l'Anglais par induction, à force d'attention e de mémoire, grâce à la représentation lucide et persistante d'une quantité de faits individuels, par l'accumulation indéfinie des documents isolés et juxtaposés*" [Taine 1874, p. 326].
The contrast between theoretical and practical orientations, between deduction and induction, elements, those,

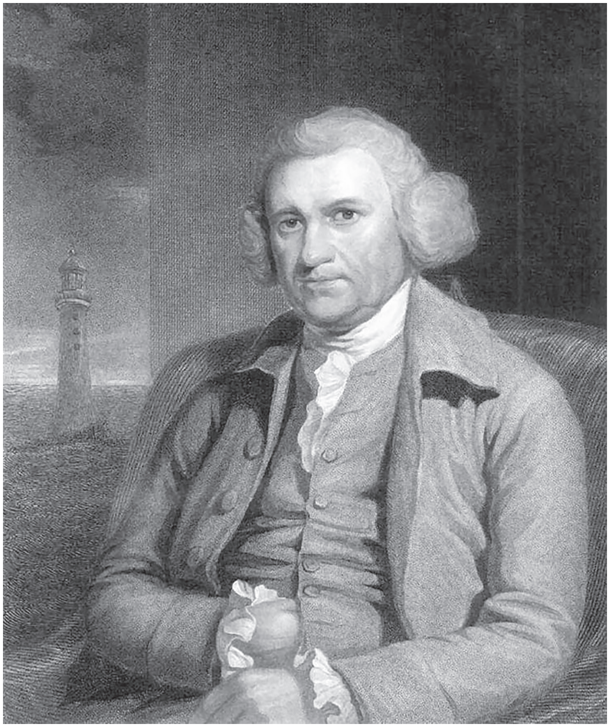


Fig. 1. John Smeaton (1724-1792). Engraving after a portrait by the painter Mather Brown, 1788 ca.

Fig. 2. Thomas Telford (1757-1834). George Patten, Portrait, 1829. Oil on canvas. Glasgow Museums. Image distributed under a CC BY-NC-ND licence.

which appear specific peculiarities of the two peoples, does not arise only from a rhetorical emphasis on two antithetic and historically competing traits. It finds precise evidence in the training models and in the approach to science and technology. And it is precisely the British education system of the time, perhaps, the main cause of the failure to disseminate a method that was sublimated in its theoretical aspects.
A first reflection can be made on the engineer's education in the Nineteenth Century in both countries. The French engineer was a state figure, hinged into hierarchical bodies such as the *École des Ponts et Chaussées* or the *Corp du Génie*. He was trained in specialized schools and was considered part of what could already be called a professional category [Picon 1992]. The British context was completely different. In Britain between the eighteenth and nineteenth centuries engineering was not yet a fully organized profession [Buchanan 1989] and engineers were still figures trained through a traditional craft apprenticeship, often as millwrights, mechanics, instrument makers or stonemasons. Among them, we can mention some of the most brilliant innovators of the century such as engineer John Smeaton (1724-1792), founder of the Society of Civil Engineers in 1771, who made his apprenticeship in London as a mathematical instrument maker (fig. 1); Thomas Telford (1757-1834), engineer and first president of the Institution of Civil Engineers, who formed itself as stonemason (fig. 2); or even George Stephenson (1781-1848), who, before discovering his genius in the construction of locomotives, worked as brakeman [1].
The opportunities for formal education or training were reduced and, in general, even men of science acquired their basic skills from apprenticeships or as self-taught, naturally endowed with ingenuity and entrepreneurial ability. Technical and scientific instruction, despite the great results achieved by the industry, was in a state of backwardness as well as the whole educational system [2]. More generally, the teaching of scientific-engineering disciplines, at least until the mid-Nineteenth Century, was only exceptionally provided in the ancient English universities or in public schools, however of a clerical type [3].
Many of the engineering pioneers or scientists who received scientific education in these areas studied in continental Europe schools, or, if in England, in the so-called 'dissenting academies'. These academies were run by the 'dissenting' or those who did not conform to the Church of England. Dissenting academies spread to England after 1662 as a result of the so-called 'Conformity legislation' that accentuated the differences between the Orthodox and non-Orthodox state schools.
They formed a significant part of England's educational systems from the mid-seventeenth to the nineteenth centuries [4]. In Britain the best education was the Scottish one, offered by the universities of Glasgow and Edinburgh who excelled in medicine, science and engineering much more than the less enlightened Oxford and Cambridge did [5].
Therefore, if in France, Monge's Geometry was a catalyst for the reform of engineering studies, centered on a system in some way ready to incorporate its enormous formative scope, in Great Britain not only did the discipline delay in spreading for political reasons, but when it arrived, it did not even find an educational and training-professional system prepared to welcome the disruptive novelty.

The new technical language, established thanks to the Monge method, allowed in fact to outline a new engineer figure; on the one hand offering a common repertoire, which allowed to control the details of the construction with extreme precision, without the need to acquire the manual crafts skills or to take an interest in the practical-realization aspects of the artefacts. On the other hand, the modalities of this form of drawing had important implications for the work organization and the design of artifacts, redefining in fact the role of the engineer in the production cycle. That is an increasingly clear separation between the designer-creator of a work, and its executor. As Joël Sakarovitch writes, the Descriptive Geometry "can also be viewed as a transition discipline that allowed a gentle evolution to take place: from the 'artist engineer' of the Old Regime, whose training was based on the art of drawing rather than scientific learning, to the 'learned engineer' of the 19th Century for whom mathematics–and algebra in particular–is going to become the main pillar of his training" [Sakarovitch 2005, p. 240].
It is clear that in Britain, where constructive practice still had an extraordinary educational force for professionals and where state intervention on training was marginal [Baynes 2009, p. 15], an extremely theoretical approach to the engineering discipline of drawing could not have found fertile ground [6]. However, it is certain that Monge's method, to some extent, came to be part of the cognitive baggage of the English technicians even if there was, at least until the mid-Nineteenth Century, a translation that perpetuated the systematic dissemination for technical instruction.

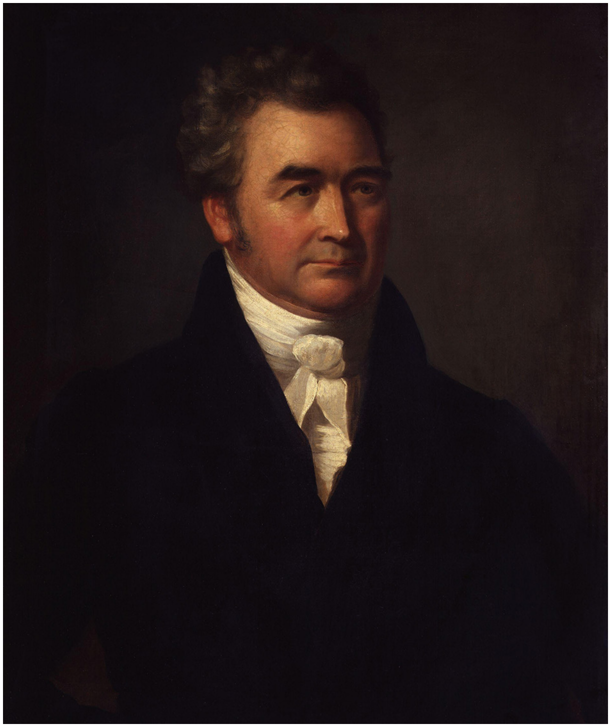


Fig. 3. Peter Nicholson (1765-1844). James Green, Portrait, 1816. Oil on canvas. National Portrait Gallery of London.

The diffusion of Descriptive Geometry: adaptations, translations and autonomous orientations

It seems certain that, as soon as the *Géométrie descriptive* saw print in France, the British War Office obtained a copy [7]. However, the office did nothing with it [Belofsky 1991, p. 35]. Regardless of this circumstance, likely since the subject was no longer subject to secrecy, certainly some copies of the method in French circulated among the experts of the field.
His entry into the professional knowledge has been traced back to some time before, linking him to the figure of Marc-Isambard Brunel. During his training, the Franco-British engineer had the opportunity to meet Monge, who was given to him as a tutor during a course in Rouen to became an official navy cadet. Known for his 'realist' ideas, he emigrated to the United States in 1793 where he became chief engineer of the city of New York, before moving to England in 1799 [8]. Concerning Brunel's activity, however, even though there may certainly be recognized a fundamental role in disseminating a new orientation in engineering design, it did not condense into theoretical writings of the Beaune's master work, as happened for Crozet in the United States of America. The first writings on the Monge's method, even if partial, are instead dated to 1812, by the Scottish architect, engineer and mathematician Peter Nicholson (1765-1844). His eclectic personality and his multi-faceted activity represent the typical characteristics of the teaching and architectural-engineering profession in Great Britain at the beginning of the Nineteenth Century, aimed at the essentiality of a theory always devoted to

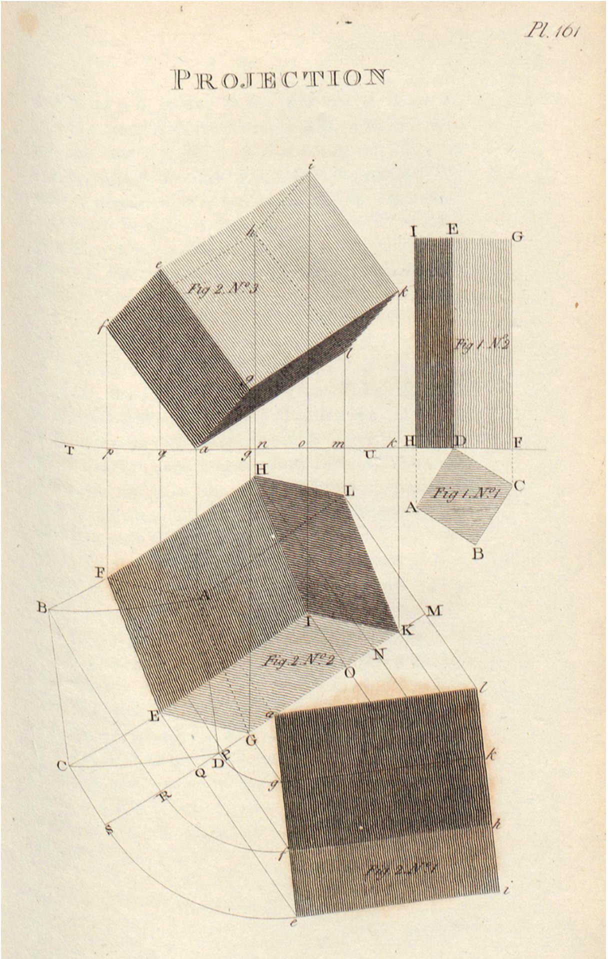


Fig. 4. Peter Nicholson. Ichnography and elevation of a rectangular parallelopipedon [Nicholson 1797, vol. II, Fig. 2].

the building practice (fig. 3). He was able to put together, with awareness and versatility, the scientific aspects of the geometrical drawing and the architectural and engineering practice, distinguishing himself for its works aimed at education and for its mathematical spirit that will characterize even a large part of its vast production.

In many of his treatises he inserts exemplary drawings derived from its professional practice in which there is always the worker's eye, activity that had characterized his early training.

In 1794 he attempted the orthographical projection of objects in any given position to the plane of projection and he succeeds in describing the "ichnography and the elevation" of a rectangular parallelopipedon [9]. The printed drawing (fig. 4) of the plates processed in those years appears in II vol. of the *Principles of Architecture* (fig. 5) published in 1797 [Nicholson 1797], but the work is republished with improvements in the year 1809.

The principles of the projection formed at that time for English draftsmen the British equivalent of Monge Descriptive Geometry. And Nicholson can be considered one of the main scientist on the subject at that time in England. He himself was claiming its autonomy from Monge asserting, strongly and with many arguments, that he did not knew the treatise of Monge until the year 1812, when the engraver Wilson Lowry would have lent him a copy [Nicholson 1828, pp. 44-54].

Although he often uses his personal projection method in different works intended for building operators, he produces a more rigorous dissertation at first in the *Architectural Dictionary* of the year 1812 s.v. '*Projection*' [10]–in which also inserts a large extract of the Descriptive Geometry of Monge s.v '*Descriptive Geometry*' translated by Mr. Aspin [Nicholson 1819a]–then in the *Ree's Cyclopaedia* of the 1814 [11]. That year he is called by Abraham Rees, as an expert in the subject, to write, for the vol. XXVIII, one of the most relevant articles (more than 15 columns s.v. '*Projection*'), to be followed by the related graphic plates in the IV vol. (plates) of the year 1820 [Nicholson 1820].

The Nicholson projections soon became the British system of representation [Grattan-Guinnes, Andersen 1994]. In its final version, it has collected some principles and nomenclatures of descriptive geometry, preserving, however, his original prerogatives [12]. This system indeed, closely linked to the practice of stereotomy and carpentry, had the advantage of being easy to remember and readily adaptable to the practical problems of architecture and engineering. A forerunner of the method 'direct' called by the Anglo-Saxons [Rowe, McFarland 1939], which determined, in English-speaking countries, an increasingly sparse production of theoretical texts of Descriptive Geometry in favor of those more properly called of 'technical drawing'; in these latter, theoretical assumptions are reduced for the benefit of

practical techniques for graphical visualization. The knowledge that Nicholson had of projection techniques used in the crafts of the stonemasons and joiners was unquestionably important in the definition of his method.
The personal research to develop a graphical method of valid use, not only for architects and engineers, but also for workmen, led him to constantly expand its studies on the subject. So he refined at first the orthographic projections in the treaty of the year 1827 *A Popular and Practical Treatise on Masonry and Stone-cutting* [Nicholson 1827]. Later he defined the system that he called "oblique parallel projection"; a projection system offering along with orthographic views also a three-dimensional image of the object.
Therefore, it is indisputable that in Britain, in those years, there was an independent research orientation that was not only supported by Nicholson, perhaps less known to historiography than scientists as William Farish, Joseph Jopling and Thomas Sopwith. Indeed, the attempt to define a universal system of graphic communication [Booker 1963] based on a clear geometric visualization had led many island theorists to try developing less abstract and easy to apply methods of representation [Docci, Migliari 1993; Càndito 2003] compared to that of Monge, which however did not remain without echoes.
Actually the parallel orthographic projection of Nicholson, having as reference a single plane of projection (fig. 6), can rightly be considered an axonometric representation that, before Farish and unlike the latter's work, starts from the true shape and size of the object to represent. Examples are the plate of the year 1794, and the plates accompanying the writings of the years 1812 and 1814. These are orthogonal axonometries (figs. 7, 8), which under certain conditions–such as an inclination of the plane of projection of 90 degrees with respect to the plane of the figure (original plane)–result as projections entirely comparable to those theorized by Monge. For example, when solids are represented in that condition, the axonometric projection of the base is reduced to a segment; in this way, the axonometric image of the volume is tantamount to an elevation (a second projection in Monge method), that it is moreover correlated with the true shape of the base.
So, when William Farish, scientist and professor of Chemistry and Natural Philosophy at the University of Cambridge, published in 1820 his study on isometric orthogonal axonometry, the science of representation in Great Britain seemed to have finally arrived at a new method, simpler, more effective and respectful of a peculiar identity.

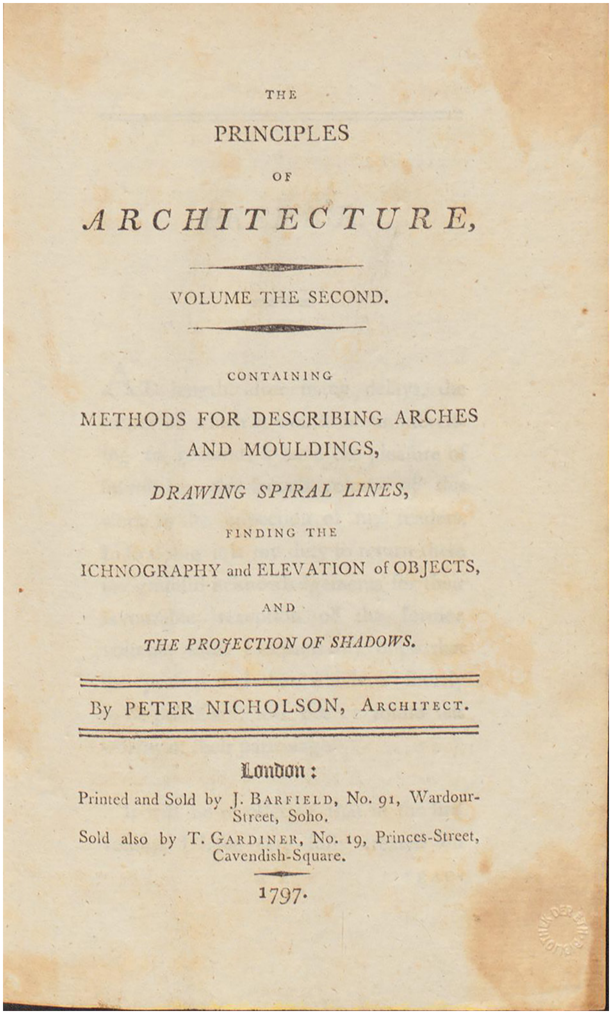

THE
PRINCIPLES
OF
ARCHITECTURE,
VOLUME THE SECOND.
CONTAINING
METHODS FOR DESCRIBING ARCHES
AND MOULDINGS,
DRAWING SPIRAL LINES,
FINDING THE
ICHNOGRAPHY and ELEVATION of OBJECTS,
AND
THE PROJECTION OF SHADOWS.
By PETER NICHOLSON, ARCHITECT.
London:
Printed and Sold by J. BARFIELD, No. 91, Wardour-Street, Soho.
Sold also by T. GARDINER, No. 19, Princes-Street, Cavendish-Square.
1797.

Fig. 5. Frontispiece of The Principles of Architecture, vol. II [Nicholson 1797].

Apart from the works of Nicholson and a reference to the topic of Descriptive Geometry, made by the Scottish scientist John Leslie [13], Monge's work in those years does not seem to have been fully accepted by the British

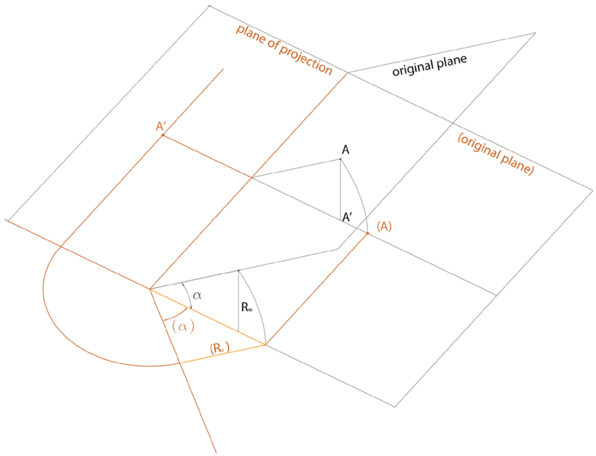


Fig. 6. Spatial scheme illustrating the method of projection used by Nicholson (graphic elaboration by the author).

scientific world. This is evidenced by the fact that various encyclopaedias of the time such as the *Encyclopædia Britannica* or the *Chamber's Cycopædia* do not hint at the subject neither under the heading '*Monge*' nor by presenting a specific note under the heading '*Geometry*'. On the other hand, in 1836, Mr. Thomas S. Davies [14], at that time one of the mathematical masters at the Royal Military Academy in Woolwich, wrote " several years ago a considerable extract was made from Monge's work in the Architectural Dictionary of Mr. Peter Nicholson. […] Mr. Nicholson afterwards commenced a work in numbers, bearing the title of Descriptive Geometry, but the commercial casualties of the period (1825) put a stop to the undertaking […] Nothing further on this branch of science has appeared in England" [Cunningham 1868, pp. 49, 50].
In 1837, again Nicholson published *A Treatise on Projection* in which the method of parallel oblique projections was anew presented, and in a more complete form [Nicholson 1837]. On the work of Nicholson, the engineer and geologist Thomas Sopwith in the preface to his own 1838 treatise on the isometric drawing will write: "This method possesses the advantages of being extremely simple in its principles and universal in its application; nor in the writings of either continental or English authors has any other general method been proposed" [Sopwith 1838, p. 66]. A method based on the clarity of perception in relation to the intuitive relationship between orthographic view and the spatial configuration represented.
Only in 1841 was published by the editor J. Parker the first text in English of Descriptive Geometry entitled *The Elements of Descriptive Geometry, chiefly designed for Students in Engineering*. It was an educational text written by the Reverend Thomas Grainger Hall [15], a professor of mathematics at the King's College in London, in support of the students of the course of Mr. Thomas Bradley [16], then lecturer of geometric design at the Department of Civil Engineering and Mining from the same College (figs. 9, 10). The writing, produced in close collaboration with Bradley himself, was, in fact, largely a translation from the French of the Lefébure de Fourcy treatise [17].
In 1849 the Lords Commissioners of the Admiralty [18] intrusted the publication of a *Treatise on Descriptive Geometry and its Applications to Shipbuilding* to the Reverend Joseph Woolley [19], for the Portsmouth Dockyard shipbuilding school. The treatise also had to be adapted to university students in civil engineering.
The treaty was published in 1850 [Woolley 1850]. It is interesting to note how the British scientific community began to become aware of the Monge's work importance and the delay with which it was received until the middle of the century by the British scholars. This is, in fact, what Woolley writes in the preface: "The properties of Descriptive Geometry have been thoroughly investigated by continental mathematicians: they have paid the greatest attention to the subject: by us it has not met with that regard it most deservedly merits; since it contains not only a course of geometrical reasoning of a most interesting character, but it also unfolds to us properties of the highest value to practical mathematicians. As this volume is designed not only for students who have the advantage of constant direction, but also for those who, deprived of tutorial aid, may yet be desirous of acquiring a knowledge of the principles of the science, it became necessary, in the introductory and elementary parts, to have an especial view to the latter class of students" [Woolley 1850, pp. III, IV].
It is also clear the commitment not only to design the work for university students use but, according to the British tradition, also for those who, without a tutorial aid, were desirous of acquiring a knowledge of the principles of the new science. The text still refers to two French works. This is the volume of A.F. Amadieu, *Notion*

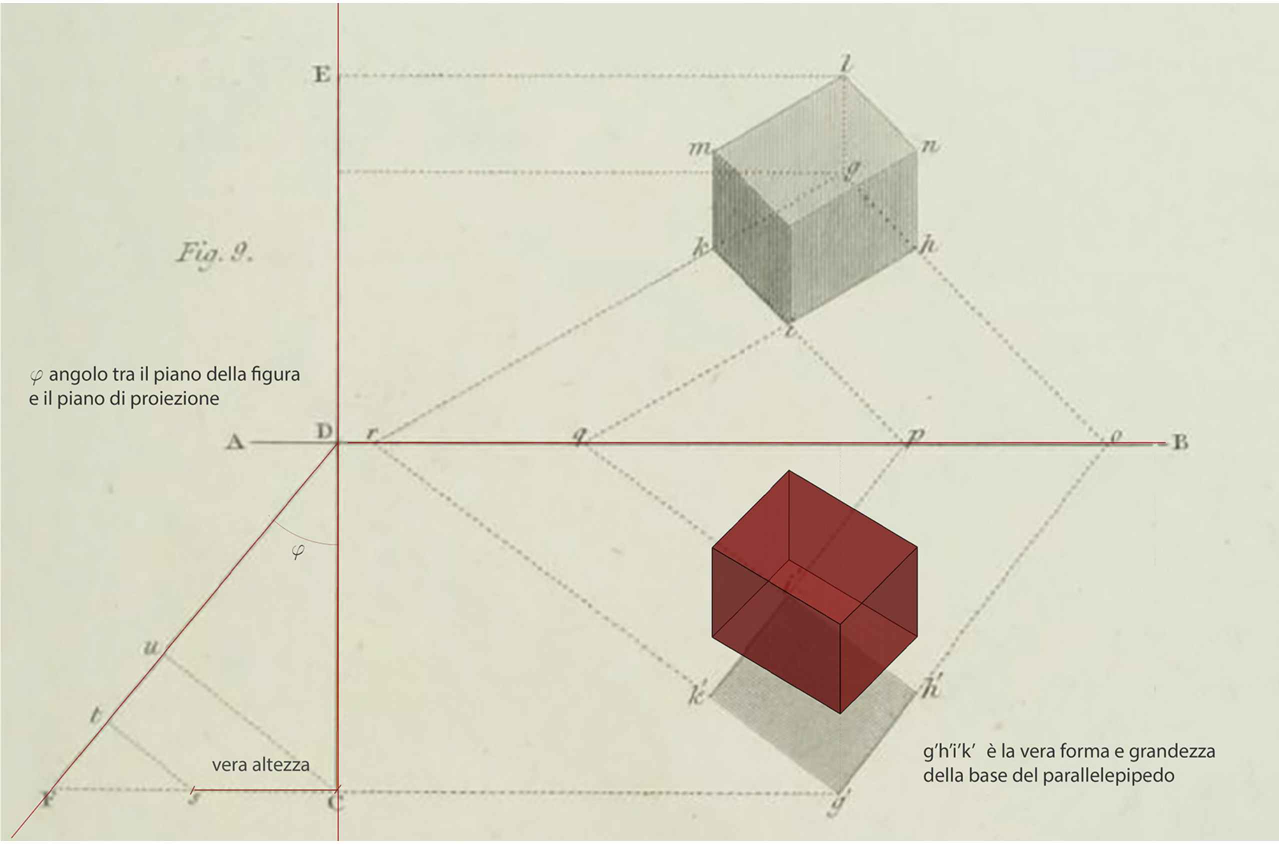


Fig. 7. Digital representation on the basis of a Nicholson drawing: projection of a solid object (graphic elaboration by the author).

élémentaires de géométrie descriptive éxigés pour l'admission aux diverses écoles du gouvernment published in Paris by Bachelier in 1838 and, again, the work of Lefébure de Fourcy, already mentioned, used in this case to treat the properties of the hyperboloids of revolution, the hyperbolic paraboloid, and the twisted surfaces in general, as well as the properties of the spherical epicycloid. At the end of the introduction to the two volumes the author still makes some considerations on the state of knowledge of the new science of representation in England: "The scarcity of works on this subject in the English language has encouraged the author to hope that much of the contents of the present volume will be new to the English student: that not only the Naval Architect and Engineer (who is especially interested in this branch of mathematics) will find it of use, but also students in the Universities, to whom the principles of the Geometry of Space are usually accessible only in an analytical form, will find this subject rendered much more distinct and clear when seen by the light which the more palpable methods of Descriptive Geometry enable us to throw upon it" [Woolley 1850, p. IV]. In Woolley's text, for the first

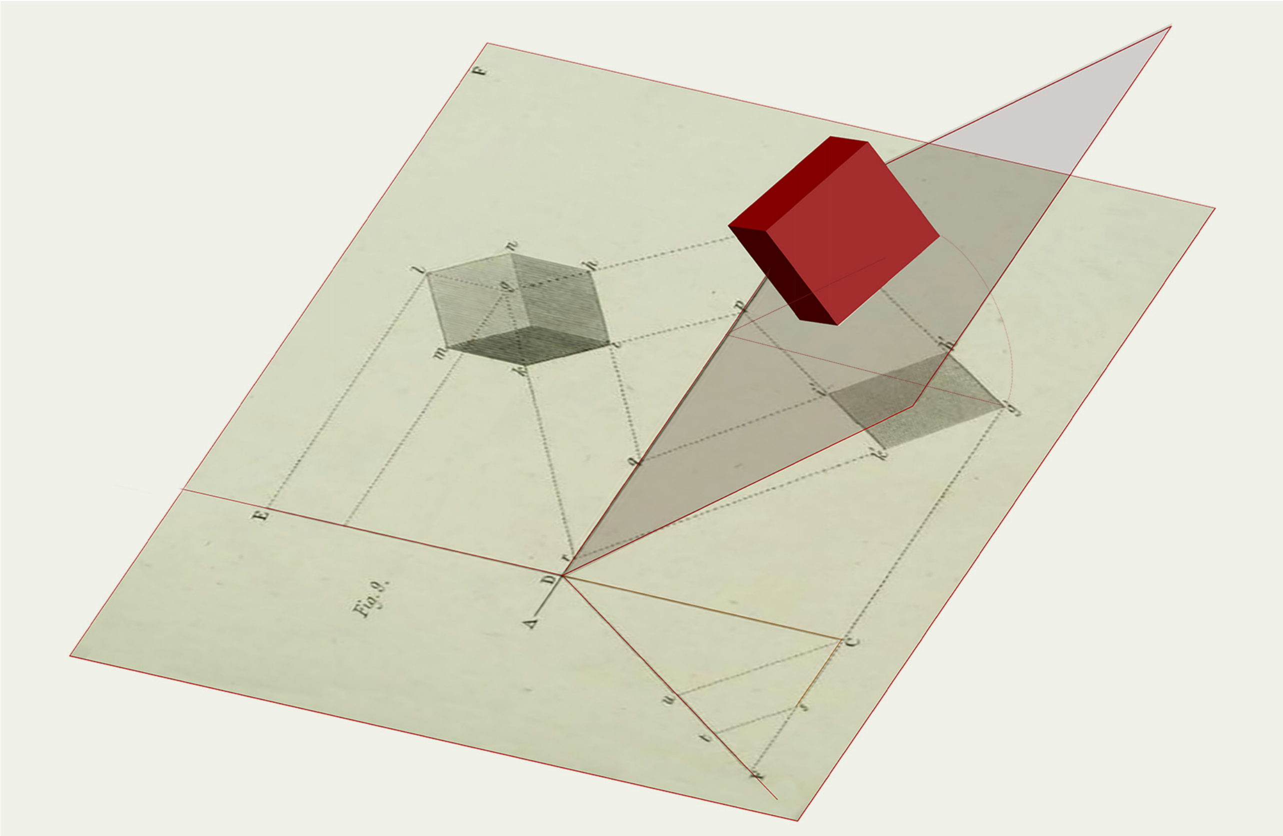
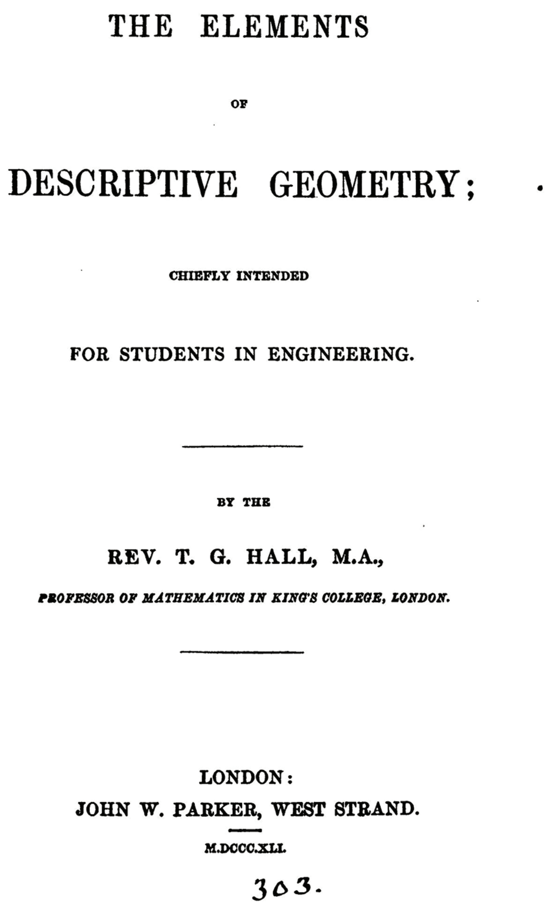


Fig. 8. Axonometric scheme; projection of a rectangular parallelopipedon (graphic elaboration by the author).

time the rabatment principle is clearly explained and the French term '*Rabattement*' is left unaltered. It is significant to note that in the 1860 *Encyclopædia Britannica* under the heading '*Shipbuilding*', in the part dedicated to the practice, the author of the article says that the principles for making constructive drawings are "very able treated by the Rev. Dr. Woolley, in a work entitled *Descriptive Geometry*. Before the publication of this work the efforts in this direction in this country had been chiefly made by practical men, each showing the mode of delineating the more difficult object in his own art" [Murray 1860, p. 184].

Conclusion

Immediately after the Universal Exposition, the English educational system was the object of a profound reflection; it was highlighted the weakness of a scientific approach that could have driven industrial development itself. In a tight period of time new university institutions arose. Between 1840 and 1860 in the architecture and engineering programs even in the most traditional schools, some teachings of descriptive geometry, projections and axonometric drawings appeared, hybridizing the national



THE ELEMENTS

OF

DESCRIPTIVE GEOMETRY;

CHIEFLY INTENDED

FOR STUDENTS IN ENGINEERING.

BY THE

REV. T. G. HALL, M.A.,

PROFESSOR OF MATHEMATICS IN KING'S COLLEGE, LONDON.

LONDON:
JOHN W. PARKER, WEST STRAND.

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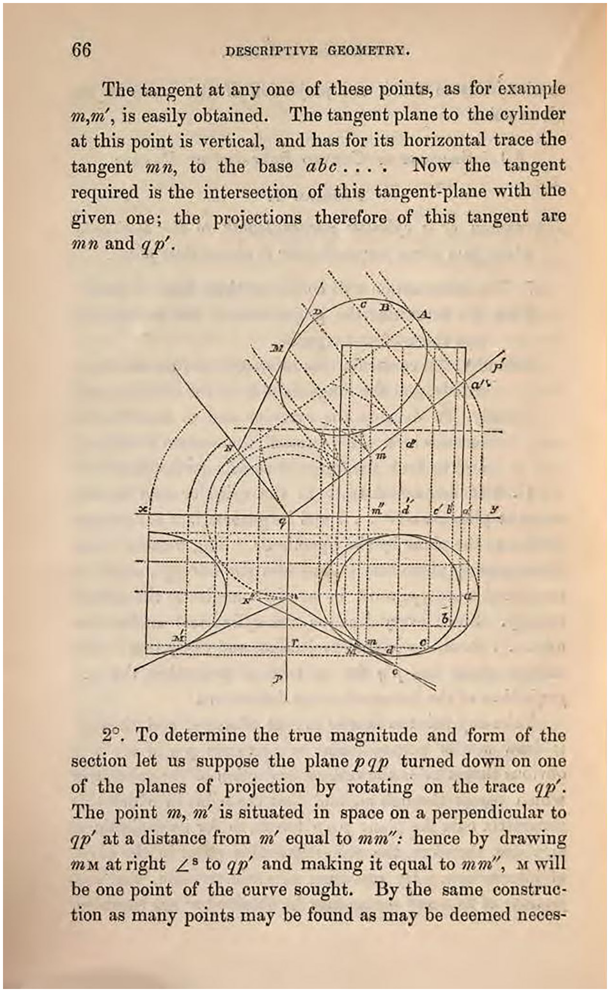

66 DESCRIPTIVE GEOMETRY.

The tangent at any one of these points, as for example *m,m'*, is easily obtained. The tangent plane to the cylinder at this point is vertical, and has for its horizontal trace the tangent *mn*, to the base *abc*.... Now the tangent required is the intersection of this tangent-plane with the given one; the projections therefore of this tangent are *mn* and *qp'*.

2°. To determine the true magnitude and form of the section let us suppose the plane *pqp* turned down on one of the planes of projection by rotating on the trace *qp'*. The point *m, m'* is situated in space on a perpendicular to *qp'* at a distance from *m'* equal to *mm''*: hence by drawing *m*M at right ∠s to *qp'* and making it equal to *mm''*, M will be one point of the curve sought. By the same construction as many points may be found as may be deemed neces-

Fig. 9. Frontispiece of The Elements of Descriptive Geometry [Hall 1841].

Fig. 10. Sections of curved surfaces by planes [Hall 1841, p. 66].

theories of Nicholson and Farish with the Monge's ones [Lawrence 2003, Cardone 2017].
In 1851 it was John Fry Heater [20] of the Royal Military Academy of Woolwich who still published a book on Descriptive Geometry. This time the text is composed of copious extracts of Monge's work. Although this represents a further step in the transfer of the original contents of the French engineer, the fact that it did not offer the whole work, but only extracts, was the object of criticism. In 1868 Cunningham wrote that, although the Monge's text itself, albeit with the posthumous additions of Brisson, is complex and perhaps not suitable as a textbook, Heater's book, certainly excellent, has damaged the cause of Descriptive Geometry in the Country. Indeed: "It has been a stumbling-block to many, who, regarding it as a complete elementary text book on the subject, have, after a brief inspection, laid it aside, and rashly pronounced that Descriptive Geometry was not sufficiently practical for their requirements" [Cunningham 1868, p. 52].
In any case, in the sixties of the Nineteenth Century the Descriptive Geometry is a matter required also in universities, so much so that in 1861 the Committee of Council on Education asked Mr. Bradley–at the time a professor at the Royal Military Academy and at the King's College in London–to prepare a complete course of Geometric Drawing ("Graphic Geometry"). The text written for the above course, divided into two parts, will be titled *Elements of Geometrical Drawing, or Practical Geometry, Plane and Solid, including both Orthographic and Perspective Projection* [Bradley 1861], and was considered, in those years, one of the most complete works both in practical and theoretical terms, also accompanied by splendid drawings [Cooke 1866, p. 136]. Bradley's book became a fundamental text for training and was used as a reference for qualifying certification exams periodically issued by the Royal Society of Arts [21].
We have to note that both Woolley and Bradley's text were produced on the initiative of the government, interested in those years to improve training within many special schools of the Army and Navy. With considerable delay, but with great awareness of its usefulness, the Descriptive Geometry, although taught in a different way than France, is now firmly part of the study programs, both in technical schools–for example the Royal School of Mines–both in the Universities, in particular in the schools of architecture, engineering and mechanics [Lawrence 2008].

Notes

[1] The list could also include other famous names as James Brindley (1716-1772) who was trained as millwright; James Hargreaves (1720-1778) who began his career as carpenter and hand loom weaver, as well as Samuel Crompton (1753-1827). See also Buchanan 1978.

[2] Babbage writes: "It cannot have escaped the attention of those, whose acquirements enable them to judge, and who have had opportunities of examining the state of science in other countries, that in England, particularly with respect to the more difficult and abstract sciences, we are much below other nations, not merely of equal rank, but below several even of inferior power. That a country, eminently distinguished for its mechanical and manufacturing ingenuity, should be indifferent to the progress of inquiries which form the highest departments of that knowledge on whose more elementary truths its wealth and rank depend, is a fact which is well deserving the attention of those who shall inquire into the causes that influence the progress of nations" [Babbage 1830, p. 1].

[3] Religion has significantly influenced the development of technical education in England. Indeed, all the phases of the English educational system have been subjected to religious dogmas and beliefs that have hindered the development of an effective national education system over many centuries.

[4] The Uniformity Act of 1660 established that: "Every schoolmaster keeping any public or private school and every person instructing or teaching any youth in any house or private family as a tutor or School master' should subscribe a declaration that would confirm to the liturgy as by law established and should also obtain a licence permitting him to teach from his respective archbishop, bishop or ordinary of the diocese" [Parker 1914, pp. 46, 47].
[5] Until the Oxford University Act of 1854, the University of Oxford requested an admission test of conformity to the Church of England. [Brock & Curthoys 1997, p. 220; Marsden & Smith 2005, pp. 251, 252].

[6] Booker in its text *A history of engineering drawing* claims that Monge's Descriptive Geometry slowly spreads to England "possibly because they were on too theoretical a level for the practical Englishman" [Booker 1963, p. 130].

[7] Several authors, including Lawrence (2003), Sakarovitch (2005) and Belofsky (1991), converge in dating the arrival of Monge's work in England. Both Lawrence and Sakarowitch refer to a translation of Monge's method in 1809. In particular, Lawrence writes: "*Géométrie Descriptive* was translated into Spanish in 1803, and into English in 1809, presumably for military

purposes, as there are no publications to be found in English libraries to suggest that the work was made public" [Lawrence 2003, p. 1270].

[8] Regarding Brunel's contribution to the arrival in Great Britain of Monge's Geometry, Cardone writes: "He […] left France when engineering studies had not yet been reformed and descriptive geometry was still covered by military secrecy; but he had to know the new discipline, set by Monge as early as the mid-sixties of the century, in Mézières. To prove it, the fact that the French gendarmerie searched him for a long time, just fearing that he was the depositary of some secrets of the master. And, even more, the noble title of which Brunel was awarded in Britain, precisely because he introduced the new discipline beyond the Channel and not, as was also believed, for the construction of the Thames Tunnel": Cardone 2017, p. 150. A careful biography of Brunel is in the recent book of Bagust 2006.

[9] Precisely, Nicholson writes: "In the year 1794 I first attempted the Orthographical Projection of objects in any given position to the plane of projection; and, by means of a profile; I succeeded in describing the ichno-graphy and elevation of a rectangular parallelepipedon: this was published in volume II of the 'Principles of Architecture'" [Nicholson 1828, p. 46].

[10] The *Architectural Dictonary* was published between 1812 and 1819. The edition consulted and reported in the bibliography was found online at the Universitätsbibliothek of the Berlin Technische Universität and is dated 1819.

[11] The vol. XXVIII of *Rees Ciclopædia* was published for the first time in 1814. However, the text quoted in the bibliography dates back to 1819. To avoid errors in dating, it is important to clarify that the encyclopedia was printed from January1802 to July 1820. After the conclusion of vol. XXXIX, the entire series was reprinted with the only date of 1819. Since this, however, posed a problem of priority of published scientific research, in the Philosophical Magazine of 1820 a list was published with the correct dating of all 85 parts of the 39 volumes: "We have been sorry to observe the date 1819 affixed to the title page of each of the 39 volumes, instead of the particular year, in which each volume was finished; because of the great number of discoveries and improvements in the useful Arts and Sciences, which have been for the first time submitted to the Public […] We trust therefore, that our Readers will approve our giving here, a list containing the Dates of Publication, of each of the 85 Parts of this extensive Work" [Tilloch 1820, p. 222].

[12] In the treatise *The School of Architecture and Engineering*, Nicholson, introducing to the projections, points out the difference between the Descriptive Geometry and the projection he treated: "Projection is an art which teaches the rules for representing (or drawing) upon one plane, any body or solid whatever, the position of one of them, and the position of one of them to the Plane of projection are known" [Nicholson 1828, p. 51].

[13] John Leslie (1766-1832) was a Scottish mathematician and physicist, professor of Mathematics and Natural Philosophy at the University of Edinburgh and a correspondent member of the Royal Institute of France. He refers to the Descriptive Geometry in the preface to the text *Geometrical analysis, and geometry of curve lines, being volume second of a course of mathematics, and designed as an introduction to the study of natural philosophy* of 1821: Leslie 1821, p. IX. Here, he advances the personal purpose of writing a book on Descriptive Geometry and Solid Theory. That Leslie was aware of the new discipline is probable. The part on the geometric analysis of 1811 Leslie's text [Leslie 1811], is translated into French by M. Comte, to be inserted in the text of M. Hachette of 1818, *Second Supplément de la Géométrie Descriptive*, published in Paris by Firmin Didot: [Hachette 1818, pp. IV, X].

[14] Thomas Stephens Davies (1794?-1851) was a British mathematician. In 1834 he was nominated among the mathematical masters of the Royal Military Academy in Woolwich.

[15] Thomas Grainger Hall (1803-1881), of a deeply religious family, first studied in the city of Wisbech and then at the Magdalene College of the University of Cambridge. He obtained his Bachelor's degree in 1824 and became a Master of Arts in 1827. In the same year he was ordained deacon and then received the priesthood in 1828. He taught mathematics at King's College in London from 1830 to 1869. From 1851 to 1861 he held the office of Dean of the Applied Sciences Department and from 1861 to 1862 he was Dean of the engineering section of Applied Sciences Department. He was the author of several writings of algebra, differential and integral calculus, and trigonometry. See Cambridge University Alumni, 1261-1900; Secretary's In-Correspondence, KA / IC / G31, King's College London Archives.

[16] Thomas Bradley (1797?-1869), was born in Westminster in London. On Bradley's date of birth there are still some uncertainties, since on some documents the date of birth is 1797, while the documentation held by King's College shows the date of his baptism on 28 April 1799 at St. Anne's Church Soho in London, and this leads the same historians of the College to date their birth in that year. In 1838 he was appointed superintendent of the Royal College of Practical Science and was appointed as a lecturer of Geometrical Drawing at King's College London. He became a professor in 1848. In 1855, while maintaining his position at the London University, he was also called to teach at the Royal Military Academy in Woolwich. Thomas Bradley was the first to give lessons on Descriptive Geometry during the sessions of 1839-1841 at the Department of Engineering at King's College. These lessons were also part of the architecture curriculum.

[17] Thus declares Hall himself in the preface: "The treatise on Descriptive Geometry, by Mr. Lefébure de Fourcy, has been selected, and the following pages are, for the most part, translated from it": Hall 1841, pp. V-VI. Louis Lefébure de Fourcy (1787-1869) was a French mathematician. He worked at the École polytechnique as deputy assistant and then assistant at the course of Descriptive Geometry by Charles François Antoine Leroy. Although this is a secondary figure [Cardone 2017, p. 157], his text of Descriptive Geometry, along with other mathematical writings, has long been considered a 'classic', as evidenced by the fact that in 1847 it was in its fifth edition [Havelange et al. 1986, p. 452].

[18] It was the Admiralty Office Council, one of the great British state offices that ran naval affairs.

[19] Joseph Woolley (1817-1889), was a naval architect. He trained at the University of Cambridge and for about 25 years served Admiralty as instructor of naval architecture and as inspector. Noteworthy was his contribution to shipbuilding education.

[20] John Fry Heater (1815-1886), naval architect.

[21] The Royal Society for the Encouragement of Arts, Manufactures and Commerce or simply called the Royal Society of Arts, became the first association to offer vocational qualifications at the national level. The qualification exams, established in 1852, were specifically aimed at the so-called working class, whose education began to be considered fundamental for the economic prosperity of the country. In 1863 it was possible to support the examination also in Geometric Drawing. Among the recommended texts were those of Bradley and Hall and "in consequence of the great deficiency of English works on Geometrical Drawing" also the French texts of Descriptive Geometry of Lacroix, Lefébure de Fourcy, Armengaud and Amouroux (for industrial drawing) and Bardin. See [Blake 1862].

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Geometric and Instrumental Measurement in Representation

Cristina Càndito

Abstract

The recurring references to the topic of measurement in perspective studies between the seventeenth and eighteenth centuries highlight a return to objectivity in the method of perspective representation at a time when more emphasis was placed on its perceptive aspect. The present contribution examines a series of treatises, which contributed to achieving the perspective construction system of the measuring points, together with the evolution of a number of instruments used to measure architectural structures and spaces.
The manuscript on perspective by Jacques Alleaume, written in 1627 and posthumously published by the mathematician Estienne Migon (La perspective speculative et pratique, 1643), contains one of the first methods to represent segments in perspective, which are assigned by values of inclination and length.
The identification of the measuring points through the progressive generalisation of the problem is first found in the Cours de mathématiques by Jacques Ozanam (1693) and then in the work by Brook Taylor (Linear Perspective, 1715), whose most noted contribution was the systematisation of the reverse perspective method.
The claim by Ozanam to extend the use of the Universal Instrument to practical geometry (1688) reflects the general focus on the topic of measurement with regard to the fundamentals in theoretical mathematics, the scientific value of the representation methods, and the instruments to survey architectural structures.

Keywords: Drawing, Perspective, Measurement, History of Representation, Survey Instruments.

Perspective between perception and measurement

> «Aveva il senso della misura ma non quello delle proporzioni.
> Per questo non fece molti errori in vita sua, ma tutti colossali.»
> [Mauro Parrini 2009]

The most evident purpose of perspective is to create three-dimensional perception of a represented subject. Unlike cylindrical projections, in order to obtain measurements from conical projections it is necessary to apply inverse procedures that are so complex that the role of measurement in perspective may be overlooked as a result, even though it has always had a strong tradition in architecture. This aspect is connected to artistic and instrumental applications, which developed over time and have relevance even today, such as digital photogrammetry that has been increasingly spreading and used for various purposes than ever before.
The present contribution pinpoints some key moments in this evolution, referenced in books on the history of perspective and survey, and in studies on the relationship between architecture, science, and technique. The application of these innovations to surveying methods demonstrates the versatility of this field of study, which encompasses all methods of representation of the space on a plane [1].
The close relationship between measurement and architecture is often mediated through representation, because representation is recognised as the preferred method to quantify the value of a spatial concept from a physi-

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cal, aesthetical or functional point of view. Currently, the theme of measurement has a tangible feedback in the challenges of contemporary architecture, which combines historical visions and current designing proposals, also through their poetic interpretation [2].
The search for configuration of the proportional ratios between architectural elements seems to be at the core of the contributions by Filippo Brunelleschi (1377-1446). Besides the extraordinary and demonstrative importance of his two lost perspective panels (their age is still debated today, between 1413 and 1424) [3], he was interested in the aspect of measurement –not only perception– concerning the new (or rediscovered) representation method of three-dimensional reality on a plane.
His choice of a symmetrical subject for his first experiment, the Florence Baptistery, allowed Brunelleschi to overcome the discrepancies connected to the method that was probably used to perceive representation, i.e. specular representation. The first method of perspective representation in the Renaissance and many of its subsequent echoes in the arts seemingly cannot be compared with the configuration methods that are found mainly in the current figurative world, which is often specifically focused on going beyond the symmetry rules of classical architecture and its derivatives [Cohen 2001].
From the point of view of perspective representation, the use of measurement was likely introduced with the perspective construction using measuring points, besides the processes of reverse perspective, even if evident signs of this connection can be noted in the entire history of representation.
Of the wide and unending debate on perspective between theory and practice in the Fifteenth and Sixteenth centuries, it is relevant for the purposes of the present study to mention the discussion on the introduction of the distance points, as the forerunner of the methods more generically adopted by the measuring points.
Within pictorial art, Leon Battista Alberti (1404-1472), in his treatise *De Pictura*, was the first to illustrate a perspective method that, even if limited to one particular case, was able to offer painters the possibility to create a measurable space [4]. The checkerboard floor, projected on a three-dimensional space, provided a model for painters to draw accurately, while at the same time leaving them considerable freedom, as much like metrics gives to poetry. In fact, the aim of the great architect and humanist was notoriously to elevate figurative arts to the same dignity as liberal arts. He sought to achieve this by changing the concept of the bottega (workshop) itself, which started to adopt a more scientific approach using perspective constructions.
In Alberti's construction, it is possible to define the decreasing distance in perspective between the equidistant parallel lines, perpendicular to the picture plane, through the rabattement of the observer's position. Apart from a number of significant precursors [5], from this moment onwards painters started applying this same method in various paintings. This can be verified thanks to one parameter described in Alberti's text and based on aligning the intersection points of the checkerboard floor: this is not yet an intentional use of the distance points, but there is undoubtedly the same geometrical reasoning at work.
There are plenty of transgressions in the paintings by those artists who understood and valued the corrective effects of perspective, but could not renounce a certain degree of autonomy in their art. In fact, there are often compromises to conciliate the contradictions resulting from diminishing one dimension in the attempt to represent reality, which then alter even the most evident perspective rules. In some paintings, the parallel lines do not converge in one vanishing point or, more frequently, there is an alteration of the measurements in depth, as one can observe in the works by some of the greatest practitioners in perspective art, such as Paolo Uccello[6].
The present contribution will not explore the complex evolution of the discipline's theory and practice, but it is worth noting that in the sixteenth century the transgressions to the norm became increasingly more elegant, while measurement was becoming consolidated even more so as an element that could be controlled through perspective. According to some critics, distance points were first used to their full extent by Jean Pélerin, known as Viator [Pélerin 1505] [7] but there are earlier illustrations in works by Leonardo da Vinci and Piero della Francesca [Piero della Francesca 2017].
Jacopo Barozzi, known as Vignola (1507-1573), and Egnatio Danti (1536-1586) described the two constructions [Barozzi da Vignola 1583, pp. 69, 100] [8], i.e. the *'albertiana'*, based on the intersection, and the *'pierfrancescana'*, using distance points. Combining the two methods (fig. 1) shows that the intersection rule (on the left, with the distance point *D*, as a rabattement of *V*) and the rule of the distance point (on the right, with the profile of the picture plane π and the point of view *V*) lead to the

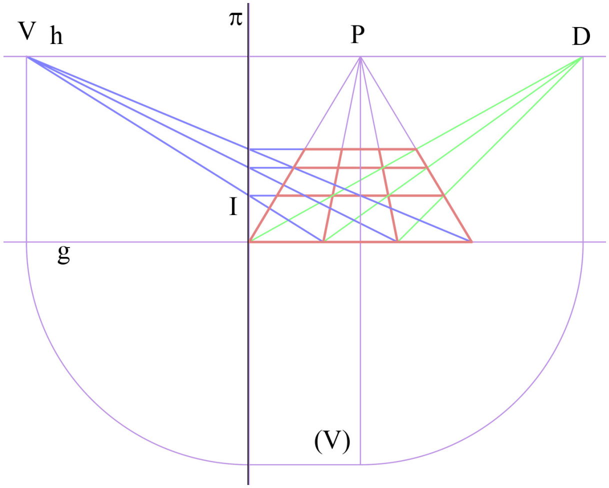
same result. The text by Vignola and Danti also describes a device used to unveil secret perspectives [Barozzi da Vignola 1583, p. 96], which, even if notoriously recognised as an approximate method to generate or interpret perspective anamorphosis, is still effective to reproduce the proportion of an otherwise deformed drawing (fig. 2).

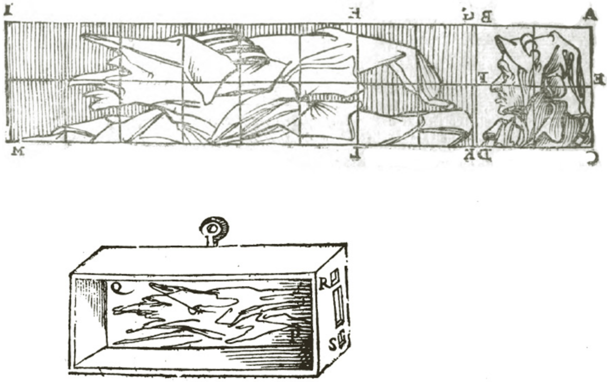
Seventeenth-century contributions between measurement and projection unification

A number of significant events in the Seventeenth century led to the revival of measurement in perspective, thus affirming a common basis for what are classified today as methods to represent space on a plane.
Among the pioneering texts, critics recognise the text on perspective by Guidobaldo Bourbon del Monte (1545-1614), written in 1600 [Del Monte 1600], with direct perspective constructions of figures (second book), which pioneered the studies on recognising projective relationships between the projections of the same object.
Today the role of Girard Desargues (1591 1661) is also commonly acknowledged for his text [Desargues 1636], in which he explained a method based on identifying the reduction of measurements in perspective. Without using distance points or other points outside the picture plane (as stated in its title) and based on dimensional perspective scales, Desargues utilised the only proportion that is maintained in all types of projections: the cross-ratio. Also, the contributions deriving from Desargues' text on conical projections in 1639 [Desargues 1639], intended as central projections of a circle, introduced the improper elements (points and lines at infinity) that constitute the essential premise in projection unification [Docci, Migliari, Bianchini 1992].
In 1605, Simon Stevin (1548-1620) [Stevin 1605] recognised –even after the rabattement of both the picture plane and the horizontal plane that crosses the horizon line– the characteristics of the perspective image are maintained, and he identified that the projective ratios between the real figure on the geometric plane and its perspective image are also maintained [9].
Regarding the relationship between perspective and the measurements of the represented object it is important to pinpoint the premises and the systematisation of the construction using the measuring point system. The manuscript on perspective by the engineer Jacques Alleaume

Fig. 1. The intersection rule (on the left of the drawing) and that of the distance point (on the right of the drawing) lead to the same result.

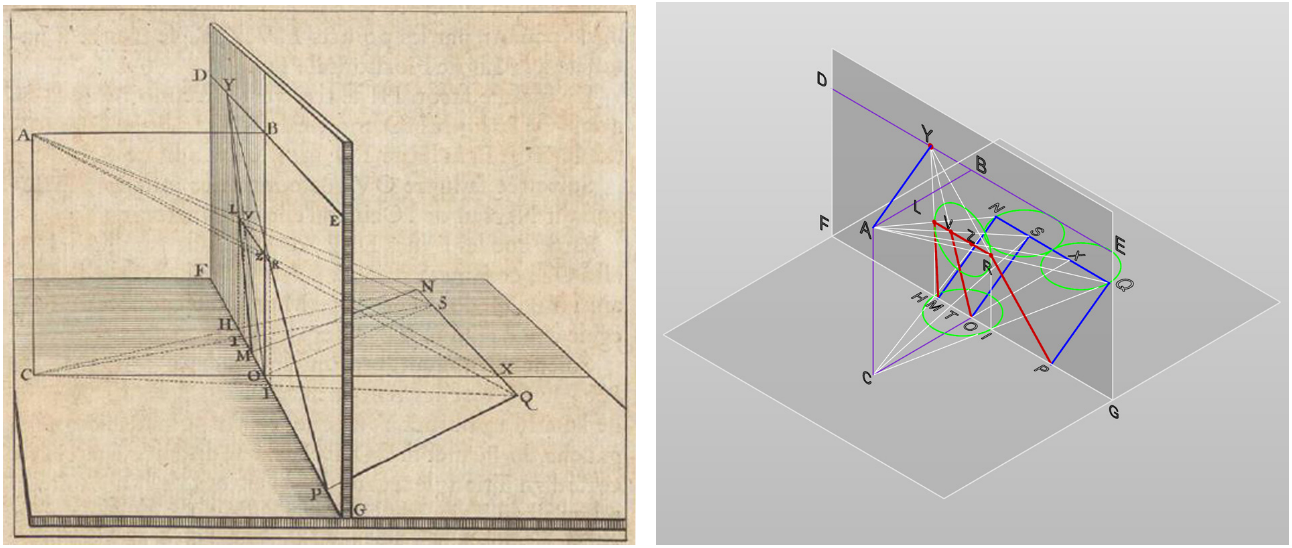
Fig. 2. Pitture segrete [Barozzi Vignola 1583, p. 96]. An approximate construction of anamorphosis.





(1562-1627), titled *Introduction à la perspective, ensemble, l'usage du compas optique et perspectif* [10] is considered an extremely significant contribution to this topic. After its author's death, the text was not printed in its original version and it is now lost. Mathematics professor Estienne Migon bought the book's rights and published it with some adaptations and additions [Alleaume, Migon 1643] –that cannot be clearly differentiated from the original text– in order to give credit to Alleaume for the perspective method by Desargues [11]. In his text, articulated in eight propositions and eleven problems, there are even pioneering elements of the measuring points in *proposition V* and *problem VI I* [Vagnetti 1979, pp. 385-398].
Proposition V [Alleaume, Migon 1643, pp. 39-43] illustrates a spatial system aiming to demonstrate the concurrence of the images of the parallel lines in one point of the horizon line (fig. 3). The process is complex but it does not offer general elements useful to recognise the precise ratios of measurements in perspective, because the provided example refers to the particular case of one segment placed at a distance from the picture plane equal to the main distance. In fact, the observed doubling and halving (e.g. *HI = 2 NQ*) do not seem to aim towards measuring functions, but more towards the construction of similarities able to lead to the demonstration of the concurrence in one single vanishing point (*Y*) of the parallel lines.
In *problem VII* [Alleaume, Migon 1643, pp. 128-130] there is a greater focus on the theme of measurement in perspective, as it sought to provide a method to construct segments of a desired length and angulation (fig. 4).
This contribution provides the following an interpretation of this proposition, which reveals its original structure, but also its limited general application. With the given line *NL*, with *N* as its intersection point with the horizontal line and *L* as its intersection point with the horizon line (i.e. its vanishing point), the perspective of one of its segments of a 16-unit length (it could be any unit of measurement, in this case feet), starts from any point *M* on it. From *N* count 16 units (or multiples) along the ground line –scaled appropriately– and identify point *O*, which connects with *L* and allows *MP* to be drawn, which represents in perspective a 16-feet long segment, parallel to the horizon line. To project this measurement on the half-line *ML*, consider that, because *ML* forms an angle

Fig. 3. On the left, Proposition V [Alleaume, Migon 1643]. On the right, three-dimensional elaboration with the proportional ratios due to the position of NQ, (graphic elaboration by the author).



of 58° with the ground line, one can consider *MP* as the side of an isosceles triangle, the other side of which, *MR*, along *NP* has to be determined. This triangle *PMR* must have two equal angles at its base, the sum of which is supplementary to 58°, i.e. 122°, which divided by two shows that *MPR* = *MRP* = 61°. For this reason, from point L count 61 notches on the horizon line, to identify point *Q* and draw the line *QP*, which intersects the line *NL* at the desired point *R*. In this way *MR* = *MP* = 16 feet. *Problem VII*, actually, seems to provide completion of the entire text's programme stated in its title [Alleaume, Migon 1643], which refers to an original method of perspective construction that does not use the main point or the distance points, but it utilises the horizon line. In fact, this method's validity seems to be connected with the accurate construction of the chart described previously in the text, particularly with the graduation of the horizon line [Alleaume, Migon 1643, from p. 73 ff.) that allows one to delineate the images of the lines through the knowledge of their inclination with respect to the picture plane.

It appears then that one cannot find any general guidelines, contrary to what was pre-empted by Simon Stevin, of whom Alleaume had been a scholar of [12]. In fact, Alleaume seems uninterested in these topics, but focuses only on the creation of a graphic scale to draw the perspective of predominantly linear elements [13]. Unfortunately, it is not possible to find out what was in Alleaume's dissertation on the perspective compass, which was omitted from the 1643 text, because it should have been discussed in one of two other volumes that Migon never managed to write. The possible connection between this tool with the graphic chart described previously is destined to remain hypothetical as well as its potential link with other optical tools studied and designed by Alleaume himself [Molhuysen, Blok 1912], whose original work still remains largely in the dark.

The observations on measurement in perspective by Jaques Ozanam (1640-1718) seem to have an extremely different origin than Alleaume and Migon's. Ozanam notably studied vastly diverse mathematical applications with the aim to make the discipline of mathematics more accessible, also through illustrations of its most paradoxical and amusing aspects [14]. In a complex educational text [Ozanam 1693], Ozanam studied perspective in great depth without simply listing known elements, in fact the text shows the first introduction of measuring

Fig. 4. Problem VII [Alleaume, Migon 1643]. Graphic elaboration with elements of linear and angular elements (graphic elaboration by the author).

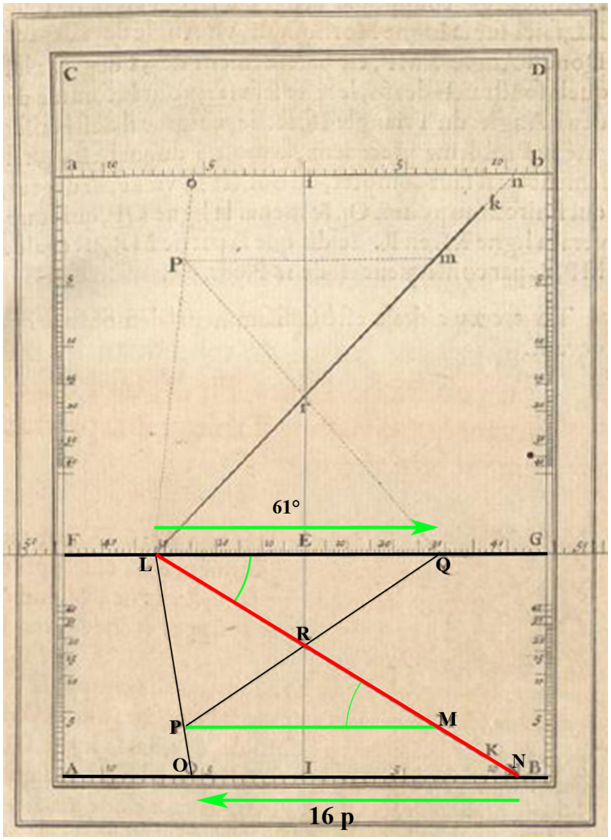


Fig. 5. On the left, Chart 7, fig. 14 [Ozanam 1693]. On the right, application of point D to obtain equal segments along AV (graphic elaboration by the author).

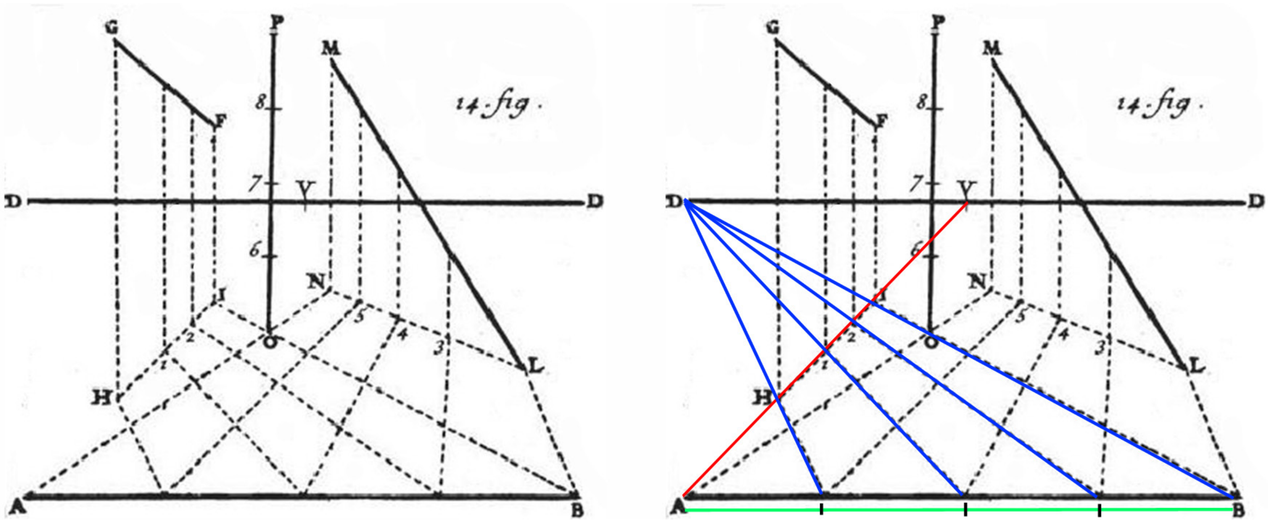
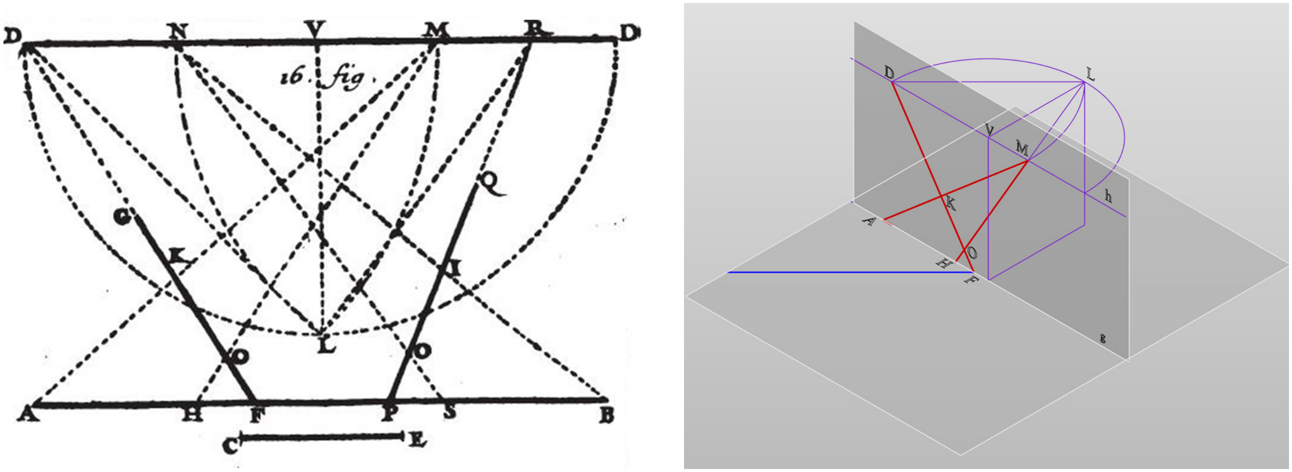


Fig 6. On the left, Chart. 8, fig. 16 [Ozanam 1693]. On the right, three-dimensional elaboration with the spatial ratios between D and M, measuring point (graphic elaboration by the author).

