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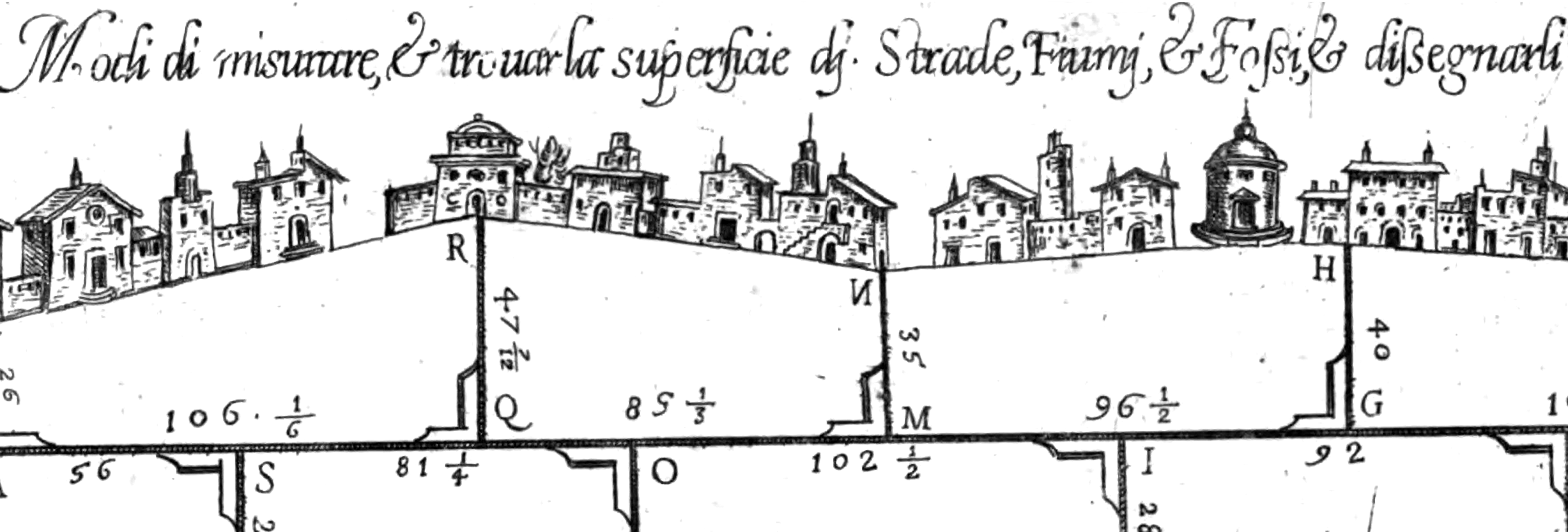

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DRAWING AND MEASUREMENT

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Pomodoro G. (1599). Geometria prattica, tratta dagl'elementi d'Euclide et altri auttori..., Roma: Stefano de Paolino. Tav. XXXIIII, detail.

The articles published have been subjected to double blind peer review, which entails selection by at least two international experts on specific topics.
For Issue No. 7/2020, the evaluation of contributions has been entrusted to the following referees:
Fabrizio Agnello, Piero Albisinni, Laura Baratin, Salvatore Barba, Marco Giorgio Bevilacqua, Carlo Bianchini, Fabio Bianconi, Maurizio Marco Bocconcino, Stefano Brusaporci, Marco Canciani, Cristina Càndito, Laura Carnevali, Andrea Casale, Emanuela Chiavoni, Alessandra Cirafici, Antonella di Luggo, Laura Farroni, Paolo Giordano, Carlo Inglese, Fabio Lanfranchi, Alessandro Luigini, Federica Maietti, Marco Muscogiuri, Leonardo Paris, Ivana Passamani, Fabio Quici, Michele Russo, Nicolò Sardo, Roberta Spallone, Graziano Mario Valenti.

English translations of the editorial and of the essays by Roberto de Rubertis, Francesca Fatta, Marco Gaiani, Ornella Zerlenga sono di Elena Migliorati.

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Editorial

Francesca Fatta

This issue is dedicated to the memory of Cesare Cundari, who suddenly left us on November 23, 2020, in the days during which the editing and the preparation of the texts for publication were nearing completion.
Measurement and Cesare form a very intimate bond, both scientific and in terms of character.
He founded his activity as a researcher on measurement, from descriptive geometry to the elements of photogrammetry, to architectural survey, revealing the dimensions of great monumental complexes such as Monteoliveto in Naples, and Castel Sant'Angelo in Rome.
And measure could also be read in the traits of his character, like a polyhedron with many edges. He moved with measured gestures, waiting for the right moment to open himself with generosity and much affection.
With him, UID has lost a Maestro and a Friend.

"Measure what is measurable,
and make measurable what is not so"
Galileo Galilei
Cit. in AA.VV. (2018). *Il libro della scienza*
(tran. M. Dominici e O. Amagliani). Milano: Gribaudo, p. 43.

The theme of Issue No. 7 of *diségno* originates from former solicitations that always regain a great sense of relevance. The return to the term measure is an authentic aspect of the present condition that tends to become lost in less and less measurable liquid spaces.
Today the uniform nature imagined by the mathematicians of the seventeenth century presents less linear measures in a space where the qualitative apparatus has, in any case, also substantiated the quantitative one of measure itself; a complementarity is sought between the two categories that in synthesis again find the harmony of measure.
The antecedents that I would like to recall date back to 1989, when Adriana Baculo, in Issue No. 9 of *Quaderni Di* entitled *Smisurate misure!* (Immeasurable dimensions!) wrote: "To obtain a sum or a remainder it is necessary to establish measured limits, created in relation to conventions, customs, traditions, languages. These are the rules capable of tracing the horizons within which we move, not without falling into the temptation to go forward and backward, weaving a weave of threads straddling that limit. […] To calculate differences means to catalogue and compare, to measure and then recognize that measurement itself can be abandoned, that the rule can be replaced by another rule." [Baculo, A. (1989). Premessa. In *Quaderni Di* 9/1989. *Smisurate misure! Differenze di scala di fattura di ruolo informativo di significato*, p. 3].
A few years later, in 1991, the Fifth Spring Seminar organized by Rosalia La Franca and dedicated to *Il disegno di architettura come misura della qualità* (Architectural drawing as a measure of quality), the theme of measurement was confronted with the two categories of quality and quantity: "architectural drawing measures quality because drawing is essentially projectual, that is, it allows us to represent, with decipherable forms, what is announced by the project itself, but which does not yet exist in reality. Through drawing, therefore, the choice of the project is made as, on the other hand, through drawing, the interpretation of the belonging, the recognizability of the universe of the forms already produced is made. This means that drawing gives form to quality with the expedient of measurement, therefore of quantity" [La Franca, R. (1993). L'intero come eccedenza della somma delle parti. In AA.VV. *Il disegno di architettura come*

misura della qualità. Atti del Quinto Seminario di Primavera, Palermo, 16, 17 e 18 maggio 1991. Palermo: Flaccovio editore, p. 32]. Twenty years later, Franco Purini presented the exhibition *Gli Spazi del tempo. Il disegno come memoria e misura delle cose*, which featured twenty ink drawings in which the sense of measure was interpreted with the citation of just a few architectural elements: walls, stairs, windows, which observe a deliberate dimensional ambiguity between measure and immoderation, space and time, memory and project [Purini, F. (2011). *Gli Spazi del tempo. Il disegno come memoria e misura delle cose*. Roma: Gangemi editore].
There are three interpretations of the relationship between drawing and measurement that we would like to highlight. Three events that can be considered independent, given the different meanings given to the word 'measure', but closely connected since they refer to the practice of 'drawing.'
The act of measuring has an ancient depth supported by the epistemological thought of the great philosophers, mathematicians, scientists. The sensitive–therefore subjective–sphere of drawing is confronted with the phenomenological therefore objective–sphere of measurement. A dialectic that, in parallel with the word, only drawing can be able to unravel.
For those who express themselves through drawing, and with drawing do research, measurement is a value that is expressed through a graphic description and relates in a multidimensional context by implementing algorithms that are formalized in compositions substantiated by deep geometries.
Measurement is the certainty that anchors us to a present that can be quantified, systematized, classified, compared and modified according to scientific procedures that can be followed and that are comparable. If we take as an example the debate stemming from the themes of architectural surveying, the question of measurement is always ignited (and set ablaze) with renewed interest, in relation to the refinement of the instruments and to the growing number of experts from different scientific disciplines increasingly involved in the science of metrology.
But measurement cannot be reduced to a merely quantitative characteristic, its qualitative distinction must also be sought for. From the secret geometries of artists, to the art of composing, to the dimensions of the different contexts of 'doing architecture,' measurement establishes the link with the spatial dimensions according to the rules and geometric-mathematical models (Euclid, topological, fractal, differential) that have a refined and superior theoretical consistency in which the imaginative action operates with great incisiveness.
The contributions have been divided into four topics in order to articulate this extensive discourse: the first, *Drawing and measurement for building a cosmic harmony*, is opened by Roberto de Rubertis, who invites us to refer today to a harmony that considers drawing more as intention (program, purpose), and measure as balance.
This is followed by the second topic *Drawing and measurement for structuring scientific knowledge*, entrusted to Stefano Brusaporci, which deals with "instruments for measuring by sight."
Drawing and measurement for defining a reason between thought and project is the third topic, opened by Riccardo Florio in dealing with the necessary dialectic drawing/project, to bring into play a process of transformation between man and reality. The fourth and last topic, *Drawing and measurement for communicating the complexity of images* is approached by Edoardo Dotto who, in a play between the parts, relaunches the need for a synthesis between the need to govern large amounts of data and the need to identify and manage those essential for ensuring an immediate and effective understanding of the forms.
These are thematic openings that stand out for their freedom of approach and their way of interpreting the significant binomial between science and art and between ontological qualities and quantities. The authors of the essays outline a scientific path reflecting their specific interests on the subject according to a common thread that links the need to govern the large quantities of data related to measurement, and the need to identify and manage, through drawing, the essential elements that then define the quality of the artifacts.
The thematic section dedicated to the Image has been entrusted to Laura Carlevaris, who proposes a commentary on Luigi Ferdinando Marsigli's *Mappa Metallographica*; while Ornella Zerlenga, for Readings/Rereadings, deals with the classic text by Leon Battista Alberti, *Ludi matematici*.
The issue ends with the reviews of the events that have characterized these last months of 2020 and of several volumes received from authors working within our Scientific Disciplinary Sector.
As always, I would like to conclude with a heartfelt thanks to all the editorial staff for their work, and with the hope that the contributions of this issue will increase our knowledge and create new perspectives for research on the theme.

The Drawing of Measurable Space and of Calculable Space

Francesca Fatta

"Man is the measure of all things:
things which are, that they are, and
things which are not, that they are not"
Epigram attributed to Protagoras (490 BC-400 BC)

A science for measuring the earth

In the third century BC, it happened that Eratosthenes of Cyrene (a city located in today's Libya) wanted to measure the radius of the earth, and he tried to do so using the instruments that were available to him at the time. The experiment gave an incredible result, obtaining a measurement that differs only 5% from the value currently known. The merit of Eratosthenes was to make a measurement with a good degree of accuracy using only one instrument: the gnomon, which is a stick planted vertically in perfectly flat, level ground [1].
This demonstration marked an important milestone in the field of mathematical science and of the measurement of the space within which we move. The measurement, both ancient and modern, of the earth, whether arable or constructible land, in a reference to farmers and masons [Serres 1994], is a mathematical geometric science. Geometry is a word derived from the Greek *γεωμετρία*, which is a fusion of the words *γή*, 'earth' and *μετρία*, 'measurement.' Stemming from its universal etymological meaning, 'measu-

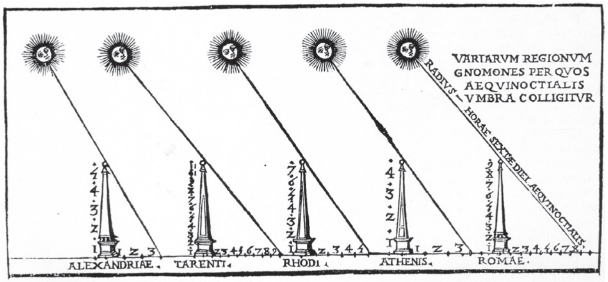
This article was written upon invitation to frame the topic, not submitted to anonymous review, published under the editor-in-chief's responsability.

rement of the earth,' many other geometries and relative measures are differentiated: the simple figures of Pythagorean arithmetic, Plato's World of Ideas, Euclid's elements, Piero della Francesca's perspectives, Descartes' axes, the descriptive axonometries of the Industrial Revolution, the non-Euclidean reconstructions, Leibniz's *Analysis Situs*, the topology of Leonhard Euler, Georg Friedrich Bernhard Riemann and Henri Poincaré. Geometry is a *complex unicum* that deals with the science of measurement and adopts reasoning to prove all differences; it constitutes an objective investigation that observes reality with the detachment of universality.
But within this universality, the many geometries are nevertheless united by the Euclidean principles to which they all refer. In any case, the square and its diagonal, the triangle and its elements are present in every geometry, as if to testify the origin of everything, even if they refer to different systems of thought.

Measurement between space and time

Historians of scientific thought such as Alexandre Koyré and Michel Serres relate measurement to two important parameters: space and time. They propose a profound reading of the connection between infinity and eternity and of the inferences generated, especially between the sixteenth and eighteenth centuries, by the space-time relationship, which called into question all the elements of culture and common experience [Koyré 1988; Serres 1994].
The infinite, which eluded the Greeks, was dealt with by Titus Lucretius Caro, in *De rerum natura*, with the theory of space

Fig. 1. Cesariano, Measurement of the meridian solar radius on the day of the equinoxes as a function of latitude, 1521.



being 'infinite in all directions': "If the existing space were to be considered limited, assuming that a man runs forward towards its furthest boundaries, stops at its outermost limit and then hurls a flying javelin, do you think, once thrown with great force, the javelin will fly to a certain distance, or do you think that something will obstruct its trajectory to stop it? Either of the two suppositions cuts off your escape and forces you to admit that the universe stretches without end" [Lucretius, I, p. 420 foll.].
Nicolaus Copernicus, in 1543, published his treatise on the revolutionary theory of the earth revolving around the sun, questioning all the relationships between man-earth-space, and Giordano Bruno, in the wake of the new science, wrote fifty years later: "Henceforth I spread confident wings to space; I fear no barrier of crystal or of glass; I cleave the heavens and soar to the infinite" [Bruno 2002, vol. 2, p. 31].
René Descartes took up the same concept, differentiating the *Res extensa*, the physical world, and the *Res cogitans*, the human mind, two distinct realities from which the idea of measurable and immeasurable space springs: "The extended matter that composes the universe has no limits, because, wherever we would try to feign them, we still can imagine indefinitely extended spaces beyond, and because we do not merely imagine them, but we conceive them to be in fact such as we imagine them, in such a way that they contain an indefinitely extended body, for the idea of extension that we conceive in any space whatsoever is the true idea that we must have of body" [Cartesio 1644, parte II, par. 21, p. 52]. Cartesian thought generates the idea of an absolute space that Newton connects to an absolute time suitable to the spirit of modern man: "All things are placed in time as to the order of succession; and in space as to the order of situation" [Newton 1965, p. 104].
Space 'flows' like time, and time 'passes' like the water of a river or expands like music, made up of flows connected in such a way so as to compose the movement in which the oldest roots of the Italian word 'tempo' (time) are found: *τεμννω*, 'cut into parts,' and *τεὶννω*, 'extend continuously.' Immersed and carried along in a stream of harmonies generated by general and specific intuitions, man lives, thinks, invents, composes and remembers his own time and plunges into it, as if into a river. Michel Serres argues that time does not flow but 'percolates,' that is, like a liquid, it filters through a mass, more or less slowly depending on the density of the mass itself [Serres 1994]. The result is an idea of time that advances, stops, turns back, goes forward again, reconnects and intersects objects, spaces, thoughts and words.

Man lives his own time, which in turn, while 'percolating,' deforms space and shapes it according to the geometry regulating it. Perhaps this is precisely why there are many geometries, to identify time spheres or flows that flow differently.
To measure the earth through geometry means, according to Serres, writing "a universal language that neither engraves nor traces any mark on any medium since no figure shown on it could correspond to the one it in truth measures and proves. In order for no point or stylus, as sharp as you'd like, to be able to cut or incise into it, in order for no engraving or wrinkle to be preserved in it, a more than adamantine hardness, infinite, and a more than aquatic, aerial or ethereal softness, infinite as well, are required for this earth whose material or special consistency causes the infinite of a maximal resistance and the infinite of a minimum of light breath to become equal in it" [Serres 1994, pp. 10, 11]. Thus measuring means accessing a land that is not the domain of geography, but a 'non-place' that includes all the knowledge of the universe, from astronomy to biology, art, music, architecture.
Geometry measures both physical and mental places; Albert Einstein clarifies that, if it were to investigate only physical spaces, it would cease to be an axiomatic-deductive science to become part of the natural sciences; this frees measurement from the behavior of physical bodies and to assume conventional values deduced from the type of geometry adopted. In this regard, the conventional value of geometry is proposed by Henry Poincaré, who supports the theory that there are no geometries 'truer' than others, but only geometries 'more functional' or suitable to the measurement that needs to be produced. Just as Newtonian space represented a convention that was well suited to the scientific discoveries of that particular moment in history, the geometry of the Greeks based on proportions was equally suitable for defining the dimensions of the classical world.

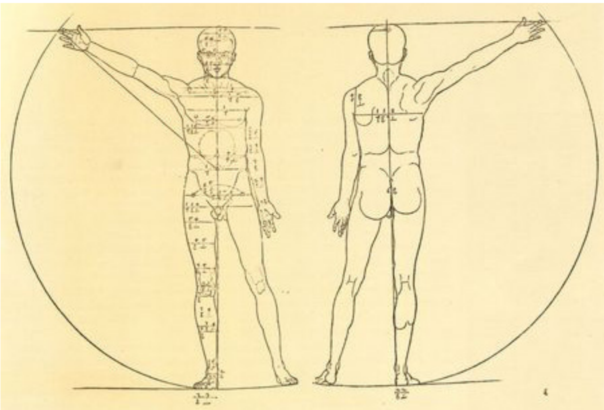
The dimensions of geometry

All geometries have a common basis, a three-dimensional continuum identical for each one; they constitute an indispensable science for relating the mind with space; but we must go back to the Pythagoreans to find the first school of thought in which the study of the world was expressed in terms of number and measure. Mathema-

Fig. 2. Daniele Barbaro, Cover of I Dieci libri dell'architettura by M. Vitruvio, 1556.

tical science for the Pythagoreans was applied mainly to numbers and to the geometric constructions that could be deduced from them: the mind produces numbers applicable to the formal qualities of the real world so that a certain geometric figure, however it is present in nature, will always have the same characteristics for the intellect and the same geometric-mathematical laws will always be applicable to it. The Pythagorean spirit considers number not a symbol, but a 'thing,' and 'things,' according to this school of thought, take on the appearance of geometric quantities: the sequence of numbers is a line, the product of two numbers is a plane, and of three numbers, a volume, since it is conceived as a combination of points. "The unit is conceived as a point having position and extension: a number both even and odd. Even numbers are, in fact, made up of units that are represented in equal quantities on one side and the other of another unit or point. The juxtaposed units form fields (*χώρα*) that represent numbers, and the properties of these numbers are in turn determined by the figures they give rise to. These figures can be of one, two or three dimensions and thus we have (linear) numbers in general, 'plane' numbers and 'solid numbers.' Euclid did not ignore this tradition and defined the plane number as the product of two numbers and the solid number as the product of three numbers. Plane numbers, then, according to the different properties of the figures that arise from the arrangement of their units are further

Fig. 3. Albrecht Dürer, Figure in metric scale, 1528.



defined as triangular numbers, square numbers, gnomon numbers, oblong numbers; solid numbers were considered tetrahedral, cubic (hexahedral) numbers etc." [Bairati 1952, p. 29]. A vision of the number is thus deduced analogous to a figurative construction consisting of or designed from geometric units that express the representation of mathematical facts. Form (*εἶδος*) and number (*λόγος*) mark a conjunction between concrete and abstract, measure and reason. A theory that does not intend to measure nor calculate, but to 'harmonize,' in simple ratios, the relationships between the parts.
Cesare Bairati observed that when the tension of the relations generated by the magnitudes is understood by the observer, then the sense of human rationality is satisfied. But the aesthetic emotion goes far beyond, it invests the spirit, and yet none of the many factors that intervene in the poetic synthesis lends itself to the reading of the artifact as much as the numerical entity. In the Egyptian pyramids, the unity of the architecture is expressed by the simplicity of the form, that seems to exalt the concept of absolute unity in the vertex. The major Roman architectural works put the accent on the volumetry of the organism that shapes harmonized, unitary spaces; while Gothic cathedrals find their unity in the overall structure and in the detail of the construction according to vertical directions and geometries, Renaissance geometry finds its unity in the central plans of its buildings, surmounted by domed vaults, the maximum expression of the spatial unity of the composition.
The concept of compositional unity in the Baroque period is to be referred to the symmetrical scheme of the plans and façades; the absolute obedience to symmetry gives rise to, despite the spatial jaggedness given by the redundant decoration, an impression of unity expressed (and emphasized) with vigor.

Space and symmetry, time and *eurythmia*

Symmetry, from the Greek *συμμετρία*, composed of *σύν*, with, and *μέτρον*, measure, represented for the Greeks all that is commensurate, proportional. The notion of symmetry as a harmonic proportional system became canon, a unit of measurement that goes beyond number itself. Of symmetry, one of the best definitions of the original term is that of Hero of Alexandria (Ist century BC), who considered symmetrical quantities those measurable with a

common measure, and asymmetrical quantities those that do not have a common measure. Vitruvius, in Latinizing it, makes the concept broader, though less precise, referring it to the "harmonic relationship of the individual members of a building" and "proportional correspondence, calculated in modules, of the individual parts with respect to the overall figure of the work" [Vitruvius, Book I, Chap. 2].
Symmetry contains within itself two categories, one logical and the other aesthetic, and all the works by authors of treatises can be read from two different angles. These texts always deal with these two moments, theoretical and operative, and the treatise, with all its rules, becomes a code of interpretation and measure, even aesthetic, and Leon Battista Alberti, Filarete, Sebastiano Serlio and Andrea Palladio, on the Vitruvian model, clarify (or simplify) the complexity of reality. Thus, at the end of the sixteenth century, Mons. Daniel Barbaro interpreted Vitruvius: "Order is thus comparison of inequalities which commences in a previously taken quantity (notion of module) that serves as a regulator for all the parts and refers to those and to the whole, making an agreement of measure called symmetry" [Barbaro 1567, p. 28]. These considerations contain notions of quantity that determine the aesthetic criteria referred to architecture, the mother of all arts.
A few centuries later, Le Corbusier wrote, "In order to construct well and to distribute your efforts to advantage, in order to obtain solidity and utility in the work, units of measure are the first condition of all. The builder takes as his measure what is easiest and most constant; the tool that he is least likely to lose: his pace, his foot, his elbow, his finger. In order to construct well and distribute his efforts to advantage, to obtain solidity and utility in the work, he has taken measurements, he has adopted a unit of measurement, he has regulated his work, he has brought in order. […] He has imposed order by means of measurement. […] By imposing the order of his foot or his arm, he has created a unit which regulates the whole work; and this work is on his own scale, to his own proportion, comfortable for him to his measure" [Le Corbusier 1973, pp. 53, 54].
The sense of proportion, the study of ratios and proportions, the concatenation of proportions in symmetries and *eurythmia* are based on the mathematical order of the parts in analogy with musical harmony. The belief that architecture is a science and that each part of a building must be integrated into a single system of geometrical-mathematical relations can be seen as the fundamental axiom of architects of the classical age. This system was born from the proportions of the human body, the highest and most complete expression of 'divine will.' Within themselves, architectural proportions must comprise and express the cosmic order. This order is revealed by Pythagoras and Plato and taken up in a cosmic key by Renaissance theories.
On the other hand, the harmony of the infinitely great is already reflected in the infinitely small in God's command to Moses when he ordered him to build a tabernacle on the model of the universe; later, Solomon transferred those qualities to the Temple of Jerusalem, in the architectural proportions.

Fig. 4. Matila Ghyka, Les nombres et les forms, Planche V, in: Philosophie et mystique du nombre, 1952.

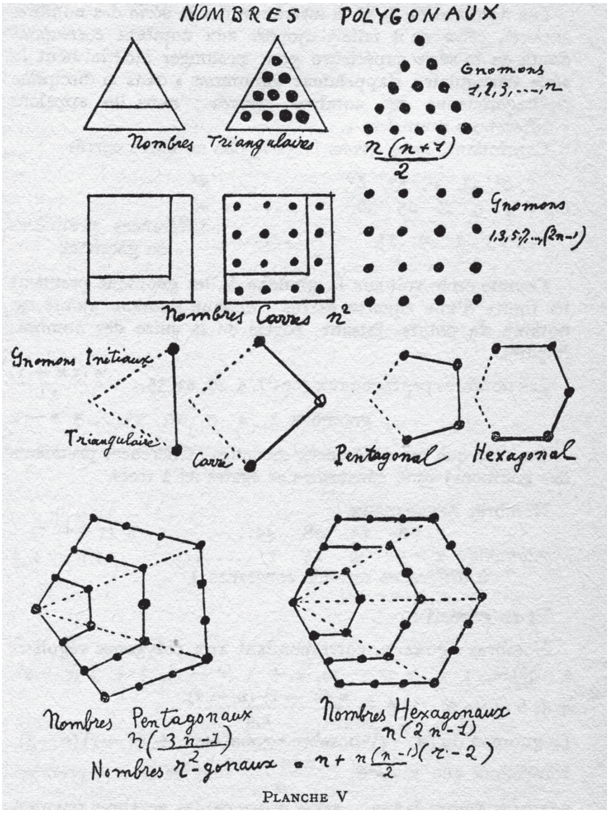
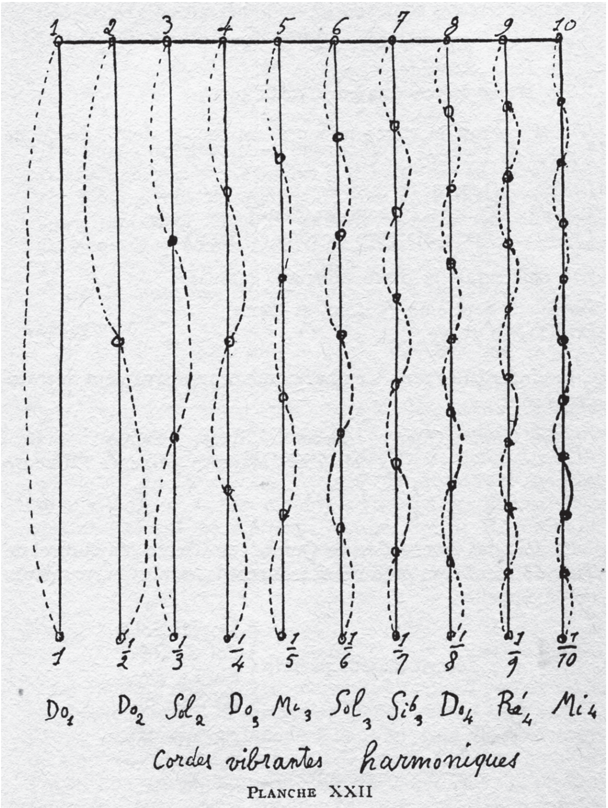


Fig. 5. Matila Ghyka, Le nombre et la musique Planche XXII, in: Philosophie et mystique du nombre, 1952.

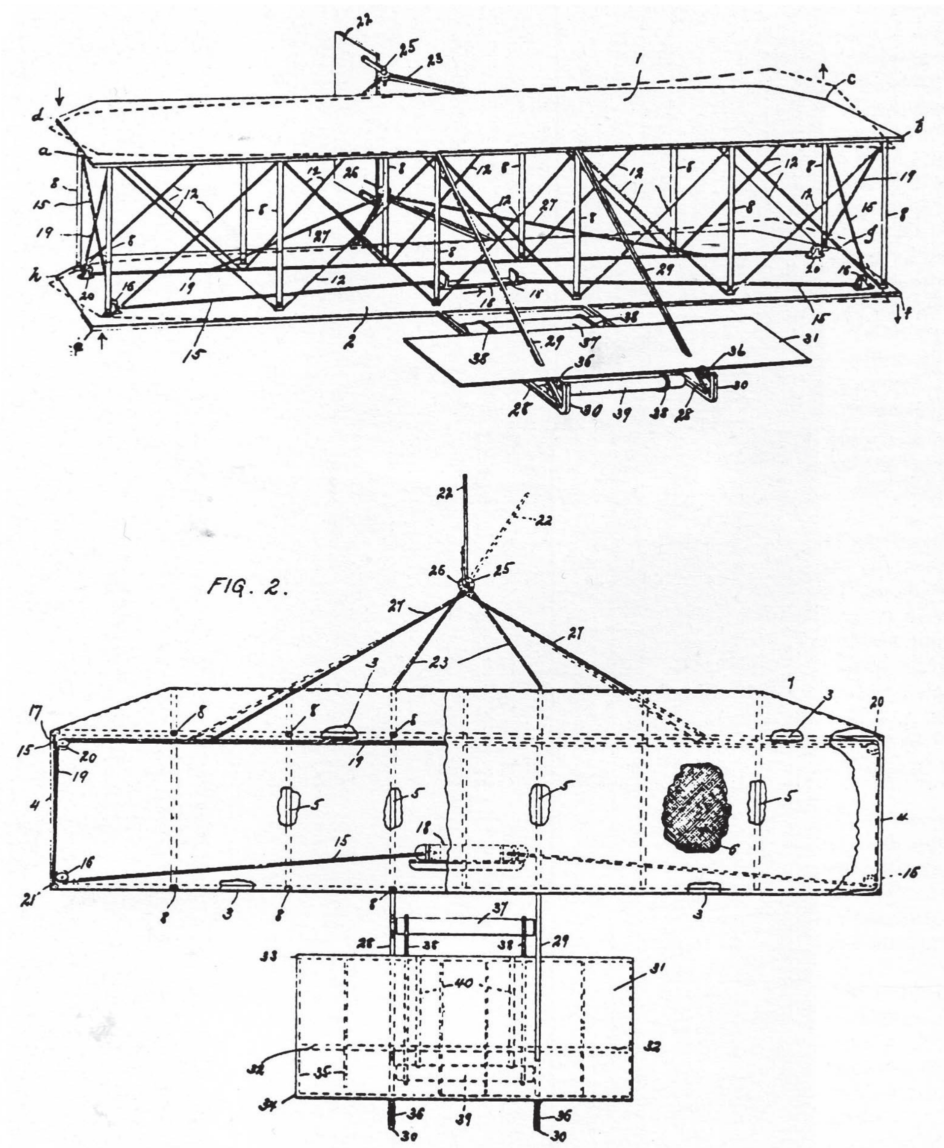


Order, clarity, simplicity are the prevailing requirements in the beauty of classical compositions where number and measure are revealed in the highest aesthetic expression. These are commonly summarized in the concept of 'serenity' (what aesthetics at the beginning of the twentieth century called *Einfühlung*), as architectural forms are 'ordered' according to a perceptive understanding of the dimensions. The 'symphonic' concept of architectural composition, and of artistic work in general, derives from the classical idea of a measured and harmonious universe, musically ordered according to a comparison made by the Neo-Pythagoreans between the geometric theory of proportions and that of the intervals of the musical scale.

Measured rhythm

Auguste Choisy wrote that *eurythmia* seems to imply a rhythmic composition [Choisy 1873], and, in fact, the etymology of the word derives from the Greek *αριθμός* and *ρυθμός* (from *ῥέω*, flow), which both mean number; the first refers to the isolated number and gave rise to the arithmetic meaning, the second is used to indicate the number as an element of a succession governed by a law and gave rise to the word 'rhythm' with which the concept of periodicity, of measure is expressed.
Architecture, "composition, structure, the way in which the various parts of an organism or work are designed and distributed," [2] participates from an aesthetic point of view in the 'arts of duration.' One can also speak of rhythm for architecture, in analogy with music, substituting 'space' for 'tempo.'
Matila Ghyka studied the analogy between architectural and musical *eurythmia* at great length. He drew on Pythagorean and Platonic aesthetic studies that, for the arts of space proposed the human body as a model of ideal *eurythmia* [Ghyka 1938]. For architects, the temple was the 'proportional medium' in the mystic universe-human proportion; but just as the human body had provided architects with models of eurythmic lines and proportional scales from large to small, for the "arts of duration," man returns as a model for the rhythms that vibrate in him, which are the expression of his soul, his vitality [Ghyka 1938]. The two vital psychophysiological cadences: heartbeat and breathing, give us a sense of the search for the fundamental rhythm, for an order that flows within us. These natural rhythms each involve a tension, a deceleration and a pause. Similarly,

Fig. 6. O. e W. Wrigth, Technical table illustrating the flying machine, U.S. Patent Office, May 22, 1906 (patent and design) [Rassegna n. 46 1991, p. 43].



human physiology also searches for rhythm in visual perception. The measure of architecture is structured rhythm; the aesthetic function takes on the role of making this scansion evident to the eye by defining rhythms and measures that in turn are formalized into 'styles.'
It has already been said that aesthetics had a strictly mathematical starting point with the theory of proportions and symmetry; it has also been mentioned that initially the meanings of 'rhythm' and 'number' were equivalent; and it has been observed that the ratios or periodic series that identify proportions or rhythms are perfectly expressed in numbers, both integer (discontinuous proportions) and irrational (continuous proportions). These numbers and their geometric figurations, for the "arts of space," were examined in detail in the works dedicated to the study of Greek canons with renewed enthusiasm at the beginning of the twentieth century.
Proportions, canons, the golden ratio, anthropomorphism, symmetries and regulating lines were restored to the tradition of design, they became tools that facilitate the creation of spatial arrangements, essential for the structuring of a renewed geometric language of architecture.
Jay Hambidge published *Dynamic Symmetry* in 1919, Paul Valéry published *Eupalinos ou l'Architectur*e in 1921, Miloutine Borissavlievtic published *Théories de l'Architecture* in 1926 and Matila C. Ghyka, *Le nombre d'or* and *Estetique et proportiones dans la nature et dans les arts* in 1926; the rereadings of texts such as August Thiersch's 1888 volume also promoted this interest.
Le Corbusier, taking up the theories on the module, devised the Modulor: a range of double measures derived from the subdivision, according to the golden ratio, of the average height of a man (red series), and the height of a man with his arm raised (blue series). He thus realized a modern synthesis between man and space for the design of houses and the modern city. Just as Le Corbusier attempted a synthesis between classical language and modern architecture, the Bauhaus school also interpreted the efforts to re-establish contact between the structure of the object and its aesthetic value through the search for a renewed link between nature and geometry, structure and form.

Measure and/is module

The module is a measure, according to the meaning of the Latin word '*modulus*', that is, element, model, quality to be compared to a whole [3]. The module, in architecture and classical art, is the unit of measurement that lies at the basis of any proportional calculation between the individual parts of the work and the whole, and vice versa. Established on the basis of technical-constructive, aesthetic, mathematical criteria, the module was the compositional rule linked, in particular, to the syntax of orders. In Greek architecture it was identified with the base of the column shaft (*imoscapo*), or with the distribution of triglyphs. This criterion was taken up by Vitruvius (Ist century BC) and later, from the Renaissance on, it was investigated for several centuries by architectural treatises. In the language of modern architecture, a module is a normalized unit of measurement, intended to facilitate the design and assembly of building elements.
A measurement is a numerical value attributed to a magnitude, expressed as the ratio between this and another quantity of the same kind, conventionally chosen as a unit of measurement.
This concept of measure, intimately linked to that of dimension and magnitude, is referred to any type of organism: it must verify certain formal properties and is the subject of study of the theory of measurement, in which the procedures for measuring lengths, areas, volumes, etc. are studied. Measurement is knowledge, it enters into the nature of things. At the end of the fifteenth century, thanks to the rediscovery of Vitruvius's treatise and its diffusion, the knowledge of ancient thought was discussed and deepened. The "modern" spirit of knowledge and the desire to study the architecture of the classical age led many scholars and architects, not only Italian ones, to concentrate on Roman ruins. The need to see those testimonies first-hand was described by Vasari: "measuring the cornices and taking the ground-plans of those buildings. There was no place that they left unvisited, and nothing of the good that they did not measure" [Vasari 1962, p. 251]. Alberti wrote of his activity as a geometer-architect: "No building of the ancients that had attracted praise, wherever it might be, but I immediately examined carefully, to see what I could learn from it. Therefore I never stopped exploring, considering, and measuring everything, and comparing the information through line drawings" [Alberti 1966, vol. II, lib. VI, cap. 1, *Gli ornamenti*, p. 440]. On the other hand, the eagerness to know, measure, represent and document is fully understood in the design research of Renaissance architecture. Measurement is a conquest of the modern world, an expression of a quality inherent in classical *mimesis*. Alberti, speaking of the power of drawing, defines it as ideal form par excellence,

as *imago ab omni materia separata* [a separation of image from all matter]; capable of subtracting from architecture the inertia of matter, the quantity that disposed it, sublimating itself in the quality of form.
Modularity requires precision, and precision, as Alexandre Koyré explains, is the modern conquest that has revolutionized the space in which we live [Koyré 1967] The discovery of precision leads us to verify quantitatively (with the theory of measurement) the quality of architecture [Docci, Maestri 1984, cap. III, *Teoria della misura*]. The approach to measurement in architecture is the practice of surveying which, in addition to being irreplaceable for the understanding of the architectural object under investigation, constitutes a very important training ground because, with direct observation, one becomes accustomed to spatial synthesis, to the geometric-structural understanding of the composition and to the graphic representation of the measurements reported in scale.

Fig. 6. Le Corbusier, Le Modulor, 1950.

The accuracy of the measurements reported allows us to reproduce the shape of the object surveyed, to reread the dimensional and spatial relationships between the parts, and between the parts and the whole, coming to express, thanks to a deeper knowledge, a judgment of value De Simone 1990]. "Today's thought, architectural culture and historical-critical culture almost unanimously recognize a strong educational content to survey operations. Those who approach this type of experience, in fact, have the opportunity to confront the operational reality, measuring, operating rationally, getting used to the practice of perceptual control of the physical dimensions of an architectural work, not to mention that the graphic analysis, conducted directly, is a great and irreplaceable means of knowledge." [Docci, Maestri 1984, p. 15].