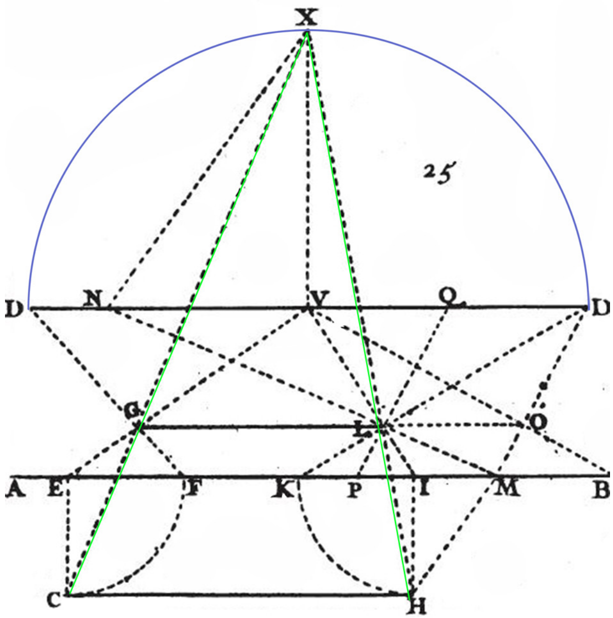


points [Andersen 2007, pp. 407-409], achieved through a method of progressive generalisation.
Having identified generic auxiliary vanishing points that allow the division of one segment into equal parts without, however, checking the real measurement of the segment and its parts [Ozanam 1693, chart 6], Ozanam attributed to the distance points the property of enabling the measurement of the direction orthogonal to the picture plane (fig. 5) [Ozanam 1693, chart 7, fig. 14], as shown in the earlier studies between the Fifteenth and Seventeenth centuries, cited previously.
The decisive passage is provided by the identification, through the rabattement of the viewpoint, of the vanishing point *M*. This direction enables the measurement of the segments on the lines at an angle of 45° with respect to the picture plane (fig. 6) [Ozanam 1693, chart 8, fig. 16], as for example segment *OK*, measuring *AH*: this is how the measuring point was created. It was destined to be key in the field of architectural representation.
It should be observed that Ozanam also developed the construction for the rabattement of the viewpoint and its use in perspective constructions (fig. 7) [Ozanam 1693, chart 8, fig. 25], illustrating the projective relation generated between the real object (segment *CH*) and its perspective projection (*GL*), the extremities of which are aligned with the rabattement of the viewpoint *X*. This scheme might have been inspired –or it could be simply a coincidence– by construction in the text by Philippe de La Hire in 1673 [15] [Andersen 2007, p. 344], identifiable by a homology, which has its centre in the rabattement of the viewpoint and the axis in the ground line.
The question is still open, whether the method of the measuring points was applied, or even invented, previously in the artistic field. The experiments of reverse perspective on seventeenth-century paintings show a degree of license when it came to the geometric norms, which is comparable to the artistic license in previous periods and is based on the necessary comparison between the objective and perceptive data of the represented object. This remained valid even in the moment of greatest diffusion of geometric logic. A rigorous result can be obtained even without the aid of measuring points, as it is true with distance points, and the effectiveness of these methods would be possible to prove with evidence remaining recorded on the supports, canvasses or plastering of the paintings, on which the paintings were carried out [16].

Measurement and dis-measurement: instruments for a scientific and transgressive representation

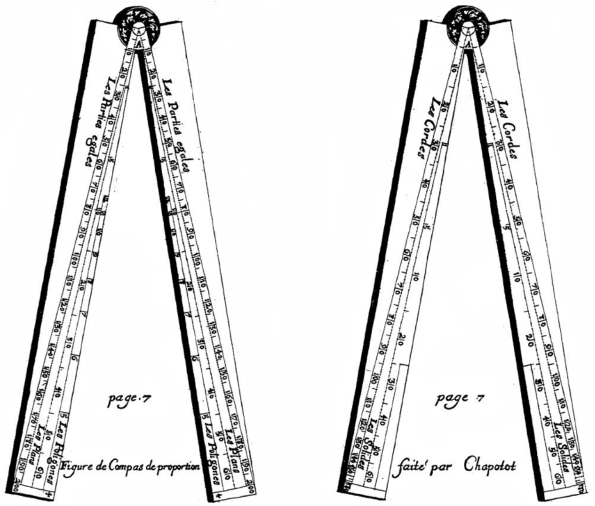
Ozanam's interest in the topic of measurement becomes evident in his texts on practical geometry and survey, such as his monographies dedicated to a number of measurement instruments. The text on the proportional compass, *L'usage du compas de proportion* [Ozanam 1688a] provides an extensive explanation of the instrument (fig. 8), which Galileo Galilei (1564-1642) had illustrated in 1606 [17] and as an instrument which is useful to carry out measurements and calculations applied to all the processes related with the art of war, ballistics or measurement of distances and places.
In the same year, Ozanam wrote a book on the universal instrument [Ozanam 1688b], which was constituted by a small rectangular board with fixed mobile rulers (fig. 9) used to measure angles even on vertical planes, to draw pa-

Fig. 7. Chart 12, fig. 25 [Ozanam 1693]. Graphic elaboration with the projective relation that is generated between segment CH and its projection GL (graphic elaboration by the author).



rallel and perpendicular lines and to draw plans, as it can be observed in the book's IX chart (fig. 10), where it explains how the instrument can be used to enlarge drawings through its homothetic relations.
Ozanam dealt with methods of measurement in his book *Traité de l'arpentage, et du Toisé* [Ozanam 1699], which were not particularly original, but extremely practical and very popular at the time. In his other book *Méthode de Lever les Plans et les Cartes* [Ozanam 1693], Ozanam examined the theme of surveying with a more systematic approach, with a thorough description of other instruments, such as the semicircle and, again, the universal instrument. These tools are based on the principles of ancient instrumentation for territorial and astronomical measuring (for example the Jacob's staff and the quadrant), and on the transposition of the angular measurements of natural vision into objective angular and linear measurements: this scientific foundation can also be found in the projective principles of the geometric linear perspective.
Jean François Niceron's book, *La perspective curieuse*, [Niceron 1638] contains an interesting chapter on the use of distance points, measuring the direction orthogonal to the picture plane. In it, distance points were given the function of measuring the distortion applied in the anamorphosis (fig. 11) and lead to an evolution of the approximated solution by Vignola and Danti [18].
To achieve a reversible relationship between the object and its perspective representation, it is important to quote the work by the English mathematician Brook Taylor (1685-1731) [19]. His text, written in 1715, titled *Linear Perspective or a New Method of Representing justly all manner of Objects as they appear to the Eye in all Situations* [Taylor 1715] was a theoretical and practical treatise on perspective, and the theory of shadows and reflections. The book was criticised for its complex and succinct language, which prompted Taylor to compile a second edition four years later, longer than the original text [20], which described a construction of the measuring points that resembled that by Ozanam [Taylor 1719, fig. 17]. The new text included two sections: the first one dealing with perspective construction and related topics, while the second section of the book was dedicated to reverse-perspective constructions (fig. 12). Lastly, the book had two appendices dealing with perspective on curved surfaces and the theory of Isaac Newton on colour. Taylor's research on the inverse problem might have gone on to influence the work of Johan Heinrich Lambert in 1759 [21] and contained the principles of photogrammetry that form the basis of the tools that are still used today in architectural surveying [22].

Fig. 8. Jacques Ozanam, L'usage du compas de proportion, 1688 [Ozanam 1688, p. 7].

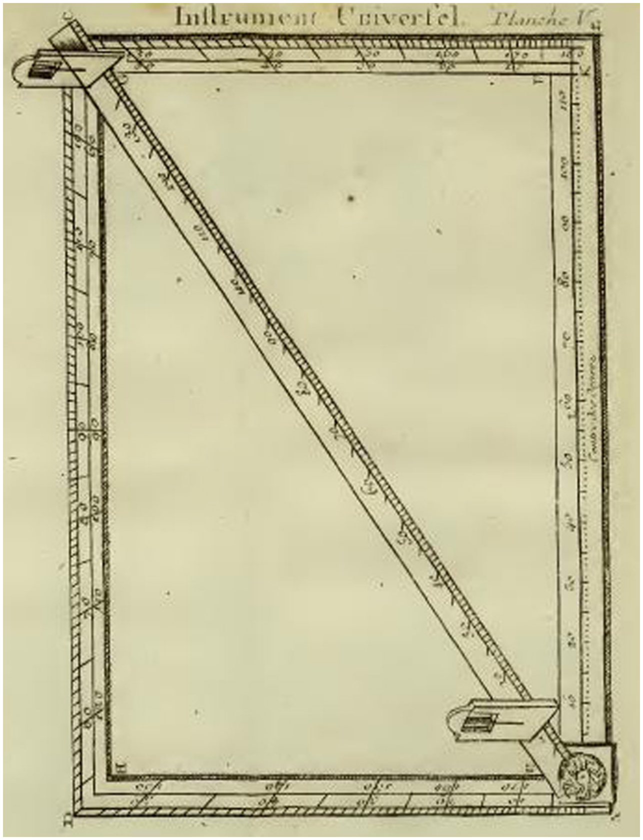


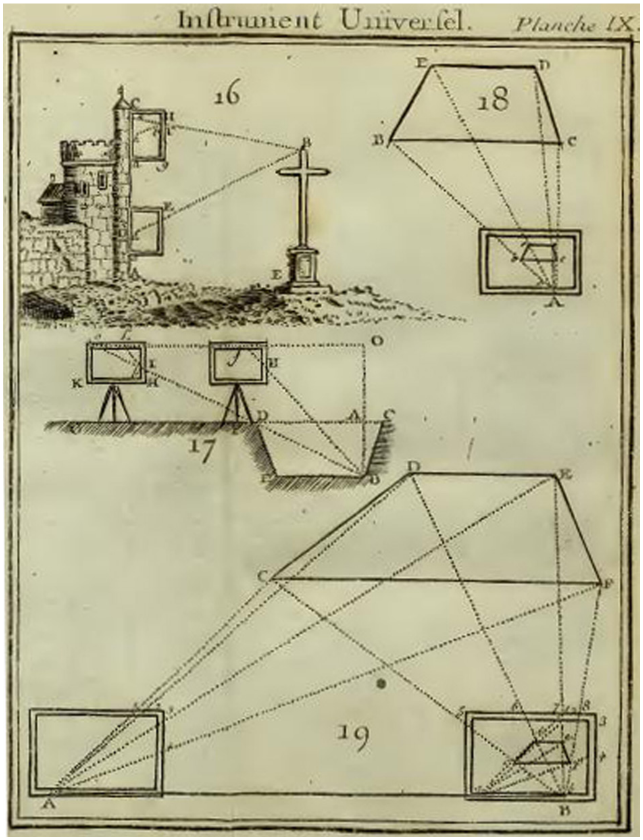
Conclusions

Between the Seventeenth and Eighteenth centuries, the importance of the perspective function of controlling measurements was gradually restored alongside the creation of perceptively significant images. There were many relevant contributions for the progressive focalisation of the problem, as demonstrated by the indications in the texts by Guidobaldo Burbon del Monte [Del Monte 1600], Simon Stevin [Stevin 1605] e Girard Desargues [Desargues 1636; 1639]. Fundamental milestones were the introduction of the perspective measuring systems in the text by Jacques Alleaume and Estienne Migon [Alleaume, Migon 1643], the identification of the measuring points by Jacques Ozanam [Ozanam 1693] and the systematisation of the reverse method by Brook Taylor [Taylor 1715] and Johan Heinrich Lambert [Lambert 1759].
An introduction to the measuring points can be observed in the use of the distance points, as measurements

Fig. 9. Jacques Ozanam, L'usage de l'instrument universel, planche V, 1688 [Ozanam 1688b]: the universal instrument.

Fig. 10. Jacques Ozanam, L'usage de l'instrument universel, planche IX, 1688 [Ozanam 1688b]: the application of the universal instrument to the surveying of spaces, and its application to scale drawings.





for the direction orthogonal to the picture plane, as well as in the continuity of theoretical studies and their instrumental application in surveying.
Measurement is in the end still one of the fundamental elements of perspective. Projective implications allow us to extend the range of our interpretations, because the reciprocal relationship created between the two projections, orthographical and perspective, leads to a relative understanding, as each projection represents one version, distorted in its own unique way, of the same three-dimensional object [Cohen 2001, pp. 54, 55]. There is therefore a strong –although contradictory– relationship between the most rigorous developments in perspective and the most peculiar ones [Barozzi Vignola 1583; Niceron 1638], both belonging to the same scientific field, which opened up to the infinite implications of representation with regard to conceiving and interpreting spatial phenomena.
The wide diffusion of these perspective innovations and their application to the instruments and methods used in surveying demonstrate, yet another time, the versatility of perspective theory as well as the strong relationship between drawing, architecture, science, and technique.

Fig. 11. Jean-François Niceron, Chart 13,1638 [Niceron 1638]: anamorphosis correctly built with the aid of the distance to points, used in this case not to make measurements proportionate, but instead distort them.

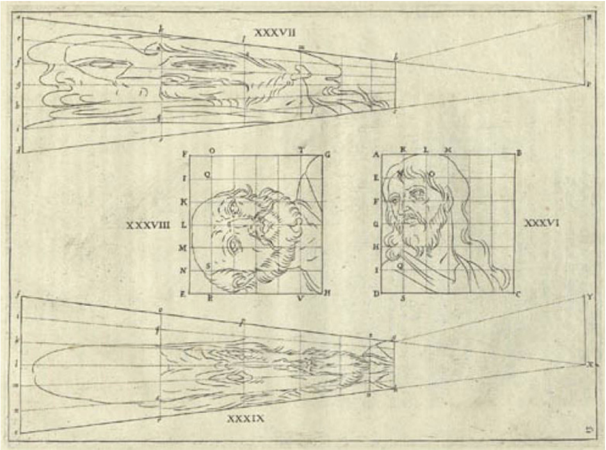
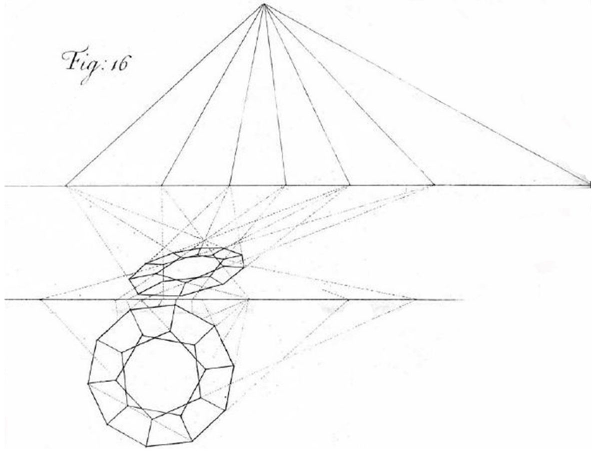


Fig. 12. Brook Taylor, Fig. 16, 1719 [Taylor 1719]: perspective and reverse perspective.



Notes

[1] Among the many reference texts, see: Docci, Maestri 1993; Sgrosso 2001; Giordano 2001; Camerota 2006; Paris 2014.

[2] Consider the significant title of the collections of essays on the relationship between architecture and art by James S. Ackerman [Ackerman 1991] and the exhibition held in New York *Measure. Exhibition. Storefront for Art and Architecture*. New York, August 14th, 2015-September 19th, 2015.

[3] The present contribution can provide only few references to study this topic in further detail: Damish 1987; Camerota 2006.

[4] For the dating of the Latin and vernacular editions, see: Sinisgalli 2006.

[5] See the Holy Trinity by Masaccio, Florence, Santa Maria Novella, 1426-1428.

[6] As in the Miracolo dell'ostia profanata, Urbino, Palazzo Ducale, 1465-1468

[7] For the Viator's text, see Brion-Guerry 1962. An illustration of the distance point method by Leonardo can be found in the Ms. A, Institut de France, Paris, see: Massey 2003, p. 163.

[8] The text *Le due regole della prospettiva pratica* was compiled by Vignola between 1530 and 1545 and pubblished by Egnatio Danti in: Barozzi da Vignola 1583.

[9] Rabattement, *Theorem 5, proposition VII*; *Theorem 6, proposition VIII*.

[10] AlleaumeJ. (1627), *Introduction à la perspective, ensemble, l'usage du compas optique et perspectif*, (Ms).

[11] For the known sequence of events, see: Amodeo 1933, pp. 7, 8, 33-37; Vagnetti 1979, pp. 385 and 398; Sgrosso 2001 pp. 269-270; Andersen 2007, pp. 418-427.

[12] Alleaume was also a scholar of the mathematician François Viète (1540-1603). See: Molhuysen, Blok 1912.

[13] The work by Migon can be considered an anticipation of the measuring points according to Vagnetti [Vagnetti 1979, p. 398] and Anna Sgrosso [Sgrosso 2001, p. 269], who inserted the image of a graduated circle that cannot be found in any of the two consulted [Alleaume, Migon 1643; 1663].

[14] Ozanam, J. (1694). *Récréations mathématiques et physiques, qui contiennent plusieurs problèmes d'arithmétique, de géométrie, de musique, d'optique, de gnomonique, de cosmographie, de mécanique, de pyrotechnique, et de physique. Avec un traité des horloges élémentaires. Paris: Jean Jombert*. For the work by Ozanam, see: Càndito 2015.

[15] Philippe de La Hire, *Nouvelle méthode en géométrie pour les sections des superficies coniques et cylindriques*, Paris 1673. See: Andersen 2007, p. 344.

[16] Marks can be detected with instruments that are not limited to photographic shooting. For some studies on this topic, see: Valenti 2014; Bartoli 2015.

[17] Galilei described it in its pamphlet *Le operazioni del compasso geometrico et militare*, 1606, but the instrument had been described previously, for example by Fabrizio Mordente and by Muzio Oddi. See: Mordente, F. *Modo di trovare l'astrolabio*. Venezia 1567; Oddi, M., *Fabrica et uso del compasso polimetro*. Milano 1633.

[18] De Rosa 2013, pp. 13-17. For the anamorphosis: Camerota 1987.

[19] Brook Taylor is mostly known for the famous formula, that bears his name, presented in *Methodus Incrementorum Directa et Inversa*, London, 1715.

[20] The modern edition of the two editions by Taylor 1719 can be found in Andersen 1992.

[21] Lambert 1759 see: Loria 1921, pp. 43-48; Vagnetti 1979, pp. 441-443; Kemp 1994, pp. 167-170; Andersen 1992; Giordano 2001, pp. 53-61.

[22] For the contribution by Aimée Laussedat del 1899 and the evolution of photogrammetry, see: Paris 2014.

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Digital

Representation Degree Zero

Alberto Sdegno

"*Drawing vs. moving*"

"Conventionally, of course, drawing is an active process which leaves a trail of carbon on the paper. With a computer sketch, however, any line segment is straight and can be relocated by moving one or both of its end points." [Sutherland 1963, p. 102]. With these surprisingly laconic words, the twenty-five-year-old Ivan Sutherland described, in his doctoral thesis [1], the most obvious difference between a traditional drawing and an electronic graphic document. Creator of the first interactive design system to be made public, called *Sketchpad*, presented precisely in the abovementioned thesis, and the first man to have drawn luminous lines on a monitor, he posed questions that have not yet been fully resolved even today, more than fifty years after that earliest act. Is it possible, in fact, to call this new iconic artifact with the same name by which an object drawn by hand has been defined? Sutherland answered in the abovementioned chapter that he had significantly entitled *Drawing vs. moving*: "[…] there is *no* state of the system that can be called 'drawing'." [Sutherland 1963, p. 102] (fig. 1).
The distance between the manual, physical, material tracing of a graphic mark on a sheet of paper and the digital, abstract, immaterial equivalent, was now definitively handed over to the pages of the history books that could thus record the *zero degree* of representation. It was not a slow, centuries-long change –as in Barthes' analysis of literature [Barthes 1960]– but a sudden change, as instantaneous as it was unexpected.

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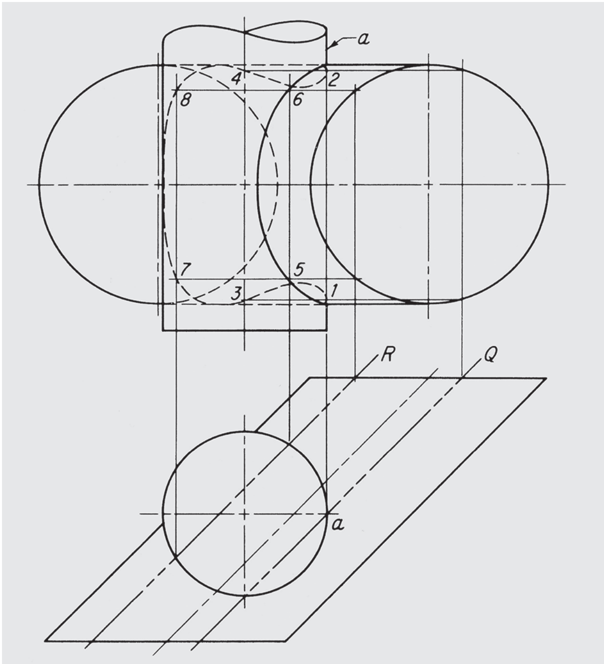
It was certainly not the light pen, from which a beam of radiating light emerged and remained imprisoned in the screen, that could evoke the radiant charm of a pencil held by a draftsman. Despite being of the same shape and size, this new tool forced an unnatural, mechanical behavior, which denied the user the spontaneity of an instinctive and instantaneous gesture, even if it offered in him a surprising precision in exchange, that no other drawing tool –whether ruler or compass– had ever granted him.
Nor could the rules for learning the art of drawing described, for example, by Eugene Viollet-le-Duc in his *Histoire d'un dessinateur* [Viollet-le-Duc 1992], or by Ruskin's Elements [2] be any longer applied. Although, paradoxically, about 150-180 hours of practical application for learning the art of drawing suggested by John Ruskin –"an hour's practice a day for six months, or an hour's practice every other day for twelve months," [Ruskin 1857, p. 3] as the well-known teacher's promise goes– correspond to the average duration of the learning course of a Computer Aided Design (CAD) or Building Information Modeling (BIM) software.
Closer, perhaps, to the rigorous methods of descriptive geometry that accompany the designer in the recognition of syntactically congruent forms, thanks to the delineation of discrete segments and arcs, or to the enigmatographic games in which hidden pictures are revealed by connecting numbered points in sequence, the mark made up of bright pixels on the screen can represent geometries of surprising complexity in a very short time. Morphologies so articulate that they would have taken a student of Gaspard Monge –or the same *professeur de mathématiques* himself [3]– hours of work to solve similar operations of geometric construction. It is no coincidence that Steven Coons [4], professor of mechanical design at the Massachusetts Institute of Technology, responsible for the theoretical formalization of the system later developed by Sutherland, in the book written with John T. Rule [Rule, Coons 1961], has dedicated many pages to the graphic solution of geometric-descriptive problems of solids and their intersections in space (fig. 2). It can be well understood, therefore, that Sutherland's work was born downstream of a collective work of investigation on these research topics and following a substantial funding by the U.S. Department of Defense, which had previously also funded the SAGE system [5], progenitor –in terms of video pointing systems– of Sutherland's system.

Fig. 1. Ivan Sutherland and the Sketchpad system, Massachussetts Institute of Technology, 1963.

Fig. 2. Intersection of solids [Rule, Coons 1961, p. 218].



In fact, starting from 1959, MIT's *Computer-Aided Design Projects* had been initiated with the aim of defining the characteristics of a representation system based on electronic technology. In one of the first reports on the subject, written by Coons and Robert Mann [Coons, Mann 1960], it is established that "the objective […] is to evolve a man-machine system which will permit the human designer and the computer to work together on creative design problems" [Coons, Mann 1960, p. III], with a further specification in the foreword, namely that "it is not contemplated that fully automatic design without human guidance and decision is a possibility for the foreseeable future" [Ward 1960, p. V]. It was, therefore, to define a "perfect [digital] slave" [Cardoso Llach 2015, p. 49], leaving to the human being the creative contribution in the design process. To confirm the fact that the work that had led to the realization of Sketchpad was collective, it is sufficient to skim the proceedings of the Spring Joint Computer Conference held in Detroit in 1963, in which a whole session –entitled "Computer Aided Design," continuing for more than fifty pages– is dedicated to the presentation of this new drawing tool [6].
Research for characterizing drawing more towards diversified strategies for the formalization of contents would soon begin: on the one hand, experimentation in the aerospace and automotive industries, at first mainly by Boeing and General Motors, and on the other hand, the development of applications oriented toward architecture and construction, immediately renamed with a different acronym: CAAD, or Computer Aided Architectural Design [Negroponte 1975; Mitchell 1977]. But this greater qualification of the graphic document could hardly have remedied that sharp distinction between manual drawing and digital representation that, at the same time, would have developed a greater distance, especially with the definition of an unprecedented graphic modality: three-dimensional representation.

3D

If innovation in the field of representation manifested itself with the technological transformation of the instrumentation available, the real technological revolution consisted in the informative and communicative paradigm that for the first time offered itself to those who wanted to represent a form. In the same Lincoln Lab of MIT in which Sutherland gave rise to the origin of two-dimensional computer graphics, Timothy Johnson [Johnson 1963], in the same period, translated into three dimensions the genetic code written by his friend and colleague, so much so that we can say without fear of contradiction that the drawing done with the computer is born with a stereometric characteristic, not granted to traditional drawing. An added value that immediately leads us back to Malevich's description of his *Black Square* [a black square on a white background] of 1915: "I have transfigured myself into the zero of forms," said the Russian painter, "and have gone beyond the zero" [Malevich 1915]; with these words he anticipated by a few years his most decisive work, that *White on White* [a white square on a white background] that did not allow any possibility of mediation with the past. "Going beyond the zero" could, therefore, mean, if we consider the three-dimensionality of a drawing, completely modifying the operative paradigm with which a drawing is done: no longer a stable product on our sheet of paper, static in its Cartesian coordinates or bound to proper or improper projective procedures that prevent its variation, if not a physical erasure of lines and a re-drawing of the figure. Now *drawing* –if it can still be defined as such– becomes dynamic, mobile, infinitely variable, without leaving a trace of a possible elimination of segments. Infinite perspectives can be generated by the simple touch of the pointing tool, which remained in the shape of a stylus until the next decade. The patent for the mouse (fig. 3), in fact, was obtained in 1970 by Douglas Engelbart [7] seven years after the birth of *Sketchpad*. But parallel projections, enlargements and scale reductions were also foreseen in this new *digital notebook*. With a further figurative peculiarity based on the transparency of its filiform essence and presenting itself as the computerized translation of that graphic stratagem which calls for the stratification of a traditional drawing with layers of tracing paper. In this case as well, the difference between tradition and innovation is evident: hand drawing uses semi-translucent paper to express different contents on various levels, such as the drawing of a floor plan or an elevation, in an integral form. In the case of digital drawing, instead, the *layers* can hold small homogeneous parts of the same altimetry or planimetry, such as, for example,

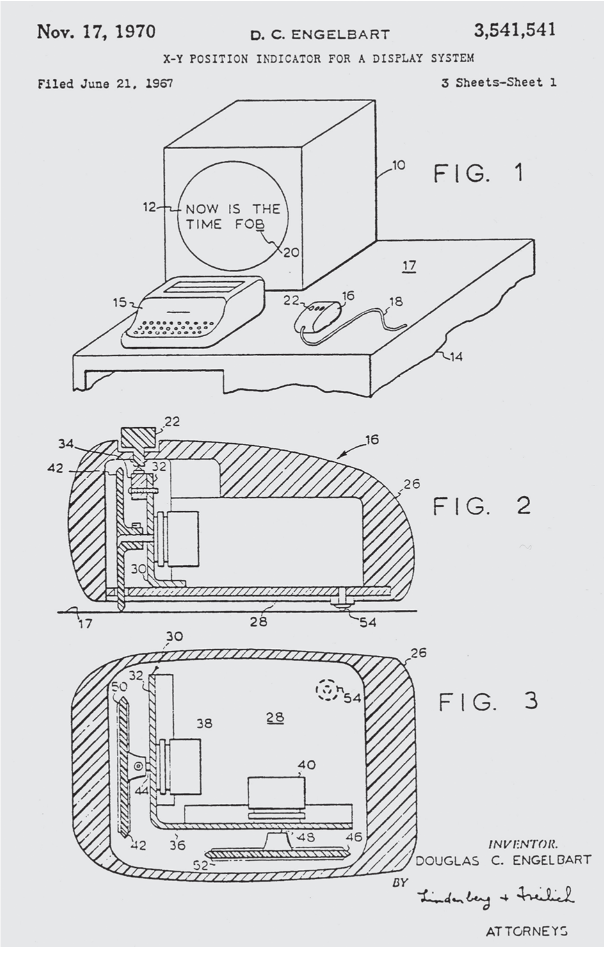


Fig. 3. Drawings accompanying Patent No. 3541541 filed by D.C. Engelbart for the mouse, 1970 [Bardini 2000, p. 100].

openings, stairs, windows, with an additional discretization of the components, which can contain infinite structures of information.

A clean cut with the past, then, a new graphic technique that contemplated a figurative device that negated with one stroke, surpassing them, the two principles at the base of projective geometry: the concepts of projection and section. It is now possible to generate a filiform model, which has little to do with the outcome produced by a manual draftsman, bent over his table, amidst pencils and sheets of paper.

Starting from that 1963, solids, more or less complex, began to twirl on the screens of computers in their three-dimensional representation (fig. 4), replacing the less captivating strings of characters that, until that moment, were common to the life of programmers and users alike. Computer technicians and users of software from then on would have lived different experiences, the first regulated by algorithmic systems composed of endless lines of code, the latter by visual and interactive contents, always richer in shapes and colors, so as to make even that machine, that looks so unattractive and untempting, seductive and user-friendly.

The real subversion, in fact, is deposited in a sort of exponential similarity that this *new drawing* has with the real, full-scale object: if the model has always been, as Massimo Scolari reminds us, "an initiation instrument for generations of architects who in the realization of objects in the form of small architectural works were preparing to build on a large scale" [Scolari 1988, p. 16], the digital model is at once analogous to the real object and equivalent to its scale copy, of which it retains that morphological affinity that has made it an irreplaceable tool for new representations.

Models of skeletal airplanes, of filiform cars, of urban landscapes in the form of simple luminescent parallelepipeds, begin to be hosted in technical magazines and public presentations: all artifacts strictly produced in a paperless mode, that is to say without the consumption of paper.

This sharp distinction between traditional drawing and digital representation has expanded over time thanks to the invention of new means of expression that, starting from three dimensional contents, reverberate in more complex contexts, through the intercession of another important mediation between analogical and digital: the invention of the electronic image.

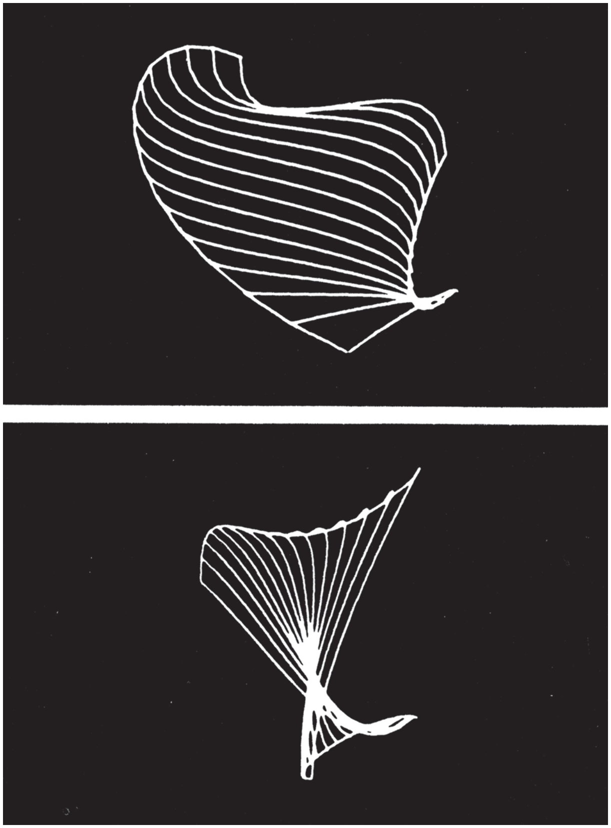


Fig. 4. Double curved surfaces realized by S.A. Coons, 1967.

Fig. 5. Original image and numerical scan realized with the system of R.A. Kirsch, 1957 [Kirsch 1958, p. 223].

Discretizing images

"We have chosen to sample at 500 KC rate and we define each one of these samples as a picture element or a *pixel*" [Billingsley 1965, p. 3]. It may seem strange that one of the most significant terms in the history of computer graphics –the definition of pixel, a contracted form of picture element, that is, the unit of measurement of the digital image– appears for the first time in the form of a remark in a technical essay of 1965 written by Fred C. Billingsley, a researcher at the Jet Propulsion Laboratory of the California Institute of Technology, as set out in a recent paper [Lyon 2006]. Above all it is unusual that this should appear at a distance of almost two decades from the first use of the term.

The invention of the instrument capable of translating analog images into digital pixels, in fact, took place in 1957, when a group of researchers coordinated by Russell A. Kirsch, gave life to the first linear scanner in a laboratory of the National Bureau of Standards, which would be officially presented in December of the same year at the *Eastern Joint Computer Conference* held in Washington [Kirsch et al. 1958].

But in rereading the proceedings of that conference, it appears that the revolutionary nature of what had been presented there was not appreciated. The essay that described the scientific procedure and tools was not given more space than the other papers, unlike what we have seen with vector drawing. Yet within the nine pages of the essay there was described the translation of a photographic image into an image formed by dots, or "pixels," which will forever mark the path of digital image processing, becoming, in fact, a new mode of iconographic elaboration and laying the foundations for that substantial transformation in the field of photography and cinematography that has not yet today been fully accomplished.

Paradoxically, therefore, the problem of digital scanning of paper-based data was only reported as a means of reaching what was considered the real objective: the automatic recognition of forms and characters from a pre-existing analogue document, with the aim of speeding up manual input processes by an operator.

From a technical point of view, the machine was based on a rotating roller system, on which the image to be scanned was placed and illuminated by a beam of light. Through a complex optical impulse detection mechanism –which also included the use of a stroboscopic disc– the object of the research was achieved: a square ID photo having measuring 44x44 mm. The scan time was 25 seconds and the digital result consisted of 176x176 points (30,976 characters) (fig. 5). These points –which, as we said, only in the following decade would be called *pixels*– were black or white: the first to identify the figure, the second to describe the background. Although not considering the shade of gray, nor undoubtedly, colors, the essay underlined some experiments on the recognition of form and character which immediately raised interest in the participants. This modality of use in black and white, in fact, allowed the simplification of the operations for the identification of text and figures: regarding, in the first case, the subsequent development of OCR systems [8], and in the second case –as also emphasized by Kirsch himself in the final discussion [Kirsch et al. 1958, p. 229]– the instantaneous association of fingerprints with the face of a criminal. If the image described above, concerning the scanning of a human figure, appears only in the abovementioned essay, Kirsch has stated that, in reality, the first scanned photograph was that of the face of his newly-born son, Walden. The original of this scan has been kept since 2003 in the archives of the Portland Art Museum [9] (fig. 6). Although this record is recognized by the web's search engines, it is not confirmed by official publications that describe, as does the essay we have mentioned, the outcome of the experimental research: probably, however, the association between the invention of a new scientific instrument –such as the scanner– and the image of a new-born child, can be perceived as a more effective equivalence on the communicative level.
Having defined the way in which it was possible to see on a monitor any analogically-produced graphic document –be it a drawing, a page of a book or a photograph– opened the doors to fully digitalized representation, as a further evolution of the CAD representation systems that we have described at the beginning.
It is no coincidence that among the first questions raised by researchers there was the problem of shading a 3D model, or rather, of how to give a true-to-life appearance to those filiform objects which, in fact, did not look very realistic.
Already in the late 1960s, the problem of hidden lines presented itself as a topic for experimentation. Many algorithms were created, permitting the problem of the simulation of shading to be quickly solved.

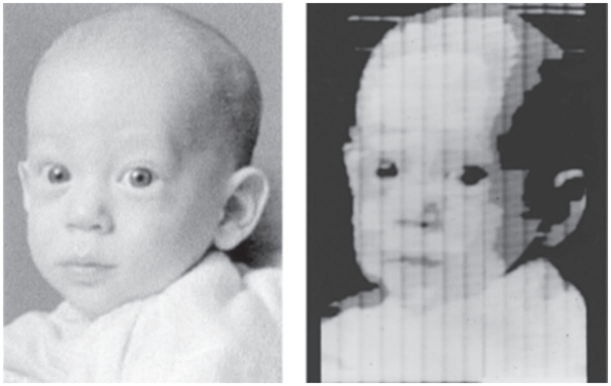


Fig. 6. Original image and numerical scan of Walden Kirsch, realized with the system of R.A. Kirsch, 1957 <http://portlandartmuseum.us/mwebcgi/mweb.exe?request=record;id=2112;type=701> (accessed 2018, September 20).

If the first algorithm for the generation of chiaroscuro on a surface was based on the law of cosines –defined about two centuries earlier by Johann Heinrich Lambert in his *Photometria* [Lambert 1760], shortly thereafter various researchers proposed different solutions that over time were indispensable for obtaining that figurative realism that can now be obtained with any simulation software.
The rendering images that from the 1970s began to hesitantly emerge from researchers' computer screens led to a further level of innovation that, once again, clearly distanced itself from all previous experiments: Virtual Reality (VR). In fact, thanks to VR, from an operational point of view, what had already appeared as a primary source of new visual suggestions –the 3D model– acquired a strong expressive value in terms of total, complete, immersive interaction. From a conceptual point of view, as Franco Purini wrote, "virtual reality presents itself not as what can happen but as what just happened, like an *accelerated present*" [Purini 2000, p. 108].

New virtualities

"The fundamental idea behind the three-dimensional display is to present the user with a perspective image which changes as he moves." [Sutherland 1968, p. 757]. This is how the young creator of Sketchpad would present his stereoscopic and interactive visualization system only five years after his revolutionary invention, calling it, similarly to what had been done for the CAD drawing system, with an equally evocative term: *The Sword of Damocles* (fig. 7). Like the legendary sword, hung by a strand of horsehair by Dionysius I, tyrant of Syracuse, and suspended over the head of Damocles, it referred to the dangers always threatening the man of power, just like a support anchored to the ceiling, holding a mobile helmet equipped with special viewers, could be worn by a daring user. The movement of this particular helmet allowed the user to visualize a virtual space –made up of transparent threadlike volumes constructed with Sketchpad– as though he were virtually present in that scene. The movement of the user's head also changed the perspective view of the object.

A few years after the invention of CAD, the foundations were laid for what Jarom Lanier defined twenty years later Virtual Reality, that is to say, a system that associated a virtual scene with a digital viewer, allowing movement within it by use of particular electronic gloves to be worn by the user, called *datagloves*. If the electronic drawing completely changed the figurative register codified through a slow development of the history of representation, the reflection around a virtual reality system induced to consider new paradigms also of theoretical-speculative order, fueling a debate, perhaps already inherent in the first association made by Sutherland, between its system and the danger of an impending blade suspended over the head of Damocles.

Virtual reality was followed by other experimental researches that make use of computerized systems of vision and perception, which amplify the distance between new media and traditional tools for the use of objects and spaces. Think, for example, of Augmented Reality (AR), in which the interface allows users to superimpose digital contents of various kinds –videos, texts, images, sounds, etc.– analogue artifacts, demonstrating the added value of a new communication system. Founded in 1990 as a technical instrument for visual inspection of the electric cable system inside the equipment of an airplane fuselage, thanks to the intervention of Tom Caudell [Caudell, Mizell 1992], called by Boeing to solve this problem, it soon became a very widespread tool both in the field of scientific divulgation –in museum spaces that can be explored interactively thanks to this system– and in the commercial

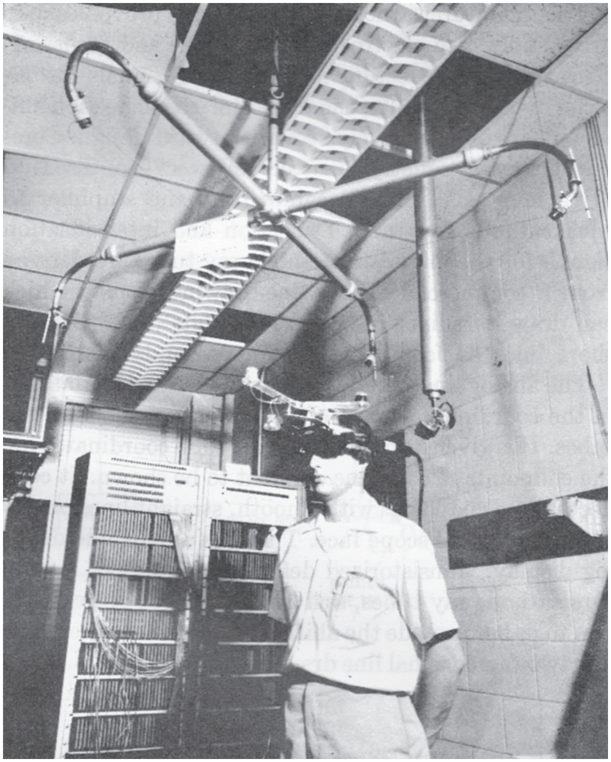


Fig. 7. The Sword of Damocles created by I.E. Sutherland, 1968 [Sutherland 1968, p. 760].

sector –offering the possibility of superimposing a virtual article to a real environment, as seen in the catalog of one of the most important furniture chains [10]– both in the entertainment sector, with applications such as Snapchat –for the superimposition of digital masks on real faces– and Pokemon Go, based on a GPS geolocation system that allows the search for fictitious creatures within a real environment. Among other things, it cannot be concealed that this recent electronic game –commercialized starting in July 2016– also takes into account a previous digital experience based on the construction of imaginary worlds, which with its name declares a clear separation from traditional contents: Second Life (SL). The concept that welcomes the visitor of this new web-based explo-

Fig. 8. Nunox Cyberpunk City in Second Life. <https://secondlife.com/destination/nunox-cyberpunk-city> (accessed 2018, September 20).

ration platform is different from the logic of videogames. The user, in fact, through an avatar –a 3D copy of himself in digital form– can perform all the functions of a human being, doing them in an electronic environment, like in a kind of *virtual life* [Unali 2014]. He can visit places with a traditional appearance, such as Rustica or Lake Templeton Beach or futuristic places like InSilico or Nunox Cyberpunk City (fig. 8), play a musical instrument, talk to other users, purchase items using a virtual currency, carry out business activities, or make digital artifacts –such as a sculpture or a building– giving free rein to his creativity and without a specific purpose

The contents envisaged by the general concept of the *digital divide* –that is to say, the gap that electronics determines between users who use advanced technology and those who are excluded from it– now constitute an unbridgeable gap between those who live in the virtual space of SL and all of mankind, whose life is still firmly –and inevitably– anchored to the earth's surface.

The extreme creativity, however, offered by SL to those who want to generate morphologies of any kind can only introduce another central theme, that of the use of advanced digital modeling for the construction of architecture with surprising complexity.

Electronic architecture

A few years ago we proposed the neologism *e-architecture* to indicate those architectural works that owe their design to digital processing tools [Sdegno 2001]. And we had pointed out two prominent personalities –Peter Eisenman

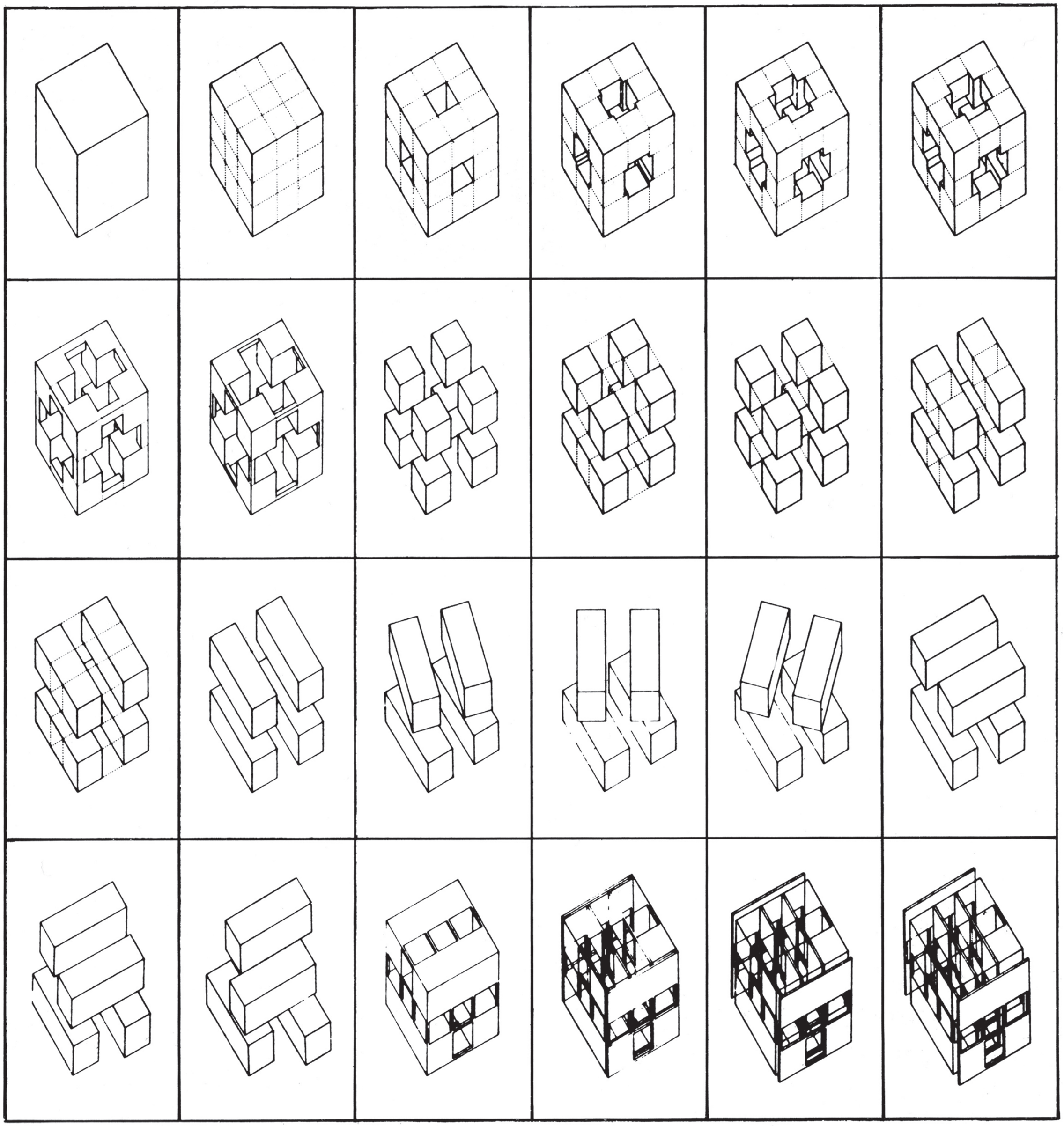


Fig. 9. P. Eisenman, House IV. Falls Village, Connecticut, 1971. Diagrams for the compositional process.

and Frank O. Gehry– as those architects who impersonated two quite different behavioral strategies, which identified –even in the simplification of such a classification– two different types of relationship between designer and digital tool: that is, one who works *ex ante*, with electronic tools right from the initial, conceptual phase of the design, and the other who works *ex post*, when the design is practically finished, using digital technology to give constructive consistency to their design ideas.
This diversity has remained substantially the same today: on the one hand there are those who use morphological control procedural systems, such as the Grasshopper visual programming language [11], and algorithms of advanced modeling; on the other hand, there are those who use traditional methods of drawing based on the realization of physical models or technical drawings at appropriate scales, then translated into digital format.
The two architects mentioned were indicated for the uniqueness of their experiences: Eisenman, in fact, also used Boolean geometry for the construction of his houses of the 1970s (fig. 9), in the absence of digital technology; Gehry, on the other hand, did not change his traditional behavior towards designing, still building small plastic and cardboard models –as can be seen in the film on him created by Sidney Pollack [Pollack 2006] (fig. 10)– whose three-dimensional forms will be subsequently digitized for the realization of the wireframe model within the modeling software. It is no coincidence that both authors are present in a recent volume devoted to digital archeology [Lynn 2013].
There are countless digital tools available to designers, so much so as to be in the presence of a real "information technology revolution in architecture" [Saggio 2007], in which a new "electronic paradigm" is defined [Eisenman 1992, p. 17]. But one cannot ignore a decisive factor manifested with this new operating mode of design: the risk of the loss of authorship.
Mario Carpo has in various ways dealt with this issue, both in relation to the issue of copying and reproduction [Carpo 2011], and underlining a new substantial change introduced by the digital tool, with reference to the previous use of technology [Carpo 2017]. A recent essay further reiterates this aspect: "architects –Carpo writes– cannot do without technology, but technology can do without them" [Carpo 2018], distilling in such an effective critical consideration how, long ago, it had vehemently emerged in a two-way dialogue between Jean Nouvel

Fig. 10. Frames from the film Sketches of Frank Gehry [Pollack 2006].

and Jean Baudrillard [Baudrillard, Nouvel 2003]. Also in that case the topic of authorship was repeatedly put in stricter terms: "Is there anything easier than reusing existing data –the architect wondered– given the fact that the computer can modify that data so quickly? You change a parameter here, another there, and after a few hours, it's done. The system is ready for a new building. […] Within that architectural space –the philosopher asked himself– does the possibility still exist for the architect to make his mark? […] Most of the time –replied Nouvel– there is no architect in the sense generally understood. There are engineers who are pretty efficient at working with the standards." [Baudrillard, Nouvel 2003, pp. 53, 54].

The extreme engineering of the architectural product, even in the form granted by BIM technologies, branches, in fact, into different competencies the success of a project, so that in some cases –as in the example described by Livio Sacchi in this issue [Sacchi 2018, p. 138]– the actual creative contribution of the work is hardly imputable to a single human subject. It is no coincidence that Jean Nouvel concluded the debate with a few disarming words confirming the significant change taking place within the discipline: "an automatic architecture created by interchangeable architects. This fatality doesn.t bother us; it's an essential part of today's reality" [Baudrillard, Nouvel 2002, p. 80].

Notes

[1] Sutherland 1963 as well as Sdegno 2013.

[2] Ruskin 1957. On the theme of the didactics of drawing according to Ruskin see also: Levi, Tucker 1997.

[3] As is well-known, Gaspard Monge is defined mathematician, physicist, engineer, draftsman. Here we use the most frequent definition. For a further analysis of his figure, see the recent volume: Cardone 2017.

[4] On the figure of Steven A. Coons see: Sdegno 2012 and Cardoso Llach 2015, pp. 49-72.

[5] SAGE is the acronym of Semi-Automatic Ground Environment, air defense system for the American territory that used a light gun aimed at a screen.

[6] The mentioned session of the Spring Joint Computer Conference is found at pp. 299-353, with texts by S.A. Coons, D.T. Ross, J.E. Rodriguez, R. Stotz, E.I. Sutherland, T.E. Johnson, all MIT researchers or professors: AA.VV. 1963.

[7] The patent for the mouse was issued on 17 November 1970, with U.S. Patent No. 3541541: Bardini 2000, pp. 81-102.

[8] OCR stands for Optical Character Recognition, a system for the recognition of text characters.

[9] The image is archived with Code No. 2003.54.1: <http://portlandartmuseum.us/mwebcgi/mweb.exe?request=record;id=5273;type=101> (accessed 2018, July 8).

[10] We are referring to Ikea Place, permits placing virtual furniture in a real setting: <https://www.ikea.com/gb/en/customer-service/ikea-apps/> (accessed 2018, October 10).

[11] Grasshopper was developed for the Rhinoceros 3D modeling software.

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Cybernetic Drawing. A Unifying Language of Pask's Cybernetics and Computer Art in Germany

Liss C. Werner

Abstract

The essay provides an overview of relationships between the cybernetics with a special emphasis on the British cybernetician Gordon Andrew Speedie Pask and the computer art developed in Germany in the 1960s-70s with an introduction to the artists Frieder Nake and Georg Nees. In the 1960s, early computer artists, such as the Max Bense, Vera Molnar, Georg Nees, Frieder Nake and others, began to explore the relationships between art, design, science and the cybernetic principle of feedback. Their computer art investigated esthetics of computer languages for automated process of generative iterations away from the fixed states of pre-determined formalism. In the meantime, in the UK, Gordon Pask developed Conversation Theory*, a formal model applied in his cybernetic 'machines'. The networks and conversation diagrams that described CT represented possibilities of interaction between actors resulting in emergent forms of behavior. Both, the early computer art and Pask's logic can are based on cybernetic foundations, as a unifying language. The fields' concerns have expanded significantly and partly merged since then. The discussion still lies in the dichotomy between the urge for control and authorship over form and method of creation, and the approach of understanding form and its aesthetics as result of an activated dynamic systemic pre-programmed set of rules rather than states –all under the wings of a unifying language, namely cybernetics.*

Keywords: Cybernetics, Gordon Pask, Frieder Nake, Georg Nees, Computer Art, Germany.

Cybernetics as Unifying Language for Interrelated Systems

In 1948 the American mathematician and philosopher Norbert Wiener coined the term Cybernetics. His first published book on cybernetics *'Cybernetics: Or Control and Communication in the Animal and the Machine'* [Wiener 1948] has had a great impact and is regarded as the theoretical foundation for cybernetics as a science that would bridge between the disciplines. At that time, Wiener may not have suspected that cybernetics would grow from a tool for steering linear systems into a generator for complex drawings and self-organizing multi-dimensional semantic-networks. Cybernetics as operation is concerned with the issues of *controlling*, *managing*, *steering* and *regulating*. All of those are slightly different in definition, execution and modes of communication and the process of information transfer; and all of them exist in systems of all kinds. On the paper I continue the argument that cybernetics can provide a unifying language to help bridging different sciences; I suggest that today we are in the process of cybernetification. [Werner 2017, Werner 2018] Communication, or the process of information transfer, is relevant to all four facets of cybernetics. Cybernetics is based on feedback. Feedback is a reaction which to an extent, not necessarily exclusively, influences the future behavior of a system; may it be for its flourishing, formal change or its termination. It is an essential driver for a cybernetic system, may it be a social system made of human interaction, a cognitive-biological system made of neurons and muscles, a technical-sensoric system –such as a thermostat– or an

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algorithmic system made of binary code and memory and artificial learning algorithms. In principle a cybernetic system is made of 'programmed' signs that enable interacting constructs; interacting constructs are isomorph to the form(s) that represent them, while the form may be a numerically described algorithm or a graphic visualization. In the widest sense any 2-, 3- or more-dimensional static or dynamic data-visualization. Depending on the observer of the data-visualization the cybernetic system can a) communicate an information, possibly it carries a semantic meaning and b) extend insofar that it includes the observer into the system –as an active part of it.

The birth of cybernetics as bridging science was triggered through the problem of specialization in the various fields of sciences, such as the hard sciences mathematics, statistics, biology, (neuro)physiology, electrical mechanics, chemistry, engineering and the soft sciences, such as sociology, anthropology or psychology in the 1940s followed suit by disciplines of design such as architecture (Christopher Alexander, Cedric Price), and urban design (Yona Friedman, Constantinos A. Doxiades, project Cybersyn) in the 1960s and 70s [Werner forthcoming]. The group around the mathematician Norbert Wiener, the engineer and inventor of the *Differential Analyzer* Vannevar Bush [Bush 1931], the physiologist Arturo Rosenblueth and the computer engineer Julian H. Bigelow, based as Massachusetts Institute of Technology, Harvard University and the Bell Laboratories, pushed cybernetics as unifying science [Stewart 2000] [Van Alstyne 2006]. Goal was to solve scientific problems that were related to a number of disciplines and only solvable through each discipline depicting the issue through the specific means and expertise, the method however, was envisaged to be similar; as Wiener recalls "Dr. Rosenblueth has always insisted that a proper exploration of these blank spaces on the map of science could only be made by a team of scientists, each a specialist in his own field but each possessing a thoroughly sound and trained acquaintance with the fields of his neighbors; all in the habit of working together, of knowing one another's intellectual customs, and of recognizing the significance of a colleague's new suggestion before it has taken on a full formal expression" [Wiener 1948, p. 3].

By the mid 1940s, the group had the opportunity to collaborate on projects, Wiener and Bigelow investigated "the theory of predictions and of the construction of apparatus to embody these theories" [Wiener 1948, p. 6]. Part of the equation was the knowledge about the human who would 'assist' a machine, e.g., a fire-control apparatus, to perform successfully. Wiener suggested, that the characteristics of this part of the system needed to be understood in order to translate into mathematics and subsequently to include it mathematically into the machines. In his book, Wiener brings up the relevance of feedback, as concluded together with Bigelow; he explains feedback as a motion, or reaction to an input. The difference of the reaction between the expected (simulated) and the actually performed one is the input that feeds back into the system. Communication and control became a focal point of the discussion. Wiener, Rosenblueth, Bush and Bigelow decided to "call the entire field of control and communication theory, whether in the machine or in the animal, by the name of *Cybernetics*, which we form from the Greek κῠβερνήτης or steersman". At this moment Wiener refers to the Clerk Maxwell's paper on *feedback* in 1868. Apart from the engineers and mathematicians mentioned above the US group of scientists in and around cybernetics as a bridging discipline on communication in the human and the machine included Aiken, von Neumann, Goldstein, McCulloch, Pitts, Weaver, Selfridges and Kurt Lewin. The anthropologists Margaret Mead and Gregory Bateson discussed and researched the side of communication within human organization and social systems –always in exchange with their colleagues from the 'hard sciences'.

On the other side if the globe, in the UK the psychiatrist Ross Ashby, the computer scientist Alan Turing and the neuro-physiologist and robotics pioneer Gray Walter [1] joined the innovative group followed by the economist Stafford Beer and the cybernetician Gordon Pask, the Austrian biologist Heinz von Foerster and others. The Macy meetings, later Macy conferences held between 1956 and 1953, funded by Josiah Macy, Jr., provided the first official frame for discussions between scientists of different fields to thrive the interdisciplinary community and to foster a unifying language for all fields [Pias 2016]. Gray Walter's tortoise is of special interest to the idea if cybernetics as unifying language, since the robots to which Walter referred to as *Machina Speculatrix* exhibited an unforeseen form of behavior based on a) a pre-programmed system and b) a combination of sensors, amplifiers, and a motion apparatus [Walter 1950].

Also, in Germany the term *Kybernetik* had been discussed and tested to a similarly large extend since the 1950s. The German physician Hermann Schmidt [2] (1894-1968) was professor for cybernetics at Technical University Ber-

lin and is considered the German father of cybernetics and specialized in "Allgemeine Regelungskunde" (science general control and regulation) focusing on technical and living systems. He also discusses cybernetics as bridging sciences [Schmidt 1941]. Herman Schmidt is regarded as the German father of cybernetics [Fasol 2002]. Schmidt, like Helmar Frank, applied mathematics to psychology and pedagogy. While Schmidt researched the effect and changing nature of the human through technology, Frank focused his on the act of learning, cybernetic pedagogy and the development of *Lernmaschinen* [3] (learning automata). While the book *Kybernetik – Brücke der Wissenschaften* (Cybernetics – Bridge between Scientific Disciplines) edited by Helmar Frank, first published in 1962 [Frank 1966], offered a foundation for the discussion about cybernetics as unifying language and science, wrote Felix von Cube *Was ist Kybernetik* (What is Cybernetics) [Cube 1967]. The latter introduces basic principles, such as the steersman, feedback and the relationship of different disciplines. One focal point in his book is the term Information (Informationsbegriff) across research fields. He states "Der Begriff der Information (im kybernetischen Sinne) läßt sich auch in den Geisteswissenschaften und […] in den Sozialwissenschaften mit Erfolg anwenden. Freilich ist stets zu bedenken, daß der kybernetische Begriff der Information nichts mit Inhalt oder Bedeutung zu tun hat. Will man im Rahmen irgendeines Wirklichkeitsbereiches inhaltliche Aussagen machen, muß man erst eine Zuordnung des betreffenden Inhalts zu den Strukturbegriffen und Strukturgesetzen herstellen" [4] [Cube 1967, p. 33]. Cube includes chapters by the German mathematician, philosopher and author, professor for philosophy and Max Bense, Professor of History and Science and Georg Nees on *Generative Aesthetics*.
The German philosopher and author Max Bense founded the Stuttgart group (Stuttgarter Schule / Stuttgarter Gruppe) at the end of the 1950s, which implemented his ideas of information-theoretical aesthetics. Computer-generated art forms such as graphics, literature, and semiotics found their place around Bense. In 1965, Bense arranged the first exhibition for computer art showing works of the artists Georg Nees and Frieder Nake in Stuttgart. Max Bense manifested cybernetics in a third field titled *Esthetics of Information* (*Informationsästhetik*), esthetics of the digital (Ästhetik des Digitalen), algorithmic esthetics (algorithmische Ästhetik) or cybernetic esthetics (Kybernetische Ästhetik) [Bense 1965]. In 1968, Bense, Nake, Nees and other computer artists of the Stuttgart group, along with Gordon Pask and other international computer artists, showed part of their work in the exhibition *Cybernetic Serendipity* in London curated by Jasia Reichardt [Reichardt 1969].
Bense, who had exhibited at the exhibition Cybernetic Serendipity founded the Stuttgart Group end of the 1950s with which Frieder Nake and Georg Nees where affiliated. Bense's work and research focused on aesthetics and semiotics.

The Unifying Language of Gordon Pask

Gordon Andrew Speedy Pask (1928-1996) was a British Cybernetician, who in rhe beginning of the 1950s began designing a theory for conversation, which could unify disciplines of science, principoles of interaction between humans, humans and machine and machines, theories of architecture and methods of teaching and learning. From the 1950s onwards Gordon Pask developed cybernetic teaching and entertaining machines as well as interacting spaces such as *Musicolour* in 1953, or the *Colloquy of Mobiles*, exhibited at the exhibition *Cybernetic Serendipity* in 1968. One of his most known interactive architectural spaces is the *Fun* Palace, designed by the British architect Cedric Price.
Pask delved into understanding cybernetics as a general system to approach, observe, understand and analyze. His cybernetics operate on a multitude of levels, phenomenal domains and are subject to observations from all disciplines. The machines acted as physical proofs of concept for his *Conversation Theory*, which he published in of two books in 1975 and 1976. In the beginning of the 1990s the theory was complemented by his *Interactions of Actors (IA). Theory and Some Applications* [Pask, de Zeeuw, Nov 1992]. Conversation Theory entails agents and their ways of communication in a conversation, which essentially is an exchange of information in a system equipped with cognition ability. Each agent is subject to his or her previous knowledge and repertoire of signs to communicate with. CT had the "cybernetic aim of unifying theories and concepts across disciplines. Thus, for Pask, anything that can be sensibly said about 'conversation' is part of CT. As a cybernetic theory, CT is the theory of conversations." [Scott 1987, Pask 1978] Conversation theory also entails what is currently applied in experimental digital and medial architectural representation and production, specifically in the generation of computer-based or algorithm-driven design

(architecture). Based on similar principles, it emerged as a foundation before what we know in digital architecture as genetic or evolutionary algorithms. This describes an interactive algorithm that conquered digital tools, motherboards and parallel processors; with the possibility to apply parameters and disturbances in dynamic environments (ecologies, systems); these environments (ecologies, systems) experience smaller or more far-reaching radical changes that can lead to the mutation of the ecosystem or its elements.

A review by Bernard Scott engages with Pask as a theoretical cybernetician, curious and witty [Scott 1982]. He suggests that Pasks passion and life-long commitment to cybernetics as field of research began at the 1959 conference on 'The Mechanisation of Thought Processes' where the thirty-one year old inventor, biologist and physicist met the piomeers of cybernetics including Warren McCulloch, Stafford Beer, Marvin Minsky, Ross Ashby. As Pask's *An Approach to Cybernetics* shows, those early cyberneticians highly influenced the young man [Pask 1961b]. His paper *Physical Analogues to the Growth of a Concept*, mentioned by Scott, presents the advent a conversation of Pask cybernetics, design strategies and their connection to form advents. Pask discusses "the circumstances in which we can say a machine 'thinks', and a mechanical process can correspond to concept formation" [Pask 1958]. Another influential event may have been the interdisciplinary *conference on Self-organizing Systems* on May 5th and 6th at the Illinois Institute of Technology with Heinz von Foerster, Marvin Minsky, Rosenblatt, Warren McCulloch and others. Pask presented a hypothesis on *The natural History of Networks*, a paper in which Pask introduces the 'Network Space' as four-dimensional open reaction system [Pask 1959]. He applies a similar way of thinking as he does for the 'Phase Space' in *An Approach to Cybernetics* (fig. 1).

Even though we may be able to categorize Pask's cybernetics in the fields of conversation, learning, architecture and computer technology there is little chance to pinpoint and reduce Pasks cybernetics to a particular model. However, Stafford Beer's *Viable System Model (VSM)* and Ross Ashby's *Law of Requisite Variety* influenced Pask's model of *Conversation Theory*. For Pask "cybernetics is no more restricted to the control of observable assemblies and the abstract system that correspond with them, than geometry is restricted to describing figures in the Euclidean space which models our environment" [Pask 1961a]. In the 1974 BBC documentary featuring Gordon Pask, he states on the

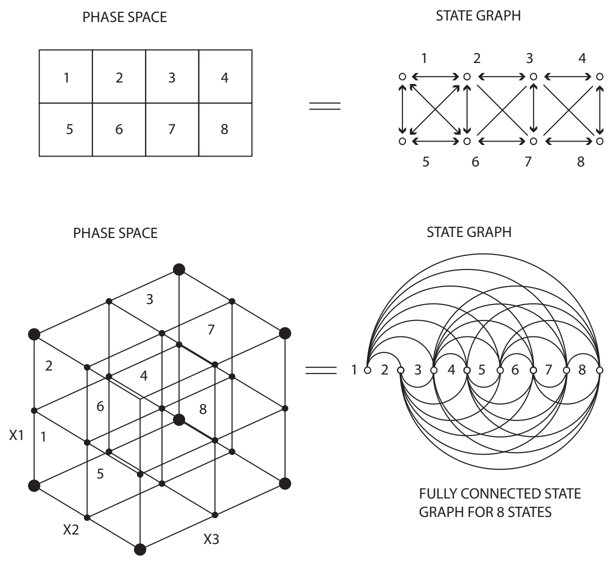


Fig. 1. Diagram of 'Phase Space' and 'State Graph' in two and three dimensions [Pask 1961a] (graphic elaboration by the author).

interest of cyberneticians that "We are not much interested in what the conversation is about, we are interested in how it takes place. And the hypothesis we test are about how people understand or learn or what can we understand about processes of conversations" [Davies 1974]. Rather than engaging in content as research subject, Pask emphasized on the system of information transfer. Principles of encoding, decoding, understanding and information carrier were the basis of Pask's work. We can see parallels to Felix von Cube's observation mentioned earlier. In 1976 Gordon Pask defines and describes in which man-made organizations or disciplines a cybernetic method can be applied in future. In the so-called 'Belgian Paper' *Future Prospects of Cybernetics* Pask states: "Cybernetics is the science of control, communication and organization. As such, it is primarily concerned with synthesizing goal directed (purposive) systems or analyzing the behavior of internal functioning of those that already exist. These systems may be of various sorts. For example, there are mechanical or electronic regulators for plant control, factory control (automation), vehicle control and the like; […] The mind and the brain of man is a goal directed system in the province of psychological cybernetics (sometimes known as cognitive studies) and it is possible to imitate certain mental faculties by machine or computer programs ('heuristic programming' and 'artificial intelligence'" [Pask ca. 1976]. Main characteristic, for Pask, is that the system is required to be goal-directed. Pask differentiates between cybernetics and operational research. He emphasizes on a man-system interaction that implies from man-machine interaction, learning and decision-making processes through computer assistance (man-machine-interaction). In the paper Pask defines cybernetics as a science, a method, and approach, a characteristic for a system (cybernetic system) and a theory. He stresses the necessity to research cybernetics in light of human's involvement in a system. He describes cybernetics as a method and a theory in his thoughts as plea to the future: "Although the mathematical theory of engineering Cybernetics is more sophisticated that that of the other branches it is interesting to observe that the theory is underutikised by industry and commerce. […] The fact is that in view of the nature of man, society and the economic system automation (computerisation, mechanisation etc.,) is frequently undesirable. In one sense this is disappointing to the professional, in another, it suggests that as a general rule insufficient attention has been given in the past to man machine relationships, cognition and the character of the social organisations in which all Cybernetic systems are ultimately employed. Hence I am inclined to the view that the most exciting and fruitful directions of Research are those that involve human beings as part of the system" [Pask ca. 1976]. Gordon Pask finally suggests that the cybernetic approach is "conversational rather than authoritarian" or mathematics based "automation like systems" [Pask ca. 1976].