"What cannot be measured does not exist"

Starting from these reflections, we can consider the operations of survey, the analyses, the phases of knowledge of a work of architecture, as the premises that make clear the reasons of a certain form that has found substance. The classical world already specified how the *dispositio* alludes to a hierarchical system of competence. The codes of classical order, for example, refer to hierarchical statutes through which history and theory become science, skill, competence.
"What cannot be measured does not exist," states Carl Werner Heisenberg in his famous *Uncertainty Principle* [4]. In refuting the classical principle of randomness, he argued that only what is measurable can be produced experimentally; that is, what can be measured is also possible, while what can be calculated is merely potential [5].
To take measurements, to interpret the measurements taken, to know, to reveal, are operations falling within the sphere of the possible that in essence allow passing from the description to the understanding of the phenomena of architecture.

The role of drawing becomes the passage from description, to interpretation, modification: from knowledge (survey), to possession (interpretation), to use (project). Here, therefore, the sequence 'knowledge-possession-use' completes the cycle of intervention on the existing.
But representing means entering into the merits of the possible and the calculable; it is possible to measure what already exists, that has a form (survey) while everything for which a modification, a prediction (project) is necessary, is calculable.
This duality defines the field of validity of our work: on the one hand, the sphere of the built, of the existing, on the other hand, towards the sphere of the modification.
This duality also marks the fields of training and research: if teaching work is mainly a work that conveys previously consolidated knowledge, research work is a work that ventures into the elaboration of knowledge and experimentation.
In our field, for example, this means overcoming the descriptive habit of cataloguing ('quantitative' recording of data) to aim towards the interpretative context of classification ('qualitative' aggregation of data). In fact, classifying means recognizing areas of relevance and analogy: to include and exclude from classes and families according to an evolutionary order of language. To classify is also to exercise a judgment on the rule and its variation. The notion of order guides this practice since, in the absence of rules (rule = order = hierarchy = recognizability) it is not even possible to transgress the rule itself. Even in architecture, the notion of transgression, of exception, exists if the concept of order is clear. How would it possible to understand the giant order of Michelangelo, or the neoclassical language, or the references of the postmodernists, or the liquid architectures of the digital, without knowing the notion of classical order? Order, hierarchy, harmony, *eurythmia* and symmetry are tools that make known things decipherable. From this certainty, from this confrontation with nature, all the evolution of architecture becomes a question of challenge between rule and exception, between order and disorder, between nature and artifice.
But evolution itself is a continuous transformation of rules into exceptions and exceptions into rules. Inhabited places are the sum of the successive stratifications of different types of settlement amplified by the space-time dimension. Contemporaneity is also the segment of an evolutionary process that comes from afar, since awareness of the present stems from the knowledge of history. That is to say, the center of the issues related to the studies of representation of architecture is always a matter to be connected with a context of very integrated relationships in which to find the less apparent and deeper sense of meanings.
Drawing, in essence, not only describes architecture, but explains it and often constructs it; just think of the relationships between representation and non-Euclidean geometries or even the four-dimensional or hyperdimensional implications of the current processes of digital and virtual representation.
Drawing, in relation to measurement, implies a continuous experimentation that leads to a wealth of interactions, a constant challenge between sign and number, between observation and transformation, between theoretical component and instrumental component. Measurement and drawing are, in any case, instruments in precarious equilibrium: drawing is an instrument, since it is an extension of the hand and of the mind, while measurement is an instrument of reason for investigating the properties and the quality of things.

Notes

[1] With the measurement of the shadow, the movements of the sun can be followed both during the day and throughout the year.

[2] <https://www.treccani.it/vocabolario/architettura/> (accessed 2020, December 5).

[3] *Dizionario enciclopedico di architettura*. (1969). Item *Modulo*. Roma: Istituto Editoriale Romano.

[4] Carl Werner Heisenberg (awarded the Nobel Prize for Physics in 1932) was referred to for his theories on quantum physics in the opening address of the Conference *Il disegno di architettura come misura della qualità* organized by Rosalia La Franca, held in Palermo in May 1991, and in the context of the round table *La qualità tra misurabile e calcolabile*, in AA.VV. 1993.

[5] Enunciated in 1927 by W. Karl Heisenberg and confirmed by innumerable experiments, this is a fundamental concept of quantum mechanics that sanctioned a radical break with the laws of classical mechanics.

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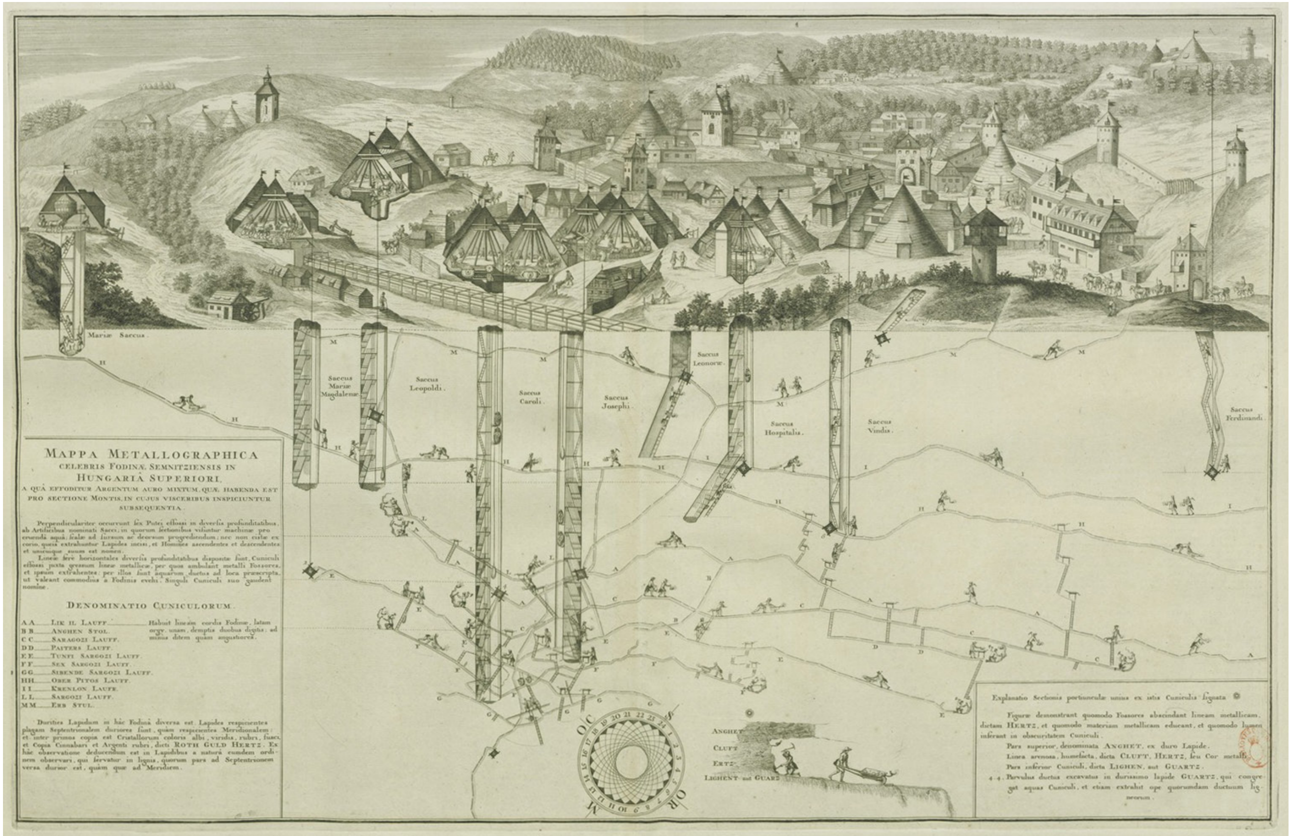
The *Mappa Metallographica*

Luigi Ferdinando Marsigli



Luigi Ferdinando Marsigli and the *Mappa Metallographica*: Graphic Creativity and Scientific Measurement

Laura Carlevaris

The *Mappa Metallographica* (45.5 x 70.5 cm) is part of *La Hongrie et le Danube*, a collection of twenty-seven cartographic tables drafted over a period of fifteen years to illustrate the orography, hydrography and metallurgy of the Hungarian stretch of the Danube [1]. The map drawn by the soldier, scientist and naturalist from Bologna, Luigi Ferdinando Marsigli (1658-1730), [2] is one of the drawings he published in 1726 to illustrate his much more extensive printed work [Ceregato 2015, p. 59]: the *Danubius Pannonico-Mysicus* [Marsigli 1726] [3]. This six-volume book [4] provides a detailed description of the Danube territory, including all major orographic, landscape, naturalistic and faunistic features, as well as its mineralography and metallurgy; it presents them in a comprehensive textual treatise, but above all, in an exceptionally high-quality and very modern illustration [5] undoubtedly invented by Marsigli in close collaboration with his assistant and cartographer Johann Christoph Müller (1673-1721) [6].
Marsigli was passionately interested in many subjects, in particular cartography, which he practiced at length and for which he also developed innovative acquisition and graphic restitution systems, probably assisted by Müller's extensive expertise.
The territorial measurement systems that had boomed in the seventeenth century continued to be developed in the eighteenth century. This was due to increased interest in geography, prompted by issues of military and political control and simultaneous improvements in surveying instruments and methods [Edney 1993, p. 63; Török 2012, p. 420]. In the early decades of the eighteenth century improvements in large-scale mor-

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phological and dimensional control as well as renewed requirements regarding the reproduction of the orographic and hydrographical characteristics of the territory appeared to converge in an effort to produce new images. Although the projective basis used to create these representations does not always appear to be scientifically sound, certain graphic models seem to have been produced prior to a trend which, during that century, was to lead not only to greater mastery of surveying operations and the attempt to unify measurement units and systems, but was also to have a strong influence over the definition of descriptive geometry and the science of representation.
Marsigli studied in Bologna and matured in the wake of the naturalistic approach adopted by Ulisse Aldrovandi and Marcello Malpighi; he believed drawings should not simply accompany a scientific text, but be part of it [Olmi 2000]. The reciprocal support between the text and illustration benefited both the draftsman and reader: the former because this combination was an additional communication tool, the latter because he understood the message thanks to the unitary nature of such a complete and comprehensive description.
One particular feature of the Bolognese approach inspired Marsigli with the idea that representation should be flexible, versatile and adapted to the requirements of communication. Ever since his first military expeditions to the Bosporus where he put into practice his naturalistic ideas he quickly realized that, apart from working intensely on a tactical approach so that cartography be considered as its first graphic interpretation, the section was an important and irreplaceable means to achieve a unitary survey in which the outer part of the organism could be understood only thanks to the functions made possible by its internal structure and arrangement. He also realized that this could only be illustrated by making several appropriate cut outs which, he noted, was similar to the method used to represent the human body [Déak 2014, p. 99].
Several successful attempts to extend this section concept to orography and the study of the territory are present in the works of seventeenth-century authors such as Athanasius Kircher (1602-1680) or Agostino Scilla (1629-1700). Kircher appears to cut away parts of mountains to show what happens inside, how rivers start in the heart of the earth or how whirlpools are created at sea due to the presence of rivers and the way they flow through the land. Scilla, born and educated in Sicily, sectioned Mount Etna to show how lava and heat flow from the depths of the earth, its terminal ramifications, and the craters where the magma exits.
Marsigli seems to have visually remembered these and other previous experiences when he had to solve the problem of how to describe a territory with important metallurgic veins and a multifaceted and diffuse arrangement of the vertical underground shafts (wells going deep into the earth) and horizontal underground passages (linking the wells or collection areas) which he visited personally [Déak 2014, pp. 99, 100]. The marvellous internal machine made by man to exploit natural resources to the full (in this case silver and gold veins) was studied by Marsigli as an integral part of the landscape, just like the vegetation and orography. This was the objective behind his rather unique graphic arrangement of the *Mappa Metallographica*.
Faced with the problem of describing what happens on the surface–position of the huts where the materials exits the vertical shafts and is initially processed, protection of the wells, transportation of the materials–and the internal network of production activities–with places for pit stops and collection as well as passages for the distribution, collection and hoisting of the waters and precious materials–Marsigli had to invent a system to explain the correlation between above and below ground so as to clarify the unitary nature of the process between the surface and underground space. Elsewhere he had cut out the sides of mountains, taking away segments to see inside, as Kircher and Scilla had done before him, and not unlike the method used many years earlier by Leonardo da Vinci when he wanted to show the position of a foetus in the womb. However, in the case of the metallurgical area, Marsigli needed a truly innovative drawing combining the effectiveness of a perspective drawing (to show the superficial environment of the Hungarian mountains and woodlands) and the precision of an accurate scalar scientific drawing showing the workings of the perfect underground machine made by man.
So Marsigli came up with a unique representation system for the *Mappa Metallographica* in which a broken horizontal line divides the upper part of the drawing, the outdoors, represented in perspective (occupying a little over a third of the drawing height), from the section in the lower part; the latter takes on the role

of Piero della Francesca's *rabattement* of the reference plane or plane of construction, around what we now call the 'trace' of the plane itself.
In the *Mappa Metallographica* there is no real *rabattement* of the plane of construction, but the vertical plane of the section starts under the 'trace', as in a perspective section. In Piero's drawings the part under the perspective view describes the real form and real measurement of the represented elements: likewise, in the Map there is a drawing under the 'hinge line' which, due to its very nature, conveys the real form, the real measurement, the real depth and real inclination of the wells, tunnels, passages, excavation systems and ascent/descent into the entrails of the earth.
The surface activities and woodlands are represented above the 'trace': Marsigli's intention was to convey the orographic ensemble and settlement; the image is in fact a bird's-eye perspective view, well-suited to this purpose. He uses a section drawing under the trace, in the lower part of the drawing (63,63% of its height) illustrating the underground area. Here communication has to be effective, scientific and measurable, and the orthogonal view is the only projective mode that can solve the problem. The section looks inside the earth, sectioning the characteristic elements, vertical links (wells and steps) and passages that have to be used to move and push the carts full of minerals. What was important was to describe not only the exact length of the passages and their inclination, but also the magnitude of the whole mining area and convey it in a drawing which is 'flat' and definitely two-dimensional. Therefore the section seems 'flattened' on a single plane: by eliminating the earth and solid areas and indicating only the hollow elements that are of interest, the latter are shown as if they were on the same vertical plane despite the fact that the perspective image shows them to be at differing depths compared to the observer. To link corresponding elements, the sectioned wells in the orthogonal projection are connected by vertical straight lines to the external cones above the mouths of the wells shown in the perspective view; these straight lines are almost 'lines of recall' to facilitate the interpretation of a drawing that is only ostensibly simple.
The two projections are also graphically very different. The perspective part is in chiaroscuro and highlighted, with only slightly shadowed areas but with textured surfaces and recognizable materials, including several trees and plants in the fields. The lower sectioned part appears to have be a line drawing without hatching, not even to distinguish the solid parts from the tunnels; it has graphic conventions to indicate the passages, ladders, ascent steps, work tools and equipment, and letters indicating special points in the network of sloping or vertical horizontal passages, the place where they meet, the corners, and how to find one's way in what looks very much like a labyrinth.
In the perspective part, the only concession to a method slightly more similar to a technical drawing is the fact that some of the conical spaces are drawn in such a way that viewers can see inside. Instead the lower part is described in all respects like a technical scale drawing in which distances and gradients appear measurable; these measurements can make the work of the miners quantifiable and therefore organizable.
On the whole the *Mappa Metallographica* is like a landscape drawing, but also a technical diagram. A drawing based on the reflections and curiosity of a soldier who loved nature, and those of a scientist who strongly believed in drawing and its communicative versatility. His work made cartography [7] flexible so that it could convey precise messages: not surprisingly, Marsigli is recognized as the father of thematic cartography [Török 2012]. Although his maps were drafted for practical reasons and military and political purposes, they nevertheless reflect the intellectual curiosity and broad perspective of a naturalist and man of science [Török 2012, pp. 422, 425]; In Marsigli's ideative imagination, the *Mappa Metallographica* was to combine the meaning of drawing and that of the measurement of represented things, passing from appearances to being accurate and dimensioned, from an airy outdoors to a perfect functioning machine that seems to enjoy its own personal 'breath'.

Notes

[1] The maps were drafted between 1726 and 1741. The collection can be consulted on the website of the Bibliothèque nationale de France: <https://gallica.bnf.fr/ark:/12148/btv1b5971966r> (accessed 2020, November 10). The image of the *Mappa Metallographica* is from Bibliothèque nationale de France: https://gallica.bnf.fr/ark:/12148/btv1b53039391j (accessed 2020, November 10).

[2] Luigi Ferdinando Marsigli is often cited as "Marsili". The question of how his name is written is discussed by Deák who believes that "Marsili" was a latter form and decidedly opts for "Marsigli" [Deák 2006, note 8].

[3] The map is shown at the end of *Tomus III. De Mineralibus Danubium effossis, Necnon Aquâ Abrasis, & in eum deductis*: Marsigli 1726.

[4] In the first version it was drafted in six volumes, in the second version in three: the story of the map is reported in Deák 2014. For more information about the history of Marsigli's monograph, see Deák 2004. The map is included in the attached documentation on a CD and published in Deák 2006.

[5] In the six books of the *Danubius Pannonico-Mysicus* the sprawling area of the Danube was studied from a large to small scale. *Tomus I* focuses on geography, hydrography and astronomy. *Tomus II* analyses the bed and banks of the river, but primarily Roman archaeological remains. *Tomus III* studies the territory and underground areas as well as the minerals that can be found there; it studies and documents the position of the mines of gold, silver, copper, ferrous minerals, antimony, cinnabar, mercury, magnetite, garnet, opal and salt [Deák 2014, p. 103]. The minerals are then described in detail, on increasingly smaller scales, with important tables probably etched by Francesco M. Francia who worked from Italy [Deák 2014, p. 97]. *Tomus IV* describes the fishes in the Danube, while *Tomus V* illustrates the birds in the river area, the nest of several species and the description of their eggs. *Tomus VI* is dedicated to all the issues not covered in the previous books [Deák 2014, pp. 94, 95], including the anatomical characteristics of the animals. The dissections of these animals by Marsigli himself are shown in the tables.

[6] The map was probably etched in Italy by Francesco M. Francia (1657-1735): Deák 2014, pp. 95, 96.

[7] The maps drafted by Marsigli and Müller were studied and gathered together in Deák 2006. See also Ceregato 2015, p. 60.

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DRAWING AND MEASUREMENT

For building a cosmic harmony

Drawing and Measure for Building Cosmic Harmony

Roberto de Rubertis

Drawing and measure are two fundamental words for the field of representation. Both can have two different meanings: one concerning their instrumental use, the other referring to their finalizations. As to the cosmic harmony called into question by this topic, I would like to say that it is an objective of great importance and extent, but also very generic and difficult to define. I will, therefore, start from definitions that permit me to specify the scope of application of the terms I will be using. Further on I will be more explicit.

In its most obvious and commonly understood definition, drawing is the representation of everything that can be depicted, with suitable graphic procedures, in a way that corresponds to how it appears or how it is thought of by an observer; that is, in the projective modalities with which it presents itself to his gaze, or with which it is imagined, remembered or even appropriately schematized.

Measure is, instead, the value that is attributed to the dimensional (quantitative) characteristics of objects, substances or actions, whether concrete or even abstract, or referred only to the representation, that is to say, whether they exist in reality, or to which one can only make mental reference, by comparison with other objects, substances or actions taken as a unit.

Both terms defined above are subject to certain limitations.

Not everything that can be represented with drawings or other types of images can be measurable; for example, attributions of value regarding quality are not measurable, or are so, but only in a very subjective way.

Likewise, not everything that is measurable can be represented with drawings or images, if not through symbol-

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

isms or allegories. In fact, it makes no sense to represent time, nor even space itself, which are still knowable and quantifiable entities, but devoid of material substance.
The digital tools and techniques used to represent and measure have today extended the fields of application of both drawing as well as measure, as described above, even to virtual figurative simulacra of everything that can appear, that is, everything of which it is possible to build, with the appropriate optical instrumentation, even the only visible (or perhaps only thinkable) image on which to intervene, as though it were real.
This extension of representability also to what is endowed only with an image allows visual accessibility to the world of virtual appearances that are neither tangible nor differently accomplishable. With various technologies, it is possible to simulate their coexistence with the concrete physical reality, offering, in this sense, variously applicable examples.
In fact, also giving rise to measurable representations are all of the experiments carried out in building or detecting the virtual (computer) simulacra of appearances on which it is then possible to intervene "as if" one were intervening on reality. In the same way, graphic descriptions of events can be constructed that are useful for experimenting operations (a classic example, Galileo's "mental experiments") whose representation can be drawn even before verifying their realization.
Most of the graphic operations that make use of the representation of traces and of the observations connected to them, that is, a large part of Descriptive Geometry, falls within this field of "measurable drawings": that is, those that go in search of that "universal" order of which we always feel the presence, underlying everything we succeed in understanding of the world we live in. Perhaps anticipatory of "cosmic harmony."
Kinematics (the science of movement) is the science that studies and measures the movement of bodies and that, therefore, makes use of the "drawings" that represent them and the "measure" that evaluates them. It is, therefore, the science that explores drawing in its figurative changes and measures the metric results. But these are results that only apparently confirm the existence of the harmony that, in other ways, we seek everywhere, when in our mind we explore the features of the world in search of the common laws connecting them. I therefore consider it inappropriate to call drawing and measure into question to confirm that the logical symmetries that unite them are part of the marvelous play of that general order that in ancient thought seemed to regulate the laws of the universe and that even today still attracts us so strongly. It would reveal itself to be a countercurrent reference to what now proves to be a progressive growing complexification of the nature of the world, even in the infinitely small, and, in any case, at every scale and in every sphere of the scientific investigations underway.
The universe, in fact, reveals itself to be increasingly unknown and far from those simplifications that until the last century had deceived even the most aggressive science and philosophy, suspicious of any easy, illusory logical symmetry. The most updated studies today confirm that the matter and the energy of which the universe is composed become progressively less comprehensible in their profoundest essence, where, moreover, kinematics and, substantially, even geometry are of little help.
In particular, it would be an error to believe that drawing and measure are two symmetrical aspects of reality, easily accessible through knowledge and easy to investigate, for listening to the marvelous harmony of the cosmos, and perhaps even for indicating appropriate strategies of its in-depth study.
On the contrary, the image of the world that today the most advanced science presents to us is very different and more complex than one might have expected.
Therefore, it is not through a simple juxtaposition of the two words "drawing" and "measure," with the meanings previously defined, that we can refer today to a cosmic harmony; however, the reference can be supported by attributing other meanings to them, these also being of wide and frequent use. By "design" [1] we also mean "intention" (plan, objective) and by "measure," we also mean "equilibrium" (moderation, control, canon, limit); meanings that attribute to both terms the objective of operating with wisdom and foresight in any intervention which should be planned for the health of the world.
The question to which the present reflection strives to give an answer, however, does not change. Drawing and measure are basically the same two ancient words and their alternative meanings, for the purposes of this forum, without detracting anything from their other meanings, of more ordinary use within the context of representation, now aim to address more directly the desired results, which are synthesized with the happy formula "cosmic harmony." Therefore, the essential references to these two words remain valid for the correct participation of

mankind in global destinies, but in the context of a new and more concrete presence of man in evaluating, deciding and, if necessary, changing the trend. It will no longer be just a matter of knowing how to observe and evaluate the evolution of things, but of knowing and being able to influence them by understanding their nature and being able to anticipate their mutations. Precisely those mutations that today concern the dramatic questions of human survival on the planet; those that man has neglected for much too long, operating recklessly and producing, with his intervention, more damage than improvement.
In the innovative exploration that the two new meanings suggest, however, kinematics and metrics are no longer helpful.
On the contrary, the image of the world that today's most advanced science presents to us is very different and more complex than one might have expected. This is testified in particular by Erwin Schrödinger, whose studies, on several occasions, show how strongly scientific knowledge of the world differs from those simplifications that until the last century had deceived even the most aggressive science and philosophy, suspicious of any easy and illusory logical symmetry. Schrödinger, in fact, reminds us how important it is, even in the pursuit of a lucid self-awareness, for man to possess a clear and true "image of the world" in which he lives.
Thus one must believe in the new morality that results, also to guide the quest to achieve the desired (cosmic) harmony.
The attitude that must instead distinguish those who today work moved with these intentions must be very different: it must aim to remedy the well-known errors that the civilization of consumption has produced in the last century, and especially in recent decades, leading the planet to the brink of ecological disaster. This is the only true objective that can deserve the definition of "cosmic harmony" and towards which the productive convergence of drawing and measure would be opportune; precisely with their meanings of design and equilibrium, in acting, evaluating and providing appropriately.

Epilogue

This will only be possible when skillful draftsmen and measurers will be able to address, using the tools of representation, that is, the "design" to save the world, with

Fig. 1. Carlo Enrico Bernardelli, Rhythms of matter in formation.

the "measure-equilibrium" necessary and appropriate for ensuring its future.
Rarely do the divulgative publications that deal with these themes, of extreme vastness and, above all, of difficult illustration, dwell in offering readers an adequate apparatus of charts, schemes, diagrams, in any case, of images, able to transfer to the figurative plane that which is presented verbally or analytically. Whoever knows how to do this, and thinks he can contribute to fill this gap, should do so.
This is because, especially in the field of scientific divulgation, there is a lack of tools to properly illustrate in which dimensional and figurative field, that is, at what scale and in what way, the phenomena described by science only on the basis of theoretical statements occur. On the other hand, it cannot be excluded that in the graphic representation of complex phenomena, even problems that seem obscure by analytical means can be solved.
Classic, in this regard, is the resolutive idea proposed by Friedrich August Kekulé in 1825 for the structure of the benzene molecule: he suggested a hexagonal configuration of carbon and hydrogen atoms, thus succeeding in understanding the true shape of an atomic structure that with a linear arrangement could not be found.
Therefore, it is not enough to call drawings and measures into question, as requested in this call, but it would be a fine adventure of thought, and above all an effective result of dissemination, to inform the reader, also through "designs," [2] intended precisely as "operational programs" and through measures, intended precisely as "control instruments," of how serious the environmental situation is towards which, unfortunately, with nonchalant unawareness, humanity is heading. And, therefore, what a splendid "cosmic harmony" we risk losing forever.

Notes

[1] Translator's note: in this case, the appropriate translation of the Italian term "*disegno*" is "design," rather than "drawing."

[2] See note 1.

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Measuring Knowledge. Notations, Words, Drawings, Projections, and Numbers

Carlos L. Marcos, Michael Swisher

Abstract

Humans have communicated with each other since they became such. Undoubtedly, the fact that we have developed symbolic systems to communicate should account for such a difference. Moreover, our own evolution in terms of knowledge is inextricably connected to such use.
Different symbolic systems contribute to our knowledge acquisition in different ways. A fundamental divide can be established between verbal languages and graphic ones. Words are easily connected to abstract thinking and a generic approach to reality; we use them to reason and to think. Figurative drawings, on the contrary, appeal to our senses and to visual appearance; they are focused on the material world and try to define relations based on resemblance between tangible reality and modes of its representation, however this controversial term may be. Yet, drawings can also be used to achieve knowledge aided by graphic thinking both through ideation and through representation, depending on the directionality of projections. Most remarkably, architectural drawings based on geometric projections establish an unrivalled and privileged relation with material objects that words or even numbers cannot match. Instead of appealing to the generic –as words– or to the numerically quantifiable –as numbers–, they describe and define a point to point relation with the material existence depicting proportions.

Keywords: notation, drawings, projections, measures, proportions.

Introduction. Knowledge and existence

The methodology in this essay is based on a dialogic enquiry on the nature of knowledge and the different ways in which symbolic systems serve to its nurturing. A distinction is made between allographic and autographic arts, on the one hand, paying special attention to the difference that can be established, within the graphic realm, between the visual arts and architectural drawings beyond their notational nature. Verbal languages are also opposed to graphic languages, while a relation between numbers, measurement and proportions is discussed; between the generic or abstract and the material or concrete as a corollary of the research, thus addressing the proposed theme for this monographic issue. It is necessary to reflect here in certain detail on knowledge and how it is acquired, to ponder the importance of drawing and measuring epistemologically. Plato's theory of Ideas establishes a duality enormously influential throughout history: a substantial difference between abstract thinking and perception, between reason and the senses; ultimately, between *form* and *matter*. According to Plato knowledge has three different stages: *aesthesis* –perception, sensation–, *doxa* –belief, opinion or judgement– and *episteme* –pure knowledge–. In his *Theaetetus* he reflects on the contingency of material existence and is conscious of the deceitful nature of our perception and our subjective interpretation of it [Plato 1987]. He introduced the notion of *Ideas* detached from matter in his philosophy to ensure dealing with pure realities to reach *episteme*. That is why on this *ideal otherness* –the only *reality*– he imposes to such *Ideas* the attributes of "abso-

Fig. 1. Willem Claesz Heda. Still Life with Oysters, a Silver Tazza, and Glassware 1635.

lute reality, eternity, immutability, universal and independent from the phenomenological realm" [Grube 1973, p. 20]. This duality ended up duplicating the world while undermining material existence, the world we see and are able to touch [Bueno 1990, p. 38].
Aristotle, critical with regard to Plato, managed to unite the formal and the material realms in his hylomorphic doctrine by introducing the complementary ideas of *power* and act to explain changes [Aristotle 1971, I, VI]. Stepping beyond the pre-Socratic limits of *being* and *non-being* he added an intermediate category, relative non-being or becoming, thus, managing to explain accidental as well as substantial changes. He conceived *substance* as the *real* being composed of two elements: form and matter –*primary matter* [1]–.

Let us comment on an easy example diving now into Physics [2], using, for instance, the combustion of hydrogen to obtain water. The chemical notation for this reaction is as follows:

$$2H_2 + O_2 \rightarrow 2H_2O$$

Two molecules of hydrogen and a molecule of oxygen will produce two molecules of water. This exogenous reaction will imply a substantial change in Aristotelian terms. Two distinct substances, hydrogen and oxygen, are transformed through this chemical reaction into a new substance, qualitatively different from the previous ones. The water is in *act* once the bond between hydrogen and oxygen molecules is established [Zubiri 1989, p. 136]. Any chemist will truly

understand the meaning of that formula quantifying the proportions needed for such transformation as well as the qualitative difference of every element involved.
Whereas *form* is the characterizing element that makes water be what it is, a material element is needed to explain its corporeal existence within the physical realm. The formula of the molecule defines its precise composition but it is not really water as it is not material. In Aristotelian Conceptualism the *real* water is the concrete and specific liquid we may drink in a glass of water, such as the one that tempts to quench the thirst of the observer depicted in Claesz Heda's superb still nature (fig. 1); in Platonic Realism, only the formal existence of the water molecule is the *real*.

Languages and symbolic systems

Humans have managed to develop complex languages to communicate with each other in different ways. They contribute to articulate our judgement and, derivatively, to reach knowledge. According to Goodman [Goodman 1976, p. XI] they are based on symbols [3] in which we embed information in extraordinarily complex and nuanced ways.
A major divide, however, can be distinguished between verbal or textual languages, and figurative graphic languages. The first typically use characters as part of a notational system which, combined, produce words to which we assign a particular meaning; the latter use drawings or images to express and convey a message of visual nature. This establishes a major distinction in the way in which we represent the world that surrounds us, but also the ways in which we acquire knowledge. Such distinction, has had implications within the philosophical debate and knowledge itself, since words are based in abstract or generic thinking. The association between meaning and signifier is fundamental to understand the nature of abstract or generic thinking: common aspects within a given class are used as an operational classification strategy. If we think about it, is it not extraordinary to be able to refer to all the men in mankind with one single word?
This debate on *universals* –species or genders– in opposition to *particulars* –real individuals with material existence–, was held for centuries by philosophers. Nominalism questioned the very existence of universals arguing that words were simply *flatus vocis*, mere sounds, that we operatively use to communicate [Ferrater Mora 1994]. Thus, for nominalist philosophers, universals are neither part of or alien to individuals or sensible objects, they are rather elements of language –words– that structure and articulate our judgement.
When we use drawings or images to refer to that same object we base this association in terms of a certain resemblance between the real object and its representation. The closer a portrait of someone is to his visual appearance –with all the proportions and details that constitute his physiognomy–, the more accurate will we say the picture is. This relation, albeit entailing a certain amount of codification, is based on analogy [Deleuze 2008]. Words are *arbitrarily* chosen to stand for a meaning whereas drawings and images have a direct and precise relation with the objects they represent which is not *arbitrary* –at least not in that same way–, for it is based on visual resemblance. Goodman is one of the first authors that has dedicated part of his inquiries to suggest the cognitive dimension of art [Allepuz 2016, p. 790], analysing it beyond its expressive or aesthetic attributes. He has thoroughly studied the relation of resemblance or similitude that is specific to graphic languages within symbolic systems. Although he argues that "plainly, resemblance in any degree is no sufficient condition for representation" [Goodman 1976, p. 4] his reasoning seems to be too conditioned by the aim of his investigation on symbolic systems. Of course, part of the problem appears with the difficult and problematic term of *representation*, and a series of other considerations around it such as imitation, perspective, realism, description and depiction. Summarizing, Goodman suggests that representation transcends the mirroring of reality subsuming it "with description under denotation" [Goodman 1976, p. 43]. In other words, it could be said that a drawing or a painting –a figurative one, we must add– denotes the object or motive it refers to while it describes it in terms of resemblance to its visual appearance.
Goodman's theory of symbol systems also addresses the idea of notation, something very relevant for our research. Accordingly, there are allographic and autographic arts. The first use notations that allow those who use them to convey to third parties their creative endeavours, such as it happens with scores in music or with plans in architecture. The second are considered autographic "if and only if the distinction between original and forgery of it is significant" [Goodman 1976, p. 113], as is the case of painting. Goodman heavily relies on the role of copies and originals, on the one side, and on the relation between the referent and its representation. Some disciplines use different notational systems in order to effectively denote or refer to the reality symboli-

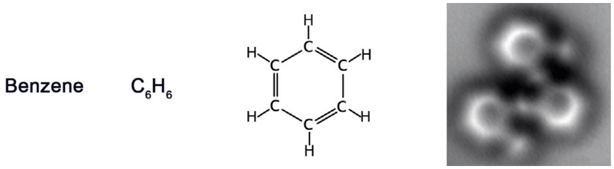


Fig. 2. Three Connected benzene rings (noncontact atomic force microscope). Lawrence Berkeley Lab. University of California at Berkeley.

cally represented through them. For instance, we can use four very different ways to refer, notate, diagram or even graphically represent benzene (fig. 2).
The word 'benzene' stands in English for "a clear liquid obtained from petroleum and coal tar, used in making plastics and many chemical products", according to the Oxford dictionary. If we have previously seen and smelled benzene, and know English, we understand what the word refers to but have no clue in relation to its chemical composition. The condensed chemical formula adds a layer of quantitative and partially qualitative information stating that it is composed by six atoms of carbon and six of hydrogen. Of course, we could only understand its meaning in the context of chemistry provided we are aware that 'C' stands for carbon, 'H' for hydrogen and the '6' subscripts stand for the number of atoms of each element. The same benzene molecule notated using the Lewis structure or chemical notation diagram still adds an extra layer of relevant information: it effectively gives the same quantitative information of the condensed chemical formula, but unlike it, it is also a diagrammatic attempt to graphically display the bonding between atoms and the lone pair of electrons that may exist. Lewis notation structure manages to show in a very synthetic way an enormous amount of relevant information. These three different notations for benzene convey different kinds of information. However, the first two, are strictly 'textual' whereas the third also includes some graphical information however symbolic and non-figurative as it may be. It is because of its diagrammatic nature that it is capable of adding relevant information regarding its formal structure. It is of course an idealized denotation of the benzene molecule, not a real representation of its essence, but this graphical envisioning of information [Tufte 1990] certainly accounts for the divide between verbal and graphic languages and the information they bear. There is yet a fourth truly graphical representation of the benzene molecule in figure 2. In fact, it corresponds to an image of three connected benzene rings revealing the positions of individual atoms, achieved through a noncontact atomic force microscope. Whereas the previous three are different notations to denote benzene thanks to symbolic systems, the fourth is actually a microscope image of three real –*material*– bonded benzene rings. And this is indeed an extraordinary difference in metaphysical terms: the word 'benzene', the condensed formula, and the benzene Lewis structure are abstract ways in which we refer to benzene as a *form*, whereas the microscope image is, in fact, a true representation of a particular reality with true *material* existence of three benzene molecules.