Algorithmic Art, Computer Art, Information Esthetics

Algorithmic esthetics, generative esthetics, digital esthetics or information esthetics refer to the esthetics, the perceived formal outcome, of computer programs. Rule-based art as such irritated and simultaneously stipulated the discipline of art in the 1960s and 70s. German philosopher-physicist Max Bense, the French-Hungarian media artist Vera Molnar, the German mathematicians Georg Nees, Michael Noll, Frieder Nake and others, began to explore the relationships between art, design, science and the cybernetic principle of feedback. Their work was a part of a digital

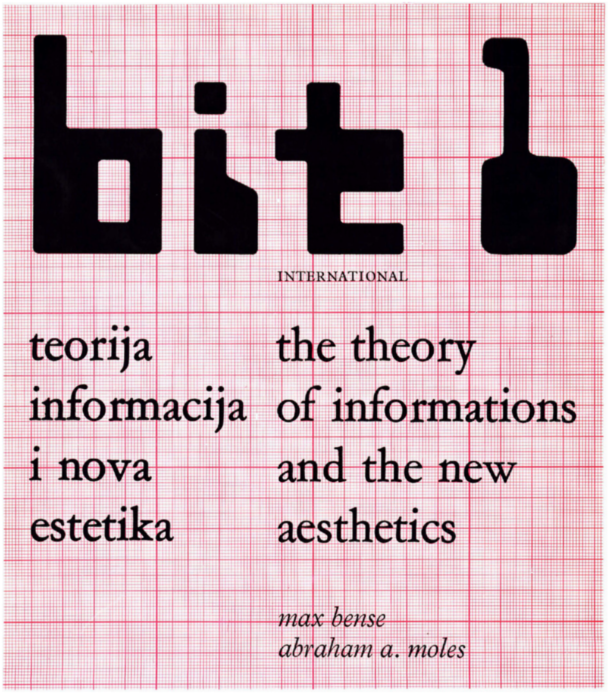


Fig. 2 Cover of the first issue of Bit International Magazine. <https://monoskop.org/File:Bit_International_1_The_Theory_of_Informations_and_the_New_Aesthetics_1968.jpg> (accessed 2018, October 24).

media revolution celebrated with an exhibition titled *Algorithmische Revolution – zur Geschichte der interaktiven Kunst* (Algorithmic Revolution – on the history of interactive art) curated by Peter Weibel und Dominika Szope Katrin Kaschadt and Margit Rosen between 2004 and 2008 at the ZKM, *Zentrum für Kunst und Medien* in Karlsruhe, Germany. The work triggered the idea to rationalize, represent and describe design formally abstract – rather than figurative. It was an experiment, a movement and a trigger to create art (drawings) through rules. A scientific approach, where by the artist would design the system, the computer program, and not a final product. One of the birthplaces for computer art in Germany was the literature department of Max Bense - who had studied physics, chemistry, mathematics, geology and philosophy. The so-called *Stuttgarter Schule / Stuttgarter Gruppe* [Döhl 2012] researched on

Sl. 12. Na svakom nivou komunikacije između odašiljača i primaoca, koja se odvija po bilo kakvom kanalu, moguće je uvijek razlikovati dva aspekta poruke. Poruka ima s jedne strane semantički aspekt koji odgovara stanovitom repertoaru standardiziranih i univerzalnih znakova, a s druge strane postoji estetski aspekt (MOLES) ili ektosemantički (MEYER, EPPLER) koji je izraz varijacija što ih signal može podnijeti a da ne izgubi svoju specifičnost u granicama jedne norme. Te varijacije predstavljaju polje slobode koje svaki odašiljalac iskorišćuje manje-više originalno. Poruka koja stiže do primaoca može se dakle smatrati sumom informacija semantičkih H_s i estetskih H_e.

Fig. 12. A chaque niveau de communication entre l'emetteur et le récepteur par un canal quelconque, il est toujours possible de distinguer deux aspects dans le message. D'un côté l'aspect sémantique, correspondant universels, de l'autre, l'aspect esthétique (MOLES) ou ectosémantique (MEYER EPPLER) qui est l'expression des variations que le signal peut subir sans perdre sa specifité autour d'une norme; ces variations constituent un champ de liberté que chaque émetteur exploite de façon plus ou moins originale. Le message qui parvient au récepteur peut donc être considéré comme la somme des informations proprement sémantique H_s et estétique H_e.

Semantički i estetski modus shvaćanja poruke.
Modes sémantique et ésthétique d'apréhension de message.

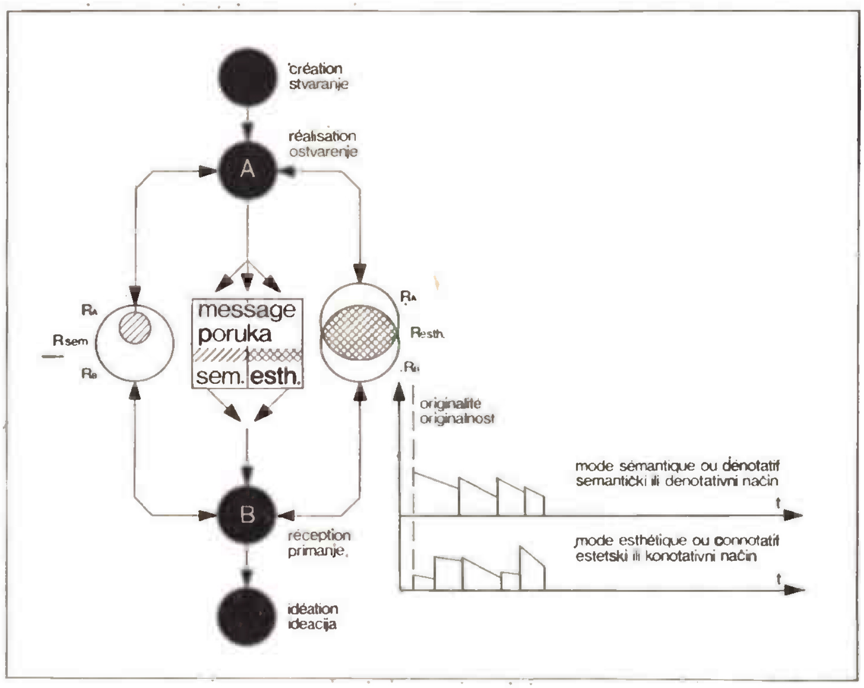


Fig. 3 Diagram 'semantic and esthetic modes of message apprehension', by Abraham A. Moles. Source: Bit International, Issue 1, Zagrab, 1968, p. 39.

computer poetry, whereby the semantics and semiotics of words would have been transformed into visuals. Bense initiated the first exhibition of *artistic computer graphics* in Germany in 1965 (the exhibition *Cybernetic Serendipity* curated by Jasia Reichardt took place in 1968), where he showed works by Georg Nees, and later works by Frieder Nake. Georg Nees, who had worked for the Siemens AG, was mathematician who later received his doctoral degree in philosophy from Max Bense.

In 1968, Max Bense and Abraham Moles contributed largely to the journal *bit international – the theory of informations and new aesthetics*, published in Zagreb –former Yugoslavia– with texts published in English, Croation, French and German (fig. 2). It discussed the subject of information and esthetics through philosophical ideas, generative drawings and newly developed theories compiling and juxtaposing semantics and aesthetics through e.g. phenomenology, experience or reception. The core of all texts is a cybernetic principle of information transfer. Abraham A. Moles' diagram (fig. 3) is titled 'semantic and esthetic modes of message apprehension'. It shows the process from creation to realization and its translation to reception and ideation through the attribute 'message'. He describes (originally in French) "At every level of communication between the departure and the recipient, which takes place through any kind of channel, it is always possible to distinguish two aspects of the message. On one side the semantic aspect of a certain repertoire of standardized universal characters, and on the other hand there is an aesthetic aspect (MOLES) or ectosemantics (MEYER, EPPLER) which it is

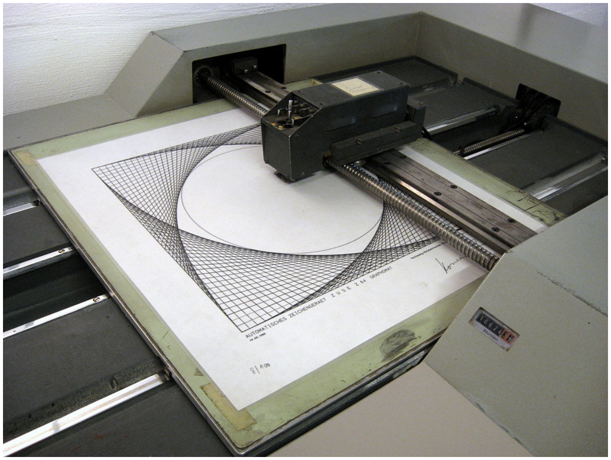


Fig. 4. Automatisches Zeichengerät ZUSE Z64, flatbed drawing machine Graphomat Z64, photograph by Tomasz Sienicky: <https://commons.wikimedia.org/wiki/File:Automatisches_Zeichengeraet_ZUSE_Z64_ubt.JPG> (accessed 2018, September 24).

the term variation of the Ito signal. It is used by the signal without losing its specificity within the boundaries of a norm. These variations represent a field of freedom that every dispatcher uses. Message received by the recipient are therefore to be considered a sum of information of the semantics Hs and aesthetic He" [Moles 1968, p. 39]. Max Bense's text 'ästhetik und programmeriung' theorized modern esthetics. He states that modern esthetics defined the artistic object as carrier of an 'esthetic state'; and that this esthetic state is –in comparison to the actual material object– rather weak. Bense differentiates between *numeric esthetic*, *semiotic esthetic*, *sematic esthetic* and *generative esthetic*, whereby the first describes the material esthetic of the artistic object the second and third describe the ontological aspect and the fourth relates to the computation of the artistic object. This includes a de-construction (Zerlegung) of the processes used to produce the art. In the case of generative art generative esthetics derives from the algorithm used [Bense 1968, pp. 83-86].
Georg Nees, Frieder Nake and Michael Noll, became the 3Ns, "pioneers of computer art [Klütsch 2007]. Nees experimented with the computer language ALGOL (Algorithmic language) on a *Zuse Graphomat Z64*. The Z64 was a combination of a computer and a drafting machine (fig.

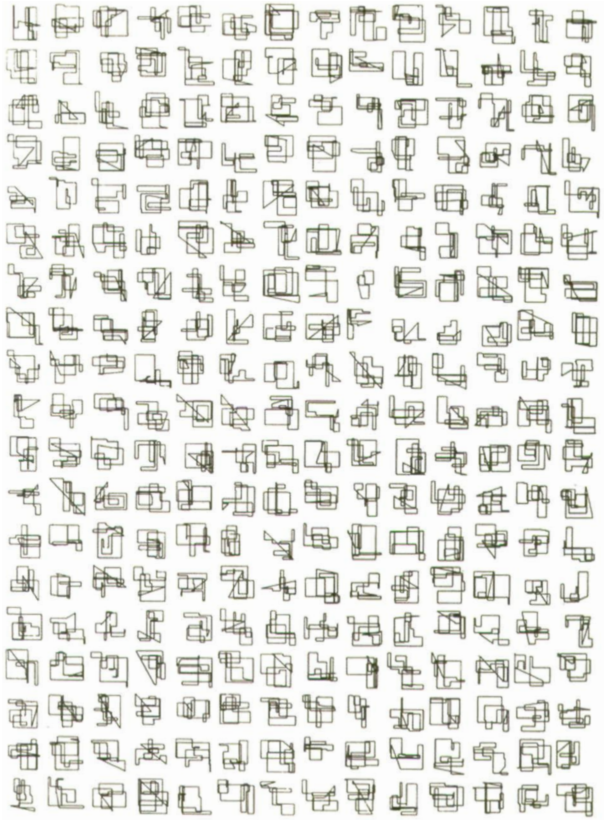


Fig. 5. 23-ecke, by Georg Nees, ink on paper (29,7 x 21 cm). Originally published in the journal rot issue 19, Stuttgart 1965 [Nake 2009].

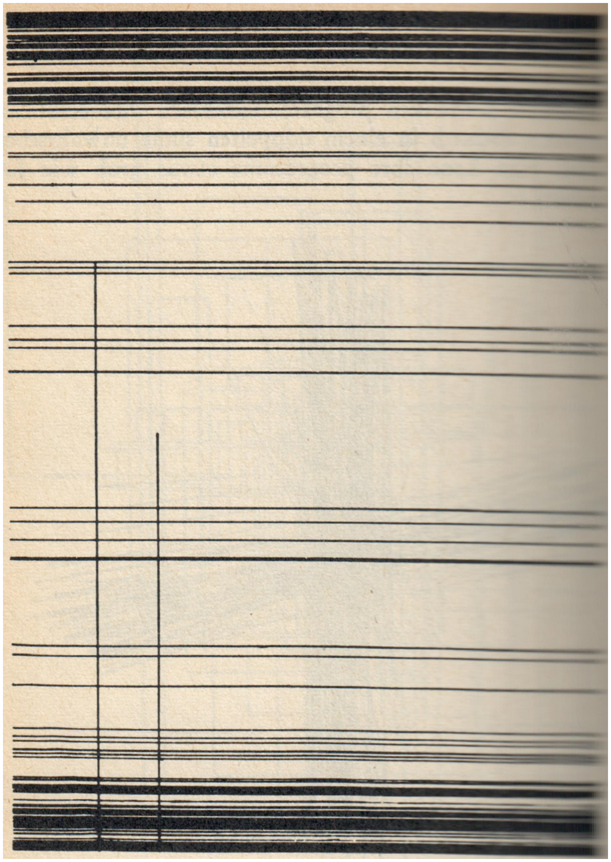
4). The programs (sets of consecutive commands) were given to the drafting apparatus in form of punch cards. The programs would repeat constantly executing the same set of rules. Stochastic control created a random scattering of the output data, so-called *esthetic innovations*. In context with his description of his artworks –his impossible esthetic states– *8-ecke* and *23-ecke* [5] (fig. 5) Nees describes: "jede grafik besitzt zufällige parameter. das program zur einzelnen grafik wiederholt operierende grundoperation so, daß die bloßen wiederholungen die ästhetische redundanz, die zufälligen parameterwerte bei jeder wiederholung die ästhetische unwahrscheinlichkeit der grafik erzeugen"

[6]. According to Georg Nees, the random factor would repeat after 2^{30} repetitions. Cube describes the realized computer program for the information aesthetic *'Gardinen'* as a set of instructions: in the frame of a rectangle draw 60 lines parallel to the shorter edges of the rectangle in a way that the distances between the parallels decreases randomly towards the outer edges (fig. 6). Drawings by A. Michael Noll (Gaussian-Quadratic, 1965), Georg Nees and Frieder Nake (Nr. 5 'Verteilung elementarer Zeichen', 13. Sep. 1965) [7] were exhibited at the *Cybernetic Serendipity* exhibition in 1968. In the very same exhibition Gordon Pask's showed his interactive kinetic spatial sculpture *Colloquy of Mobiles*.
He states "Man bemerkt, daß die maschinelle Erzeugung *der Unwahrscheinlichkeit ästhetischer Zustände* durch eine methodische Kombination von Plan und Zufall ermöglicht wird" (One notices that the machinic creation if the impossibility of esthetic states is enabled through a methodical (systemic) combination of plan and coincidence) [Cube 1967, pp. 27]. In 2012, Nake describes the momentum critically "Information Aesthetics was a short-lived but influential attempt to establish an aesthetic theory of mathematical rigor without subjective elements. It was based on information theory, semiotics, and communication theory. It was mainly developed in Germany and France during the 1960s. It not only" gained some influence among designers and artists, but also among teachers of art. Its concepts turned out to be reductionist and schematic, which we argue led to its eventual disappearance, if not failure" [Nake 2012]. In the 1960s, however, the momentum was similarly to the momentum of cybernetics at the first peak of its existence.

Conclusion

Both, Gordon Pask's cybernetics and the early German computer art, describe a cybernetic approach to interrelated systems, their algorithmic causation and aesthetic appearance. The biggest difference can be regarded the approach to what happens with the information after it arrived at its destination. Nake refers to the Shannon/Weaver model, *The Mathematical Model of Communication*, conceived in 1948, which allows for input, process and output. The debate around the questions of aesthetics and art rose, that question discussed an ultimate truth or existence of an objective aesthetics vs a subjective aesthetics [Nake 2012]; or in cybernetic understanding by the observer. Claude E. Shannon's model does not include feedback for a next iteration. The model is restricted to itself as a closed system. It can be observed, analyzed and evaluated from an external observer, but does not encounter for including the observer into the process of operation, into the equation. The cybernetic model used by Gordon Pask made use of the observer. It included the observer as active part of the system, who could learn and teach the system. Pask referred to conversations; the output of a conversation would act as input for a next iteration of the conversa-

Fig. 6. Gardinen, by Georg Nees, 1968, created on a Graphomat Z64 [Cube 1967, p. 276].



tion. Thus, the process of conversation would be driven by itself, and continuously create new forms. Strictly speaking, the model referred to for computer art in the 1960s is a model of 1st order cybernetics, the model referred to for the work of Gordon Pask is a model of 2nd order cybernetics; Pask included the human. If we extend the system to create computer art, generative aesthetic, information aesthetics to the designer of the computer program, such as Georg Nees, who experimented with circles, amount of lines and the parameters to arrive at an emergent artistic expression, if we include the designer, the programmer artist into the equation, then, I suggest, computer art in the 1960s followed by a model of 2nd order cybernetics.
We observe a two-level construct, with the first level being reduced to simply executing an algorithm through e.g., a flatbed drawing machine, and the second level with the observer who, as part of the construct, processes the produced drawing as input for further decision-making and action, as input for tweaking the algorithm. I would like to conclude with the suggestion that systemic principles applied to the act of creating information aesthetics in the 1960s and the systemic principles of creating interacting robots, teaching and learning machines are based on cybernetics as unifying language –not only because of their common affordance to interdisciplinary creation, but to their common principles of information process, their focus on information handling, rather than evaluation of content or meaning. I would further like to refer to Cube's thought that the combination, the almost coincidental collision of planned and spontaneous non-planned events is a pre-requisite of *the impossibility of esthetic states* or, if we look through the lens of cybernetics of the pre-requisite of a constant emerging and growing of new states, new situations, new constructed realities based on epistemological ground. Cube emphases on the operation of the *systemic combination* which affords a steersman.

Notes

[1] Gray Walter (1919-1977) invented the 'Anticipating Tortoise', one of the first automated small moving robots, that could recognize objects and avoid them while transiting.

[2] Hermann Schmidt's scientific works are currently kept safe in the university archive of Technical University Berlin. We are in the process of viewing the works for further research on cybernetics.

[3] Helmar Gunter Frank (1933-2013) was influential in the development of learning automata based on a cybernetic theory of psychology and pedagogy. He pursued his PhD at University of Stuttgart in Informational Esthetics. He was appointed professor for informational sciences (later cybernetics) at the Pedagogical University Berlin.

[4] "The notion of information (in the cybernetic sense) can also be used successfully in the humanities and social sciences. Of course, it must always be remembered that the cybernetic concept of information has nothing to do with content or meaning. If one wants to make substantive statements in the context of any realm of reality, one must first establish an association of the relevant content with the structural concepts and structural laws."

[5] The titles *8-ecke* and *23-ecke* refers to the initial graphics with either 8 edges or 23 edges executed by the Z64.

[6] Translation by the author: Every graphic has random parameters. the program to the individual graphic repeats basic operation so that the mere repetitions produce the esthetic redundancy, the random parameter values with each repetition the aesthetic improbability of the graphic.

[7] See *Bit* issue 1, page 95. <https://monoskop.org/images/b/bf/Bit_International_1_The_Theory_of_Informations_and_the_New_Aesthetics_1968.pdf> (accessed 2018, September 24).

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The Role of Digital Technologies for Project Representation

Matteo Del Giudice

Abstract

In recent years construction industry is crossing an innovation process based on the digitization of information to reliably describe the existing architectural heritage. Therefore, the need to adopt a new graphic language based on information modelling that summarises graphic and alphanumeric characteristics of a certain building has emerged. This contribution focuses on the analysis of aspects that have characterized the idea of representation in the past, proposing information modeling as a natural renewal of design representation through digital technologies.

Keywords: Drawing, 3D parametric modelling, BIM, Existing building.

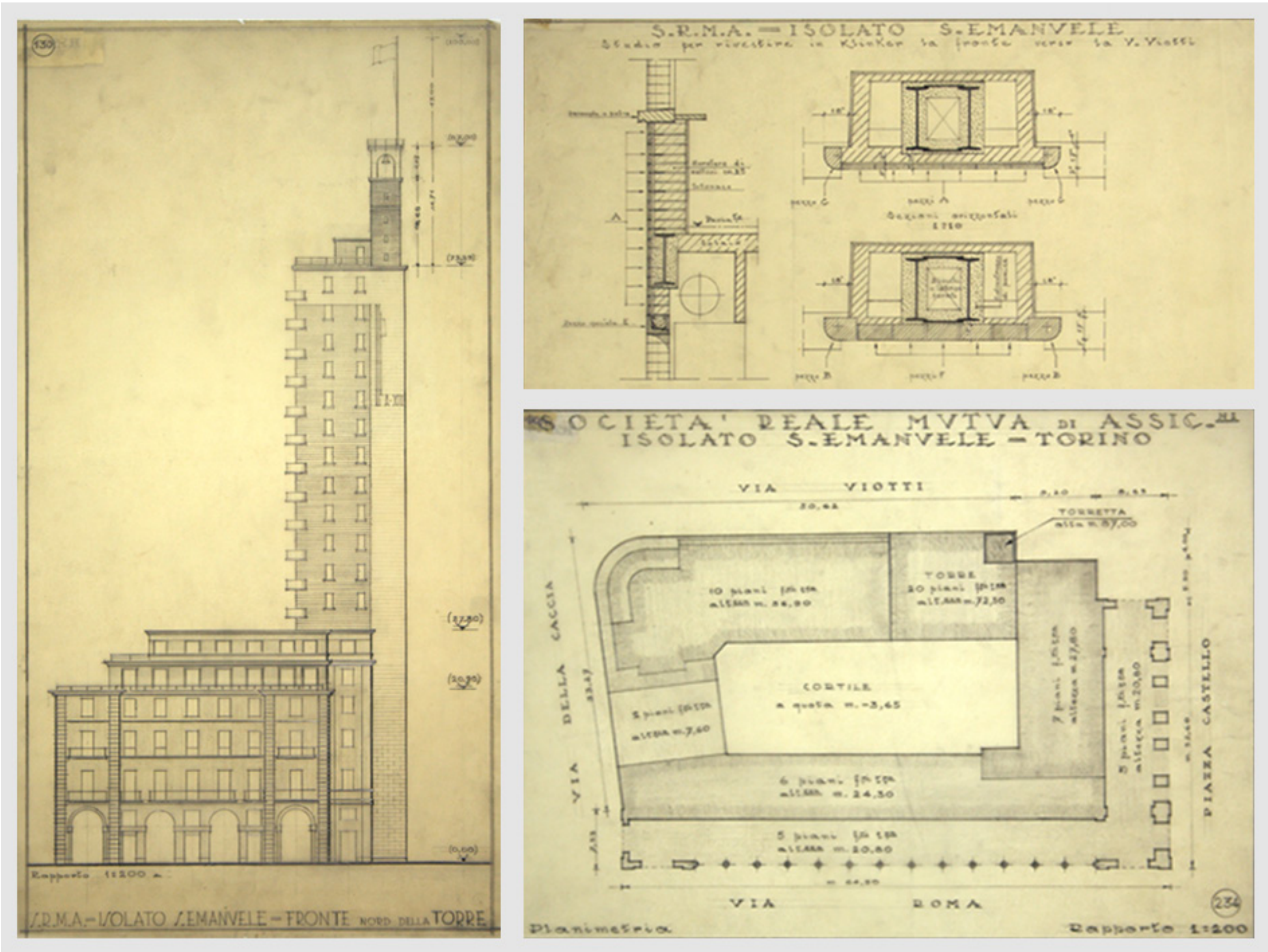
Introduction

The ability to communicate an idea or information about the project is fundamental for the human being who studied in history different ways and tools to describe reality, using various methods of representation, through drawing as a fundamental device to transmit a certain design idea.
Moving from idea to physical shape using drawing, has posed over time a series of questions about the meaning of representation to which many scientists have tried to respond with their researches. This contribution aims to explore the science of drawing, taking into account various definitions that have been given over time by scholars, clarifying the current role of digital technologies for existing heritage representation.

In XVIII century, the need of a drawing's theory was studied by Gaspard Monge who, thanks to descriptive geometry, encoded the method of orthogonal projections by defining exactly rules for representing space on the flat surface. Also in this case the drawing is declined as a necessary language both for the man who conceives a project and for those who have to realize it [Bennicelli 2006, pp. 261, 262]. One of the main challenges faced by Monge was explicit the need to describe entities properties of three-dimensional space in the two-dimensional one of the othogonal planes. The solution proposed by the scientist consisted on the fact that the object position was described by a representation on two orthogonal planes. According

to this procedure, the object can assume any position with respect to the reference planes that describe the position of the object itself in space through a projection system. Through this coding system, the French mathematician has succeeded in eliminating any ambiguity in the passage from representation to reality and vice versa.
In this way a discreet method was developed in order to speed up operations to be carried out more objective and clearer the process of representation. Gaspard Monge was therefore able to codify the topic of parallel projections with his texts, transforming drawing into the graphic representation science. The method he proposed satisfied the need to represent actual and very accurate shapes and sizes that useful for manufacturing production [Docci, Migliari 1992, pp. 74-78].
The language proposed by descriptive geometry thus becomes a suitable candidate to play a fundamental role in the industrial production era.
With modernity, technical drawing is able to respond to the mechanization of cities needs which knew the introduction of architectural forms and spaces of new conception based on new materials such as iron, during industrial revolution. With this transformation, the size of the city changes together with the shape and relationship of buildings in the urban context, proposing new styles of urban representation. The use of the prefabricated iron beam soon became the symbol of a new architectural formalism that also extreme the value of the design as a necessary tool to return the idea of project ready to be realized in series. With the industrial era, architectural drawing was transformed from a conceptual and cognitive tool into a functional project for building production, which would then need to create precise rules and regulations to codify the language of design drawings [Bennicelli 2006, p. 265].
The design sector was in line with the needs of the time, highlighting the descriptive characteristics of a certain artifact as a whole, even if observed for significant parts and no longer privileging the individual parts, plan, elevation, section [Bennicelli 2006, p. 266].
In the modern era, architectural design has seen a wide use of axonometric as a communicative language of spatial communication, highlighting the volume and describing the components of an artifact through the exploded drawing.
Through these languages, the importance of interdisciplinarity is enhanced by highlighting the need to communicate different information about form, matter and technology in relation to levels of focus such as context, artifact and detail.
Beside the stylistic research characterized by formal purity, the aim of the design was to represent architectural and urbanistic complexity in two moments of the design phase. The first one was related to the idea identified by the sketch, while the other one was concerned to the design development through the systematic proposal of materials and construction technologies inspired by industrial production, looking for a new industrial aesthetic [Bennicelli 2006, p. 268].
The attempt to understand and describe the role of representation, not only as a tool for translating the mental idea into a graphic sign, but also as a place where the design idea is expressed as the highest expression of the architect's poetics. The spirit of the Modern Movement is then embodied and substantiated, examining the architectural drawing as a mental and cultural tool [Florio 2012, p. 12].
In this sense, drawing is conceived as a vehicle to transmit information, but above all as a possibility that it identifies itself with the purpose to be achieved [Melis 2016, p. 891].
In this context, the activity of reading a building of the existing architectural heritage using a sign or a technology need to concretize the image of the human thought of a certain artifact through the direct consultation of graphic documents produced in the time of the project activity (fig.1).
The survey activity allows therefore developing representations of the reality that produce mental images of the artifact that can be materialized in the development of a virtual model information augmenting the detail degree from time to time (fig. 2).
In this context, Riccardo Antonini tried to formalism at this vision of drawing by introducing a formal theoretical model in which reality representation by the human being intrinsically produces a three-dimensional virtual world that is implemented through the mechanism of perception [Antonini 2004, pp. 54-61].
The mental images of reality and of its very representation produce a series of relationships that give life to the project. Thus, several definitions are available on it: the mental image representation of a person who

Fig. 1. North elevation, vertical and horizontal sections and the layout view of Torre Littoria, located in Turin. Fondo Melis de Villa, LSBC Politecnico di Torino.



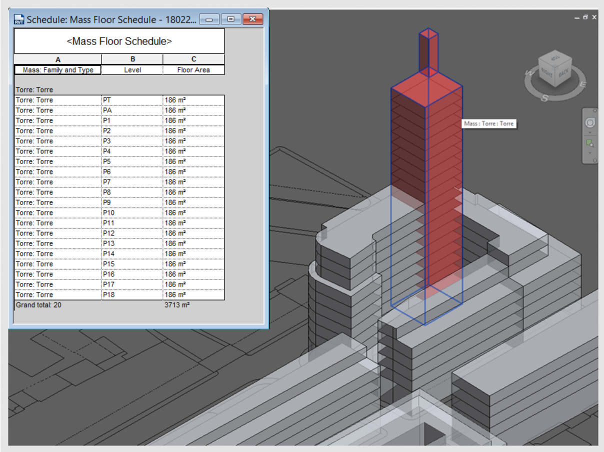


Fig. 2. Mass Axonometric view of Sant'Emanuele district with mass floor schedule (graphic elaboration by the author).

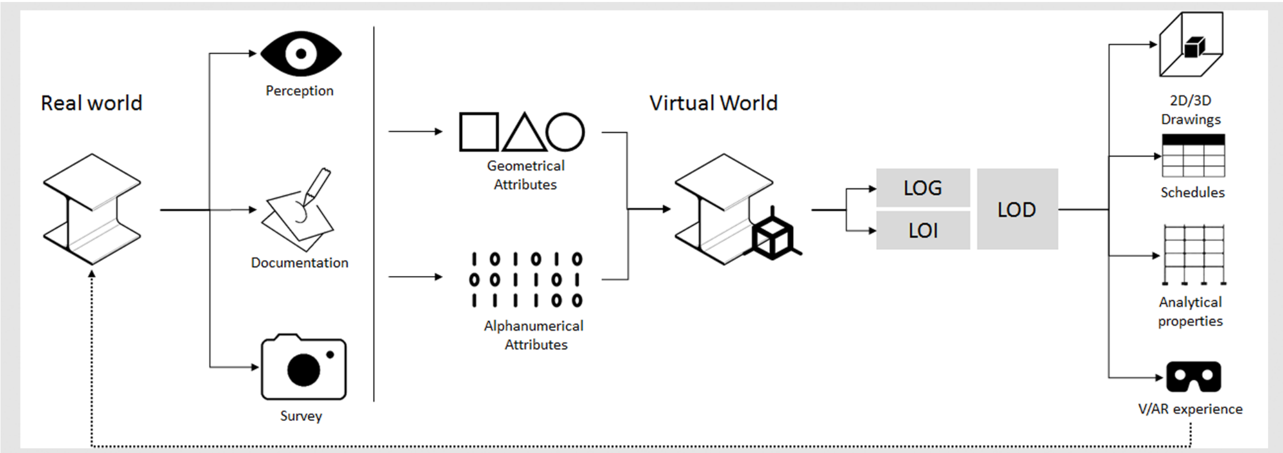
imagines the perception of an object as if it had already been developed and the representation of the project itself through the drawing activity. This operation has brought over time the real world closer to the virtual one by defining some differences between drawing and simulating the imagination, creating two areas such as the design-drawing/survey and that of Virtual Reality (VR) (fig. 3). Through object modelling and the materialization of the project image through informative 3D models, the two sectors are producing several interaction aimed at optimizing the construction process.
La comunicazione dell'idea progettuale può essere attuaTherefore, communicating the design idea can no longer be implemented only by means of a graphic sign on a surface, but also by processing a digital model.
This is enriched from time to time with information, generating different products including immersive visualization and graphic works, bringing the world of representation closer to the real one. In this way, representing the existing heritage occurs through the production of virtual models that transform traditional image of drawing as an instant that stops the flow of time [Dal Co 1989, p. 6], in a contemporary path that makes dynamic the reading of a building, through a communication language focused on the efficient data management through Information and Communication Technologies (ICTs).
In the era of digital transformation, representation is innovated with this language based on the creation of parameterized three-dimensional models in which heterogeneous information is brought together to generate possible scenarios. In this way, Drawing sector is revisited as a fundamental actor in the path that, from reality, passes through the mental images present in the formal conception of the represented object [Spallone 2012].

The role of digital technologies and information modeling

Traditionally, professionals have communicated their design content to the whole construction process developing a series of 2D and 3D graphic documents. This is associated with the concept of importance that underlines the value of direct consultation of these documents observed in their original materiality to disseminate knowledge of a built heritage.
Currently, Building Information Modelling (BIM) is innovating this procedure, focusing on the development of a shared graphical database that describes a large amount of information stored in 3D parametric objects including walls, floors, beams and analytical connections richer in data than simple sign-based drawings. Thus, digital information is considered the real added value because it favours the optimised data management which can also take place in a delocalised way, based on platforms that allow sharing of interdisciplinary knowledge. The collaboration between all the actors involved in the construction process takes place, adopting a working methodology based on common languages to transfer information and optimizing data management. Developing one or more databases facilitate the creation of data interactions, enhancing its uniqueness that can be filtered for different uses through interoperability. The information models can then be integrated by all professionals, adopting a shared protocol based on the creation of intelligent objects according defined exchange rules [Osello 2012, p. 61].
While traditional representation of built environment is characterized by two-dimensional products based on silent objects without any connection or relation between them, the development of 3D parametric models

describes reality with intelligent objects that are combined with each other to create a single database (fig. 4), containing the whole building data [Ciribini 2013, pp. 15-22].
This innovative methodology is based on the concept of worksharing among the different actors involved in a project activity that is identified as a specific moment in which each user tries to define an image of reality or of what he would like to achieve to satisfy a certain need. Thus, over time, informative models have improved their quality, thanks also to technological evolution, developing an important increase in performance of work. Taking into consideration the existing architectural heritage, the knowledge phase relating to a certain artifact, which can also be carried out by means of surveying activities, establishes a first image of the real world that can be traced through the production of digital or non-digital works. This activity is currently concretized through the elaboration of information models, simulation vehicles and the contracting of a resulting product or a process of the construction sector, through information contents of graphic, alphanumeric and multimedia type [UNI 11337-1:2017, p. 11]. By processing object-oriented parametric models, representation is enhanced including information as an added value in graphic design.
Architectural space is therefore described by solid components and spaces reproduced in various simulations that can be developed thanks to computers that have the ability to connect real world with the digital one. With information models, the artifact representation no longer falls within the usual orthogonal 2D projections or axonometric and perspective views, but in the reproduction of something that exists or need to developed subsequently.
In this sense, the idea of drawing was not modified according to the mechanical or electronic tools, but it has been enhanced continuing to hold the fundamental role of communicative language to optimize representation of both reality and project.
The elaboration of simulation models, offers today the opportunity to optimize the management of data, making them consistent with each other with the opportunity to narrow the distance between real and the virtual world. Simulation images of both real and project can therefore take place starting from models that can evolve over time, according to the objectives and uses that have been drawn up or requested.
Thus, the starting point for these information models is the definition of geometrical (LOG) and alphanumerical (LOI) detail levels for each object that

Fig. 3. Conceptual scheme of representation process from Real to Virtual World



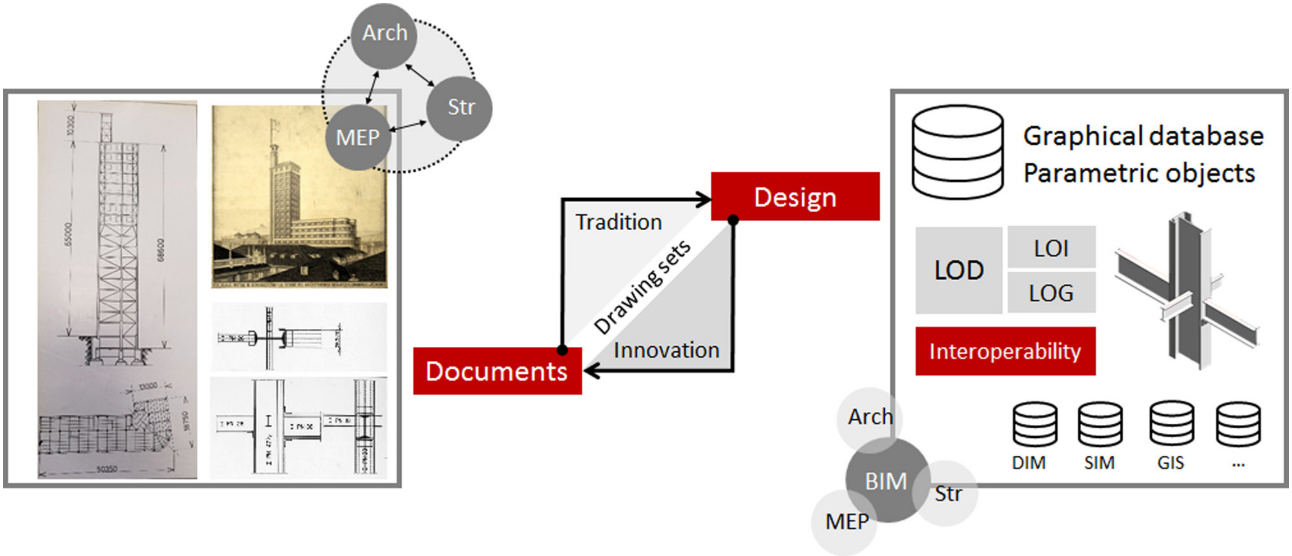


Fig. 4. Methodological scheme for comparing traditional and innovative approach in the construction industry.

must be related to the totality of the model through its attributes, to be increased subsequently. Taking into account the existing building heritage, the Level of Detail (LOD) of the objects needs to regard objective information, related to reality, with the aim of assimilating and extrapolating data for future planning or management [Pavan 2017, pp. 14-28].
The simulation of real building components with virtual objects libraries allows to describe a certain object in different ways by computer in terms of attributes and geometries through schedules, 2D and 3D views, bringing the world of representation closer to reality.
For this reason, information management related to the creation of a parametric model starts from the analysis of historical documents, the reading of the building characteristics through freehand sketch of the artifact and multimedia documentation. then, the definition of the geometric and alphanumeric attributes are the starting point for elaborating the BIM model composed by objects with a proper LOG and LOI for the declination of the relative LOD. Some of the information inserted in the objects can still be linked to traditional representation means, while others refer to structural analysis or immersive visualization through Virtual/Augmented Reality (V/AR).

Methodology

The attempt to understand how the role of representation is fundamental in order to make effective the process that translates the mental idea into an information model is examined in this contribution by analysing the Torre Littoria in Turin, a steel frame building, built in the 1930s. At that time, the image of the capital of Savoy needed to be renewed driven by the fascist current that clearly emphasized its requirements also in urban and architectural terms. The development of an architectural national style rooted in classicism, lead to the introduction of innovations in the use of building materials and in the site management, which was to reflect the production lines of factories.
The adoption of the welded metal structure is certainly one of the most important innovations proposed by the designers Armando Melis de Villa

and Giovanni Bernocco. The main body consists of ten floors above ground which become twenty in the tower with an overall height of 85 meters. The tower is placed in adherence to the body of the building to be preserved in Castello Square [Moglia 1995, p. 117].

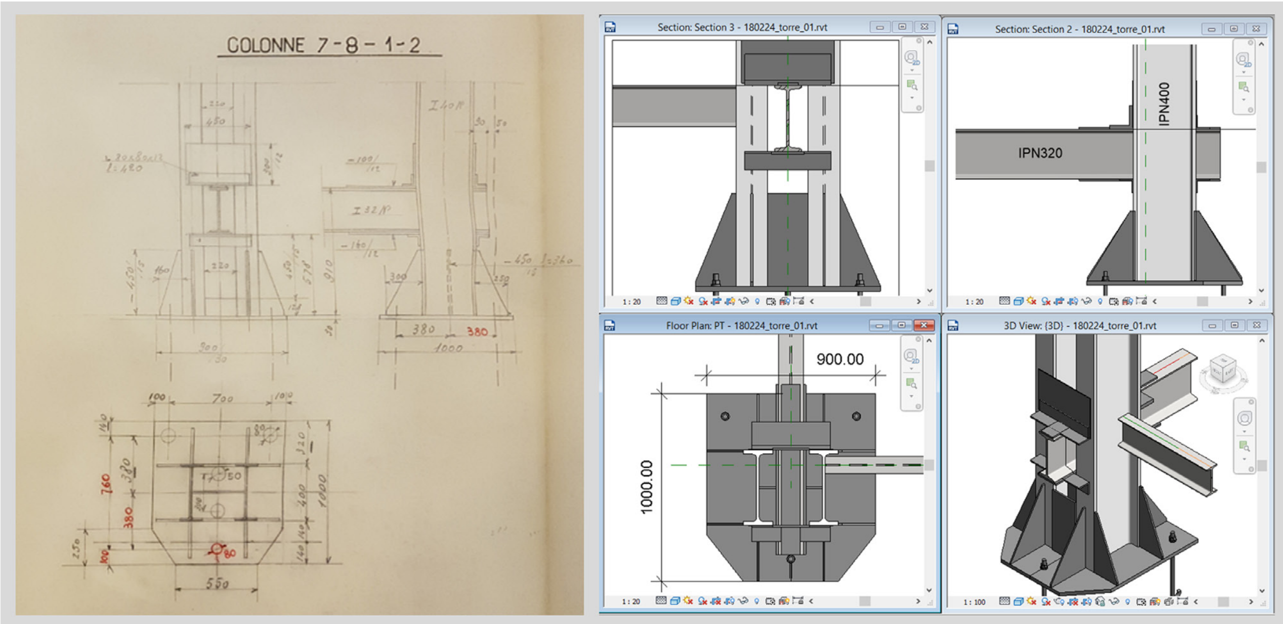
In a Casabella article of 1938, the load-bearing structure of the tower is included among the examples of constructions with a metal cage frame that is fully welded. The columns are uniformly made up of double-T beams coupled and connected by welded flat irons placed at a distance of about one meter. The pillars extend every two floors and the main beams are perpendicular to the facades to provide stable frames with the columns, ensuring transversal stability of the building. The use of metal framing facilitated and speeded up the building construction, which is made up of various standardized components that can be assembled on site by a few workers [Fava 1938, p. 40].

The consultation of project documents related to the tower took place both at the national archive of Turin (AST) and the Melis de Villa Fund, located at Politecnico di Torino. This archival research has favoured the creation of the mental image of the tower, which has triggered a process of research about geometric and alphanumeric attributes that characterize the building components of the metal structure.

Therefore, the information model was drawn up focusing on certain construction details such as the basement of the columns (fig. 5), the joint between columns of different levels and also the beams – columns connection.

The modeling process started from the main components analysis of the metal framework, focusing on BIM objects loading into a BIM authoring platform, such as Autodesk Revit. The ability to reproduce construction details by creating a series of objects that describe each part facilitated the handling of problems related to detailed modelling scale. Each con-

Fig. 5. Comparison between an archival document (Archivio SNOS, Torino) and a BIM costruction detail of a column basement.

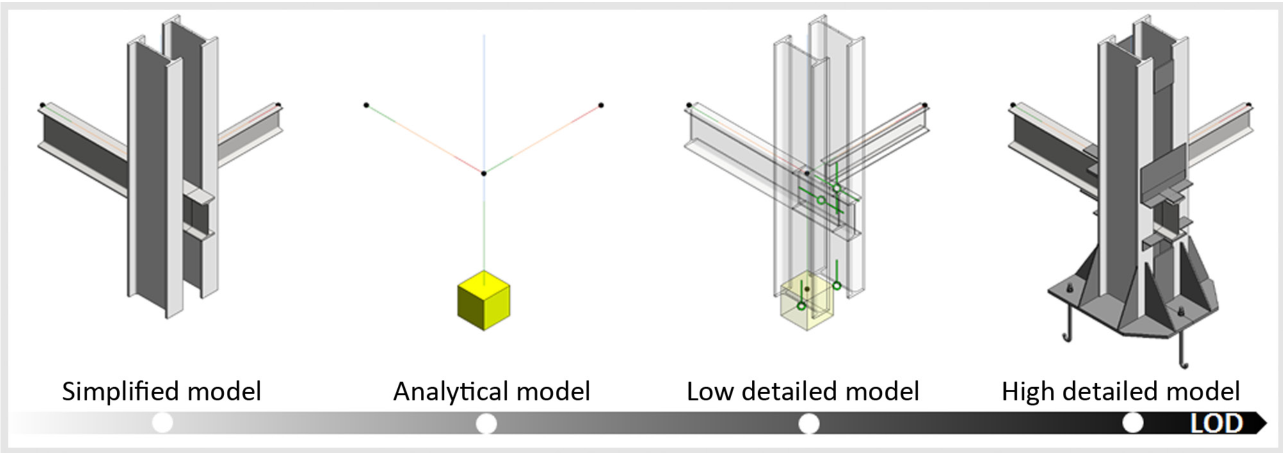


struction detail is described according to the architectural components visible in historical documents, taking into account data relating to shape, quantity, size, position, assembly details and characteristics of the manufacturing world.
In addition to the physical characteristics, the proposed details also describe the structural characteristics, geometric, material properties and are able to describe structure loads.
This information generates an analytical system of rods and nodes. This virtual reproduction offers the chance to use BIM dataset also for specific structural analysis and simulation applications. The physical model representation is therefore related to the analytical model, even if the latter can be managed independently. In particular, although the object describing the physical column consists of two IPN beams connected with battens, the related analytical column have to be modified to uniquely describe the rod that must represent properties used for structural simulation.

Results

Developing objects able to represent multiple information of various disciplines has allowed a progressive gap reduction among virtual and real world. In this way, this digital development can offer a variety of artifact reproductions that can be used for the management of existing architectural heritage.
This goal required considerable effort in modeling, strictly related to the hardware capabilities of applications available currently on the market. The development of information models with a large amount of geometric and alphanumeric information can reduce the computer performance and make the modelling process complex and laborious. The evaluation of suitable LOG/LOI was fundamental for the achievement model objectives and uses, which in this case were focused on the ability to reproduce a construction detail in virtual world (fig. 6).
The proposed solution in this contribution aims to demonstrate how information models can achieve high levels of geometric accuracy, describing a certain object with heterogeneous characteristics.
However, a number of issues have been identified concerning the standardization of objects used to represent digital models of existing buildings.
These considerations highlight the potentiality offered by BIM methodology based on the generation of a single information model composed of a series of components that describe a construction node. The detail

Fig. 6. Representation of the BIM construction detail, related to a progressive LOD.



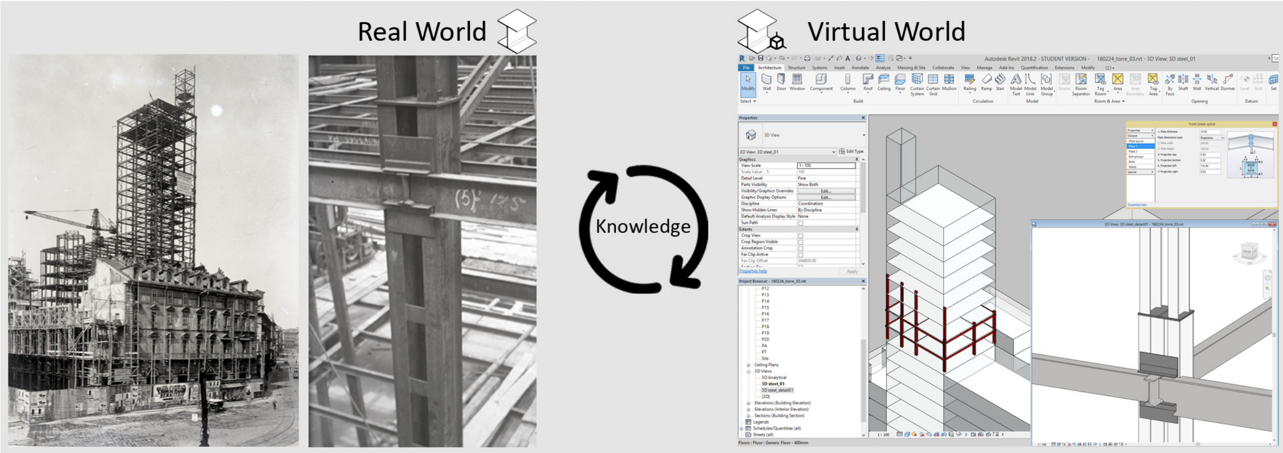


Fig. 7. Comparison of archival sources describing the real world (Fondo Melis de Villa, LSBC Politecnico di Torino) with the informative model.

proposed as a digital prototype of reality is characterized by shape, relative information and its analytical capabilities for a possible use in a specific structural analysis application.
The tests carried out show some data losses such as for structural connections are not kept during the interoperable process, thus making data exchange not error-free. Thus, importing the model into specific software does not retain all the assigned features in the native environment causing data loss. This result must therefore raise questions about rules that must be followed for the development of objects that describe the construction nodes both from architectural and structural point of view.
Through the creation of some structural details related to Torre Littoria, the investigated process outlined can be assimilated to an iterative process in which it is possible to improve the idea of the perceived environment with digital model. For this reason, the fill in data on each single objects becomes fundamental to transform itself into information through various interactions between them in the modelling environment. Clearly, BIM methodology innovates the traditional approach of representing reality based on the creation of a series of technical drawings that illustrate the project (fig.7). Starting from a unique model, in fact, it is possible to get the information related to each other, avoiding waste of time and costs, improving the knowledge of the built heritage.
The virtual reconstruction of an artefact can therefore be considered the starting point for the creation of a digital platform based on various heterogeneous databases that can be correlated to describe, as an example urban space, energy distribution networks and territory.

Conclusion

The comparison between traditional and innovative technologies, expressed in this contribution, enhances the role of representation within the building process that is constantly evolving through to ICTs.
The perception of existing buildings can therefore be concretized in the elaboration of an informative model that is an interpretation characterized by a series of operations of reading and synthesis through the language of the parametric 3D modeling. In conclusion, the representation becomes an expression of a past not directly observable, but perceptible through the interpretation of historical and multimedia sources using innovation technology.

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Design

How Drawing Changes

Livio Sacchi

Compared to just a few years ago, architects' drawings today seem to have changed substantially, especially as regards a few important general questions which are, furthermore, closely related, some well-known, others perhaps less: parametric design, BIM, Big Data and artificial intelligence. In the background, there is yet another revolution concerning authorship, of both drawings and, of course, projects. But let's proceed in an orderly fashion. We can state, to begin with, that architectural drawing has enjoyed extraordinary historical stability over time. On closer inspection, it has remained substantially unchanged, subject only to small instrumental innovations such as, for example, the adoption of the drafting machine or of transparent paper, which speeded up the operations of correcting and of tracing copies on superimposed layers of paper. On the methodological level, parallel and central projections, of which Vitruvius writes, have remained the same for about 1,500 years; the Renaissance added the section and, above all, rediscovered the culture of perspective, dictating canons for the following five centuries. The changes to which drawing appears to have been exposed in recent years, on the other hand, seem to be quite different in nature and extent compared to the previous, reassuring continuity. This implies

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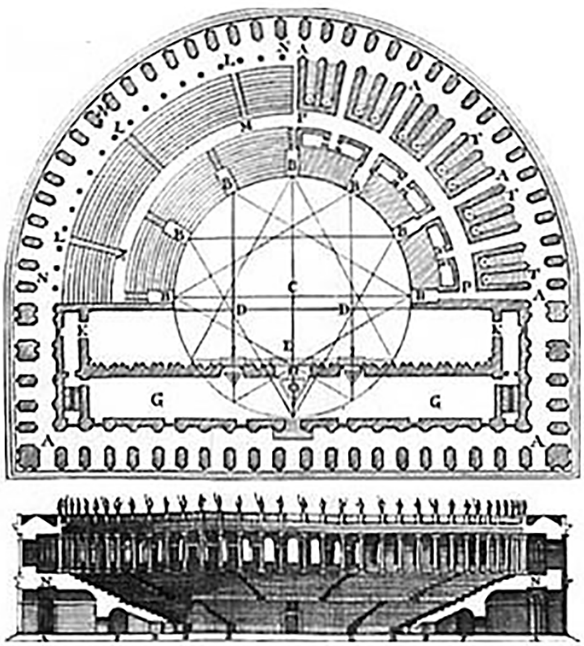
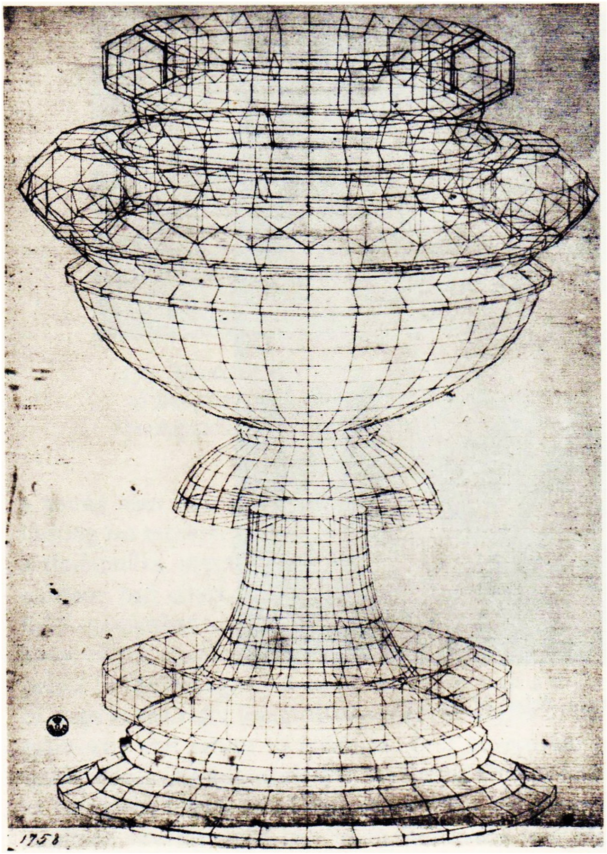
Fig. 1. Marco Vitruvio Pollione, Illustration of the Roman Theatre, 1790.



that we must pay great attention: to avoid the risk of finding ourselves prematurely sidelined from a professional point of view, and to avoid, from an educational point of view, training young architects who become old before they even start to work. Of course, and fortunately, not everything has changed: it is reassuring to recall that, as always, drawing serves us, that is, architects, for designing: it is a medium for representation and analysis, and the principal, unavoidable medium at our disposal. Designing is an operation of conception and communication essential for the construction of architecture; a project is therefore a primarily predictive tool, something that precedes reality, anticipates what it will be, but also an instrument able to move and overcome the limits of what can be realized. And that is no small thing, at least insofar as it reaches its goal: the construction of a good building. By simplifying a little, it is possible to identify at least four different types of projects: the architect's project, and then the client's project, the engineer's project and the contractor's project, bearing witness to its inclusive and versatile nature. Such not-particularly-original types, referred to among others by Patrick Schumacher [Schumacher 2011], deserve, in any case, further consideration. The first is evidently constituted by the architectural project, which includes the initial part of work in which the designer enters into a dialogue with himself in search of the best solution and the one addressed to other architects (communication targeting magazines and websites, the juries of competitions, exhibitions, awards, etc.). The second consists of the part specifically addressed to a client (a communication, therefore, addressed to non-professionals), which includes concepts, renderings and mood-boards (or sample-boards), the drawings that present materials, finishing and the relative combinations used in interior design; but it is also constituted by the direct contribution that the client gives to the project, according to his maturity and ability to interact. The third type consists of the structural and plant design. Its importance has grown for at least two foreseeable reasons: on the one hand, the progressive abandonment of the old and new classical codes, including rationalism, has made contemporary planning much more exposed to the authority of structural engineers than it was in the past; on the other, the new centrality assumed by the digitization of buildings and their sustainability, energy efficiency, etc., has burdened building systems projects with a historically unprecedented load. Finally, the fourth is constituted by the so-called shop drawings, the executive worksite plans, but also bills of quantities and specifications, as well as plans for the construction site's set-up, safety plans, etc.: charts often drawn up in collaboration with manufacturers of construction and finishing materials, with artisans and different operators. We expect that, in the renewed climate of sharing triggered by BIM, the 3D model will assume absolute centrality: the four types shown above, in reality more numerous and articulate, determine a circular process of progressive approach to the solution to take to the construction site. Today, designing is done in 3D, realizing what is ultimately the dream of every designer, who has always, more or less clearly, known that the essence of architecture is the internal space that is determined, the resulting void inside the envelope designed by us, but also the reverberation that the volumes have on the urban or, in any case, open space, surrounding the building. The 3D model generates, only subsequently, the 2D: plans, elevations and sections. The plan is still, in many aspects, generative in the creative, conceptual process of a building, but the three-dimensional model is the new protagonist. Quantities are measured from the model; the technical and performance contents are specified; compliance with standards is verified; it is possible to visualize spaces with renderings, even photo-realistic ones,

Fig. 2. Piero della Francesca, Study for a chalice, 15th century, pen on white paper, 34 x 24 cm.



often so effective that it is difficult to distinguish them from a photograph; finally, the more or less interactive navigation of the designed spaces is obtained, anticipating the fourth temporal dimension, so essential to the concrete experience of architecture. Almost thirty years ago, William Mitchell rightly attributed to the model the task of ontologically defining the projectual sphere as opposed to the building [Mitchell 1990]. Rightly, Mario Carpo recently spoke of "Digital Renaissance of the third dimension" [Carpo 2017].
But let us now examine the four general questions mentioned at the beginning, which more than others seem to summarize the changes taking place.

Parametric design

This is an experimental form-finding process that allows the architect to design structures of considerable geometrical complexity using parametric software, which recur to algorithms. The first research conducted in schools such as the Institute for Computational Design of the University of Stuttgart or the Bartlett School of Architecture of the University College of London, immediately gave interesting results, following the expe-

Fig. 3. Vincenzo Scamozzi, Copy of the preparatory drawing for the Theater of Sabbioneta, 1589.

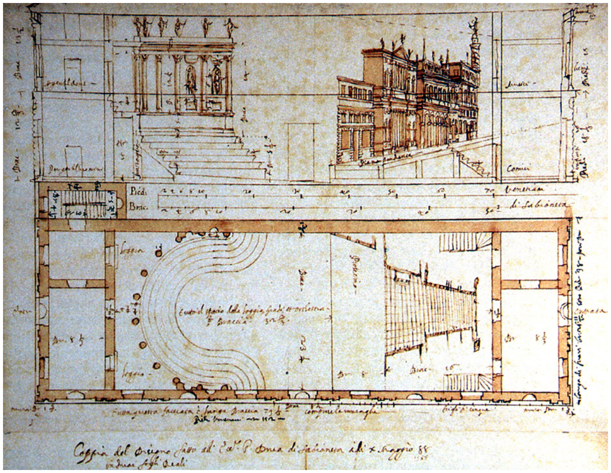


Fig. 4. Le Corbusier (1887-1965).

Fig. 5. Frank Lloyd Wright (1867-1959) in Taliesin.

riments started, as early as the 1990s, on the curves, or splines, generators of more or less complex surfaces. A pioneering work, carried out by a few architects operating between the end of the last century and the first years of the new century, all more or less influenced by what was called the 'Deleuze connections', which spread following the publication of the book The Fold: *Leibniz and the Baroque* [Deleuze 1993]. It was probably the aforementioned Patrick Schumacher, at the *Smart Geometry Conference* held in Munich in 2007, the first to give a name to the new 'ism': Parametricism [Schumacher 2016]. Since then, architects have begun to work with primitives such as splines and NURBS, using design procedures different from traditional ones (even if the standard charts for clients and companies have continued to be presented in the traditional form). A drawing essentially based on the use of straight or curved lines that separate portions of surfaces or mark their intersections, is replaced by drawing based on three-dimensional parametric modeling. Revit, which, as is known, is a software developed by Autodesk, or Digital Projects, which Gehry Technologies developed from the now historic Catia of Dassault Systèmes, have long allowed all this, albeit with different methods (everything is referred to a single master model in the first case, and to an open network of correlated models in the second). With parametric design –which undoubtedly determined the fortune of some great studios, first of all ZHA, Zaha Hadid Architects– architecture, while risking to see the image prevail, if not transform itself into celebrative self-representation, has reached formal horizons unimaginable earlier. The spectacularity of the forms is linked to their arbitrariness, the latter made possible by the adoption of algorithms that, with the aid of *Visual Programming Language* (VPL), such as Grasshopper, which regulate geometric complexity, charting schemes and production. Forms based on the serial repetition of formal elements that, sharing a common mathematical structure, reintroduce the organic discourse (think of a text like *On Growth and Form*, published a century ago, to be precise in 1917) [Thompson 1917].

BIM

Acronym of Building Information Modeling, BIM designates –as it is known– a design process that allows the digital simulation of building construction in a computable, interoperable way, able to ensure consistency between the elements that compose it, also responding to the phenomena that could occur at every stage of its life cycle. A digital representation of the constructive process that facilitates the exchange and interoperability of information in digital format, ie a method based on sharing knowledge as suggested by Chuck Eastman, director of the Building Lab of Georgia Tech [Eastman et al. 2016]. It is, in other words, a process that –using digital technologies based on parametric logics able to combine geometric and alphanumeric data, thus overlaying images and information, and ensuring design consistency thanks to the verification of the financial (cost) and chronological (time) dimensions– has assumed increasing importance in recent years within the processes of conceptualization, design, realization, management and maintenance of buildings. Interoperability and consistency of 3D models are the key words that, better than others, summarize the main features. With BIM, all the subjects involved in the design of a work carry out, together, a real digital construction of the artifact, in which the logical and temporal prerequisites are not dissimilar from those of realization, and possible errors and omissions become obvious before the construction site is set up, and can, therefore, be correct or resolved.

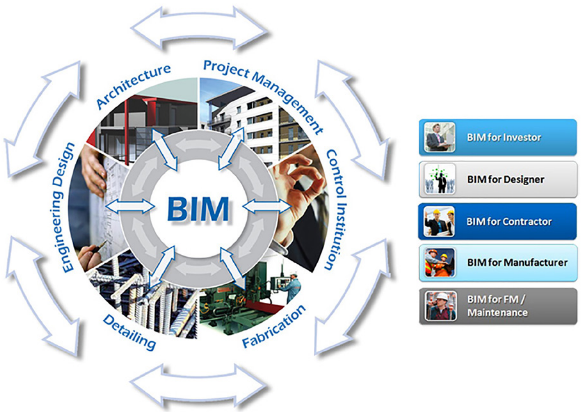
Fig. 6. Ludwig Mies van der Rohe (1886-1969) con Philip Johnson e Phyllis Lambert, New York 1955.

An interesting aspect of digital design is that, unlike traditional drawing, it can be modified by anyone, at any time. With BIM this aspect becomes even more relevant if we consider the fact that all the many different operators (architects, structural engineers and installers, interior designers, landscapers, builders, suppliers, experts, etc.) intervene, at different times, modifying and refining the model; the latter is open-ended, that is, never really concluded until the moment work starts at the construction site. But even during the construction of the building it continues to permit the correction of possible errors, while a laser scanner survey of the construction phases, which in major works can take place even daily, allows its progressive adaptation to what is being built, gradually bringing it to coincide with the so-called 'as built' drawings that document the completed building. This final model will subsequently be used for facility management, that is, for the management and maintenance of the building over time. It should be noted that this process is somewhat far from the authorship with which the project was –or was imagined to be– managed the in the past: instead, the result is achieved with progressive approximations, a very long series of shared revisions: a process that is, on the one hand, circular, which closely resembles the hermeneutic circle, and on the other hand, redundant, according to a principle –precisely that of redundancy– widespread in graphic software (just think of how many different ways there are to obtain the same result). To limit ourselves to a first provisional conclusion, we can say that the main objective of BIM, in addition to saving time and money, seems to us to be that of reducing the gap between design and construction, bringing architecture closer to its true nature: that of being the 'art of making'. No small thing.

Big Data and artificial intelligence

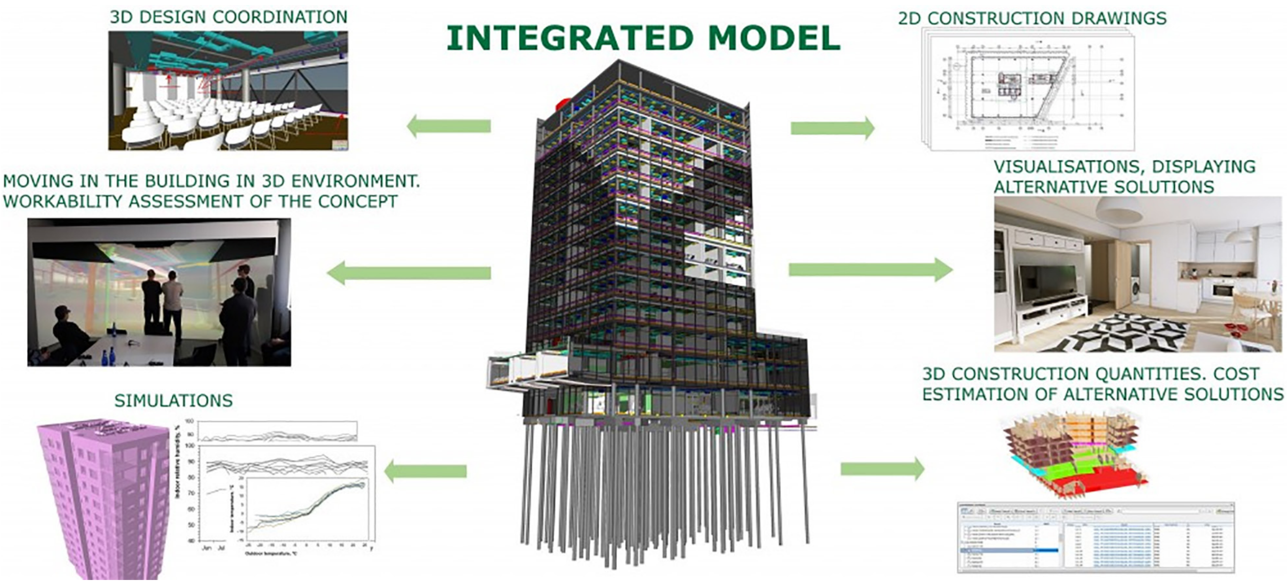
Big Data is a well-chosen term first used in 1999 by Steve Bryson, David Kenwright, Michael Cox, David Ellsworth and Robert Haimes in an article published by the American journal *Communications of the ACM* [Bryson et al. 1999] which summarizes a complex process: on the one hand, it indicates the impressive amount of data we are exposed to, and on the other, the increasingly demanding work of analysis that we are called upon to do. At the root of the issue is crowdsourcing, which

Fig. 7. The figures of BIM.



essentially led to the replacement of encyclopedias with Wikipedia (think, for example, of the end of the publication of the authoritative *Encyclopaedia Britannica*), and the so-called Internet of Things, which with its 'related objects' contributes significantly to the accumulation of these data streams. Even the architect who is about to design a building is exposed to numerous data, perhaps much more numerous than those controllable, if not those actually needed. Their management certainly makes our task more complex. Hence the delegation to software, able to collect and analyze in our place. These are more or less advanced forms of artificial intelligence, in a process, once again circular, of design optimization. Learning to use artificial intelligence from the standpoint of designing will take some time. But it is undeniable that it is entering, massively and inadvertently, into everyone's life. Facebook, for example, is able to analyze the photos and texts that we post, thus orienting the advertising messages addressed to us (and making the use of such advertising messages more profitable).

Fig. 8. The composition of the integrated model into the BIM.



In addition to being the title –*AI, Artificial Intelligence*– of a film by Steven Spielberg released in 2001 based on an idea by Stanley Kubrick, artificial intelligence is a set of advanced technologies that allows computers –more generally, to machines (think of MBUX, the system just marketed by Mercedes Benz based on user experience)– to understand, learn and act accordingly. Together with robotics, it is destined to radically change architectural design and construction scenarios. To stop at the first ones, that is to say to the design scenarios, we cannot fail to ask ourselves two symmetrical questions. What is the degree of creativity of artificial intelligence? That is: what impact can it have on the design process? Some answers are easily imaginable: today many software help us to perform operations related specifically to designing. It is not difficult to predict that the architect will deal more and more with the intuitive and creative part of the work, linked to strategic choices, while the development of the project, the part currently often delegated to collaborators, will be carried out by software. But it is also easy to think that, gradually, we will come to the definition of increasingly effective methods: Google, IBM, Salesforce and other companies are working on software able to optimize the interaction and use of the product with the final user. Google AutoDraw, for example, allows you to easily transform rough sketches into well-defined drawings. Not surprisingly, the slogan that advertises it is: "the tool that transforms doodles into drawings." Artificial intelligence helps the process, but, at least for now, it hasn't stolen any designer's job.

The crisis of authorship

As we mentioned earlier, against the background of the reasoning on how architects' drawings have changed, yet another revolution is taking place regarding the authorial nature of drawings as well as of projects. Will we come to jointly-authored architectural projects created by many 'hands'? Certainly yes, it's already been that way for a long time. In order not to move away from our field, we should remember that it is not difficult to look, for example, at a city like a work made by many authors; similarly, different forms of collective creative intelligence have been expressed by schools and artistic movements. Will it be so –or maybe it is already so– even for an architecture, or at least for an architecture of a certain

Fig. 9. Three-dimensional model as a project information generator.

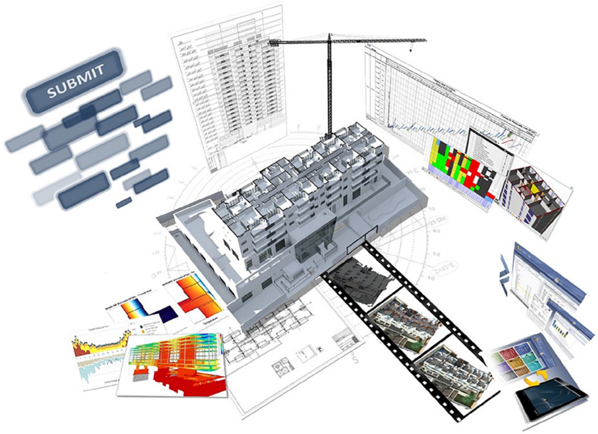


Fig. 10. The export of information in the specific formats of different softwares.

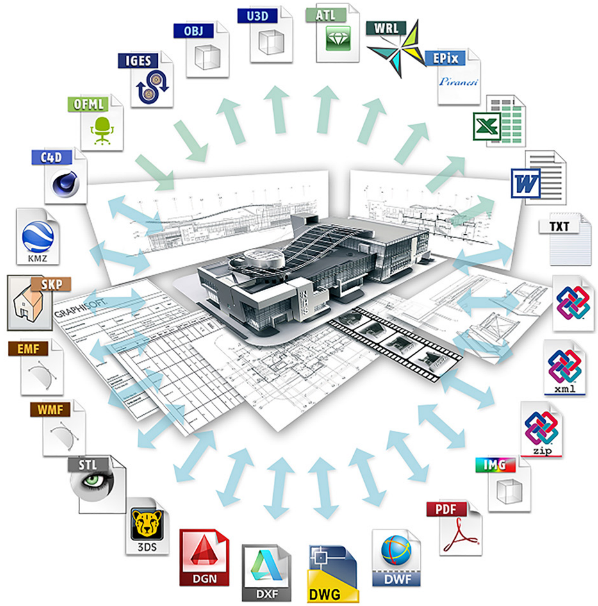
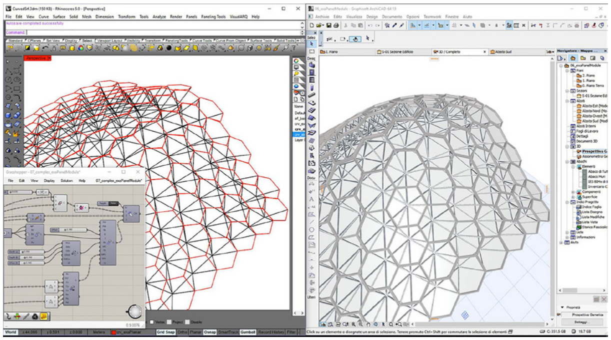


Fig. 11. Zaha Hadid Architects, building site of the King Abdullah Petroleum Studies and Research Center (2009-2017).

Fig. 12. Grasshopper graphical interface.



complexity? Is the creative and constructive intelligence of multiple minds, supplemented by the support of artificial intelligence, really better than that of a single designer?
An interesting contribution to this reflection is offered by the comparison between two large, relatively recent projects. The first, modern, the product of the creativity of Frank Lloyd Wright, undoubtedly the authorial mind *par excellence*: we refer to The Illinois, the famous Mile-High Skyscraper designed by the American architect just over sixty years ago, precisely in 1957. A project of extraordinary propositional force, which was never realized, also because it was too advanced for the construction techniques of the time. The second, contemporary, rather, in progress: we are referring to the Kingdom Tower in Jeddah, Saudi Arabia. The formal resemblance to Wright's design is evident. But who can claim to be the author of such an ambitious work, destined to exceed 1,000 meters in height with the aim of conquering the title of the "world's tallest tower"? This is not easy to understand. In reality, it is a large group of different firms, all very well known, in their different sectors, at the international level: to mention only the main ones, Thornton Tomasetti for the structures (a giant based in New York and with about fifty branches scattered throughout the world); Environmental Systems Design for construction technologies and acoustics; Langan International for geotechnics, traffic and parking; Lee Herzog Consulting for façade access; SWA Group for the landscaping; Rowan Williams Davies & Irwin for wind resistance; Rolf Jensen & Associates for fire prevention; AEGIS for security; Fortune Consultants for vertical transport; Lerch Bates for the management of materials and waste; Forcade Associates for signage; Fisher Marantz for lighting. There are also, of course, the architects: Adrian Smith + Gordon Gill Architecture, a studio founded in 2006 in Chicago by a group of former SOM partners (authors, among other things, of some of the world's tallest towers: from Burj Khalifa in Dubai to Jin Mao in Shanghai). We are aware of how it is not correct to compare an idea of a project, what we would now define a concept, even if it emerged from Wright's extraordinary intelligence, with an executive project currently in construction; we are also aware of how the architectural idea that presides over the realization of the Kingdom Tower is probably attributable, at least to a large extent, to Adrian Smith. But we think the comparison is, in any case, very informative.

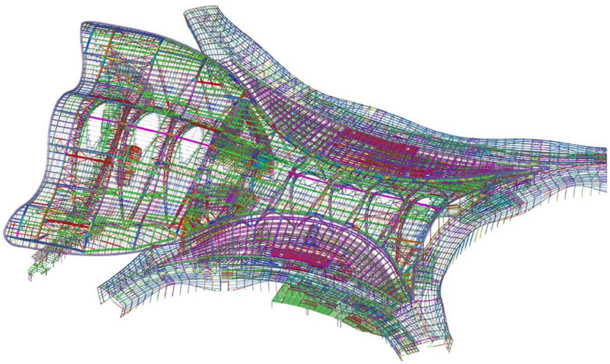


Fig. 13. Kohn Pedersen Fox Associates, Abu Dhabi International Airport, elaboration of the BIM structural model.

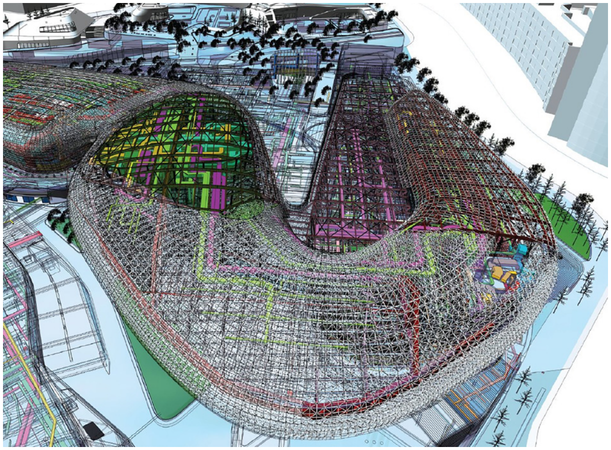


Fig. 14. Zaha Hadid Architects, Dongdaemun Design Plaza, Seoul 2007-2015, integrated BIM model.

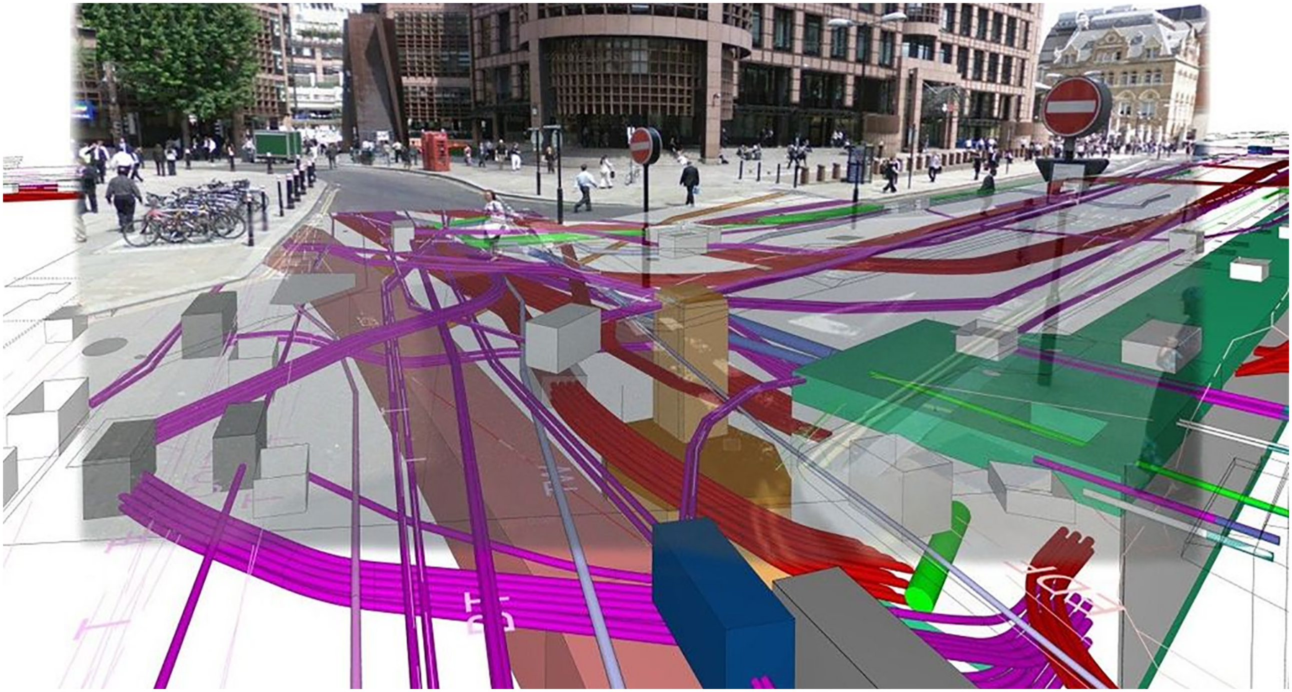


Fig. 15. Use of BIM for urban-scale designs of technical systems.

Mario Carpo, who in his *The Second Digital Turn* deals extensively with the issue of artificial intelligence, cites two contradictory anecdotes: on the one hand the story of the camel which is "a horse drawn by a commission" [Carpo 2017], assuming that a camel is uglier than a horse and that group creativity is the result of compromises that make it difficult to produce something beautiful. On the other hand, the so-called Galton experiment. Galton was an eclectic mathematician and scientist of the Victorian period related to Charles Darwin who studied a curious case: at a cattle fair, the average of the rough estimates of the weight of an ox was closer to the real weight of the animal than each individual estimate was. What emerges from this experiment? First of all, the affirmation of a sort of superiority *ante litteram* of crowdsourcing (we must not forget, however, that this was a large, but not generic group, as it was made up of expert breeders). It then allows us to reflect on the dichotomy that contemporary political scientists are so worried about: on the one hand, confidence in the ability to identify problems and their possible solutions on the part of the masses, for example those of voters in democratic systems; on the other hand, the positive results achieved by the technocracies, more or less disguised as democracies, which seem to work so well in some countries of the world.

In conclusion, we will go back to the theme of authorship. We are faced with three lines of thought: the first simply considers digitization as something capable of speeding up the design process and of managing large amounts of data more easily, without affecting the architect's creative role; the second one, instead, foresees the gradual disappearance of the authorial role of the architect, who withdraws in the face of increasingly intelligent machines, with the consequent, substantial, though not easily foreseeable, downsizing of his creativity; the third, hypothesized by Lluís Ortega [Ortega 2017], lastly outlines an expansion of new

Fig. 16. Scheme of the interactions of Artificial Intelligence.

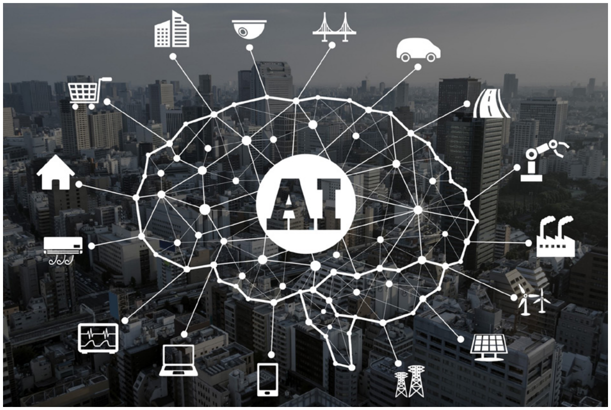


Fig. 17. Scheme of the fields of interest of Artificial Intelligence.

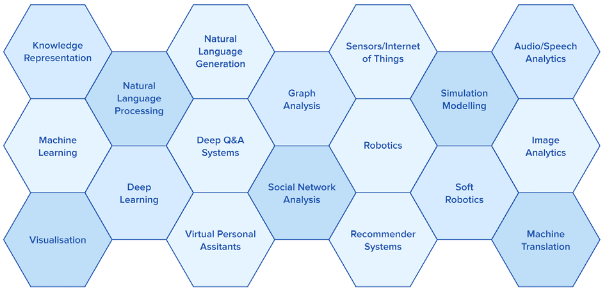
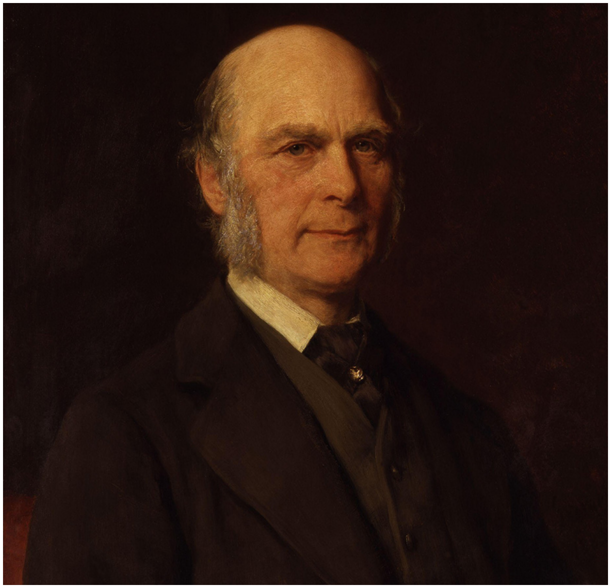


Fig. 18. Sir Francis Galton (1822-1911).



design horizons, a sort of 'augmented reality' made possible by digitization, which will not lead to the architect's being stripped of his authority, but rather to a growth of his awareness, elevating his role to that of mediator or negotiator between his personal creativity and the collective creativity deriving from different forms of crowdsourcing and artificial intelligence. Therefore, a *Total Designer*, rather than an *Automated Architect*: to quote Artaud, "a manager of magic, a master of sacred ceremonies" [Artaud 1938].

Fig. 19. Frank Lloyd Wright (1867-1959) with the project for The Illinois, The Mile High Skyscraper and design drawings.

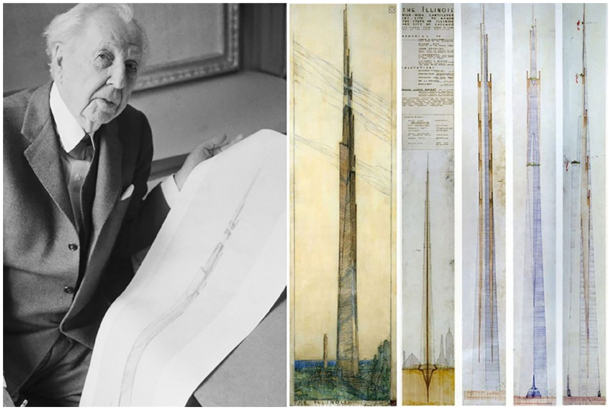


Fig. 20. The building site of the Kingdon Tower in Jeddah at the beginning of 2018.

Fig. 21. The Mile High Skyscraper (on the left) and the Kingdon Tower in Jeddah (on the right).

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Architectural Drawing in the *Escuela de Madrid* during the 1960s

Carlos Montes Serrano, Amparo Bernal López-Sanvicente, Jesús Luna Buendía

Abstract

This article is intended to provide a sample of the architectural drawing undertaken by Spanish architects of the so-called 'Madrid School' in the 1960s. During that decade, a good number of architects were prominent within what came to be known as the 'modern organic style'.
This comprised works strongly rooted in the places where they were built and of considerable construction quality, thanks to the use of traditional materials. The article also has an objective on the theory front. In contrast with the relativism of criteria for evaluating art, it claims that it is possible to speak of a 'canon of excellence'.
The basis is a rigorous selection of the architects with the highest profiles in the years under consideration. This would rate drawings as of greater or lesser relevance, and see means of representing architecture as of more or of less significance at a given point in historical time.

Keywords: Architectural Drawing, Spain, 1960-1969.

Introduction. Materials for a History of Drawing

Although recent decades have seen the completion of a good number of doctoral theses on the main Spanish architects of the twentieth century, very little attention has been paid to specific studies of how they represented their projects. This includes the type or style of drawing they used or the influences from other countries that affected them. Similarly, there have been no more general investigations such that would enable the detection of graphical characteristics or trends common to a given school or time period. It is noteworthy that, in comparison with Italy, Spain lacks books like that edited by professor Carlo Mezzetti, *Il disegno dell'architettura italiana nel XX secolo* (2003). In order to fill this lacuna, the journal *EGA: Expresión Gráfica Arquitectónica* has started to include in each of its issues a final section under the general heading of historical approaches to architectural drawing in twentieth-century Spain. This series of articles is intended to cover those architects who stood out by reason of their practices in drawing in relation to graphical thinking and their architectural works. So far, four have been published, relating to Antonio Palacios, José Luis Sert, Luis Moya Blanco and Luis Albert Ballesteros.
This present text has the same aim, offering a significant sample of the various uses of drawing employed by several Spanish architects resident in Madrid during the 1960s. This was a period of especial relevance in Spain. It saw the last years of Franco regime. There were major technological advances. There was a decided opening to the outside

world, bringing in many values and ideas hitherto alien to Spain. There was an unprecedented growth in the economy which facilitated a peaceful transition to democracy in the next decade and integration into shared European institutions, and so forth. In architecture there was a group of leading lights who were beginning to have an international profile, publishing work in journals outside Spain.

Criteria for Selecting Drawings

The principal problem in dealing with drawings from those years is the criterion of relevance. Most of the architects of the generation arising after the Spanish Civil War were able draughtsmen, thanks to the demanding syllabuses of the two schools of architecture in existence in Spain at that time, Madrid and Barcelona. However, a historical account must above all select the graphical output of those architects who held more prominent positions thanks to their architectural works. This is because the interest and quality of their projects led to the diffusion of their drawings through journals and books.

It is hence imperative to go back to bibliographical sources in making this selection. The history of Spanish architecture in those years is not well covered, as there were scarcely any architectural publications, and the most widely available books frequently came from publishers outside Spain. Nevertheless, there are a number of collections of journals: *Arquitectura* (established in 1916), this being the publication of the Madrid association of architects, *Cuadernos de Arquitectura* (established in 1944), the equivalent for Barcelona, *Hogar y Arquitectura* (1955 to 1977), issued by the Spanish Ministry of Housing, and *Nueva Forma* (1966 to 1975), an independent journal of high critical standard, if somewhat short-lived.

These journals include considerable amounts of information on the work of the most outstanding architects. It is true that the greater part of the data is limited to architects from Madrid and Barcelona. This is both because they were close to the editorial committees of the two main journals and because they were the individuals who were awarded the largest contracts for public works or for private promotions [Montes 2017, pp. 170-179].

This article will concentrate on what has been termed the Madrid School or *Escuela de Madrid*. The expression was first used by the architect Juan Daniel Fullaondo [Fullaondo 1968, pp. 11-23], one of the most insightful writers of the time. It was in contraposition to the Barcelona School or *Escuela de Barcelona*, called such by Oriol Bohigas [Bohigas 1968, pp. 24-30] in an attempt to identify two clearly differentiated modes of practice in architectural projects.

Among the architectural tendencies of the period, one outstanding style, which is normally termed 'modern organicism', was associated with the *Escuela de Madrid*. This followed the ideas of Bruno Zevi on the honesty of materials and looked for its sources of inspiration in the work of Wright, Alvar Aalto and other Nordic architects [Ruiz 2001, pp. 43-52]. A second tendency derived from rationalism and modern technology; its principal model was the architecture of Mies van der Rohe, and it resulted in a number of striking pieces of work in Spain. Finally, in the second half of the decade it is possible to detect an increasing influence from Brutalism, involving work of strong formal expressiveness constructed using reinforced concrete [Capitel 1986, pp. 23-28].

All this leads to the conclusion that the architectural trends occurring in Spain appeared the better part of ten years later than they did in more advanced countries nearby. This chimes with the sociological tendencies of the period, which the cultural trends of the 1960s elsewhere in Europe enter Spain and spread through the country with some delay between 1966 and 1975, in other words during the final years of the Franco dictatorship.

Thanks to research carried out on architectural journals of the 1960s [Bernal 2011], it has proved feasible to specify with some degree of objectivity which were the architects achieving the highest profiles during that decade by means of the publication of their projects, many awarded through architectural contests. It has been possible to check and to nuance this by means of monographs that have been published over the years since the 1980s, when a growth in, and consolidation of, architectural publishers took place in Spain.

These are well-known figures in the field of Spanish architecture, with careers that in some cases had begun to be established as early as the 1950s, whilst others burst onto the national scene more suddenly. Even a rigorous weeding out would probably find extensive agreement that any list of such architects would have to include: Francisco de Asís Cabrero, Alejandro de la Sota, Francisco Javier Sáenz de Oiza, José Antonio Corrales, Ramón Vázquez Molezún, Fernando Higueras, Antonio Fernández Alba, José María García de Paredes, Javier Carvajal, Julio Cano Lasso and

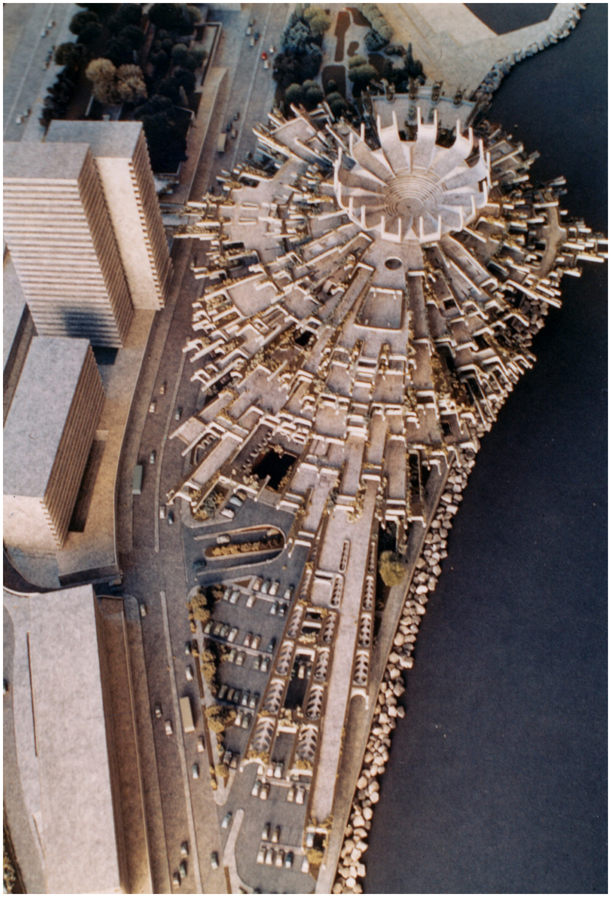

Fig. 1. Fernando Higueras, Competition for an Entertainment Centre in Monte Carlo, 1969. Library of the School of Architecture, University of Valladolid.

Rafael Moneo. As always happens in the drawing up of any standard for excellence, there would naturally be some hesitation as to whether certain other architects should be incorporated into the list as well as those mentioned [Montes 2010, pp. 44-51].
The limited space available for this article does not permit going into any great depth in analysing the graphical work of all of these figures. Hence, the decision has been taken to comment on just one drawing from each. Overall, this forms a very complete sample of the systems of representation most often used by architects. These include hand-drawn sketches, elevations and plans of buildings, scale models, construction details and some perspective views. Only a single axonometric projection is included, since Spanish architects barely ever used this system of representation before the 1970s. It is true that Juan Daniel Fullaondo (always attentive to the international panorama) started employing this type of drawing in the late 1960s, perhaps influenced by James Stirling or the architects known as the *New York Five*.
It should be noted why two photos of scale models have been included in the selection. In Spain the 1960s were a decade of major public calls for contests or competitions in architecture. In this competitive context, models, or photographs of them, almost ousted perspective views as a system for visualizing projects, whether at the stage of calling for tenders or in later publications in journals [Bergera 2016, pp. 8-27]. Photos of scale models thus fulfilled a role similar to more recent renderings or infographics, even suffering the same decline into overly virtuoso features and excess. An example of this are the sophisticated models produced by Fernando Higueras towards the end of the decade, the swan song of a practice that would fall into disuse in the 1970s (fig. 1).

Ten Architects, Eight Drawings and Two Scale Models

Francisco Cabrero (1912-1995) first came into the public eye in 1949 when he won the competition for the State Trades Union building in Madrid. This was a structure that moved away from the historical styles that drew their inspiration from the Escorial Palace, to find new benchmarks in the architecture of Adalberto Libera and Giuseppe Terragni, visited by the architect some years previously. In the 1960s he constructed a number of buildings inspired by the glass, steel and brick architecture of Mies van der Rohe. Prominent among these was the Crystal pavilion in the *casa de Campo* park in Madrid (1964). A little later he built his own home and studio in Madrid (1962). This was a striking structure in which Cabrero combined a range of materials (reinforced concrete, brick, steel, aluminium, wood and others), succeeding in making compatible the comfort of interior spaces and an intended outward-facing lightness and transparency. From the project for this dwelling an axonometric projection has

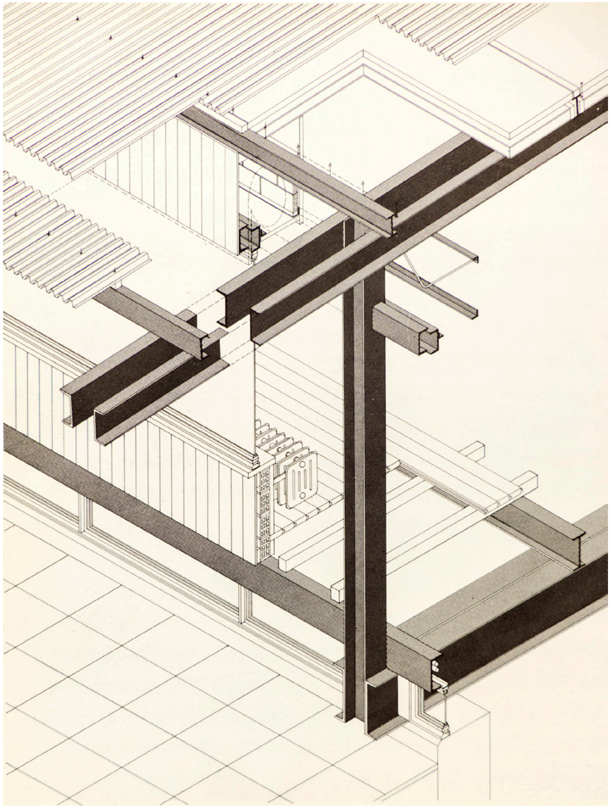

Fig. 2. Francisco Cabrero residence at Puerta de Hierro, Madrid, ca. 1962 [Climent 1979, p. 110].

been chosen in which Cabrero masterfully displays the solution he adopted (fig. 2). Although this drawing is of a technical nature, it has been reproduced numerous times in publications about Spanish architecture, as an example of the interest Spanish architects had in adopting building systems derived from the aesthetic currents predominant in the United States.

Alejandro de la Sota (1913-1996) was a magnificent draughtsman who put into practice the most varied techniques. As happens with his architecture, it is possible to see how his graphical language evolved over the course of his professional career. It ran from his early natural views

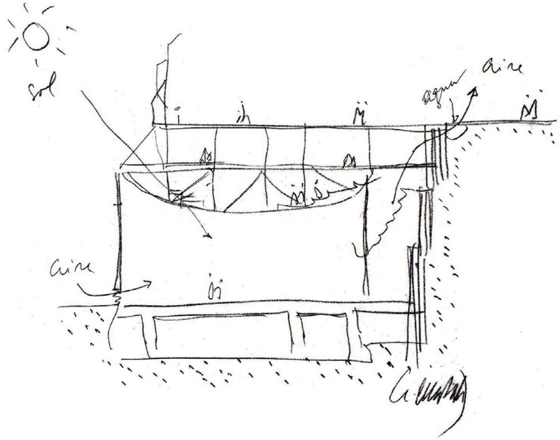

Fig. 3. Alejandro de la Sota, Gymnasium for the Maravillas school, Madrid, ca. 1962 [De Llano 1994, p. 106].

of buildings and project sketches, in which his mastery of more traditional techniques can be appreciated, through to his later more minimalist drawings. This small sectional sketch of the Maravillas school gymnasium in Madrid is without a doubt the Spanish architectural drawing most often reproduced in books and journals (fig. 3). It is a freehand pen-and-ink sketch, in which de la Sota summarizes the very best of his project. This is because it is clear that the guiding idea for the Maravillas gymnasium resides in his intelligent use of curving inverted roof trusses, something which it is possible to explain only by showing a vertical section. Hence, in this drawing it is feasible to observe not merely the structural solution, but the lighting, the crosswise ventilation, the steeply sloping spectator zone, not to mention the three levels for use achieved: the roofed playing area, the classrooms echeloned onto the trusses, and the gymnasium surface itself.

Many architects consider the *torres Blancas* building in Madrid (1961-1969) to be the best piece of Spanish architecture of the 1960s. It was the work of Francisco Javier Sáenz de Oiza (1918-2000), who was professor of Design at the Madrid School of Architecture, and was thus the teacher of a whole generation who became lecturers at that school during the last quarter of the twentieth century. Dozens of sketches and varying versions of the

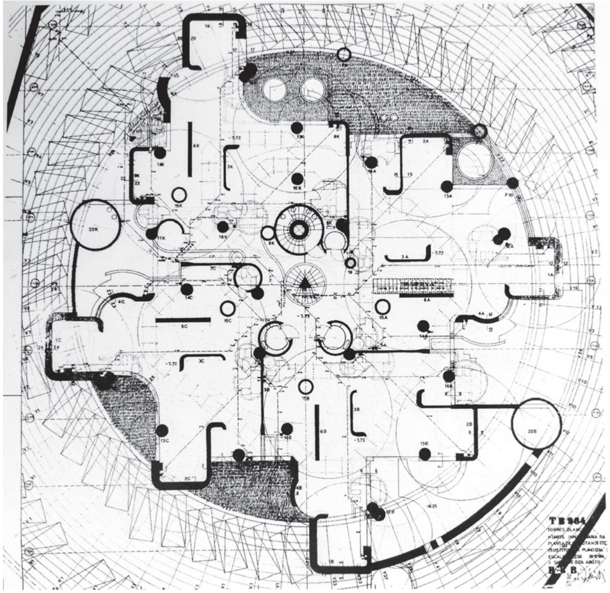

Fig. 4. Francisco Javier Sáenz de Oiza, Torres Blancas High-Rise Apartment, Madrid, 1964 [Alberdi, Sanz Guerra 1996, p. 125].

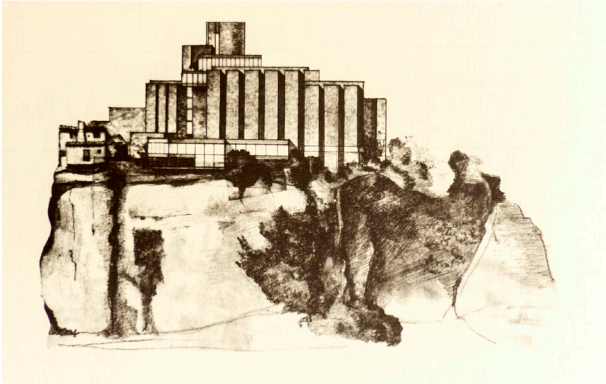

Fig. 5. Julio Cano Lasso, Entry for a 'parador de turismo' in Cuenca, ca. 1968 [Capitel et al. 1991, p. 83].

floor-plans of this project have been preserved. They reveal considerable influence from the organic architecture of Frank Lloyd Wright. Indeed, Oiza used to refer to this building as a tree with various trunks growing upwards, or as a vertical garden. Among the hundreds of drawings of the project the definitive ground-plan for the basements has been selected (fig. 4). In this it is feasible to appreciate the technical precision of the project, the formalism of the solution for the building, its structural complexity, and the stylistic organicism of the architects of that decade.
Julio Cano Lasso (1920-1996) was part of the organicist trend that is the best definition for the Madrid School. He was very deft at drawing, and over the years published many drawings of cities in the landscape (Madrid, Cuenca, Toledo, Salamanca and others), a collection of which he eventually brought out as a book with its title reflecting this concept. He was a sensitive architect, attentive to details and superb at handling brickwork, which he managed to use to root his architecture in its natural surroundings.
From the years considered here, the choice made is his proposal for a hotel for the State-owned *paradores de turismo* chain within the castle of the city of Cuenca. This won the first prize in the competition (fig. 5). The drawing shows the siting for the project, in a striking locality of great beauty and abrupt terrain. The technique employed is graphite pencil, with which he achieved varying nuances and a warmth in the drawing that was strongly in accordance with the typicality that the Ministry concerned desired for its *paradores de turismo*. As Cano Lasso wrote, after he had finished the project it became clear that the functional needs of the planned hotel were excessive, so that the resulting size would have been somewhat too aggressive in a zone of modest and traditional houses.
José Antonio Corrales (1921-2010) and Ramón Vázquez Molezún (1922-1993) formed a partnership in 1952, after the latter returned from a two-year stay in Italy financed by a grant from the Spanish Academy of Fine Arts in Rome. They gained national recognition with their Spanish pavilion for the Brussels World's Fair of 1958. There are distinctive features to this and other projects, such as the structural and constructional solution, light-weight elements, adaptation to the terrain, clarity in the drawing of floor-plans and sections, and the relevance of the roof as unifying the whole functional programme. The choice here has fallen to the plan for the roof of the Huarte residence in Madrid, because it shares some of these characteristics

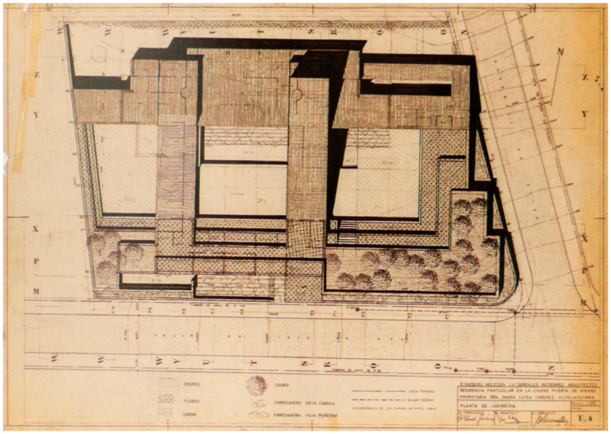

Fig. 6. José Antonio Corrales and Ramón Vázquez Molezún, Huarte residence in Madrid, ca. 1966 [AA.VV. 1992, p. 116]

and because it is probably the best known of the buildings they constructed in those years (fig. 6). It was an elegant, and timeless piece of work, sober in its use of materials. This plan highlights the importance of the roof thanks to the shadows it is shown casting. The two architects' liking for working with steep slopes is evident, the aim being to unify the various different spaces in the project, while also giving greater privacy for the inner courtyards.
José María García de Paredes (1924-1990) qualified as an architect in 1950. He lived in Rome between 1956 and 1958, having won a scholarship from the Spanish Academy a year earlier. After that, he was able to travel to Scandinavia to gain familiarity with Nordic countries' architecture. In 1960 he presented an entry in the competition for a parish church in Cuenca, a project which was so radical that it got nowhere. It was a uniform isotropic space formed by a network of slender metallic columns. In order to display his proposal better he constructed a very abstract scale model, one of the photographs taken by the architect himself having been chosen here (fig. 7). Although the image is a photograph of a model, it attempts to give the impression of a ground-plan in which the shadows cast have been exaggerated. This yields a graphic composition very similar to the famous drawing used by Jørn Utzon to explain his ideas for the platform of the Sydney Opera House. This image thus

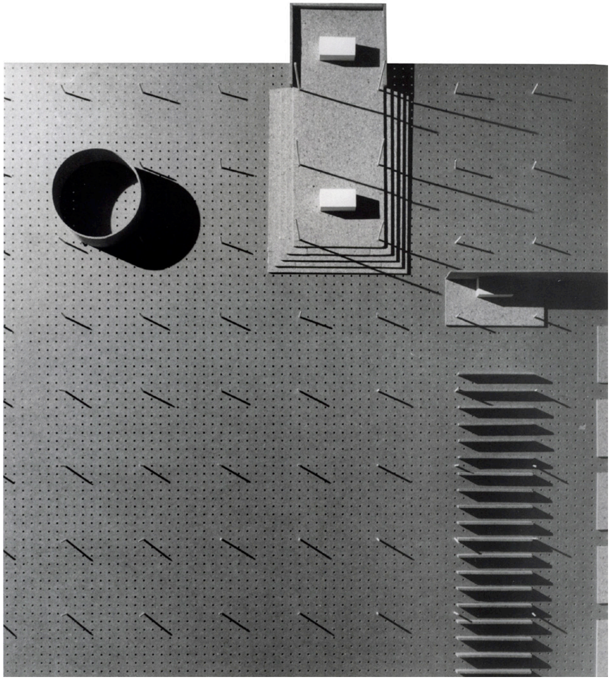

Fig. 7. José María García de Paredes, Competition for a church in Cuenca, 1960 [Bergera et al. 2016, p. 134].

lies in the frontier area where drawings and photographs of models overlap. Its effects are achieved by a process of formal abstraction that avoids the documentary finality of a photograph in order to attempt to bring out qualities more typical of architectural drawing [Bernal 2017, p. 642].
Javier Carvajal (1926-2013) graduated in 1953, and the following year was awarded a scholarship by the Spanish Academy in Rome. This allowed him to round out his studies and undertake several projects in Rome between 1955 and 1957. On his return, he combined teaching with professional work, obtaining the Architectural Design chair at the University of Madrid in 1965. He gained rapid international recognition with the Spanish pavilion for the New York World's Fair, which in 1964 won the prize for the best foreign building in the Fair. It is difficult to put Carvajal's work into a single stylistic pigeonhole,

Fig. 8. Javier Carvajal, Carvajal residence, Madrid, 1964 [Fernández-Isla 1996, p. 46].

although it is pervaded with a sculptural feel and formal elegance that might be compared with some of the buildings of Leslie Martin or Denys Lasdun. Carvajal had a special gift for thinking in three dimensions and for projecting any sort of space quickly and precisely, without losing sight of the building as a whole, its dimensions, or its scale. The ground-plan chosen here is that of his own home in Madrid (fig. 8). On considering this drawing it is possible to imagine the architect before his drawing-board, resolving the functional distribution of the floor-plan, organizing and linking spaces, as he fine-tuned the twinned-crystal structure of the house's volumes. The floor-plan of the edifice seems to grow out from a central core as if it were an organism adapting to, and colonizing, the building plot, giving rise to a graphic composition that recalls those of the Spanish painter Pablo Palazuelo.
Antonio Fernández Alba (born 1927) was one of the most prominent figures of the 1960s, thanks to the buildings he constructed, his writings on architectural theory and his teaching as a professor of Design at the Madrid School of Architecture. Apart from this, it must be stressed that he was an excellent draughtsman, fluently using freehand pencil sketches along with other forms of representation, such as models or photographic compo-

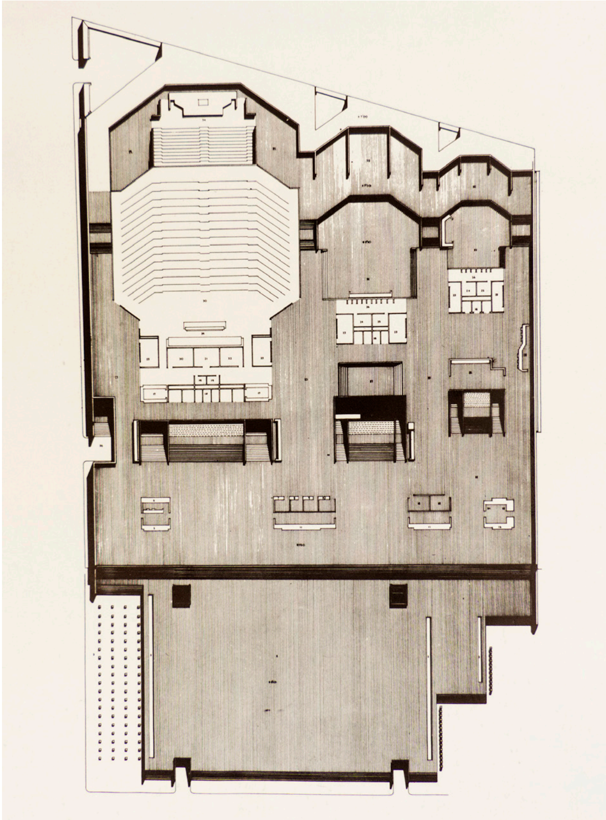

Fig. 9. Antonio Fernández Alba, Entry for a Conference centre in Madrid, 1965 [Uría et al. 1981, p. 92].

sitions. He was always aware of the international scene and it is possible to detect in his projects from that time the influence of Alvar Aalto. Jørn Utzon's drawings for the competitive tendering for Sydney Opera House must have left a strong impression on him, as he adapted the Danish architect's way of drawing to several of his proposals for competitions, such as the Conference centre for Madrid (fig. 9). Using the shadows cast and light shading, Fernández Alba manages to stress the relief of the great platform of the complex, together with the functional differentiation of its spaces: the low-level access

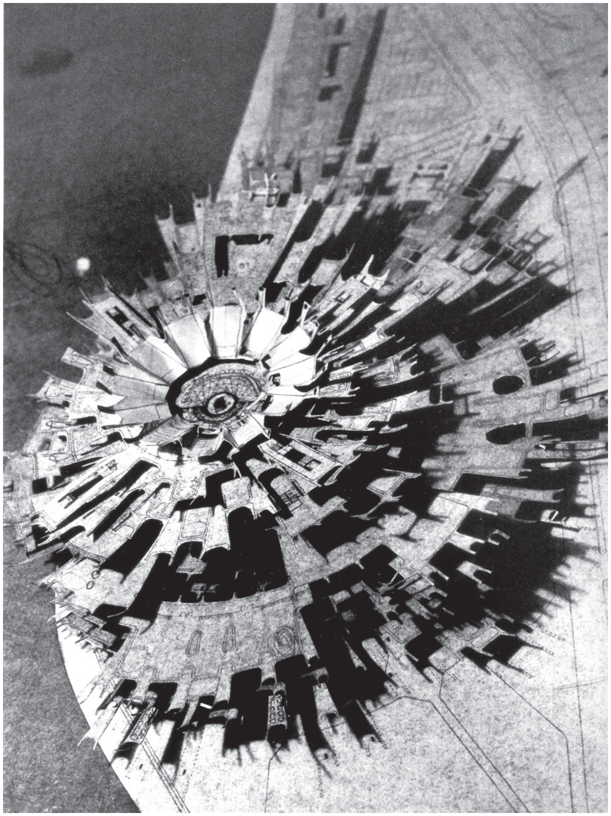

Fig. 10. Fernando Higueras, Entry for an Entertainment Centre in Monte Carlo, 1969 [Bergera et al. 2016, p. 195].

zone, the upward route, the junction with the conference rooms, and the like.
Fernando Higueras (1930-2008) was one of the most creative architects of the period under consideration. He was a shooting-star who shone with exceptional strength during that decade and then burnt out to the point of almost vanishing in the following years. In his works, always showing an exaggerated sculptural expressionism, various sources of inspiration come together. Firstly, there was his interest in geometry; secondly, there was the daring application of constructional and structural solutions; finally, there was his predilection for the shapes of natural organisms. There were three particularly outstanding projects in his career. These were his entry in the competition for a new Opera House for Madrid (1964), the centre for Art Restoration in Madrid (1965), and his project for an Entertainment centre in Monte Carlo (1969). Because of its exuberant creativity, the selection made here is a photo of his first scale model for Monte Carlo (fig. 10). This is partly because it was a really spectacular project and partly because it shows very clearly the organicist and biomorphic ideal to which he aspired, as mentioned above. However, a careful look reveals that the model in the photograph is made up of a set of drawings on card of the various floors, superimposed on the ground-plan in such a way as to give the impression of being a conventional scale model. Where García de Paredes used a photograph of a model to mimic a floor-plan, Higueras photographed a series of drawings to simulate a three-dimensional model.
Rafael Moneo (born 1937) studied architecture in Madrid and qualified in 1962. With considerable foresight, he spent the next few years rounding out his training, collaborating with various professionals, and enjoying a long stay in Italy between 1962 and 1965 thanks to having won a scholarship from the Spanish Academy in Rome. Although only a few works of his were actually built in the second half of the 1960s, there are entries from architectural competition which stand out by reason of the clarity of his ideas and the beauty of his drawings. These were something which was to be present in his major commissions from later decades. Of the proposals, a choice has been made of his entry for the Madrid Opera House (fig. 11). As can be seen, his design is related both to the organicism of the Madrid School and to certain architectures in the Brutalism of that decade. It is of interest to note the graphical style, using soft-leaded pencil, and fluency of strokes, permitting him to recreate the chiaroscuro and textures of the building. This was a very popular technique in the 1930s, at which German expressionist architects like Hans Poelzig or Dominikus Böhm became consummate masters. After the war, Gottfried Böhm continued to use the same pencil technique in his projects as had been used by his father, for instance in his drawings for the competition for a Pilgrimage church at Neviges in Germany (1963). It is not known whether Moneo, always with an eye on the architecture of the moment, became familiar with these drawings, widely publicized at the time. If not, it would indicate the young Rafael Moneo's fine sensitivity for being in tune with the architectural trends of the day.

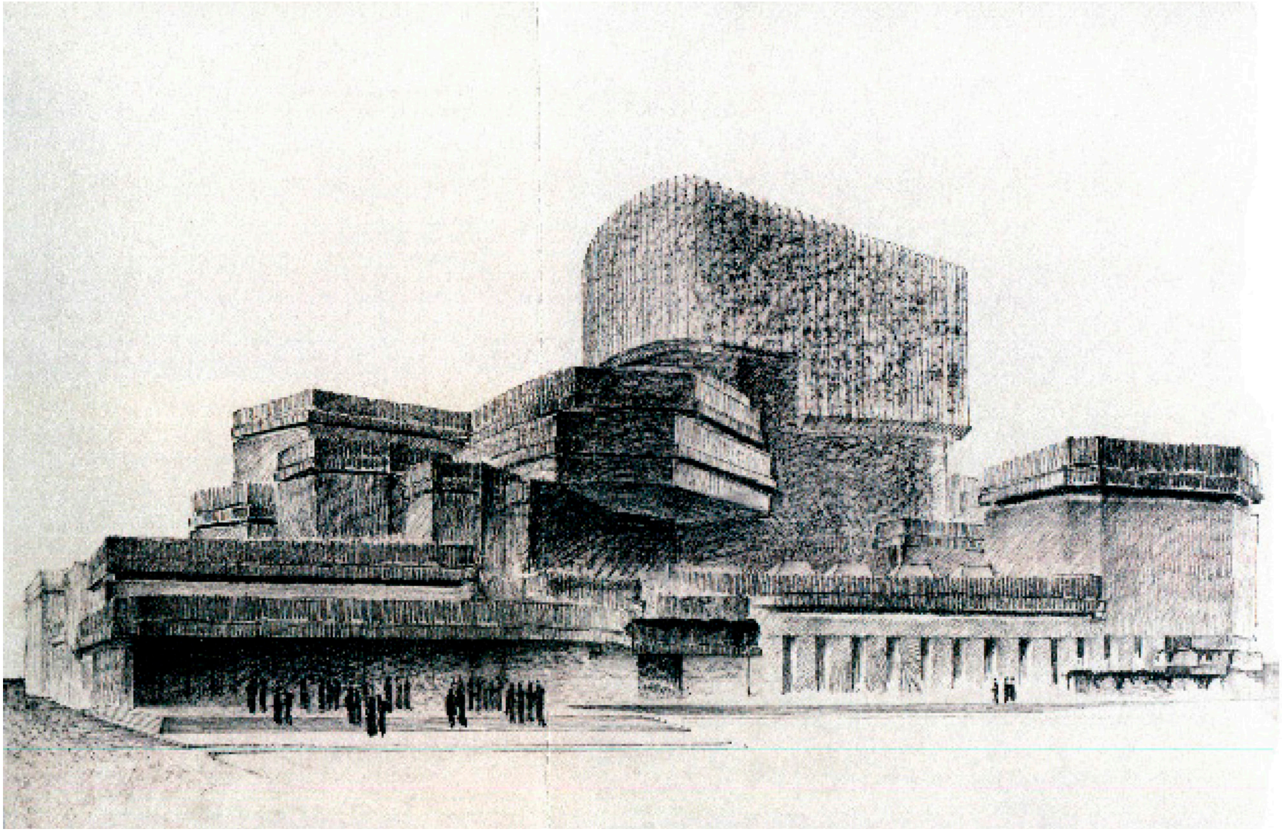

Fig. 11. Rafael Moneo, Entry for a New Opera House in Madrid, 1964 [González de Canales et al. 2017, p. 155].

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Talking to the Eyes by Drawing: Design Representations in the Magazines in the Mid-19th-Century

Roberta Spallone

Abstract

Since the 1840s in Germany, England and France, the architectural magazines, born in the last years of the 18th-century, have been considered a privileged medium *for the spread of architectural debate and topicality. Driven by continuous improvements in printing techniques, design representations have increased and been integrated with texts in ever more organic ways, reflecting the need for an ambit in which the respective professional skills are defined. New architectural typologies, materials and construction techniques are shared through drawings that, in the different geographical areas, take on particular features, which are linked to artistic culture, architectural debate and the representation methods developed in the Enlightenment schools and proposed in the coeval treatises.*

Keywords: Design drawing, Architecture magazines, Representation methods, Representation techniques, Printing techniques.

Introduction

"*Il faut parler aux yeux par le dessin*", said Cesar Daly in 1864 on the pages of *Revue générale d'architecture* [Saboya 2001, p.73]. From the 1840s in Germany, England, and France, architecture magazines underwent considerable development. The magazine was an open form to the plurality of debates and experiences, a spreading agent of categories and models in schools, and a rapid and up-to-date transmission medium of professional knowledge that became, at that time, the main pole of the flow of representations.
The essential interlacing of text and figures evolved into an acquisition of importance and space by the figures, favoured by the new reprint techniques that, even when in colour, had reduced costs and time, by the choice of gradually larger formats, and by the interposing of images with the writing.

The rise of the magazine for the communication of architectural topicality

"*Les Revues seules ont le loisir de rassembler des séries, de dessiner l'ensemble du mouvement des idées, d'en dégager la signification et d'en faire ressortir les consequences*" [Daly 1861, col. 9-10]. The periodical press began to assert itself during the 18th-century, as one of the most effective supports of the so-called reading revolution and its passage from extensive to intensive; mechanization must respond to the needs of this sector through rapid yet inexpensive and high-quality production [Barbier 2004, p. IX]. Nevertheless, magazines dedicated to architecture and the world of construction appeared only at the end of the century, accompanying the stages of the industrial revolution and involving an awareness of the professional figure of the architect.

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In the 1840s, an explosion of architectural periodicals occurred. The Institute of British Architects was formed in 1834 and, in 1840, the Société Centrale des Architectes. These magazines assumed the role of constitutive elements of social and professional status and agents of the transmission of categories and models [Barbier 2004, p. VIII].
While architectural activity was emancipated from the patronage of the elites, and new institutions of industrial and urban society took on rapidly growing importance (e.g., municipal companies, banks, businesses, school districts, and government departments) [King 1976, p. 32], the magazine became instrumental to the consolidation of the profession during this phase of modernization and development. The linking of press and architecture confirmed a common desire of publishers and architects to create a communication tool able to convey architectural topicality to a wider audience. Thus, architectural theory had the opportunity to spread through the periodical press, which allowed not only an extended debate but also to make it public and to include remarks by the readers.
Faced with the experimentation of new materials and the evolution of building procedures, the periodicals attempted to fill the gaps and backwardnesses of official teaching. The magazines, especially those whose publication lasted for several years, were characterized by the continuous changes they were subject to, due to contingencies, but even more so by the succession of directors and publishers who often occupied a leading position among the intellectuals of the time (think of figures like Daly, Lance, Godwin and Viollet-Le Duc son).
If the periodicity guaranteed the continuous updating of the information, other transformations concerned the frequency according to which the magazines were printed. Because of the urgency to report the latest findings of the sector, these magazines were published as often as twice per week, with imaginable repercussions on the graphics apparatus [Bouvier 2004, p. 79].
The remarkable spread of these magazines, also internationally, was favoured by the increasingly efficient transport and distribution networks. Hitchcock, in the introduction to the rich bibliography that accompanies the volume *L'architettura dell'Ottocento e del Novecento*, stated that for the study of the Western world's architecture from 1840 onwards, the most valuable sources are professional magazines [Hitchcock 2000, p. 593]. Bouvier observed that the success of the magazine as an agile means of information sharing was linked to that of the image, whose production considerably increased in the examined period; with the industrialization of the 19th-century press images become the popular media par excellence. Bouvier also highlights the need for studies on architectural representation in magazines [Bouvier 2004, pp. 1-9].
It is also important to mention Bini's study of the Florentine magazine *Ricordi di Architettura* (1878–1900), which is particularly relevant to the rigorous methodological approach [Bini 1990]. Along the same research line, the author researched the design drawing in Turin magazines between the 1870s and early 20th-century [Spallone 2017].
The architecture magazines re-established the connections between architecture and construction and practice and theory, and helped to restore the architect's function as a *maître d'œuvre* through the enhancement of technical drawing [Bouvier 2004, p. 86].
The study of these magazines, therefore, requires a parallel investigation of texts and images, as well as an analysis of the evolution of their formal aspect. Indeed, the architectural press offers the reader two distinct parts: the editorial part and the graphic part, which are at the same time independent and inseparable. During the second half of the 19th-century, printing systems were in full development; the rotary presses allowed the production of a growing number of copies and the duplication procedures of the illustrations were perfected, leading to the reproduction of high-quality photographic plates. The teams of engravers and draughtsmen of the various magazines generated a recognizable style that distinguished one from the other.
In this period, there was a profound transformation of the relationship between figuration, theory, and practice of architecture, which concerned both the techniques and graphic codes, of both the content and the status of the image [Picon 1992, p. 153].
The link between architectural theories and the iconographic apparatus of the magazine had obvious influences on the representation techniques. Thus, after 1840, the 19th-century debate on architectural polychromy, fueled by the discovery of colors in classical architecture, reverberated in the application of chromolithography, promoted by the Parisian lithographer Lemercier, which enjoyed great success, and, despite the high costs, expanded in the European press [Spallone 2016, pp. 290-292], and finally, since the 1870s, was gradually replaced by photography. Similarly, the Gothic revival (the main expression of the revivalism that characterized the architectural culture of the time) was expressed in the representation of build-

ings (often with a religious function), with perspectives of picturesque taste.
Aware of the risk of generalizations or, conversely, of partial readings of the phenomenon, given the extent of the field of investigation, it was preferred, here, to discuss the proposed theme through a selection of magazines, consulted in their original form, geographically grouped, and characterized by a long period of publication and a wide international diffusion, in order to construct a plot for more extensive studies and to suggest possible thematic developments of the survey.
Specific readings on thematic lines focusing on the centrality of the drawing could provide deeper insights into aspects such as the representation of new typologies at the service of 19th-century society, new materials, the survey drawing of the ancient buildings (with their specificity and use of color, but also with the stereotomical applications to the vaulted systems) and the design of the decoration that manifests the intertwining of geometry and color.

Germany: the technical representation conquests space

In Germany, the architectural theory was influenced by the recent debate on the style raised by Schinkel and, in the mid-century, was dominated by Semper, who intervened on central themes of contemporary thought: the value of the architectural shape as expression of an idea, the polychromy of ancient architecture, the truth of materials, their constructive meaning and the problem of cladding. Architecture magazines became the scenery for such discussions [Kruft 1987, pp. 60-69].
In the European context, German magazines represent a paradigmatic example of the passage, in the transmission of design models, from the formula and format of the book to those of the magazine.
Indeed, in Germany, we witness the progressive and inevitable abandonment of the page *in-octavo*, in favour of larger formats, which went hand-in-hand with the ever-increasing space dedicated to the drawings, present both intercalated to the text and on separate plates. To this was added a typical aspect of German publishing: at their origins, they used the Gothic characters, while in the mid-19th-century there was a transition to Roman characters, which facilitated the international dissemination of texts.
Architectural education took place in the academies, including the Academy of Berlin, founded in 1799 by David Gilly on the model of the École Polytechnique and the Royal Academy of Fine Arts in Monaco, established in 1808, whose regulation was drafted with the contribution of Schelling. Contemporarily, the Technische Hochschule, the Technische Universität and the Polytechnische Schule, in which civil engineering was taught, were starting to proliferate in Berlin (1770), Karlsruhe (1825), Munich (1827), Dresden (1828) and Stuttgart (1829).
In the middle of the century, the manual of Gustav Adolf Breymann [Breymann 1853] was published, which was divided into three parts dedicated to the construction of (I) stone and masonry; (II) wood; (III) iron; and a further one (IV) various buildings, where the text opens up to technological innovations fully developed in the second half of the century [Tamagno 1993, pp. 119-120].
Breymann's intent was to offer young architects a series of knowledge on the elements and systems used in construction; by delegating their connection and organization to the design experience they would become protagonists in the future, revealing a particularly innovative teaching approach: "design (and therefore architecture) cannot be considered an academic discipline as the science and technology of materials and building elements" [Tamagno 1993, p. 122]. This also prevents the manual from being quickly overcome due to the rapidity of technological innovations.
Two long-lasting magazines characterized, among others, the examined period.
Allgemeine Bauzeitung (1836–1918) was published monthly in Wien and directed by architect Förster. This publication used Gothic characters until 1865. The introduction of the first issue expressed the desire to describe and spread modern constructions with texts and drawings [Saboya 1991, p. 70]. The adoption of the *in-quarto* format (21 × 28) resulted in a harmonious inserting of the image into the text, which was articulated on two columns, while the numerous full-page plates took advantage of the greater available space for publishing plans, elevations, sections and details of the projects.
Until 1891, the magazine was flanked by a collection of plates, the *Abbildungen zur Allgemeinen Bauzeitung*, in *in-folio* format (30 × 44), which showed models and building designs of international scope, drawn up by technical drawings in large scales, which allowed an understanding of the technological and decorative features (figs. 1, 2).
The monthly *Zeitschrift für Bauwesen* (1851–1931), born under the direction of Hoffmann and published in Berlin by Ernst & Korn, used the *in-quarto* format (27 × 35) on two columns, with interspersed or full-page figures, and

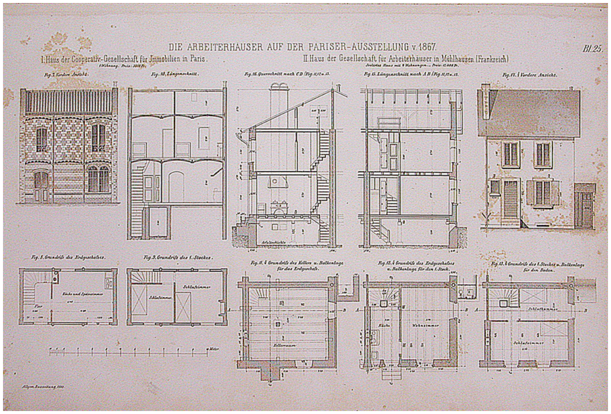


Fig. 1. Models of workers' houses at Paris exhibition in 1867, in Abbildungen zur Allgemeinen Bauzeitung 1868, pl. 25.

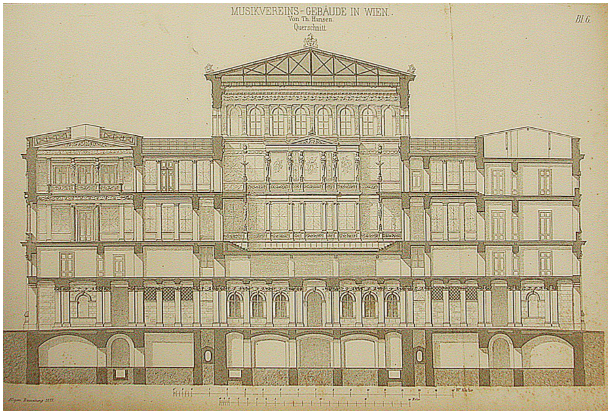


Fig. 2. Von Th. Hansen, Musikvereins-Gebäude in Wien, in Abbildungen zur Allgemeinen Bauzeitung 1870, pl. 6.

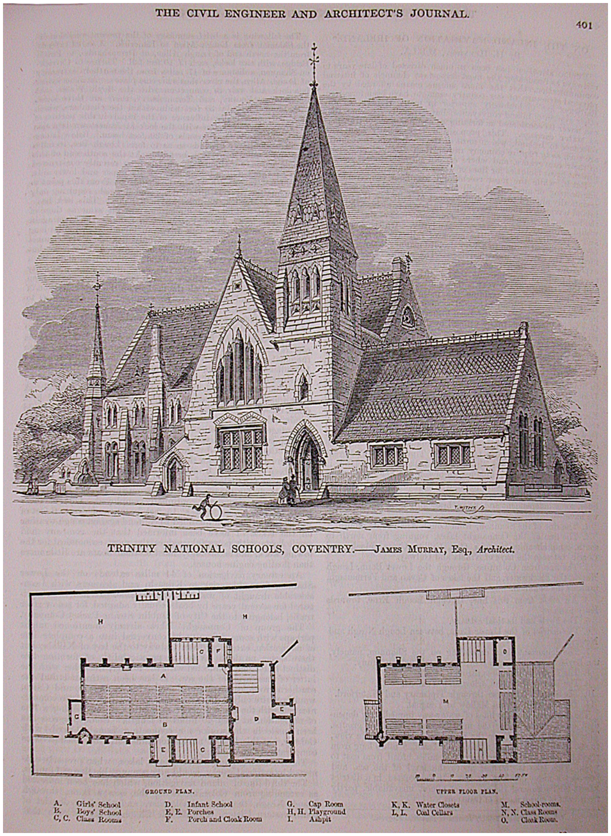
published the complementary collection of drawings. The *Atlas zur Zeitschrift für Bauwesen*, in *in-folio* format (32 × 46), was initially reproduced with lithographic technique and then with heliographic technique. In this magazine, the architectural theme, intertwined with engineering slant projects (e.g., hydraulic, mechanical), which often developed together with physical-technical checks.
In the *Atlas*, there were examples of dwellings (urban and rural) and public typologies (e.g., churches, mills, barracks, courts and galleries), but also bridges and canals (mostly national, while the foreign models were mostly French). Each building was developed on several plates, in dimensioned orthographic projections, often related to each other, and even at different scales, up to the details. Particularly interesting is the emphasis placed on the relationship between building and environment, solved both with contextualized plans that reveal an accurate use of the cartographic conventions of the time, both with detailed perspective views. The chiaroscuro technical drawings are accompanied by some chromolithographs of great pictorial quality (fig. 3).

England: the picturesque drawing affirms itself

In England, while the architectural debate focused on revivalism, with particular attention to the Gothic, and a series of architectural manuals and dictionaries revealed a technologically very progressive attitude [Kruft 1987, p. 79-113], between the 1930s and 1980s, at least 70 magazines dedicated to architecture and construction were born.
The civil engineer and architect's journal (1837–1868), founded by William Laxton, was a monthly magazine in the *in-quarto* format (21 × 29), with the text on two columns, in which some line drawings were inserted.
To the initial main engineering-oriented approach, a new focus on the buildings in phase of design and historical ones followed. The latter were mainly of worship, and had monumental character: in this case, the focus was on restorations, also testified by the drawings included in the text, especially façades and perspectives. Furthermore, full-page plates obtained from engravings of high artistic quality appeared, illustrating surveys and projects, in which the building envelope is emphasized through the representation of elevations and perspectives, with in-depth details on the decorations (fig. 4).
The weekly *The Builder* (1842–1966), was directed by George Godwin (an architect and surveyor) from 1844. For about 40 years, from 1844 to 1883, the magazine was the most important in England, right in the period when architecture became a profession [Pevsner 1992, p. 79], and Godwin was recognized as the most influential editor of his time.
The magazine introduced innovations that were inspired by the *Revue générale de l'Architecture*, which was found-

Fig. 3. Example of a façade on the new Maximilianstrasse in Munich, in Zeitschrift fur Bauwesen 1855, pl. 22.

Fig. 4. Murray, Schools in Coventry, in The civil engineer and architect's journal, vol. XVII, 1854, p. 401.



ed 2 years earlier. These innovations included the breakdown on three columns of the text in the *in-quarto* page (22 × 33), in which the interspersed figures were freely arranged, even by bleeding from one column to another. Furthermore, two high-quality illustrated pages printed on the same paper were introduced. The same social project of the respective directors was also shared by the two magazines, aimed at improving the living conditions of the lower classes through the study and publication of numerous examples of houses for the working class (fig. 5).

The full-page plates represented designs of buildings drawn in small-scale plans with typical graphics standards of the typological representation and perspective views of exteriors and interiors, generally having an elevated point-of-view compared to the human-eye view. While the technical drawings were simple and linear, the perspective representations researched for pictorial effects by rendering of the volumes through the chiaroscuro and the insertion of human figures (fig. 6).

The architect (1869–1968) was founded in London and was published in-quarto (23 × 33) on two columns, with 16 pages and two full-page plates at the end of each issue, which soon doubled. This weekly publication often hosted the debate on the education and profession of the architect, considered the main interlocutor, together with the civil engineer and the builder. In the presentation of the magazine, Smith (the director) anticipated that the illustrations would be chosen according to their practical utility and would be produced by lithography or carved by the best engravers. From the iconographic point-of-view, the magazine initially moved along the same patterns as *The Builder* and *The Building News*, although with the printing of contemporary designs' external perspectives, of picturesque taste. Later, were published also in-scale plans and sections of buildings (e.g., productive) whose technological systems took on particular significance, in connection with the new interest in health engineering. This topic, in the weekly publication, had a dedicated part of the text, accompanied by overall axonometric views (fig. 7).

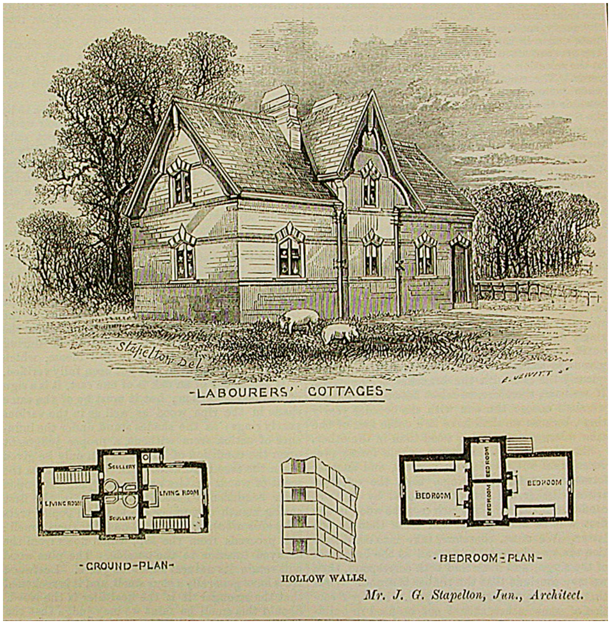


Fig. 5. Stapelton, Labourers' cottages, in The builder, 21 feb 1863, p. 131.

France: the versatile drawing becomes an integral part of the magazine

In France, the disruptive influence of the Enlightenment thought, which had found its most significant systematization in the mid-18th century in the *Encyclopédie* of Diderot and d'Alembert, had important reverberations on the scope of the art of building and its teaching, followed by a profound instance of rationality, a century after [Griseri, Gabetti 1973, p. 5].
The new Enlightenment schools founded in Paris, the École Polytechnique (1794) and the Conservatoire National des Arts et Métiers (1798), flanked the pre-existent engineering schools, the École Nationale des Ponts et Chaussées (1747) and the École du Génie de Mézières (1748), and those of an academic nature, the Academie Royale d'Architecture, reconstituted within the Institut de France in 1796, and the École Spéciale d'Architecture, from 1806, as a section of the École des Beaux-Arts.