Allographic and autographic arts. Music, drawings and technical drawings

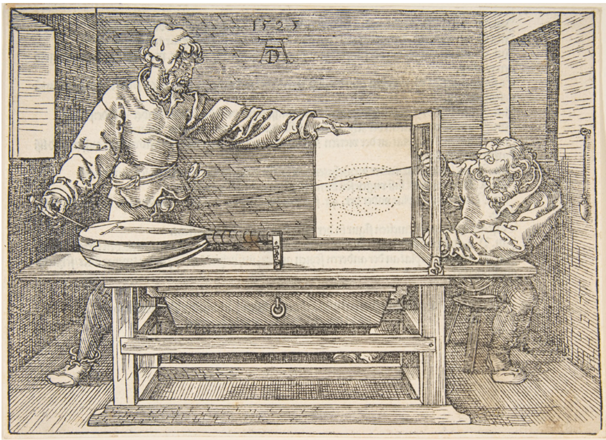
What is most striking with regard to Goodman's approach –being a philosopher– is the fact that no attention is given to the major difference between verbal languages and notational systems, on the one hand, and graphic languages, on the other. It is the unmatched potential of *technical drawing* to refer to the material world that which makes of it so extraordinarily effective in the representation of the architecture or engineering. And it is also the reason for another substantial criticism to be made to Goodman's theory: musical scores and architectural plans, however allographic as it may be their nature, radically differ in the lack of musical scores to relate to the sound they stand for in comparison to the ability for plans to precisely relate to architecture.
In the case of music, once the composer writes the score he has finished his creative work. Nonetheless, the music is *not* the score: it needs to be performed by others –or, eventually, by the composer himself, that is unimportant– to produce *sound* and *become* real music. In the case of architecture, Carpo suggests the origins of this *allographic* nature in Alberti's *lineamenta* and his redefinition of the role of architects as designers rather than builders. It was precisely at that time when architects abandoned the medieval tradition of master builders directly involved in the construction of the cathedrals –which could be considered *autographic*– and commenced their designing tradition *scripting* their art into architectural plans for others to materialise their execution [Carpo 2011, p. 16]. Allographic arts imply the reliance of the creative author on notational systems that allow others –performers or makers–, to materialise his work, be it a symphony or a cathedral. Yet, architectural

Fig. 3. Music score and tablature of Bach's Sarabande of Lute Suite no. 1.

representation clearly differs from music in as much as it belongs to the graphic realm, and, furthermore, it is based on projections, which has further significant implications.
Let us choose an object, a lute for instance. If we think of it in the context of languages such as English, Italian or Spanish we could refer to it with the words 'lute', 'liuto' or 'laúd', respectively. The fact that these different words all refer to a same object accounts for the arbitrariness of the sign.
The music that can be played on the lute can be written in a musical score. The very effective but abstract and complex notational system of the music scores led early lutenists to devise an alternative, more intuitive and instrument-oriented type of scores called *tablatures* that are still currently used among amateur lute and guitar players (fig. 3). Musical scores allow for further information and nuances but tablatures are more practical as instead of the pentagram there are six lines that stand for each of the six strings or courses –doubled strings in lutes–, the numbers correspond to the fret in the fingerboard, and normally the stems and flags above the upper line stand for the duration of the note. The score is what the composer writes for the interpreter to play the music but there is no clue in this pure notational system to the sound we will be able to listen to unless we are proficient in reading music. Note how those two very different musical notational systems in Bach's Sarabande of Lute Suite no. 1 are scores for the same music.
Someone with no draughtsmanship abilities can attempt to draw the lute that he directs his gaze at. He will eventually produce a figurative drawing that will somewhat resemble the visual appearance of the lute; most likely failing to precisely draw the foreshortenings produced by perspective. Accordingly, the drawing will look disproportionate and naïve; yet, we will most likely identify that it refers to the lute. Even a well-trained draughtsman will not be able to completely avoid small distortions and disproportions in as much as he will be attempting to reduce a three-dimensional reality into a two-dimensional drawing. His task will not include to precisely measure but will rely on his ability to reproduce a drawing as accurate as possible to the visual appearance of the lute cast on his retina. These drawings, regardless of their naivety or realism, will denote the lute both draughtsmen see.
If we observe the many portraits of the king Philip IV that Velázquez was commissioned to paint we will notice the great resemblance between them, even the aging of the monarch throughout his lifetime. This certainly accounts for Velazquez's mastery but, presumably, their fidelity to the referent is not photographic. While Picasso's was 'academically' learning his trade, he copied some of Velázquez's work (fig. 4); a purposely *forgery* and a good example of Goodman's argument with regard to the necessary autographic nature of painting as "even the most exact duplication of it does not thereby count as genuine" [Goodman 1976, p. 113]. Of course, his endeavour in this case was not as challenging as that of Velázquez: he only had to transpose from two dimensions into two dimensions. To a certain extent, his copy of Velázquez's portrait of Philip IV is a reinterpretation of Velázquez's painting –its true referent– but the king would only be indirectly referred to despite the shocking resemblance between the men depicted in both paintings. Nevertheless, these two paintings lack the relation of allographic duplication between the plan –the design– and built architecture –the construction– that Carpo [Carpo 2011, p. 22] refers to with regard to Alberti's building by design: they would be autographic forms of art in Goodman's theory.
The lute in the famous Dürer's engraving did probably exist as a referent (fig. 5). Thanks to his drawing machine, Dürer was able to produce a literal projection on a paper of its geometry. Such drawing is an accurate geometric projection of the lute –that concrete lute and no other–. Although the necessary foreshortening implicit in the chosen system of projection –central projection or perspective– does not allow to measure the true dimensions of the lute, it does establish a point to point relation between reality and its representation: a pure analogy.
This is of major importance and it is also something that Goodman fails to discuss: autographic arts establish a connection between the referent and its representation, between the particular material referent and its physical rep-

Fig. 4. Velázquez, King Philip IV, 1653-1655 (left). Picasso (copy of Velázquez's painting), 1897 (right).

Fig. 5. Albretch Dürer , The Draughtsman and the Lute, 1525.



resentation. In the case of precise geometric projections characteristic of architectural or technical drawings, that relation is far from being only notational or merely graphic, it is much more than any of the two. Invisible projection lines relate drawings and images to things [Evans 1989, p. 19] establishing an intimate connection between the material world and its representation much more precise than the best verbal description ever.
Alberti in his *De Re Aedificatoria* warns us about the deceiving nature of perspective which he recommends for the painter as his interest is focused on the representation of visual appearance. He adds that architects should only use parallel projections to ensure that 'determined and rational dimensions' in their projects may be accurately conveyed to third parties and, thus, properly serve to define their architectural designs [Alberti 1991, p. 95]. Only that which can be measured and precisely represented can be built by others: that is the reason why technical drawings have been so important to architects or engineers for centuries, and their role so influential in the diffusion of architectural theory during the Renaissance [Carpo 2001]. In other words, plans are *translated into buildings* [Evans 1997]. They connect the material world in different ways; it is thanks to plans that we can anticipate architecture or graphically represent it, depending on the direction of the projection. While the plans architects draw before the construction of the building anticipate architecture itself, reversely, built architecture can be also cast back onto survey plans [Evans 1989, p. 19]: both representations are virtually architecture or rather, *potential* architecture, whereas built architecture is *actual* architecture in Aristotelian terms. Note that the virtual nature of architecture in architectural drawings affects project's or survey plans alike. This relation is so intimate that it lead Boulleé, and others after him (Allepuz, Marcos 2017), to sustain that architectural drawings, being the cause of built architecture –its *effect*– should be considered architecture as much as the building is if not more.

Quantity, numbers, measures

Numbers are also codifications or notations which stand for the countable. A new plane of abstraction is needed to understand their nature because unlike words, images or drawings, they do not refer to objects themselves, but to the quantifiable that can be inferred from them. The evolution of numbers throughout the history of mathematics is intimately connected to the need to count in different

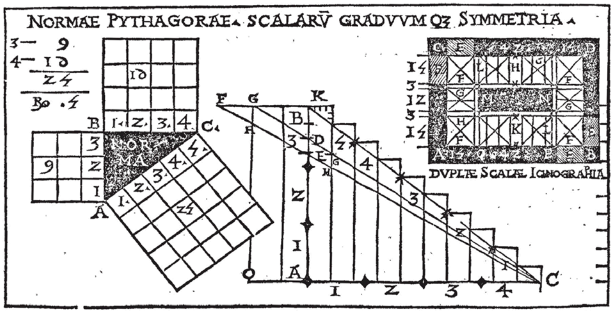
and increasingly complex problems that emerged from the discipline, most of the times derived from real life itself.
Measurements are the quantification of observed phenomena related to the material world. Typically, we measure lengths, areas or volumes although we can also measure weights, intensities, viscosities, etc. Rationalist philosophers –Descartes and Spinoza alike– didn't conceive matter segregated from space but as one and the same thing which they referred to as *extension*: that which has dimensions and can be measured [Descartes 1995, pp. II, XVIII]. Numbers are needed to quantify dimensions, and dimensions are proper for the realm of extension, regardless if it refers to matter or space. Due to their especial status and ability to represent the concrete in its material existence, drawings may surpass notational systems when it comes to represent rather than denote or stand for measuring.
Some mathematical theorems can be demonstrated graphically, through geometry. Such is the case of the Pythagorean theorem (fig. 6). One advantage of these kind of representation for the theorem is its *gestaltic* unity: one simple glimpse evidences the theorem; unlike mathematical demonstrations, it is not discursive but rather visual and straightforward. All the knowledge and the information it contains is graphically envisioned.

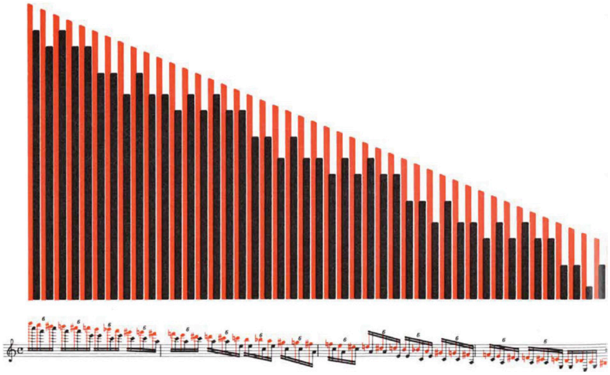
Patterns, proportions, and beauty

In the case of architecture, for instance, the use of grids and the repetition of certain patterns or spatial organization systems to ensure order have been a common ground [García 2009]. Music has also cherished order, especially since composition was based on a notational language. Some graphing attempts show to what extent varied musical compositions like those of Chopin étude no. 11, op. 25 (fig. 7) are also inspired in patterns and possess, a hidden perceptual order, which is not as easy to read through musical notation: "the magic behind magic is pattern" [Hofstadter 1982, p. 18]. Even painters have also tried to visually translate musical order into the graphic realm, as Pierre Boulez pointed out regarding Klee's *Fuge in Rot* [Chías Navarro 2006, p. 62].
Another question of great transcendence in architecture in relation to numbers and measurements is all the theory of proportions that, to a great extent, inspired while also constrained architecture for centuries. A proportion is an equivalence between two ratios or a relation between three measures [4]. As Wittkower suggested, medieval architec-

Fig. 6. Pythagoras theorem drawn. Illustration of Vitruvius book 9 by Cesare Cesariano, 1521.

Fig. 7. Chopin, étude no. 11, op. 25. Music score and diagram by R.D. Hofstadter.





ture was influenced by a geometrical source for proportions whereas Renaissance relied on arithmetic relations based on integral numbers or simple fractions partly derived from Pythagorean musical scale. In other words, the incommensurability of irrational numbers and the commensurability of integers and fractional numbers [Wittkower 1988, p. 152]. The same incommensurability of π that we see in every drawn circumference which the notational formula $x^2+y^2=z^2$ is totally incapable of displaying; that is certainly a major difference between graphic and alphanumerical mathematical formulas. Not surprisingly, musical harmony came to be a reference in the search of beauty in architecture since the middle ages. This harmonic numerology was used to relate architecture and musical notation as can be observed in the sequence

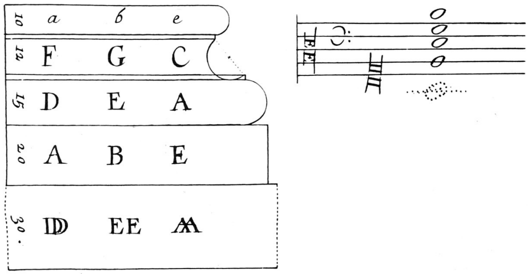


Fig. 8. François Blondel. Harmonically proportioned Attic base with its corresponding chord, Cours d'Architecture, 1683.

of capitals in San Cugat's monastery cloister and the Gregorian chants of San Cucufate's martyrdom, the saint to which the building is devoted (Cabezos, Rossi 2017). St. Augustine thought that "music and architecture are sister arts, both based on number, which ranks as the source of all aesthetic perfection" [Kruft 1994, p. 36]. This tradition extended its influence over centuries, reaching very literal attempts to achieve such perfection, for example, in the case of Blondel's attic base design (fig. 8), as Evans [Evans 2000, p. 242] has accounted for. Generally speaking, the analogy was established between the musical intervals –the basis of chords and, by extension, of harmony– although it could also be established with regard to rhythm.
Wittkower [Wittkower 1953] also explained how perspective could also include the harmonic series (1, 1/2, 1/3, 1/4…) if looking in the right direction from a precise position in Brunelleschi's Santo Spirito and San Lorenzo churches. Something that Evans carefully drew later on (fig. 9), showing these interesting relations in the perspective and others in section [Evans 2000, p. 252]. Wittkower [Wittkower 1953, p. 291] argued that when architects abandoned Brunelleschi's idea of homogeneous spatial articulation "it was a signal for the break-up of the Renaissance unity between objective proportions and the subjective optical appearance".
These measurable ratios and proportions certainly connect architecture to music through the harmonic scale but, above all, they are also related with perspective and, indirectly with painting and architectural representation. Nevertheless, it is interesting to point out how musical harmony can be related to orthogonal projections and architecture, whereas rhythmic proportions or mensuration –as it is called in music– is to be found in perspective drawing, a certainly intriguing quirk.
The sought for order in architecture as a source of beauty not only was inspired in music and the quantifiable. Additionally, Renaissance's humanistic approach found in the human figure another inspiration for proportions and beauty supported by Vitruvius himself. The parallel he established between proportions of the temples and the perfection of the human figure to be inscribed within a circle and a square led to several graphic interpretations of what was to become one of Renaissance most memorable icons –Leonardo's Vitruvius man– who was to be reinterpreted by others differently.
Comparing Leonardo's drawing with others of his contemporaries, it can be observed that even in the representation of the human figure a more pictorial and visual approach, such as the one by Francesco di Giorgio, can be perceived, in comparison to a more scientific and frontal orthogonal projection in the versions by Cesare Cesariano and Leonardo himself (fig. 10). This dual projective approach based on parallel or central projections constitute two complementary systems characteristic of graphic representation: one shows what things really are and the true measures and proportions whereas the second is focused on visual appearance and how we perceive reality [Arnheim 2005, pp. 126, 127].
The fact that those alleged beautiful proportions influenced the language of the discipline itself is certainly surprising if we consider the extent to which beauty derived from proportions is culturally relative. It is easy, for instance, to compare and gauge the very different beauty canons to be observed in painting in a simple time span of no more than two-hundred years. The mythological theme of the Three Graces –daughters of Zeus with Eurynome– has been depicted relentlessly. If we compare the versions of the topic by Botticelli, Raphael or Rubens it is easy to guess that beauty is voluble or at least, our consideration of it (fig. 11). It is, therefore, logical that architects tried for centuries to set a fixed canon of architectural beauty that could ensure the righteousness of their designs. It was the reference to the classical repertoire and its order-based language that Roman architecture had adopted form the Greeks what proved to be an unsurmountable aesthetic peak. The *autoritas* granted to Vitruvius theory only became to be questioned once the printing press allowed to include graphic interpretations of his text. Words are incapable of measuring, drawings, on the other

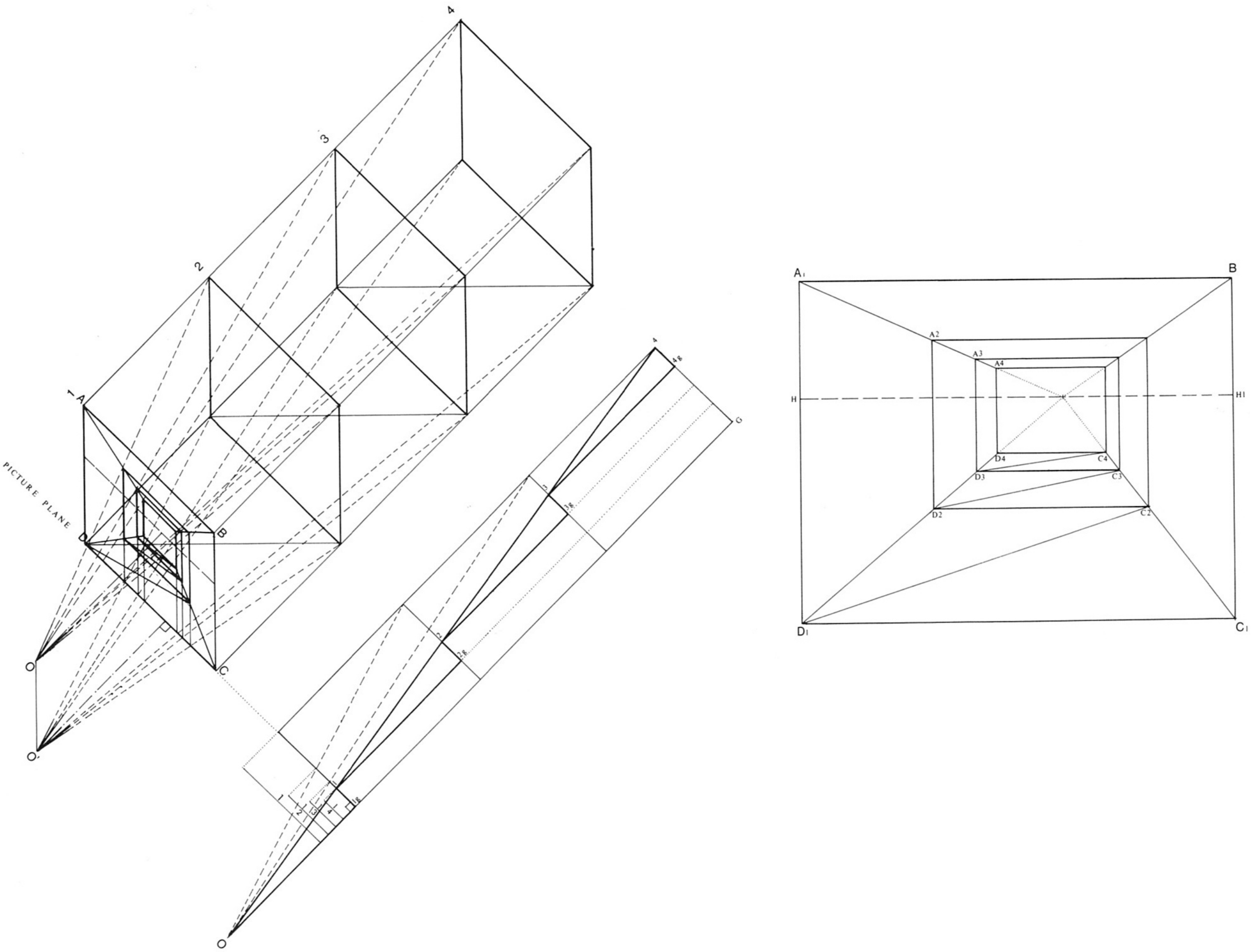
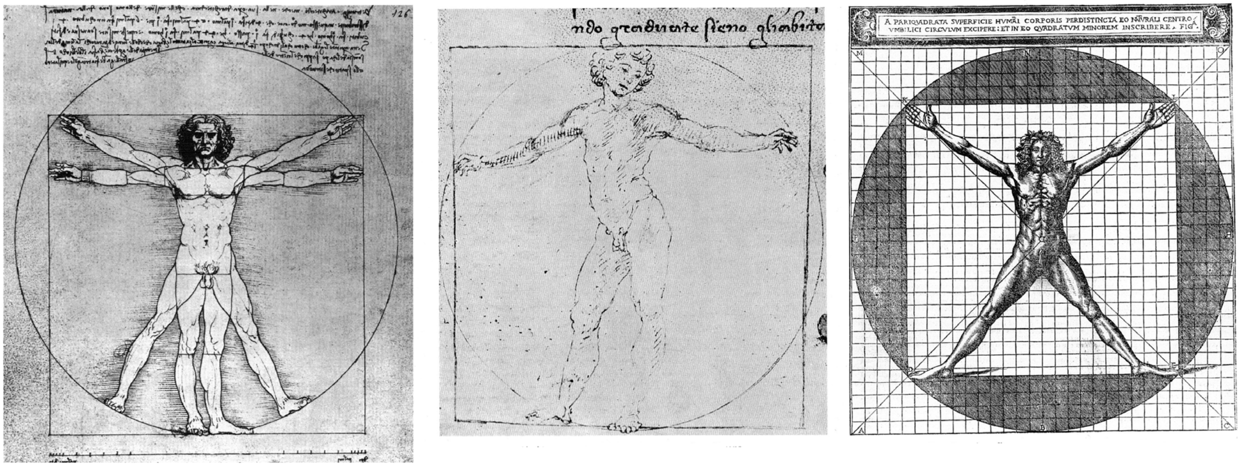


Fig. 9. Harmonic ratios in perspective (1, 1/2, 1/3, 1/4); [Evans 2000].

Fig. 10. Vitruvian figure. Leonardo da Vinci (left), Francesco di Giorgio (centre), Cesare Cesariano (right).

Fig. 11. Three graces. Botticelli, c. 1480 (left; detail), Raphael di Sanzio, c.1504 (centre), Peter Paul Rubens, 1630-1635 (right).

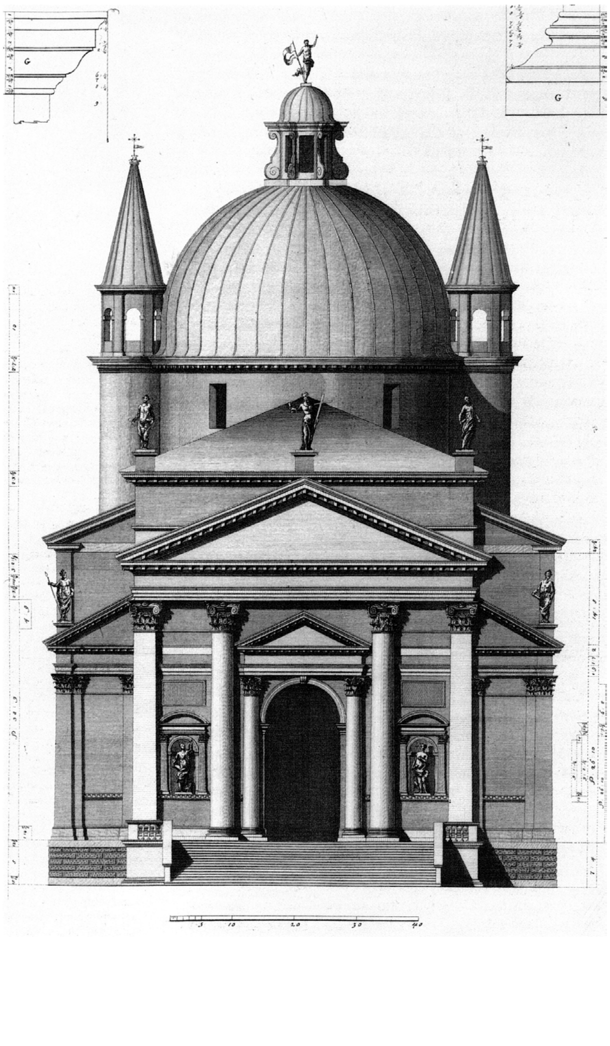


hand, are. The moment different orders started to be drawn it became obvious their proportions differed. In fact, built classic architecture did not always use the very same precise proportions but rather, a range of them for every order.
This debate became vivid during the eighteenth century in the so-called '*querelle des anciens et des modernes*', whose echoes transcended the *l'Académie royale d'architecture* [Gerbino 2010]. Blondel defended the archetypical use of the long-established classical orders because of their accredited sense of proportion and considered them a natural source of beauty, uncritically following Vitruvius *dictum*. Perrault, arguably objected that the proportions were not an absolute value of beauty but rather something we had grown accustomed to see and, therefore, learned to esteem as beautiful through experience.
Although it is certain that beauty is contextually or culturally relative it is also true that it is dependent on proportions. There is no absolute mensurable numerical value or ratio for these proportions. Although Alberti writes with regard to beauty as "a form of sympathy amid consonance of the parts within a body, according to definite number, outline, and position, as dictated by *concinnitas*, the absolute and fundamental rule in Nature" he does not give a fixed value for it. Much on the contrary, he uses a synthetic judgement in Kantian terms so that the definition of this harmonic perfect beauty is relatively open: "For every body consists entirely of parts that are fixed and individual; if these are removed, enlarged, reduced, or transferred somewhere inappropriate, the very composition will be spoiled that gives the body its seemly appearance." The elevation of Palladio's *Redentore* drawn by Scamozzi is eloquent to this regard (fig. 12).

Conclusions

Symbolic systems contribute to our acquisition of knowledge in different ways. Verbal languages fail to accurately represent sensible objects whereas architectural drawings define a precise relation between material reality and its representation. This basic divide establishes an effective difference in the way technical drawings and knowledge should be considered. They are notational systems that possess an unmatched accuracy regarding their referents. Unlike music, their allographic nature surpass the natural allographic limitations of musical scores as they establish a point-to-point relation based on analogy and projections. Accordingly, they can precisely depict the quantifiable and its proportions.

Fig. 12. A. Palladio, Il Redentore, Venice, 1576-1592. Drawing by O. Bertotti Scamozzi.



Notes

[1] Primary matter is the material continuum of the real world: the basic *bricks* of existence.

[2] Even though philosophers naturally establish a distinction between Physics and Metaphysics it is precisely the point that we attemt to make here: the difference between the concrete especificity based on particulars that characterise the physical world and the abstract and generic one, based on universals or the formal approach constituent of Metaphysics –"beyond physics" and dealing with existence–. This has a very relevant relation with regard to simbolic systems and representation; most speceifically with respect to the very singular relation bewteen architectural representation based on projections and the material world.

[3] Goodman uses the term 'symbol' including in it: "letters, words, texts, pictures, diagrmas, maps, models and more", but has no further connotation in terms of what could be related to symbolism [Goodman, op. Cit, *ibidem*].

[4] For instance, given two measures, a and b, a/b is the ratio between them whereas a/b=(a+b)/a is the equivalence that defines the so-called divine proportion.

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On a Human Scale. Drawing and Proportion of the Vitruvian Figure

Veronica Riavis

Abstract

Among the images that describe the proportions of the human body, Leonardo da Vinci's one is certainly the most effective, despite the fact that the iconic drawing does not faithfully follow the measurements indicated by Vitruvius.
This research concerned the geometric analysis of the interpretations of the Vitruvian man proposed in the Renaissance editions of De Architectura*, carried out after the aniconic* editio princeps *by Sulpicio da Veroli.*
Giovanni Battista da Sangallo drew the Vitruvian figure directly on his Sulpician copy, very similar to the images by Albrecht Dürer in The Symmetry of the Human Bodies *[Dürer 1591]. Fra Giocondo proposes in 1511 two engravings of homo ad quadratum and ad circulum in the first Latin illustrated edition of* De Architectura*, while the man by Cesare Cesariano, author of the first version in vernacular of 1521, has a deformed body extension to adapt a geometric grid. Francesco di Giorgio Martini and Giacomo Andrea da Ferrara also propose significant versions believed to be the origin of Leonardo's figuration due to the friendship that bound them. The man inscribed in the circle and square in the partial translation of Francesco di Giorgio's* De Architectura *anticipates the da Vinci's solution although it does not have explicit metric references, while the drawing by Giacomo Andrea da Ferrara reproduces a figure similar to Leonardo's one. The comparison between the measures expressed by Vitruvius to proportion the man and the various graphic descriptions allows us to understand the complex story of the exegesis of the Roman treatise.*

Keywords: geometry, drawing, measure, proportion, Vitruvian man.

Man and architecture: measure and proportion according to Vitruvius

In the definition of the Renaissance "new man", the rediscovery of Vitruvius' *De Architectura* was very interesting for scholars and architects of the time. The treatise, in addition to addressing in ten books the problems and fundamental principles connected to architecture –*utilitas*, *firmitas* and *venustas*– according to a precise technical-constructive language and appropriate terminology, transmits a series of philosophical-mathematical theories deriving from the elaborate geometric research in Greece on proportions and harmony. On these concepts, which influenced the Renaissance architectural language of the orders, Vitruvius found a correspondence between the ordered and proportionate structure of the human body and the architecture.

This theory, exposed in the thematic section of Templar architecture, is the most consistent and extensive of the work, to which the Augustan engineer and theorist dedicates books III and IV. To introduce this topic, the author refers to the concepts of *symmetria* [1] and *analoghia* [2], recomposing fragments of various Hellenistic treatises and canons.
A templar complex is the bearer of symmetry –harmony, order, proportion– similarly to *homo bene figuratus*, a harmonic-proportional organism defined by Nature both in the modularity of its parts and in its totality [3].
The treatment examines the human physical proportions according to anthropometric units of measurement – the finger, the palm, the foot, the cubit: in fact, a proportional

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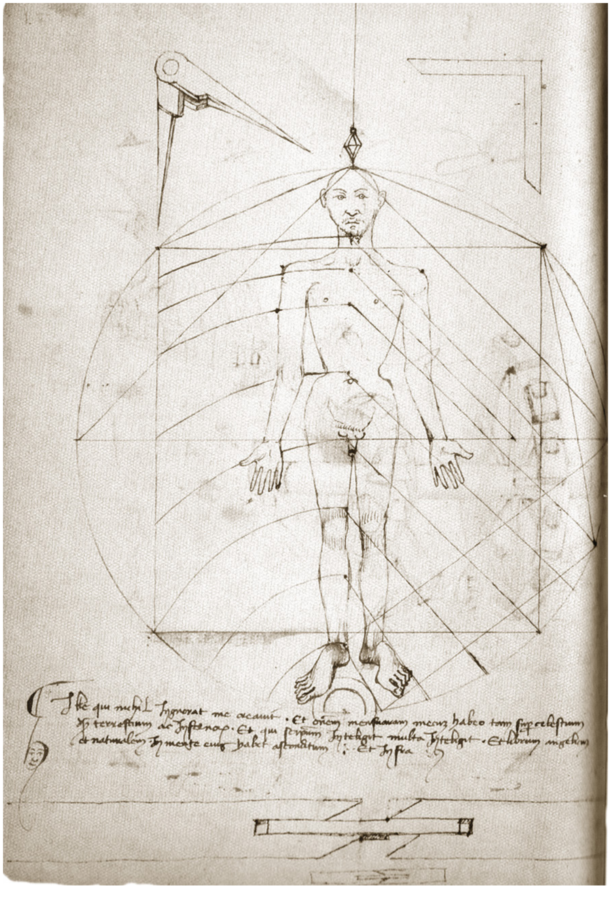
relationship closely relates each of the individual parts of the body. Thus, the ancients established that in the perfect architectural work, and especially in sacred buildings, there was a precise agreement between the maximum and detailed measures of the individual components and orders.
The natural and immanent module in reality lies in the parts of the human body whose relations are mutually commensurable. Compared to the total height of the body, the foot is its sixth part, while the head is the eighth. The face is ten times in height, similarly to the hand, whose effective length goes from the tip of the middle finger to the beginning of the palm. The face is further tripartite: chin-nostrils, nostrils-median eyebrows, and forehead.
We then learn the reason why in ancient times 6 (of Euclidean origin), 8 (proportions of the Canon of Polycleitus) and 10 (of the Pythagorean school) were considered perfect numbers.
Multiple modular relationships give beauty and harmony to a work and converge in a focal point towards which the single elements tend. Vitruvius in the navel identifies the focal sign of man. This vital centrality also derives from a conviction of Hellenic tradition, which can already be traced in Homeric culture and tributary of previous similar opinions of oriental cultures, as well as from an ideology rooted in Roman culture documented since the time of Plautus (III / II century B.C.).
The navel is the origin from which to trace the circumference –"round scheme"– in which to inscribe the man, a perfect figure like the sphere according to the Pythagorean School. The lying and supine position clearly highlights the parts of the body and their relative modular relationships, as well as the possibilities of movement of the limbs. Furthermore, the inscription of the body in a square also defines the proportion of the figure, which rationalizes and translates the perfect human figure in its circular definition into whole number measurements. According to the Greek unit of measurement, the width of the open arms is equivalent to six feet or four cubits, while in the Vitruvian system this value defines the height of the man. The correspondence between width and height not only expresses the main dimensions of the figure, but through this geometric principle, Vitruvius determines the areal regularity of the square.
However, Vitruvius does not mention about a true squaring of the circle; much less of a possible areal equivalence between the two geometric figures [Gros 1997, p. 279]. He associates the construction of the surface of the square with technical-architectural tools at right angles –norms or squares– and that of the circle with the compass – a tool for geometric and architectural drawing, which is, also indispensable for finding and transferring measurements. The man lying with his hands raised vertically straight above the head and the feet together would correspond in height to the measure of the perch, a third architectural instrument used in the Roman world as a 5-cubit scale, similar to the graduated ruler or the metric cord. Vitruvius teaches the

Fig. 1. M. di Iacopo called il Taccola, Drawing of the proportions of the human body, De ingeneis, c. 1420. Ink on paper, 30 x 22 cm, Munich, Bayerische Staatsbibliothek, Clm. 197, f. 36v.

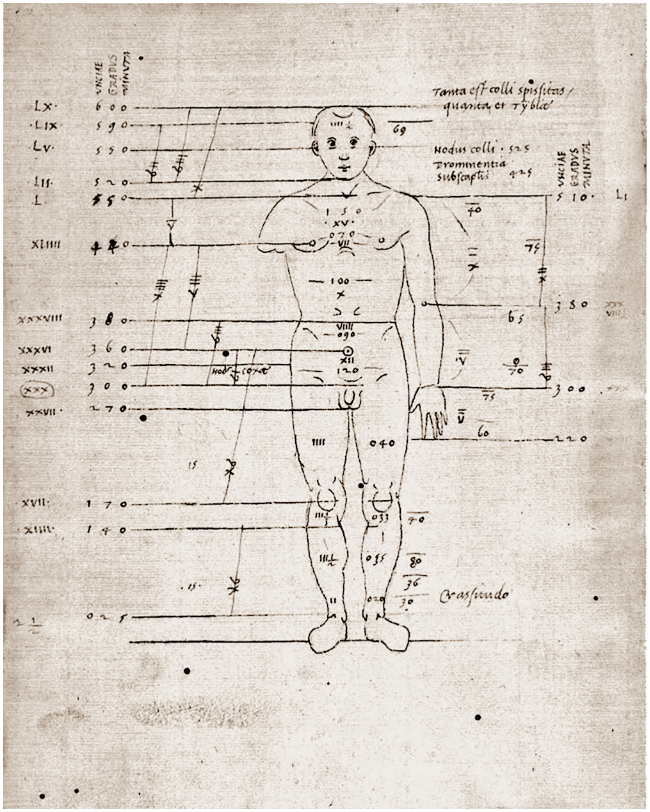


importance of geometry and measurements for sculpture and architecture using *homo ad circulum and ad quadratum as a yardstick and ratio* [Zöllner 1995, pp. 337-339].

De Architectura, translation and graphic interpretation between the 15th and 16th centuries

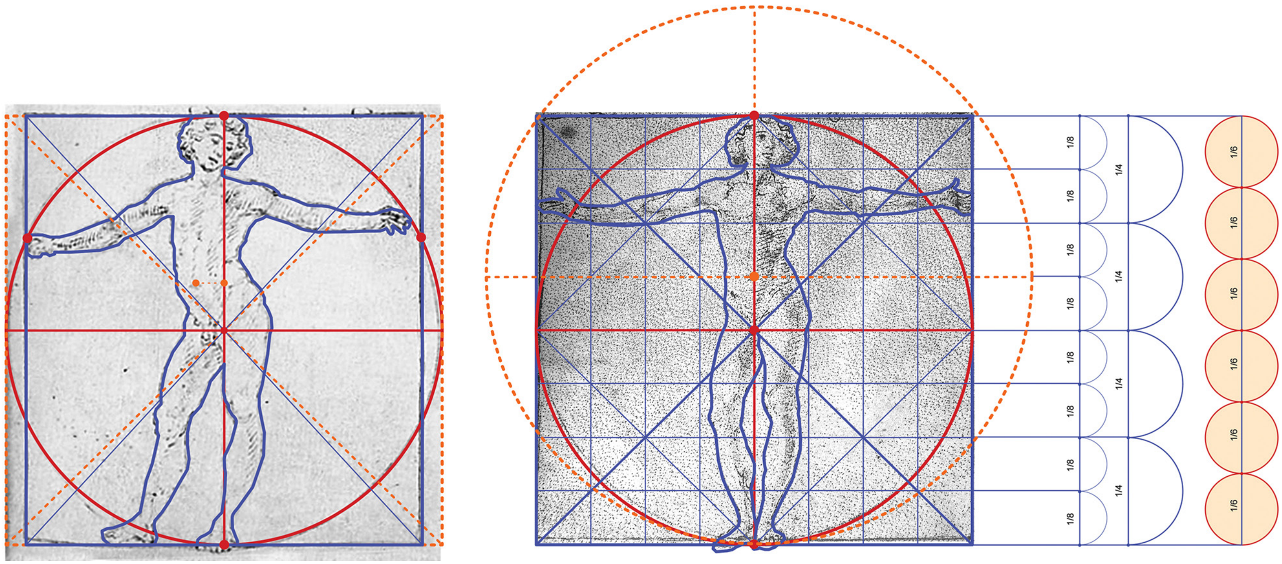
From the fifteenth century, there was a real rediscovery of the Vitruvian treaty. Re-reading and studying the work, many scholars and architects ventured into the arduous exploit of interpreting the Latin text. Among the main difficulties was the translation of technical terms to explain fundamental architectural principles with an obscure meaning, and the loss, copy by copy, of the illustrations that originally accompanied the Augustan treatise, depriving the argumentation of clarity.
Initially, the interest in the textual problems of *De Architectura* was exclusively of philologists and only later of architects, useful in filling the graphic deficiencies of the grammarians. An example is the aniconic Roman *editio princeps* by Giovanni Sulpicio da Veroli (1486), laid out with large margins precisely to give a way, to those interested, to enrich the text with images [Sdegno 2005, p. 171].

Fig. 2. a) L.B. Alberti, Ideal measurements and proportions of the male figure, Tabulae dimensionorum Hominis, MS Canon Misc. 172, f. 232v, Oxford Bodleian Library; b) L.B. Alberti, Finitorum, De Statua, 1468.