From the early 19th-century, in such institutions, teachers such as Rondelet and Durand, through the writing of manuals, linked the educational opportunity to the process of reviewing the projectual disciplines that, in France, "proceeds aiming at scientific rationality while the educational institutions play an important role as a link between theoretical research and the operative scope" [Ramazzotti 1984, p. 12]. These teachers were convinced of the importance of providing students with general principles, rather than examples of the various types of buildings: therefore, their texts affirmed their distance and complementarity with respect to the first French magazines. In particular, Durand's radicalism was expressed through the proposal of a combinatorial logic according to horizontal and vertical projections that connected the architectural composition to the representation of the design by plan and elevation, from which the watercolour and the chiaroscuro were banned [Durand 1809].
The birth of architectural publishing in France occurred at the beginning of the century, with the *Journal des Bâtiments civils et des arts* (1800–1810). An inventory undertaken in the mid-20th century counted 265 titles between that date and 1914 [Lipstad, Lemoine 1985]; a subsequent study identified 341 titles [Saboya 2001, p. 68].
The rivalry between the professions of architect and engineer, also in terms of conquering the market, is an essential component in the historical interpretation of the period and seems to have arisen concurrently with the growth of the magazines [Lipstadt 1980, p. 371].
Until 1839, French magazines were mainly dedicated to engineers, while from 1830 onwards, those of architecture began to spread competitively.
The *Revue générale de l'architecture et des travaux publics* (1840–1890), considered the archetype of modern architecture magazines [Saboya 2002, p. 330], was founded and directed by César Daly. This monthly magazine was the first example in which the drawings of projects, realized or not, were an integral part of a magazine.
The director, who from the beginning said he wanted to address to the readers' desire to see the written descriptions replaced by drawings [Daly 1842, p. 1], was the artifex of a significant formal renewal: the *in-quarto* format (24 × 36) allowed the publication of large-sized plates that, thanks to the engraving technique on steel (imported from England), were of great precision and allowed great runs without alteration of the lines. Furthermore, the distribution of the text in two columns allowed the insertion

Fig. 6. Barry, Floral hall - Covent Garden, in The builder 11 feb. 1860, p. 89.

Fig. 7. The Plough Brewery in London, in The architect, 23 January 1869.

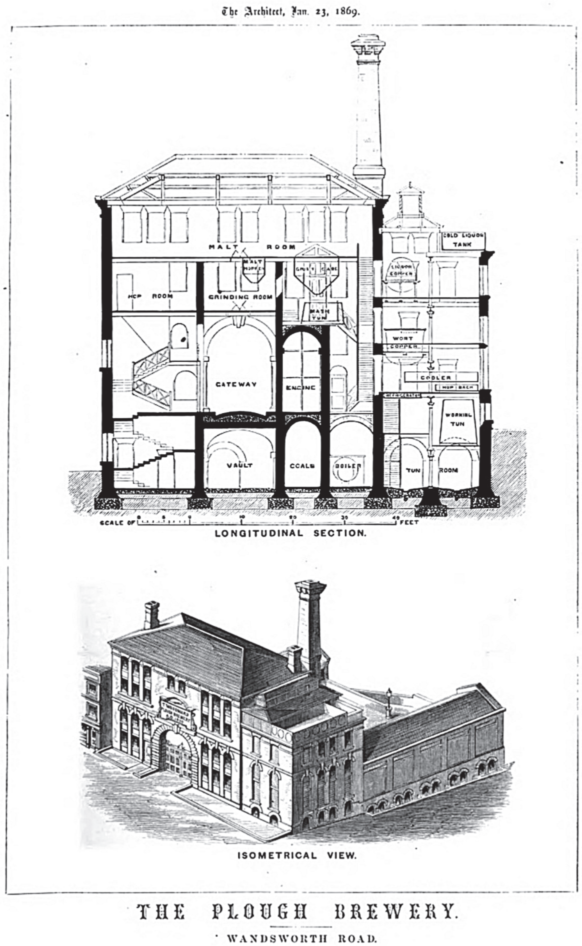
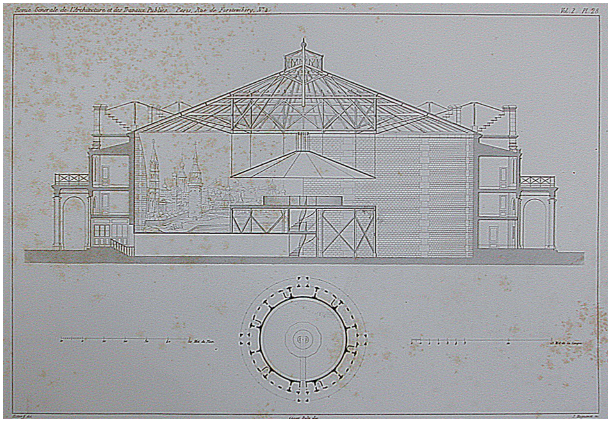
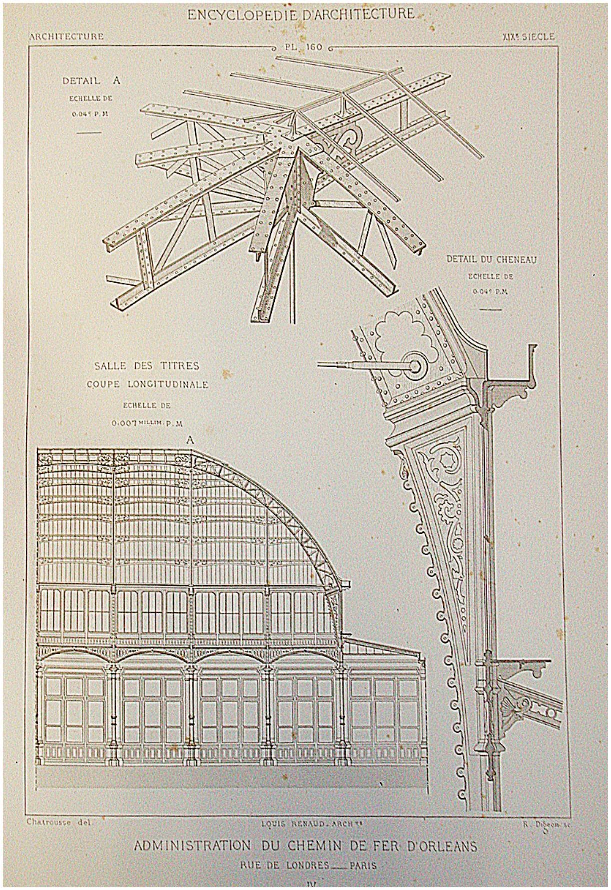


Fig. 8. Hittorff, Panorama at Champs Élysées, in Revue générale de l'architecture et des travaux publics 1841, vol. II, pl. 28.

Fig. 9. Renaud, Hall of the headquarter of Compagnie du Chemin de fer de Paris à Orléans, in Encyclopedie d'architecture 1872, tav. 160.





of xylographies interspersed in the discourse, which often represented plans and elevations of buildings of the past, technological details and technical installations.
To these were added the chromolithographies, introduced since the first issues, which returned the colour of ancient architecture, flooring, decorations and wall paintings.
Daly hosted proposals by young architects and pioneers of the shaping potentialities of iron architecture, such as Baltard, Garnier, Hittorff and Labrouste. Daly was hostile to the teaching of the École des Beaux-Arts, privileged ordinary residential architectures, medium-sized settlements, new 19th-century typologies and eclectic projects.
The theme of urban residence, with reference to European capitals, was also developed through collections of plans typologically represented in a manner not unlike the contemporary treatise by Reynaud [Reynaud 1850].
In the plates of the *Revue générale* we witness an interesting attempt to standardize the scale reductions of drawing and to use standard scales for each type of representation. Thus, plans were typically printed in 1:200 scale, elevations and sections in 1:100, profiles in 1:100 or 1:50, and window frames in 1:40 (fig. 8). This standardization facilitated the reading and rapid use by professionals and students.

Under the impulse of the *Revue générale*, the periodicals in France were multiplied, taking up the formula of Daly: the adoption of the format *in-quarto*, the text on two columns interspersed by the illustrations, and the plates collected at the end of each issue.
In 1850, Calliat, architect and skilled draughtsman, founded the *Encyclopédie d'architecture* (1850–1892) with the publisher Bance. The magazine consisted of a collection of *in-quarto* plates (27 × 35) that responded to the purpose of spreading a wide and continuously updated repertoire of what happened in the art of building using monographic insights on current and past cases [Bouvier 2004, p. 33]. Since 1851, Calliat, responsible for the plates, was flanked by Lance, who was responsible for editing the texts, with the aim of creating a significant harmony and coherence between text and image.
Since then, the magazine was in explicit competition with the *Revue générale* for the exclusivity of projects [Saboya 2002, p. 332] and proposed a wide repertoire of plates, one for every two pages of text.
The magazine affirmed itself as the richest in quality plates of its time, with reduced selling prices [Bouvier 2004, pp. 72-73].

Fig. 10. Lheureux, College Saint-Barbe in Paris, in Encyclopédie d'architecture 1872, pl. 849-850.

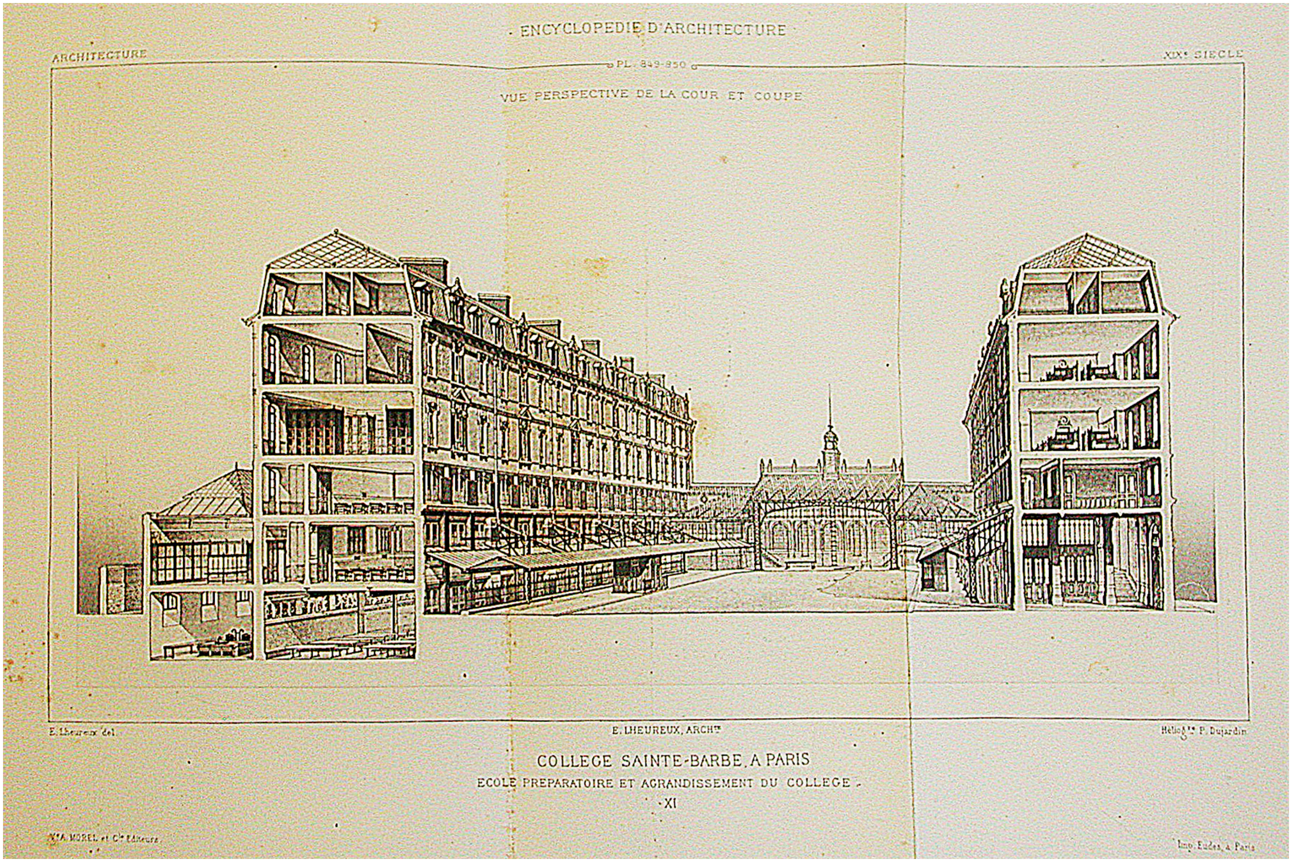
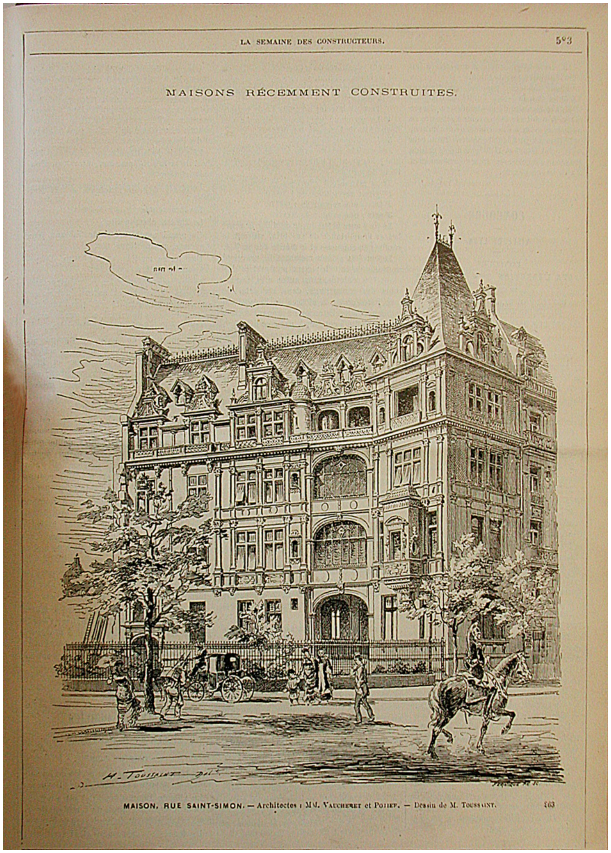


Fig. 11. Vaucheret e Poiief, House in rue Saint-Simon, in Semaine des Constructeurs 1882, p. 503.



The *Encyclopédie d'architecture* dealt with the theory, the history of techniques and innovative technologies, making these interests converge in didactic plates. The architectural representations covered more roles: some reinforced the links between architecture and technique, others, between architecture and construction.

The technical plates insisted on the construction details approaching those present in engineering magazines, such as the *Nouvelles annales de la construction* (1855–1925) and showed that the architect was involved in the project from conception to execution and, consequently, must master all of the technical aspects of the realization.

In the first 12 years of publication, following graphic choices that connected to the didactic setting of the École Polytecnique and, in particular, to the teachings of Durand, the magazine privileged a technical representation, rigorous and aimed at execution. The drawings were based on the Monge's projections (sections, plans, elevations) that brought them closer to the world of engineering and manifested the intention to aim at the practical aspect of construction [Bouvier 2004, pp. 84-86]. Nevertheless, also airy perspective sections appeared, which provided information on the technological system (fig. 9) together with the image of the spatiality of the building (fig. 10). In this period, the published projects range from new typologies, such as department stores and current issues (e.g., school buildings).

The plates offered general and detailed views using appropriate scales of reduction that allowed the handling of the illustrations. The scale prevailing in the drawings was 1:200, while the reproduction was made by copper engraving. This magazine was not printed between 1863 and 1871, but reappeared in 1872 under the direction of Eugène Viollet-le-Duc son, who considerably reduced the number of plates.

In 1876, more than 30 years after the launch of the *Revue générale*, Daly promoted a new magazine, the *Semaine des Constructeurs* (1876–1898), whose frequency required the rapid production of full-page drawings (24 × 34), initially limited to one or two per issue, and those included in the three-column text. Full-page drawings were generally perspective views illustrative of contemporary Parisian buildings, animated by scenes of everyday life, reproduced on the same low-weight paper of the text, similar to postcards of the time. Only occasionally, to facilitate the comprehension of the details, there were linear technical drawings of the whole of the constructive feature, printed in 1:100 scale. With the passing of the years, the illustrations increased, preserving the interest in technical drawing at standardized scales, together with pictorial drawing (fig. 11), and welcoming photography in the late 1980s.

Conclusions

The overview of the drawings in European periodical publishing in the mid-19th-century, briefly outlined here, offers much food for thought.

Various nuances characterize the magazines and their iconographic apparatus in the three countries from where the phenomenon appears to be driven, Germany, England and France, among which we must recognize the leading role of French publishing, but also a transnational capacity to transpose theoretical instances, formal choices and innovations in printing techniques.

The constitution of new educational systems inspired by the Enlightenment for training in the art of building, the determination of roles and professional duties distinguished between architects and engineers, the rapid development and innovation of construction techniques related to the use of new materials and the new typologies, attentive to the needs of 19th-century urban society, contribute to determining dynamic scenarios, in which magazines offer themselves as an ideal place for gathering, exchanging and disseminating knowledge and experience. The drawing gradually conquers space, establishing itself as a language sensitive to both the influences of contemporary architectural thought and the graphic conventions proposed in the schools and in the manuals. The magazines, emancipating themselves from the format of the book, welcome drawings and schemes, first in a separate form as atlases or full-page plates, then integrating them in the columns and between the written pages, to become, in some cases, an album of plates accompanied by descriptions. The drawing progressively imposed itself as a *medium* for the transmission of the most up-to-date design knowledge, useful and necessary in both training and the profession.

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Architecture: History and Representation. Designing an Interactive Athlas. Proceedings and Communication

Alberto Grijalba Bengoetxea, Julio Grijalba Bengoetxea

Abstract

Nowadays a qualitative leap is found in graphic production, a graphic discourse which is encouraged by new technologies and reproduction systems. There is a change in the visual grammars and we find a hyperinflation of the spreading of the new proposals in the new Information society. There is a need to construct a graphic and visual discourse on the History of Architecture. We finf thata while postmodernsociety does not believe in a big history discourse, especially in Architecture; contemporary media demand for it, as Lyotard pointed out, in this commoditized society. Time has arrived to reflect on the capabilities new technologies and communication hold. We pretend to analyze thegraphic documentary as a language and as an effective mean to express and communicate Architecture History in the last half of the XX century, when different graphic production strategies were used. The documentary research, identification and cataloguing of the graphical material follow the production of Modern Architecture Atlas *that consists of partial maps. This would be an interactive map suitable to be consulted from a different range of fields and categories; an Athlas capable to compare architects, art movements and architecture schools.*

Keywords: Athlas, Technology, Communication, Representation, Information.

Introduction

Once advanced XXI century, over the equator of the second decade, the question around a metanarrative about the History of Modern Architecture as an essential vehicle to its understanding and communication is still pending. Nowadays an outline of what could be considered as the state of the art is still incomplete, we find it broken and disperse, probably due to two simultaneous factors. The first one is related to the capability to put documentary in order, its analysis and read, attending to visual culture and current graphic discourse. Parallelly, we have the new information technologies, the so known Big Data's capability and its own roles for visual communication, as developed by the Architecture of information AI [Wurman, Bradford 1996].

The second of the factors is the inexistence of a Visual Architecture History of the 20th century as a catalyst for data. This lack may be due to the impossibility of putting together a unitary story about drawing according to the great story of the rise of the Modern Movement, as pointed out by professor Carlos Montes [Montes Serrano 2010, pp. 44-51]. Great story understood as the polyhedrically simplified interpretation of a complex reality, somehow idealised, but comprehensible by generality, as defined Lyotard.

The complexity of treating the Information together with the disbelief of metanarratives in a postmodern world, are the starting points of this investigationt. We assume the difficulty to create a global narrative in a hyper-communi-

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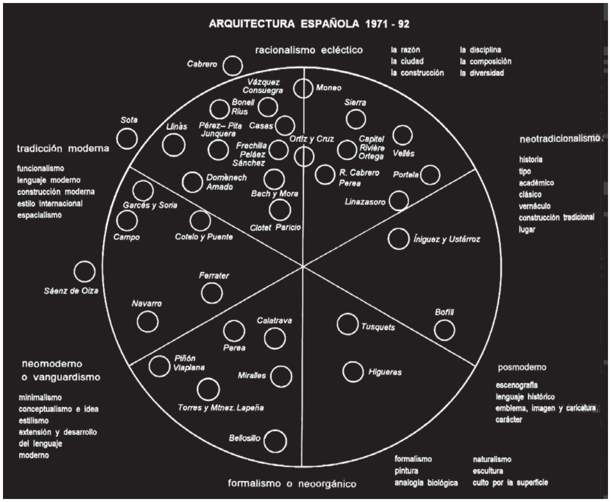


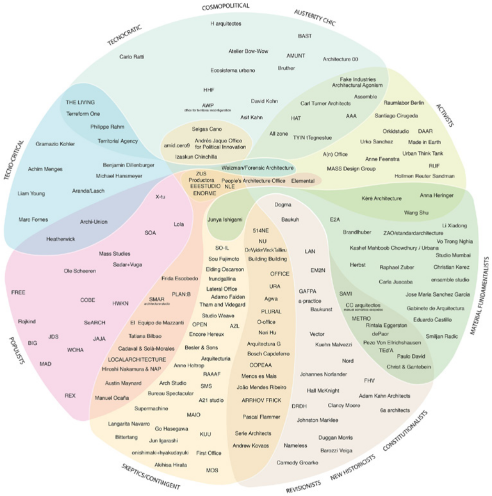


Fig. 1. Arquitectura Española 1971-92 [Baldellou, Capitel 1995].

Fig. 2. Alejandro Zaera-Polo, Guillermo Fernández Abascal, Brújula política de la arquitectura global, 2016 [Zaera-Polo, Fernández Abascal 2016, p. 254].

cated and over-informed society, in which the econmy of means and the economy of visual language in this regard are evident. Communicating turns into a challenge. We face a reality in which you can know the whole, but there is always the chance of a partial discourse, so the narrative can be interrupted and altered.

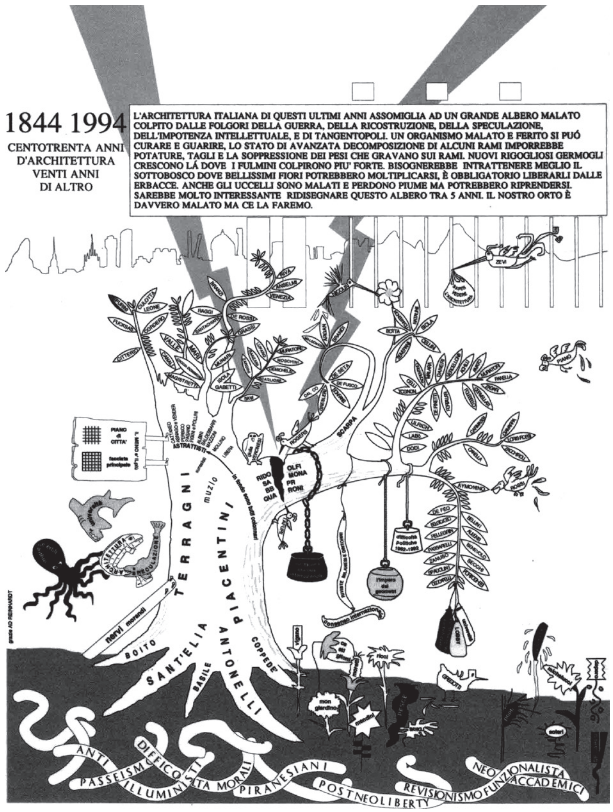
This starting point is contradictory with the current need of studies about the old Great Narratives. In recent time research and publications on new Art and architecture standars thrive. Editorial compilations and gathering in research works and diffusion of its conclusions can be seen in publications such as: 100 Years of architectural drawing, 100 houses for 100 architects, 1001 paintings you must see…..1001 films…1001 books…1001… This contradiction is, to a high degree, due to the incapability that theoretical criticism holds to communicate when facing the society need for a practical knowledge. Even if it is only to contribute to the big communication networks, knowledge is what we need, what we seek for. All this proves the discourse's commodity character [Lyotard 1987]. Everything is created to be consumed, and everything is communicated to be desired.

Indeed, the contradiction is evident; we currently find a qualitative gap in graphic production. A graphic discourse that helped by new technologies and new reproduction systems finds itself in a constant development and evolution. At the same time that this change in the grammatic visuals [Marchán 1990] occurs, we find a hyperinflation of the diffusion of new proposals.
At the same time our ways of interpreting and knowing reality is changing. On one side, nowadays we have the possibility to find any information or knowledge due to its diffusion both in paper and virtual publications. Never was this much knowledge within the reach of so many. But on the other, facing the reality of the vast aspect of knowledge, we need an analytic and ordering system that simplifies it. A document that allows us to quickly access information, place and locate it, attending to certain categories that allows us to create an essential map of its relations. Definitely, we need an Atlas.
The same as at the beginning of the 20th Century, Arntz's Isotypes and Pictograms, elaborated for Neurath, proved to be an effective mechanism to share knowledge. Jacques Bertin established inthe sixties the Graphic Semioligy in order to explain territory. It was not only about a graphic representation but, for him, it most of the times implied a strong responsability on what and how to perform. A visualization between the quantitative and qualitative [Bertin 1973].
After these first experiences, Richard S. Wurman was the one to code the Information presentation systems under the name of Information Architecture, IA. It is at this point were we stand; information is a group of images and texts categorised around the principle of: Location, Alphabet, Time, Category and Hyerarchy LATCH.

Research and development

Our approach to the research is to create an *Athlas of Modern Architecture of the 20th Century* consisting of several partial maps that follow the proposed categories: architects, art movements, their relationships and chronology. To achieve our purpose we are analyzing the partial maps created in the late years of the 20th Century toghetehr with the new technologies, the new graphic narrative and their application to the act of communicate and inform about History of Architecture.
There were many attempts to generate a map of the evolution of Architecture in the 20th Century.

Fig. 3. Italo Rota, Centrotrenta anni d´Architettura. Venti anni di altro, 1979 [Rota 1979, p. 95].

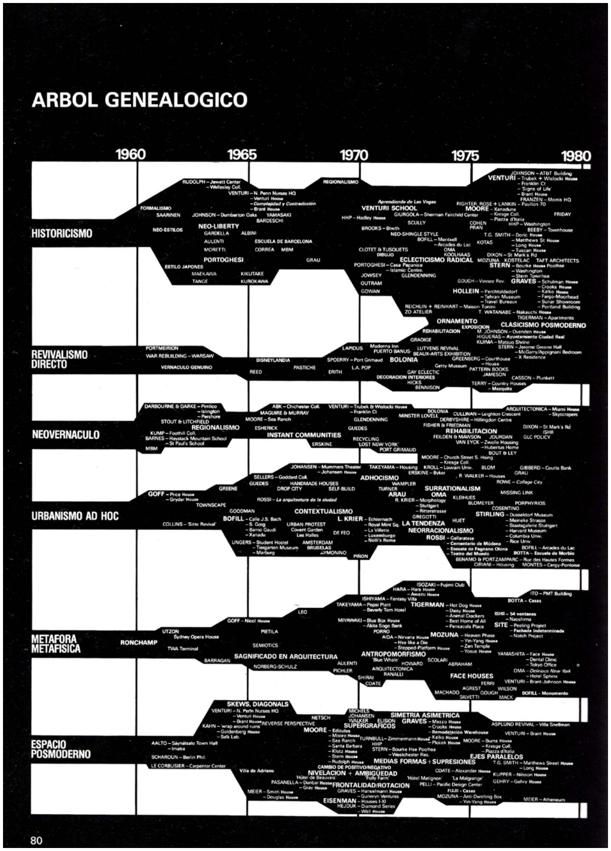


Some tend to be similar to the famous London Metro map by Beck in 1933, where the most important are relations, crosses and colours. Others, like the ones from Charles Jenks, are multiform masses that relate architects, tendencies and data, placed in a strict temporal frame, but where only names and texts are referenced (1980). The diagram from Professor Capitel about Spanish Architecture on the last third of the 20th century [Capitel 1995] discards time and places the diverse architects depending on hierarchy and the proposed categories. So does Italo Rota in his *Centrotrenta anni d´Architettura. Venti anni di altro* [Rota 1979] where he draws the tree of Architecture that emerges poetically over history's natural soil. From the branches, depending on its position and size, leaves with names of architects are born, which are shaded by small suspended decorations where the unclassified place their singularity.
All of them are an attempt to explain the complex in a simple way, to understand, paraphrasing Albert Einstein.

Time frame

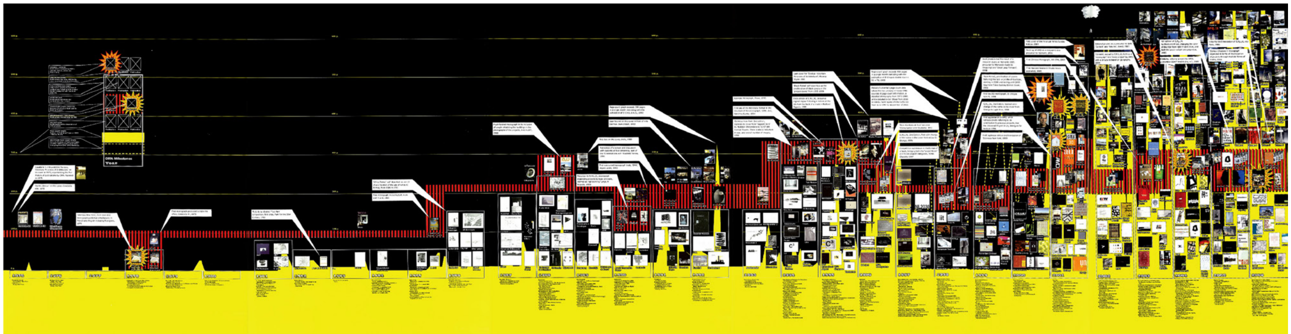
The time frame in which we pursue to realize this analysis of the drawing as graphic language and effective means of expression distinctive of the History of Architecture, focalises in the second half of the 20th Century. This period is subsequent to the Modern Age of the first half of the century, where diverse graphic production strategies were used.
The context in which this work and investigation are placed has a very clear beggining with the CIAM that has place in Dubrovnik (1956), where the TEAM X is built and an also outstanding end with the 10th International Architecture Biennale in Venice (2006), where international architects such as Norman Foster, Zaha Hadid, Richard Rogers etc. concur under the title *Cities, Architecture and Society*.
This time frame has been chosen because it results interesting to observe the gap produced in the Architecture of the 50s; how the second half of 20th century started with a clear predominance of the Modern Movement but with the years, and especially from the 60s, its bases started to be questioned. It is like that the great diversity of proposals of all sorts of styles appears, which makes of the chosen time one of great interest for analyzing the different movements. The architectural panorama referring to the

Fig. 4. Charles Jencks, Arbol Genealogico, 1980.



graphic discourse finds its way through the use of diverse formulas, the management of a more complex and sophisticated technology, getting to the use of informatics as the key tool, showing a special interest for the problems on the fields of urbanism, sociology and economy.
In that sense, it is key to start the period with Dubrovnik's CIAM, where categories as mobility, cluster, growth and change, urbanism and habitat are proposed.
The CIAM (Congres Internationaux d'Architecture Moderne) were a very important piece on the development of 20th century Architecture (1928-1956) and on the theory and practice of urbanism. The Modern Movement appeared as a result of 19th century rationalism and the need of a social development, making architects' worry about style move onto themes such as method, organisation and technology.
Unlike in the past, Modern Movement architects developed, as a working tool, the need to create communication strategies to put their architecture in the map. Well known are the publications Domus, Stijl, L'Esprit Nouveau, Baumeister, A.C. in Spain. All of them didactic, revolutionary and clearly propagandistic [Frampton 2000].
The dissolution of the CIAM was obvious when the high number of members, over three thousand, made the discussion about any topic complicated, generalist and diffuse. It was then that the TEAM X was left in charge [Giedion 2009]. Some movements make then their way whose characteristics and renewing ideas turn the comparison among them the key to understand this assorted epoque. From the new Brutalism to Ecologism we have selected the Team X, the Metabolists, Archigram, Archizoom, Superstudio, High-tech, Postmodernity and Deconstructivism [Benevolo 1987].
Several architects have also been included, who despite not being considered inside any movement should be taken into consideration for their importance in the development of the Architecture of the second half of 20th century. Not only references to architecture are made, but to understand the Athlas in its complexity other ways of artistic expression must be included, together with some relevant exhibitions and competitions that give as a result a wider comparative spectrum [Grijalba Bengoetxea, Ubeda Blanco 2012].
The end of the period coincides with the X International Architecture Venice Biennale (2006), Bienal that for the first time regards the problem of urban development and its planning, continuing with the worry for urbanism that, as mentioned before, occupied the architects of the 20th century. The topic cities, architecture and society focused the development of this Biennale in urban planning from the social dimension of the city, the relation between architecture and society. The comparison with the chosen date as a starting point for creating the map: the CIAM from Dubrovnik and the architects of the TEAM X in inevitable to obtain a better communication efficiency. Like this, beginning and end of this time frame are chosen because of their 50 years difference (1956-2006) and because of their similarities on reflecting similar worries related to architecture and urbanism by the outstanding figures on those moments.

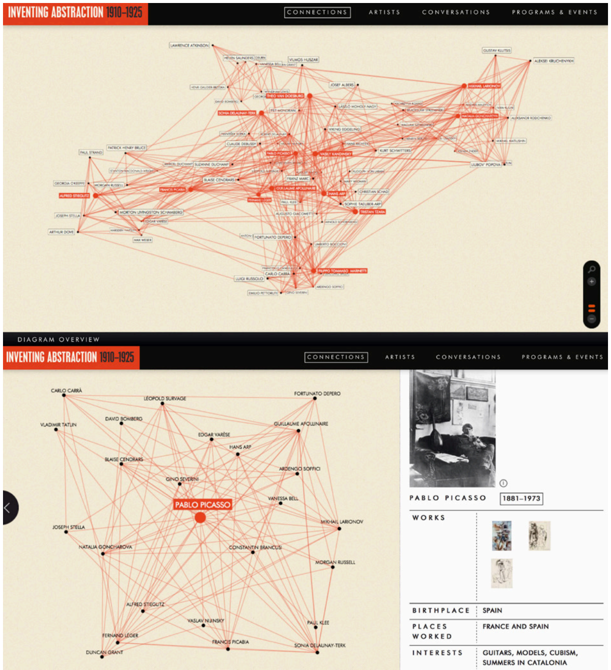
Fig. 5. Urtzi Grau, Daniel López-Pérez, Publications in Architectura of OMA/AMO, 2007.



Maps / Athlas. From the diverse to the particular

The development of the investigation comes from a documental search, a Big Data that enters a process of acknowledging and cataloguing on a first phase. We chose a series of examples from that period with all their graphic material for an ulterior analysis, whose final objective is the making of an Atlas: an interactive map of space-time. It is important to emphasize that the gathered documentation needs to be first filtered and evaluated because what interests us is to process it in order to turn it into a graphic representation that can be immediately visualized. Since there has never been a similar study to follow, we have selected the pieces of work according to several criteria: their inclusion in History of Architecture manuals, the number of referred times in bibliographical resources, and finally their presence in the indexes of architecture magazines published within the studied period, all these included in the bibliography [Curtis 1986; Gösel, Leuthäuser 1991; Hitchcock 1981; Jenks 200; Rossi 1986]. The aim is to create a document that analyzes diversity using an accessible and userfriendly communication tool. A mixture of a written and visual communication [Berlin 1977]. In contrast to the nice only visual icon used by Otto Neurat and Nigel Holmes [Holmes 1991] and to Tufte's complex combination of text and image [Tufte 1983], we have opted for a halfway conciliatory intermediate.
In the last decades the graphic discourse has emerged even stronger, encouraged by new advances in reproduction systems and new technologies that contribute to a new reading of information in this digital era, when the use of new gadgets influence our way of receiving data and of communicating in a very visual way.
A previous approach to the topic consists in a search of examples of maps related to architecture and arts through time. Inside the frame of architecture we find various examples. Charles Jencksì's paradigmatic genealogical tree, shown in the image, analyzes different architecture movements during a tuenty-year period. He places different tags with names of architects and architectural pieces of work. It is interesting to observe the disposition of the information in relation to the time location, the category and the hierarchy: according to the importance of the piece of work the tags are bigger and depending on the concepts they are related to, they appear closer to each other. This example uses, however, only keywords and names, it lack images that transmit the information in a more direct and visual way. This is a map that depends on the viewer to be understood, it depends on their knowledge. It is an initiatic diagram.
The next example includes one of the aspects relative to the visualization by diagrams and images that focus on a very effective way on what they want to transmit. It is the case of the Production of the Architecture Publications by OMA/AMO.
Along a chronologic axis, images of diverse magazines, media, etc. are placed. All these graphics are supported by extra information at the bottom of each column. Occasionally comic balloons appear and the most important events unfold as an explosion. Under the apparent chaos a magnificent order is hidden, where all the studio publi-

Fig. 6. Leah Dickerman, Masha Chlenova, Exposición Inventing Abstraction: 1910-1925, MoMA, 2013. Interactive Virtual Map, general connections and example of particular links of Pablo Picasso: <www.moma.org> (accessed 2018, June 10).



cations are stacked in organized growing order through time. It is a complete map.
In 2013 MoMA created a map towards which a fesher approach and reading are possible its interactive character. It lacks a physical format; you can only acces it online. It depends on new information technologies. The apparent cobweb set up is disturbing and at the same time inviting, it comprises a game and a change in shape, something necessary in new communication systems.
Names of artists show up in different colors depending on their relevance, and once you zoom over them you can observe their relationship with other authors and at the same time a technical file opens with information about their lives and work. The map itself does not contain images, but the names of the artists. It is once you get deeper into a particular author that you can access more information on his work. This map adds a fundamental aspect towards the configuration of our own map, the interactive part. The visual process that accompanies the acquisition of new knowledge has changed to be dynamic; an online connection system, accessible across the globe. It is a new way to code, order and communicate.

An interactive Athlas. The outcome

Through these examples we analyzed the ordering principles to consider when designing the new Atlas. It is important that the great amount of documentation we have at the begining becomes into quality information, which means that the Big Data is includeds and compressed in a graphic representation that incorporates not only tags but images and connections among the tags. At the same time, it must facilitate the display of more information zooming on some elements and allowing that different windows of information are included within the document.
In this interactive space-time map, affinities and differences along the timeand even more formal aspects, both plastic and graphic should be fit to be compared. The fields of study presented are connected by itineraries and categories depending on the established hierarchy: 100 architects, 10 architectonic movements, 50 pieces of art, 10 artistic movements, expositions, etc… As part of the interactive process, its itineraries should be activated or turned off enabling us to meassure the impact and their relationships depending on the needs of our search or study. Each category is composed by files with information related to pieces of work, architects, exhibitions, etc, and its codification referring to the ideas of the movement in which it is included.

An open Athlas

The creation of our Atlas, understood as a compendium and as a complex addition of diverse maps, started by arranging the information in written and using. Then, once the images referring to the chosen graphical examples had been collected, we have designed a digital map and finally we introduced the playful- dynamic component to facilitate a better understanding of the existing relationship among the diverse items.
To make the most of this interactivity, we need an open Athlas. An open working field suitable to be expanded ans filled in with new tags, images, connections, etc. It should not be considered as a unique graphic representation; on the contrary, and due to the itineraries and layers that can be activated or turned off, various maps are prone to be created depending on the characteristics to be compared or the interest of the study.
Our Atlas seeks for a contemporary view of the graphic discourse; one that gives access to knowledge through an interactive tool that allows us to make a comparative and temporary study. It is a compilation of diverse partial knowledge maps that, in their continuity, interpret a reality. The final objective is the creation of a tool that allows us to make a comparative study through the exemplification of architects and works.
As an example of great communication, we musy have a look at the very interesting map created by the first director of MoMA, Affred H. Barr, *Cubism and Abstract Art* [Barr 1936]. In 2013 the museum decided to revise the leyendary exhibition under the title: *Inventing Abstraction 1910-1925* [Dickerman, Chlenova 2013]. The well known poster, condensing knowledge and advertising, was created a dynamic model and completed with personalized files of movemenets and artists. The final result is a clear, simultaneous, interactive model. This is a remainder and an information tool that brings together accuracy and play with strict information. It recreates the old proceedings using modern techniques, a good model.
In our *Athlas of Modern Architecture*, when we compare the informative graphics to the text diagrams the result is surprisingly effective. The facts are orderly presented and

Fig. 7. Alberto Grijalba, Julio Grijalba, Carolina Heising, Working holographic map, 2014.

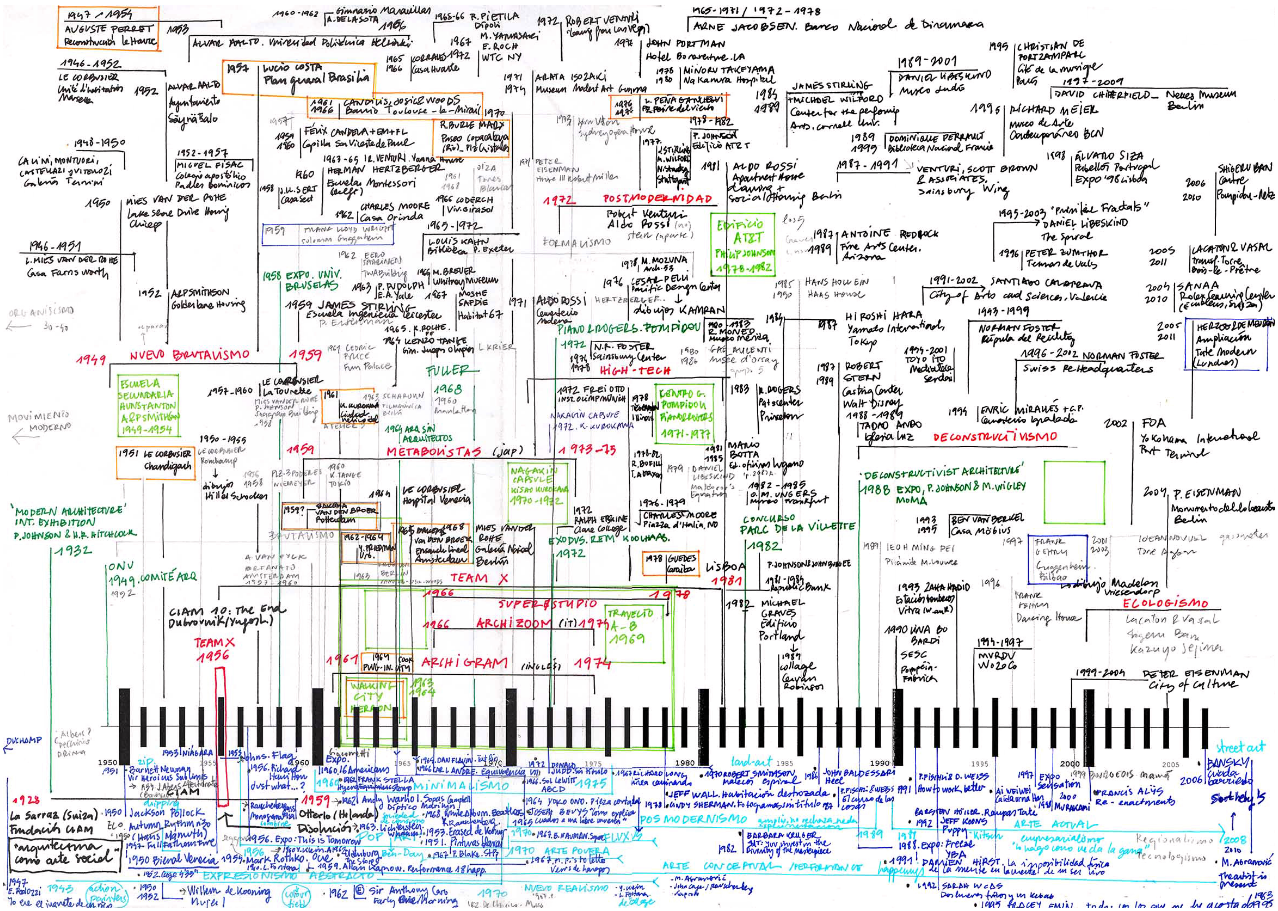


Fig. 8. Proposed map.

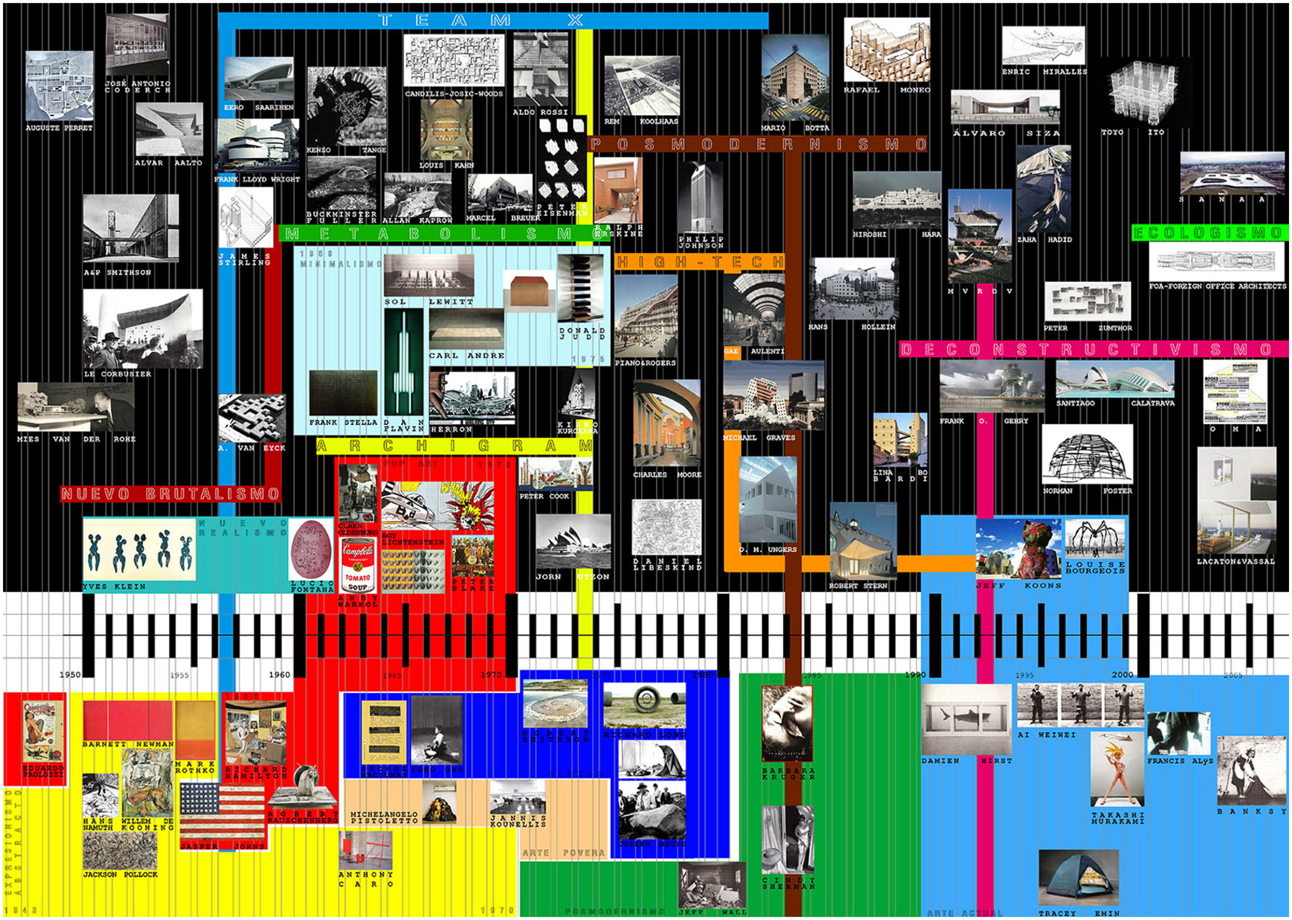
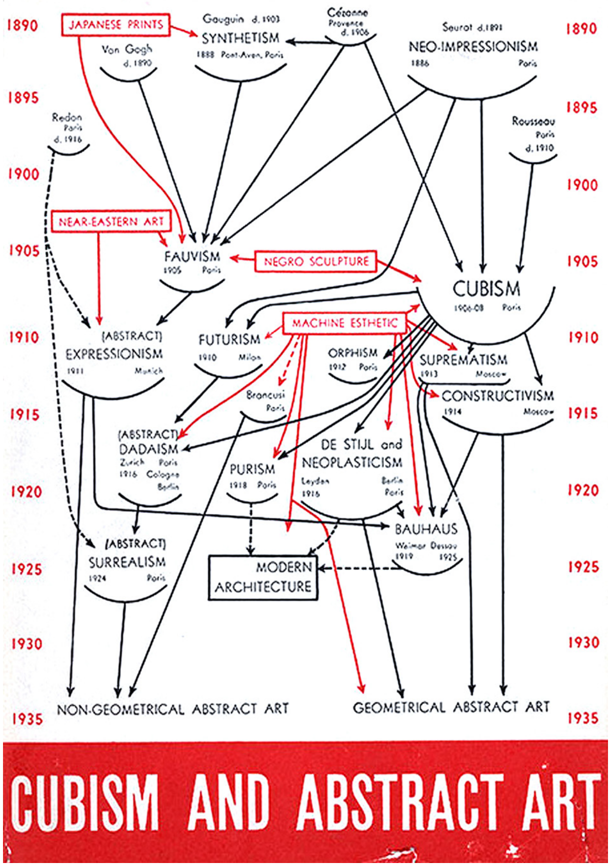


Fig. 9. Alfred H. Barr, Cubism and Abstract Art, exhibition MoMa, 1936, April-March [Barr 1936]



the connexions are easy to understand. In the digital era links are increasingly used to communicate; blocks of text that combined with graphics, photographs and diagrams to create a story, give an explanation or explore our world [Rendgen, Wiedemann 2015].
Probably working on an Athlas about the graphic discourse is a conclusion itself: the process of working on the proposals, the analysis, the choice of the documents and their transformation from the first holographic sketches to a digital application as a result. Despite the trial for aseptic objectivity with which the process has been taken there is always some subjetivity. From every choice a positioning on History of Architectureand its representation in the last five decades is taken [Cortés, Moneo 1976].
The treatment of visual information has become an objective in itself; clarifying and analyzing the contents; being aware of hierarchy, association and position of the elements in order to provide the most possible information at just a glimpse [Holmes 1991]. It is not, then, a document only seeking for compositional-graphical excellence, but an effective as a narrative of the knowledge in a graphic discourse one too. It is an Athlas capable of communicating a comples subject in a clear way [Alcalde 2015].

Image, text and simultaneity. Epilogue

The humongous work has been limited to 100 architects, 10 architectural movements, 50 pieces of art and 10 artistic movements in pursuit of a clearer communication. But, despite the need for a limitation, obviously needed in any investigation work though efficient, it has proved to be in some cases partial and exiguous, hence its open character. Information has been arranged following three criteria: time; relashionship and interrelationships within the different movements and cathegories and the critique impact. It is a map that can be completed and clarified, eventhoug not any change can be accepted in favour of an accurate and clear communication. More graphic documentation does not necessarily mean a better transmition of knowledge or a better clarityas we have realized during the process. Efficient graphic communication implies choices and hierarchization [Tufte 1997].
This 'Athlas of Architecture' does not pretend to reduce knowledge to an image on relation to its position in time. Our intention is not to trivialize its content, to achieve a simplistic communication. It is not a reductionistis sketch

that pretends to be a superficial analysis reducing knowledge. On the contrary, wee tried to avoid the common disfunction of the Theory of Big Data Communication: fast read but little knowledge. With its interactive capacity, which enables modification of the search mechanisms and amplification of information with emerging windows of complementary documentation, it is not only a map to orientate but an Athlas of knowledge, which also makes the addition of as many maps as we will be able to elaborate possible. All this is achieved using technological mechanisms of communication accessible nowadays.

Simultaneity is finally the last contribution. The new Athlas can interact in several windows at the same time, even use several registers making good use of the moder features new technologies offer; the multi-window and multi-taks. It is possible to view the general map at the same time that we activate a particular line of affinities, from the general map we can open an emergingwindow about an author, a work or an architertural movement. It is as flexible and as dense a tool of knowledge as the user needs.

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Fig. 10. Proposed Map. Samples of emergingwindow.

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The Representation of Staircases in Italian Treatises from the Sixteenth to Eighteenth Centuries

Vincenzo Cirillo

Abstract

The representation of the staircase is part of the more general theme of architectural drawing. Since ancient times, the designing of the staircase has been worthy of attention, due to both its useful function in overcoming the differences in floors as well as the not immediate mental visualization for articulated spatial solutions; as a consequence, its graphic representation is just as difficult. It has therefore been interesting to investigate this theme by researching it in the Italian treatises that, from the sixteenth to eighteenth centuries, both in literal and graphic form, welcomed and manifested the debate on the designing of staircases.
The aforementioned theme was carried out through the analysis of the sources contained in the treaties of Serlio, Palladio, Vignola (commented by Danti), Scamozzi, Guarini and Vittone. Working through the similarities and differences, the ways of describing the staircase have been highlighted and the results placed in the historical-scientific contexts of reference in relation to the geometric coding of the methods of representation. Without prejudice to the common use of drawing as a conceptual conception of visual synthesis, aimed at creativity, knowledge and communication, the reading of the sources has confirmed, on the part of the treatises, the existence of a critical choice of the most appropriate geometric methods of representation (although not yet scientifically codified) or exemptions from them to better describe the spatial qualities of a complex architectural element such as the staircase.

Keywords: Staircase, Treatises, Geometric representation methods, Graphic techniques, Modelling.

Introduction

This study does not pretend to examine the question of the staircase models discussed by the Italian treatise writers from the sixteenth to eighteenth centuries in their multiple thematic aspects, but, mainly, to investigate them from the perspective of the various ways of their graphic representation through drawing, intended as a visual language according to which mental images take shape through the aid of devices, whether they are analogical or digital: from the primordial experience of marking with a finger the shadow of the profile of a face projected onto a surface [Sgrosso 1984, p. 9], to a writing tip with ink on paper, to the contemporary computer tools that allow to draw lines on a screen.
Starting from the staircase models proposed by the Italian treatise writers (Serlio, Palladio, Danti, Scamozzi, Guarini, Vittone), the ways of visualising these *exempla* have been investigated through the use of graphic analysis, along with a scientific comparison in terms of application (intuited and not yet fully coded) of the geometric methods of representation such as orthogonal projections, perspective and axonometry.
The analysis started from a review of the different models proposed and their cataloguing through the structural configuration (pillar, shaft, wall plug), geometric configuration of the planimetric layout (straight, curvilinear, mixtilinear and, therefore, square, rectangular, circular, ovate, polygonal), as well as the number of ramps and stairs (from one to four or double, triple, quadruple). This made it possible to verify how the different

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staircase models, in addition to presenting themselves as the outcome of a lively theoretical experimentation (and, therefore, of ideational expression), are also the result of construction techniques coeval with the historical period of reference, which have made their "putting into shape" possible. The technique has always been a functional component of the form and, in its deepest meaning, determines the modalities of real and material existence of the model itself. Therefore, the analysis of the structural configuration seemed to be essential from the formal analysis; so much so that the introduction in more recent times of more advanced technological and constructive systems has allowed the creative imagination to configure increasingly efficient models of staircase [Calvo López 2001, pp. 38-51].
However, the mental imagination of the staircase (especially in the case of very complex structural and formal configurations) has always appeared to be a difficult operation, just as the description and communication in terms of graphic representation have never been a simple operation, revealing in the reading of these treaties a rather difficult application. This entailed that, in the above-mentioned treatises, the image of the proposed model was often associated to a detailed explanation in writing to guide the reader both in the mental imagination of the spatial configuration as well as in the comprehension of the proposed models in typological and constructive terms. Moreover, the difficulty of transposing on paper a complex architectural element such as a staircase required, not only the choice of suitable geometric methods of representation, but also the use of artifices and/or exemptions from the methods themselves. This circumstance has also been related to the specific biographical profile of the treatise writer, recognizing in the use of different methods of conventional application of architectural drawing, a differentiated communication goal: a different approach to the treatment (more or less theoretical-practical) or an argument aimed at a different audience of readers (generalist or specialist like that of the architect).
In conclusion, the architectural systems of the staircase models, catalogued by the treatise writers, were distinguished by structural and typological form and analysed graphically in relation to the geometric matrix [De Rosa, Sgrosso, Giordano 2000] by analogies and/or differences. In this operation, the modelling [Migliari 2003] and the digital visualization of the models (here used for the first time by the writer in almost all the types presented) took on a particular importance, which allowed to better describe the peculiar spatial connotation as well as graphically represent the architectural models introduced by the treatise writers in the written form. Thus, the graphic representation has once again confirmed the historical role of the conceptual means of visual synthesis, aimed at creativity, knowledge and communication.

Representation of the staircase in Italian treatises from the sixteenth to eighteenth centuries between design and communication

Drawing, in the more contemporary meaning of the term, means " 'to draw lines on a surface', but to draw is to establish a purpose, to expose an intention, to describe a program, it is also 'to design' " [de Rubertis 1994, p. 11]. Thus, designing is representing a mental form translating it into an image through graphic signs.
The forms that, in an intuitive or conscious way, are destined to become a graphic sign do not constitute reality but only the model since the act of drawing (i.e. the action, guided by the mind, of drawing a shape on a surface with the aid of an instrument) implicitly implements a specific selection of the characteristics to be expressed. Whether wanting to use the drawing as a tool to clarify intentions or use it to propose the latter to different receivers, the graphic operation is never immediate, but requires numerous reviews to prepare a summary image that can be understood when read by the public who will use it.
According to this function, the drawing becomes a conceptual means of visual synthesis aimed at communication or the process through which the transmission of information between author and recipient takes place through the exchange of messages elaborated according to the principles of shared graphic codes. The graphic signs (drawings and/or writings) constitute a powerful means of expression, so much so that their reading by the receiver can take place even in the absence of the one who transmits the message.
All this occurred in the treatises analysed. The graphic representation of the staircase presupposed an author (the treatise writer, who communicated his instructions) and a receiver (the architect, who accepted the message). Thus, the drawing, as an instrument of communication of the author, represents an indispensable means for the "putting

into shape" of his intentions (whether they are aimed at creativity or knowledge), just as geometrical methods of representation are fundamental (intuited or codified) to which the author refers for the description of the mental model [Giandebiaggi 2016, pp. 99-109].
From this, it follows that the methods of graphic representation of an architectural model (the body of the staircase) can differentiate according to the different formative profile of the author. Therefore, in order to evaluate the motivations underlying the use of multiple geometric methods of representation used by the treatise writers examined here, it was considered useful to relate them to their different biographical profile, hypothesising in this difference the possible reason for a different representation of the representation itself, although all the treatise writers examined in the context of those scientific foundations of the representation (*ichnographia*, *orthographia*, *scaenographia*) described by Vitruvius in the *First Book* of the treatise *De Architectura libri decem*.
The theme of the designing of the staircase, which for its important function of vertical connection is as old as architecture itself, leads to interesting developments in the production of treatises from the sixteenth to eighteenth centuries when space systems with increasingly complex geometries were introduced to the Italian and European scene [Zerlenga 2017, p. 45].
Specifically, in the Renaissance and Mannerist treatises, the body of the staircase still appears as an element linked only to the functional reasons of the act of "going up". Only through the successive and numerous conceptual and formal experiments of the Baroque period (due also to the codification of new architectural types linked to the noble residence), is it possible to see the elevation of this element at the fulcrum of the architectural project, in which the shape of the space plant becomes one of the most peculiar and representative characteristics of the home.
An analysis of the architectural treatises examined here shows a wide variety of staircase models: from the more traditional to more innovative ones [Gambardella 1993], from the simplest spatial solutions to the most complex. This entails a growing difficulty not only of mental imagination but also of the correct visualization of these spaces.
As already anticipated, the modes of graphic representation privilege a communication according to the classic references of the Vitruvian tradition with the need to recall, though intuitively, to geometric methods only subsequently codified, so that the drawings of the treatises examined here can be traced back to the usual three methods of scientific representation in perspective (Serlio), axonometric (Danti in Vignola) and orthogonal projection (Palladio, Danti, Scamozzi, Guarini, Vittone).

The "infallible rule" of Sebastiano Serlio and the "most important" staircases drawn "foreshortened"

Sebastiano Serlio (1475-1554) described different staircase models in *Libro II*, published in Paris in 1545, which was part of his more general work *I sette libri dell'architettura*, with it dedicated to perspective and scenography. The iconographic apparatus through which Serlio presented the various staircases is proposed through a collection of types with an exclusively straight-line geometric-configurative matrix and rectangular and square planimetric layouts (fig. 1A). The curvilinear staircases, and in particular the circular ones, are only mentioned in the text and, due to their construction, Serlio suggested adopting the same procedures described for the square-shaped model.
Specifically, Serlio stated that «among the things that have great strength in the demonstrations of prospects, I find staircases to be the best, since they return the best effect» [Serlio 1545, p. 53 v]. The "most important" staircases proposed by Serlio (mainly external) are represented in perspective and, therefore, the drawings are drawn by Serlio "foreshortened". The arrangement of the architectural space with respect to the representation frame is frontal, with points of view in relation to the staircase located both in the central and asymmetric direction and whose derived perspective views are respectively defined "in profile" and "per side" (fig. 1B). In describing the geometric construction for the perspectives of the proposed models, Serlio recommended always applying "this rule, which is infallible" [Serlio 1545, p. 55 v]. Beginning with the "easier" types, the writer stated that "for the ordinary, a step, it is half a foot in height, and a foot in width, that is, its plane" [Serlio 1545, p. 51 v] and, therefore, referred to both the horizontal and vertical plane to an orthogonal lattice having the aforesaid measurements on its sides. The lattices and measurements allow to easily draw the proposed models, once the measurements of the staircase have been defined as multiples of these values. Moreover, the verbal description continually refers to the drawings, which show the lines of geometric construction: the sloping lines of the ramps, those "pulled to the horizon with

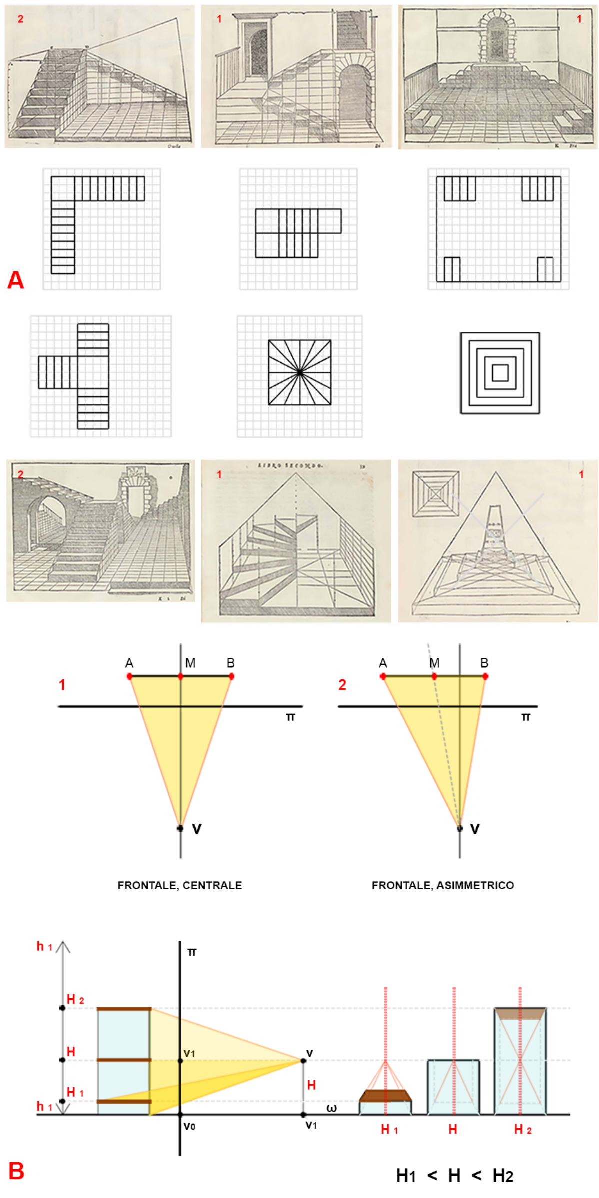

Fig. 1. Sebastiano Serlio: "infallible rule" to draw staircases "foreshortened" and geometrical patterns (graphic elaboration by the author).

occult lines" [Serlio 1545, p. 51 v] and others, still called "occult" and drawn as dashed lines [Serlio 1545, p. 53 v]. It is worth mentioning the last two staircase models that Serlio described. They have a square plan and are represented in frontal and central perspectives. The typology refers to the "lumaca quadra" (spiral) staircase [Serlio 1545, p. 55 v] and to that which "from all sides are assembled" [Serlio 1545, p. 57]. In the first model, the drawing placed at the bottom refers to the plan of the subdivision in steps, while the one at the top gives a perspective representation of the staircase, in which on the left part of the geometric construction, it is indicated to put nine steps in perspective while on the right only the planimetric and altimetric lattices are marked, which lead to the spatial configuration of the steps. In the second model, the geometric construction is established to realise the aforementioned staircase starting from the "slatted lines" [Serlio 1545, p. 57] (or diagonals of the square), which is proposed for half of its development as a staircase for courts, altars and similar things. This same construction is adaptable to make "round stairs, and still eight faces, or six" [Serlio 1545, p. 57]. Serlio does not correspond any drawings to this indication.

The drawing of the "various ways" of staircases in the treatise of Andrea Palladio

Andrea Palladio (1508-1580) was interested in the treatment of *Delle Scale, e varie maniere di quelle, e del numero, e grandezza de' gradi* in the XXVIII chapter of the treatise *I quattro libri dell'architettura* (1570). The architectural treatment presented a decidedly taxonomic approach in describing the different structural characteristics and typological elements that make up a staircase. He listed the staircases in relation to the geometric shape of the planimetric basin, combining them in curvilinear, of which "round" (referred to by the writer as "à Lumaca" or "à Chiocciola" (spiral) and "ovate", and rectilinear (called "straight"). The verbal descriptions of these models are accompanied by two full-page graphic tables, which contain eight scale drawings, all referenced in the text.
Both the curvilinear and straight stairs are grouped by static behaviour depending on whether they have cantilever ramps ("Spiral staircase empty in the middle", "Ovate staircase without columns", "Straight staircase without walls") or supported by load-bearing elements

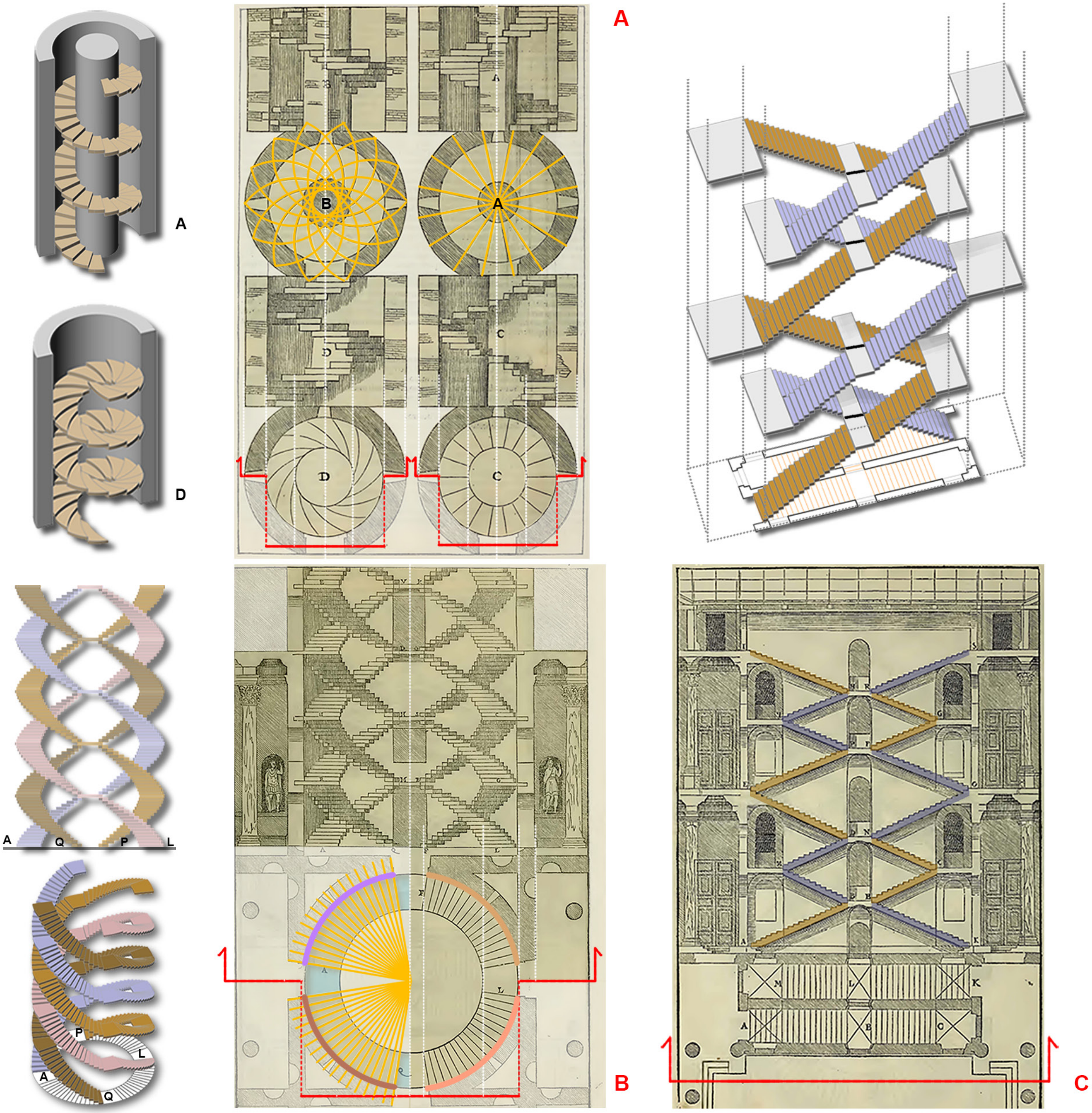

Fig. 2. Andrea Palladio: visualization of the "various ways" of staircases (graphic elaboration by the author).

in a central position (respectively "Spiral staircase" or "Ovate staircase with a column in the middle", "Straight staircase with a wall inside"). For the "Spiral" staircases, Palladio distinguished two other types: "with twisted steps" or "straight" or with the profile of the circular step (i.e. portions of circumferences that revolve around the common centre of the staircase) or straight (fig 2A). Rectilinear staircases, on the other hand, differ in the number and arrangement of the ramps, being "spread out in two branches, or square, which turn into four branches" [Palladio 1570, p. 61], but also due to the presence of resting landings in the corners (called by Palladio "Requie") which, absent in circular staircases, appear in this model as well as the "ovate" staircase, with the latter presenting a greater number of steps along the longitudinal axis.
The last staircase model presented by Andrea Palladio is that of the staircase built by King Francis I in the Château of Chambord in France. This is a "spiral staircase" made up of "four Staircases, which have four entrances, each one having its own, and ascending one above the other, so that it is in the middle of the building; they can serve four apartments, without those who live in one, going up the staircase of another: and being empty in the middle; everyone can see each other going up and down, without creating the least impediment to each other" [Palladio 1570, p. 64] (fig. 2B). On this configurative criterion, Palladio proposed one last staircase model, which he called "Double Staircase" and which, set on a rectangular system, consists of two parallel ramps with an independent development (fig. 2C).
Andrea Palladio, theoretical architect and builder, represented the staircase models described above, not in perspective (i.e. according to allusive drawings of the three-dimensionality of the architectural space), but rather as floor-plans and cross-sections. The two distinct images (drawn in the same scale of representation) are not however recalled by straight canons in orthogonal projection but are arranged according to a reading in vertical succession that binds the plant to the cross-section, and vice versa. As already noted elsewhere for the architectural drawing introduced by Sebastiano Serlio in his treatise, these drawings "reveal with great immediacy how the modern concept of relationship is acquired in the mutual reference of the prospectuses, exactly executed and completely devoid of perspective corrections to the relative plants" [Sgrosso 2001, p. 136]. This principle is also adopted by Palladio in his drawings, which appear rich in graphic and aesthetic sensibility even if not without surprises. In the drawings from "A" to "F", observing the relationship between the floor-plan and cross-section, it is possible to verify how in reality the writer uses an artifice to better describe the difficult nature of the development of the proposed models in the space. The risers of the ramps do not correspond to the cross-section plane passing through the centre of the planimetric plant (circular or ovate), but to a view only possible by removing the front half of the walls and leaving the entire helical development of the ramps in place.
Similarly, this artifice is also used to illustrate the complex quadruple "spiral staircase" of Chambord in France as well as the double one with a straight planimetric layout, where the continuous articulation of the independent ramps is made visible by eliminating the opacity of the perimeter walls (in the first case) and in front (in the second), while the canonical cross-section plan is respected only for the side areas.

The drawing of "double", "triple" and "quadruple spiral" staircases by Egnatio Danti

In his commentaries on the treatise *Le due regole della prospettiva pratica* (1583) by Jacopo Barozzi da Vignola (1507-1573), Egnatio Danti (1536-1586) recalled the theme of the "double spiral" staircase, also citing that of the aforementioned castle of Chambord [Barozzi 1583, p. 144]. Specifically, two models were presented. In the first one, called "open", the ramps rest on a central pilaster system (fig. 3A), which allows the staircase to be flooded with "light". Danti compared this staircase to that of the well of Orvieto, stating that it has not caved into the tufa and that instead of the ramp, there are the steps. In the second, the staircase is open in the middle and cantilevered, with the steps being "stuck with the head in the wall and placed one above the other, one on top of the other, with the same steps making up the staircase" [Barozzi 1583, p. 144].
This "double spiral" staircase model can also be applied to an oval planimetric profile, which Danti does not draw considering it more difficult [Paris, Ricci, Roca De Amicis 2016] because in the oval profile the lines «go to different points» unlike the circular ones, which go to the "point and centre of the middle". The two circular models are represented in floor-plans and cross-

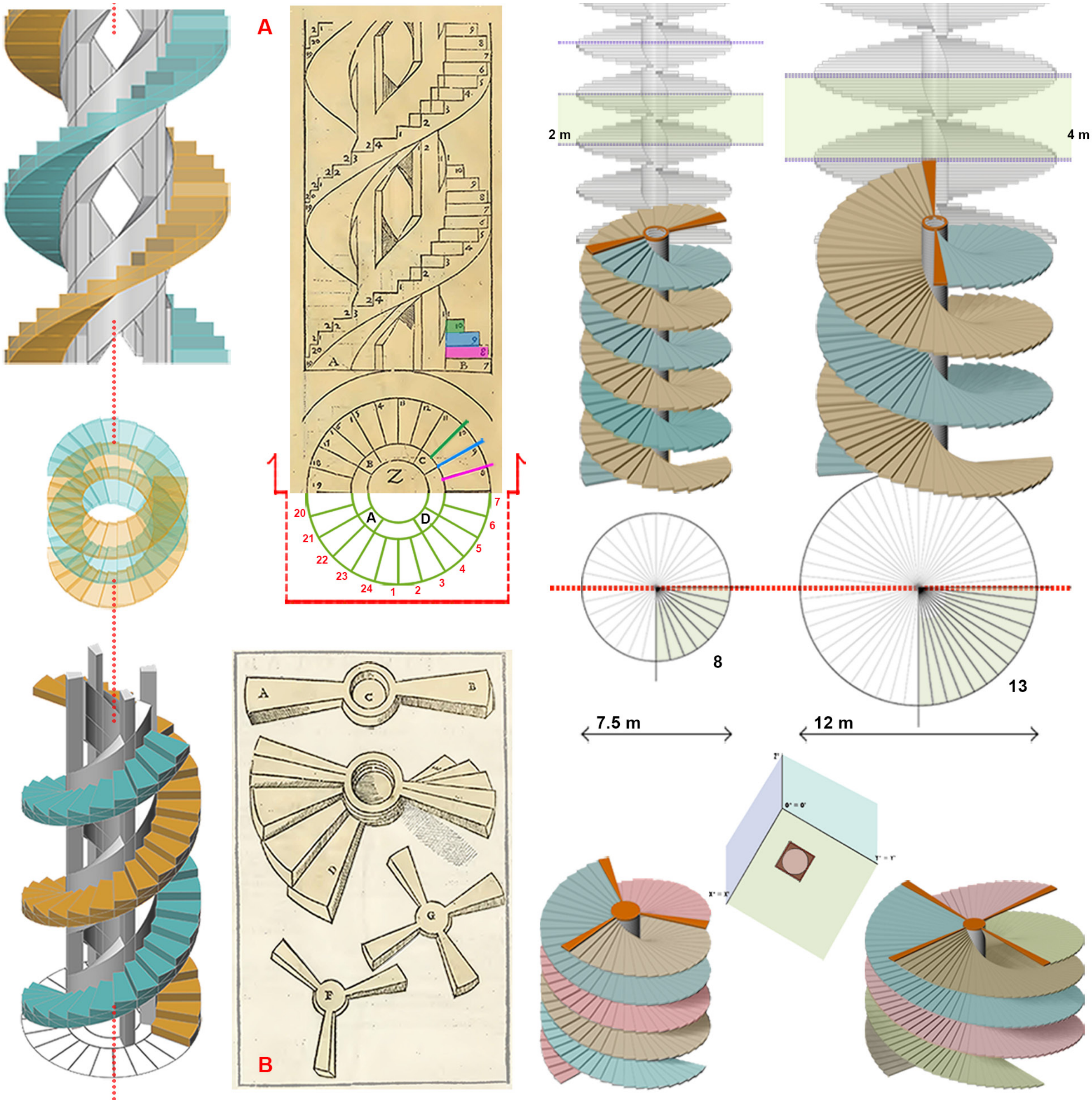

Fig. 3. Egnatio Danti: visualization of "double", "triple" and "quadruple spiral" staircases (graphic elaboration by the author).

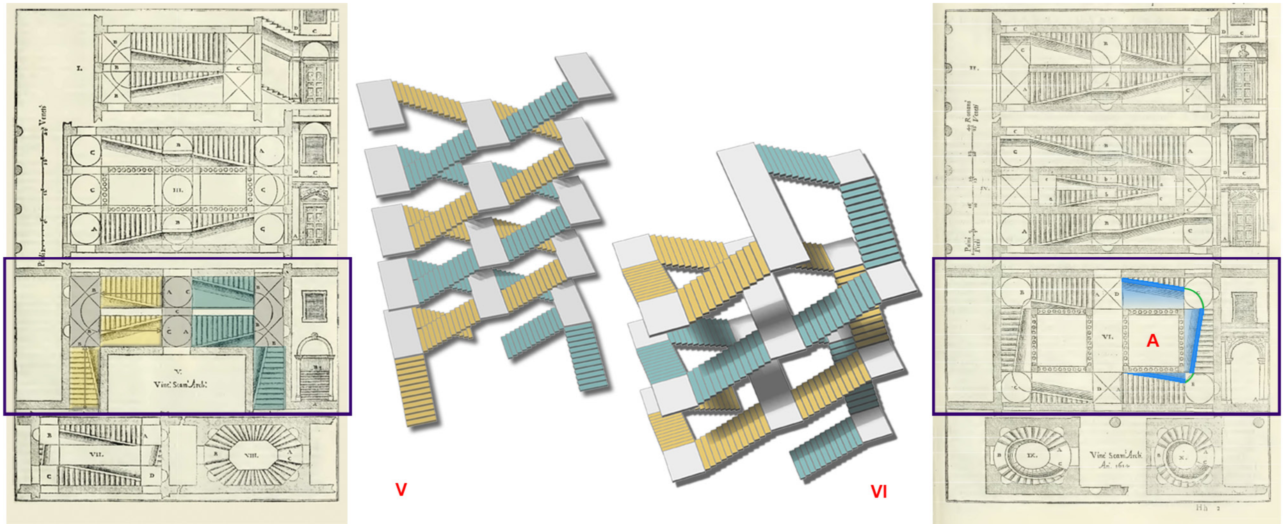

Fig. 4. Vincenzo Scamozzi: visualization of the "main staircases" (graphic elaboration by the author).

sections, drawn in the same scale of representation and according to the usual vertical arrangement that places the elevation-cross-section above the plant. However, from the examination of the drawings it is easy to notice the inversion of the sense of reading of the plant with respect to the elevation and since perceptually these drawings allude to a spatial view of the interior made possible by the removal of the perimeter walls.
What is particularly interesting for the historical-cultural context linked to the history of geometric methods of representation is the discussion of the last example described by Danti. These are circular double, triple and quadruple staircases, which the writer considered as a set of unified elements whose assembly configured the staircase. Specifically, Danti drew the staircase obtained so and the standardized elements with two, three and four steps in oblique military cavalier axonometry, whose top view well represents the measurement and spatial composition of the elements (fig. 3B). This unusual way of representation places these drawings in the chapter of the parallel projection, anticipating one of the most interesting works on the theme, *Lo inganno de gl'occhi* by Piero Accolti (1578-1627), published in Florence in 1625.

The "Drawings of the Staircases described in different forms" in the treaty by Vincenzo Scamozzi

The formal experimentation of the Baroque period elevated the staircase to a scenographic element of the home, so much so that in the treatise *L'idea della architettura universale* (1615) by Vincenzo Scamozzi (1548-1616), *Chapter XX* discusses *De' siti, e forme convenevoli a varie maniere di Scale private ad uso de' tempi nostri, e alcune introdotte dall'Autore* [Scamozzi 1615, p. 312]. Six pages are dedicated to the subject, two of which include the "Drawings of Staircases described in different forms" [Scamozzi 1615, p. 315]. In introducing the theme, Scamozzi affirmed that the "ways of the staircases are many, and different, but according to our opinion, they can be reduced to ten ways, or forms" [Scamozzi 1615, p. 312].
In line with tradition, from a formal point of view Scamozzi confirmed the already known planimetric systems with curvilinear matrix (circular and ovate) and rectilinear (rectangular, square, polygonal). In particular, the polygonal form is defined by the treatise "à mandorla" and referred to by these as a way realized in the staircase of the "stellata in Prague of Bohemia" [Scamozzi 1615, pp. 314, 315], current Star Summer Palace. Similarly, from a structural point of view,

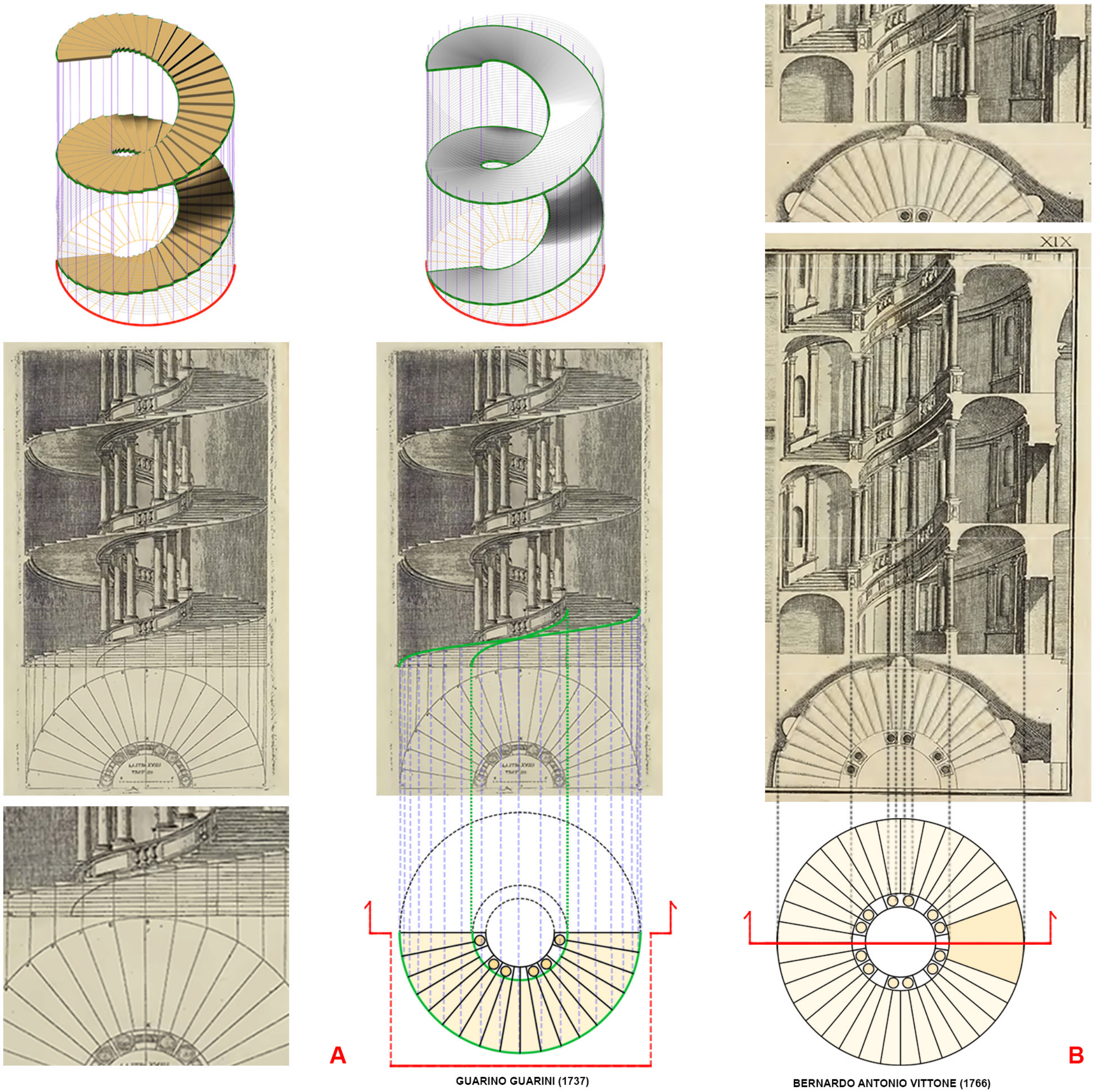

Fig. 5. Guarino Guarini and Bernardo Antonio Vittone: comparison between scientific representation and technical-perceptive representation (graphic elaboration by the author).

the staircases can be supported by pillars and columns, by "full walls" or be "suspended in the air" or cantilevered.
The choice of the site where the staircase is located assumes particular importance for Scamozzi, since most of them mainly serve noble houses. He distinguished the "main staircases" from the "secret" ones or those that "are very good among the apartments of the rooms" [Scamozzi 1615, p. 314]. Consequently, from a typological point of view, Scamozzi introduced several ways of "main staircases", some of them "invented by us" [Scamozzi 1615, p. 314] (like V and VI, analysed in fig. 4), in which the ramps are articulated according to a symmetrical bilateral system, generating models of double staircases with one or two "wells" (synonymous with the previous term "empty"), often destined to house a "secret staircase" in the void.
The staircase models proposed by Scamozzi and drawn in Roman palms or Venetian feet, foreshadow complex spatial articulations in the succession of ramps and landings; the choice to represent these "ways" in floor-plans and cross-sections does not facilitate communication. Scamozzi, while recurring in the written text to detailed explanations with references to the drawings, in the latter he introduced some graphic artifices to overcome the absence of an allusive image of the three-dimensionality of the system. In representing the plant of the ramps, Scamozzi overlapped the vaulted intrados of the ramps and used graphic symbols to indicate the common dismount of the ramps to favour the mental imagination of the spatial path (fig. 4A). In general, the reading of the spatial configuration of the "main staircases" introduced by Vincenzo Scamozzi in his treatise is not immediate and requires a considerable effort to understand both the decoding of the graphic signs as well as the spatial imagination, since the planimetric drawings do not adequately correspond to the altimetric cross-sections, with only a discrete mention of the span of access to the staircase on the ground floor. Therefore, for the ways V and VI digital models were used to better describe the spatial articulation. These models were viewed in perspective.

Guarino Guarini and the awareness that "Ichnography depends on Ortography, and this on the other"

The theme of the staircase is developed by Guarino Guarini (1624-1683) in the posthumous *Architettura civile* (1737). In *Chapter Seven* of the *Treatise II,* entitled *Del modo in generale di disegnare le Piante*, Guarini addressed the description *Della pianta delle Scale* and in introducing the argument he stated critically that: «The staircases are the most difficult parts, that the House has to accommodate, maxims that Vitruvius gave no rule for, if not of their ascents" [Guarini 1968, p. 105]. Guarini distinguished "three types of Staircase" and referred to the verbal description of the models proposed to the figures contained in *Table VII* of the Treaty. The first example of staircases corresponds to those that "in ascending diminish, and have steps that are always shorter, or get bigger" [Guarini 1968, p. 105]. The second type corresponds to staircases «with branches, or arms, which ascend with equidistant steps, and parallel, and always equal» [Guarini 1968, p. 105]. For this second type, he distinguished three models according to the different number of ramps, the shape of the planimetric basin (rectilinear, square, hexagonal), the static behaviour ("full in the middle, or empty, or horn, that is with the vaults that ascend like the Staircase, or with the vaults level") [Guarini 1968, p. 105]. Moreover, he attributed the hexagonal type to the model published by Palladio in his treatise, namely the double staircase of "Sciamburg in France made by King Francis" [Guarini 1968, pp. 105, 106]. The third type of staircase is "round, or ovate" and, as usual, can be made "with a column in the middle, others vacuous, and suspended" as well as "with rising horns, or on level" [Guarini 1968, p. 106].
From the point of view of the history of the geometric methods of representation, Guarini has a fundamental role: "he is in fact concerned with giving back to the discipline all those scientific supports of which most of the coeval texts, addressed to the practical operators and artists, appear to be lacking" [Sgrosso 2001, p. 296]. During his lifetime, Guarini loved to call himself "a mathematician", with this being his greatest vocation: this training led him to understand architecture as part of mathematics, placing his studies among the anticipations of the projective geometry of Girard Désargues (1591-1661) [Docci, Migliari, Bianchini 1992] and the codification of the double orthogonal projection by Gaspard Monge (1746-1818) [Cardone 2017].
The judgment of objective representation that Guarini placed in orthogonal projections is explicitly expressed in *Trattato II*, *Capo Settimo*, *Del modo in generale di disegnare le Piante* where he stated: "knowing how to draw the plants perfectly, and carry out the documents of Ichnography, depends on Orography, and this on the other; so without knowledge of both, it is difficult to know how to draw on a perfect Ichnography" [Guarini 1968, p. 96]. With reference to this method, in *Trattato III*, *Capo Vigesimoquinto*, *Osservazione sesta*, Guarini described a circular staircase (similar to the Scala Regia of the

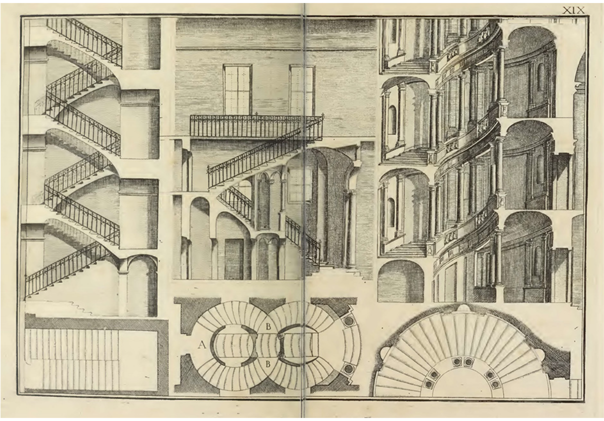

Fig. 6. The drawings of the staircases by Bernardo Antonio Vittone in floor-plan and cross-section.

Palazzo Farnese di Caprarola [Paris 2016]) which is illustrated in Table XXVI of the Treaty (fig. 5A). For this type of scale, he believed that "Spiral staircases in expressing them in drawing hold the same difficulty as oblique plants, and something more to be not only oblique, but also ascending" [Guarini 1968, p. 274]. Assigned the plant, Guarini described in detail the geometric construction "to place the plant above the orthography". Proceeding step by step, he defined the points that "will determine the floor-plan of each step, and will have the cut of the staircase towards the outer wall; there will be more towards the soul, or we would like to say the horn of the same staircase, if in operating we will observe the same rules" [Guarini 1968, p. 274]. However, it should be noted that the arrangement of the plant below the cross-section appears in a reversed position and that the cross-section itself is likewise imagined (as for Palladio and Danti) without the front perimeter walls in order to visualize the complete development of the cylindrical helix in the space.

Delle Scale represented in the *Tavole* of the treatise by Bernardo Antonio Vittone

In the treatise by Bernardo Antonio Vittone (1704-1770), *Istruzioni diverse concernenti l'officio dell'Architetto Civile* (1766), the author dedicated a large paragraph (eight pages of written text) to the theme of *Delle Scale*, in which he described with a wealth of detail seventeen examples of theoretical and built models. The seventeen examples are then recalled in separate tables (ten) which, in a large format and according to the now more and more consolidated technical representation in floor-plan and cross-section, present the types described. From a morphological point of view, the proposed solutions appear to be highly articulated due to the presence of more ramps that are enveloped in space on the basis of planimetric plants with a straight, curvilinear and, above all, mixtilinear matrix. The unprecedented concave-convex trend connotes several unpublished examples, as well as the sinuous staircase on a double page in *Tav. XXII*.
The comparison with Guarini is particularly interesting in relation to the graphic representation by Vittone for the "grand Staircase of the famous Castello di Caprarola" [Vittone 1766, p. 152] (fig. 5B), shown here "half" in table XIX. Despite the interest of Vittone being mainly directed to the morphological and perceptive aspects of the spatial peculiarities of this staircase, the drawing that he published seemed to be correctly executed in terms of the orthogonal projections with respect to that of Guarini. Furthermore, the architectural plan in floor-plan and cross-section drawn by Vittone not only has a technical value, but also a strongly perceptive value since the skilful graphic techniques which he used make it possible to restore, through the application of chiaroscuro, the complex plastic dimension of the staircase, almost as if a modern photorealistic effect (fig. 6).

Conclusions

The contribution offered by this paper on the theme of the ways to represent staircases in Italian architectural treatises from the 16th to 18th centuries aims to demonstrate how it is included in the more general history of architectural drawing, although specifically documenting two central nodes. The first is expressive of a critical reading of the different ways of representation through which the staircase has been analysed. This diversity highlights how representation is never neutral but is affected by its cultural and scientific contexts [Fatta 2016].
The second relates to the world of digital innovation and, the modern concept of modelling, where this practice allows to give shape to complex and/or never figured design ideas. In the analysis of the sources referred to

here, the verbal description of the staircase models often presented does not correspond to the graphical representation or the same is insufficient to describe the peculiarities, resulting in a greater difficulty in imagining the spatial configuration of the same for the reader. The modelling elaborated and the subsequent visualization of these models through adequate axonometric or perspective views has been useful for the critical representation of the spatial characteristics, favouring a more immediate understanding to the specialists of the sector and not only. Thus, the study aims to demonstrate that visualization gives a significant result, while also playing a powerful strategic role: giving voice to creativity, knowledge and communication.

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Survey

Survey 4.0: the Challenge of Complexity

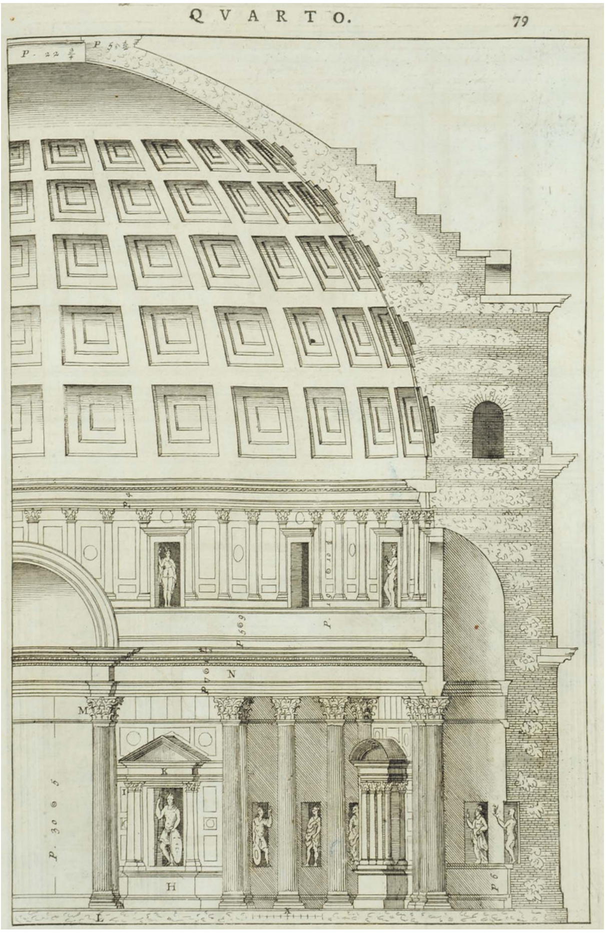
Paolo Giandebiaggi

Introduction

Over time, the scope of Survey had periods of greater or lesser consideration, but I would also say of mere attention of academic and non-academic scholars who confronted in the field of Drawing. This is due to the wide spectrum of cultural interests that are present in this sphere: from the geometry to the project, from the techniques to the systems. The considered focuses have an enormous variety of scale, from the object to the landscape.
The long history of the Survey itself represents such difficulty that has developed hand in hand with the history of man, his needs, his curiosity, the need to understand what is around him. On the one hand, the description of the surroundings as a need to understand the context in which it is located, on the other hand the inherent desire for inquiry and for an increasingly profound knowledge of what it meets. These considerations pushed man to deepen the analysis in all applications and methods aimed to investigate the elements that make the architecture, the city, the territory. The English terms of survey and inside summarize the same nature that drives a researcher to his task in each sector: but in the architectural field, it rises to a specificity that carries the Survey to be able to almost consider itself a discipline in its own.

This article was written upon invitation to frame the topic, not submitted to anonymous review, published under the editor-in-chief's responsability.

Fig. 1. Andrea Palladio, Drawing of the Pantheon, Rome [Palladio 1570, p. 81].



If in fact the scope of the 'description', as applied to the existing, falls within the definition of 'representation', the research on the built, and in particular the depth of the investigation itself exclusively relates to the field of Survey. Obviously guided by man, it will always maintain a representative subjectivity intended to explain the documented information, but it is no longer made only by graphic representation, but it extends its demonstrative amplitude to the various fields of the description of events and information, starting with, but not exhausting, from those expressed with graphic methods. In this sense, Survey assumes its own autonomy. The Representation begins and ends in itself and through itself, or autonomously (graphic representation, musical representation, theatrical representation, literary representation) using a specific and unique language to explain the subjective interpretation. In reverse, Survey starts from knowledge, from the information, from the analysis of the case study, and only through certain survey methods including the graphic one, it 'download' (restitute) again through the Representation its results: from the most superficial to the deeper ones.
Over time, Survey accentuated its distance from the representation and in particular the one of the surface: switching from the ancient but useful life drawing, to the acquisition of shape and measurement also through increasingly complex instruments, until the laser scans and photomodelling. It chased the accuracy of the physical-material component, but increased the description of a broader spectrum of information that goes beyond these aspects, to implement the deep knowledge of the object investigated. In order to do this, it necessarily had to follow the evolution of Science, which in particular in the last century has seen to undermine the constitutive paradigms that supported research for at least two centuries, from Newton to the present day.

From Survey 1.0 to 3.0

The traditional Drawing of the existent is realized through the critical and geometrical description of the architecture, perhaps with some graphical considerations about the technologies and of building materials and/or their conservative state. From Palladio to Piranesi, the Survey 1.0 especially increased the knowledge of form and dimension, through tools that pushed the Survey forward

from the second half of the 19th Century [1]. The wide use of mechanical, optical and photographic technologies applied to the survey field, different from the traditional tools of the Drawing, increased the quality of the description, but lengthened the distance between the Drawing as the sole instrument of investigation and the investigation itself as a place of competence of the Survey. The completeness was greater than the exhaustive aspects of the relationship between form and dimension. The progress made using those tools until the early 20th Century were evident [2].
The flanking of the of the non-contact survey to the direct one, with an enormous development of use of the last, definitely sanctioned a cultural transition whose effects have been very evident, precisely on how to conceive a survey (Survey 2.0). Progressively, the use of such tools increased the innovative-technological and methodological improvement: from the graphic description of architecture to photography / photogrammetry / stereo-photogrammetry, from levels and theodolites to mechanically and optically more and more refined and efficient instruments. Progressively, Survey reacted to the complexity required by the times, to the increase in the need for quality of the information restituted and more and more aimed at understanding the object, and not only at its description, but through a representation always more precise and reliable.
This passage corresponded to the parallel industrial development (Industry 2.0) which introduced industrial products, the 'machines', in all anthropic fields, from everyday life to scientific research. This spread caused a heated debate on the identity of the Drawing/Survey relationship, traceable in a wide bibliography by the detractors of this innovation, traditionally linked to the exclusivity of traditional techniques, against the 'modern reformists', strong of the actual results that these innovations brought in accuracy and coherence of the geometric information obtained [3].
In the second half of the 20th Century, the advent of information technology and the digital world provoked a further leap. As careful contemporary scholars pointed out, this responded to a need for a world that had to give faster and above all wider answers. 'Information' of increasingly different nature had to be linked, because their comparative reading gave answers to increasingly complex questions. The same definition of computer science placed emphasis on information, different from data. Of course, even more this approach developed the ability to investigate the phenomena in different sectors, in particular for those involved in research and knowledge aimed at understanding.
With the advent of computer science, the Survey 3.0 greatly expanded the field of investigative action, no longer focused on a purely mechanistic investigation regulated by cause and effect (measurement and drawing), but to a system that correlates information of various nature and of different origin than the previous geometric construction. The gap further expanded between investigation (survey) and description. In this case as well, the parallel transition was decisive from Industry 2.0 (the second industrial revolution) to 3.0 (the technological improvement) with the introduction of electronics, IT, telecommunications in the fields of knowledge and generally in everyday life.
In our field, the so-called CAD Computer Aided Drawing and therefore Survey, on the modernist line of the survey assisted by optical-mechanical instruments, more or less rapidly led to digital representation, 3D modelling, rendering, up to information systems, gene-

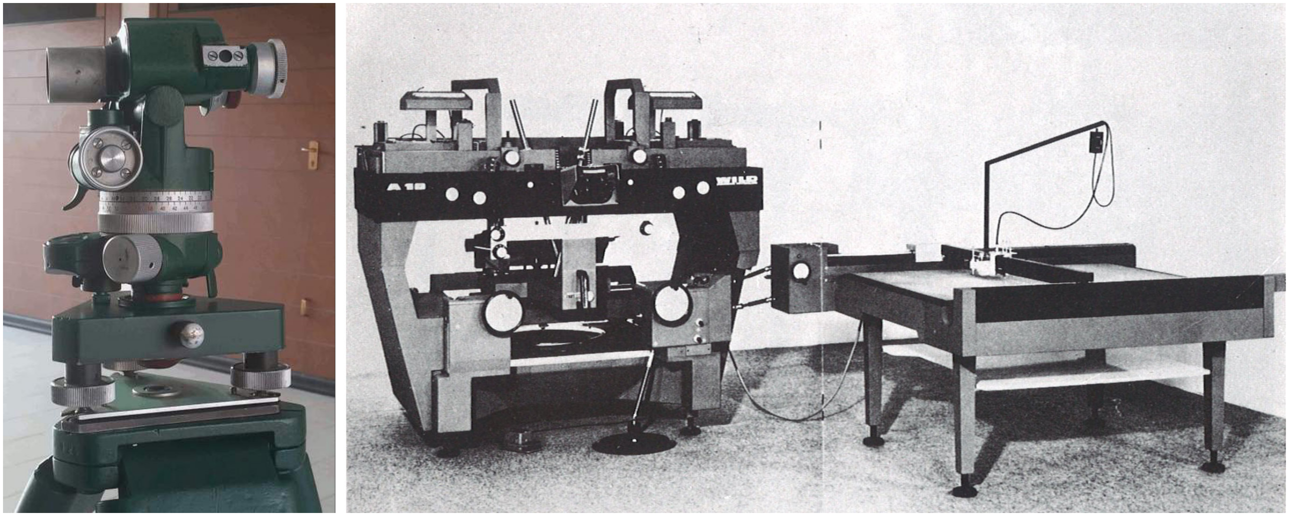
Fig. 2. Giovan Battista Piranesi, Perspective view of the interior of the Pantheon, Paris 1765-1768: <http://www.artnet.com/artists/giovanni-battista-piranesi/the-pantheon-interior-4TuI8P9OPaD2lCGvwFBexQ2> (accessed 2018, June 22).

rating a new description/representation of the facts detected. We are not talking about the acquisition phase that, through measurements before from Total Station and then from Laser Scanner, implemented possibilities of precision where the indirect survey developed in the previous century become unavoidable. In fact, computerization allowed validating and strengthening Survey as a synonym of the general system of knowledge of the case study object, for architecture but not only. A complex of information from different sources (historical, structural, technological, artistic, performance, etc.) was holistically integrated on models that are increasingly geometrically precise and pervasive. They get an apparent comprehensive knowledge, which would allow little room for a further implementation [4].
Only ten years ago, a profound completeness (inside) of acquisition and management of information was thought to be reached. Instead, now almost paradoxically it poses continuous further questions, undermining the self-reference of the inquisitive process. Once, one would have said: 'The more I know, the more I realize I do not know'. The pace of innovation that these fields have shown in all directions demonstrates this: from CAD to BIM with a conceptual change of the 'representation/reconstruction' of architecture [5]; from digital stereo-photogrammetry to GIS, GPS, 3D capture technologies; from laser scanning to photomodelling [6]; from the introduction of the fourth dimension (time) to a hybridized representation through animation and cinematographic techniques; from the digital photomontage to Virtual and Augmented Reality. All this must be adaptable to the new Web that, with further complexity and with consequences on the representative process, from computers switch to tablet and smartphone [7].

To the Survey 4.0

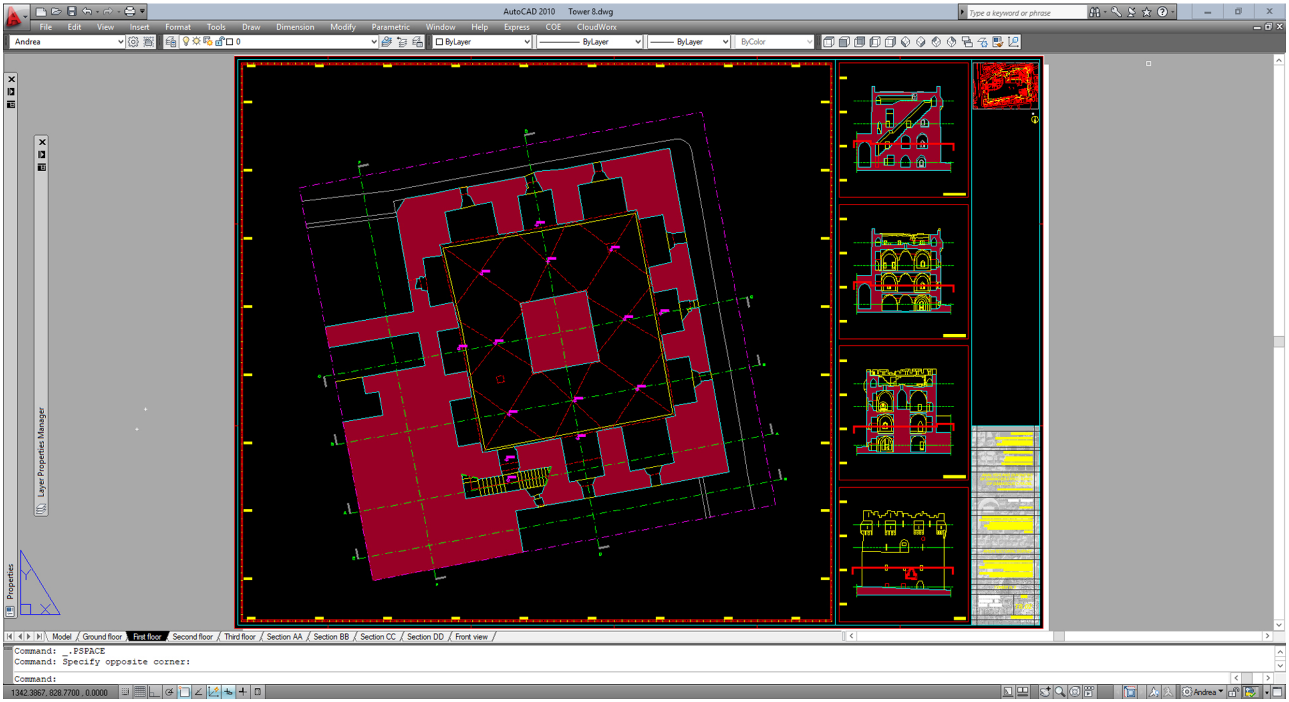
This has had and still has a notable impact on the development of application and professional sectors: if once there was only a professional figure in the field of Survey (the 'surveyor', be it geometra, architect or engineer), today there are several actors. The specialization in the field of the metric acquisition almost never corresponds to the skills necessary for restitution and afterwards for 3D modelling, rendering and transferring the data into

Fig. 3. On the left, optical-mechanical theodolite; on the right, restorer Wild A10 with pantograph [Cundari 1983, fig. 40 p. 78].



a communicative and fascinating representation, able to increase the value of knowledge and dissemination. The specialists of information systems, especially on the ability/need to relate data and information from disparate sectors, usually have not the same skills of those who know how to work with BIM. Not to mention experts, like drone pilots or who digitize ancient documents, which are far away even if both aimed at understanding the same architecture. The fragmentation/separation of skills can be an opportunity for possible economic growth, jobs and qualification of professionals in the field, but it poses problems of connection and overall vision.
All these innovations approach the close relationship between academic discipline and professional practice, both in Drawing and Survey, up to fear the risk of slipping into pure application. This peril always menaced our disciplines and only the scientific approach to the reasons behind the operating procedure maintains the academic status necessary but not acknowledged by everyone. The know-how cannot be separated from how and why we do things and above all from the symbiotic correlation that they maintain with other disciplines that guarantee their validity and correctness (Descriptive Geometry in first place). However, the link with the professional aspects should absolutely not be underestimated, so that they spread and every day find their application and stimulate a constant innovative development.
It is also true that now, the disciplines with which Survey dialogues are increasingly almost all the possible, not only in the so-called 'technical' field. Today, a survey can support almost every field of knowledge and it can enhance its usefulness in linking all competences. Currently, Survey is apparently comprehensive of all possible knowledge, both on the physical and on the cultural level, not only for

Fig. 4. Digital restitution of survey: Tower 8, Damascus Citadel (graphic elaboration by: Gruppo di Rilievo, DICATeA Unipr).



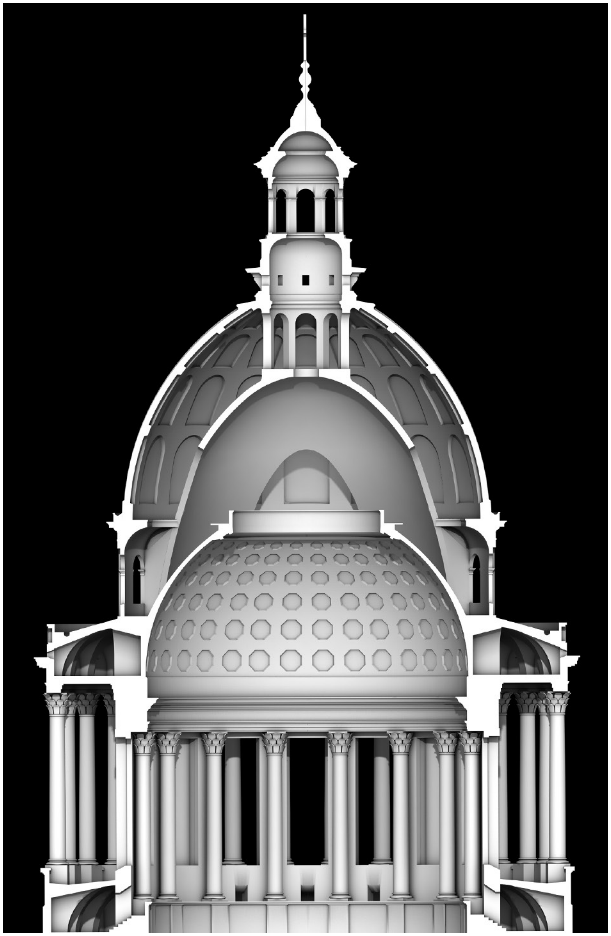


Fig. 5. 3D model of surveyed architecture: section of Pantheon, Paris (graphic elaboration by: Gruppo di Rilievo, DICATeA Unipr).

including data and information directly or indirectly acquired, but also for the specific and countless links applicable to the model. They lead to a theoretically infinite, multi-dimensional and multi-cognitive relationship context (i.e. hypertexts): "*Le scienze neo-meccanicistiche danno il colpo di grazia al concetto classico di oggetto singolo, sostituendolo con quello di sistema […] dove le indagini singole si spostano sulle relazioni che si instaurano tra elementi appunto di un sistema […] al posto dell'Uno, l'unitas-multiplex*" [Anselmo 2017, p. 20]. It is another cultural milestone.
According to Morin [8], the challenge of complexity is leading us from a world where the traditional knowledge faced problems whose factors obeyed the laws of classical logic (by their nature, they are for the most part measurable), to a new world in which the research itself is incalculable and boundless. The new frontier is the understanding of relationships rather than data, and a new organization of the knowledge. Survey 4.0 will adapt (maybe it is already beginning to do) to analyse the case study and the tools necessary for in-depth investigation, searching for the achievement of a deterministic, objective, definitive knowledge. It will also take into account and favour the relational aspects of the information itself, accepting a changing truth. This, through constant criticism, interrogation and dialogue. This is actually a huge step to take.

The challenge of complexity

Today we are able to document in a survey conducted with contemporary systems an extremely high quality and quantity of knowledge and it is clear to everyone how difficult it is to put it 'in order' and make it functional. Why? Because we are used to conceiving such a scattered order –a disorder– as a lack of our knowledge. Always, to understand we have been used to put things in hierarchical and pyramidal order. In front of such a mountain of information collected in different fields with different tools and increasingly moving beyond fields of competence of others, we are destabilized not only scientifically. It is highlighted the fragility of a method that instead should support and satisfy us, thanks to its pervasive deepening. The same principle of separability is vulnerable, according to which up to now it was necessary to break down a very complex problem into simple elements to solve it. This, despite the connection systems (information sy-

stems, GIS, BIM, etc.) are almost structured: at each subdivision, they leave on the field a gap of knowledge and a loss of relationship between the decomposed elements. By this time, an emblematic intellectual discomfort is almost physically felt [9].
The example of biological research shows: "*la scoperta della molecola convinti fosse l'elemento primario, ultimo ed indivisibile, per poi giungere invece alla scoperta dell'atomo, poi al suo nucleo, poi alla particella, per arrivare e giungere al quark di cui si è certi la particella sia composta ma che non può essere isolato materialmente, ma è solo postulato attraverso il calcolo*" [Anselmo 2017, p. 17]. Another example is the separation of disciplines in academia, where the continuous spasmodic pursuit of their singularity, specificity and identity has shown that the deviation from the very purpose of the application field causes more loss than gain. This applies to the human, medical, engineering, architectural sciences. The current attempt of a possible reconstruction of the whole is only a first sign of the intellectual discomfort that each of us feels [10]. Yet no one knows how to reassemble the fragments, without losing depth of expertise.
In the architectural field, the separation by nature of acquisition and origin of the information collected in a survey seems to disperse in a loss of the overall vision. The need to hold together the whole and the parts is fundamental as a mandatory condition for true knowledge. Even the reductionist process (through which a survey is conducted on smaller and smaller pieces, more and more in detail, seeking for accuracies at the limit of measurable) shows the fallibility of historicised method for which scientific is only what is measurable and quantifiable. The aforementioned case of the quantum physics demonstrated that the immeasurable is the frontier of the measurable and that any large, medium, small, very small or infinitesimal element find its true essence and meaning in its relationships and not in its composition/decomposition.
The basis of the encoded representation we use to graphically explain the architecture is the concept of the relationship between the signifier and the meaning. It leaves space to inductive, deductive and identifying systems, such as the icon, which today, paradoxically, seems to rediscover its intrinsic symbolic value in communication. It seems to have a greater capacity to show contemporary Truth, a truth no longer unique and determined, but changeable, conditioning, almost questionable. Already today, this changing truth testifies transformations, relationship, intangible values that architecture, the city, the landscape daily witness.
To give another example: how to detect the sociological effects of an architectural transformation in urban regeneration? The 'cultural' landscape, today so evoked and requested, is it detectable through the cataloguing of all the values present in the area? Would it be better to describe the impact it has on economy and on the development of the society, through the number of presences in terms of cultural heritage, employment, social inclusion or who knows what else? The incidence of the effects of that particular architectural/urban operation carried out in the city in transformation, is it detectable in order to be able to demonstrate a positiveness or negativity, as the local political debate perhaps requires?
The more we try to use the current methods of investigation and their representation, the more they appear arbitrary and lacking of sufficient completeness to produce a judgment that is not a factual data. How are these things measured? How are they represented? Assuming that we know how to investigate them, how can we transfer them through the Survey? We already know that this search, even if endowed with seemingly infinite technological innovative potentialities, it will appear absolutely incomplete and limited. Any relational critique, conducted

Fig. 6. Urban informative system: North avenues, Parma (graphic elaboration by: Gruppo di Rilievo, DICATeA Unipr).

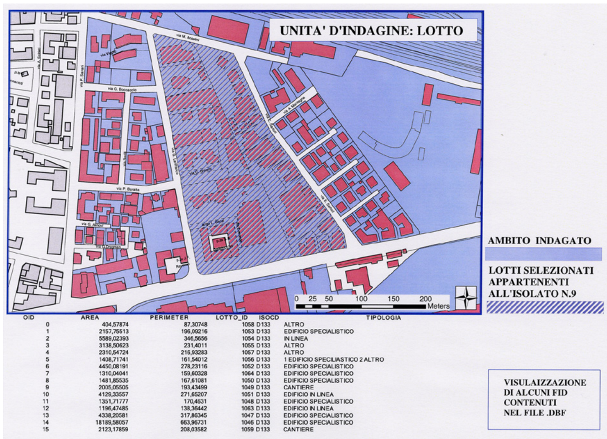
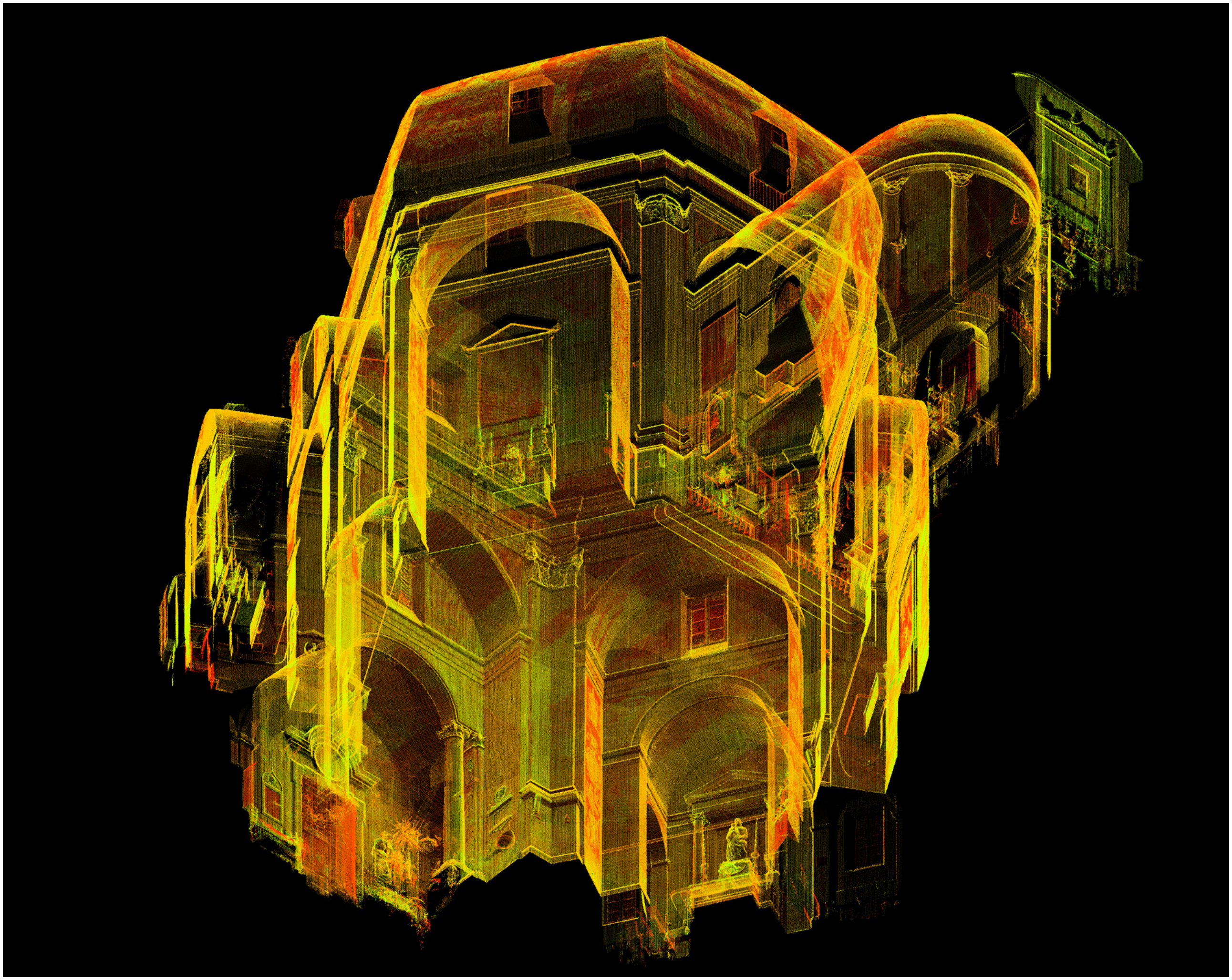


Fig. 7. Laser scan of architecture: Santa Maria del Quartiere, Parma (graphic elaboration by: Gruppo di Rilievo, DICATeA Unipr).



by an improvised commentator of contemporaneity in any television broadcast (the columnist), seems to have greater credibility.

Conclusion

Our investigations are so scientific and conducted in disparate disciplinary fields on the border of deterministic knowledge, but contradictions and uncertainties appears. This poses a new frontier, in which often the individual sensations, intuitions and presentiments can synthesize in empirical but appropriate way what appears elusive and indeterminate in the traditional methodology of serious thorough investigation.
A new challenge. A challenge for new generations. A vision of the future that should not scare, but on the contrary, it should fascinate for many positive implications, which could contaminate the technical and application Sciences with human Sciences, in order to pursue a path of *Virtute e Canoscenza*.

Notes

[1] The history of direct survey methods is widely described in: Docci, Maestri 1998.

[2] The chapter IV – *Strumenti e meraviglie* [Kemp 1990, pp. 187-244] is a very important compendium to understand the slow and inexorable progressive insertion of the machines in the drawing and survey of architecture and the city, in particular the evolution of stereoscopic photography from the end of the 1800s to the early 1900s.

[3] Cesare Cundari, introducing in 1983 his volume *Fotogrammetria architettonica*, intellectually registers the achieved overcoming of the "contrast between supporters of direct architectural survey and supporters of the instrumental one".

[4] From the mid-90s until the entire first decade of 2000, at the University of Parma the research group coordinated by the undersigned, was particularly involved in the search for a mature relationship between computerization of knowledge and Survey, from the modelling to the information system, both in architecture and urban environment. It can be found in some publications that progressively show the rapid change in attitude in the sector: Giandebiaggi 2007a; Giandebiaggi 2007b; Giandebiaggi 2006; Giandebiaggi, Zerbi 2005; Giandebiaggi 2003; Giandebiaggi et al. 2001a; Giandebiaggi et al. 2001b; Giandebiaggi, Melley, Zerbi 1999; Giandebiaggi, Ceiner 1997.

[5] The developments in the representation of Survey in the transition from CAD to BIM and up to Augmented Reality are extremely detailed in: Osello 2015.

[6] Considerations on the moment of transition that the Survey is experiencing in this historical moment are expressed in: Docci 2013; Bianchini 2014. For a complete knowledge of the theoretical geometrical and applicative passage from the passive and active 3D acquisition methodologies and the genesis of the 3D models in the fields of Design and also Architecture, see: Guidi, Russo, Beraldin 2010.

[7] The example of how the Survey has been completely pervaded by the digital age is extremely evident in the table of contents of the Italian research in the international arena, published in: Giandebiaggi, Zerbi 2014.

[8] The book by Edgard Morin was published for the first time in double version by the publisher Armando Siciliano from Messina in 2002 for the conferral of the Honorary Degree in Philosophy.

[9] See the chapter *La crisi della riduzione e la comparsa dell'inseparabilità nella separabilità*: Morin 2017, pp. 44-48.

[10] In recent years, the various reforms in the academic SSDs noticed the extreme and excessive fragmentation of the educational and scientific knowledge. They began a process of recomposition in a lower number and type of 'disciplines' and this path is still ongoing for a further regrouping in order to limit specialization without losing a holistic view of different knowledge.

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Fig. 8. Methodological process AR: AR media [Osello, Ugliotti 2017, figg. 8.8-12, p. 130].

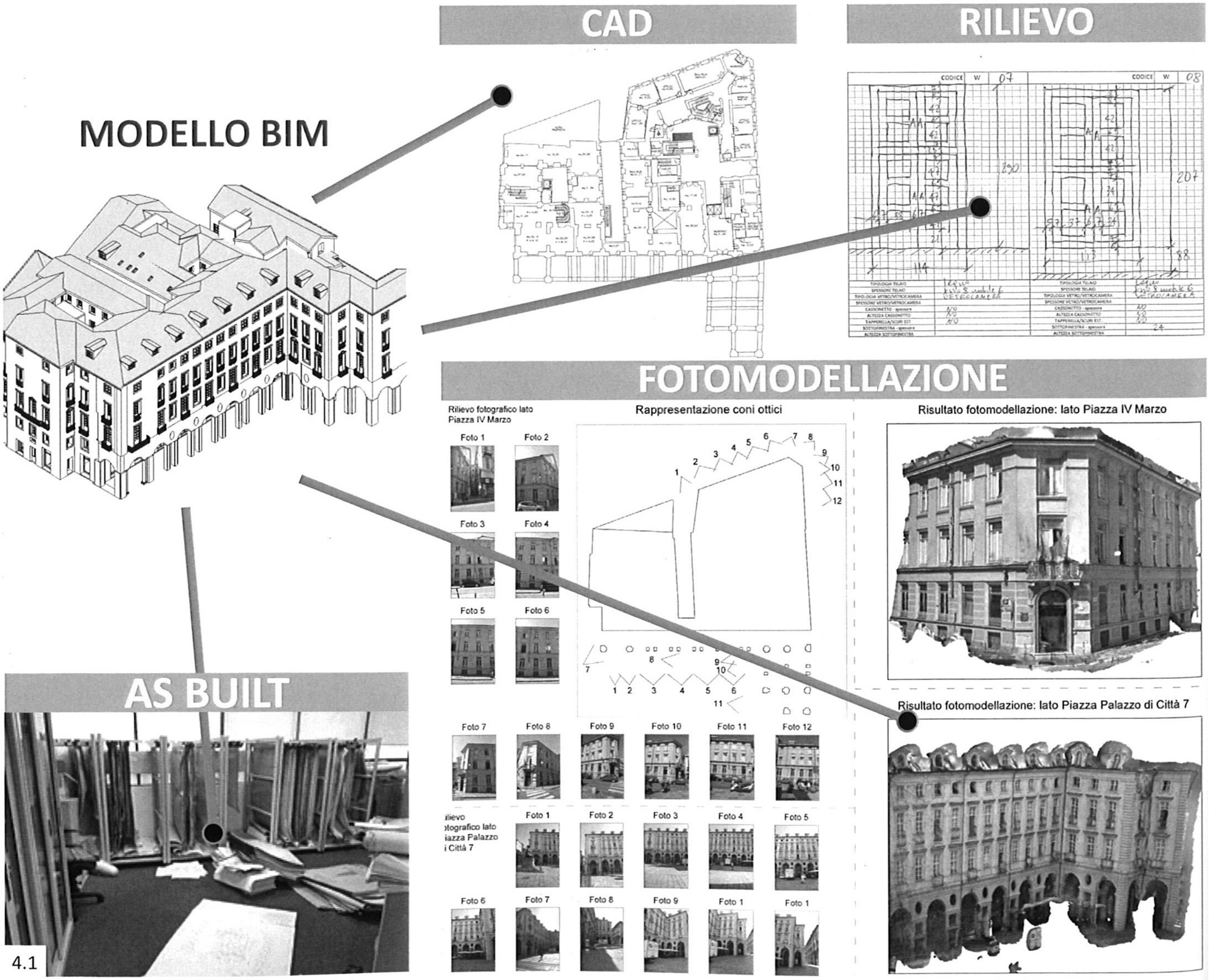
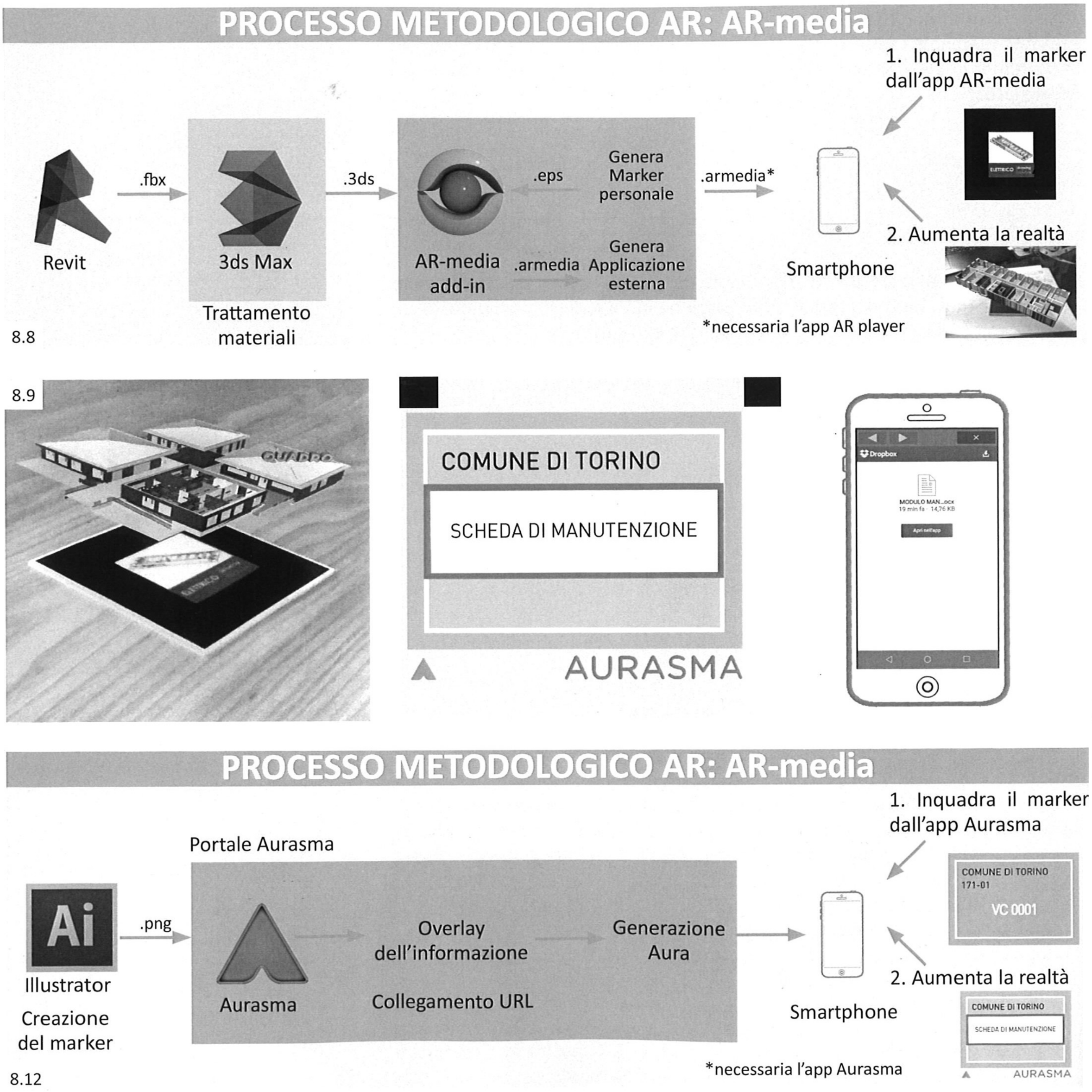


Fig. 9. BIM model and survey systems [Osello, Ugliotti 2017, fig.4.1, p. 46].



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The Basilica of Saint Peter: Surveys as Models of Knowledge (XVII and XVIII Centuries)

Aldo De Sanctis, Antonio Lio, Nicola Totaro, Antonio A. Zappani

Abstract

St. Peter's Basilica has attracted painters and surveyors since the early stages of the construction site, but it was its completion and the start of the «sinisters and various voices» on the dome's solidity to promote unprecedented aptitude in surveys both to reveal the marvel of its forms and to verify the stability of its structures. Different surveys that take over a century to elaborate: from 1620, when Martino Ferrabosco published his renderings on the basilica, to 1743 when Giovanni Poleni and Luigi Vanvitelli did their surveys for their analysis on its static behaviour and for the restoration of the Vatican dome.

Keywords: Survey, Restitution images, Knowledge models.

Introduction

Among the surveys of Martino Ferrabosco on the Basilica of Saint Peter (1620) and those of Luigi Vanvitelli and Giovanni Poleni on the stability of the dome of the same basilica (1743), graphic renderings are created so as to transform the survey into the most versatile discipline available are drawn graphic returns such as to transform the survey in the most versatile discipline available for the analysis and knowledge of architecture. Clearly different surveys, which are used both to render the formal characteristics (functional etc.) of the entire building and to study of specific problems, such as the solidity of the resistant system formed by the tambour-dome-lantern. Surveys are, in any case, essential in order to know the different aspects of an architectural reality, to analyze its determinants (spatial and technical) and to intervene, having full awareness of its state.