Many authors translated the treatise and gave graphic form to the contents explained: among them, the passage that defined the perfect man and his ideal proportional system, based on pre-established relations and modules applicable to architectural projects.
The Vitruvian man was not only a metaphorical and geometric metaphor, but from the fifteenth century, he assumed an additional conviction compared to that provided by the Augustan treatise writer. In fact "with the Renaissance revival of the Greek mathematical interpretation of God and the world, and invigorated by the Christian belief that Man as the image of God, embodied the harmonies of the Universe, the Vitruvian figure inscribed in a square and a circle became a symbol of the mathematical sympathy between microcosm and macrocosm" [Wittkower 1988, p. 25]. The relationship between the structure of the universe and man has already interested scholars since the middle Ages, although the representation of this concept differed greatly from the ancient proportional canons [4]. The figurations of man, drawn according to different expressive principles in different eras (from the 10th to the 17th century) were often framed within circles (or curved lines), to highlight the transposition between the earthly limit of the human being and the perfect dimension of the celestial world [5] [Zanini 2009].
In the centuries preceding the Renaissance, scholars knew Vitruvius's *De Architectura*, as shown by the image created between 1300 and 1400 by Mariano di Iacopo called the *Taccola*. The engineer of Siena, author of the treatise *De Ingeneis*, represents a man with his arms extended at his sides, back straight, feet and head tangent to the ends of a circle inscribed in a square (fig. 1).
The Vitruvian scheme inspired several treatise writers from the second half of the fifteenth century: among them Lorenzo Ghiberti, who was the first who devoted himself to the theme of the Vitruvian man. He analyzed the disposition of the *homo ad circulum*, especially for the diversity of posture of the limbs and for the identification of the human center in the genitals and not in the navel [Ghiberti 1912, I, pp. 227-231]. The circle in this case is no longer

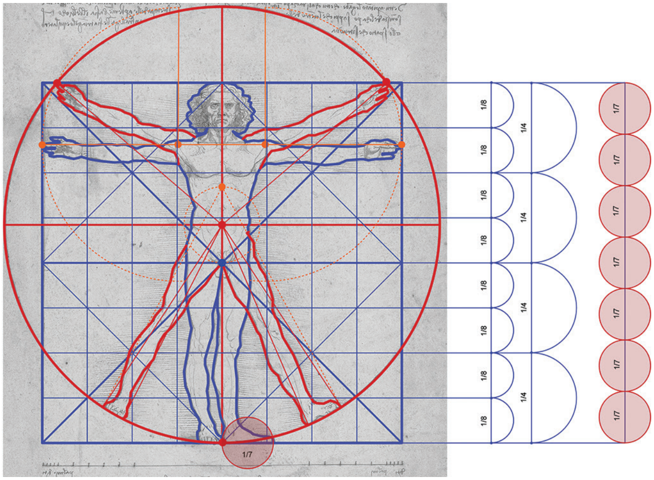
Fig. 3. a) F. di Giorgio Martini, man in the circle and in the square, Codex Saluzziano 148 (f. 6v), Treatise on civil and military architecture, handwritten copy of about 1482-1486, Turin, Biblioteca Reale. Identification of the geometric references of the drawing (rectangle and circle), (graphic elaboration by V. Riavis); b) F. di Giorgio Martini, Homo ad circulum, Treatise on Architecture and Machines, c. 1480, Ms. Ashburnham 361, f. 5r. Study and identification of concentric geometric figures of circles and squares (graphic elaboration by V. Riavis).



a symbol but is the result of a geometric and measuring construction [Zöllner 1995, p. 340].
Other fifteenth-century authors such as Leon Battista Alberti, Filarete, Piero della Francesca and Francesco di Giorgio Martini also gave their reinterpretation of the classical canon, changing the basic unit of measurement.
Of the Vitruvian text, Alberti took up the setting and concepts especially on man and architecture in *De Re Aedificatoria* [Alberti 1485]. Furthermore, in *De statua*, written between 1447 and 1464, he proposed an accurate system of measurement and definition of the human body based on the tools *exempeda* [6] and *finitorium* [7] [Alberti 1804] (fig. 2b).
The studies of Filarete and Francesco di Giorgio barely hinted at the connection between measure and geometry, focusing instead on anthropomorphism. Filarete –like Ghiberti, did not identify the center of man in the navel– argued that a building derived from the shape, limbs and measures of the man, and the geometrical schemes of square and circle were fundamental instruments for measurement [Filarete 1972, I, pp. 20, 21 e 28].
However, in the illustration of the perfect man there were several unresolved issues. Vitruvius writes of an upright man inscribed in the square and a supine one in the circle. Therefore two images that cannot both have the same position. There is not distance or ratio between the center of the square and the center of the circle (between the genitals and the navel). He also divides the height of the man into ten modules taking a cue from the measurement of the face that goes from the hair root –and not from the top of the head– to the base of the chin, and indicates the foot as $^1/_6$ of the height of the man [Sgarbi 2012, p. 184].
The Sienese painter and architect Francesco di Giorgio Martini testifies great interest in the proportional study of man and subsequent application in the architectural field. This research is evident in his fragmentary translations of the Vitruvian treatise, in which he tried to give a graphic form to the man inscribed in the circle and square. In the *Treaty on civil and military architecture* (1481-1484) [Di Giorgio Martini 1979], he outlines the modules of buildings based on the human body proportions of the human body, thus also relating architecture and anatomy [8]. Analyzing two Vitruvian versions proposed by Francesco di Giorgio (figs. 3a, 3b), we can see how they undoubtedly anticipate da Vinci's solution, especially due to the superimposition of the two geometric figures. However, both images do not exhibit the symmetry of the body with respect to the central vertical axis, preferring the ¾ pose, while the coincident geometric centers are at the level of the genitals and not of the navel.
Furthermore, the small male figure of the Turin *Codex Saluzziano* (f. 6v), inserted in a page to describe the necessary correspondences between the city and the human body, is represented inscribed in a circle and in a rectangle, whose geometric arrangement involves the modification of the height and proportionality of man. The silhouette is in a structure devoid of rigor and which seems to casually lap the two geometric figures [Sgarbi 2012, p. 178] [9] (fig. 3a). The identification of the anthropometric center in the genital area is also present in the work of the Venetian monk Francesco Zorzi [Zorzi 1525] that provides the image of a man with legs apart and arms folded inscribed in a circle (fig. 4) [Perissa Torrini 2018].
The Study of Proportions of the Human Body (fig. 5) by Leonardo da Vinci of 1490 kept at the Gallerie dell'Accademia in Venice in the *Gabinetto Disegni e Stampe* (cat. no. 228) is the most famous representation of the Vitruvian Man. However, there are not always precise correspondences

Fig. 4. F. Zorzi, Quod homo imitetur mundum in figura circulari [Zorzi 1525, tome VI, chp. 2, p. Cv] (graphic elaboration by V. Riavis).

Figs. 5, 6. L. da Vinci, Study of proportions of the human body, c. 1490, Venice, Gallerie dell'Accademia. Geometric and modular analysis (graphic elaboration by V. Riavis); Giacomo Andrea da Ferrara, proportions of the human body inscribed in a circle and in a square, Vitruvio Ferrarese, Ferrara, Biblioteca Ariostea, Ms. Cart., 1490-1515, [Sgarbi 2004, f. 78v]. Geometric analysis of the human figure and comparison with Leonardo's one (graphic elaboration by V. Riavis).



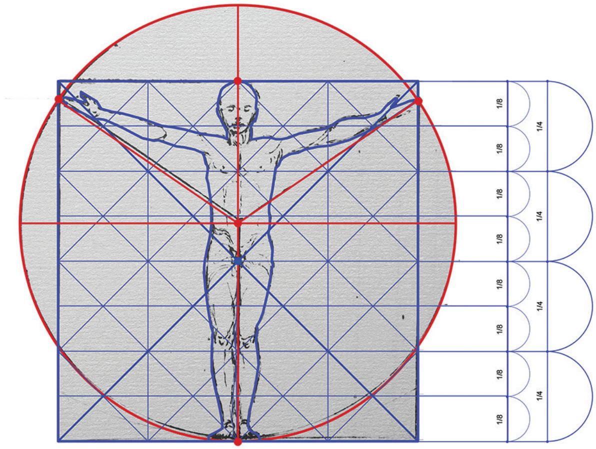
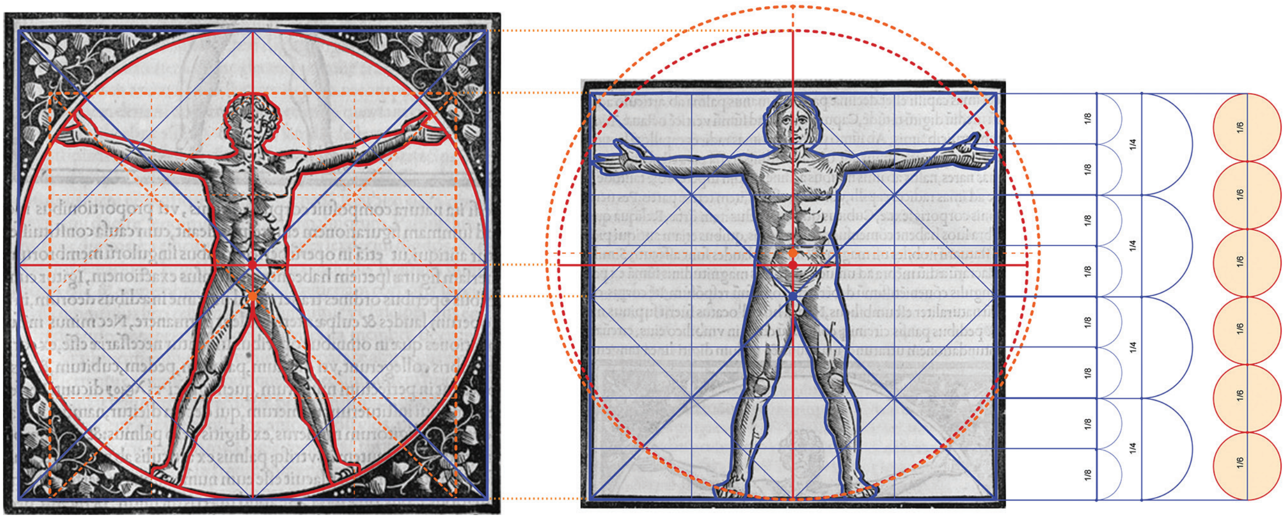


Fig. 7. a, b) Fra Giocondo, Homo ad circulum and Homo ad quadratum [Vitruvius Pollio 1511, p. 22 recto and verso]. Resizing and geometric analysis of the two different illustrations by Giovanni Giocondo (graphic elaboration by V. Riavis).



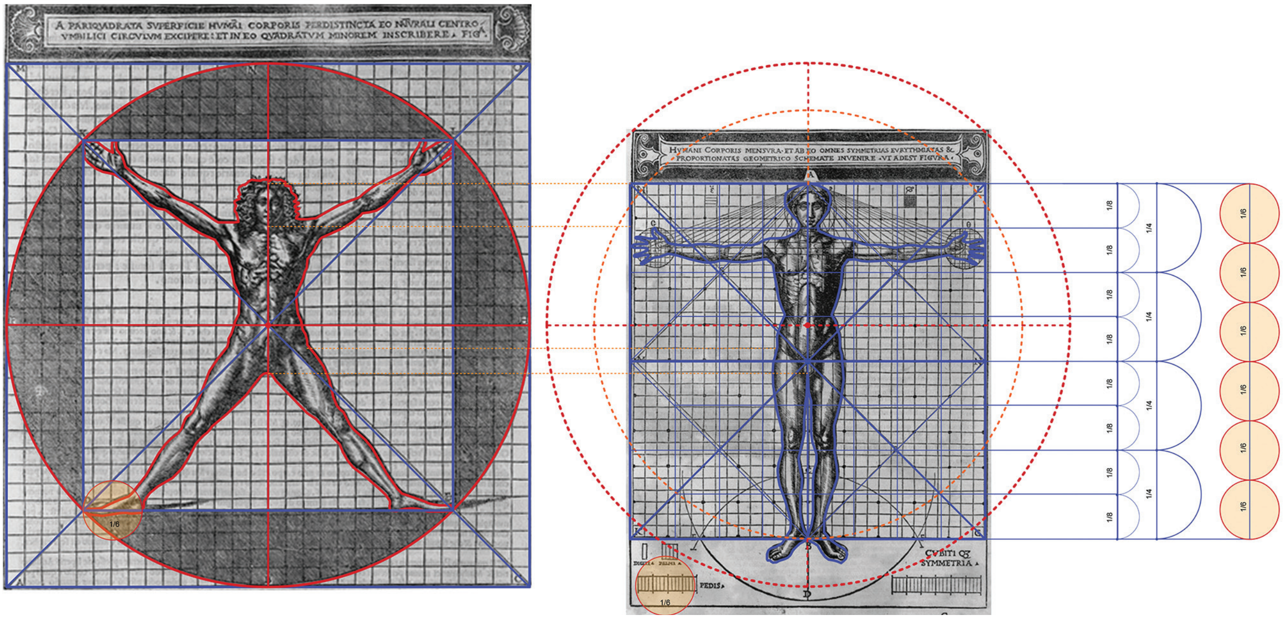
between the proportional description provided by the Augustan author and the da Vinci's figuration, perhaps because Leonardo drew the concept not knowing Latin and without having a copy of the *De Architettura*. The well-known representation is more than anything else the result of careful studies on human anatomy, mathematics and proportion [10] as well as the friendship with Francesco di Giorgio Martini and Giacomo Andrea da Ferrara with whom, met on several occasions in 1490, probably discussed the Vitruvian passage in question. Leonardo's man bases on the real measurement of the human body. It is the result of a long anthropometric and movement investigation initiated by the author as early as 1487 and confirmed by a series of earlier drawings –later copied by Carlo Urbino in the Huygens Codex (ca. 1560-1580)– which led him to a dimensional system that largely coincided with the Vitruvian description.

Inserted within a seemingly concentric circle and square, the one-busted man has four legs and four arms that define two different overlapping positions.

The profile of the left foot defines the unit of measurement and it is "the seventh part of man" according to Leonardo [Di Teodoro 2019]. The human figure divided into seven parts with a unit of measurement corresponding to 26 cm, therefore smaller than the Vitruvian one. A mathematical body, more than natural, in good physical and mental health, not altered by emotions: it is a conceptual model, drawn with precise contours deeply understandable by the intellect.

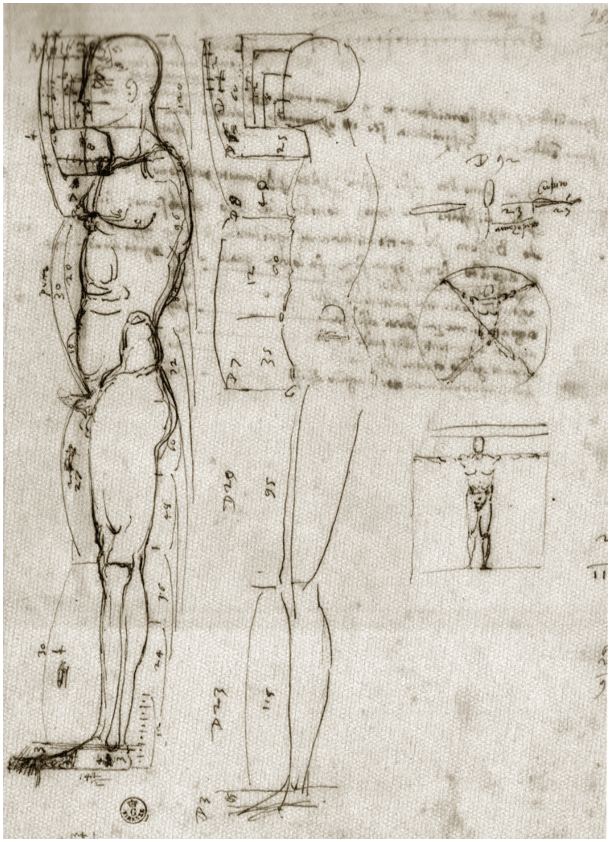
The image of Leonardo is very similar to that of his close friend Giacomo Andrea da Ferrara (fig. 6), who tragically died in 1500. The analogy presupposes a collaboration between them on the study of the Vitruvian canon, presumably initiated between the pages of the front and back of a single sheet of the *Vitruvio Ferrarese* [Sgarbi 2004; 2012, p. 181]. The square respects the layout scheme used by Giacomo Andrea in the manuscript: the square and the circle are not concentric, but they are tangent in their lower sides. The circle is pleonastic and the human body

Fig. 8. a) C. Cesariano, Homo ad circulum et ad quadratum, engraving, 37.2 x 25.1 cm, Milan, Castello Sforzesco, Ente Raccolta Vinciana, [Cesariano 1521, p. Lr]. Geometric references (elab. V. Riavis); b) C. Cesariano, Humani corporis mensure et ab eu omnes symmetrias eurythmiatis, engraving, 31,2 × 21,6 cm, Milan, Castello Sforzesco, Ente Raccolta Vinciana [Cesariano 1521, p. XLIXr]. Resizing, comparison and geometric analysis between the two illustrations proposed by Cesariano (graphic elaboration by V. Riavis).



only touches it at the points coinciding with the square. Furthermore, the two geometric figures have the same ratio between side and radius equal to 0.603 and the same dimension of radius (110 cm) [Pierantoni 2009, pp. 132, 133]. The silhouette with legs tight together and arms outstretched is partially similar to Leonardo's drawing, but it is much sketchier and the body is more slender.
Da Vinci's man graphically personifies the Renaissance mentality, although its meaning and great innovation remained unknown to those who later ventured into giving visual form to the words of Vitruvius, almost nullifying the results achieved by Leonardo [Perissa Torrini 2009].

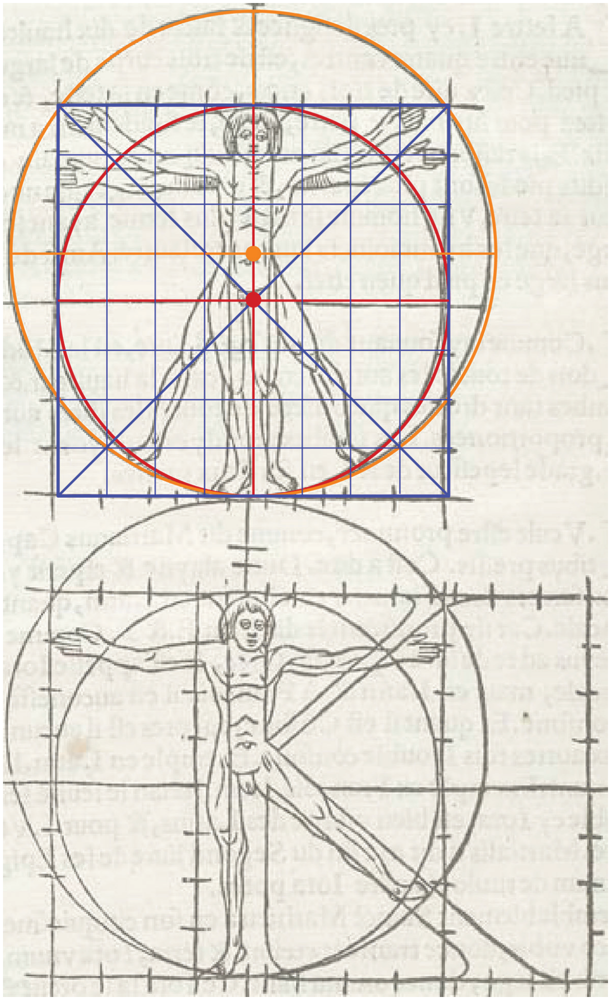
Fig. 9. A. da Sangallo the Younger, Vitruvian man, c. 1528, Florence, Gallerie degli Uffizi, Gabinetto dei Disegni e delle Stampe, n. A 1249r.



Fra Giocondo was the first curator to provide an illustrated printed edition of the treatise and to correct the Latin text to make it more understandable. He published the work several times: the first in Venice in 1511 [Vitruvius Pollio 1511] and in subsequent reprints in the years 1513, 1522 and 1523 [Di Teodoro 2014]. In support of the description of *homo ad circulum* and *ad quadratum* he inserted two distinct images with poor graphic and proportional precision (fig. 7a, b). The two versions are not at the same scale and on consecutive fronts of the page: assuming the side of the square as the height of the man, we have therefore proportioned the figure inscribed in the circumference. The geometric research shows that the position of the navel of the two silhouettes is different, at the same height. A dimension that should be invariable (fixed and not subject to movement) would relate precisely to the distance from the top of the head to the navel. By superimposing the two images and assuming the height of the man as a scale parameter, we also note that the two geometric figures are not concentric: the origin of the circumference is in the navel, while the meeting point of the diagonals of the square is in the pubis.
Luca Pacioli [Pacioli 1889, p. 129] and Cesare Cesariano also addressed the question of measure and geometry, giving greater importance to anthropomorphic measurements and the link with geometry. This emerges in the first edition in the vernacular language edited by Cesare Cesariano [Cesariano 1521], in which the figuration of man is very forced, disproportionate and tense, inserted within a square grid. The hands and feet touch the vertices of the square whose median lines intersect at the center of the circumference that circumscribes the human figure. Man stretched to the ends of the geometric perimeters of perfectly superimposed figures. The letters on the sheet correspond to the fundamental points of tangency and intersection (fig. 8a). We compared the human figure with another image proposed by the treatise on the symmetry and measurements of the human body (fig. 8b). In this case, we used the foot reference to relate the two solutions, depicted on the side in the *homo ad circulum et ad quadratum* and in the graphic scale of the study of proportions. The main parts maintain the same proportional ratio and the same focal points in both versions. The grid has more representative utility than metric, as it is independent from the graphic scale reported by the author. Very similar to the representation of Cesariano is the one represented in the work of Walther Hermann Ryff [Ryff 1547, pp. 124r -125v].

The Vitruvian notion, on the other hand, covered only a conceptual interest for Antonio da Sangallo the Younger, who in 1528 drew two small separate sketches of the *homo ad circulum* and *ad quadratum* close to the right margin of a sheet, preferring to devote himself rather to anatomical measurements (fig. 9). We deduce from the drawings how he took the measurements of the limbs, taking them from reality, thus abandoning the canon of Vitruvius. For example, the Augustan essayist indicates that a foot measures 16 fingers, a dimension in nature considered too large by Antonio da Sangallo who reduces it to 14 fingers referring to the real model. He also brings the height of the entire human body to 120 fingers instead of 96, thus changing the entire measurement system [Zöllner 1995, p. 341].
A little later are the images of *Champfleury* by Geoffroy Tory [Tory 1529]. The simplified drawings are significant because they recall Leonardo's composition and the choice of superimposing two postures and two geometric figures. Tory also inserts two circumferences (one centered in the genitals and one in the navel) and divides the image into modular relations (fig. 10).
Antonio da Sangallo's younger brother, Giovanni Battista Cordini called '*il Gobbo*' is known for the Vitruvian studies started from 1513, aimed at translating and integrating the Sulpician version of the treatise. In particular, his annotations on the *editio princeps* present interesting representation of the Vitruvian man presumably made in 1540. Surely, Giovanni Battista knew the figurations of Fra Giocondo (1511, 1513) and of Cesariano (1521), but did not take them as reference [Sdegno 2005, p. 171].
The author draws the human figure on four blank pages added posthumously to the volume (pp. 55-58). The modules divide the height of the first man, represented on page 55, into 100 fingers and into four parts of 25 fingers each, with further subdivision of the upper quarter comprising the head. On the reverse of this sheet, he shows the profile of the man at the same scale, drawn by tracing for transparency. The foot also in this case measures one sixth of the height of a man. The third figure represents the *homo ad circulum* (fig. 11), with arms outstretched and legs apart inserted inside the circle, whose posture is an evident reference to the work of Albrecht Dürer *Vier Bücher von menschlicher Proportion* [Dürer 1591] printed after the author's death in 1528 [11] (fig. 12). The figure, slightly reduced compared to the previous ones, has horizontal lines that mark its proportion. Cordini's Vitruvian figure traces an omphalocentric circumference with a radius that from the center reaches the tip of the middle finger of the raised arm. Almost imperceptible grooves made on the book by the author with a stylus allowed him to set the geometry of the drawing [Sdegno 2005, pp. 172, 173-175].

Fig. 10. G. Tory, De la proportion des lettres, representation of the human figure [Tory 1529, p. XVIIr]. Identification of main geometric shapes and centralities (graphic elaboration by V. Riavis).



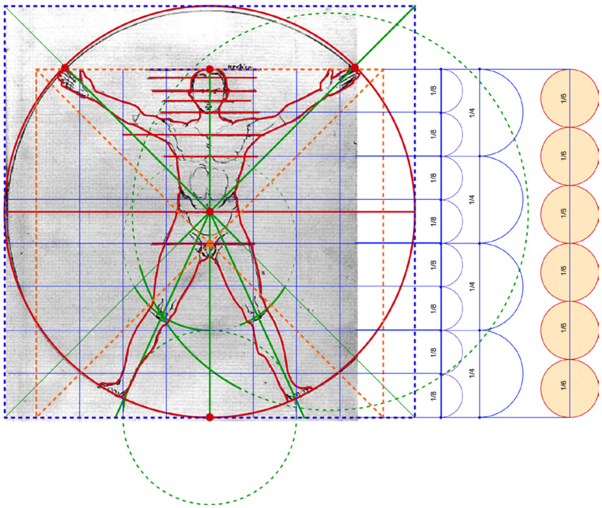


Fig. 11. G.B. Cordini da Sangallo, homo ad circulum. From: Vitruvius, De Architectura, editio princeps, Rome, Biblioteca dell'Accademia Nazionale dei Lincei e Corsiniana, inc. 50.F1, p. 57. The green lines highlight the engraved geometric construction (graphic elaboration by V. Riavis).

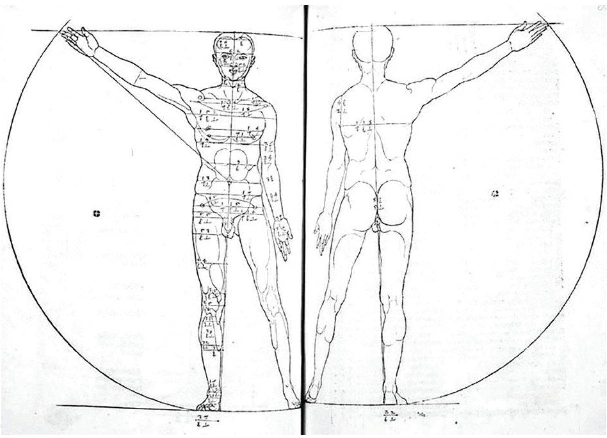


Fig. 12. A. Dürer, proportional study on the human figure [Dürer 1591, book II, pp. 58v-59r].

In conclusion, the late sixteenth-century edition edited by Giovanni Antonio Rusconi appears to be the figurative answer requested in the aniconic *editio princeps*, as this version of the treatise does not contain the Vitruvian text, but presents an extraordinary set of 160 woodcuts accompanied by short explanatory texts [Rusconi 1590]. Rusconi deliberately conceived the tables with a didactic character: in fact, they visually explained the various passages of the Vitruvian text and the related commentary referring to the alphabetic letters shown in the drawings. A narrative iconography, therefore, but with great precision and extraordinary pictorial quality, on the tradition of the treatise of Vitruvius published by Cesare Cesariano rather than the versions of Fra Giocondo and Daniele Barbaro. We compared the images of the Vitruvian man proposed by Rusconi, using the graphic reference provided by the foot identified in two images and in the total height of the human figure (figs. 13a-13c). The images of *homo ad circulum* and *ad quadratum* identify different and distinct points as geometric centers of the figures, also in this case.

Conclusions

There were numerous attempts to represent the Vitruvius canon relating to the proportions of the human body. The different authors, independently or in relation to the various translations of *De Architectura*, proposed very different schemes and sometimes similar to the one by da Vinci, the only one imposed as a real icon despite the fact that it remained in the dark for a long time and presents variables with respect to what defined in the treaty.
The matter of figuring the Vitruvian man fueled reflections on the theory of architecture and later critics interpreted it as the symbol of Humanism. The theme reflected the mentality of the time, based on the study of antiquity, expressed by philological activity and motivated by the awareness of the centrality of man. The latter in particular, with its geometry, proportion and modularity, was the yardstick of the world.
For graphic interpreters, drawing the descriptions of the treatise correctly was a very complex operation. Vitruvius's textual descriptions were not fully understandable and the authors, despite the possible influences and exchanges of opinion, proposed graphic solutions that were never univocal. Some of them decided to represent *homo ad circulum* and *ad quadratum* distinctly, inserting two men with dissimi-

lar features in the circle and square without relating them to each other. The figurations that synthetically express the concept reported in the Vitruvian work do not follow a rigorous geometric proportional study, so much so that compared with each other they do not even correspond. Other authors started more in-depth research trying to superimpose the circle and square figures with the human one, identifying one or more anthropometric centers.

The multiple Vitruvian men lead to the contradiction of a single and universal aesthetic of the geometric and anthropomorphic proportion, traceable instead in Leonardo da Vinci's Study of proportions of the human body.

Notes

[1] The term "Symmetry" indicates the commensurability of all the components of a work according to a rigorous system based on a modular unit –*commodulatio* [Gros 1997, p. 273, n. 27]. The beauty of an organic whole finds its origin in the Pythagorean precepts on numerical harmony and is figuratively defined in the Canon (about 450 B.C.) by Polykleitos, whose application is demonstrated in the sculpture and human representation in the *Doryphoros*– a canon later surpassed by Lysippus – and architecturally by Ictino with his treatise on the Parthenon [Gros 1997, p. 278, n. 37].

[2] With the word "analogy", Vitruvius would refer to the substantiated adjective *anàlagon*, which in his day denoted a proportional system on a modular basis, defined ratio symmetriarum globally for the definition of buildings. The subdivision into modules also recalls the theory set out by Plato in Timaeus, according to which nature is composed of fundamental particles – the Platonic solids – and the analogy is nothing more than a numerical system with recurring relations [Gros 1997, p. 273, n. 28].

[3] Architecture is a mimetic art deriving from natural truth with modular connotations, whose form according to the Aristotelian conception is immanent in the world but not already present exclusively, similarly to the Platonic hyperuranium of ideas [Gros 1997, pp. 274-275, n. 30].

[4] Geometric patterns in the middle Ages were useful in facilitating drawing.

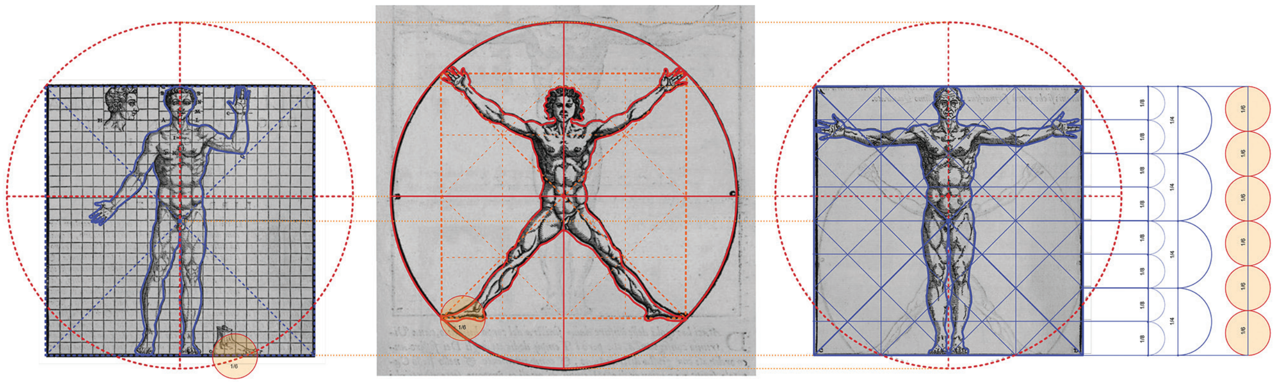
[5] We can consider several examples in this regard. The figure of the Orante by San Quirce de Pedret, Salsona Museu de Pedret (10th century). The miniature from the Latin Codex by Hildegard of Bingen (1098-1179). The miniature of the *Anatomical Man from the Très Riches Heures du Duc de Berry* by the Limbourg brothers (1410-1416). The Cosmic Man by Robert Fludd taken from the *Utriusque Cosmi Historia* (1617) [Zanini 2009, pp. 135, 136]

[6] The *exempeda* is a straight modular rod as long as the object to be measured, suitable for detecting lengths and movable squares in the shape of compasses (*normae*), with which to measure thicknesses, distances and diameters. These tools can determine the exact size and ultimately the proportions of any part of your model.

[7] *Finitorum*, or *definitor*, a circular disk with a rotating graduated rod, from which hangs a plumb line that measures the points of the figure in the space.

[8] There are numerous drawings of human figures especially related to architectural elements (for example capitals for faces) but also to plans and altitudes of basilicas.

Fig. 13. a, b, c). G.A. Rusconi, Vitruvian men and proportions [Rusconi 1590, pp. 46, 47, 48]. Geometric and comparative analysis on the drawings proposed by Rusconi (graphic elaboration by V. Riavis).



[9] The height of the man corresponds to only one side of the square (in this case a rectangle) and to the diameter of the circle.

[10] Leonardo later edited the illustration of Pacioli's *De Divina Proportione* between 1496 and 1497.

[11] According to Dürer, the beauty of the human body was not based on abstract concepts and calculations, but was based on empirical calculation. For this reason, he devoted himself to measuring a large number of individuals, without however obtaining a definitive and ideal model, since it is changeable in relation to times and fashions.

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For structuring scientific knowledge

"*di varii instrumenti per misurare con la vista*" ["on Various Instruments to Measure with Sight"]. Notes on the Architectural and Urban Survey in the Renaissance

Stefano Brusaporci

Since ancient times, the main cultures have used methods of measurement, even refined ones, for the study of the territory and for the marking and construction of important works. However, between the 15th and 16th centuries the codification and diffusion of instruments and methods expressly designed for the survey of cities and territory rise. It is a period of cultural and scientific development, as well as of transformation of the methods of knowledge transmission, also thanks to the birth and diffusion of large printing houses. In general, treatises combine rational knowledge with operational and functional applications, putting together theoretical, technical and practical interests. It is precisely thanks to treatises that knowledge spreads outside narrow circles, among a wider educated public [Maestri 2001].
In 1545, with the printing in Italian of the *Elements of Euclid*, published in Venice by Niccolò Tartaglia, Geometry becomes the scientific reference for the study of reality and consequently the basis for any initiative of Nature's domain. In particular, the concept of "measure" plays a central role as a vehicle for certain knowledge, management and transformation of the world. Consequently, measuring instruments become pivotal as devices for a scientific "quantization". In this sense, the work from which this paper derives its title is a volume by Giorgio Vasari il Giovane dated 1600 consisting of the collection of "cards" relating to surveying instruments and methods, deduced from 29 treaties; it is contemporary to the reorganization of the so-called "Stanzino delle matematiche" ["Mathematical Room"], destined to house the scientific instruments collected by Cosimo I and his successors: in fact, a real *ante litteram* "encyclopaedia" on surveying [1].

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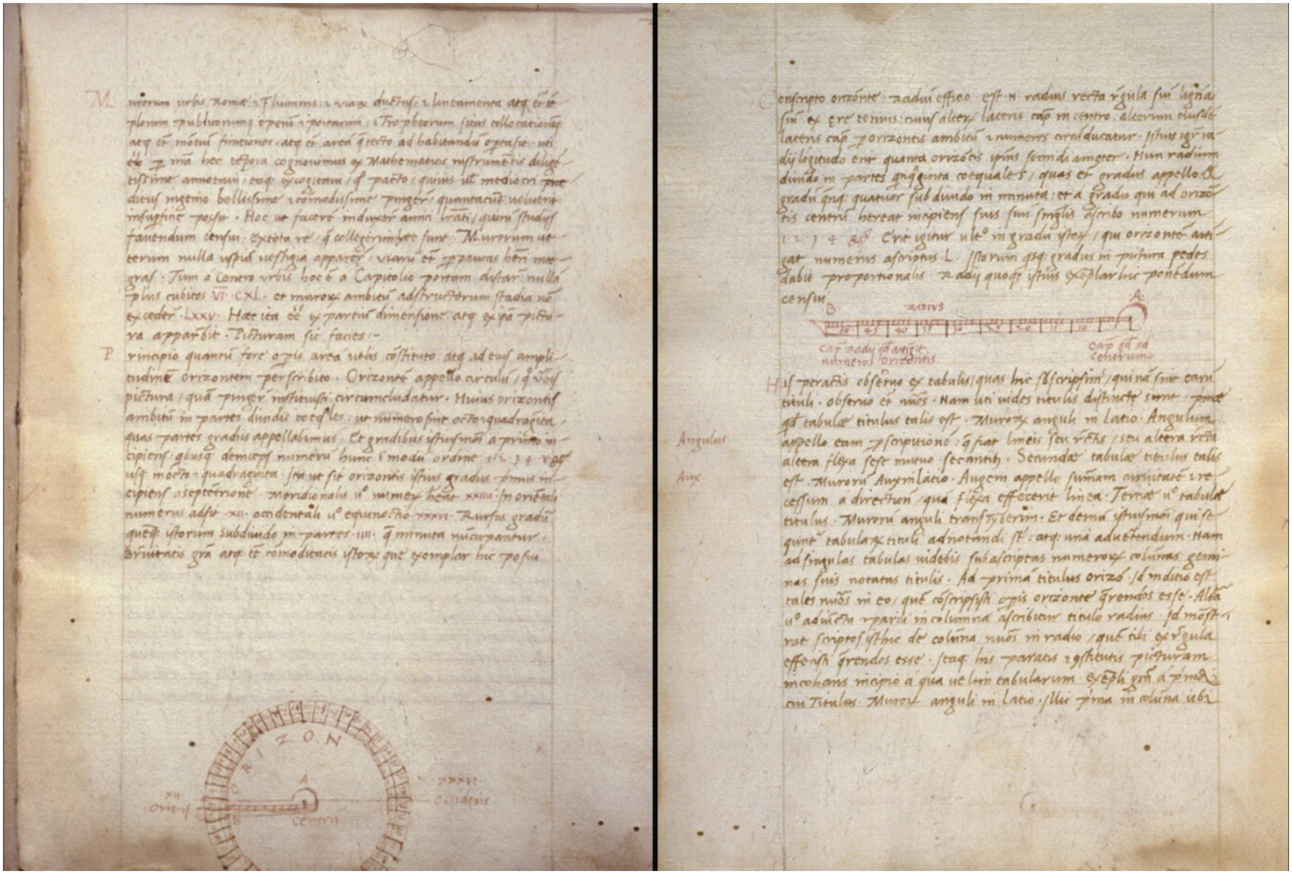
Fig. 1. L.B. Alberti, drawing of the horizon and radius in the Descriptio Urbis Romae (© Bodleian Library, MS. Canon. 172, fol. 233 r-v).



Historical methods and instruments for indirect surveying

With regard to indirect surveying of distances and heights, targeting the point to be measured from one or more station points, the treatises describe the instruments and their use with precision [Centofanti 2001; Centofanti, Brusaporci 2013]. For the most part the instruments can be ascribed to two types, based on the methodology underlying their use.

First of all, there are the tools that, by sighting the point to be measured, come to define similar triangles that allow to calculate distances applying the so-called "rule of three" – according to the diction spread by Fibonacci in his Liber abaci at the beginning of the thirteenth century –, i.e. proportions between the sides of similar triangles, so you don't have to resort to trigonometry, which is more complex to use in practice. This is how the geometric square, the Latin radio, the Jacob's staff, to name but a few instruments, work. Obviously, these tools can also be used to define alignments. Among the first examples, the one described in 1346 by Dominicus de Clavasio in his *Practica geometriae*.

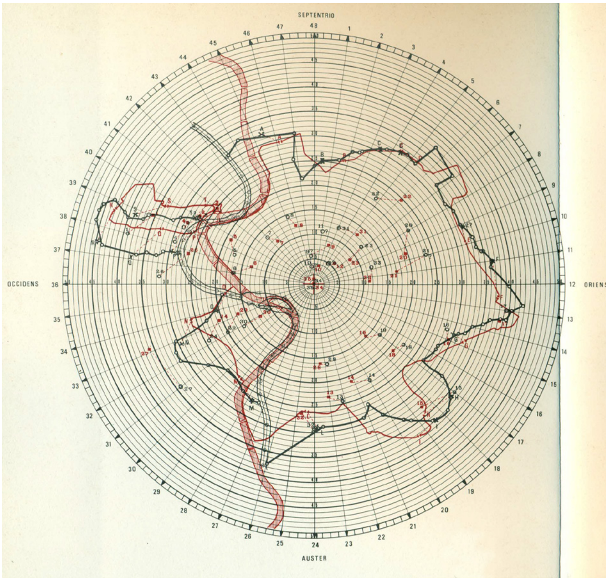
The second type, substantially derived from the astrolabe and based on the use of the magnetic needle (compass), allows you to record the directions of the visual rays with respect to the wind rose, i.e. to the north. The principle is expressly formulated by Alberti in his *Ludi mathematici* (1450-1452), where he describes a horizontal circle with a diameter equal to one arm, divided into 48 degrees, each composed of 4 minutes. It is evident that the act of drawing is intrinsically related to that of measurement, being the result of graphic processes. This is manifest in the use of the so-called "compass with the magnet", as it is called by Raffaello in his letter to Pope Leone X (or substantially the "horizon" of Alberti, or the "surveying compass", or the "Praetorius' Mensula", which differ for some details), which allows to trace the orientation of the roads directly on the map, in reduced length according to the scale.