Survey of the Basilica of St. Peter

As recalled, in 1620 Ferrabosco published his surveys [1] on the basilica of Saint Peter in the Vatican; it is an extraordinary work due to the size of the building and the figurative novelty reached (complexity of the drawings, selection of the graphic signs etc.).
The construction of the church has finished [2] and for the first time, a surveyor attempts to adapt tools, methods, scales and techniques of graphic mediation to know it in the variety of its forms and certify its quality.
Ferrabosco renders the Vatican basilica with drawings of sets and detail and, above all, with complex drawings –three plants and a section on 34 survey panels– used to render the articulation of the architectonically most important parts (the central part of the church and the dome). The drawings are so com-

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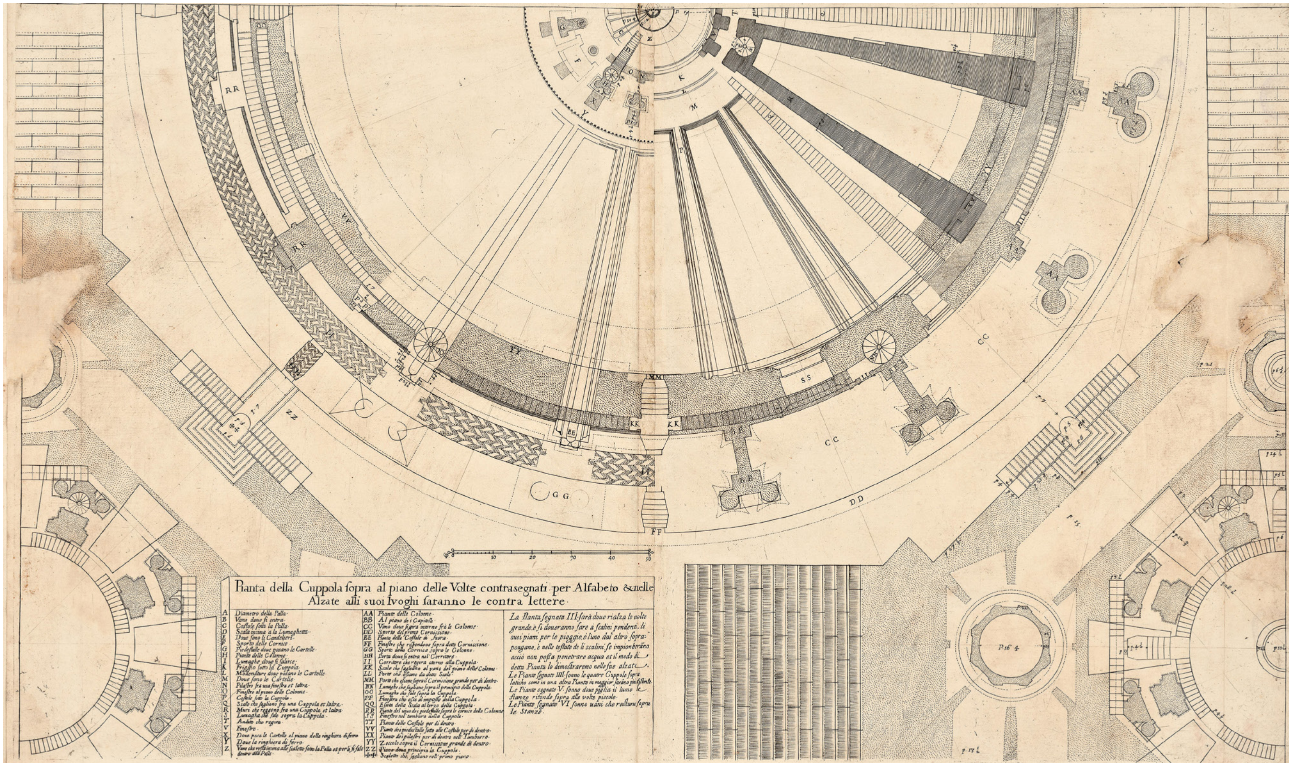
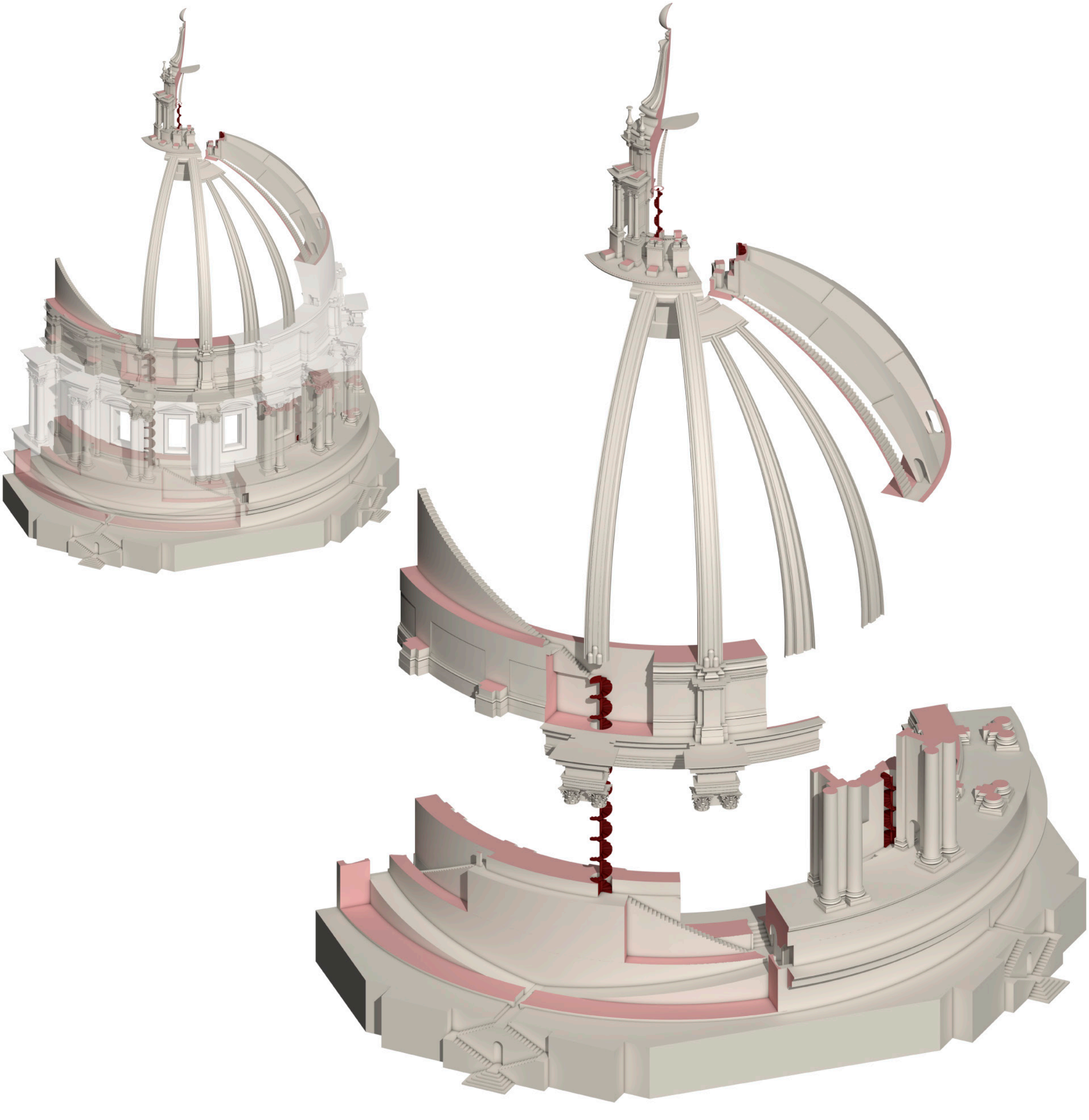
plex as to be a challenge for the "intelligent professor" [3] who will then have to read them.
In the printed publication, there is a little of all the known methods of representation, but it is in the orthogonal projections and especially in the use of plants and "multiple" sections –obtained by combining different levels on a single projection plane– that Ferrabosco seems to find the most convincing way to establish the characteristics of his work and restore the architectural complexity of the "great, and portentous Machine" [Curcio 2003, p. 20]. Plants and multiple sections that become real analytical tools, rich in detail and that, in spite of any figurative complication, are perhaps the most convincing result of his activity as a surveyor.
The "*Pianta della Cuppola sopra al piano delle Volte contrasegnati per Alfabeto &nelle Alzate alli suoi Ivoghi saranno le contra lettere*" [Ferrabosco 1620] describes, for example, the half plan of the dome system, from the octagon on which the tambour is placed to the golden ball which surmounts the lantern, of which the diameter is given (fig. 1). In evidence, six of the sixteen ribs are shown, presented two by two so as to define, sector by sector, the role (the shape, the step etc.) of each component: two ribs are seen from the outside, two from the inside and two in the intermediate space between the calottes that form the dome. The first two start from the cornice of the attic, above the twin columns outside the tambour, and arrive at the "iron fence" of the lantern. The final parts of this sector on one side present the wall section of the tambour (with the annular herringbone floored corridor which runs inside the base of the tambour, the ramp which leads to the floor

Fig. 1. Martino Ferrabosco, *Pianta della Cuppola sopra al piano delle Volte contrasegnati per Alfabeto &nelle Alzate alli suoi Ivoghi saranno le contra lettere*, 1620.



of the columns and the spiral staircase which crosses the tambour); on the other side the plan of the lantern (with the spiral staircase which crosses it and the stairs on the extrados of the small dome). With the same herringbone flooring, it is possible to see the passage which –leads to the annular corridor in the basement from the external stairs– on the octagon base.
The ribs, seen from the inside, show the drawings and the thickness of the decorative part above the dome. The terminal parts of this sector, one side, show the section of the tambour (at a different part from the previous one) with the twinned columns cut at the upper scape (the projection of the capitelli is seen) and on the other side the shelves of the lantern (which are not drawn).
The ribs between the two calottes, characterised by a strong dotting, present the way in which the same ribs taper and the twinned columns sectioned at the column base (the projection of the base of the columns is seen): the section plan passes from the start of the lantern, does not consider the presence of the external calotte and shows the ribs in orthogonal projection at the height of the annular corridor (dotted) between the two calottes. The final parts of this sector present, on one side, the section of the tambour and, on the opposite side, the corridor and the spiral staircase which climbs above the lantern. Two ramps of steps which climb the extrados of the calotte within the dome can be seen. The tambour results as being sectioned three times, but the masonry seen in the different sectors is not continuous: it presents two different parts of the tambour, one towards the inside and one towards the outside.
The drawing, despite using several viewpoints and the multiplicity of information deriving from it, is clear and without graphical interference. It presents a description which serves not only to reproduce a state which is, however, difficult to represent, but to analyze it showing the resisting sections and all the paths –horizontal and vertical– necessary to pass from one level to another and arrive at the summit. In addition to the full masonry and the voids of windows and doors, we find all the elements of passage that lead from the basic octagon to the fastigium ball: the passage that runs around the tambour and that between the two calottes of the dome; all the ramps with steps and the paths that lead inside the dome; the spiral staircases of the tambour and of the lantern and the steps on the extrados of the inner calotte and the small dome.
In the drawing –perhaps so as not to compromise the readability of the whole– there are not too many measurements; however, the reference to the graphic scale in Roman palms and a rich legend, with letters in the graphic field for identification of the individual parts, appears. The rendering scale is approximately 1:100.
The 3D model we developed, derived from the plans, confirms the descriptive richness and the metric accuracy of the work of 1620. Furthermore, it also confirms how Ferrabosco uses the survey both to evaluate the organization of an architectural reality and to analyze its components [4] (fig. 2).
In other words, it confirms that Ferrabosco knows the concept of graphic scale and the selective value that representation can play in architecture well. The figurative specifications that articulate the plan are in fact real opportunities to study the Vatican 'machine' and to disassemble it graphically, in order to understand the functioning of each part and the relationships that each part has with the whole. Each element is represented with the same logical and figurative clarity with which, in modern times, the formally completed architectural components or even the mechanical parts are represented. Yet there is more, the complex drawing we in discussion seems to have been created to restore the same architectural complexity of the work, through the very special inventory of all its elements and spaces; an inventory able to renew the wonder that the work raises in reality for the "vertigo of the list" [5] produced by the enumeration of all its constituents (distributive, constructive etc.).
At the end of the century, to dispel rumors of a possible collapse of the dome, Pope Innocent XI commissioned a new survey to Carlo Fontana. A work that therefore arises with the aim of clarifying the "sinister and various voices" that circulate in the city and above all verify the stability of the dome, but which ends with the architectural exaltation of the building and with broad and generic reassurances on the 'steadiness' [Fontana 1694, p. 20] of the same dome. The work of Fontana is therefore transformed into a new documentation on the Vatican buildings to make their singular peculiarities known to all [6].
In reality, Fontana does not fail to point out the damage he finds. Furthermore, in his book of surveys he also writes of a lesion along a rib of the dome, but which is due to minor causes (settling, collection of materials etc.); a lesion that does not appear in the drawings because all the parts of the building are without any doubt solid [7].
In the archive documents there is no trace of the report that Fontana prepared for the Pope, but in his book and in a letter from 1695, he writes of the iron chains existing in the

Fig. 2. Dome 3D model according to Martino Ferrabosco's plan; all the elements of the ingenious Vatican "machine" can be seen (graphic elaboration by Antonio A. Zappani).



construction and of the proposal for three new chains (fig. 3) to improve the resistance of the tambour and the dome [8]. In general, Fontana's renderings are rich in information and each drawing presents attention to architectural forms and a good number of measurements: there is also reference to the graphic scale in Roman palms.
Differing from the previous plan, Fontana does not launch challenges to "the intelligent professor", but seeks with different drawings to describe even the parts which are formally difficult to represent. The theme of the dome, for example, as well as with plants, sections, elevations and details [9] is rendered with five partial plans (1/4 dome), sectioned at different parts (fig. 4); plants which contain the same information and the same elements present in Ferrabosco's drawing, but separated into more drawings and therefore easier to examine.
In the surveys, each component is delineated with clarity and highlighted with shadows or shadow effects. The parts sectioned are dotted both in plan and in section although often to balance the graphic tone of the drawings, the sections are left blank.
Beyond the banal professional rivalries, it is possibly worthy of highlighting the different nature of the surveying operations conducted by the two authors. Ferrabosco does not appear to worry to much about the difficult drafting of his graphics, nor does he worry about the judgement of who will consult them. His aim is to find a way to render –even with the invention of new figurative tools –both the articulation of forms and spaces as well as the catalogue of elements which make the ingenious Vatican machine work. Instead, Fontana's intention seems to be that of presenting everyone with all the beauty of the buildings now complete; the new basilica of Saint Peter appears to him as a perfect example of project method and of architectural knowledge and it is above all this type of information that the author appears to want to remember and share.

Survey of the constructive system of the dome

In the surveys seen so far, no alarming instabilities were reported and nor were any urgent restoration interventions indicated. However, the concern continues so much that, some decades after Fontana's publication, Pope Benedict XIV will assign other Commissions [10] to verify the integrity of the dome, such as the commission formed by mathematicians Tommaso Le Seur, Francesco Jacquier and Ruggiero G. Boscovich [11]. The explicit task of the three mathematicians is that of removing any doubt on damage present, studying the causes and proposing necessary remedies [12].
The work of this Commission is notable and includes both the detailed survey of the cracking pattern as well

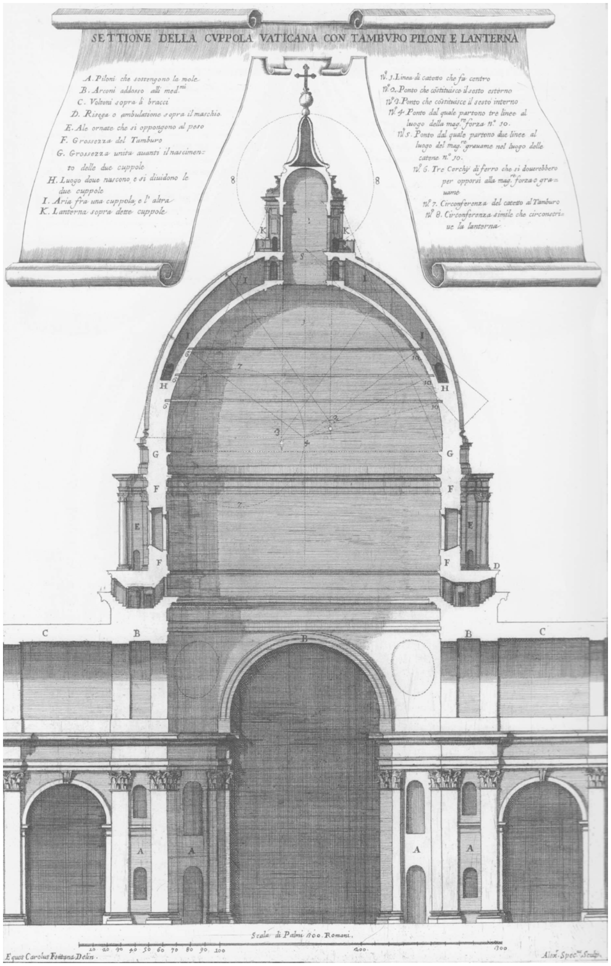
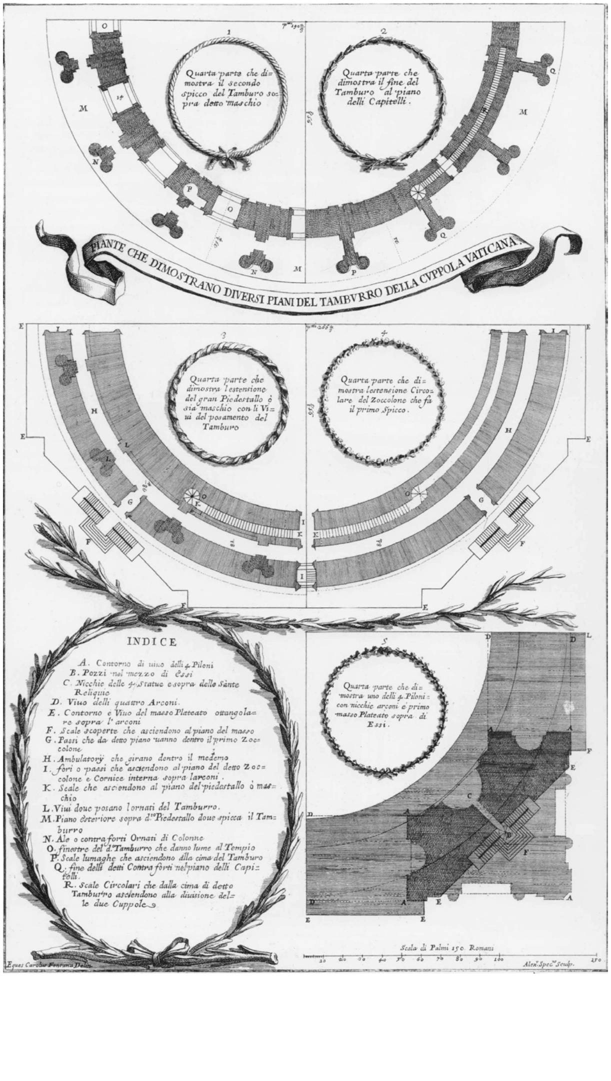


Fig. 3. Carlo Fontana, Settione della cuppola vaticana con tamburo piloni e lanterna, 1694; hypothesis of the positioning of the iron chains.

Fig. 4. The theme of the cupola is also rendered with five partial plans, extended to 1/4 of the dome, sectioned in different parts [Carlo Fontana 1694].



as the characteristics of resistance and the mechanism of the breaking of the used construction materials.

The method which the mathematicians say they will use includes direct observations and an updated theory on the mechanics of structures capable of recognising the causes producing instability of the work from the effects [13]. In their study, they list thirty-two critical points and warn, moreover, that the base of the tambour is damaged, the, the walls of the buttresses are all damaged, there are vertical lesions between the ribs and the calottes, horizontal detachments between the bricks, broken architraves of the windows, unstable spiral staircases to enter the tambour etc. In their report to the Pope, they also provide a possible dating of the main damage, which they clearly consider to be caused by structural defects and not from the settlement of materials.

The report is detailed and the indications for restoration foresee remedies in all the critical situations; remedies which, in line with the knowledge of the period, consist of the placement of six new iron chains, in the enlarging or the remaking of the ribs, in the creation of a 'buttress' and of a statue for each of the existing sixteen buttresses [14].

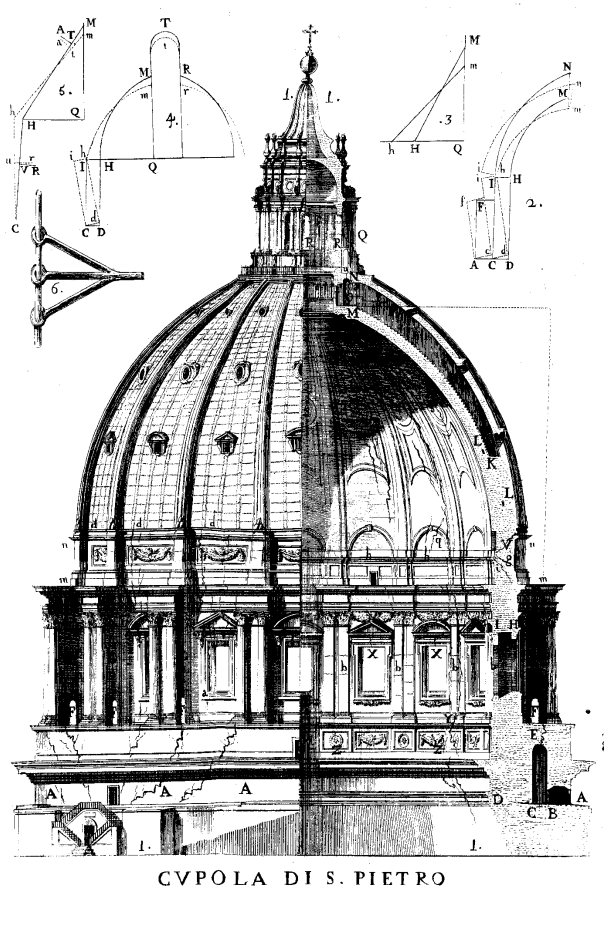
All the planned interventions –the mathematicians write– have an irrelevant weight, which is worth 1/60 of the existing one. What the mathematicians do not write of are the operational difficulties and the cost of the proposed remedies. Moreover, the mathematicians minimize the effects of such an intervention, which radically transforms the work of Michelangelo and Giacomo Della Porta.

The observations made and surveys conducted in this phase obviously regard only the part involved and are dedicated to defining the cracking pattern and the erroneous leaning of the tambour-dome-lantern system: they describe the form of the elements, the organization of the masses involved and the state of the lesions.

From the surveys, mathematicians also deduce a schematic model (consisting of four graphic drawings) on the static behaviour of the work. A model which is inserted in the survey drawing (fig. 5) of 1742 attached to the report and which allow the same mathematicians to analyze the stress patterns under its own weight, to predict the collapse mechanisms of the resisting elements and to define the works for restoration of the work. According to these graphic schemes, the separation of the tambour and the dome into sectors –produced by vertical lesions– provokes a rotation towards the outside of parts of the tambour with consequent lowering of the portions above the dome and

the lantern towards the inside. With "such kinematics –writes Mario Como– the scholars also carry out an evaluation of the thrust of the dome segment" [15].
On the basis of their schemes, the mathematicians hypothesise the 'imminent' collapse of the entire resisting system, but as recalled also propose restoral solutions shown in the report and summarised with the detail of an iron chain inserted in the schemes.
The conclusions cause strong disagreement and discussions so that the same mathematicians, in 1743 published a second report [Le Seur, Jacquier, Boscovich 1743] in order to better explain the content of the first both in terms of the language used to analyze the damage and in terms of the solutions proposed.
The reactions provoked by the relation of the mathematicians convince Pope Benedict XIV to further deepen the problem inviting new experts, including Giovanni Poleni [16] who from the beginning has the merit and authority to attenuate any controversy, to use the experience of Luigi Vanvitelli and to promote a favourable study climate in order to know about the actual situation of danger.
Poleni criticises the conclusions of the preceding Commission for the absence of "circular fractures along the intrados of the internal calotte" [Como 2015, p. 400] and, making the vertical lesions of the dome derive from subsidence localized in the tambour, does not hold the collapse of the work to be imminent.
In his 1748 *Memorie istoriche* [17], Poleni gives a detailed report both of the opinions of scholars who had intervened on the problem and of the results of his analysis "which had deveoped applying Robert Hooke's 1675 theory of the stability of arches" [Como 2015, p. 402].
His inspections, substantially, confirm the cracking pattern detected previously, but exclude subsidence in the pylons [18].
For the intervention to secure the dome, Poleni proposes the insertion of five new iron chains which will be implemented between August 1743 and September 1744. During the works, Vanvitelli reports that one of the old chains is broken and assumes that the second one is too. Poleni suggests repairing the broken one and adding a new rim "in compensation" [Poleni 1748, p. 438] of the one presumed to be broken.
For the different inspections [19], Luigi Vanvitelli slowly predisposed the drawings relative to the part to be examined on which all the lesions and necessary conditions are annotated. They are drawings which are "delineated with perfect correspondence to the works" [Poleni 1748, p. 136] and which make it possible to have an exhaustive framework on each individual part and on the whole.
Vanvitelli works on the problem of the dome since the first Commission with the task of verifying and he has the occasion to execute a series of broad surveys, particularly calibrated on the theme and on the constructive problems of the work. They are surveys in which the decorative part is simplified, and the lesions are delineated in red

Fig. 5. Lesions on the dome and graphic schemes on its static behaviour [Le Seur, Jacquier, Boscovich 1742].



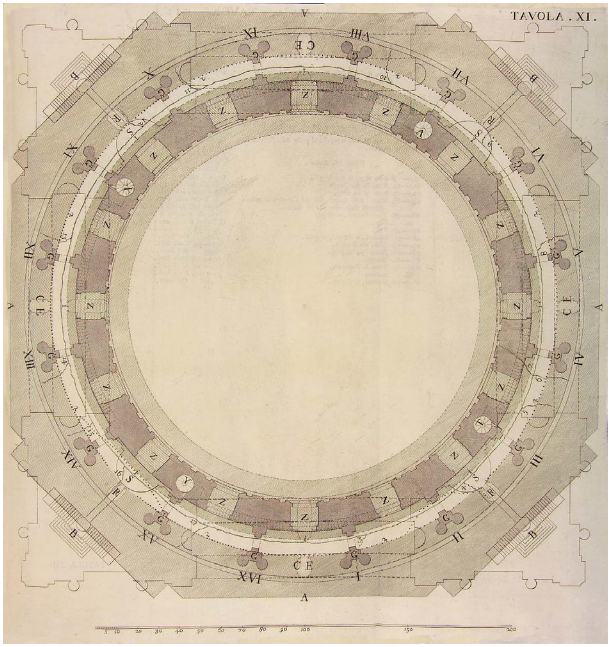
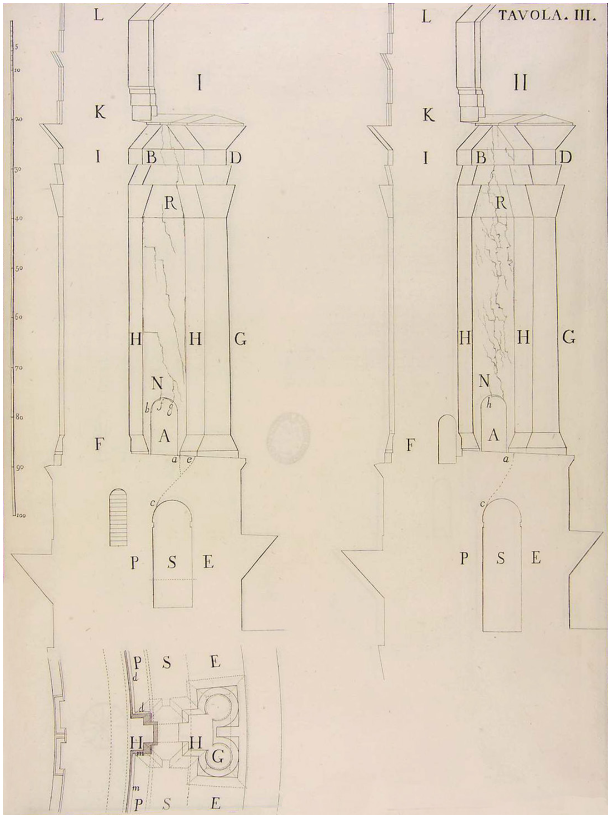


Fig. 6. Luigi Vanvitelli, Pianta della cupola, 1743-1748; the graphic complexity is necessary to show the relation between all the elements.

Fig. 7. Luigi Vanvitelli, lesions of the dome buttresses with the simplified decorative party, 1743-1748.



[20] (highlighting their position and progress in each part and in each single rib). The surveys also indicate erroneous leaning, etc. Poleni, in his book, praises the clarity of the drawings as they give simplicity to the elements, when "the appearance of the ornaments" is not needed [Poleni 1748, p. 140]. The "annotations placed in comparison with the drawings" [Poleni 1748, p. 140], necessary to evaluate the effective seriousness of the cracking pattern (with measurements of the lesions), in the reduced scale of the drawings, of approximately 1:200, complete the work.
Among the surveys, that of the *Plan of the dome* (drawing XI), sectioned at the start of the internal calotte, appears interesting. In this, it is possible to see: part of the calotte, the sixteen ribs (four with the spiral staircase), the twinned columns of the tambour, the windows that give light to the church, the annular corridor at the base of the tambour, the connecting octagon between the church and the tambour with the entrance steps and the contours of the four pylons that support the entire system. Furthermore, the main lesions (17 lesions) delineated with different graphic symbols, can be seen. In this type of rendering, the author

does not usually insert measurements (they appear in the annotations), but only the reference of the graphic scale in Roman palms (figs. 6a, 6b).
The plant is graphically accurate and as in the previous one by Ferrabosco, albeit with different figurative modalities, also in this one does the idea of a complex representation return, which is necessary to evaluate all the elements together, to show their dimensions and mutual relations; relationships that emerge for direct comparison between the parties (they reveal their 'complicit' role) and promote attention consistent with the architectural situation in question. The figurative complexity, as an analytical and operative requirement combined, is useful to adapt to the articulation of the work and –in the example of these notes– to give certainty on the static behavior and the safety of the constructive system considered.

Conclusions

The surveys seen so far present a discreet repertoire of graphic models and of figurative modalities that progressively adapt to reality in order to examine it and to get to know it in depth. Graphic models that at the same time make clear how the descriptive versatility of the renderings is the answer to different solicitations of study and how the production of images for the knowledge of architecture develops for the simultaneous action of doing and all those factors of executive stimulus that derive from the means chosen to operate (scales, representation techniques etc.). In this sense, not only the probable renderings, but all the drawings –whether they are sets, wholes or schemes– become necessary in order to trigger a research process and to build conditions of coherence and analytical effectiveness.
The figurative complexity referred to above, therefore, is not a rule to represent, but as a necessary product (in a phase of study) to have drawings pertinent to the architectural problem to be investigated. Furthermore, even today, despite the evolution of tools and methods, this seems to be the prevalent attitude of surveys: not so much a way to replicate the appearance of an architecture in the laboratory, but an opportunity to analyze it through a succession of figurative reformulations. capable of intentionally synthesizing the forms and spaces of architecture, making its decisive features emerge; or, on the contrary, figurative reformulations able to aggregate all the elements that contribute to define the articulation of the same theme of study. That is to say, an occasion to experiment on shapes and spaces and to realize the presuppositions, impossible otherwise, to see and fully understand the architecture or the parts that we intend to consider.

Notes

[1] M. Ferrabosco, *Libro De L'architettura Di San Pietro nel Vaticano*. Roma 1620, published again in 1684. The book presents 11 single and 23 double drawings. In the views of the volume we also find parts which have not yet been built such as the façade and the colonade etc.

[2] The ball which will go above the lantern is already under construction in 1592; the lead cover of the dome was finished in 1594; Carlo Maderno in 1608 transforms the Greek cross plan into Latin and in 1622 the façade will be finished; in 1614 the vault of the central nave was completed and in 1626 Urban VIII will consecrate the new basilica.

[3] The phrase is in a legend plant, "*La descrittione della Pianta non si nota per essersi fatta distinta dalla passata, e qualche differenza […] l'intelligente professore la troverà facilmente*" [Ferrabosco1620].

[4] In a 2010 study, in order to explain the complexity of the drawings, further explanations are offered, such as the articulation of the building, the theme of the fragment etc. see: Martinez Mindeguía 2010, pp. 46-57.

[5] The literature and the art are rich in similar lists "laid out for the same taste of the enumeration, for the cantability of the list" [Eco 2009, second cover].

[6] Fontana writes of publishing the surveys "*acciòche più al vero, e con proprij termini siano le loro singolari qualità mandate alla luce, e possino essere manifeste non solo a' Popoli […], ma anche a' Posteri*" Fontana 1694, p. 21.

[7] Fontana writes that the parts are solid "d*a non potersi mai dubitare della loro permanenza e stabilità*": Fontana 1694, p. 185. The volume, published in Italian and Latin, becomes a sort of official certification of the architectural and construction quality of the new basilica of Saint Peter. It consists of seven books and 79 engravings.

[8] For the content of the 1695 letter see: H. Hager, *Del Tolo, o Cupola doppia che cuopre il Tempio Vaticano* in Fontana 1694, p. CLX. Furthermore, in his book, the author writes of "*Tre cerchij di ferro che si doverebbero per opporsi alla maggiore forza e gravame*" [Fontana 1694, p. 226.]

[9] On the theme of the dome, we find: five sections of sets and two of detail; four plans of sets and six details; four elevation sets.

[10] In 1742 that guided by Abbot Saverio Brunetti in which also Luigi Vanvitelli participated.

[11] Le Seur and Jacquier to the Order of Minims of Saint Francis of Paola, Boscovich is of the Order of the Jesuits; all three are followers of the new scientific knowledge promoted by Isaac Newton.

[12] The task is that of studying "*danni presenti che si osservano nella cupola […], e molto più per la sua restaurazione*" [Le Seur et al. 1742, p. III].

[13] The three mathematicians write to avail themselves of both "*proprie oculari osservazioni, e sperienze, che di una buona teoria fondata sulla Meccanica per conoscere dagli effetti la causa del male*" [Le Seur et al. 1742, p. III].

[14] For the mathematicians, the ribs threaten "*imminente rovina. Vanno essi perciò rifatti*". And against the danger that the stress breaks the attic floor, they write that they want to "*alzare sopra il cornicione de' contraforti in m uno sperone ben centinato, che andasse a ripigliare la Cupola più alto in n. Potrebbe il medesimo cominciarsi con un zoccolo, che sostenesse una Statua, e servisse insieme di peso, ed ornamento*" [Le Seur et al. 1742, p. XXXIV].

[15] For a discussion on the structure of the Vatican dome see the excellent essay: Como 2015, pp. 311-438. On the same topic see: Bussi, Carusi 2009.

[16] Giovanni Poleni (1683-1761) at the age of twenty-six he is professor at the University of Padove and member of the Royal Society of Londra. In 1743 he enters the debate on the dome provoked by the mathematicians writing *Riflessioni di Giovanni Poleni, sopra i Danni…* and on March 30th of the same year receives an invitation from the Pope to verify the state of the work.

[17] Poleni 1748. The volume consists of five books; the images are those of Luigi Vanvitelli, redrawn for the occasion. Before this publication, Giovanni Poleni writes *Riflessioni di Giovanni Poleni, sopra i Danni… (1743), Lo stato de' difetti da considerarsi… (1743) and an Aggiunta alle Riflessioni… (1743).*

[18] In his book, we can read that: "*ombra non vi era di patimento ne' Fondamenti, o di danno ne' Piloni*" [Poleni 1748, p. 136].

[19] Poleni and Vanvitelli conduct 17 highly accurate inspections and create "*appoggi […] ponti e simili apparecchi*" [Poleni 1748, p. 135].

[20] In his *Memorie istoriche*, Poleni signals that the drawings in the publication are copied from those presented to the Pope, but "*ne' nostri si sono tralasciati gli ombramenti, acciocchè in campi più chiari meglio potessero comparir li segni delle Fessure [underlined in red in the originals*" [Poleni 1748, p. 139].

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RUBRICS

Readings/Rereadings

Readings/Rereadings

The National Edition of *De Prospectiva Pingendi*: a Philological Approach to the Drawings in the Treatise

Laura Carlevaris

The monumental editorial initiative to publish a National Edition of *De prospectiva pingendi* by Piero della Francesca (Sansepolcro c. 1410-1492) has recently been completed. The initiative is sponsored by the Ministry of Cultural Heritage and Activities and Tourism (MiBACT) and the Fondazione Piero della Francesca [1]. The book, published by the State Mint and Polygraphic Institute, is the third volume in the epic series –the National Edition of Writings by Piero della Francesca– established by Presidential Decree 26.2.1974 and initiated in 1985.

The critical edition of *De prospectiva pingendi* by Giusta Nicco Fasola was published in 1942 [Piero della Francesca 1942]. Although it is undoubtedly an important critique, the author did not consider all available texts, in other words he did not compare the many versions of the manuscript, some in the vulgate, and others in Latin. Instead linguists are interested in Piero's writings precisely because of the peculiarities of the language he uses: a Tuscan vernacular, very different to Florentine, and with Umbrian nuances [2].

In 1984 an anastatic copy of Nicco Fasola's edition was reprinted: it includes several critical essays [Piero della Francesca 1984]. One year later the need for a philological approach led to renewed study on the manuscripts written by the painter and treatise writer from Sansepolcro. The initial results of these new studies was the publication of the *Libellus de quinque corporibus regularibus* in 1995 [Piero della Francesca 1995].

The Ministry nominated Cecil Grayson, who had edited the vulgate texts written by Leon Battista Alberti [Alberti 1960-1973], as chair of the scientific commission. He was later as chair replaced by another member of the commission, Marisa Dalai Emiliani, currently assisted by two co-chairs: Ottavio Besomi and Carlo Maccagni.

The National Edition continued in 2012 with the publication of the *Trattato d'Abaco* [Piero della Francesca 2012] and two parallel publications about *De Prospectiva pingendi*, published respectively in 2016 (National Edition of the Parma Codex 1576, in vulgate) and in 2017 (National Edition of Bordeaux Codex 616, in Latin). The last envisaged publication will focus on the *Archimedis Opera*.

Every National Edition is a meticulous, Herculean, and undeniably scientific task: each one is an extremely interesting national endeavour backed by a substantial financial investment, but it is also and above all pregnant with expectations. The MiBACT website contains the following paragraph: "National Editions satisfy the basic scientific need to ensure the protection, enhancement and fruition of our literary heritage and philosophy, as embodied by the written texts of Italian authors: in fact, these initiatives guarantee the publication of the *opera omnia* of an author (or, in some cases, the most important works of a group of authors) in editions based on the identification and critical transcription of all pertinent manuscripts. They propose all the published and unpublished texts of an author and use all available documentation to clarify the history and structure of the texts" [3].

The National Edition of *De prospectiva pingendi*

The enormous amount of work focusing on *De prospectiva pingendi* was published over a two-year period; the study was divided into two separate series (each made up of three books) and is presented in two box sets.

The first series, marked by the letter A and published in 2016, tackles the vulgate draft of the 1576 codex housed in the Biblioteca Palatina in Parma. The second series (2017), marked by the letter B, focuses on Latin Codex 616 preserved in the Bibliothéque Municipale in Bordeaux.

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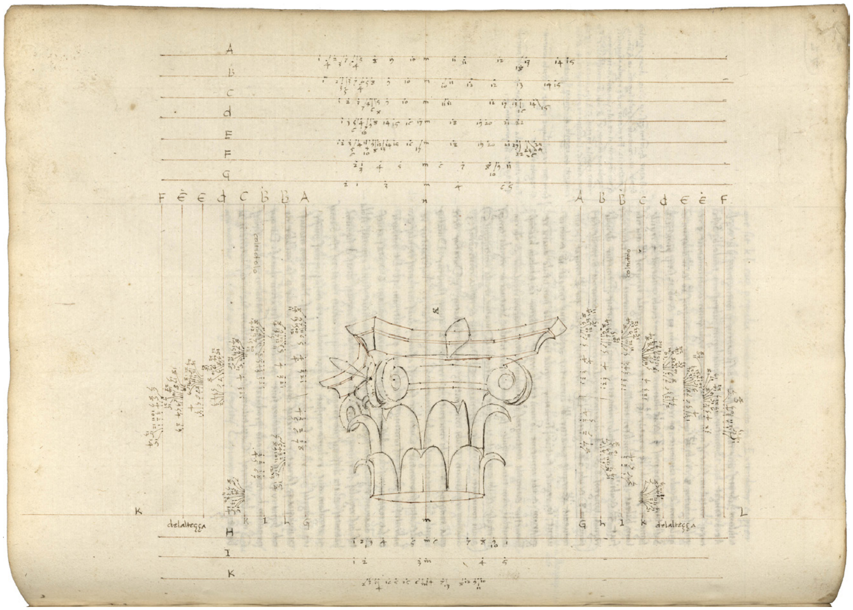
Each series is made up of three books. The work on the texts is performed using the same approach and in parallel: Book I presents a critical version of the text; Book II provides a critical edition of the drawings; Book III contains the anastatic copy of the surviving text.
The work was carried out by several scientific referents: Chiara Gizzi (critical edition of the vulgate text), Franca Ela Consolino (critical edition of the Latin text), and Riccardo Migliari (critical edition of the drawings) [Piero della Francesca 2016; 2017].
Flavia Carderi curated the critical edition of the Latin text (Book I, III.A), Chiara Gizzi curated the critical edition of the vulgate text (Book I, III.B), while the critical edition of the drawings (Book II, III.A and Book II, III.B) was a joint effort by Riccardo Migliari, Leonardo Baglioni, Marco Fasolo, Matteo Flavio Mancini, Jessica Romor, Marta Salvatore (Sapienza Università of Rome) and Federico Fallavollita (Alma Mater Studiorum-University of Bologna). Alessandra Sorci inputted some philologically critical contributions.
It is the many different features of this edition of the treatise that makes it so important.
First and foremost, it's important to note that the two different versions of the text (vulgate and Latin) were studied in parallel using the same method. This synchronised interpretation provided important data about the language used by the author who, unlike Alberti, appears to have written in Italian and only afterwards translated the text into Latin, not vice versa. Piero della Francesca wrote the text using the language he spoke everyday and then translated it into an aulic language in order to be considered a humanist. In any event, this is the first time the Latin version of the treatise has been published. The fact it is contextually compared to the vulgate version allowed important headway to be made regarding the glossaries since the latter are crucial when an in-depth study is performed on its contents and the *humus* that existed when it was written [4].
This undertaking is the product of a truly interdisciplinary team, another unique feature of this initiative during which the fourteen scholars pooled their skills and expertise (historians, art historians, language historians, philologists of both the vulgate and Latin, experts in the fields of descriptive geometry and perspective). Rather than working separately they adopted an integrated approach, toiling side by side in order to enhance our knowledge of such a key text in Italy's artistic and scientific landscape. Indeed, the topic of the manuscript –the codification of the perspective method during the Renaissance– is indissolubly linked to Italy's culture and its status in the world.
In order to get a better understanding of the concept of 'interdisciplinary' research –a crucial characteristic of this new edition of *De prospectiva pingendi*– let us turn to the words written by Migliari in another essay: "Interdisciplinary research is in fact the form of collaboration that produces the best, most fertile results. Researchers who are experts in their own fields work together, compare their findings, and continually exchange their results. They learn from each other because as they study they first clarify the work they are doing in their own minds and then explain what they are doing to each other; they communicate their drive, reasoning, successes and setbacks" [5]. This approach is what makes the publication so radically innovative. This publication –perhaps for the first time– exploits an integrated methodology and parallel studies to examine both the text and graphic images. Each investigation was inspired by another investigation, or better still, 'in conjunction with' another investigation: the effectiveness of this synergetic exchange was acknowledged by all the scholars who inputted into the success of the undertaking as well as by the chair of the scientific commission, Professor Dalai Emiliani.
The traditional philological approach to the manuscript was based on a documented comparison between all the known surviving texts (in this case three vulgate and four Latin codices [Baglioni 2018, p. 7]. It also included a double, 'diplomatic' and 'critical interpretation of the treatise and drawings. This methodology was elaborated after many detailed discussions between all the experts and was adopted for the first time on this occasion. The need for a double edition of every drawing is a characteristic of the National Edition of the Writings by Piero della Francesca. The idea was a brilliant intuition by Francesco Paolo Di Teodoro, curator of the first treatise, the *Libellus de quinque corporibus regularibus*. In De prospectiva pingendi this mechanism appears to have been adjusted and updated as well as particularly effective in revealing features of the text that are not only profoundly innovative, but also inspired by the culture and science of past centuries.
In addition, after a new and meticulous philological interpretation, the undeniable progress in the range of available options provided by increasingly sophisticated graphic models makes the analysis of the images particularly enjoyable but, even more importantly, effective and incisive *vis-à-vis* the comprehension of the originality and historical importance of the manuscript as well as future developments.

The *De prospectiva pingendi* and the edition of the drawings

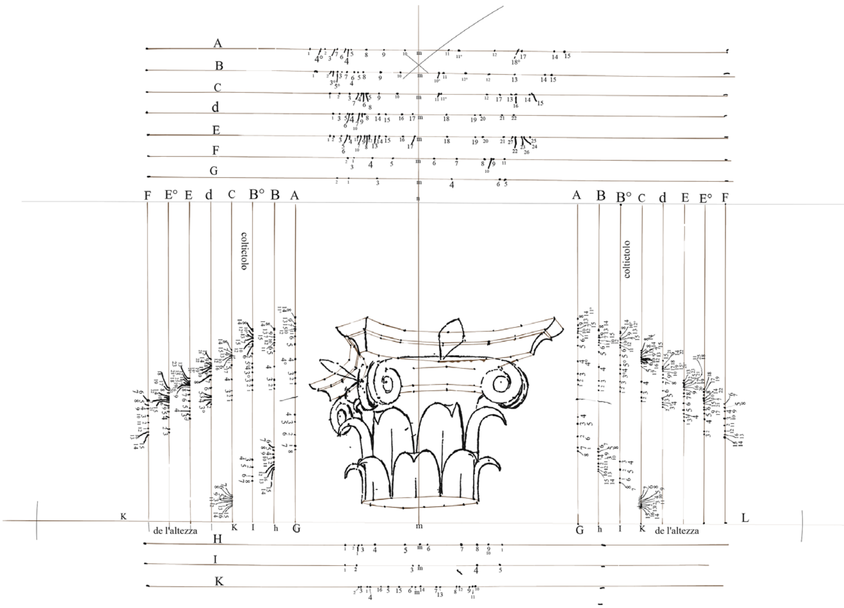
The strict parallelism between the work on the text and the approach to the drawings made it possible to verify and reveal the logic between these two parts of the treatise, assigning the work its truly important feature, i.e., its status as the first, real scientific instrument used to present a representation method based on its subjacent scientific procedures, and exploiting all the devices available to the author and reader to achieve this goal.
The manuscript was written between the 1470s and the 1480s. Before the fifteenth century even most of the instruments used to find directions in a city were in written form and the difficulties associated with the dissemination of images meant that urban cartography basically depended on written lists and descriptions [6]; this situation began to change during the second half of the fifteenth century. Given the above, it's easy to understand how Piero della Francesca's text must have appeared 'modern' and explosive due to its most important characteristic: drawings accompanying the text, and a text that helped to interpret the graphics. Finally the time was ripe for a study of this combination and its specific, decisive role as precursor of so much subsequent scientific literature. As mentioned earlier, the only way to do this was to implement an approach and method undertaken jointly by those who had focused on the text (historians and philologists) and those who had concentrated on the drawings using a multifaceted, methodical and above all joint procedure.
The approach to the drawings developed by Riccardo Migliari and his research and work team involved analysing each of the graphic images in the treatise. This analysis can be used as an important starting point for any future comprehensive study of Piero's work; it can also act as an example of how to study texts with numerous graphic images that are, quite rightly, not only part of the *corpus* of documents about the history of representation, but also constitute its most important chapters. Migliari is convinced that "a researcher […] has to develop new, more general, and more efficient procedures" [7] in order to create experiences that can always be reviewed, repeated and verified at any moment. It's true that these experiences represent the end result of a process, but they are also the starting point of any future research [8].
As mentioned earlier, when working on the *Libellus* the curator highlighted the close link between Piero's text and drawings, emphasising the need to consider the textual description and graphic description as equally important insofar as they were closely interrelated and integrated to form a *unicum*, the importance of which can only be understood if they are considered as a single unit. In his *Introduction* to Book II. *Drawings* of the National Edition of the *Trattato d'Abaco* [Piero della Francesca 2012, p. XIII], Vladimiro Valerio acknowledges that this brilliant intuition was not however adopted in later studies about Piero. It was Valerio who took up the gauntlet of this proposed philological approach to the drawings, one which

Fig. 1. Piero della Francesca, De prospectiva pingendi, codex 616, Bibliothèque Municipale, Bordeaux, sheet 72v: last figure illustrating the proposition dedicated to the perspective of the capital [Piero della Francesca 2017, Book III, sheet 72v].



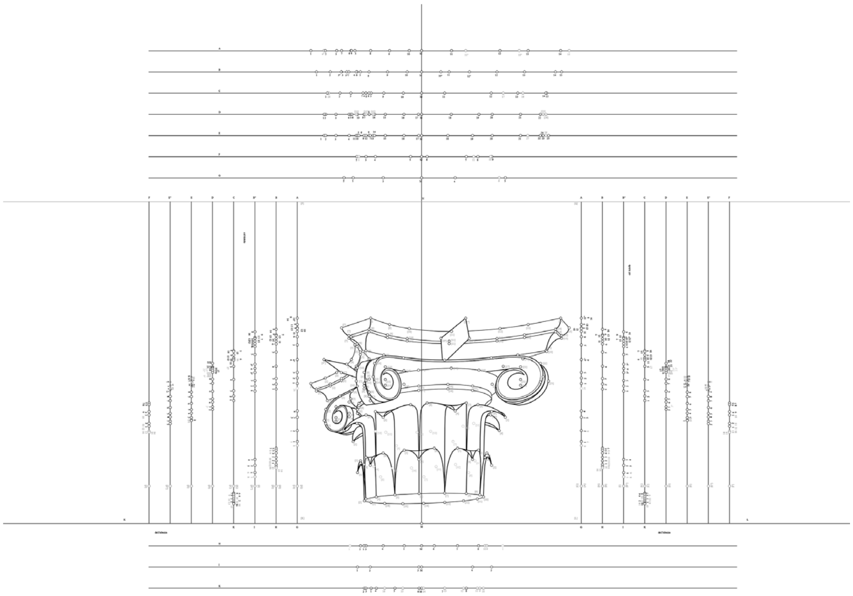
he continued to focus on and develop in his own work on the *Trattato d'Abaco*. The work on *De prospectiva pingendi* moves along the same tracks; the close link between text and images appears to be the key issue and in particular structures the part we are most interested in, i.e., the edition of the drawings and the way in which they were tackled, studied and re-proposed, clearly based on the intention to initiate a novel philology of historical geometric drawings.
The importance of *De prospectiva pingendi* as part of the work of its author is undeniably obvious, as is the role of what is considered the first systematic treatise of perspective theory. However, the modernity of the treatise lies in the fact that it was the first text which, between the lines, revealed the existence of a precise relationship between space and its two-dimensional representation obtained thanks to perspective construction. The latter –the subject-matter of the treatise– is proposed as one of the graphic transpositions of the spatial model, something that emerges from the continuous operational and functional exchange between orthogonal projection and, specifically, perspective.
As mentioned earlier, this is the first treatise on perspective in which the text is systematically illustrated by more than 150 autographed drawings [Migliari 2016a, p. XIII]. This forced the group working on the drawings to perform a critical assessment; it involved drafting and defining an approach method in line with what was proposed for the textual philology.
A philological approach to the text traditionally distinguishes between a 'diplomatic' interpretation and a 'critical' interpretation. While the former involves re-proposing the text as it is, the latter not only provides an interpretation, but also highlights the many possible interpretative solutions (including the ones that are clearly excluded) based on the analysis of all existing 'surviving texts', in other words all available documents, in most cases manuscripts.
The work on the graphic images in the treatise is therefore based on a similar philologically-based matrix. It defines a methodology to perform a philological critique of the drawings [9] based on a 'diplomatic' edition of each of the graphics (i.e., relating to the codified restitution of the material and objective appearance of the drawing 'as it appears' in the treatise) as well as on a 'critical' edition (in which the drawing is based on an accurate analysis of the written text).
The methodology developed for Piero's work is also based on the execution of intermediate study drawings that help to understand the geometric concept behind the propositions in the three books of *De prospectiva pingendi*.
The goal of the diplomatic edition of the drawings was to present drawings that were as similar as possible to the originals. The objective was to try and portray the size of the graphic image and the different kinds of signs. The latter were reproduced with variable thicknesses in order to indicate the speed with which they were drawn. The beginning and end of the signs were highlighted, and certain special signs were also identified, for example, the presence of visible notches on the sheet of paper [Migliari 2016a, p. XVI]. As Migliari himself points out, this work was heavily influenced by the quality of the copies

Fig. 2. Jessica Romor, diplomatic edition of the figure on sheet 72v of the treatise [Piero della Francesca 2017, Book II, sheet 72v, p. 150].



of the original sheets of paper and the quality of the acquisitions on which the work necessarily had to be based. Although they are high resolution acquisitions they are often deformed or lit in such a way that they do not reproduce the actual pattern of the signs on the sheet of paper (this refers not so much to the ink marks but to the just as interesting 'silent' signs, in other words graphic construction signs, notches, or the holes made by a compass) [Migliari 2016a, pp. XVI, XVII].
The objective of the critical edition of the drawings is instead to convey the message transmitted by combining the text and the graphic works. Its goal is to turn the meticulous textual indications into signs, taking the reader by the hand and recreating their construction step-by-step by trying to follow Piero's reasoning, his work logic, and the summarised didactic method he used to 'communicate' what he wanted to transmit. Here the signs are all the same thickness and the letters are all the same height. Any omissions in the drawings (lines and points indicated in the text, but not present in the drawing) are appropriately highlighted. Likewise, the geometric shapes that are not cited in the text, but present in the drawing. This version of the drawings does not provide a 'qualitative' reproduction of the autographed drawings but instead focuses on the procedure behind the construction.
The chosen method involved initially studying the scansion of a drawing in the treatise (fig. 1). A diplomatic version was then developed (fig. 2), followed by a critical edition (fig. 3). Unlike what happens when there is a close link between text and drawing, it's obviously impossible to separate these three drawings (the first is an autographed drawing, while the other two are critically developed). They must be studied together (and contextually with the text) in order to recreate the unity that was philologically dismembered to provide readers with enhanced data as well as unusual and systematic interpretations.

Fig. 3. Jessica Romor, critical edition of the figure on sheet 72v of the treatise [Piero della Francesca 2017, Book III, sheet 72v, p. 151].



The fundamentally new approach was developed after thoughtful, joint considerations not devoid of methodological doubts and gradual rapprochement; it led to an important decision regarding the role of the illustrations accompanying a scientific text. Their role is considered as functional on various levels: they are 'demonstrative', insofar as they reveal what exactly one obtains when the proposed scientific method is applied; they are 'educational', because the drawings accompanying a text are tools to ensure whether or not the method has been learnt by the user, but perhaps even earlier, by the treatise writer himself, since drawings act as a continuous exercise arena to improve the clarity of the presentation and verify the procedure in question [Migliari 2016a, p. XIII]; finally, they are 'experimental', since "the theoretical hypothesis is validated by an experiment providing the expected result"; it is intended to dissipate every possible interpretative misunderstanding and eliminate the danger of subjective interpretations [Migliari 2016a, p. XIII].

The *Introduction* to the work on the Drawings

Apart from the graphics and restitution, one should not forget the critiques and historical contributions that the work

on the drawings provides in the essays published in the *Introduction* to Book II. *Drawings*, as well as in the Parma codex (III.A) and Bordeaux codex (III.B).
Traditional introductions generally underline certain features of the work and suggest an interpretation. However this *Introduction* contains the critical assessment of both the work that was performed and the conclusions drafted at the end of the study.
The contributions are organised so as to create a unitary discourse. They purposely leave aside personalisms and the albeit recognisable paternity of each essay in order to convey the fact that this was a team effort. By doing so they structure the initiative and provide solid justification as regards methodology. The contributions help readers during the complex approach they need to adopt in order to not only understand the treatise, especially Piero's drawings, but also their diplomatic and critical restitution. At the same time the written words reveal the amazement generated by the authors' discovery of the 'freshness' of Piero's work, the effectiveness of his method, and the intelligence of the painter from Sansepolcro. In short, these essays reveal not only the authors' love of research, but also the adventure which, with great difficulty, involves rethinking, backtracking, and starting over, but in the end leads to unexpected, but always exciting results.
In order to create a unified *Introduction*, these contributions (but I would prefer to say 'this contribution') provide a particularly enlightened and documented 'technical' interpretation of the two different ways in which Piero approaches perspective construction. The latter emerges in all its clarity and effectiveness and finally reveals many of the aspects which had so far remained difficult to comprehend.
The *Introduction* is divided into three parts.
In the first part Migliari clarifies what is intended by philological critique of the drawings and how it is performed. He introduces the diplomatic and critical edition, clarifying the structure of the technical sheets. He then goes on to tackle the issues related to terminology. Romor instead focuses on the digital technique that was adopted, the graphic conventions, and the general features of the illustrations.
The second part focuses on several general features of the illustrations in the treatise. The contribution describing the laws of degradation of apparent magnitude is particularly interesting. It is written by Migliari who notes how in the text, and despite Piero's extremely clear exposition, there are no figures next to the explanation. Migliari therefore proposes a critical interpretation and provides clarification in the form of graphic images.
The law of degradation presented here was used by Piero when he adopted his first method to create perspective representation in Books I and II of the treatise where the constructions begin with what is called "*vera forma*", describing the objects "as they are", and then the objects "as they appear", in other words their perspective (Baglioni and Fasolo).
One important observation by Migliari focuses on the disambiguation of "puncto A", a point that appears in all the illustrations of the first method and Piero calls "*ochio*", whether it be the centre of projection, or the point where the perspectives of the straight lines perpendicular to the picture plane converge, in other words what we would call the "principal point" of the perspective. His interesting hypothesis is that point. A is derived from the strong link with catoptrics, a science well known in the Renaissance and extensively present in fifteenth-century perspective construction. In this case, it is possible that "in point *A* of the perspective Piero simply sees the reflection of the eye observing the scene" [Migliari 2016b, p. XLI; Baglioni, Migliari 2018]. Once again, this is what we now call the "principal point", one which we would describe as the vanishing point of straight lines orthogonal to the mirror or picture plane, even if we should not omit to say that this awareness, or better still, this way of interpreting perspective construction was unknown when Piero was alive since it was developed during seventeenth-century studies [Migliari 2016b, pp. XLI, XLII; Baglioni, Migliari 2018, pp. 42-51].
When studying Piero's treatise Fasolo identifies the concept of "*veduta vincolata*" (proposition 1.12) and the limits of the visual field, i.e., the angle of aperture of a cone with a vertex in the monocle eye of the observer and axis aligned with the particular direction of space which, connecting point *A* in space with point *A* on the picture plane, represents the orthogonal to the picture plane itself. This approach, as I have had occasion to say, appears to be derived almost directly from Ptolemy's conclusions when he broadened the field of optics to include stereoscopy. In fact, Ptolemy spoke of an "*axis communis*" orthogonal to the binocular distance and considered the points in space nearest to this axis as points of clear vision. This particular research approach led Ptolemy to identify an privileged orientation for a plane in space, the one orthogonal to this axis. By adopting this line of thought he anticipated the fifteenth-century approach of linear perspective executed on a vertical picture plane, with point *A* in a central position

compared to the painting or frescoed wall [Carlevaris 2003] [10].
While marginal aberrations are tackled by Fallavollita also with regard to later developments of large-scale architectural perspective, Salvatore explains how the drawings associated with this first method are not simple two-dimensional images, but three-dimensional models. Something that is irrefutably established by the current initiative.
In the third part of the *Introduction*, Mancini, Romor and Fasolo explain the 'complex' illustrations, the ones that refer to the "*corpi più deficili*" [Piero della Francesca 2016, vol. III.A, Book II. *Drawings*, pp. XLIX-LXXXIX] (the "*corpora difficiliora*" [Piero della Francesca 2017, vol. III.B, Book II. *Drawings*, pp. XLIX-XCI]). For a variety of reasons the analysis and interpretation of these illustrations is particularly difficult. Piero tackled the perspective construction of these figures in Book III of the treatise. He introduced a second method; alternative to the first, but just as effective and simpler to understand, this was a method he could apply to complex cases. Romor emphasises how this second method "cannot be considered a representation method since it does not lead directly to the construction of the perspective image but requires intermediate representations in plan and elevation" [Romor 2016, p. LIV].
In this case Piero works in space using double and associated orthogonal projections so as to determine the intersection between the visual pyramid and the picture plane ("*termine*" of perspective). He performs operations in space, such as translations, rotations and rabattement, and works on the projections of the object as if he were working on the object itself. By performing these operations he obtains the perspective of the object.
Given all the above, and everything else we cannot add for brevity's sake, this *Introduction* to Book II. *Drawings* of the National Edition of the treatise by Piero della Francesca represent a masterful critique of Piero's work.
In light of this careful and meticulous scientific interpretation of the *De prospectiva pingendi* –a text which if rapidly interpreted is both fascinating and perhaps 'easy' to understand– actually turns out to be rather complex, sophisticated and, above all, full of clues that provide a broad understanding not only of its author and his ideas about perspective theory, but also of the approach adopted by the Renaissance to its 'sweet' invention [11]. At the same time the text also hints at the future developments that were to take place in the field of perspective theory.

Notes

[1] <http://www.fondazionepierodellafrancesca.it/interno.php?id=139> (accessed 2018, June 27).

[2] Extract of the words spoken by Carlo Bertelli at the presentation of the National Edition: Rome, Accademia di San Luca, 15 December 2017.

[3] The Ministry provides acknowledgement and support to the National Editions. After consulting the Council of national committees and national editions, the Ministry of Cultural Heritage and Activities and Tourism issued a decree assigning their production "to a board of scholars with specific expertise responsible for monitoring both the scientific and operational implementation of the editions". The board was also responsible for establishing the criteria of each edition, choosing collaborators, authorising publication, and referring to the MiBACT by submitting annual reports: <http://www.librari.beniculturali.it/it/edizioni-nazionali/index.html> (accessed 2018, June 25). There are currently ninety-eight National Editions.

[4] Extract of the words spoken by Lucia Bertolini at the presentation of the National Edition: Rome, Accademia di San Luca, 15 December 2017.

[5] Migliari, R. La ricerca nell'ambito della geometria descrittiva. In Carlevaris 2017, p. 18.

[6] For example the *Mirabilia Urbis*, textual and "non-spatial" instruments intended for those who travelled to Rome: Pazienti 2013, p. 33.

[7] Migliari, R. La ricerca nell'ambito della geometria descrittiva. In Carlevaris 2017, p. 16.

[8] See Migliari, R. La ricerca nell'ambito della geometria descrittiva. In Carlevaris 2017, p. 16; Carlevaris, L. La ricerca che impara, la ricerca che insegna. In Carlevaris 2017, p. 8.

[9] In the field of philology, the Italian term "*ecdotica*" (from the Greek "*ἔκδοσις*" = publication), means the preparation of a critical edition of a text. Its objective is to "reconstruct an ancient text in a form as similar to the original as possible through study and the comparison of any surviving texts (mostly manuscripts)": cfr. Item "Ecdotica". The product of this kind of preparatory work is the so-called "critical edition" that refers not only to the hypothetical text written by the philologist, but also the variants that were discarded.

[10] For Ptolemy's text, see also Lejeune 1989.

[11] "Oh what sweet thing is this perspective": this sentence is reported to have been said by Giorgio Vasari to Paolo Uccello [Vasari 1758 (1559), p. 211]. It is often used when defining this "thing" that is the centre of art, science and mathematics, certainly from the Renaissance onwards, but perhaps, as many have repeatedly asserted, even before that (think, for example, of the illusory space recreated in Roman frescoes). Coupling the adjective "sweet" with perspective was re-employed and disseminated by Parronchi 1964.

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Reviews

Reviews

Carlos Montes Serrano

Del material de los sueños. Dibujos de arquitectura en la modernidad

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In the Preface of his latest book: *Del material de los sueños. Dibujos de arquitectura en la modernidad*, Carlos Montes begins by stating, "The history of architectural drawing of the last century is still to be written". Having specified that he does not pretend to fill this void, but only to make a contribution in this sense, Montes offers us a significant insight into the drawing of architecture and of the city in the last century. There is thus a sort of return to a strict disciplinary specific, after the learned digression he indulged in his previous book *Cicerón y la cultura artística del Renacimineto* (2006), which analyses–within the more general theme of the diffusion of ideas and their migration in different cultural contexts–several aspects of the impact of Cicerone's rhetorical work in the visual arts, in particular painting and architecture.
This new book–whose striking title is taken from Shakespeare's *The Tempest*–is composed of nine chapters which, according to the author, can be understood as "partial episodes of a possible history of architectural drawing in Modernity". They are all richly illustrated with highly relevant and significant photographs and drawings, although the latter are often of small size. The various essays have all originated in conferences, *ponencias*, reports given in seminars and conferences in the area, generally in Italy and Spain, then published (starting in 2005, but especially in recent years) in articles for journals, conferences, collective volumes; these original publications have almost all been expanded, integrated, enriched with images and provided with a more consistent bibliography.
I would like to point out that Montes underlines the fact of "having tried, in any case, to not lose the original didactic approach" because his "intention has always been to explain with the greatest possible simplicity" those themes that attract his interest. It is no coincidence that the clarity of exposition, entrusted to a rigorous but comprehensible language, characterizes all his books (at least from *Representacion y analisis formal,* of 1992) and his writings.
In short, the first chapter–*Un canon de dibujos de la Modernidad*–deals with "the idea of the canon applied to architectural drawings of the twentieth century". It begins with an analysis of the role of the lists of the best works–in photography, painting, private dwellings, Spanish buildings–and notes their great usefulness in teaching, as "they serve to help first year students to develop an initial map of fundamental knowledge about the world of art and architecture, as well as to arouse the necessary critical spirit in them". Montes then demonstrates that it is possible to select the 10 architectural drawings (one for each architect) that are "the best known in modern times", in the sense of being the ones most frequently reproduced in publications dedicated to modern architecture, which "would become part of an imaginary museum of the architectural drawings best known by the majority of us".

Some of these may have "a great graphic quality, others be truly original for their expressiveness, for the wealth of information they provide or for having discovered new ways of understanding or using architectural drawing". All are "intimately linked to their authors. This means that the best known architectural drawings will inevitably belong to the great masters of modernity".
It follows that among the 10 selected drawings there are ones by those who Montes considers the 4 major architects of the century: the structural scheme of the Dom-Ino house by Le Corbusier, perhaps the most reproduced drawing of the last century; the plan and the elevation of Frank Lloyd Wright's Robie house; the sketches for the church of Vouksenniska, by Alvar Aalto; the freehand sketch of the Seagram Building plaza, by Mies van der Rohe (whose most reproduced drawing is, in any case, the plan of the Barcelona pavilion). The other 6 selected drawings are: the plan and the section of the chapel in the Woods in the Stockholm cemetery, by Gunnar Asplund; the sketches for the Einstein tower in Potsdam, by Erich Mendelsohn, a canonical work of German Expressionism; the spatial Diagram for a house, by Theo van Doesburg, an axonometric projection: a method of representation more suited to the twentieth century avant-gardes; the roof plan of the Yale University Art Gallery, by Luis Kahn; the design for the Sidney Opera competition, by Jørn Utzon and, to include a Spanish architect, the section of the *Gimnasio del colegio Maravillas de Madrid*, by Alejandro de la Sota: the most reproduced drawing of 20th-century Spanish architecture. Of Aalto, Kahn and Le Corbusier, Montes also reproduces several travel drawings, underlining the influence that the architectural works visited had on their works: in spite of the *tabula rasa* which has been so erroneously spoken of in regard to the Modern Movement.
Chapter 2, for example, is entirely dedicated to Le Corbusier's *Voyage d'Orient*: decisive in his long self-taught training, during which he came to "understand the ultimate meaning that drawing would have for him" and that, in particular, produced a gradual change in his way of drawing, culminating in the rapid and schematic sketches realized in Italy with which he began to capture the permanent values of popular architecture, classicism or the ruins of Roman antiquities. For Montes, moreover, the drawings presented in the *Voyage* constitute a real revolution in the context of architectural drawing.
Chapter 4, instead, is strongly focused on Kahn's travel drawings realized in Italy, although it is dedicated to the influence and common interests between the Kahn's drawings and those of Louis Lozowick: a great draftsman and lithographer, famous for his images of New York City. Both practiced real life drawing, but their works–as on the other hand has always been true, for almost all urban sketchers–are usually the result of successive elaborations, starting from sketches made *in situ* and photographs. Kahn even used illustrated postcards, to the point that his visions were mediated by the more picturesque sights offered by travel guides and postcards.
The last chapter–*Españoles dibujando en Nueva York, 1930*–also deals with travel drawings: those made by the Spanish architects Luis Moya Blanco and Joaquín Vaquero, the author of the cover and illustrations of the book by Paul Morand (the cultured, cosmopolitan French diplomat and traveler) on the city of skyscrapers. In particular, in the black and white drawings, executed in Indian ink with pen and brush, in which Vaquero tries to reflect the soul of the city, the influence of *The Metropolis of Tomorrow,* the very successful publication by Hugh Ferriss of the previous year mentioned several times in Montes' book, is evident.
The works of Ferriss are at the center of the especially interesting Chapter 3–*Una ecología de las imágenes*–dedicated to the reciprocal influences and contaminations between photography, engravings and architectural drawing, analyzed on the basis of the work of a few artists active in New York during the 1920s and 1930s. In it the author notes how, for example, from black and white photography and engravings came the use of charcoal and white pencil, which spread out Europe from America, imposing itself as one of the characteristics of the representation of architecture in the years between the two World Wars, which is perhaps the most investigated period in the book.
Montes returns to drawing with charcoal and grease pencil in Chapter 5, specifically dedicated to architectural drawing between the two World Wars, in which he notes how although the avant-gardes and the architects of the rationalist current had chosen as their method of representation and planning, above all, axonometric projection–in particular, the military one–there were also those who, starting with Mies, mostly adopted perspective, often drawn with charcoal, which allowed leaving out the ornamental details and concentrating all creative effort in the plastic play of volumes and textures.
In this book, the architect of whom Montes publishes the greatest number of drawings is undoubtedly Gordon Cullen. We meet him for the first time in the extensive Chapter 6, dedicated to the *New Architecture Exhibition of the Elements of Modern Architecture*, which

was held in London in January 1938–organized by the *Modern Architecture Research Group* and initially designed by Walter Gropius, László Moholgy-Nagy and Maxwell Fry–with whom a very young Cullen collaborated, realizing various graphic works. Illustrated almost exclusively with Cullen's drawings, instead, are the two following chapters. Chapter 7–*Gordon Cullen: dibujando el Townscape*–is dedicated to the articles he wrote for The Architectural Review, published together in 1961 in his book *Townscape*, which Montes defines as a true classic of architectural literature, which "educates the eye and teaches us to see". Chapter 8 deals with the lesser known monographic issues *Outrage* and *Counter-Attack against subtopia*, which the magazine published in 1955 and 1956, with articles by the young writer Ian Nairn and drawings by Cullen.
In all these publications the novelty and the real style are determined by Cullen's illustrations: always original drawings, executed with different techniques, simple but able to condense and express many ideas, which together delineate an effective and simple use of graphic works for the analysis of urban complexity and interventions in the city. With his drawings Cullen illustrates and disseminates ideas, not revolutionary, but only the result of a good civic sense and respect for sedimented architectural and urban values which, however, proved to be avant-garde, considering that some of them were established with a few decades of delay and today characterize the widely shared approach to the problems of the city, while others are unfortunately still unrealized.
Ultimately, we are in the presence of a book that is read–and is seen–with pleasure and interest, which shows the author's absolute mastery of the topics covered, at times his active involvement, albeit in the context of a strict critical analysis, and which testifies to the vast culture, not only architectural and never flaunted, of its author, which affords him a truly transdisciplinary approach and style.