The representation of Rome by Leon Battista Alberti

Among the methods to "measure with sight", we cannot help but linger on "intersection forward" used by Alberti for the survey of Rome in his *Descriptio Urbis Romae* (1443) (fig. 1). Based on a graphical method, the map of the city is returned through a table of polar coordinates that identify the position of the monuments in relation to the Campidoglio (fig. 2) [Vagnetti 1968]. If in the *Descriptio Urbis Romae*, Alberti explains how to return the coordinates graphically, it is in the *Ludi mathematici* that he illustrates the method of "intersection forward". But in the surveying of Rome, the question of what further station points might have been used remains open (fig. 3).
Luigi Vagnetti, commenting the *Descriptio Urbis Romae* in the light of the *Ludi mathematici*, writes «Alberti does not mention the need for direct measurement between the two station points, which is however implicit in the procedure» [Vagnetti 1968, p. 40], but if in all probability Alberti was aware of the question, however, this issue might not be so "implicit" because, as Vagnetti himself observes "Albertian coordinates do not provide any actual measurements, reproducible in any ratio; they give angular values that can be quickly transported on the drawing sheet by means of a goniometer equal to the one used by Alberti, but radial values that are only fractions of a hypothetical semi-diameter of an horizon large at will; therefore the metric scale of the drawing is dependent solely on the graphic width

Fig. 2. Panorama of Rome from the roof of Musei Capitolini. The Campidoglio is used by Alberti as the reference for the graphic restitution of monuments position listed in the Descriptio Urbis Romae (photo by the author).

Fig. 3. L. Vagnetti, graphical reconstruction of Rome map drawn according to the coordinates presented in the Descriptio Urbis Romae in relation to the real position of the monuments (Vagnetti 1968, p. 43).



of the horizon" [p. 53]. What has been observed is tacit in the use of similar triangles, where, if the length of the base is chosen at will, the result returns in proportion, but on a different scale. The considerations that the monuments identified in the *Descriptio Urbis Romae* are surveyed with great precision – according to the method and the age –, but also that the overall plant omits many other elements of great importance, strengthen the idea that the author's intentions are not to provide a detailed map of Rome for practical city management, but rather to demonstrate the usefulness and simplicity of a method.
Alberti works in an analytical way, so as to be able to describe the map of the city through a coordinate system, and not to have to insert a drawing in his manuscript, which would have entailed reproduction difficulties for copyists. In this way it elevates the operation of tracing signs to an intellectual act of geometric knowledge and physical representation [Carpo, Furlan 2005]. The presence of one of Alberti's rare drawings in the *Descriptio Urbis Romae* – with the representation of the "horizon" and of the "radius" – is an element of particular interest, worthy of specific study and reflection. Mario Carpo writes "albertian renunciation of the illustration of the text […] is a direct and paradoxical consequence of the new importance and the new function that Alberti gives to the image. New forms of knowledge, new techniques and new fields of knowledge require figural representations, experimentation, and verification through the image. The image is now the irreplaceable vector for the representation of figuratively quantitatively precise data, which, however, cannot be transmitted as precisely in graphic format. Alberti can already create, but still cannot communicate modern images" (p. 22). Therefore, remembering how in *De re aedificatoria* the intention to express "solis verbis" is expressly stated, the fact that Alberti, contrary to his mistrust of the depictions, inserted in the *Descriptio Urbis Romae* the drawing of the "horizon" (fig. 1), instrument to measure but also to redraw, representation in any case accompanied by a detailed textual description, could be interpreted as a choice dictated by pragmatic reasons: the text is intended for a wider audience than that of scholars alone. And in fact Alberti, in the opening of *Descriptio Urbis Romae*, writes: "I have devised a method, by which anyone *with normal intelligence* will be able to graphically represent the above mentioned things in the most suitable and convenient way" [Vagnetti 1968, p. 61]. This hypothesis would go hand in hand with the spread of knowledge and techniques during the Renaissance, also remembering how Alberti, while usually writes in Latin, do not disdain the vulgar, writing his *De Pictura*, or *Sulla Pittura* (1435) in both languages. Even if the *Descriptio Urbis Romae* is written only in Latin, there is no doubt that the work aims at a wide diffusion.

The eidotypes of Leonardo da Vinci

It is considered interesting to comment on Leonardo da Vinci's surveys of the fortresses of Cesena and Urbino, and of the city of Imola (1502), of which one is fortunate that we have the notes of the surveying campaign [Docci 1987]. In the eidotypes of Cesena, limited only to the fortified perimeter, Leonardo traces on the sheet the sections of the walls oriented according to the north and notes, adjacent to each line, the measurement of its length and orientation in relation to the wind rose, evidently using a Dioptra with compass (fig. 4).
The surveying sketches concerning Imola present the road network and the perimeter of the town (fig. 5). The road axes are generally traced in their relative correct orientation, the lines of the roads are accompanied by a note of the length, but the measure does not correspond, in scale, to the real length. In particular, the orientation with respect to the wind rose is not indicated. Moreover, even if the eidotypes show the length of the roads, the Via Emilia and the external perimeter of the built-up area take exception (except for a few small sections); but the same Via Emilia, traced in a straight line, i.e. ignoring the flexure in the eastern part, is used as a reference to divide the city into the districts on the basis of which the survey is conducted, becoming the main reference.
Also in consideration of the fact that it is difficult to imagine how the so accurate and well known Imola map can be derived from these sketches (fig. 6) – unless we take into consideration the possibility, not entirely to be excluded, that Leonardo's drawings are based on previous maps [Mancini 1979] –, hypothetically speaking, it could be assumed that the survey under analysis was developed in two phases: a first phase, whose drawings would have been lost, could have been dedicated to the survey of the Via Emilia and the external perimeter, with a methodology similar to the one used for the survey of Cesena, i.e. making a polygonal including the measurement of direc-

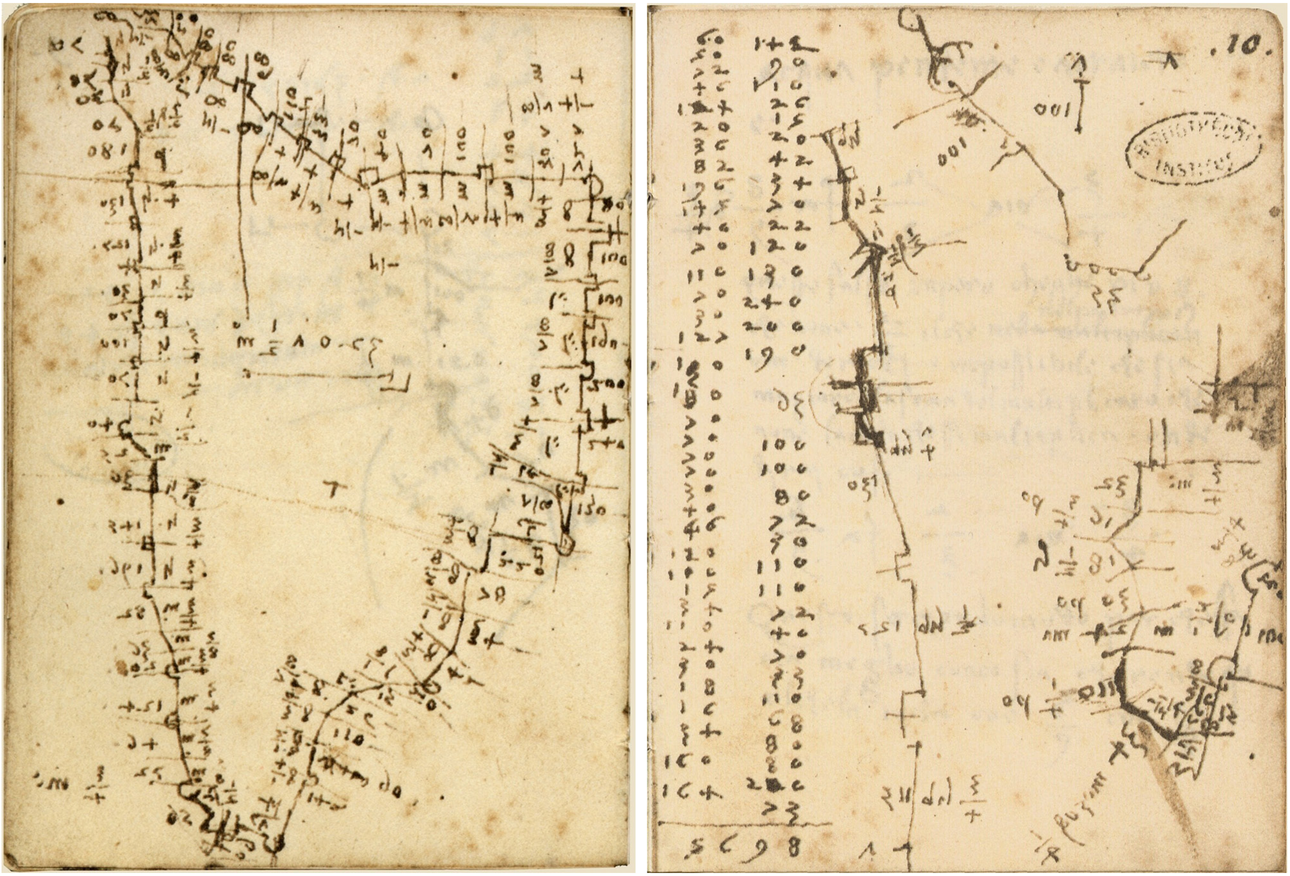


Fig. 4. Leonardo Da Vinci, surveying eidotypes of the Cesena fortification (Manoscritto L, f. 9v e f. 10r).

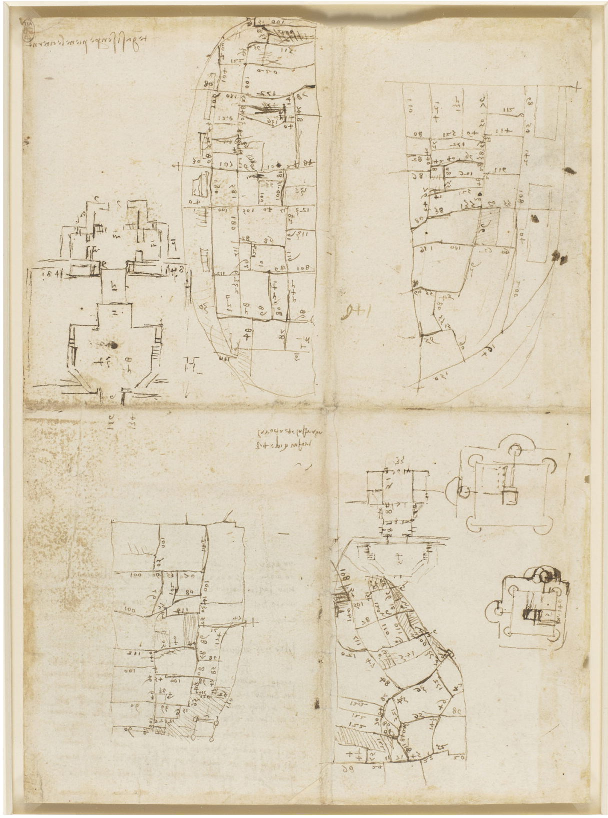


Fig. 5. Leonardo Da Vinci, sketches of the roads of Imola (Royal Collection Trust / © Her Majesty Queen Elizabeth II 2019, RCIN 912686).

tions; a second phase, dedicated to the survey of the internal roads, would have been carried out at a later stage, using a traditional Dioptra of Heron without magnetic compass, or a Geometric square with moving sides (also called "squadra zoppa") able to trace the relative orientation between roads. If accepted this hypothesis, the small crosses drawn by Leonardo at the external entrance of the current via Emilia (east side), via Appia and via Bixio could indicate points of station referred to the rose wind, by means of a compass, connecting the surveys of the external perimeter of the built-up area and the internal road network (fig. 7). The irregularity of the rectilinear part of the via Emilia, in the west area in the famous map, could be the result of the need to compensate for measurement errors between the external perimeter and the internal roads during the restitution phase, consequently to the use of different surveying methodologies. And that there was some uncertainty in the measurement phase is evident from the fact that the notes present at the same time a sketch of the entire northern part of the city – with various corrections for the northeast area –, and a second sketch of the northeast part, the one with the real flexure of the via Emilia.

The *Geometria prattica*: a treatise that becomes an "handbook"

In 1599 the treatise *Geometria prattica* was published; it was written by the Venetian Giovanni Pomodoro, scholar of vast experience, probably involved in that great project of transformation that the Serenissima, as new continental power, was consolidating (fig. 8).
The treatise is a posthumous publication of an unfinished work, consisting of the tables drawn by Pomodoro, with the subsequent addition of comments by Scala [Brusaporci 2016]. The work configures with a particular practical and operative point of view, also thanks to the graphic quality and expressive clarity of Pomodoro's drawings, and in particular those relating to methods and tools for surveying (figs. 9-11). And indeed in this, in all probability, lies the fortune and modernity of the work: it configures as an "handbook" more than an exhaustive "treatise". The *Geometria prattica* is constantly mentioned above all in relation to the use of the surveyor cross, an instrument to which numerous tables are dedicated. However, many other instruments are represented in the treatise,

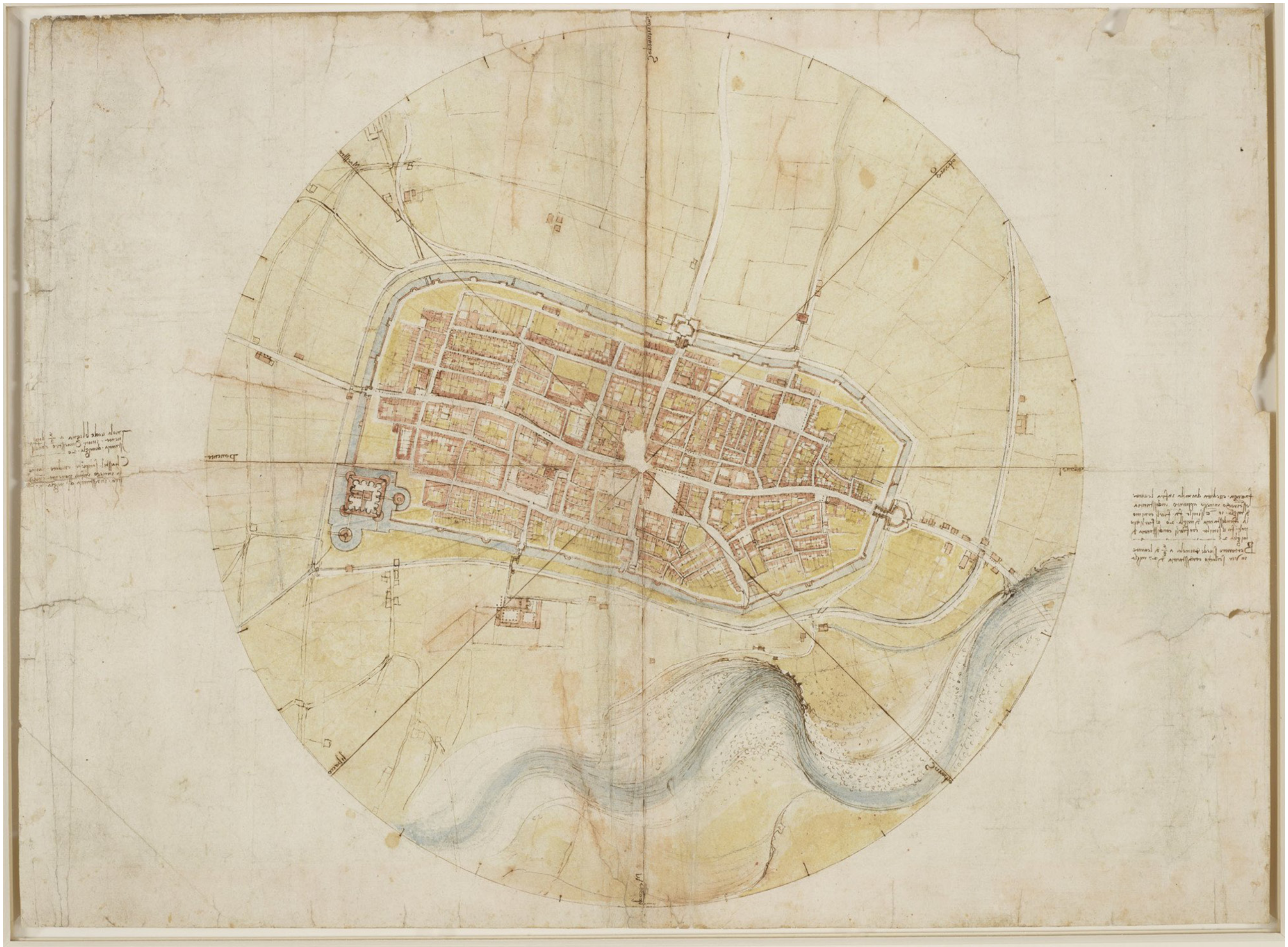


Fig. 6. Leonardo Da Vinci, Map of Imola (Royal Collection Trust / © Her Majesty Queen Elizabeth II 2019, RCIN 912284).

Fig. 7. Overlapping between the sketch of the northern area (cfr. fig. 5) and the map (cfr. Fig. 6) of Imola by Leonardo Da Vinci. Highlighted: 1) the roads inside the built-up area with the annotation of the length; 2) the external perimeter without measures; 3) the Via Emilia traced with a linear course, without taking into account the real irregularities and without measuring the length of its sections ; 4) one of the crosses drawn at the external entrance of some roads, hypothetical station points, perhaps to connect different surveying campaigns.

such as the "squadra zoppa" and the geometric square with quadrant.

The drawing of the geometric square, at the Table I (fig. 8), is particularly accurate and with important dimensions with respect to the whole table: the represented instrument is refined, in all respects comparable – if not more elaborate – to the ones of Walther Hermann Ryff (1548), Giovanni Francesco Peverone (1558) or Cosimo Bartoli (1564). Considering the importance that Pomodoro gives to this representation, as well as the fact that the geometric square allows the calculation of distances using proportions between similar triangles – that is according to the method used and systematically explained by Pomodoro – it is believed that it cannot be excluded that the *Geometria prattica* could have foreseen other tables, not realized due to the premature death of the author, precisely related to the use of the geometric square. And the characteristic of an "unfinished" work appears from various drawings, partially incomplete. This is only a hypothesis, but in this case the complete work would have taken on a different character, so that it could not be counted substantially as a "treatise on the surveyor cross" and taken on a greater breath.

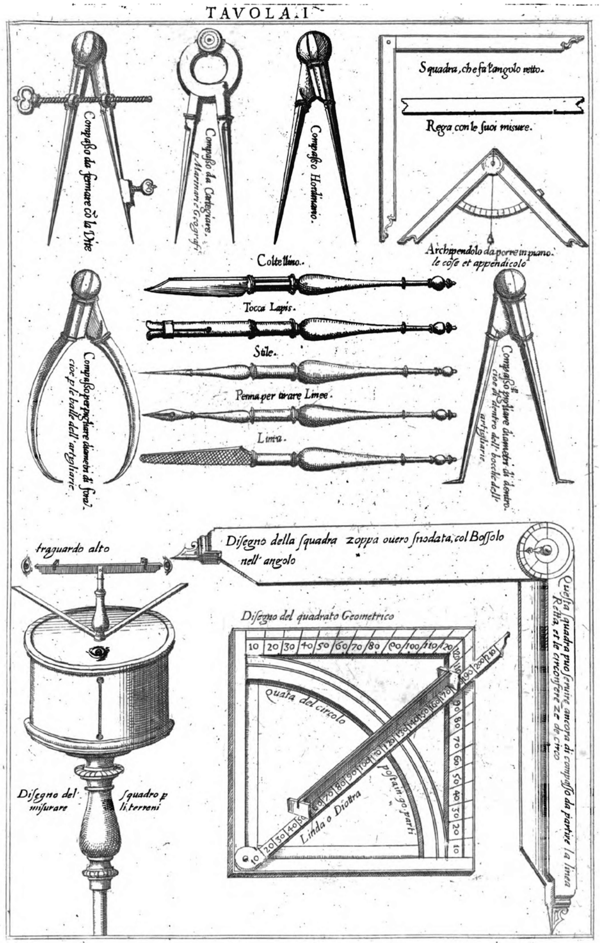


Fig. 8. G. Pomodoro, Geometria prattica, Tav. I. Representation of drawing and surveying tools. In particular we can see the surveyor cross, the geometric square and the square with hinged sides.

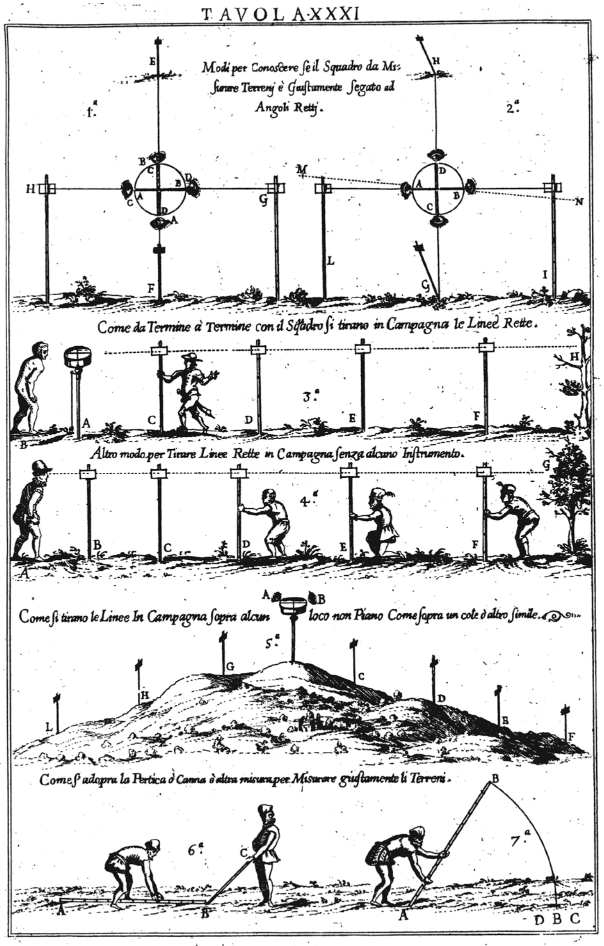


Fig. 9. G. Pomodoro, Geometria prattica, Tav. XXXI. Illustration of the use of the surveyor cross for land survey.

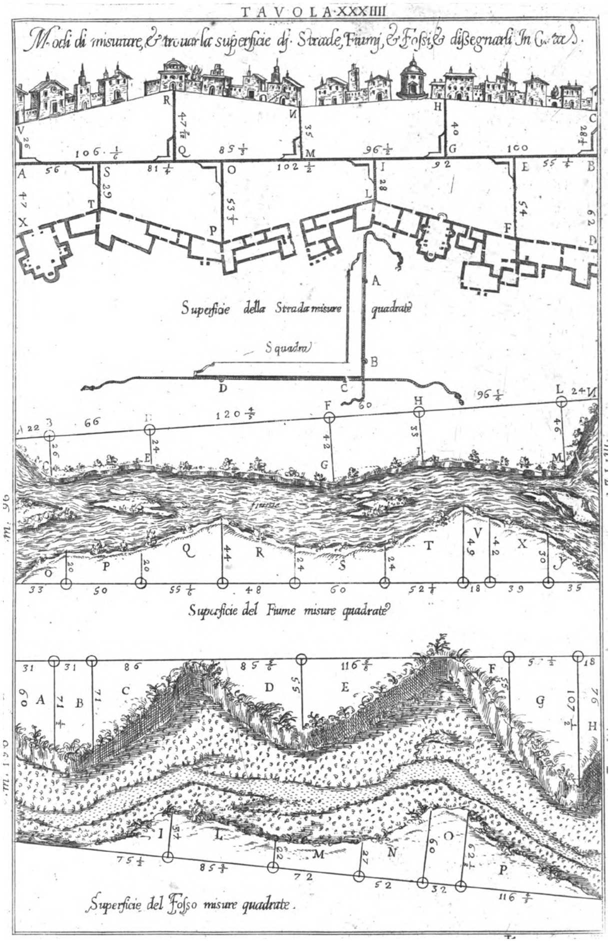


Fig. 10. G. Pomodoro, Geometria prattica, Tav. XXXIIII. Use of the square and the surveyor cross to survey roads, rivers, and territories.

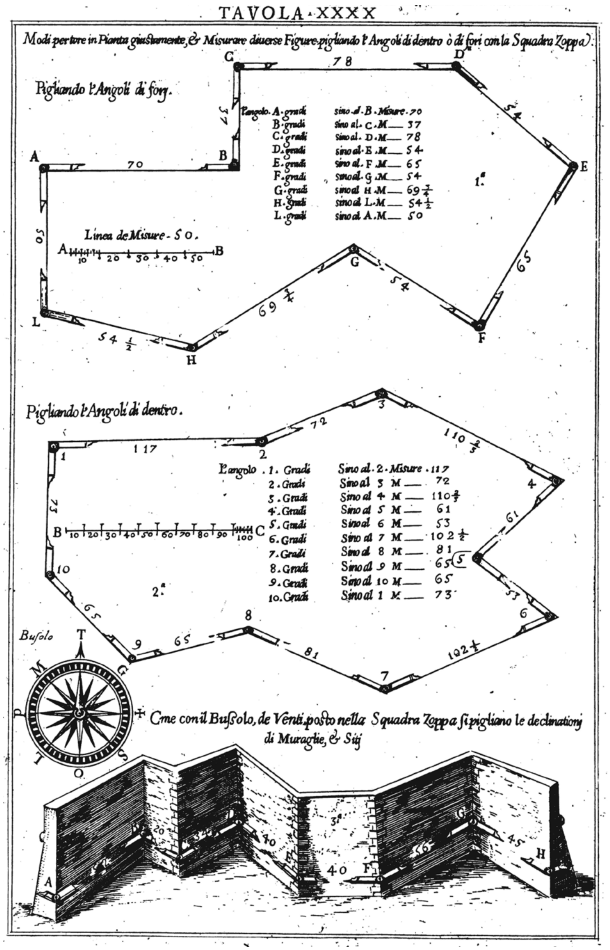


Fig. 11. G. Pomodoro, Geometria prattica, Tav. XXXIX. Example of the use of the square to measure and drawn a territory.

Fig. 12. G. Pomodoro, Geometria prattica, Tav. XXXX. Realization of surveying polygonal using of the square with hinged sides.

The Table XXXX (fig. 12) describes the "squadra zoppa" i.e. a square with hinged sides with goniometer and magnetic compass, to measure internal and external angles between the walls of buildings. The tool is of particular interest as it allows you to trace polygonals accompanied by field notes, where the measurement of the length of the sides is accompanied by the one of the angle formed by the segments, and at the same time by their orientation with respect to the wind rose. It is an instrument of simple use, therefore potentially very effective also compared to the Dioptra of Heron [2].
Given an overall structure of the *Geometria prattica* marked by a first theoretical part and an applicative second one, the treatise of Pomodoro offers to his contemporaries a work in keeping with the needs of clients, useful for practical administrative requirements, and simple in format and content. The rigour that in any case underpins Pomodoro's writing shows the ambition to offer everyone the discipline of measure. It is a context where academies flourish, fostering the dissemination of knowledge, and they become the centre of intellectual life. The *Geometria prattica* works in consonance with this context, in fact offering a volume accessible to many, in a certain sense making a "vulgarization" of knowledge [3]. This in line with the spirit of the Counter-Reformation "capable of welding the culture of the dominant classes to that of the subordinate classes in order to achieve the process of more complete ideological homogenization that the Church had carried out up to then" [Cozzi 1987, p. 25].
In a certain sense, the *Geometria prattica* accomplishes an ideal path of translation and diffusion of knowledge, which moves from Alberti's textual dimension to the visual power of Pomodoro's tables.

Conclusions

With the turn of the 19th century and the development of the mechanical industry, the creation and diffusion of precision instruments for indirect surveying have supplanted the use of traditional instruments, with the consequent recovery of the use of trigonometry.
Also because of the rise of a specific historical attention to the ancient instrumentation that by now was finding its place in the museum, a series of writings dedicated to the history of surveying instruments and methodologies spread. These writings present different declensions, highlighting, depending on the case, the characteristics of the instruments, their historical-critical framework, the methods used, the types and characteristics of the restitution graphs [Lyons 1927; Boffito 1929; Kiely 1947; Vagnetti 1970; Docci, Maestri 1993; Stroffolino 1999; Lindgren 2007; Cigola 2016]. In particular, Edmond R. Kiely correlates the historical aspect with that of applied teaching, based on the conviction that "It is scarcely controvertible that an engineering education which does not include the history of the particular branch of engineering being pursued is incomplete" [Kiely 1947, p. ix].
Similarly, the study of historical methods and instruments of surveying and the culture behind them have to be an integral part of the training of scholars and professionals who aims to dedicate themselves to this field of knowledge, so as to be able to operate with critical awareness in the study of historical works and documents, in the drafting and analysis of surveying representative models, where the critical capacity of the surveyor plays a central role.

Notes

[1] Giorgio Vasari il Giovane. (1996). *Raccolto fatto dal Cav.re Giorgio Vasari: di varii instrumenti per misurare con la vista*. Reproduction of the edition of 1600, edited by F. Camerota. Firenze: Giunti, 1996.

[2] In this regard, in the first table of the treatise where the main instruments of surveying are represented, there is not the Praetorius' Mensula: considering it unlikely that Pomodoro, a professional in the field of surveying, would ignore its existence, perhaps the author wanted to suggest the "squadra zoppa" as an easiest tool to use.

[3] An indirect evidence of this phenomenon of making techniques within the reach of many, is the "aristocratic" attitude that, for example, is evident from a passage in the treaty Geometria (1597) of Fonticulano: "Because if I wanted to describe the practice of swarms, which is so easy, that every mediocre genius could have exercised it, I would have done the professors wrong because they never wanted so much to facilitate the path to the ignorant [...] who have nothing but that bare practice which they themselves do not know whether it is good or bad, and they want to prove that they know, and presumptuously to be a professor": Ieronimo Pico Fonticulano. (1597). *Geometria*. Anastatic reproduction of the edition of 1597, edited by D. Maestri. L'Aquila: Fondazione Cassa di Risparmio della Provincia dell'Aquila, libro VII, p. 258, q. 2.

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From Drawing to Measure. Reconstruction of the Facade of Palazzo Aiutamicristo in Palermo

Fabrizio Agnello

Abstract

Laser scanners and SfM photogrammetry corrupted the secular connection between measure and drawing, based on sketches drafted on site that usually prefigured plans, sections and fronts of the surveyed building.
This study aims at stating, through a test on a case study, that digital tools set up new connections between drawing and measure and provide unprecedented opportunities for investigations that address the design of a monument or a work of art.
The proposed case study is the reconstruction of the design of the facade of Palazzo Aiutamicristo, built in Palermo in the last decade of the XV century by the caput magister Matteo Carnilivari. The facade was deeply transformed few years later, probably before 1535, when the palace hosted King Charles V visiting Palermo.
Traces of the windows and cornices of the original facade survived the transformation; the reconstruction of Carnilivaris's design, developed on a digital replica of the facade, evidences the strength of the digital connection between drawing and measure; drawing detects connections that allow the reconstruction of an architectural element from a fragment.
The detection of the alignment of windows at different levels led to the detection of new traces, new measures and new correspondences.

Keywords: survey, geometric analysis, virtual reconstruction, palazzo Aiutamicristo, Matteo Carnilivari.

Introduction

Measuring is, and has ever been, one of the best tools to study architecture. Measure and design form a whole: measure rules architectural design and architecture is a measure itself; at the same time measure always points at design, both when we measure a site where a building will be located or an extant building to be restored and when we measure a monument to find out its hidden design.
Laser scanners and SfM photogrammetric procedures have broken the centuries-old connection between measure and drawing; up to few decades ago architects and surveyors used to draw sketches that served as a reference for the surveying process, because they supported, on site, the choice of the measures needed for the graphic restitution of a building. These sketched, where measures were noted, always prefigured the plans, sections and elevations of the building.
The traditional surveying was developed in two stages: in the first one, on site, the drawing (sketches) guided the surveying process; in the following stage (restitution), drawings were shaped according to the surveyed measures.
The first stage demanded an accurate observation of the building; sketches supported the comprehension of the shape and structure of the architectural elements: a pointed, oval or round arch demand different surveying strategies.
Today no sketches are needed to survey the spatial coordinates of millions of points that precisely render the shape and the size of a building; we can, alternatively or in com-

bination, use photos to build very dense point clouds and well-detailed polygonal models of the building; sketches are no longer used.
In the practice of digital surveying, observation is delayed to the processing stage; surveyors stay on site for a very short time and they are usually concerned to manage the surveying process so to prevent errors or loss of time. Quick and elementary graphic annotations note the stationing points of the laser scanner, or the position of markers used as a reference to size and refer the photogrammetric model to a specific coordinate system.
Point clouds and high resolution polygonal models accurately and precisely document the morphology and size of a building; these faithful digital replicas of reality can be easily managed by a computer.
It is no coincidence that scholars often refer to digital survey as *3D recording*; what surveyors do on site is actually data recording, managed with a special care to time optimization; operators leave the site bringing with them lots of stored data but no, or very lacking memory of the surveyed building.
In best practices, the building is observed and analyzed by means of its digital replicas; in bad practices, observation and analysis are not performed at all; the recurrent output of 3D recording are fascinating textured polygonal models. All we can do, when we watch such models, is being amazed by the power of computers and ask ourselves how many polygons make the model, how many pixels make the texture and if the model has been optimized and can be visualized on the web or on smartphones.
Measure, apparently powered by the accuracy and speed of digital tools and techniques, has actually vanished; even when we record lots of data, we must acknowledge that 3D recording has actually unsettled the very idea of measure.
The slowdown of the updating speed of digital tools today offers the opportunity for a neat and non-nostalgic discussion on what has happened, and for an exam of the huge opportunities offered by digital surveying, often neglected by the specialists themselves, usually concerned in staying in touch with technological evolution.
Although we assume true what reported above, we must absolutely state that analysis, observation, discretization and measure of architecture on digital replicas are far simpler, more effective and more insightful if compared to what happened with the use of traditional tools.
Digital replicas makes the graphic analysis of architecture more powerful and allows a deeper knowledge of those buildings whose design is ruled by geometric patterns.
Drawing, apparently diminished by textured polygonal models, becomes, with digital replicas, a powerful tool to study architecture, more powerful than ever.
The complexity of the process that started with the development of tools for digital survey and representation and has led to a permanent modification of the connection between drawing, design and measure, cannot be obviously dismissed in a few lines. Even the single idea of measure, here hastily assumed as a process that leads to know the dimensions of a building, is the subject of countless studies. This study aims to state that digital replicas of monuments and works of art are strengthening and reviving the studies on the use of geometric patterns in architectural design, an extremely relevant subject, often dealt with conceit and today neglected or assumed obsolete by most scholars.
Researchers in survey and representation are well aware that geometric analysis is an extremely deceitful subject: how many times, while inspecting a proposed geometric and proportional analysis, have we asked ourselves if it succeeded in rendering the design of the artifact or if it deepened the knowledge of the artifact itself? How many times have we wondered if the proposed analysis exceeded the purpose of the designer and the tools of the time?
One of the unfavorable circumstances that hindered the progress and dissemination of studies on geometric analysis is the self-referential approach; geometric studies never interact with similar studies on works of art designed by the same architect, in the same period or built the same cultural area.
This circumstance has discredited a subject that could otherwise be very fruitful, since for centuries architecture and works of art were drawn and designed *more geometrico*.
The update and success of studies on the history of art and architecture comes from the methodical proposition of interpretations and their later refutation or revision.
To the contrary, studies on geometric drawing and design never reach synthesis, comparison and settling.
This is probably the second opportunity that digital survey and drawing offer to researches on geometric patterns: the chance to share with other scholars both the proposed geometric analyzes and the digital replicas of the artifacts. This opportunity would make comparison easier and thus support the progress of geometric knowledge; rejection, enrichment or refinement of proposed geomet-

ric patterns would free them from the subjective and occasional approach.
This study aims therefore at a twofold purpose: first of all to show, through a case study, how digital tools make geometric analysis easier and more penetrating; then start a research on the connection between geometry and construction in monuments built in Sicily in the 16th-century, when the isle was politically and culturally connected to kingdom of Aragon.

From drawing to measure

In traditional surveying methods drawing comes first and directs measure; the sequence drawing-measure appears, albeit in a modified form, in the study of architecture on digital replicas. Even if no one can deny that digital replicas are the output of a measurement process, it is also true that the dimension of the building (or its parts) come forth from drawing, i.e. querying the length and radius of lines and circles interpolating the points or triangles of digital replicas. Measure, even in its most basic sense, is provided by drawing.
The drawing-measure connection is particularly relevant when the analysis and virtual reconstruction of geometry-based designs use digital replicas. The dimension of the elements that make the work of art result from geometric drafts and from drawing-based connections.
The reconstruction of the facade of Palazzo Aiutamicristo, designed by Matteo Carnilivari [1] and built in Palermo in the last decade of the fifteenth century, is the subject of this study. Carnilivari, born in eastern Sicily, came to Palermo in 1489 to design and build the residence of the Aiutamicristo family; from 1490 he was charged by another prominent family in town, the Abatellis, for the design and construction of their palace. Carnilivari leaves Palermo few years later, in 1493; documentary evidence prove that, at that time, Palazzo Abatellis was almost completed, but no reports about the progress of the construction of Palazzo Aiutamicristo have come to us.
Carnilivari recruited skilled stone carvers from eastern Sicily, northern Italy and Aragon; these workers carved cornices, stairs and other moldings for both palaces. The profiles of these elements were usually drawn by the caput magister, but it cannot be excluded that these highly qualified workers could be charged for the design of some specific profiles.
The Palazzo Abatellis became a convent few decades later, after the death of the widow of Francesco Abatellis, the patron who had charged Carnilivari; today the palace hosts a museum. Palazzo Aiutamicristo remained a prominent residence in the Historic Centre of Palermo. In the first decades of the 16^{th} centuries, given the poor conditions of the royal palace, the Palazzo Aiutamicristo is the most suitable place to welcome prominent people visiting Palermo.
Carnilivari's design probably appeared out-of-date when, in 1535, King Charles V came to visit to Palermo. The heirs of Guglielmo Aiutamicristo promoted a deep revision of the façade before the king's arrival; large windows with balconies took the place of the original windows; therefore, the cornice that marked the division between the mezzanine and the *piano nobile* was almost completely removed.
Many fragments of the original facade luckily survived the revision process; these remains inspired the virtual reconstruction of Matteo Carnilivari's design.
The reconstruction, developed on a digital replica of the front [2], used lines and circles as a tool to measure and detect correspondences that revealed new traces, overlooked in previous studies based on traditional surveys. This circumstance proves that some 'phenomena' appear only if their existence is supposed [3]. Measure is no more the mere survey of what is visible; the connection drawing-measure brings to visibility what was previously hidden.
The reconstruction of the facade of Palazzo Aiutamicristo aims at a twofold purpose: i) contribute to the studies on Matteo Carnilivari's design method; ii) provide an example of the effectiveness of digital geometric analysis in the study of architecture.