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Reviews

Francesco Manganaro,
Alessio Altadonna, Adriana Arena

Mario Manganaro “...un disegnatore generoso”

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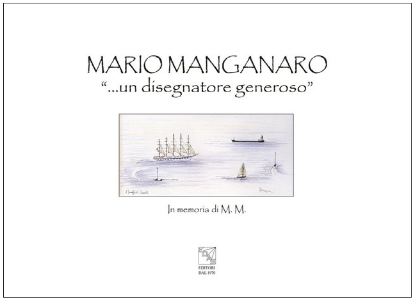

The book here exposed is the exhibition catalogue of *MM I RICORDANDO una mostra di disegni di Mario Manganaro*, but it is also much more, collecting, next to drawings, texts written by friends, family, students and colleagues of Mario Manganaro to ensure memories, shared practice, thoughts addressed to him.
Edited by Francesco Manganaro, Alessio Altadonna and Adriana Arena, the book, entitled *Mario Manganaro "… un disegnatore generoso"*, published by EDAS, collects ninety-five *Drawings by M.M. on the left pages* and sixty-one *Drawings by M.M. exhibited* (drawings are cataloged by title, year, place, size, technique, support), side by side to fifty-five textual contributions signed by the same numbers of authors.
These short texts appear as a collection of letters written to a friend and to themselves, reconstructing episodes of life lived together and shared memories. "Even fragments of correspondence by e-mail, some publishing, testify, to have received in support of their studies, at that intersection, even at a distance that he did not miss" [Marchese 2018]. The texts seem to repeat the drawings in words: meticulous report of events, descriptions in which we recognize the places of meetings, the talks, the quit warnings of the professor, the academic and scientific authoritativeness, the delight of being together silently. Each part is usefull to complete the other one. As well as the presence of his wife, sons and nephews, at the exhibition opening, is usefull to complete his absence.
Prepared on a design by Claudio Marchese, in collaboration with Michela De Domenico, the exhibition is divided into five thematic 'rooms': *Visions of the Strait, Architecture, Nature, City and Landscape, Art.*
High white partitions, orthogonal to each other and rotated diagonally to the room, border the 'rooms' that hosting drawings according to particular themes; the open corners of the partitions allow the adjacent 'room' to be seen, anticipating, in oblique views, different visions and panoramas. Each session is introduced by a vertical banner in which in addition to a sketch there are an autograph text and the title session. The drawings are arranged on metallic canvases in rows misaligned at the height of the visitor's visual horizon. Twenty drawings for each theme, framed in ash frames and detached from a passpartout that enhances the uniqueness and at the same time makes the focus on the single scene drawn.
The sketchs are detailed part of the world seen by the professor. Each sign shows a real detail of architectures, landscapes, faces, transcribed in the redrawing world. The real world he has traveled and seen, the world of which "takes possession of something, though impalpable, of the place" [p. 15].
Places of which he leaves traces in drawings that are repeated sometimes for many years, at distance of signs,

each of them shows the modification of the time passed "in the hope that the drawing could stand as an incomplete but structured witness on the territory surveyed or to be surveyed" [p. 161].
Two trestles host the perspective *Palace of Culture of Messina Competition*, made in 1975, and *I Ponti in Tasca*, a haulietic bridge made on 2007, which Mario Manganaro so commented in a text: "At the waiting dimension the input to narrate part of what the place represents for a Strait of Messina observer prevailed. A large liquid square, constantly crossed far and wide from big and small boats, full of people and things, […] which in the face each other '*ab antiquo*' created an imaginary mirror, in which the one reflects in the other its indefinite and mysterious part". [Manganaro 2008]. *Hortus Linearum*, is a drawings composition from 2003, standing alone in a dedicated space and a projector sends in loop photos, drawings, interviews, videos.
It has begin to "realize that vision of the world" [Cacciari 2007, p. 11] for sequential signs that only in a general exposition – when all the drawings will be shown – can be captured in a single vision. It is the world vision of an observer, left to the students, to the scholars now able to reconstruct the geographical units of those fragments of "recognizable places" mentioned by Laura Carlevaris in her presentation.
Mario Manganaro is not the Fra Mauro of Cowan who draws the world told by the merchants coming to Venice, it is rather the Marco Polo of Calvino, the traveler who knows the lands of the Empire better than Kublai Khan. His drawings are not opposed to reality, they transcribe it, transfer it to the notebook, allowing essence and consistency, degradation or integrity of the portrayed object; the form of the place is not expressed, but it is the sign that becomes a story, *logos*, and even conversation. Those conversations apparently difficult *per verba*, become eloquent in the narrative trace of the sign, in a too loud solitude, often disturbed by curious colleagues who, not satisfied by the signs, tried to steal the words.
The event *MM I RICORDANDO una mostra di disegni di Mario Manganaro* is the last of a series of meetings held in memory of the professor from Messina. The first meeting was held on May 7th, 2017. During this event "Mario's family, friends and collaborators remember him on the first anniversary of his death […]. The intent of the group was not to forget my father's studies and his work and to define ways to show them to the scientific community", so wrote Francesco Manganaro on the scientific journal Galileo [Manganaro 2018, p. 31]. The aim is to make available to the scientific community and to the others, researchs and the work of professor Manganaro, who left an archive of more than 3.000 china, pencil and color drawings, made on valuable papers or on simple sheets, cataloged by "description, year, place, grammage, support and tools" [Manganaro 2018, p. 31].
Francesco Manganaro is the creator ad editor of the <www.mariomanganaro.it> website where we can read 'In memory of Mario Manganaro'; it is a storage under construction, presenting on the menu two main items: the first is '*Incontri*' ('Meetings'), in which are inserted the events that have already been held and those to be held; the second is '*Ricordando*' ('Remembering'), an exhaustive documents, images, videos and drawings repertoire.
From 5th to 8th May 2018 at the Palazzo della Cultura PalaAntonello of Messina hold the first exhibition of Mario Manganaro's drawings. "The exhibition, although defined, appears to the visitor, …under construction: more than anything else, it can be completed! Of course, an anthology would need a museum entirely dedicated to him, such was the great attention that Mario Manganaro reserved for everything that came before his eyes and aroused interest in study and research, as well as affection" [Marchese 2018].
The exhibition opening includes some speechs introduced by Adriana Arena and Francesco Manganaro. The speakers are the President of Unione Italiana per il Disegno (UID), Vito Cardone, Laura Carlevaris (Sapienza University of Rome), Antonio Conte (University of Basilicata) and Sereno Innocenti (University of Brescia).
Cardone, speaking of his "things out of place", highlights the exceptional qualities of teacher and researcher of Mario Manganaro, "not to confine his

figure only in the role of draftsman", he remembers "far from the academic power" but keeping strongly his role as teacher and Engineering Department director. He mentions the "educational value" that is on the exhibition catalogue *Introduction*: "now I draw together with my students the city and its suburbs. […] To consider himself as one of the students is important to understand their problems and to make sure that the experiments always concern something that unites us and does not take us away" [pp. 15-17]. Drawing together –highlights the president– "is a method of learning by osmosis among students. Il break down the crystal barriers. Together with the teacher there is a mutual learning, without detachment". Cardone concludes urging them to think about the possible production of a critical anthology of thematic writings, "those for example, which show clear educational and operational indications".

Laura Carlevaris recalls the "silent presence of the professor" as a strong figure whose role was always that of "connecting and placing each one of us in his place". In the same way in which in his drawings we recognize urban details or landscapes that come out of minute signs that are shattered and are composed by reconnecting the whole in a single unitarity. Carlevaris recalls in metaphor the drawings of *Felicittà* by Richard Scarry or those of Iacovitti, in which each character, placed in the graphic context and busy in his things has a role of close relationship with others and whose balance depends on the position he occupies in the context where it is located. "There is a sense of belonging to the place of every single element that participates in the construction of the whole within a graphic equilibrium".

"As well as –continues the professor– his drawings of the Strait of Messina, in which the water join the two banks with the boats that travel in a transversal direction, Mario Manganaro, has helped to place each of us, teachers of architectural drawing, in the place that suits him, in order to paint a unitary context".

Antonio Conte says about his participation in the construction, starting from 2006, of a "collective place of work and research" to which "drawing and representation of the world" were the main focuses. Conte compares the work of Mario Manganaro to the *Soun of human voice* with which Paul Valéry notes the Cartesian variations in the pressing repetition of the action. "The representation of things that he observed during a life is like the representation of the frenetic pulsation of our daily things that interlace and crystallize in that infinite place made up from the weaving of his signs enclosed in the small spaces of his notebooks. He searchs through the signs the things that comprised of the world trying to crystallize the sense of a knowledge through a silent reasoning".

Finally, Sereno Innocenzi 'builds' a "drawing that begins and a drawing that ends". Starting from the rectangles that define a tatami, through rotations, overturns and prolonged lines, he composes places, architectures and details in a historical narration of which the projected light of a lamp becomes the connecting element.

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Reviews

Vito Cardone

Gaspard Monge, padre dell'ingegnere contemporaneo

DEI Tipografia del Genio Civile,
Roma 2017
pp. 238
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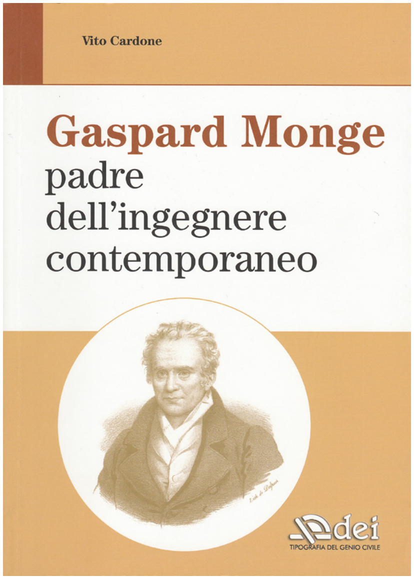

The book by Vito Cardone *Gaspard Monge, padre dell'ingegnere contemporaneo*, published in 2017 by DEI Tipografia del Genio Civile, deals with the precious cultural heritage that the French scientist has passed on to our days. This legacy must be extended not only to the formulation of the rules of descriptive geometry, but also to the study plan designed to train engineers; because, as the author states: "its effectiveness and farsightedness are evident, indeed, after more than two hundred years, it still permeates most of the schools for engineers around the world, whose choices are within the criteria and problems already identified at that time" [p. 79].

Vito Cardone guides the reader in the fascinating and adventurous life of Monge, focusing in particular on the vicissitudes that led to the formulation of descriptive geometry and the organization of the study program for the École Polytechnique in Paris. He also traces the enlargements and transformations of the program over the centuries by his direct successors or by those who have taken inspiration from the cultural heritage left us by the famous French scientist.

The pages of the book outline the multifaceted personality of Gaspard Monge, revealing known 'profiles' of the scientist, first of all that he was a very good teacher.

Monge was undoubtedly a charismatic teacher, he influenced many talented young people who were lucky enough to meet him and follow his famous lessons. He was loved by his students and, despite a slight stutter, he was able to explain in a simple way the complex geometrical phenomena of space; there are many witnesses in this sense: "When he describes, in words, and draws with his hands a surface of revolution, you can see it; a developing surface, you develop it with him [...] abstraction takes shape with him; he had the art of making simple things that are complicated and clear the ones that are more obscure" [Jomard 1853, pp. 12-16]. The introduction of Cardone's book shows an emblematic episode: the parade organized by the students, Sunday, August 2nd, 2018, to pay tribute to the master, who had been buried a few days earlier in the Père Lachaise cemetery. The solemnity of the event was immortalized by the painter Hippolyte Lecomte; among the students there were also those who were the promoters of a subscription to erect a funeral monument on the burial site, which is still possible to admire. Today the remains of Monge are at the Panthéon, they were transferred on the occasion of the bicentenary of the French Revolution. This relocation to a more representative place by the authorities of the French Republic should not surprise us; indeed, the pages of Cardone's book show the figure of a civilly engaged man. The author starts from the training years

of the French scientist identifying, also in the difficulties encountered for his non-aristocratic origins, the enthusiasm for the revolutionary movement, which promised to establish a more just, egalitarian and meritocratic society.
In the first chapter Cardone analyzes the political context, talking also about the sincere friendship between Monge and Napoleon. First the general asked for his friend's technical, cultural, and scientific advice; later, while continuing to maintain the relationships of mutual esteem, Napoleon –now an emperor– undermined the Monge's most loved creature, the École Polytechnique, imposing the scientist to transform the institution, ecumenically open to all talented fellows, in a military school subject to the payment of a fee.
Cardone takes advantage describing the important roles held by Monge during the French Revolution and the Empire; the aim of the author is to outline the global figure of the man. So, the reader finds out that Monge was tenderly attached to his family, who kept constantly updated during his long journeys by means of a detailed correspondence. In the missives, written during the Italian campaign, the scientist is not too much impressed by the beauty of our Country, usually providing a political reading of the places more than an artistic and architectural one. He, as a Jacobin, criticizes harshly and repeatedly the Church both as a temporal and spiritual institution. Yet there is no shortage of enthusiasm, such as the one reported in the letter addressed to his wife in which she dwells on the *Ecstasy of Santa Cecilia* by Raffaello Sanzio; or the descriptions of Lake Trasimeno and Campi Flegrei in which he abandons himself to nostalgic reminiscences linked to the readings of his childhood. Instead, the Egyptian campaign sees Monge engaged in the drafting of maps and surveys of ancient monuments and buildings but especially in the analysis of hieroglyphics, thus setting up modern Egyptology.
The second chapter of Cardone's book focuses on the wide scientific legacy left to us by Monge. Indeed, the French scientist, who has gone down in history as a codifier of descriptive geometry, has also worked in other theoretical and practical fields, providing important contributions on partial derivatives and pushing for France to adopt a single measurement system based on the meter. But it is in the didactic approach that Cardone identifies one of the most original contributions of this great master. Cardone analyzes the relationship between science and technology and, in particular, how these produce relapses in descriptive geometry. The reading of the book shows how much Monge was convinced of the close relationship among science and technology and how much effort he has faced to address both the theoretical and practical aspects of the issues. In this regard we can only agree with the author when he states that: "Monge was the most emblematic scientist of that fruitful period of transition from the age of enlightenment to that of the industrial revolution. If this happened quickly it is also thanks to the creation of a new universal scientific and technical language –the graphic one– that he developed so that all the engineers and technicians responsible for the design, management and execution of the engineering works could speak a same language" [p. 16].
On descriptive geometry Monge marked a revolutionary school, it is a unitary method of study, in which applications play an important task: the connection between the various scientific disciplines. The École Polytechnique of Monge will be a point of reference for all the contemporary and successive engineering schools. The topic of the third chapter of Cardone's book deals with the diffusion over the centuries of descriptive geometry and the training model for engineers. The author shows how great the interest of the entire scientific community was both for the new drawing discipline –the *Leçons* were a great success and they were spread out to the point that they could be considered a 'classic'– and for the teaching organization of the École Polytechnique –from the Americas to Russia, schools for engineers were founded, inspired by the French model–. Monge's students spread out throughout the world the teaching method and organization of their professor. From the pages of the book interesting data and considerations emerge in this context, such as: the detailed analyses made by the author on subsequent developments both at a theoretical and practical level carried on by the Germans; the comparison with a certain form of "backwardness" of the British; the pragmatic set in the United States of America, dictated by the need to face urgent infrastructural problems; developments and repercussions in Spanish and Portuguese speaking countries, as well as in Italy and in France.
The book has images related to Gaspard Monge: the artistic works he admired in Italy; the engravings and paintings that portray him in important political moments of the revolution and the empire; the portraits that immortalize him in different moments of his life; and the elegant tables, extrapolated from the treatises of the master and his successors. Finally, Cardone provides in the Appendix the program and excerpts of descriptive

geometry taken from *Géométrie Descriptive. Leçons données aux Écoles Normales, l'an 3 de la République, par Gaspard Monge de l'Institut National*.
Cardone's book is very relevant today, since many nations, including Italy, have started a reform of engineering studies in the last decade of the XX century, driven by a request from the business world that pressed for a first level training of the engineer aimed at strengthening professional practice. This has led to an inevitable impoverishment of basic scientific knowledge in the provision of university courses. At the conclusion of this book, Vito Cardone, having followed these problems very closely as President of the Conference of Deans of Engineering Faculties, expresses a certain confidence in the possibility of absorbing the damage caused by the reform of the Engineering Faculties, hoping for a reformulation of the training courses based on historical knowledge and starting from the origins, i.e. the foundation of the first organic study plan for engineer training that Gaspard Monge delineated within the École Polytechnique of Paris.
The book by Vito Cardone is therefore particularly valuable, not only because it provides a complete, 'all-round' profile, of the French scientist but also because it deals with stringent and current problems, for which this book is a convincing tool for identifying a valid solution. Indeed, it is essential to provide the engineering students with a precise identity starting from their roots.

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Reviews

Laura Carlevaris (a cura di)

La ricerca nell'ambito della geometria descrittiva. Due giornate di studio

Gangemi Editore, Roma 2017
pp. 190
ISBN 978-884923504-3

The book, edited by Laura Carlevalis and published by Gangemi Editore in 2017, includes the reports presented during the two days of study held on February 18 and 25 in the Ph.D. program in History, Design and Restoration of Architecture organized by the DSDRA of Sapienza University of Rome, and dedicated to the history and innovation of research in the area of Descriptive Geometry.

The contributions, signed by Riccardo Migliari, Vito Cardone, Agostino De Rosa, Maura Boffito, Maria Teresa Bartoli, Nevena Radojevic, Camillo Trevisan and Roberto Ciarloni, deal with the theme of the symposium with different dissertations where the common denominator resides in the close relationship that binds the search for tradition, as Laura Carlevalis emphasizes.

This relationship is thus clarified by Riccardo Migliari: "what is included in History is, of necessity, new (otherwise it would not appear). And what appears, today as new, is only in comparison with the past, remote or recent" [p. 14]. Migliari also describes some aspects related to the 'research', in order to distinguish it based on the results achieved, identify the activities included in it and the related methods of investigation, and deal with the central issue of collaboration of competences, concluding with a reflection on the excessive use of digital technology by researchers in the area. In fact, the current possibility of developing models using automatic devices (software) has attenuated the interest of researchers for the in-depth learning of geometric issues, the knowledge of which is instead essential for the control of the procedures and results developed by the computer. Most often this indifference derives from an incorrect assessment of the study opportunities inherent in a discipline considered exhausted and surpassed by the most recent digital representation procedures.

Instead, the contribution of Vito Cardone [pp. 23-44] highlights the importance of the study of the discipline, starting from a synoptic historical digression. From the effective report it emerges that today's attitude towards the descriptive, in the past, had already repeatedly shown itself in relation to the whole geometry, although it has risen every time studies have been undertaken on ancient situations and problems considered resolved or unsolvable. And since the corpus of the descriptive is still incomplete, a re-examination of the issues that have been resolved or rectified, carried out with the aid of the most up-to-date tools, could give new impetus to the discipline. But if research through a new exegesis can give a further development to what has been achieved in the past, only history can attribute value to that innovation.

To this thesis comes also the essay by Agostino De Rosa [pp. 45-76] who, starting from the Platonic cave, explores the procedures adopted by the au-

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diségno ISSN 2533-2899

thors of images to channel the attention of the observer on representations born of projective or natural processes. In examining the works that impose visual difficulties on the viewer, Agostino De Rosa notes how these procedures involve all the senses and observes that in perception, visual negation generates in the subject a sensorial contamination capable of increasing his perceptive faculties. Paradoxically, therefore, the viewer sees better when he is deprived of sight, a revelation that emerges precisely from a careful re-examination of history.

The story of Maura Boffito [pp. 77-106] also takes place in history, where together with an oneiric personification of the Perspective, spans two centuries to recall the events that led to the discovery of projective geometry from the outset of perspective. The itinerary, which begun in Florence in the fifteenth century, proposes the same informative path that at the time made known the prospective method in Europe. At each stage of this ideal journey in space and time, the author and her partner attend to the main events or contemplate the work of those who concur to the development of the discipline.

The contribution of Maria Teresa Bartoli [pp. 107-122] demonstrates how the reexamination of the geometrical peculiarities of some well-known works in perspective can still lead to unprecedented attestations. The well-known experiments performed by Brunelleschi on the famous tablets did not intend to demonstrate the visual effectiveness of the representation but rather to show a means by which to prove the rule that interpreted the vision. The intuition, perhaps inspired by the perspective value of the bacula, was revived to his students by means of a synthetic scheme based on a square mesh, which was used to correctly portray the depth of an environment according to a vision in line with the prescription of the unique and immobile eye. The same decking is also present in a panel of the Ghiberti's *Paradise Gate* (the *Scene of Solomon* and the *Queen of Saba*) and in the Piero della Francesca's *Brera Altarpiece*. But the monocular static does not seem to have been a necessary condition in the construction of much more relevant works, from which we can hypothesize meanings and purposes attributed to perspective at the time: it is the case of the *Flagellation* of Piero della Francesca or the *School of Athens* of Raphael whose geometric analysis has revealed an intentional renunciation of the uniqueness of the point of view. In both, the transgression to the rule seems to make explicit the aims of an applied science that the authors examine by making paintings to be taken as reference models.

Geometric verification conducted with the latest technological tools by Nevena Radojevic [pp. 123-138] on the vault of the Pazzi Chapel in Florence revolutionizes the certainties inherent in its traditional attribution. Taking into consideration the shape of the sails included in the umbrella vault of the chapel, Radojevic formulates the hypothesis that this cover was designed by Filippo Brunelleschi and that its conformation can be considered as the physical representation of an astronomical interpretation. Considering the result of the survey carried out with a laser scanner on the structure under investigation, Radojevic assumes that it provides an internal sail (conchoidal) and an external one (toric), and that the first derives from a transformation of the second performed according to the laws that allow Nicomede's concoide to be obtained in the plan. This thesis has been verified in the digital environment by the almost absolute coincidence between the geometric model of the conchoidal surface and the mesh of the point cloud acquired with the scan. Since the conchoidal shape of the sail vault is similar to a solid perspective of the torus from the oculus of the dome assumed as a point of view, from that position the points of the conchoid coincide with those of torus. Therefore, if the observer's eye managed to reach such a location, he could perceive the reified view of a constrained movement, the same from which the astronomical theories of the sixteenth century originated. The evident prospective foundation of this work suggests the opinion that it was conceived by Brunelleschi.

If in the Radojevic thesis the use of an existing technological instrumentation is an indispensable prerequisite, the use of such means becomes even more essential in a perspective inversion operation. In this process, in fact, the choice of both the point of view and the geometric conformation to be assigned to the real model assumes fundamental importance, since there may be countless variations of both, all attributable to the representation object of investigation, which often also presents problems intentionally or accidentally related to its execution.

The report by Camillo Trevisan [pp. 139-158] describes the characteristics and the functioning of a software, Euclid, conceived to elaborate a perspective restitution starting from all the possible hypotheses connected to it. The program operates through the continuous verification of the compositional rules of a real model in constant transformation, which is compared with a perspective representation of the same also generated by a progressive motion of the projection center in

the space: when all the compositional laws of the model are verified (with the exception of a certain margin deemed acceptable), the configured sample is taken as originated from the perspective produced, at that precise moment, based on the position occupied by the center of projection.
Usually in the elaboration of a real model the correct geometric interpretation of the elements that compose it is complex, because it is subject to multiple possible decodifications. Roberto Ciarloni's [pp. 159-183] contribution exposes some parameters of discernment, based on the mathematical properties of the forms and on the logic of the three-dimensional design tools, useful for selecting the options with greater awareness.
Through different approaches the reports collected in this book show that, although it has not been adequately considered in recent decades, the descriptive geometry constitutes a disciplinary area with margins still to be investigated, and that through it the reconnaissance accomplished with the support of information technology on some works often leads to unpublished and far from negligible results.

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Events

Events

Arquitecturas-Imaginadas: Representação Gráfica Arquitectónica e "Outras-Imagens"

Saverio D'Auria

The seminar *Arquitecturas Imaginadas: Representação Gráfica Arquitectónica e 'Outras Imagens'*–kept in Brazil at the *Centro Universitário Maria Antônia* of the University of San Paolo from the 5th to the 9th of March 2018, one of the first abroad scientific meetings supported by *Unione Italiana per il Disegno*–has reached its fifth edition and caught the attention of the scientific representation community (fig. 1).
The first edition, named *Desenho […] Cidade,* was taken at the Architecture Department of the University of Lisbon from the 28th to the 30th of April 2014 during the namesake project started from Pedro António Janeiro in 2009 at the CIAUD–*Centro de Investigação em Arquitetura Urbanismo e Design*–of the University of Lisbon and during it the most general aspects regarding the drawing and representation of the city were analysed.
Still now the seminaries follow the first one's guidelines and the participants, chosen according to their academic and scientific profiles, have to get an official invitation.
The second seminar, still taken at the Architecture Department of the University of Lisbon from the 20th to the 30th of April 2015, in memoriam of the Portuguese professor Maria João Madeira Rodrigues, had as subtitle *Desenho […] Cidade […] EU* and proposed to debate the existing connections between the executor and the beneficiary of an image (graphic, photographic, cinematographic).
The 3rd seminar was hosted by the *Instituto de Arquitetos do Brasil* of Rio de Janeiro from the 7th to the 9th of March 2016, it had as main topic the drawing related to the modern city (the subtitle was *Desenho […] Cidade-Moderna*) laid the foundations to keep on going a wider and more articulated research project which involved researchers from abroad.
The new research project, still lead from professor Janeiro, lasts four years (November 2016-November 2020) and preserves its historical name *Arquitecturas Imaginadas: Representação Gráfica Arquitectónica e 'Outras Imagens'*. It involves more than ten South American and European Universities (among which the Faculdade de Arquitetura of Lisbona, the Escuela Técnica Superior de Arquitectura of the Universidad Politécnica of Madrid, the Politecnico of Milano, the Politecnico of Bari, the Universities of Salerno, of Basilicata, *Mediterranea* of Reggio Calabria, of Palermo, the FAU in San Paolo) and several scientific and researching bodies or organisations (for example the Instituto de Arquitetos do Brasil) and is financed by the Departamento de Composición Arquitectónica of the Universidad Politécnica de Madrid, by the Coordenação de Pesquisa of the university centre SENAC and by the Faculdade de Arquitetura e Urbanismo of the University of San Paolo, by the Fundação de Amparo à Pesquisa of the San Paolo State, by Preciare–Consulturia e Avaliação Imobiliária and by A.A.M., Architettura Arte Moderna of Roma. Among the non-Portuguese/Brazilian researchers, make up the team, just to name a few, the professors Javier Seguí de la Riva and Javier Mosteiro, from the Escuela Técnica Superior de Arquitectura of the Universidad Politécnica of Madrid and, between the Italians, Francesca Fatta, Antonio Conte, Salvatore Barba and Vito Cardone.
One of the purposes, most of which already discussed during the last two seminaries, is about analysing through the drawings the variation of the insights of the cities in order to reach an accurate knowledge of the critical issues, linked to the association between the drawing and the city starting from the perception of the last one.
The scientific research is in fact pointed around the city drawing and its identification elements–the geographic area, the inhabitants, the natural landscape,

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Fig. 1. Poster of the V seminar Arquitecturas-Imaginadas: Representação Gráfica Arquitectónica e 'Outras-Imagens'.

the data and the ongoing events–elements characterized by the body's presence and action expressed in gestures, movements, facts, motions and stays. Therefore the research analyses the processes that the subject of some society uses in order to represent the objects around him and, more specific, the images of the architectural object. Moreover, it has to think about how to represent the inexistent architecture during the design and project steps of the same in order to reduce the distance between the known architecture and the one represented. The first common considerations about the researches were developed during the penultimate edition of the seminar–kept on the 17th and 18th of May 2017 at the Escuela Técnica Superior de Arquitectura of the Universidad Politécnica of Madrid–which was focalized on the memory of the city through the drawings (*Dibujo [...] Ciudad [...] Reminiscencia*).

For the 5th and last international seminar, the scientific coordinators–the professors Pedro António Janeiro (of the Architecture Department of the University of Lisbon), Myrna de Arruda Nascimento (belonging to the Serviço Nacional de Aprendizagem Comercial, SENAC, of the University of San Paolo) and Ricardo Ferreira Lopes (of the Laboratório de Investigação DOMVS of the Architecture and Urbanism Department of the Federal University of Juiz de Fora)–have chosen the subtitle *Desenho [...] Cidade [...] Corpo, habitando a Terra*, and decided to dedicate those studying, researching and debating days to the theme of the city drawing linked to the body.

The events were divided in five study days. In the morning there was three workshops dedicated to PhD and post-doc students about *Cidade Filmada: Ma-*

pear Topia-em-Movimento; Quadrinhos como o discurso do sujeito e Produção de imagens multissensoriais: superando preconceitos visuais. In the evening the invited relators exposed their work and, on the fourth day, even a fourth workshop named: *Desenho, Arquitetura, Corpo*.
The themes treated during the speeches all followed the same line which takes the cue from the architecture considered firstly as a relationship between who lives the space and the space itself, and secondly as the consequence of different graphic representation called "images". These representations allow the body to stay in the world in a different way compared to the one in which the architecture and its built shapes confine it. Assuming that the architecture, as relation, is itself the germ inside the representations that imagine it, the researches linked to seminar activities proposed to study how this germ is born and developed in the architectural images (and so if these images are more academical, like for sketches and schemes or more technological like for the products of the parametrical design , of the NURBS or algorithmical modelling, of rendering an so on) and how it is taught to decrease the gap between the real a virtual world to the new generations of designers.
The different contributes all converged to the same themes even thought they were all characterized from the different experiences and origins of the speakers who treated their points using examples and study cases belonging to the major architects and scholars of the city (from Camillo Sitte to Le Corbusier and Kevin Lynch) or belonging to the most important cities of the new and old world (Paris, New York, Giacarta, San Paolo) and of colonial Portuguese Africa, an unknown territory for our studies.

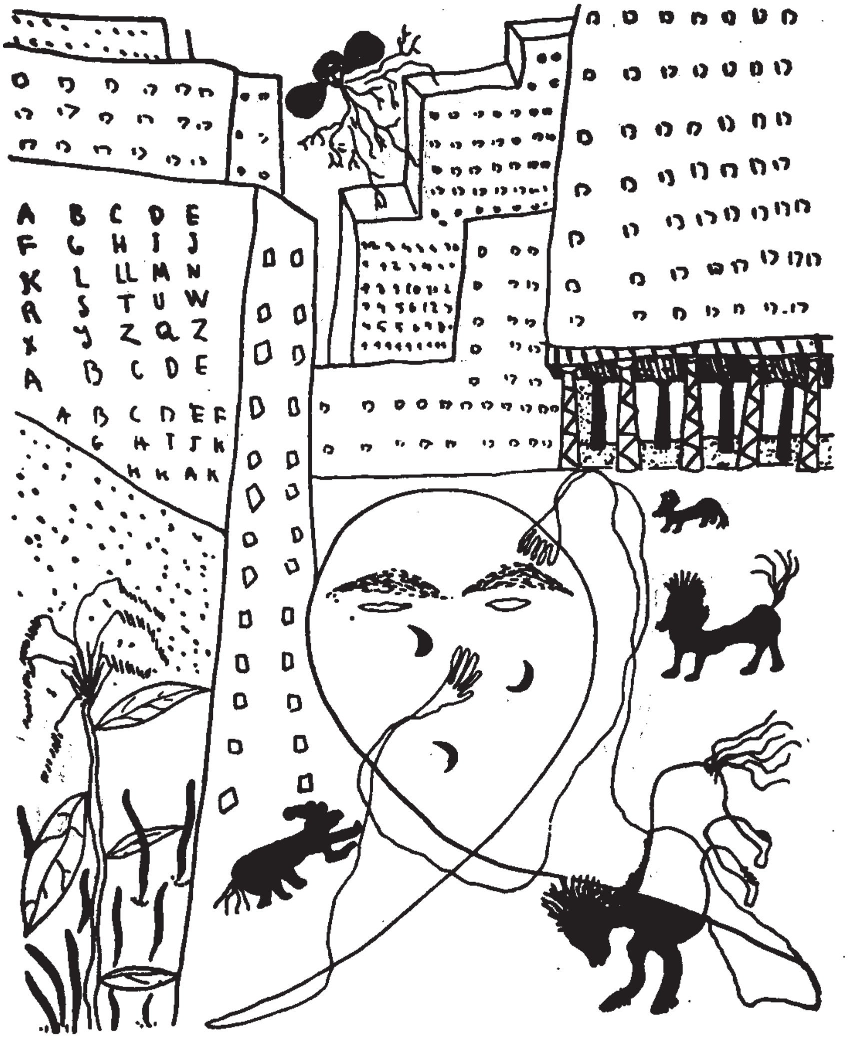

Fig. 2. Federico García Lorca. Urban perspective with self-portrait.

Some of the speakers paused most on their drawings, like Marcello Sèstito of the Architectural and Land Department of the Mediterranea University of Reggio Calabria, brilliant and compulsive illustrator, much appreciated; other speakers intervened in videoconferencing such as Santo Giunta, of the Architecture Department of the University of Palermo, who exposed *Scarpa na Sicilia. O sentido da memoria.* Other speeches instead focused on cities' descriptions made or deduced by travellers, architects or writers; among these Vito Cardone, Saverio D'Auria and Emanuela De Feo exposed a work named *Imagens literárias e descrições de viajantes para o conhecimento da cidade* (presented by Vito Cardone) and Luís Antônio Jorge (from the Faculdade de Arquitetura e Urbanismo, Universidade de São Paulo) with a relation named *Retratos de cidade* (fig. 2).

Among the most original speeches the one by Francisco Oliveira is to be underlined, *A pele da cidade–visoes para uma identidade tátil do espaço*. Almost all the contributes showed a wide approach and the needing of a multidisciplinary cut and multimedia tools in order to face the themes at stake.

The seminar ended with the conference of Pedro Janeiro called *A carne do corpo e a carne das coisas: o desenho como conversão do visível em outra visibilidade.*

As for the past editions, the papers presented at the project after the reserved call and the invited reports will be collected in the volume of the symposium proceedings edited by the CIAUD - Centro de Investigação em Arquitetura, Urbanismo e Design of the Faculty of Architecture of the University of Lisbona, and this time published the prestigious publishing house Taylor & Francis Group. The next editions of the seminar will represent new moments for sharing the ongoing studies and, most of all, will be essential for the advancement and conclusion of the research project's second part, started in November 2016.

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Events

Workshop on *3D Modeling & BIM. New Frontiers*

Massimiliano Lo Turco

The 3D *Modeling & BIM* Workshop has come to its fourth edition; this year, it is dedicated to the theme of 'New Frontiers'. As on previous occasions, the event was hosted by the Sapienza Università di Roma at the Valle Giulia headquarters on the 18th and 19th of April 2018 [1].

'New Frontiers' is the subtitle of the fourth edition of this event (fig. 1). The organizers record with satisfaction the constant growth of the event both in terms of quantity –starting from the number of contributions and members– and quality. Although the first aspect is important, the second aspect is more interesting to dwell on; looking through the type and quality of contributions, one gets the impression of entering a largely unexplored territory that is potentially rich in innovative ideas. However, it also has its pitfalls [Bianchini 2018, p. 12]. This is Carlo Bianchini's viewpoint. He is Director of the Department of History, Design and Restoration of Architecture at the Sapienza Università di Roma. He is also the host of the event.

As highlighted in one of the contributions proposed by Antonella di Luggo, the workshop, of which Tommaso Empler is the scientific responsible, "is an important time for reflection and an opportunity of discussion for researchers from different universities and it demonstrates that the scientific teaching sector of Drawing gives a lot of theoretical and operational analysis accompanying sector studies, both for the project of new buildings and for the survey and documentation of existing heritage" [Di Luggo 2018, p. 36].

Students, professors and professionals from all over Italy were compared through thirty-one contributions to the proceedings, edited by Tommaso Empler, Fabio Quici and Graziano Mario Valenti [Empler, Quici, Valenti 2018], within three working sessions: an introductory session dedicated to '3D Modeling & BIM' (with three contributions), one titled *BIM for the Construction Industry* (seven contributions), the second *BIM for the Enhancement and Management of Existing Heritage* (eleven contributions) and, finally, the last on the theme *3D Modeling* (ten contributions expressed).

The subdivision of the sessions underlines how the theme of modeling –the geometric and the informative one and that of the two together– constitutes the living and active support for the construction industry and for the valorisation and management of the existing heritage, with different specifications.

Looking at the variety of themes and the quantity of contributions proposed, which has grown from year to year and has been subjected to a double blind review, Graziano Mario Valenti, in his speech, invites us to reflect on the enlargement of the main themes to the more specialized ones through the frequency of specific keywords, excluding the most common and fundamental ones, such as the terms BIM, HBIM, 3D modeling, VR, AR, and Interoperability. The authors seem to have brought out, with greater awareness of their centrality, new keywords –sometimes drawing on similar fields of study– which, as a whole, shows an acceleration in the critical capacity to address the general theme of information modeling. This will help identify its critical issues and, hopefully, shape it with innovative and optimized features. Valenti especially refers to keywords, such as Level of Reliability (LoR), Model checking, Combine modeling, Algorithm-aided design, Complexity, Design analysis and the very remarkable Dataset. [Valenti 2018, p. 14]. Valenti concludes by affirming how the overcoming of the operative paradigm of the digital, which is used as a mere instrument of automation of old methodologies (efficiency) in

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Fig. 1. 3D Modeling & BIM Workshop. New Frontiers. (Program cover).

favour of the digital and understood as an aid for the definition of new processes (effectiveness), appears increasingly marked (fig. 2).
As Carlo Bianchini observes in his presentation, the main question intervening on the existing ("the question of questions") is "how should an H-BIM model be structured in operational terms?" He emphasises a very specific question, that of the Level of Reliability (LOR) of a geometric information model and, more generally, of its construction process:
"The coding of a set of common and shared parameters makes it possible, finally, to achieve a synthetic numeric evaluation of the LOR, a sort of 'score' for the model. In this framework, the Level of Reliability may perhaps represent a relevant methodological step forward to 'customize' BIM systems in order to make them more compatible with BCH issues –in other words, to encourage, support and implement the consolidated approaches that imply the gradual and deep knowledge of artefacts as a precondition for their conservation and enhancement" [Bianchini, Nicastro 2018, p. 46]. Therefore, he focusses on diversity in the articulation of the keywords, themes and application at different scales, looking at accessibility to information and interoperability not as mere computer facts, but as availability, freedom of access and certification.
In terms of the opportunity provided by the workshop, the number 2 of the journal *D^n. Building Information Modeling, Data & Semantics* (published by DEI Tipografia del Genio Civile, Rome) reports the most interesting contributions received and selected by the Scientific Committee this year. At the end of June 2018, a call was launched for the third issue of *Shape grammar & procedural modelling for the humanized space*, aimed at case studies and research or application examples concerning original solutions dedicated to the design of the new and the survey of the existing. The call also concerns each type of visual representation produced through the processing of datasets.
The purpose of the call is to identify a significant selection of original ideas, experiments and real applications, in order to provide a panorama of the state of the art in creativity in the construction of complex models through customized procedures of digital processing. Just the

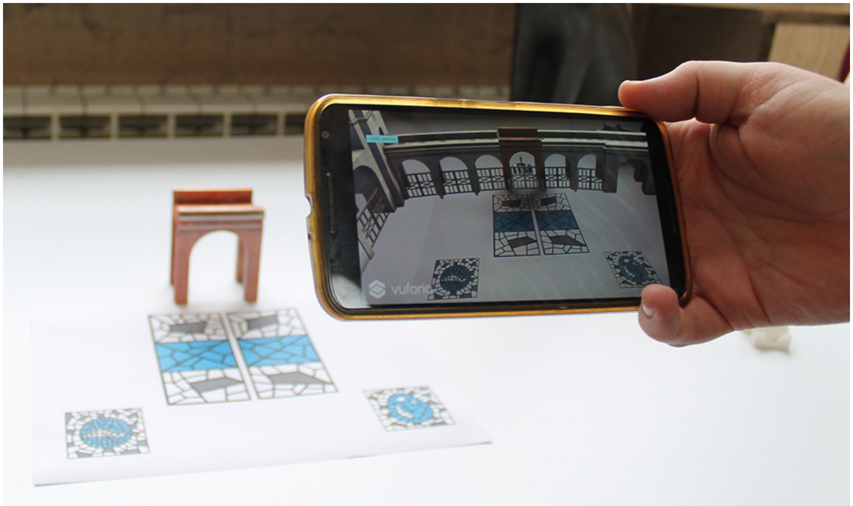

Fig. 2. Synesthesia between augmented reality and 3D printing for the enhancement of cultural heritage: an example set up in the corridors of the Valle Giulia headquarters during the workshop days, depicting the entrance of the carriages into Maxentius' circus (author of the installation Andrea Rastelli; photograph by Alexandra Fusinetti).

meaning of complexity, associated with models and processes, also referring to the deepest etymological meaning of inclusiveness, declined in the most varied activities to embrace as many disciplines/skills/professionality as possible, is always recognizable among the themes of the greatest scientific interest, cultural and operational interests exposed during the days organized by the Roman school.

Notes

[1] The workshop was held under the patronage of UID (Unione Italiana per il Disegno), ANCE Roma (Associazione Nazionale Costruttori Edili) and ACER (Associazione Costruttori Edili di Roma e Provincia).

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Events

Digital Cultural Heritage | International Experiences Documentation, Survey and Representation for Knowledge, Design and Conservation

Valeria Menchetelli

The intensive schedule of the XXV edition of the *Restoration, Museums and Cultural Business Trade Show* in Ferrara included, on the afternoon of 21st March, 2018, the inaugural day of the event, the conference initiative *Digital Cultural Heritage | International Experiences. Documentation, survey and representation for knowledge, design and conservation*, organised and curated by the DIAPReM/TekneHub Departmental Centre of the Department of Architecture at the University of Ferrara, in collaboration with the UID, Italian Union for Drawing, with the scientific coordination of Marcello Balzani and Manuela Incerti (University of Ferrara). The main theme of the conference was the relationship between digital technologies and cultural heritage: the undeniably prominence of this topic, as well as its central role in the international debate, are borne out by the importance given to digitalisation in the development trajectories set out in the European Digital Agenda, in addition to the the institution in 2018 of the European Year of Cultural Heritage, with the aims of promoting knowledge and sharing and disseminating history and culture.

During the conference in Ferrara, the theme was tackled and explained through the presentation of a mosaic of international case studies, which offered a varied and exhaustive overview of the borders of the research programs currently in progress at Italian universities, as well as the principle experiences of those aimed to internationalisation of research activity. Using the projects conducted by the Italian scientific community in the field of representation and architectural, archaeological, urban and environmental survey as its starting point, the UID presented studies and research carried out in cooperation with universities or cultural referents from other countries (China, Iraq, Algeria, Morocco, Vatican City, etc.) and founded on the themes of knowledge, protecting and enhancing the value of cultural heritage through digital documentation. The areas of study covered by the projects presented during the conference featured a remarkable degree of tranversality and a significant variety of application contexts, ranging from specific conservative and museum purposes, which assume a central role in the development of innovative research applications, to knowledge and documentation activities aimed at promoting and disseminating cultural heritage, and enhancing its value.

Coordinated by Marcello Balzani (University of Ferrara), the conference opened with the introduction by Mario Centofanti, vice president of UID, which focused on the elements that provide an expanded definition of cultural heritage, retracing the essential steps in the evolution of the concept of heritage and focusing on the importance of digital technologies in its documentation, from the architectural survey right through to its communication. In fact, the widespread use of IT tools has made possible to develop a large variety of manners for protecting, conserving and enhancing the value of cultural heritage, outlining a complex scenario where the disciplines of representation play a primary role. The series of the case studies was then opened with the intervention of Salvatore Barba (University of Salerno), entitled *Data acquisition using active and passive sensors for digital architecture survey in so-called at-risk countries. Two case studies carried out in Algeria and Iraq* that, in view of the pressing nature of the problems represented by the risk of degradation and destruction of cultural heritage, highlighted some encouraging policies for the digital preservation of architectural heritage and memory of places. In this context, new professional figures are working daily to achieve the goal of a faithful and exhaustive digital documentation of material goods, which in the presence of shared methods of linguistic coding, can contribute to build-

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Fig. 1. Image of the exhibition space dedicated to UID during the Restoration, Museums and Cultural Business Trade Show.

ing a global database. The theme was exemplified through the presentation of two case studies: the first, developed in collaboration with the *Laboratorio de Arqueologìa y Arquitectura de la Ciudad* in Granada, focused on the reconstruction of the mosque and minaret of the Algerian city of Mansourah through the use of a photographic campaign also conducted in remote; the second, which formed part of a training project in enhancing the value of cultural heritage promoted by the Italian Ministry of Foreign Affairs, with the collaboration of the CNR-ITABC, focused on the limestone block aqueduct at Jerwan (in modern day Iraqi Kurdistan), considered the most ancient irrigation system known to history and investigated using laser scanner survey systems.
The second intervention, entitled *Didactic and research experiences at Fez and Tbilisi*, was presented by Paola Puma and Giovanni Pancani (University of Florence), whose studies, on one hand, focused on the relevant aspects for enhancing the value of archaeological heritage and, on the other hand, on the need for digital architectural survey for diagnostic and protection purposes. The *Vani through Virtual heritage* project, which is a collaboration between the Faculty of Architecture at the University of Florence and the Tbilisi State Academy of the Arts-Media Arts department, involves research activity, which is still ongoing, consisting of a digital survey aimed at producing a digitally consultable documentation (with two-dimensional and three-dimensional output) of the important archaeological heritage of the Georgian city of Vani. The survey of the Arch of Caracalla in Volubilis, in the Moroccan region of Fès-Meknès, is part of a cooperation project between the University of Florence and the Université Euro-Méditerranéenne de Fès, which has also seen the launch of the École Euro-Méditerranéenne d'Architecture, Design et Urbanisme de Fès. The survey, carried out using *Structure from Motion* techniques, together with direct measurements aimed at checking and verifying dimensions, has enabled the researchers to build up an exhaustive knowledge of the evolution of the artefact, and has been extended to include a study of its seismic vulnerability, leading to the identification of the potential collapse mechanism on the basis of the comparison with the data emerging from the historical investigations.
The following intervention, presented by Paolo Belardi (University of Perugia) and Simone Bori (Academy of Fine Arts 'Pietro Vannucci' of Perugia) and entitled *Sistina Experience. An international knowledge, protection and value-enhancement experience*, took its cue from the outcome of an integral digital architectural survey of the spaces and works preserved in the Vatican Museums, performed by the Perugian company Archimede Arte, to illustrate the design concept for an itinerant multimedia replica of the Sistine Chapel (in other words, a replica that can be dismantled and reassembled anywhere in the world: from New York to Beijing, from Moscow to Rio de Janeiro, as demonstrated by the speakers' remarkable infographics). The project, developed by an interdisciplinary team drawn exclusively from the Umbria region (Archimede Arte srl of Perugia, 'Pietro

Vannucci' Academy of Fine Arts in Perugia, Department of Civil and Environmental Engineering at the University of Perugia, Tecla srl of Gubbio) was named *Sistina Experience* to underline the possibility of experiencing one of the most famous artistic sites in the world in a multi-sensorial and multifunctional way: a wooden case, which recalls the external dimensions of the Sistine Chapel, and functions as a blank, elementary volume, accommodates replicas of the works of art that it houses, realised through a combination of traditional and innovative technologies, with the aim of creating experiential visual paths capable of rendering visible details and settings that would otherwise be hidden, thereby enhancing the cultural and communicative potential of the copy and amplifying the knowledge and experience of the original cultural asset.

The fourth intervention, entitled *MONADII - Operational Methodologies for New Non-Destructive Approaches to Interoperable Interventions and Management of Cultural Heritage*, was presented by Andrea Giordano and Cosimo Monteleone (University of Padua) and illustrated the results of a research project focused on issues related to the knowledge, protection and management of cultural heritage that makes use of the specialised contribution of Duke University (NC, USA) and Nanyang University (Singapore). The proposed case study is that of the *Scuola del Carmine* in Padua, whose immersive 3D model was created both to serve the needs of the scientific community and to promote tourism; based on the premise that the development of tourism and the management of cultural heritage can benefit from unprecedented synergies between different digital technologies, the research project explores the potential offered by combining and integrating the use of BIM with Augmented Reality. Immersion in 3D space is achieved both through portable devices, which may be used by any operator, and within fixed CAVE (*Cave Automatic Virtual Environment*) stations; Augmented Reality permits the user to experience the BIM model, which is realised by using laser-scanning techniques, directly; moreover, the use of a point cloud constitutes an additional experimental frontier, placing the accent on the *SCAN to BIM* process.

The final case study, presented by Antonio Conte and Marianna Calia (University of Basilicata) and entitled *From urban* Qilou *houses to the rural fortresses of the south-eastern coast of China: research contributions for understanding, protecting and enhancing the value of cultural heritage*, was developed within the context of a broader collaboration between the University of Basilicata, the Polytechnic of Bari, the South China University of Technology of Canton and the Fuzhou University. The research, which was carried out in order to study Chinese urban, rural and landscape heritage, focused on examples located in the coastal strip of the southern Chinese regions of Guangdong and Fujian. Specifically, the historical centre of the city of Guangzhou (Canton), whose residential fabric displays evident influences of Western architecture, presents narrow, extended building lots (*Qilou*) that represent one of the essential characteristics of the traditional Cantonese residence: through documentation and monitoring it was possible to produce maps and diagnostic surveys at various scales, with the purpose of drawing up a manual of good practices for use during recovery and maintenance work and of creating tools to support the regeneration project and the processes of protecting and safeguarding the city-landscape system.

The conference concluded with the presentation of the *open access* biannual journal of the UID scientific society, *diségno*, by Vito Cardone, President of UID, and Alberto Sdegno (University of Trieste), respectively the editor-in-chief of the publication and member of its editorial-coordination committee; the journal is intended to provide space that enables members of the representation scientific community to share and compare their research experiences.

The complete picture of the topics covered during the conference was summarised in a dedicated space at the *Restoration, Museums and Cultural Business Trade Show* in Ferrara; this installation, which was also prepared by Marcello Balzani and Manuela Incerti, allowed visitors to the event to get closer to the experiences developed in the academic field, providing a further opportunity for sharing, distributing and disseminating research results.

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Events

Nexus Conference 2018
Relationships Between Architecture and Mathematics

Barbara Messina

The several relationships between mathematical principles and configurative logic of architecture have made this research topic widely debated [William, Ostwald 2015].
They are apparently antithetical disciplines: on the one hand, architecture which makes explicit in the creative process the genesis of forms and constructive realities laden with artistic values; on the other, mathematics which, with precision and scientific method, measures space. Yet, they are expressions of human thought that find a reason for greater strength and growth in the continuous and mutual confrontation. If, on one side, the logic underlying the architecture gives it the rigor necessary to exorcise the arbitrariness of the formal choices, on the other, the use of precise compositional criteria for the conception of architectural spaces, even complex ones, shows how the rule frees the architect's imagination rather than forcing it [Botta 2003, p. 9].
The *Nexus Conferences*, organized since 1996 at two-yearly intervals and characterized by an international as well as interdisciplinary approach, have been focusing on the close link between architecture and mathematics–declined in various interpretations–for over twenty years.

The twelfth Conference was held this year in Pisa, from 11 to 14 June, hosted by the Department of Engineering of Energy, Systems, Territory and Construction (DESTeC) of the University of Pisa. For the occasion, a '*LOGO Design competition*' [1] was announced, with the aim of selecting an emblematic image of the event's themes (fig. 1). The organization of the conference is in particular by Marco Giorgio Bevilacqua, with the contribution of Stefania Landi, Lucia Giorgetti and Alessandro Ariel Terranova, as well as Kim Williams Books [2].
Moreover, for the first time, the event had the patronage of the *Unione Italiana per il Disegno* (UID) which, as the President Vito Cardone highlighted at the opening of the Conference, appreciated its strong international approach. In fact, taking up his words, the *Nexus Conferences* are the meetings with the highest level of internationalization, among the scientific ones attended by professors of the graphic representation area. For this reason, they are fully part of the cultural policies that the UID has pursued since its foundation.
Forty-three authors, selected on the basis of extended abstracts that were submitted to the evaluation of the Scientific Committee [3], presented their research, all in plenary session, during the first three days.

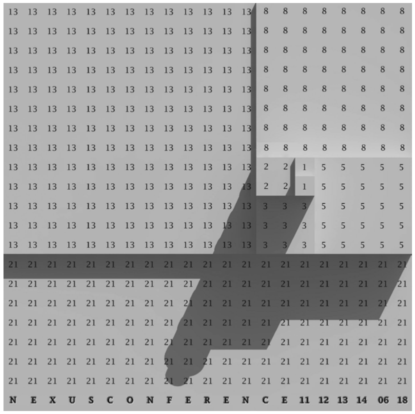

Fig. 1. The logo designed for the Nexus Conference 2018 by Ivan Mechkunov, winner of the 'LOGO Design competition'.

The conference opened with the introduction of Claudia Martini, Prorector for Research at National Level of the Pisa University, Umberto Desideri, Director of the DESTeC Department and Vito Cardone, President of the UID, as well as with the presentation of the event by Kim Williams; moderator was Marco Giorgio Bevilacqua, chair of the Conference together with Kim Williams.
The first day's working sessions, dedicated to *Perspective, Space, Dimension, Geometry*, included a first morning meeting

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entitled *Perspective and space*, coordinated by João Pedro Xavier (Portugal) and two afternoon sessions: *Space and Dimension*, coordinated by Sylvie Duvernoy (Italy)–who also was secretary of the Scientific Committee–and *Geometry*, coordinated by Mine Özkar (Turkey).
The presented interventions had as a common thread a reading of the architecture–or its elements–according to a rigorous theoretical-mathematical apparatus.
In many cases, the authors have investigated the relationships between perspective and architectural space, for example the paper presented by Agostino De Rosa and Alessio Bortot titled *Hunched Curves in the Vatican: the Vestibule Arch of the Pio Clementino Museum, between Stereotomy and Anamorphosis*. In other cases, however, the illustrated papers have directly based on the treatises or have been addressed to architectural practices consolidated over the centuries. The common denominator for all interventions was the rigor of the graphic-geometric procedures at the base of the space's conformation or of the construction of the architectural images.
During the second day, four sessions were held, all on the theme of *Historical Analysis:* the first two, during the morning, coordinated by Roberta Spallone (Italy) and Kim Williams (Italy) respectively. The other two, in the afternoon, were coordinated by Anna Marotta (Italy) and Alessandra Capanna (Italy).
The day has therefore collected papers related to the analysis of historical architectures, which has been generally carried out through a mathematical-geometrical interpretation. The shown examples–referred in some cases to existing buildings in others to imaginary architectures–all highlight a careful research of the logic underlying the project.
The investigated spaces, as evident for example in the paper of Francesca Fatta and Domenico Mediati entitled *The Design of Roman Mosaics in North Africa and their Geometric References*, are described retracing the compositional idea. The aim is to identify their proportions, the not immediately perceptible geometries that define the volumes morphology. In this way, it's possible to understand their true significance, revealing the often hidden reasons of the magic that an architecture can express (fig. 2).
The third day [6], entitled *Contemporary Analysis, Structures, Techniques of Design, Algorithms, Rule-Based Design*, has instead marked the switch from history to modernity. The four planned working sessions have been addressed to different aspects of this broad theme.
During the morning two sessions took place, the first on *Contemporary Analysis*, coordinated by Maria Zack (USA), the second on *Structures and Techniques of Design*, coordinated by Marco G. Bevilacqua. The last two, during the afternoon, have both dealt with the theme of *Algorithm and Rule Based Design*, and have been coordinated by Cornelie Leopold (Germany) and Steve Wassell (USA), respectively.
The papers have sometimes focused on architectures designed by the most creative minds of today's architects and engineers; in other cases, although addressed to structures of the past, they have given new interpretations. The analysed architectures, in fact, have been described through the use of software and digital systems, today an integral part of the design and representation process. Thanks to these, an unprecedented decoding of the space investigated is possible, as illustrated by Manuel Alejandro Ródenas-López, Pedro García Martínez, Pedro Miguel Jiménez-Vicario, Adolfo Pérez Egea

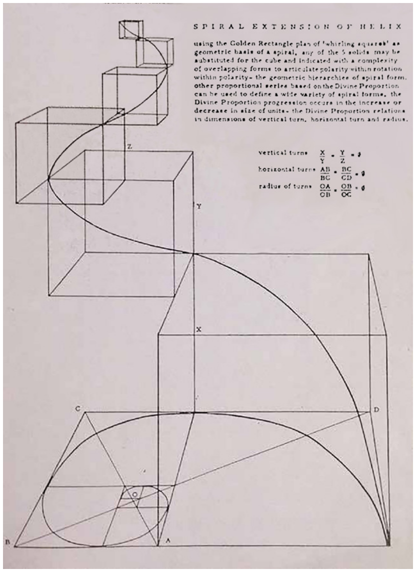

Fig. 2. Anne Griswold Tyng, 'Form finds Symmetry in Geometry', in Zodiac 19, 1969.

and Martino Peña Fernández-Serrano in the paper entitled *Parametric Design applied to Analysis and Optimization of Spatial Deployable Structures.*
The last day, organized in two consecutive sessions–the first co-ordinated by Michael Ostwald, the second by Kim Williams–was opened to the contributions of PhD students and PhDs who have achieved the PhD title in the 2016-2018 biennium in several schools from various countries of the world. Thirteen selected speakers illustrated, to a scientific community of international scope, the results of their research, all with a multidisciplinary approach and focused on issues related to the relationships between architecture and mathematics. It has been a day, therefore, particularly significant,

considering that, often, the research of young scholars remain at the edge of the scientific debate, deprived of an important moment of confrontation.
The Conference as a whole represented a precious opportunity for interaction between different knowledge and orientations of thought, laying the roots for a cultural exchange full of significant implications in the field of scientific research in general and, in particular, for the scientific-disciplinary field of Drawing.
In this regard it is important to highlight the significant participation in the Conference of professors and scholars of graphic representation, who contributed to the proposed research themes with about half of the one hundred and sixteen submitted papers.
This demonstrates the considerable interest that this interdisciplinary meeting has aroused within the area of Drawing, of which the UID is expression. Finally, it should be noted that the presented papers were further evaluated. Following the interventions held during the entire Conference, in fact, have been choosen the contributions considered by the Scientific Committee qualitatively more deserving, on the basis of the originality of the topics, the rigor of the used methodology and the clarity shown in the research proposal.
The selected authors are been invited to develop the extended abstract in in-depth articles to be published in an upcoming issue of the journal *Nexus Network Journal.*

Notes

[1] Fourteen competitors of different nationalities participated to the '*LOGO Design competition*'. The proposals received were evaluated by the Scientific Committee, which selected, as the winning logo, that of Ivan Mechkunov (Bulgaria).

[2] Kim Williams, which is in charge of the same publishing company that published the *Conference Book* [Williams, Bevilacqua 2018] for this meeting, is editor-in-chief along with Michael J. Ostwald of the *Nexus Network Journal*.

[3] Several was the fields of research in which it was possible to propose a contribution:
- *Design theory: mathematics as a design tool*;
- *Design analysis: mathematics used to analyse an existing monument or site*;
- *Geometry: Applications of geometry (descriptive, projective, fractal etc.) to architecture;*
- *Rule-based Design: Shape grammars; parame-tric design;*
- *Representation of architecture: perspective; modelling;*
- *Structures: architectural engineering application; statics related to form;*
- *Computer applications: morphogenesis, digital fabrication, virtual reality;*
- *Didactics: methods, approaches and projects in the classroom, at all levels of education.*

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Events

XVII International EGA 2018 Congress

Andrea Pirinu

Since several years, a regular biennial appointment is the International Congress of *Expresión Gráfica Arquitectónica* (EGA), now in its XVII edition, and held at the Universidad Politécnica of Alicante, organized by the Spanish teachers of the drawing area, in this case belonging to the Departamento de Expresión Gráfica, Composición y Proyectos of the same university.
The study days took place on 30th and 31st May and 1st June within the San Vicente del Raspeig campus, a university complex that, built in the area of the dismissed military airport, hosts several pavilions, the result of design competition which was attended by architects as Álvaro Siza Vieira, who designed the rectorate, and Alberto Campo Baeza, author of the library building.
The title of the congress *GRAPHIC IMPRINT. On the Influence of the Representation and Ideation Tools in Architecture – IMPRONTA GRÁFICA. Sobre la influencia de las herramientas de representación e ideación en la arquitectura* has –in the intentions of the working group coordinated by Carlos L. Marcos– deliberately defined a guideline that could foster the debate on the role that drawing and, more generally the tools of representation and ideation, have in the development of architecture and its language over time. A precise intention that has directed the choice of international guests called to share experiences and suggestions on the topic.
The main topic was divided into seven key focuses with the aim of presenting, through an overview of the current state of the art, the scientific comparison on the relationship between drawing and design, between traditional and digital tools and the result of what was designed, then between graphic expression and architecture in its various forms and applications in history.
The numbers of the conference are very important: compared to 250 proposals received, the results of a review process entrusted to 76 experts led to the publication of 155 contributions of which 137 published in English by Springer in the volume *GRAPHIC IMPRINT. On the Influence of the Representation and Ideation Tools in Architecture* edited by Carlos L. Marcos and 155 published in the book *De trazos, huellas e improntas* in the mother tongue by the curator himself with Pablo J. Juan Gutiérrez, Jorge Domingo Gresa and Justo Olive Meyer of the University of Alicante.
The contributions were focused on these topics: Drawing and Design; Architecture and Representation; Representation of Materiality and Digital Production, Cartography, Mapping, City and Territory, Architecture, Phenomenology, Perception and Interaction; Projections and Architectural Space; Innovation in Teaching and Research.
After the usual greetings by the authorities, the work began with the speech of Pablo Lorenzo-Eiroa, an Argentine architect, who has several collaborations with Peter Eisenman and the Meier-Eisenman-Gwathmey-Holl team, and currently professor of Digital Representation at the New York University School of Architecture.
His report, entitled *Multidimensional space: from Perspective to Big Data* introduced the study days, focusing on the possibilities of digital representation of multidimensional spaces at a time when the use of Renaissance perspective is replaced by diagrams and topological relationships between multidimensional and multi-scale data.
Then, the various sessions started, including the one moderated by Edoardo Carazo (Universidad de Valladolid) and the one by Vito Cardone (University of Salerno), both mainly dedicated to the focus I, titled *Drawing and Design*. Each session was characterized by papers on the theme of the historical evolution of the tools for the representation of the project

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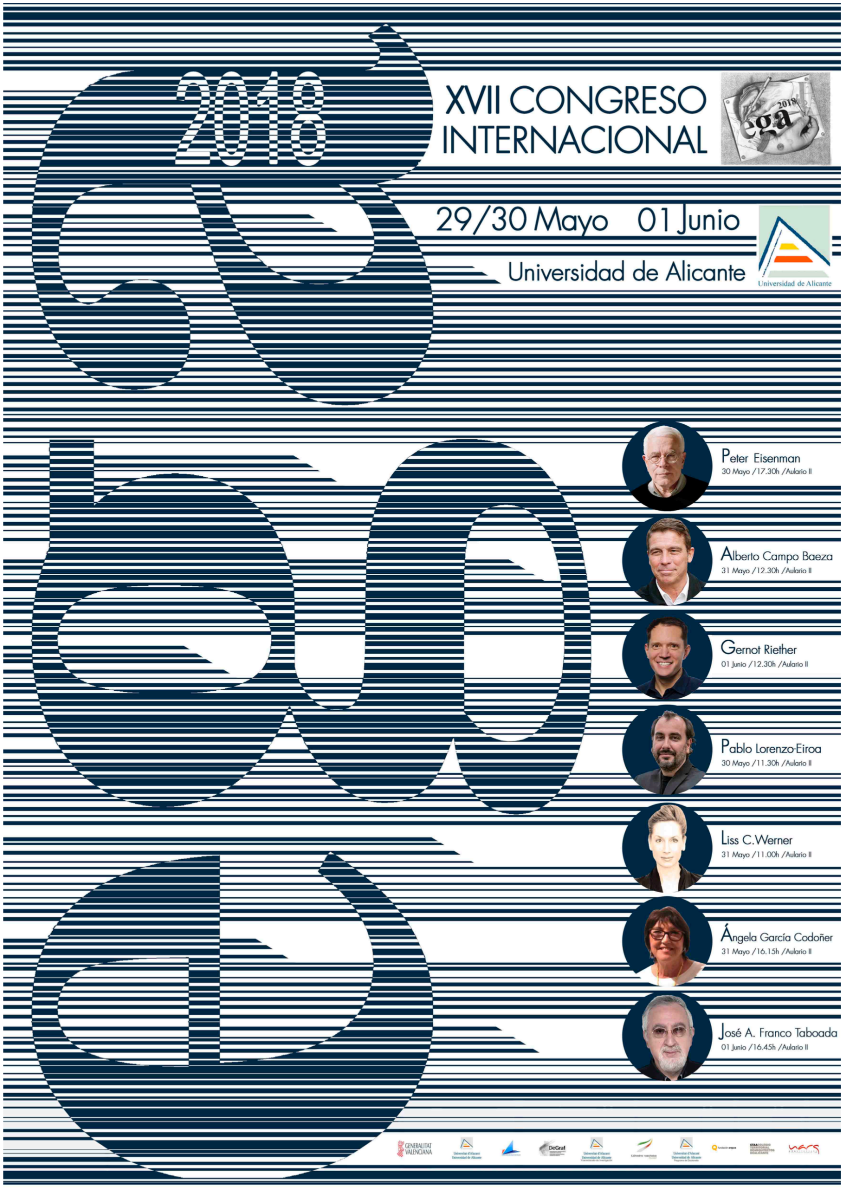

Fig. 1. Conference poster: <https://www.google.com/search?client=safari&rls=en&q=EGA+2018&ie=UTF-8&oe=UTF-8>.

and for the survey and communication of architecture, management and use of historical heritage through digital tools and BIM; the proposed selection animated the session on the role of drawing as an carrier of ideas, analysis tool and mean of thinking about architecture.
Then Peter Eisenman held the opening lecture followed by a round table with the participation of Alberto Campo Baeza, Cynthia Davidson, Antonio Millán, Pablo Lorenzo-Eiroa and Carlos L. Marcos. Eisenman's intervention reiterated the usefulness of using digital models as a means to be able to directly work on the project in the three dimensions, with interactive manipulation tools that accompanied his design activity, and which are also evident in the latest works, among which the Carlo Erba Residences in Milan, of which he showed the key steps that led to the final solution of the project still under construction.
At the end of the first day, the inauguration of the Alberto Campo Baeza's exhibition took place in the spaces of the Museum of the University of Alicante. The exhibition was titled *Pensar la Arquitectura – El bisturí en la línea. Razón, precisión y mesura en el dibujo y el pensamiento arquitectónicos* with a wide presentation of sketches, made mainly on white paper, models and video.
The conference continued the following day with presentations on the focus II Architecture and representation, proposing some contributions on a theme that sees drawing as a faithful anticipation of what will have to be "materialized" described with the necessary detail capable of communicating how architecture must be built. A particular reflection was conducted

on the role of ICT (Information and Communication Technologies) in the way of representing architecture, in the form of figurative verisimilitude – through the use of synthetic images– or in the form of graphic documents starting from the 3D model or in the construction of a geo-referenced and structured database so as to assume every single element of the model as a faithful representation of each of the real components of the project.
In this session some elaborations were also presented with BIM software (Building Information Modeling) associated with the advanced survey that employs digital technologies characterized by very high metric and photorealistic precision such as AHBIM (Architectural Heritage BIM) which provides an interaction between digital model and augmented reality. The following sessions related to this focus were held with the presentation of the speeches moderated by Liss C. Werner (Technische Universität Berlin) and Mara Capone (University of Naples "Federico II"), ended with the intervention *Winking my eyes* by Alberto Campo Baeza and the usual round table.
The afternoon of the same day was opened by Ángela García Codoñer recalling the 25-year history of the *EGA* magazine and continued with sessions coordinated by Emma Mandelli (University of Florence) and Enrique Solana (Universidad de Las Palmas de Gran Canaria) during which some essays about *Architecture, Phenomenology, Perception and Interaction* were presented to highlight a growing interest in a research that involves cognitive perception and psychology in relation to architecture and graphic language, also thanks to the possibility offered by the digital interaction/immersion in the built environment.
The last day, Marta Úbeda (Universidad de Valladolid) and Javier F. Raposo (Universidad Politécnica de Madrid) moderated sessions focusing on different themes including traditional (urban sketching) and digital techniques for landscape representation, BIM, new strategies in project teaching, graphic representation and geometric analysis of historical architecture.
During this day, Gernot Riether (College of Architecture and Design, New Jersey Institute of Technology) –reconnecting to the focus *Representation materiality and digital fabrication*– held the keynote lecture entitled *Construction as a Creative Act. Design Build in the Digital Age* rising the attention about the opportunities that the progress of digital tools and their accessibility can create for architects about architectural design, manufacturing and production. This focus was centered on the revolution in the field of representation, following the replacement of drawings with three-dimensional models and 3D prints, with applications in the field of prototyping and mass production. These topics were also taken up by José F. Taboada (professor emeritus of the Universidad de La Coruña) in the invited report *La tridimensionalidad arquitectónica en modelos y maquetas. Su papel en el proceso de ideación y configuración del proyecto a lo largo de la historia*.
Finally, Taboada moderated the last scheduled session focusing on innovations in teaching and research.
The usual final round table concluded the evening and a well-organized event full of interesting ideas for research and teaching in the field of representation sciences: a scientific meeting that, with a wide participation of teachers of Italian universities often in collaboration with the Spanish colleagues, confirmed the intense relationships in progress among the scholars and reiterated the common cultural line that moves the initiatives of the UID and EGA conferences.

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