Inductive observations

The Palazzo Aiutamicristo consists of a parallelepiped block crowned by merlons and divided into three levels: mezzanine, *piano nobile* and attic. The entrance is an independent block, aligned with the main front. A stone external staircase presumably led to the loggia added to the rear front.
The reconstruction process of the facade started with the observation of the traces and remains of the elements (openings, cornices) that were removed or replaced in the revision process: many traces are visible, while others are almost hidden.

Fig. 1. Rectified image of the facade of Palazzo Aiutamicristo.

Fig. 2. Traces of openings at the piano nobile.

The revision of the façade reshaped all the openings at the *piano nobile*; some openings of the attic and mezzanine level were not modified.
The number of openings has not changed; today, and at the time of Carnilivari as well, seven windows opened at each level; in order to simplify the description of the reconstruction process, openings will be numbered from the left to right (fig. 1).
At the *piano nobile* the most evident traces appear aside openings 2 and 3; both traces belong to arches of the original windows; the different size of the arch of window 2 and of the couple of arches of window 3 suggest that the traces belonged to different windows. Further traces, more fragmented but clearly visible aside opening 6, can be referred to the left part of a window, similar to window 2 (fig. 2).
Although the surviving traces show a single arch and a couple of small arches, it seems almost unlikely that the rooms of the *piano nobile* were illuminated by small windows; the comparison with coeval monuments built in Palermo and in Spain, suggest the use of double-arched or triple-arched windows [Piazza 2006, p. 146]. We could argue that the larger arches (windows 2 and 6) were part of a double-arched window and that the small arches aside window 3 were part of a triple-arched window.
A cornice, presumably removed when the openings of the *piano nobile* were extended downwards to the balconies, reasonably ran along the entire length of the facade and marked the lower edge of the original windows; fragments of this cornice appear above the entrance portal and at the right end of the front (fig. 1).
Observation and comparison with similar buildings led to these initial assessments; if the distance and shape of openings were not reconstructed by drawing, the reconstruction process would have stopped at this stage.
The first step of the drawing-led reconstruction process focused the geometric analysis of the single-arched openings at the mezzanine level, surmounted by a polycentric cornice.
The openings 1, 4, 5 and 7 appear in their original position. At the *piano nobile*, traces of the right ends of the original openings appear aside windows 2 and 3; traces of the left end of the original opening appear aside window 6.
The restitution of mezzanine openings started from window 7; the centers of the three arcs that make the profile of the cornice surmounting the window have been detected after the division in three parts of the segment that spans the width of the cornice.

Fig. 3. Drawing of the cornice framing the mezzanine windows.

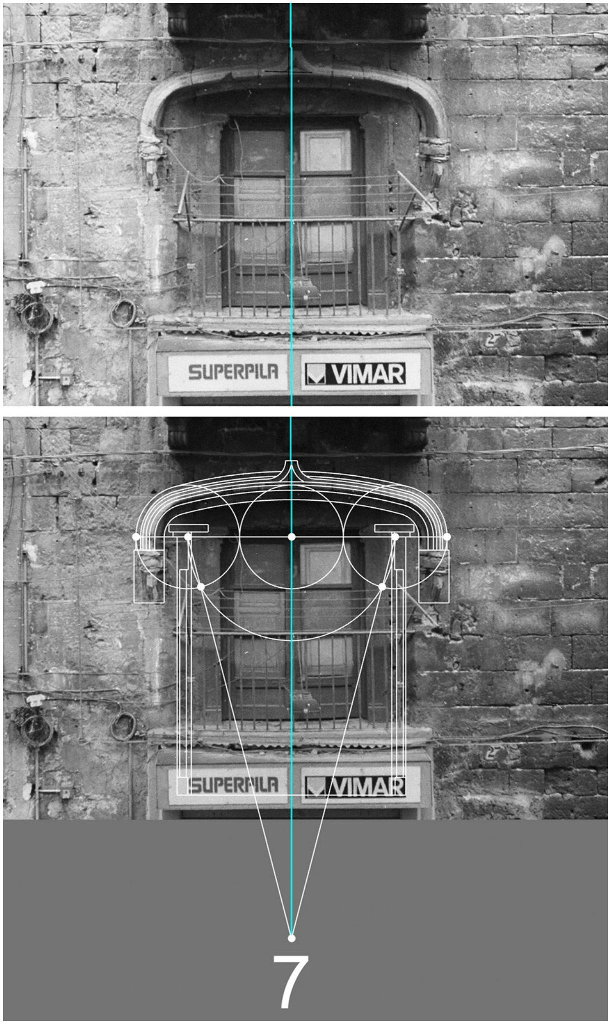
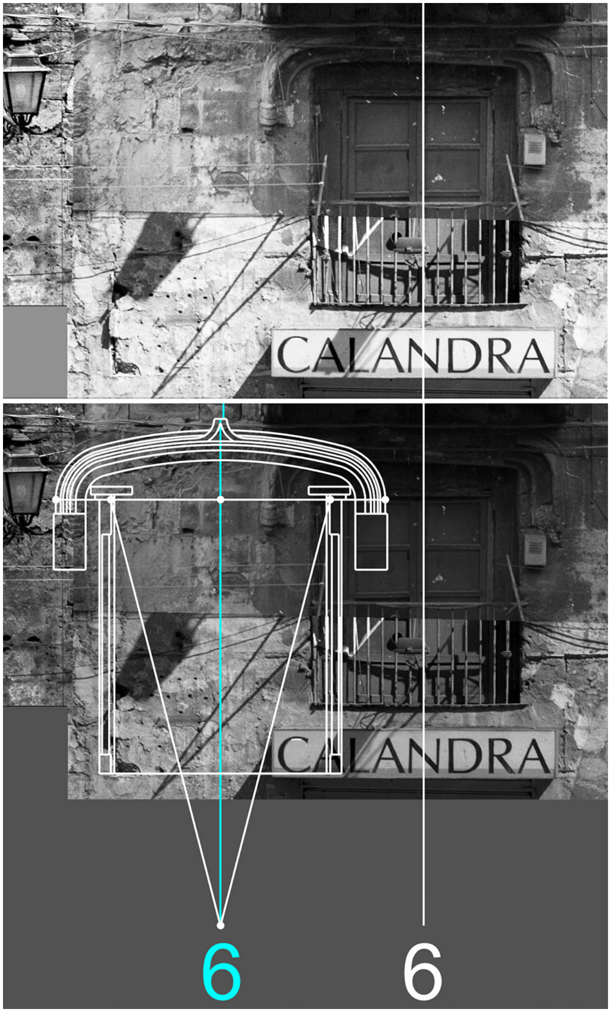
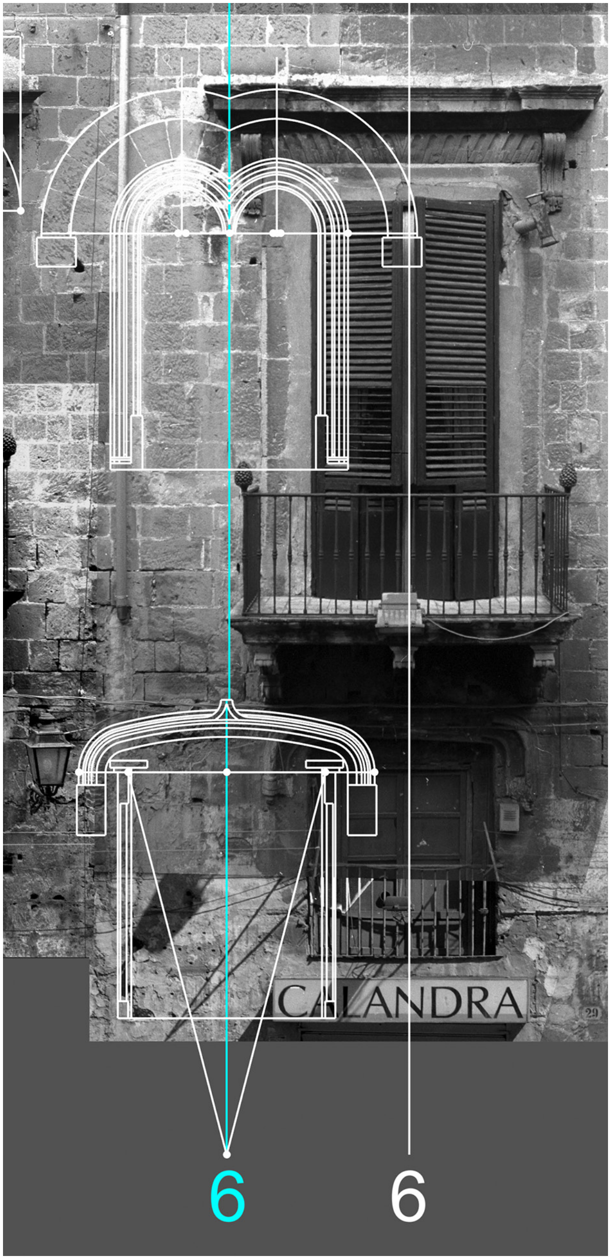


Fig. 4. Reconstruction of the mezzanine window 6.

Fig. 5. Drawing of windows 6 at the mezzanine and at the piano nobile.





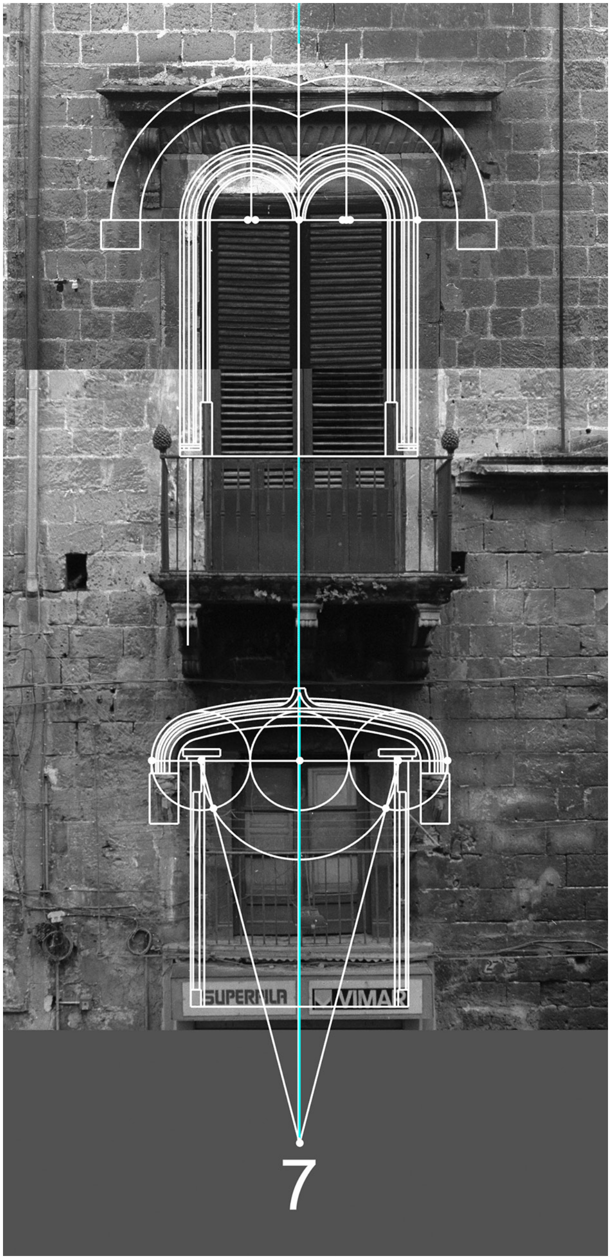


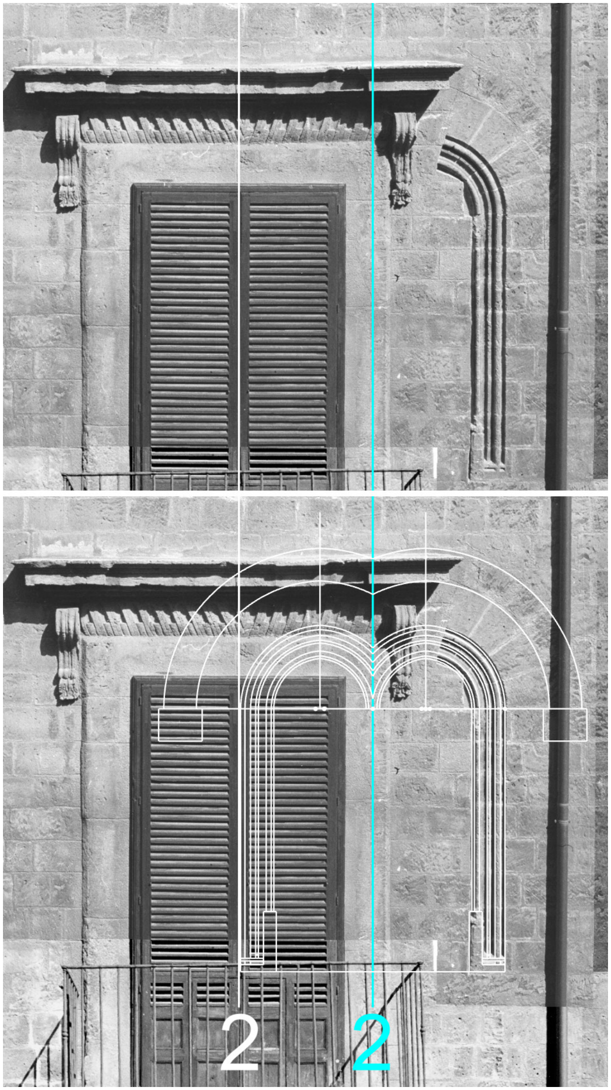
Fig. 6. Drawing of window 7 at the mezzanine and at the piano nobile.

Fig. 7. Traces of the double-arched window 7 at the piano nobile.

The division of a segment into three parts, ruled by the properties of the equilateral triangle, occurs in the design of all the curvilinear profiles of the facade (fig. 3).
A superficial observation of mezzanine window 6 could be misleading, because the extant window aligns the symmetry axis of the balcony above. Comparison shows that this window is an awkward copy of window 7, thus suggesting the idea that different carvers, less skilled than those recruited by Carnilivari, carried out the façade's revision.
A more careful observation of the masonry reveals, close to the left edge of the extant window, some faint traces of the original mezzanine window 6, which perfectly match the profile of the cornice of window 7. The reconstruction of original window 6 fixes a new vertical axis, 1.73 meters left the axis of the balcony (fig. 4).
This vertical line, extended upwards, provides the symmetry axis of the double-arched window 6 at the *piano nobile*. The symmetry led the reconstruction of the size of the original window (fig. 5).
The hypothesis that vertical axes of the mezzanine windows were aligned with the vertical axes of the corresponding openings at the *piano nobile* inspired the recon-

Fig. 8. Drawing of the mezzanine window 2.

struction process and allowed the display of traces that no one noticed before.
The hypothesis was initially tested on window 7: a copy of the double-arched window 6, positioned on the vertical axis of mezzanine window 7 (fig. 6), revealed, at the *piano nobile*, the traces of squared blocks, presumably the body of two corbels at the ends of the cornice surmounting the window (fig. 7). This circumstance validated the proposed size of the double-arched window at the *piano nobile*.
The same process led to the reconstruction of mezzanine window 2 and of the double-arched window 2 at the *piano nobile*; the surviving traces, i.e. the thin column at the left jamb of the window, provided the height of mezzanine windows (fig. 8).
Mezzanine window 2 shows that the revision process shifted the original windows, whose axis is 1.18m left the axis of the extant window (fig. 9).
The axial correspondence, tested and verified in windows 2, 6 and 7, served for the reconstruction of window 1; the transformation of this window almost echoes what happened to window 7: the new opening took the place of the original window, thus hiding the most of it.
What discussed insofar suggests that extant windows 1 and 7 took the place of the original ones, while original windows 2 and 6 were closed and new windows were opened aside them. The displacement almost certainly aimed at equalizing the distance of openings.
The following step of the reconstruction process addressed windows 3, 4 and 5 in the central area of the façade.
Traces of two small arches are visible, as above mentioned, in window 3. If window 3 aligns the corresponding window at the mezzanine (fig. 10), the drawing suggests the addition of one arch; a triple-arched window provides the expected alignment (fig. 11).
The rectified image of the facade shows the faint trace of a rectangular cornice that framed the window; the length of the upper horizontal edge of the cornice validates the proposed width of the triple-arched window.
Two copies of the triple-arched window were aligned to the axes of mezzanine windows 4 and 5 (Fig. 12). The observation of the masonry does not support the validation of this hypothesis, because the extant openings have taken the place of the original ones.
The reconstruction of the openings at the *piano nobile* proposes therefore four double-arched windows at the ends of the facade, namely 1, 2, 6 and 7 and three triple-arched windows (3, 4 and 5) framed by a rectangular cornice in the central part.
Extant openings 1, 4, 5 and 7 took the place of the original ones, while openings 2, 3 and 6 moved aside; this displacement allowed some traces of the original windows to survive.
The reconstructed layout of original windows at the mezzanine and at the *piano nobile* is all but regular. The spacing of windows 1 and 2 almost equals the 27 palms distance between windows 6 and 7 [4], but the spacing of windows 3, 4 and 5 shows slight variations; the 18 palms distance



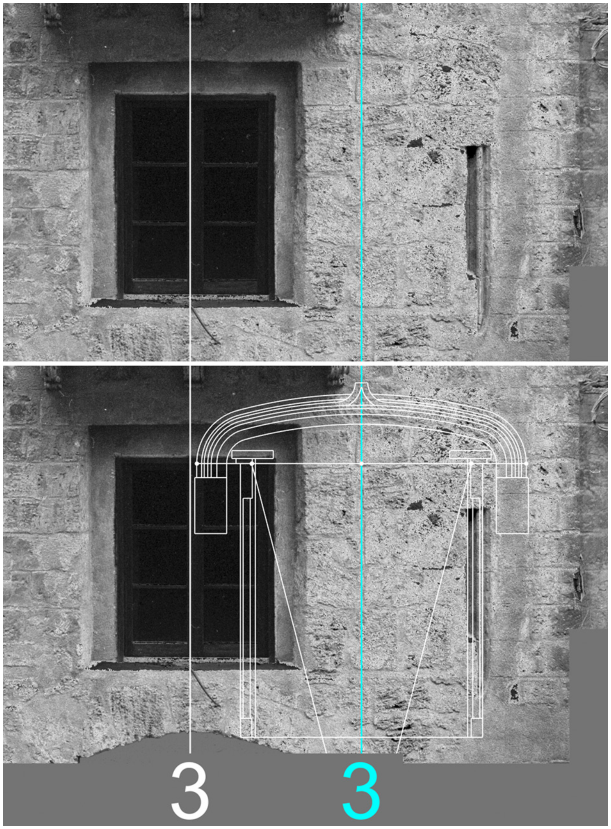


Fig. 9. Drawing of the double-arched window 2 at the piano nobile.

Fig. 10. Drawing of mezzanine window 3.

between windows 4 and 5, is greater than the 16 palms distance between windows 3 and 4.
The arrangement of windows at the mezzanine and at the *piano nobile* does not match the layout of the seven single-arched windows at the attic, framed by a three-centered cornice.
New openings with balconies replaced attic windows 1, 2 and 3, but clearly visible traces supported their reconstruction; windows 4 and 5 seem unchanged; windows 6 and 7 have been extended downwards.
The spacing of attic windows is almost regular and amounts to about 22 palms, double the 11 palms width of the three-arched cornice that frames the windows; the 24 palms distance between windows 4 e 5 is slightly greater.

The presence of three triple-arched windows in the central part of the *piano nobile*, and the slight enalrgement of the distance between openings 4 and 5 at all levels, suggests that these windows probably opened into the main hall of the palace.
Private ownership did not allow access to inner spaces at all levels. The analysis of the layout of inner spaces at the *piano nobile* was therefore developed on a plan of the ground floor of the building, restituted from an accurate 'traditional' survey [Prescia 1986, p. 54]. This plan was validated through the comparison with the rectified image of the façade and with the laser scanning survey of the rooms corresponding to windows 1, 2 and 3, owned by the public regional administration [5].
The plan shows that five windows, namely 1, 2, 3, 6 and 7 open into 5 rooms, while windows 4 and 5 open into a single room, larger than the others.
This hypothesis is backed by a plan of the palace, dated 1798 [Stella 1997, p. 74]; the plan shows that the *piano nobile* was divided into six rooms; the only room that crosses the entire depth of the building is the one that follows windows 1, 2 and 3 and precedes windows 6 and 7. In the plan, this room is noted as '*Salone*'.
Further validation of the relevance of this room is provided by the observation of the traces of openings on the rear front of the *piano nobile*. The renovation, or later transformations, completely removed the original inner openings at the *piano nobile*; yet, some faint traces suggest the presence of an arched portal opening into the *Salone*, flanked by two symmetric windows; the traces of decoration echo the windows above the entrance portal aside the facade.
A question arises: why window 3, which opened into a standard room. is not shaped like standard windows 1,2, 6 and 7 ? A reasonable answer is that window 3 probably served to balance the layout of the front; although distances are not regular, the façade was probably arranged in a symmetric design (fig. 12), with three triple-arched windows, (3, 4 and 5) flanked by two pairs of double-arched windows (1, 2 and 6, 7).
The entrance block, attached to the building, is the element that most distinguishes the palace from other contemporary buildings. In coeval palaces the entrance usually opened into the central part of the building.
The interpretation of this odd position would demand a general hypothesis of recostruction of the building and its surroundings; here, we simply state that geometric analysis led to the reconstruction of the façade of the entrance body, with two symmetric windows placed above the portal, at the level of the *piano nobile*.

Fig. 11. Drawing of the triple-arched window 3 at the piano nobile.

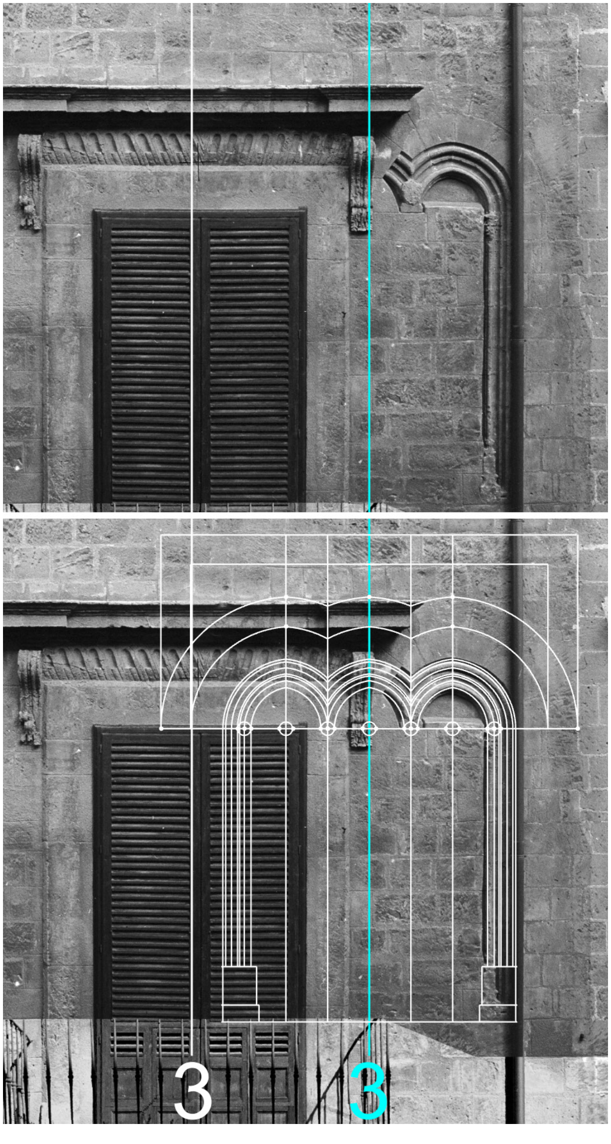
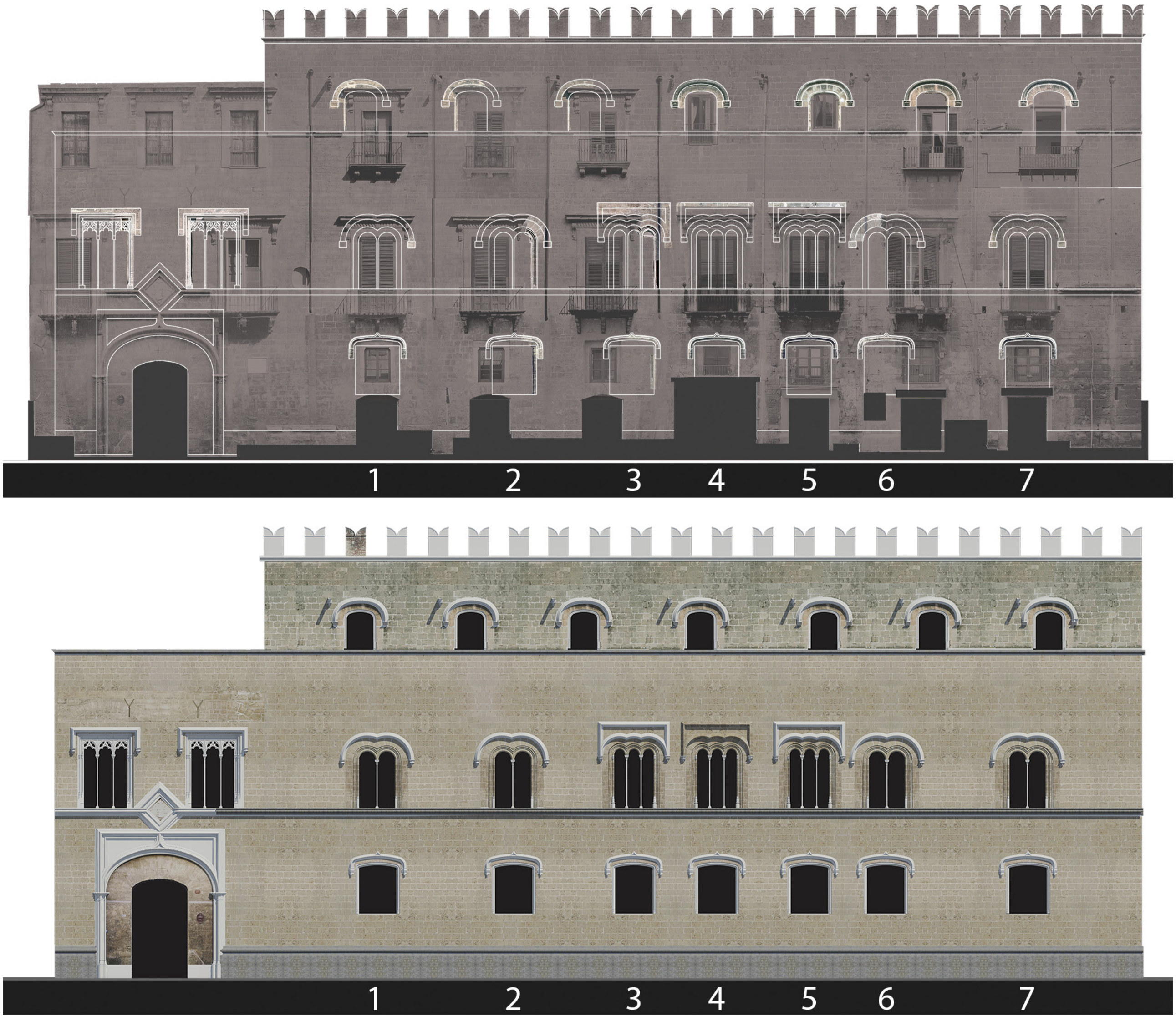


Fig. 12. Reconstruction of Matteo Carnilivari's design.



The traces of two discharging arches, symmetric to the vertical axis of the portal, made it possible to fix the symmetry of the windows and to propose their reconstruction. The residual traces of decoration suggest a strict resemblance to the windows in the façade of the *piano nobile* of Palazzo Abatellis; historic studies support this hypothesis, because they proved the presence of the stone carvers recruited by Carnilivari in both palaces.

Conclusions

The facade of Palazzo Aiutamicristo, designed by Matteo Carnilivari at the end of the fifteenth century, was deeply transformed in the half of the following century.
The reconstruction of Carnilivari's design was developed on a digital replica of the façade; the study proved that digital technologies have only apparently weakened the connection between drawing and measure.
When we work on digital replicas (point clouds, meshes, rectified images, orthophotos), drawing becomes a surveying tool. The prominent role of drawing, which directed traditional surveying methods, revives in the study of architecture with digital tools.
On digital replicas we measure by drawing.
The connection becomes clear when drawing and measure concur to propose a reconstruction.
Drawing detects correspondences, fixes the size of architectural elements and the rules of their arrangement; drawing suggests hypotheses that bring invisible traces to appear.
Drawing and measure, even in their digital evolution, are oriented and guided by a cognitive hypothesis. The replicas of reality, produced by 3D recording devices, remain 'silent' until drawing and measure begin to operate on them, revealing the richness of architectural design.

Notes

[1] The first studies on Matteo Carnilivari date back to the second half of the 20th century; in recent years, new studies have re-evaluated Matteo Carnilivari and the architecture of his time, as an alternative and coeval Renaissance developed in Sicily and in the Kingdom of Aragon. The fact that Carnilivari went back to his native region soon after having started the construction of two relevant palaces in Palermo, suggests that the caput magister was in charge for many other works, which were probably destroyed by the earthquakes that have repeatedly devastated eastern Sicily.

2] In an initial stage of this study, carried out with Prof. Stefano Piazza, the facade was surveyed with topographic and photogrammetric methods; the photos, taken from a mobile platform, were rectified and registered with Rollei MSR package. The reliability of the rectified image has been recently tested by comparison with laser scans taken with a Leica HDS 7000 shift based scanner.

[3] On the objectivity of observation and on the link between cognitive hypothesis and the perception of phenomena, we refer to the illuminating remarks of the epistemologist Paul K. Feyerabend in his "Against the method".

[4] The Sicilian palm has a length of about 0.257m, equal to the eighth part of the cana, 2.06 m long.

[5] A part of the Palazzo Aiutamicristo hosts today the headquarters of the Soprintendenza ai Beni Culturali; the author thanks the Director, arch. Lina Bellanca, for allowing access and laser scanning survey of the rooms at the piano nobile, corresponding to windows 1, 2 and 3.

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Desiderio di Montecassino Abbey. Survey: the Logic of Measure and Proportion

Laura Aiello

Abstract

Being an architect today, in the presence of the great masters of history, raises questions about the objective existence of a measurable and replicable cosmic harmony. In essence, this is a theme of remote origins, in which man questions the existence of Beauty as an objective value: whether it is inspired by the transcendence of the Platonic idea or by the immanence of the Aristotelian universal. In this paper we analyze some works that have stood the test of time: they are products of a culture different from ours but they have developed a universal language that goes beyond the conventions codified by those who produced them and by those who admire them today.
In this context, we present the case study of the Desiderio Abbey of Montecassino, a medieval building that has been lost. Today, on its site stands a modern building whose features reflect the project of the 17th-18th century. The majesty of the original building comes to us from the chronicles of the time and somehow it still reverberates in the current layout of the abbey. The aim of this study is to trace the original design model which inspired Abbot Desiderio to create his work. The survey uses the tools and methods of drawing, surveying and analyzing the graphic documents received by us thanks to the cataloging and conservation of historical archives.

Keywords: Montecassino, Desiderio, metrology, survey, mystagogy.

Introduction

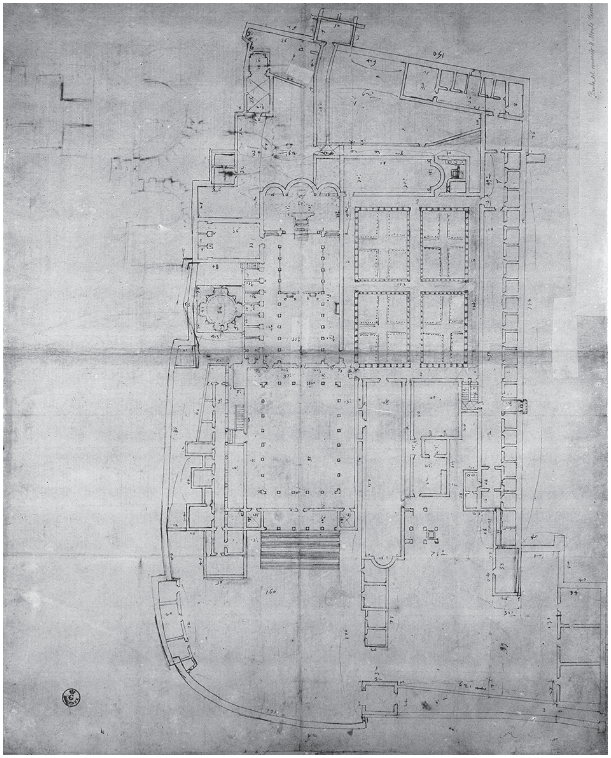
The theme we present offers a particular interpretation of a lost monument. The study is based on the cross-analysis of some important documents such as: the design description of the Desidero's project of 1071 and reported by Marsicano in his *Cronaca Monastero Cassinese*; the survey of the architectural complex carried out by Antonio da Sangallo and his brother Giovanni Battista almost 500 years after the dedication and surveys of the building complex published by Erasmo Gattola in 1733 to accompany its history of the abbey up to the archaeological surveys made by Pantone between the destruction of 1944 and the modern reconstruction. This comparison made it possible to recognize in the description of Marsicano the compositional characters represented in the sixteenth-century surveys deposited at the Cabinet of Prints and Drawings of the Uffizi Galleries in Florence. In a concatenated way, it has been possible, through metrological speculations, to explain the metric value of the cubit they desire and to put forward some considerations on the proportional logics underlying the original work.

Cronaca Monastero Cassinese

The description of the works of Abbot Desiderio of Montecassino, future Pope Victor III, comes to us thanks to his biographer Leone Marsicano who begins the drafting of the *Cronaca Monastero Cassinese* on commission of Abbot

Oderisio, who succeeded the great Desiderio as abbot. The work includes the events from the origins of the monastery, with its foundation by Benedetto da Norcia in 529, up to the year 1075 (Abbot Desiderio), offering extensive historical documentation of the arrival of the Lombards and Normans in Italy. The chronicle is divided into 4 books, the last of which is written by Pietro Diacono a few years after the death of Leone Marsicano, who will expand the discussion to the events of the empire and the church until 1138.
The figure of Desiderius is described in the third Book, presented as a monk, ascetic, abbot and pope, supporter of the reform of the church of Gregory VII. Desiderio embodies the image of the builder abbot and patron of the arts, recognized today as a key image of the syncretism of Lombard and Norman art, as well as an authoritative counterpoint to Cluniac architecture across the Alps [1].

Fig. 1. A. da Sangallo il Giovane, drawing of the Abbey of Montecassino, Gabinetto fotografico Uffizi, 1276Ar.



Particularly interesting for our study appears the accurate description of the reconstruction of Desiderio's abbey. According to the chronicler, after some architectural works aimed at improving the housing status of the community, the abbot decides to undertake a major reconstruction work. He has all the old buildings demolished, that were now dilapidated and insufficient for the community that has become numerous; He has the old church demolished and he built a basilica so majestic that it marks a chapter in the history of sacred architecture.
The building is carefully described, reporting its shape and size. The same workers are brought in from Constantinople. Given the exceptional nature of the event, a craft school was set up aimed at preserving the construction art of mosaics. The chronicle reports that in 1071, Desiderio went to the supreme pontiff and he invited him to attend the dedication. Ten archbishops, 44 bishops and magnates from all over the world were present at this solemn celebration, whose number was not thought of. Such solemnity was celebrated for eight continuous days, and the fortune of this monastery grew to the point that in two years the number of monks of the monastic family grew to two hundred [Marsicano, Diacono 2016, pp. 389-395].
Today Desiderio's building is no more visible, but we can guess its majesty from the chronicle of Marsicano. It was in fact destroyed and rebuilt several times over the centuries. The first substantial transformation had to take place in the earthquake of 9 September 1349 [Scaccia Scarafoni 1936, p. 98]. From the chronicles of the time we can deduce that the damage suffered by the structure was enormous. In this regard Gattola [Gattola 1733, p. 736] reports the annotations of an anonymous Cassinese in which we read that in the whole monastery not even a building had remained erected and that this state had to last until 1370, the year in which he reports a bull of Urban V, in which the pontiff makes appeal to all the houses of the order to help support the community in the reconstruction of the building "*super suis fundamentis quae illaesa consistint*" [Gattola 1733, p. 520] "*unde (…) constructionis aliorum monasteriorum forma processit*" [Gattola 1733, p. 736].
From what is reported, it's evident the actual state of instability suffered by the structure, but at the same time those verses let us understand that the Desiderio's project had to remain in the traces of the foundations and rise again with new elevations.
It cannot be said that the entire complex retained the same medieval imprint (especially as regards the minor buildings)

but in agreement with Scaccia Scarafoni [Scaccia Scarafoni 1932, p. 98] almost 500 years later, the survey of the abbey carried out by the brothers Sangallo still seemed to reflect the description of the Marsicano chronicle, or at least in the location of the main buildings.

The Sangallo brothers' drawings

There is a series of graphic works preserved in the Cabinet of Prints and Drawings of the Uffizi Gallery in Florence, already published by Gattola in 1733 and extensively commented by Giovannoni in 1929 [Cfr. also, Scaccia Scarafoni 1932, Cigola 1997] in which the two brothers document an accurate survey of the complex and plan some architectural interventions.

Briefly presenting these documents, starting from the critical comment published on the *Progetto Euploos* portal. The sheet 182Ar (fig. 2) is a survey work signed by Giovan Battista Cordini da Sangallo called il Gobbo. All the others (172A, 180A, 181A, 1276A *recto* and *verso*, 1316A *recto* and *verso*), cataloged as drawings by his brother Antonio Cordini, known as Antonio da Sangallo il Giovane, are instead Design drawings of the Pietro dei Medici's Chapel, to be inserted

Fig. 2. G. B. da Sangallo il Gobbo, drawing of the Abbey of Montecassino, Gabinetto Fotografico Uffizi, 182Ar.

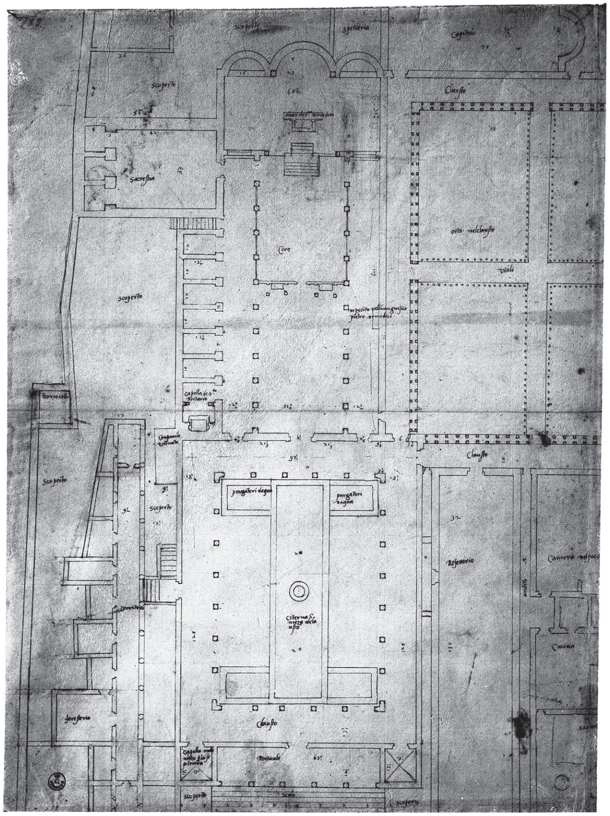
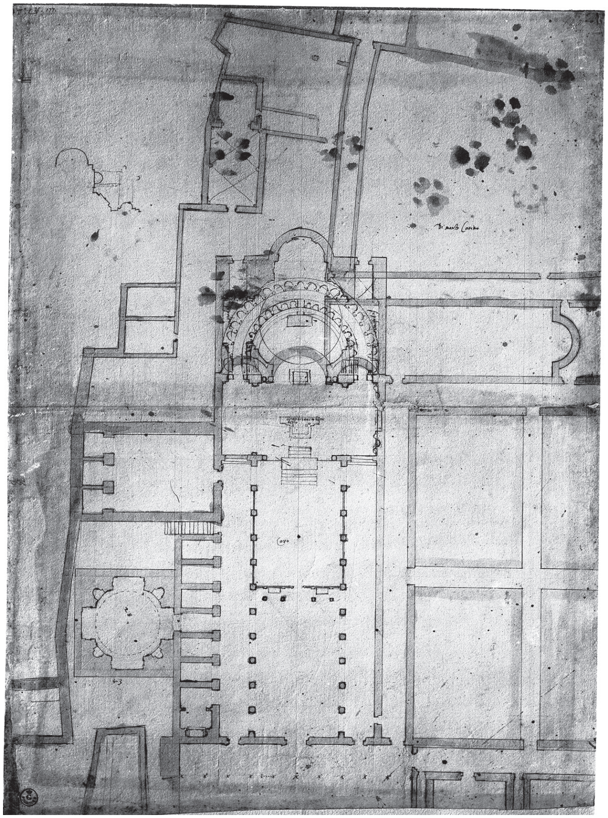


Fig. 3. A. da Sangallo il Giovane, detail of the drawing of the Abbey of Montecassino, Gabinetto fotografico Uffizi, 181A.



in the left aisle, and of the a new large semicircular choir to replace the three medieval apses.
In particular, the document 181A contains both proposals in an overlaid representation of the survey status (182Ar) and of the project status. The 180A seems to be a reworking on the same scale in which only the project status of the new choir is identified, therefore without overlapping.
The chapel of Pietro dei Medici, on the other hand, becomes the privileged subject of the detailed drawings 172A and 1316A (front and back), in which plans and sections of the monument are developed; and it is reproduced on a large scale in the drawing 1276A*r* (fig. 1).
Specifically, the present study focused on this last drawing which, although representing a design phase of the Pietro dei Medici chapel, it collects the greatest number of measure references and it allows to appreciate the whole abbey plant on a larger scale, including the cloister and the perimeter rooms of the complex.
In 1932, Scaccia Scarafoni, in one of his well-motivated essays, made various observations on the notations of the drawings, which led him to contest the dating proposed by Giovannoni [Giovannoni 1929] who dated the projects between 1531 and 1559. He goes on to establish between 1507 and 1512 the time frame within which to place the drawings' realization. Temporally, he frames them in the years in which the surveys are carried out for the design of the tomb of Pietro dei Medici, who died in 1503, more precisely after the lightning of 1507 that will ruin one of the towers (the wording "campanile ruinato" is in fact present on the drawing), and immediately before the renovation works by Squarcialupi (who in 1512 will carry out the works for the insertion of a new monumental entrance cloister of which there is no trace in the Sangallo).

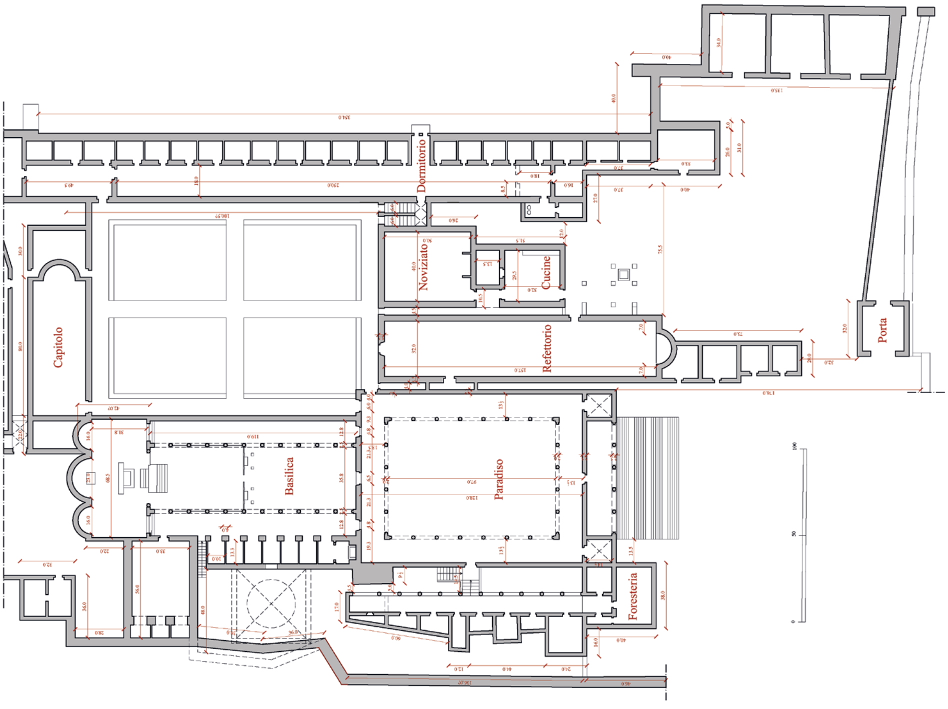


Fig. 4. Vector reconstruction of the abbey of Montecassino performed on the basis of the relief drawings of the Sangallo brothers (graphic elaboration by L. Aiello).

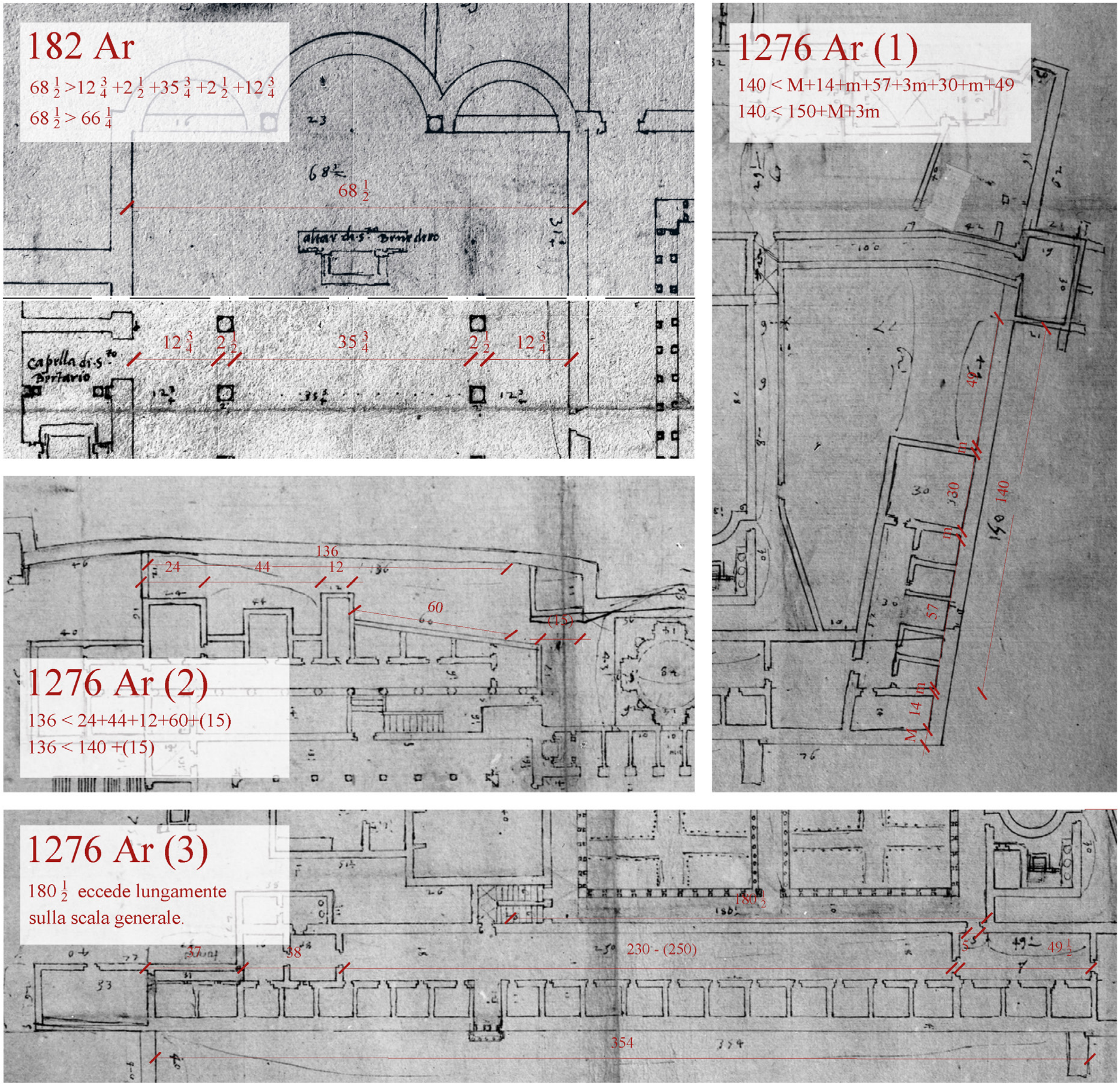
Marsicano and Sangallo in comparison

The correspondence between Marsicano's description and the Sangallo survey immediately appears plausible thanks to the direct comparison of the documents. Extrapolating some passages, Desiderio's project is described in this way:
A basilica building with three naves with 10 columns on one side and 10 on the opposite side "*columnas desuper decem a latere uno totidemque ex altero*" [Marsicano, Diacono 2016, p. 384], ending with an apsed transept. In front of the church he builds an atrium "*quod nos Romana consuetudine paradysum vocitamur*" [Marsicano, Diacono 2016, p. 384] which with Roman usage we call it paradise (in the drawing of Sangallo it is named the cloister of benefactors) with four columns on each front and eight on each side, and in front of the entrance to the basilica he builds arches "*quo vulgo spiculos dicimus*" [Marsicano, Diacono 2016, p. 384], a description that surprisingly places the construction of the pointed arch at the beginning of the second millennium [Luschi 2015, pp. 181, 182]. Speaking about the count of the columns, it should be noted that both in the nave and on the short side of the paradise only the free columns are counted. Regarding the long side of paradise, we actually have 6 free columns to which two corner semi-columns can be added. It's a detail that opens up a doubt about the descriptive license or the actual modification of the angular solution after the 1349 earthquake. In both cases, the description still seems to reflect the spatial scans of sixteenth-century drawings.
Among the scrupulous descriptions it is still possible to recognize the position of the apsidal refectory, built in adherence to paradise. The chapter "on the eastern side, sideways, so that the internal corner of its frontispiece matches the external corner of the basilica and its apse seems to approach the dormitory" [Marsicano, Diacono 2016, p. 403]; the long and narrow dormitory located south of the complex, the kitchens and the novitiate between the dormitory and the refectory.
Compared to the constructions on the perimeter, Marsicano describes also the construction of a turreted door served by a slope with a double protective wall; the guesthouse for pilgrims on the southern side, and on the northern side of paradise the guest house, near a mill which is placed not far from the entrance hall's steps (in the Sangallo drawings these architectures are indicated as a guesthouse).
The recognition of these environments therefore comforts us in affirming that the reconstruction and consolidation interventions that took place after the earthquake of 1349 must not have upset the medieval structure that still largely responds to the description of Marsicano.

Reconstruction of the Sangallo brothers' survey

We want to highlight here that the exceptional correspondence between descriptive documentation and graphic documentation represents a case of great value for the study of medieval architecture. We are in fact convinced that this union must have been one of the main proponents of the rich literature of merit concerning the historical reconstruction of the image of the Desiderian basilica. Among all the study, we mention the exemplary interpretative ones of Kenneth J. Conant [Willard 1935, pp. 144-146] and of Scaccia Scarafoni [Scaccia Scarafoni 1944, pp. 137-183] who faithfully trace the proportions of the buildings represented in the Sangallo drawings.
Analyzing the sixteenth-century drawings, we highlight that some of them have measures notations reported in correspondence with the main architectural elements. This made it possible, starting from drawing 1276Ar (fig. 1), and through appropriate comparisons with the measures indications present in the detailed drawings, to operate in a vectorial methodology a reconstruction of the abbey system on an absolute scale (fig. 4), postponing to a later work step the coding of the metric unit of reference adopted. Where possible, the survey has been re-drawn using the positions and inclinations already graphed in the original drawings. This operation let us verify the exact proportional correspondence between measurement and graphic elaboration, allowing us to check any deformation phenomena of the original paper support, or derived from digital scanning and eliminate the natural error inherent in scaling reductions.
It should be noted that the sixteenth-century drawings are the expression of a simplified representation. All the rooms show orthogonal positions, and the overall composition does not show any deviations from this orthogonality.
This is very evident in drawing 181A (fig. 3) in which the high resolution of the scan allows you to appreciate the grain of the sheet and the slight grooves engraved with a thin point to form a sort of reference squared paper.
Exceptions to this orthogonality are the perimeter constructions which somehow perform the function of defining the composition of the rooms and can absorb any reconstructive errors. Facing an analysis of the measure data reported on the documents, it is highlighted that the main dif-

Fig. 5. Details of drawings 182Ar and 1276Ar highlighting the main algebraic discrepancies of the measurements detected (graphic elaboration by L. Aiello).

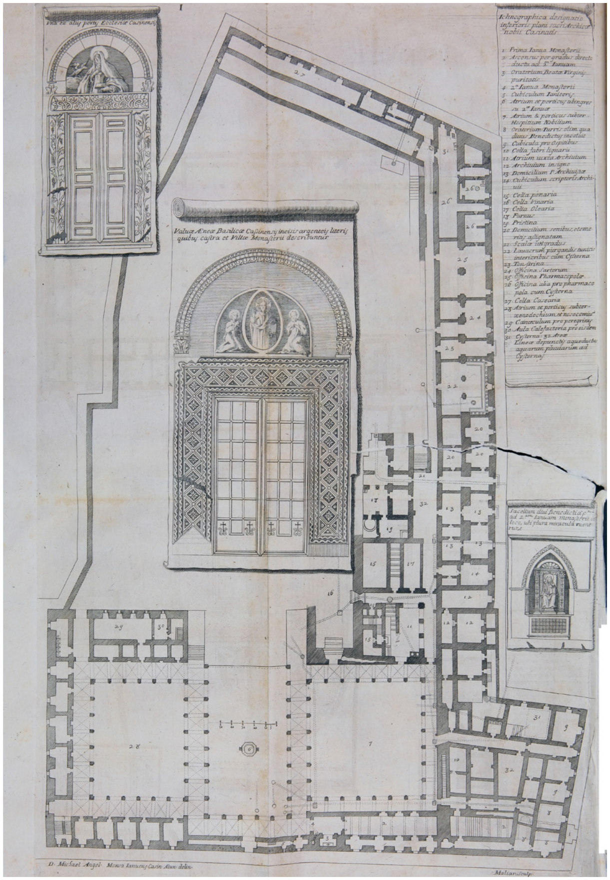


ferences between the indicated measurement and the one represented are recorded on the perimeter walls (fig. 5). In fact, it seems that in the face of a graphic simplification, the editor has however maintained documentary honesty in the measures numerically indicated.
However, some macro critical areas are highlighted in the report:
1. the perimeter wall to the east;
2. the guest buildings to the north of paradise;
3. the area of the chapter cloister and the adjacent dormitories.
To these ones we add a fourth case relating to the measurements of the internal width of the basilica.
In each of these sectors there are some algebraic incompatibilities which denounce drafting errors that cannot be resolved unless substantial corrections are evaluated.
In the first three cases, the sum of the partial measurements exceeds the total measurement reported on the outermost front. In the case of the width of the basilica, however, the partial sums are lower than the total measure indicated in the presbytery.
In detail: in the first case the sum of the internal spaces ($M+14+m+57+m+30+m$, in which M indicates the thickness of the perimeter wall, and m the thickness of the dividing wall between two internal spaces) and cloister (49 units) exceeds all wall thicknesses plus 10 units compared to the reported total of 140 units.
In the second case, the sum of the individual buildings, indicated gross of the external walls (24+44+12+60=140) even excluding the passageway (estimated on a graphical basis 15 units) already exceeds the total length of 136 units of the external wall.
In the third case, concerning the dormitory, the measures indicated exceed the graphed measures for a long time. In particular: the length of the cloister represented is more than 40 units shorter than the reported length of 180 and 1/2 units, a discrepancy that can only be solved by assuming a drafting error or a graphic reconstruction that admits a trapezoidal deformation of the cloister.
Only in the reconstruction of the width of the nave the sum of the partial measurements is lower than the total measurement reported near the presbytery (error which we will recall later in the phase of recognition of the reference module).
All these cases have ensured that the measured rewriting operation has focused on the reconstruction of the central elements, focusing on the abbey church and the main buildings, remaining faithful to the representative technique adopted by the Sangallo brothers in which the reciprocal rotations of structures have not been considered.

From the survey of Gattola and Pantoni to the Roman foot

On the basis of the reconstructions carried out on an absolute scale, the recognition of the metric unit adopted by the Sangallo brothers and the correct conversion into the metric system remains as a further step.

Fig. 6. A. Maliar, survey of the lower floor of the abbey of Montecassino [Gattola 1733]. By permission of MiBACT. BNCF ©.



The two works Historia abbattiae Cassinensis by Gattola [Gattola 1733] and Le vicende della basilica di Montecassino [Pantoni 1973] represent a great value for this phase of the study.
In fact, both authors publish large format graphic tables containing the surveys of the abbey complex.
The eighteenth-century surveys published by Gattola in addition to offering a clear photograph of the state of the complex in 1733 (figs. 6-8), still allow today to reconstruct the original appearance of the medieval floor thanks to a valuable table representing the details (fig. 9).

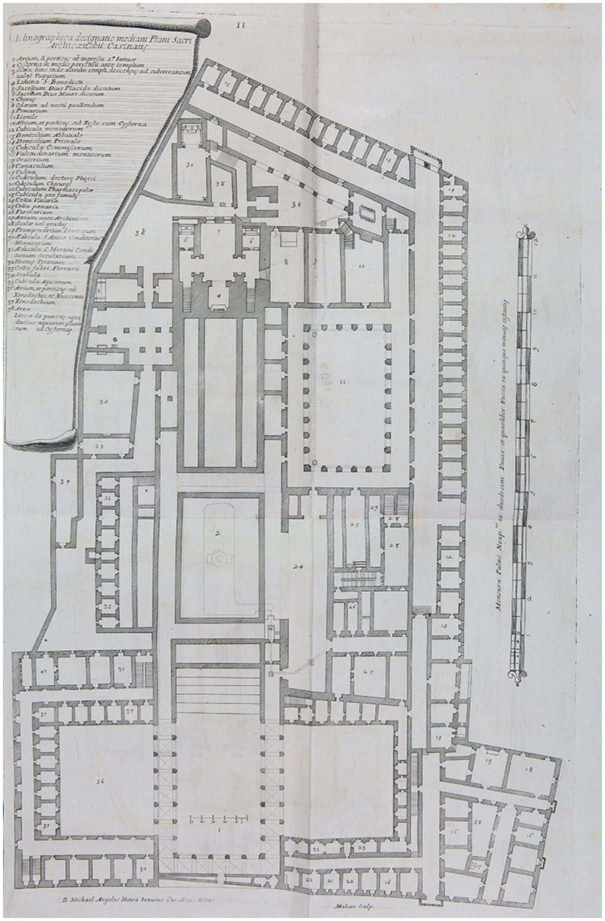


Fig. 7. A. Maliar, survey of the intermediate floor of the abbey of Montecassino [Gattola 1733]. By permission of MiBACT. BNCF ©.

Complementary to Gattola's work comes the work of Don Angelo Pantoni, a monk of the abbey who had to live through the terrible years of the Second World War seeing the great monumental complex of Montecassino razed to the ground by allied fires.
This misfortune has then become an opportunity to start an accurate and profound cognitive investigation of all the archaeological layers hidden under the floor layer of the basilica.
While the Gattola's surveys here allow us to add a piece to the documentation of the evolutionary phases of the abbey's architectures, the archaeological surveys by Pantoni have made it possible to re-weld together all the historical layers traced, allowing us today to carry out comparative studies also of a measure order.
The panel called *Antico pavimento della Basilica di Montecassino* [Pantoni 1973] clearly highlights the trace of the bases of the columns of the original Desiderian church and of the more modern eighteenth-century pillars already documented by Gattola's surveys, offering a graphic representation coded according to the metric decimal system accompanied by a graphic reference scale.
Once again, by operating in a vectorial system a proportional geometric comparison between the documents enunciated, it was possible to observe that the overall measurements detected by Pantoni seem to support the theoretical reconstruction obtained from the Sangallo surveys, offering us the opportunity to directly estimate the measurement used by the Sangallo brothers in a range between 29.5 cm and 30.6 cm.
Transcribing the comparison:
- From the algebraic comparison between the distance from the first and tenth column of the Pantoni equal to 2,815 cm (with a graphic error, on a scale of 1:50, estimated between + or - 1 cm) and the reconstruction of the Sangallo survey (95 1/3 feet), we can deduce that a foot is equal to 29.53-29.52 cm.
- Referring to the transversal distance measured between the two rows of columns 1,170 cm (+ or - 1 cm), compared with the Sangallo surveys (38 1/4 feet), we can deduce that a foot is 30.61-30.64 cm; or more probably the central nave is wider (this discrepancy has already been highlighted in the reconstruction of the sixteenth-century survey between the sum of the transversal measures of the aisles and the total measure of the presbytery).

All those uncertainty coefficients related to the state of the object to be measured must be further added to these calculations; the intrinsic uncertainty in the object itself; the procedure and measuring instrument used; in addition to any errors by the operator himself [Docci, Maestri 2009].
So, all things considered, a more than acceptable correspondence is evaluated between the conventional size of the Roman foot (29.6 cm) and the algebraic measurements obtained which in any case allow to exclude the use of the Neapolitan foot adopted by Gattola and estimated at 26.367 cm [Afan de Rivera 1840].

Desiderio and the cubit

In this transversal process of comparisons, the discussion has to seek a backward conclusion, reaching a metrically coding of the oldest measure enunciated by Marsicano in 1159: the cubit.
In addition to the detailed distribution of all the rooms of the abbey, the chronicler reports the main dimensions of the rooms that compose it. In a similar way to what was done with the drawings of Sangallo brothers, a proportional reconstruction on an absolute scale of five project areas indicated in the description was carried out:
- the church "105 cubits long, 43 wide, 28 high" [Marsicano, Diacono 2016, p. 383];
- the Paradise "77 and a half cubits long, 57 and a half wide, 15 and a half high" [Marsicano, Diacono 2016, p. 385];
- the refectory "which extended 95 cubits in length, 23 in width, was 15" [Marsicano, Diacono 2016, p. 401];
- the dormitory "200 long, 30 cubits high and 24 cubits wide from the inner wall" [Marsicano, Diacono 2016, p. 401];
- the chapter "whose length was 53 cubits, the width of 20, the height of 18" [Marsicano, Diacono 2016, p. 403].

Appropriate operations of proportional comparison between the Sangallo survey and the reconstruction of Desiderio's design space, allowed to observe a good correspondence between the main geometries.
We point out that the overlapping operation of these areas appears coherent due to the proportionality demonstrated, but it still retains a degree of approximation because of the uncertainty, at first, of having to measure before or after the walls thickness, and then, of deciding if include the additional measure given by the foundations thickness. It was therefore decided to set the limits of this approximation (graphing a maximum perimeter and a minimum perimeter) in order to visualize the interpretative limits of the reconstruction (fig. 10).
This operation made it possible to observe that the size of the basilica had to include in addition to the extension of the presbytery and the nave, also the entrance vestibule, thus excluding the chapels placed in the left aisle, probably rebuilt in place of the chapel of Blessed Nicholas and of the oratory of Beato Bartolomeo described by Marsicano as autonomous rooms next to the church.
In a coherent way, the measures of paradise, including the thickness of the row of columns that conclude the church

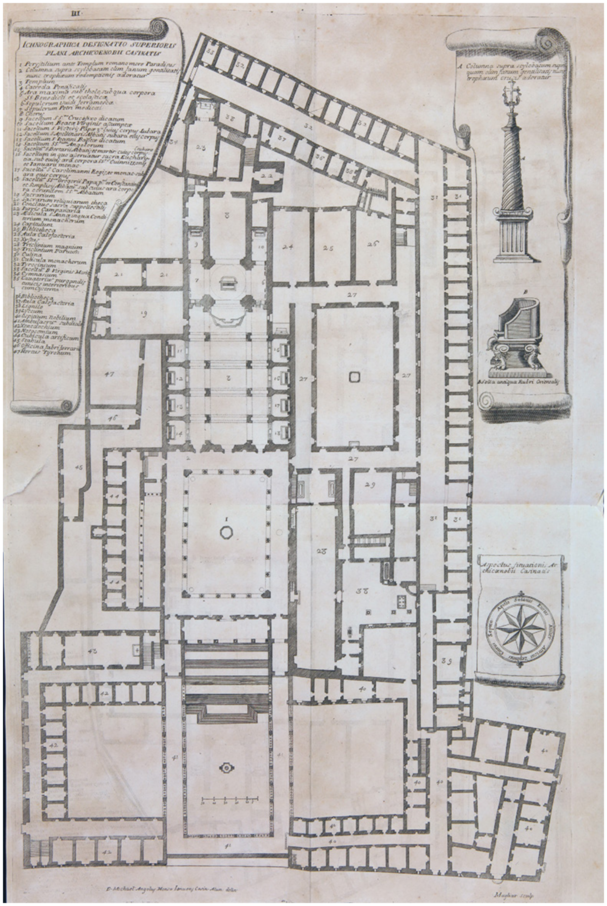
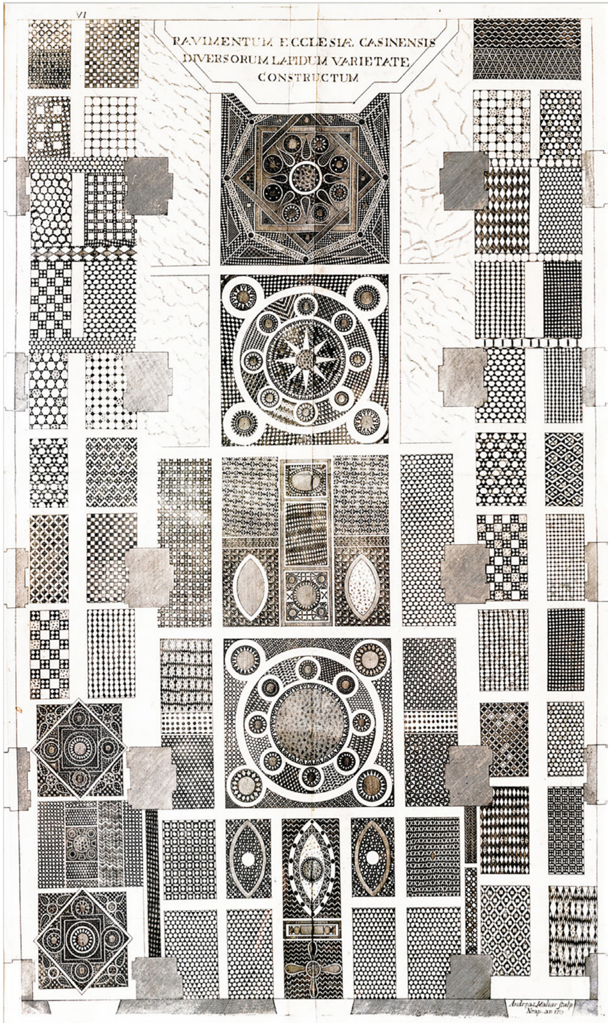


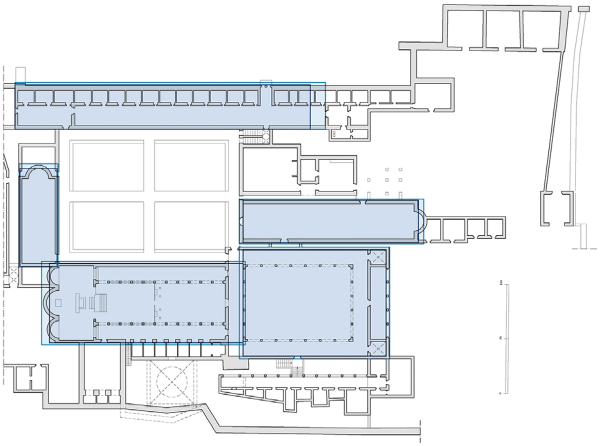
Fig. 8. A. Maliar, survey of the upper floor of the abbey of Montecassino [Gattola 1733]. By permission of MiBACT. BNCF ©.

Fig. 9. A. Maliar, Floor of the Cassinese church [Gattola 1733]. <http://www.museofacile.unicas.it/wp-content/uploads/2016/12/scheda-00_pianta-Gatola_book-postazione-Desiderio_wb1740.jpg> (accessed 2020, November 10).



vestibule, extends to the external perimeter of the entrance vestibule at the beginning of the staircase.
In this overlap, the refectory and paradise faithfully maintain the narrow and long development of the two rooms while the dormitory seems to fit well into the sixteenth-century reconstruction, highlighting that the Sangallo's design reveals a larger construction easily justified by the addition of other structures built in continuity to the original block described by Marsicano.
In accordance with Scaccia Scarafoni, we must remember that "the political events of the Papacy and the Kingdom of Naples had to interrupt the fervor of works for the reconstruction of the Abbey, and so not a few buildings of the 11th century disappeared definitively and we look for them in vain the survey in the plans of the Sangallo" [Scaccia Scarafoni 1932, p. 98].
According to this principle, the study does not want and cannot claim to definitively establish the perfect overlapping of the limits of the areas described by Marsicano on the reconstruction of the sixteenth-century surveys. However, a plausible range is identified in which to include all the possible errors accumulated during the treatment and to offer the coding of a reference interval between 52.74 and 50.19 cm. The first observation we have to make is that the variety of coded relationships exceeds the common Italic cubit of 6 palms, hypothesized by Scaccia Scarafoni and codified by

Fig. 10. Geometric estimate of the maximum extension and minimum extension of the project areas described by Marsicano in 1159 [Marsicano, Dacono 2016] (graphic elaboration by L. Aiello).



Segrè [Segrè 1928, pp. 140, 141] in 44.4 cm. It seems more properly similar to the royal cubit of 7 palms (52.5 cm), whose use seems to be proven by other studies on medieval architectures [Luschi, Aiello 2011].
We highlight that the genesis of the use of this canon in medieval times has not yet been clarified on a metrological level, however we take the view that the fortune of this unit stays in direct proportionality with the Roman foot. In fact, it is easy to verify that 7 feet correspond to 4 royal cubits and that 3 feet correspond to twice the submultiple of the royal cubit, known as a 'short cubit' of 6 palms, equal to 45 cm [Luschi 2011, p. 190].
We add that the use of royal cubit instead of natural cubit appears justified by other factors, among which we recall a theoretical motivation linked to the symbolism of a unity of divine origin (6 natural palms of man plus one given by God) [Segrè 1928, pp. 4-5] and a practical motivation according to which a unit of measurement divisible into 7 submultiples allows an agile management of irrational relations related to the diagonal of the square (root of 2) and to the circumference of the circle (Pi) [Aiello 2018, pp. 61-70].
Refining the advanced coding proposal and proceeding to an exact conversion of the measure units adopted, we can finally perform an exact scaling of all the areas described by Marsicano using a real cubit of 52.5 cm (fig. 11).

We observe in this case that the architectures indicated by Marsicano seem to include all the wall thicknesses, sometimes leaving a computable margin in the foundation scraps or attributable to small deviations that occurred in the reconstructions of the 1349 earthquake.

Conclusions

We can say that we face some building site indications, that faithfully report the measures used in the construction phase since 1066, and an equally faithful survey (at least in general measures) to what should have been the shape of Desiderio's abbey plant in the 1071 (year of dedication). The exceptional nature of this coincidence represents a basis of study open to numerous in-depth studies. However, here the attention necessarily focuses on proportional and geometric connotations that guided the project of Abbot Desiderio. Without further deeping metrological considerations, the macro geometries inherent in the project are easily highlighted.
If we analyze the basilica in its complexity, church and paradise together, the first observation appears to refer to the possibility of inscribing the building within three perfect squares built on the basis of the longer side of the atrium

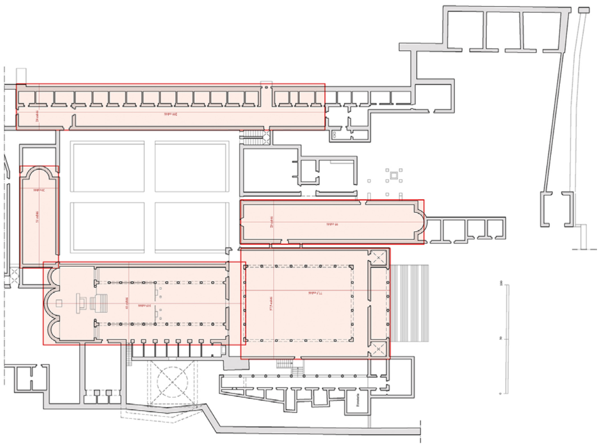


Fig. 11. Representation of the project areas described by Marsicano in 1159 [Marsicano, Diacono 2016] according to the real cubit of 52.5 cm (graphic elaboration by L. Aiello).

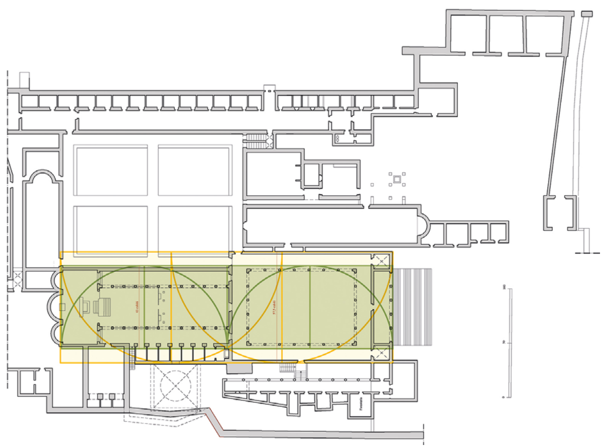


Fig. 12. Studies on the geometric proportions of the desire project described by Marsicano in 1159 [Marsicano, Diacono 2016] (graphic elaboration by L. Aiello).

(57 cubits and a half). The entire complexity of the building is therefore reduced to the simplicity of the ratio 1 to 3 (fig. 12). This composition certainly has an easy reference to the proportions of the mosaic temple designed by God in *Exodus* 27, and to the proportions of Solomon's temple described in *Kings* 1 and *Corinthians* 2 [Aiello 2018, pp. 17-28]. Using the smaller side of the basilica (43 cubits), and carrying out the same operation described above, the square obtained can be inscribed exactly 4 times in the total length (fig. 12). Such proportionality suggests the existence of a geometrical study not revealed in the description of the building but which certainly guided the abbot's project idea.
The mystagogy of architecture and symbolic intentionality thus become a tool for investigating that subtle border in which visible and invisible concur in the same reality and participate in the truth like the full and empty spaces in sacred architecture, where the column and the intercolumniation are one single scan and one is in proportion to the other.
We can therefore hypothesize, with a good approximation, that the mystagogical action that implements Desiderio, renewing the architectural language, essentially starts from reading the sacred scriptures in a continuum of Christological perspective. The Old Testament expressed in the first part of the Roman quadriportico "*quod nos Romana consuetudine paradysum vocitamur*" [Marsicano, Diacono 2016, p. 384] would indicate the necessary but not sufficient direction for salvation. The heavy threshold between the vestibule and the church embodied in the heavy bronze Byzantine doors, indicates the overcoming of death and the historical period of Christ. The church is the heavenly Jerusalem that Christians dare to experience before reality materializes: *Panem nostrum cotidiánum da nobis hódie*. So the basic geometry summarized in the three squares in addition to respecting the three aeons of the Christian temple offers itself well to represent the link between genesis and apocalypse, affirming the Risen One.

Notes

[1] To get a broader picture of the cultural climax and of the historical-architectural impact of the period, see: Carbonara 2014, Luschi 2015.

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Rules, Measurements, Geometries, and Underlying Compositions: Graphical/Interpretational Hypotheses Regarding the Holy House of Loreto

Alessandra Meschini

Abstract

This article presents the results of some studies of the Renaissance architectural/sculptural construction constituting the marble surface of the Holy House of Loreto. Detailed representations obtained from a survey using modern digital technologies served as the basis for specific in-depth graphical/analytical investigations of the monument. In particular, this article investigates the following aspects: the proportions of the Corinthian order, an architectural element on which the compositional design of the elevations is based; the proportional relationships among the parts of the capitals of the order compared to two studio drawings for the larger order of Saint Peter's in Rome deemed to be the work of Bramante; the copresence and correlation in the double rhythm that defines the architectural composition of the faces, echoing the motif of the triumphal arch and the consequent use of an alternating rhythm of two different inter-column spaces, considering as well the relationship with the module identified for the proportions of the order; correspondences with ancient systems of linear measurement in Roman 'great spans' and ancient Roman feet presumably adopted to design the marble surface; and the presence of underlying regulating traces, using the golden ratio to arrange the sculpted panels depicting the story of Mary, with particular attention to the low relief of the Annunciation made by Sansovino.

Keywords: exploratory drawing, proportional relationships, module/measurement, systems of measurement, regulating traces

Introduction

In 1507, Pope Julius II called Donato Bramante to Loreto, asking him to draft a project (for which unfortunately no drawings remain) for a marble cover [Grimaldi 1991, p. 44] to protect the relics of the presumed chapel of Nazareth (Holy House) [1]. The only related document found is a receipt for payment from 1510 referring to the realization of two wooden models commissioned from Bramante, one of which –called "modelo de la chapela di nostra donna"– seems to refer to the project for the marble ornamentation [Bruschi 1973, pp. 964, 965]. Andrea Contucci, known as the Sansovino, was called by Leone X in 1513 to replace Bramante for the moulded decoration of the Holy House from 1518 to 1527 [Bettarini, Barocchi 1966-1987, vol. IV, pp. 270-283]. When Sansovino died, the work passed into the hands of Raniero Nerucci and then to Antonio da Sangallo the Younger, who added the balustrade at the top (1536). Overall, the creation of this architectural/sculptural construction lasted about seventy years and saw the participation of numerous sculptors [2] from Sansovino's circle and beyond [Grimaldi 1999, pp. 400-409].

Bramante's project for the marble shell is composed of an architectural configuration based on the alternating rhythm of two different inter-column spaces articulated by sixteen Corinthian half columns situated on the corners and at defined intervals on the four façades. Four doors located centrally with respect to the larger inter-column areas on the north and south elevations allow access to the interior spaces of the chapel and the slab in the roof. Sansovino

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found himself working as a continuer of this design approach (fig. 1). His language, however, tending towards intentions of strong interaction between sculpture and architecture, led him to work based on a strong sculptural/decorative interpretation of the architectural scans of the construction [Macchioni 1983, Vol. 28, pp. 551-558]. In particular, the space between the larger inter-columns was dedicated to a topic that, appropriately divided, involved all façades of the work: eight 'illustrations' narrating the life of the Virgin Mary sculpted within frames with a sage dose of low-high relief and set in perspective views [Ferri 1853, pp. 13-15]. In this respect, information exists about two models created in 1519-1520 that were taken to Rome [3] which possibly refer to a phase to modify the decorative apparatus that increased the number of sculpted panels [Grimaldi 1999, p. 44-72]. Sansovino personally realized the low reliefs of the '*Annunciation*', the first panel of the '*Wedding of the Virgin Mary*', and the '*Adoration of the Shepherds*'.

The geometric/architectural representation

The first known representations of the Holy House made with the intention of 'rendering' the relic relate to: plan drawings made by Bastiano da Sangallo, called 'Aristotile' (1533), an anonymous person from the first half of the Seventeenth century [4], and Johann Blaeu (1663); a drawing of the south façade by Francisco de Holanda (1538-1541); and the etchings made of all the faces by Giovanni Battista Cavalieri (1567-1568) [Grimaldi 1999, pp. 115, 116; p. 244]. The most exquisite from later centuries are the 'pseudo-orthogonal' representations by Pieter Mortier and Johann Blaeu (1705) [Grimaldi, 1999, pp. 118, 119] and the etchings made by Gaetano Ferri (1853) [Ferri 1853, Tav. XVI, XVII] (fig. 2). However, while constituting important documents, none of these depictions can be deemed an adequate graphical basis for conducting in-depth investigations about the 'measures' of the project.

Therefore, after careful evaluation of the complexity of the construction and the particulars of its placement, the decision was made to conduct an integrated digital survey using reality-based systems: laser-scanner acquisitions combined with modern photogrammetry (fig. 3). These choices were made both to obtain homogeneous data (point cloud) and, with regard to the method of rendering, to maintain scientific control of the procedure. These aspects have already been discussed in other paper [Meschini, Feriozzi 2017a, pp. 683-692]. Here we recall that the objective was to obtain exhaustive, verified representations of the monument to not only adequately render the overall formal complexity in suitable detail, but also support specific exploratory investigations (fig. 4).

Fig. 1. Photographic snapshots of the entire marble work: north-west corner, south-east corner.

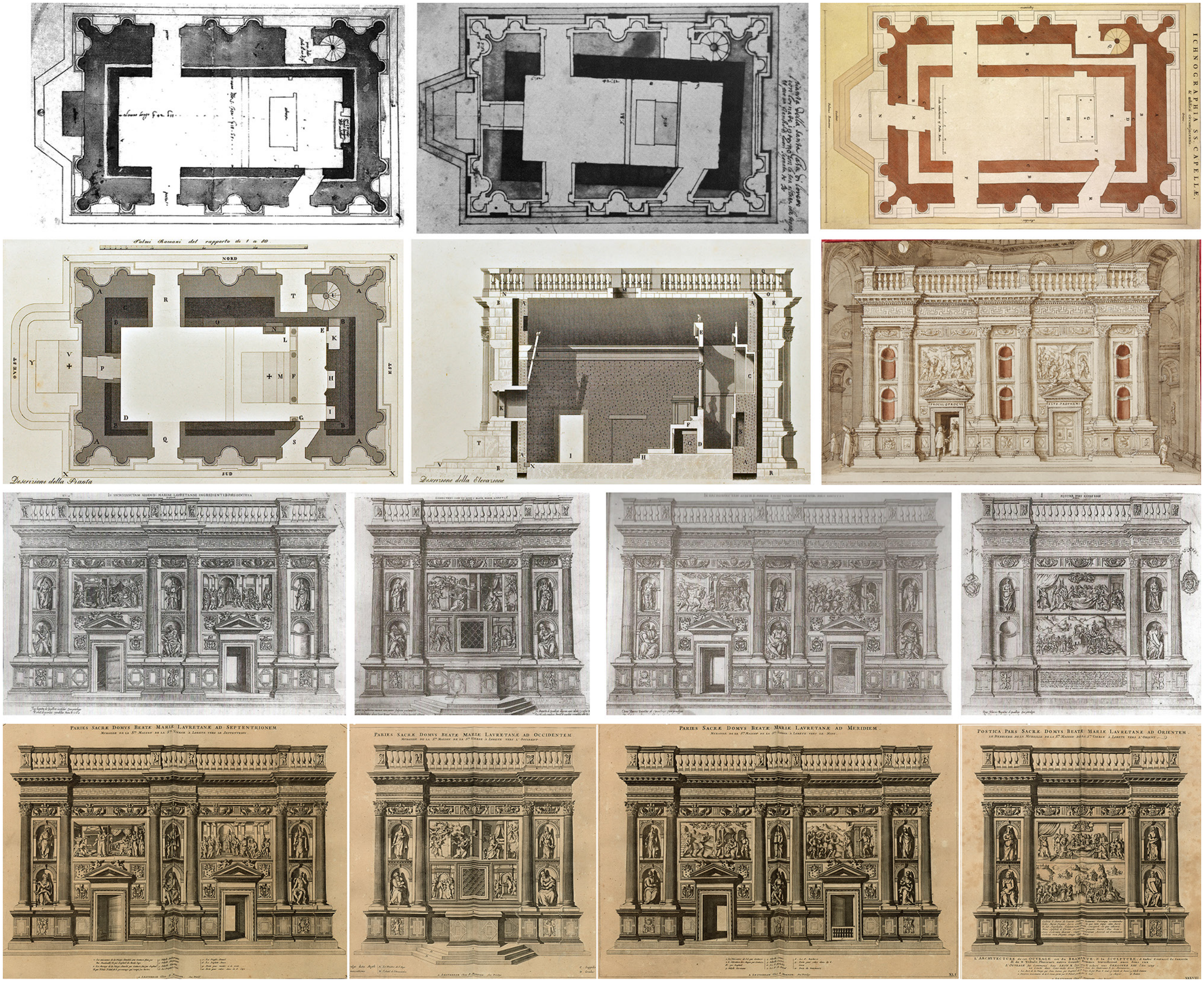
From representation to analysis: objectives and methodological basis

The main objective of the studies was to make various suitable, in-depth graphical/analytical observations regarding the proportions, composition, and measures of the construction.
The methodological arrangement adopted for these investigations were based on historical studies and related theoretical reflections primarily referring to the concept of 'imitation', that is, a practice considered during the Renaissance to be at once both inevitable and desirable. In the field of architecture, this look towards the past entailed studies of both the ruins of antiquity and architectural writings, where the only known ancient treatise on architecture –despite the enigmatic terms and illustrations that have been lost– was De architettura by Marco Vitruvio Pollione. In both cases, the imitation of predecessors represented a model, a method to learn from. In this sense, the treatise De re aedificatoria by Leon Battista Alberti (1st ed. 1485), which follows Vitruvius in its overall structure and view of ancient models, can be defined as creative imitation of the ancient treatise by Vitruvius [Ackerman 2003, pp. 109-121].
Bramante and Sansovino worked at Loreto in the early 1500s. During this period, architectural orders were studied in Vitruvius' text –or at most in Alberti's treatise– and in a wide range of ancient architecture, though these sources were often reworked, as testified by the large number of drawings of Roman ruins which the architects, more than carefully representing them, reread as a function of their own interests. At heart, even Vitruvius, in special dimensional, contextual situations, allowed small adjustments, so the architects tended to design their works not only inspired by ancient models, but also looking for a personal balance between 'decorum' (convenience) and 'licence' (freedom) [Ackerman 2003, pp. 153-200].

The study of the corinthian order and detail elements

The Corinthian order undoubtedly constitutes the architectural element on which the compositional design of the marble work is based, in that it determines both the 'dimensions' in elevation and the rhythmic layout of the façades, and therefore the two different lengths of the sides. The first topic investigated regarded the proportions of this architectural order, considering the bottom diameter of the shaft as a reference module. Although the order is composed of half columns, this does not invalidate either the identification of the module or the proportional logic of the parts.
The order was used complete with its three main parts (pedestal, column, entablature), starting with a base of three steps constituting a crepidoma that, as in classical architecture, lifts the plane of access to the chapel, alluding to the sacredness of the place.
The pedestal of the order (plinth, dado, cymatium) is based on about 3 modules, but if the crepidoma is also considered (about one module), the plane on which the column bases rest is situated at a height of about 4 modules with respect to the level of the church floor. The column (base, shaft, capital) is based on 10 modules. In other words, with respect to what Alberti indicated, it would seem slenderer by half a module. However, it should be noted that in the compositional arrangement of the work, an additional plinth is present (1/3 module) between the pedestal and the base of the column. Therefore, the slight increase in height may be due to this element, while the proportions of the shaft of the column remain based on about 8 modules. Finally, the entablature (architrave, frieze, cornice) seems to perfectly respect the proportions of 2 modules, 22.5 minutes as suggested by Alberti [Alberti, Bartoli 1550, pp. 216-226, pp. 250-257, pp. 286-294] (fig. 5).
Assuming that the project for the architectural partitions of the ornamentation can be attributed to Bramante, another investigation aimed to verify if the proportional relationship between the parts of the capital of the order could be compared to those in two studio drawings for the larger order of Saint Peter's in Rome, regarded by Frommel as the architect's work [5]. The latter echoes the division into seven parts recommended by both Vitruvius and Alberti: two parts for both rows of leaves and for the zone of the spirals, one part for the abacus. The comparison shows that the proportions are practically overlapping. Likewise, the representations arising from the survey were compared with some drawings, perhaps ornamentation surveys, made around the 1540s and attributed to Aristotile da Sangallo [6]. These representations show architectural details where the ratios between the elements and mouldings constituting the following portions of ornamental detail can be read: entablature, base of the column, and cymatium of the pedestals. In

Fig. 2. Above: plans by B. da Sangallo (1533), Anonymous (17th cent.) and J. Blaeu (1663); plan and section by G. Ferri (1853), south elevation by F. de Holanda (1541). Below: elevations by G. B. Cavalieri (1567) and P. Mortier and J. Blaeu (1705).

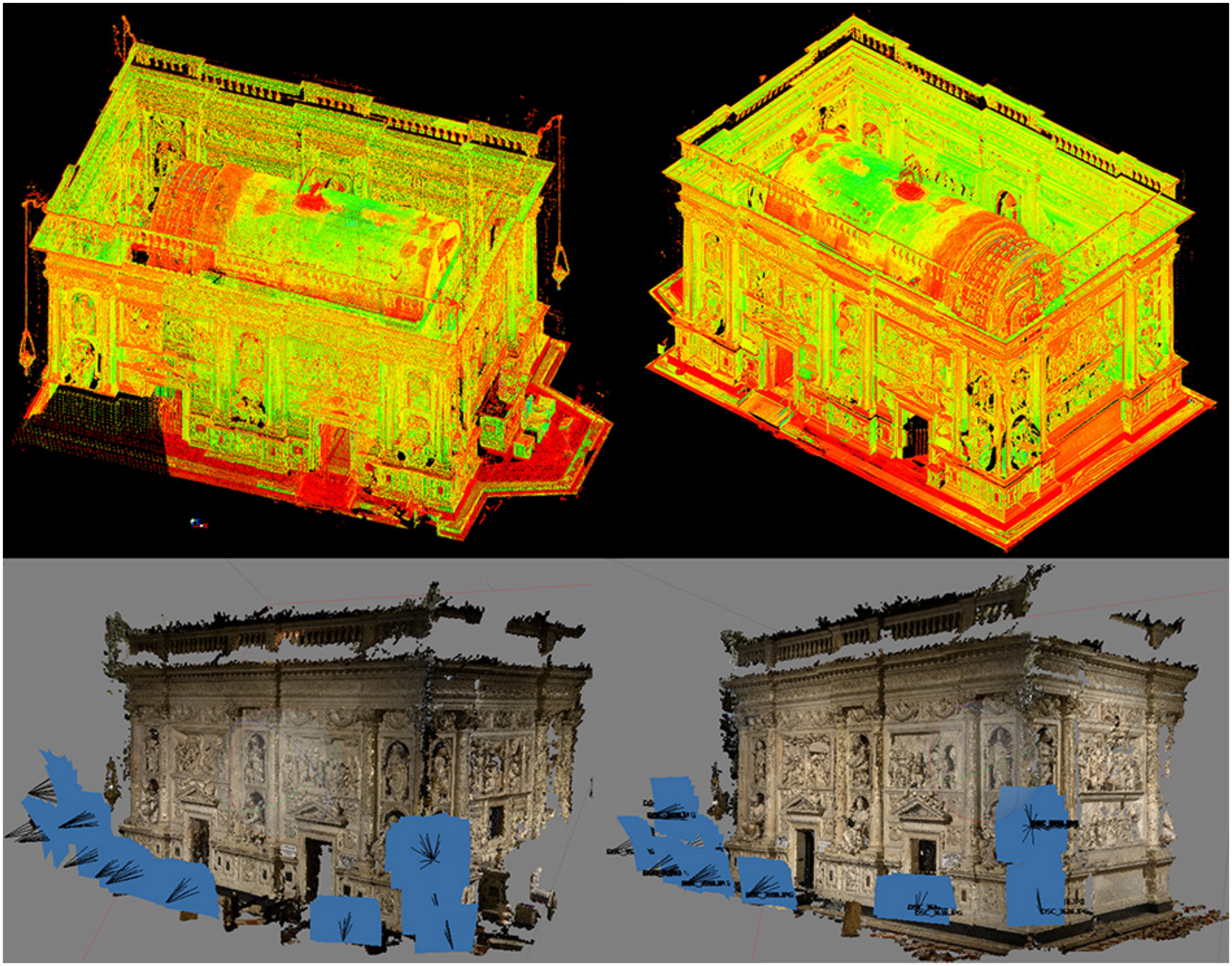


this case, while the clear margin of correspondence in the comparison attests to the mastery of the stonecutter, it also shows the reliability of the results of the survey, even on the detail scale (fig. 6).

The motif of the triumphal arch and the rhythmic inter-column spaces

The outer perimeter of the Holy House created by placing the new marble surface against the wall of the ancient chapel is almost rectangular [7], and the main compositional divisions of the design in elevation on opposite ends are identical. Therefore, the reasoning described below can be applied to two (major and minor) of the 4 faces.
The double rhythm that defines the architectural composition of the marble work is based on the repetition of two related themes: echoing the motif of the triumphal arch and the consequent use of 'rhythmic' alternating pairs of half columns interposed with niches. These themes were already used by Bramante in his 1503-1504 project for the Cortile del Belvedere, particularly the small façade of the nymphaeum and the north end of the portico of the upper garden. In addition to highlighting the reference to models of the Imperial era, this also testifies to the probable influence of Alberti's façade of Sant'Andrea in Mantua, the first model to use a series of two different inter-column spaces inspired by the very scheme of the Roman triumphal arch with a single arch between stone septa [Frommel 2003, pp. 106-109] (fig. 7).
On the minor fronts, this revisited reference can be read easily: with respect to a vertical axis of symmetry, the pairs of half columns close the ends of the elevations, ideally constituting piers of a triumphal arch where the low reliefs narrating the story of Maria stand in lieu of the arch. On the larger façades, the theme is duplicated, but not with a simple side-by-side repetition, which would have doubled central of the paired half-column layout non-aesthetically. Rather, it is mirrored with respect to an axis of symmetry placed at the centre of the pair opposite the one on the corner. In other words, for these elevations, a double vertical axis of symmetry could also be defined, but with a superposition in the middle of the right and left ends of this repeated theme (triumphal arch with an alternating rhythm of two different inter-column spaces). These aspects were the object of another analytical investigation that also considered the relationship with the module identified for the order's proportions.
Above all, an investigation of the theme of the triumphal arch that defines the partition of the major faces showed that the axes of the external columns of the pairs coincide almost perfectly with the vertical sides of a square equal to the number of modules (about 16) which proportion the layouts of the order starting with the stylobate. Within this square, a series of simple partitions can then be identified. With respect to these, some specific portions of the elevation drawing seem to be arranged. For example, the doors to access the interior chapel are located on the middle vertical axis (in place of the arches). As well, the elevation scan is arranged with respect to a four-part division of the side of a square whose upper quarter encompasses capitals and entablature, the two central quarters define the area that frames the system of stacked niches, and the lower quarter includes the rest of the work down to the grade plane of the step that constitutes the stylobate. Some studies of the Cortile del Belvedere (1503-1504) have also found that a square grid was probably used to divide the size of the loggia bays of the upper garden [Frommel 2003, p. 108].
In addition, if two circles are centred on the lower corners of the square with radius equal to the definable height at the upper limit of the architrave, we see that these intersect the plane of the stylobate at the axes where the stacked niches are arranged. Their point of intersection above also intercepts the centre of the upper limit of the rectangular panel dedicated to the low relief and constitutes the upper vertex of an equilateral triangle with sides equal to the distance between the axes passing through the keystones of the niches.
The longitudinal organization of the major elevations appears to be arranged on a division of the parts referring to dimensions proportional to the module, but maintaining a connection with the theme of the triumphal arch: 5 parts to both the left and right of the axis of the square defined before, traceable to a measurement equal to 1 3/4 of a module. Within this layout, both the decorations that embellish the lower part of the pedestals and the interposed tiles and the span of the arches of the niches seem to be defined. In addition, the total length of the major elevations, measured to the height of the dado of the pedestals, that is, the larger plinth situated below the base of the columns, is proportional to about 30 modules (15 to the axis of symmetry of the elevation). Finally

Fig. 3. Above: point cloud from the laser scanner survey. Below: point cloud from photogrammetric processing.



considering other elements in the elevations, other dimensional relationships can be traced out using the size of the module (fig. 8a).
On the minor façades, the analysis is enriched with further findings. In fact, by comparing the elevations to the square previously traced out by matching its median axis with the symmetry axis of these faces, it can be seen that the vertical sides of the square define the outer limits of the division that frame the niches between the pairs of half columns. The width of the triumphal arch theme is clearly enlarged, but this is not due to an increase in space between the pairs of half columns –exactly the same as that of the major elevations– but rather to the central area dedicated to the sculpted panels. As a result, the orders that close the edges of the faces to the right and left fall outside the square. However, if we consider an equilateral triangle inscribed within the square and represent the two circles centred on the lower corners of the square with a radius equal to the side of the triangle, we observe that at the bottom, these intersect precisely the right and left extremes of the step of the stylobate. This thus identifies the dimensional sub-units within which the

Fig. 4. The two-dimensional representations of the Holy House obtained from the integrated digital survey, the 3D model of the architectural layout and perspective cross section from the model.

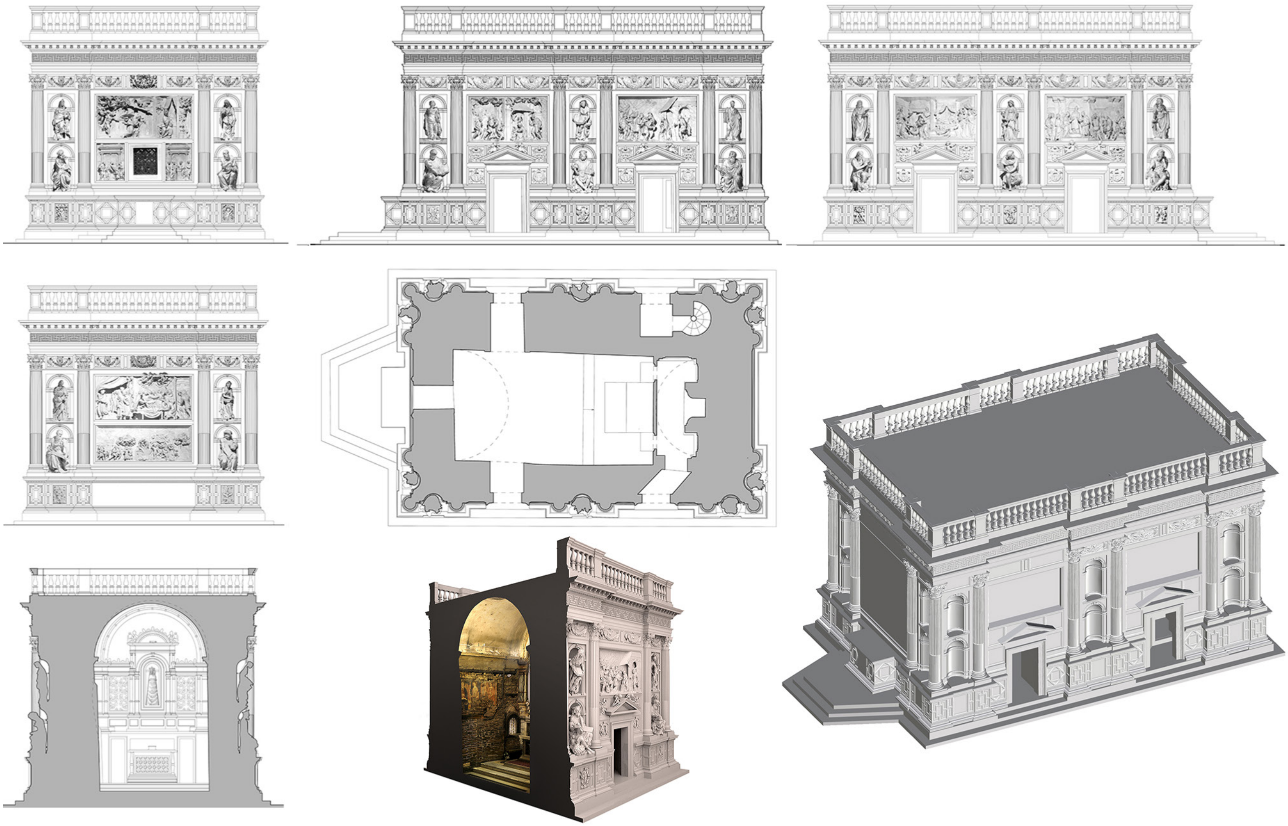
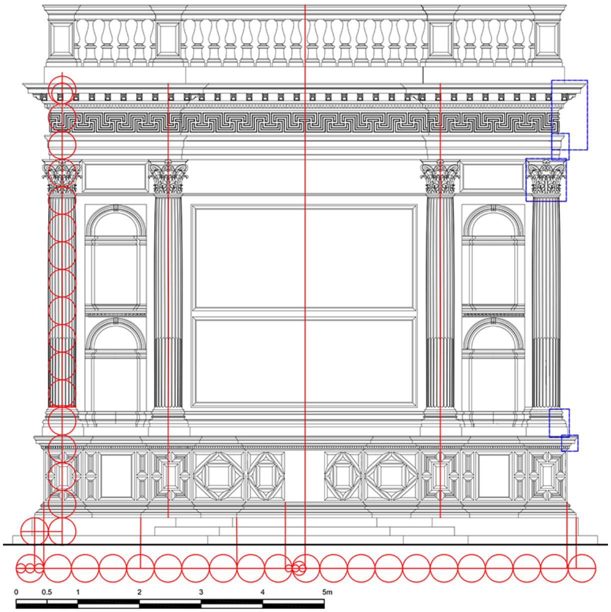


Fig. 5. Study of the proportions of the façades in relation to the module of the Corinthian order.



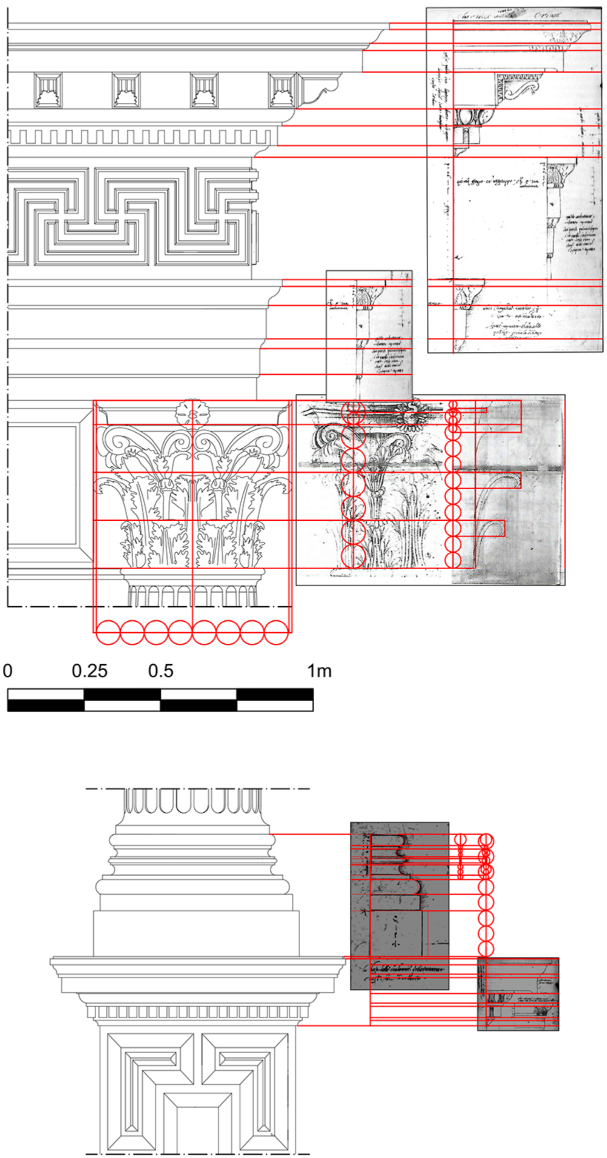
orders on the ends of the façades are perfectly contained. With regard to agreement between the geometrical investigation and the modular proportioning, most of the observations already seen for the major elevations are still valid, with the difference that with respect to dividing the horizontal side of the square into four parts, the two central quarters coincide with the partition dedicated to the low reliefs, which on these faces correspond to a width of 8 modules instead of 6.5 modules. The length of the minor elevations at the height of the dado of the pedestals is contained in 19 modules (fig. 8b).

The measurement systems of the project

The graphical documents found relating to the entire Basilica and the Holy House in particular report measurement scales in Roman spans. Historical information indicates that Bramante, in the same period (1507-1509) as his assignment in Loreto, was also active in Rome where he received commissions for his most important works and where the remains of ancient Rome certainly had a great influence on him. Likewise, Sansovino, in the years immediately preceding his call to Loreto, stayed in Rome for a decade (1504-1513), receiving prestigious commissions [8] in which he was able to create his soft interpretation of the sculptural work that is also found in the Holy House. He also was presumably able to study the ruins of ancient Rome.
The overall length of the elevations of the Holy House resulting from the survey are 13.695 m (major fronts) and 8.82 m (minor fronts) measured at the cymatium of the pedestal, that is, 13.40 m and 8.525 m if measured at the base of the columns of the order. The overall height is 8.76 m.
Starting with the historical data and survey, interest lay in investigating the correspondences with the ancient linear systems of measurement presumably used to design the marble work. In his in-depth studies on Bramante's projects (Saint Peter's, Cortile del Belvedere), Frommel refers to both Roman spans and ancient Roman feet [Frommel 1994, pp. 399-423]. Therefore, following this eminent example, the analysis was conducted by overlapping two different grids in these measurement systems on representations of the elevations [9].
The graphical investigation showed that the dimensions of the smaller elevations –in width considering the maximum

lateral overhang of the crepidoma and in height from the ground to the sky– correspond to a grid of 42 spans, 45 minutes x 39 spans, 13 minutes. However, considering the dimensions excluding the overhang of the first step of the crepidoma and the balustrade added in 1536, all the architectural layouts fall within a grid in rounded dimensions of 40 x 33 spans.
Investigating the elements more in detail, different references can be highlighted with the system in Roman spans. With regard to the width, the decorative arrangement of the pedestals, the geometric panels, and the figurative low-relief tiles alternate widths corresponding to about 3, 5, and 4 spans. The altar, placed in the middle of the west elevation, can be framed in a width of 10 spans, including the overhangs. The extension of the architrave and the balustrade at the top correspond to 38 spans, while the largest inter-column space, measured at the axis of the shafts of the columns, is 20 spans. There are other correspondences in elevation. The three steps of the crepidoma correspond to 2 spans and the pedestals correspond to 6 spans, of which the four central ones coincide with the dado. The order measures 20 spans (2 spans for the base, 13.5 spans for the shaft, and 2.5 spans for the capital); the entablature is included in the remaining 5 spans, 45 minutes. The niches between the pairs of columns are framed in 4.5 spans x 8 spans (ratio of about 1:2), while the area dedicated to the sculptural low reliefs corresponds to 16 spans x 8 spans (2:1 ratio) for the one at the top and 16 spans x 6 2/3 spans for the one at the bottom (ratio close to 2.5:1) (fig. 9, left).
If instead a foot-sized grid is created and the same aspects are analysed, the following can be noted: the dimensions of the elevations, width by height, measure a total of about 32 feet x 29 3/5 feet, that is, about 30 feet x 24 3/4 feet if we exclude the first step of the crepidoma (overhang and height) and the final balustrade. The analysis of the width measurements shows that: the decorations placed at the height of the pedestals alternate divisions of about 2 and 3 feet; the width of the altar, including the overhangs, corresponds to 7.5 feet; the extension of the architrave and balustrade corresponds to 28.5 feet, the major inter-column distance, measured from the axis of the orders, is 15 feet. Finally, the framing of the niches is about 3.5 feet x 6 feet, while the areas dedicated to the low reliefs are included in frames of 12 feet x 6 feet at the top and 12 feet x 5 feet at the bottom. Regarding in height measurements, the three steps of the crepidoma correspond to 1.5 feet, the

Fig. 6. Study of the proportional relationships between the detail elements of the capital, entablature, base of the column, and cymatium of the pedestals in relation to historical graphical sources.

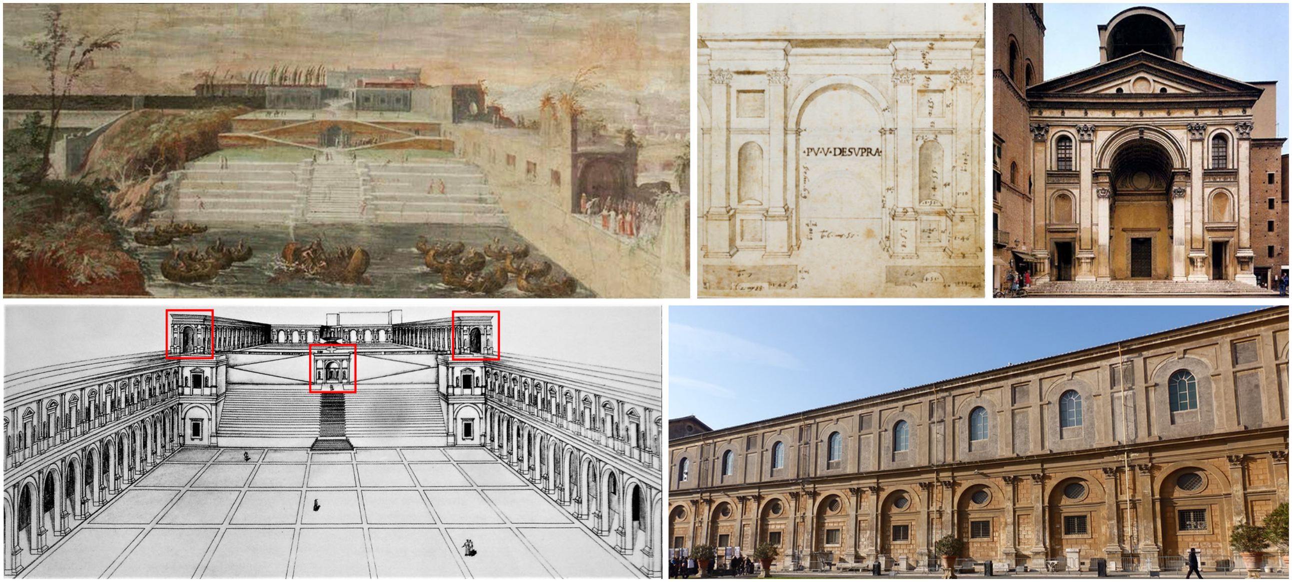


pedestals to 4.5 feet, the order to 15 feet (base: 1.5 feet; shaft: 11.5 feet; capital: 2 feet), and the entablature to 4 2/7 feet (fig. 9, right).
As for the major elevations, these measure 62 spans (i.e. 46 1/3 feet) in width if the overhang of the stylobate is excluded and 65 spans (i.e. 48 1/7 of feet) if it is included. Therefore, considering the measures in height including the lower step of the crepidoma (33 spans, 20 minutes) seen above, the overall dimensions are very close to a 2:1 ratio. For the rest, most of the layouts already seen for the minor elevations are repeated. In addition, the opening of the doors to access the inner parts of the chapel measure 4 spans, 45 minutes x 9 spans (approx. 1:2). The elements of the cornice, architrave, and triangular tympanum placed above the doors follow the alignments of the divisions into decorative panels that characterize the areas dedicated to the low reliefs (fig. 10).
It seems clear that the results obtained by overlapping the two different grids show a predominance of whole measurements in the case of the span and that this therefore could presumably have been the unit of measurement adopted.

The regulating traces in the 'Annunciation' panel

The concept of measurement does not pertain only to the practical expedient that defines physical sizes such as linear units of reference. Particularly during the Renaissance, this concept was also expressed in terms of underlying geometrical relationships and references to the golden number. Therefore, a further analysis aimed to verify the existence of regulatory traces supporting the layout of the sculpted panels by investigating in particular the 'Annunciation' by Sansovino.
The low relief measures 3.00 m x 1.47 m and elements and characters typical of religious iconography related to the biblical episode can be recognized. The observation of

Fig. 7. Above: Perin del Vaga (c. 1545), fresco of the Cortile del Belvedere with Naumachia (Castel Sant'Angelo, Rome) from: <http://www.scalarchives.it/web/>; Bernardo della Volpaia, Codice Coner, drawing of a span of the loggia in the garden (Soane's Museum, London) from: <http://collections.soane.org/THES83854>; Alberti, façade of Sant'Andrea in Mantua. Below: hypothetical reconstruction of the 1503-1504 project for the Belvedere (drawing by S. Gress and G. Diller) from Frommel 2003, p. 104; photo of the upper garden of the Cortile del Belvedere.



these aspects guided the investigations, leading to some hypotheses about the geometrical/proportional systems on which the composition of the arrangement of spaces and constituent elements of the scene seems to rest.
In fact, the combination of a series of golden rectangles placed side by side in different ways has been traced as a possible support to divide the three scenic spaces in the sculpted representation: two golden rectangles situated upright and next to each other along their long side define the proportions of the first scenic space, while the two following scenes in the story are composed within two other golden rectangles placed horizontally one above the other. The latter proportions ensure that the space delimited between the two flats defining Mary's house are built upon two overlapping squares and therefore the third and last space is in turn composed again of two golden rectangles, this time abutting along a shorter side.
Further special relationships were also found between the characters in the scene: the angel's posture follows the inclination resulting from the construction of a golden triangle whose vertex points towards the Virgin's womb and the inclination of the lightning that materialises the divine transmission of the Holy Spirit towards the Virgin also corresponds to the side of the golden triangle.

Finally, by overlapping an image of the low relief on the plan of the Holy House, one notes that its dimensions seem to correspond to those of the internal area of the chapel and that the figural partition of the three scenic spaces in the low relief corresponds to the division of the interior spaces composed of the prayer area, the altar area, and the area of the holy fireplace in the background (fig. 11).
The investigation of the perspective layout of the composition, made with inverse rendering procedures for a hypothetical 3D reconstruction of the space has already been specifically addressed in another paper [Meschini, Feriozzi 2017b, pp. 1-11].

Conclusions

As often happens in an analytical process, some investigations lead to others, that is, further investigations could be addressed, but this would require more space than the present essay allows. What was described herein can therefore obviously be extended. However, since many specific considerations have already been made addressed in detail in the treatment of the individual analyses, this closure aims to summarise more general aspects.

Fig. 8. Analysis of geometric findings between the architectural layout of the marble work and the theme of the triumphal arch (blue) with the relative relationship with the system of modular proportioning (red): a) east elevation, b) south elevation.

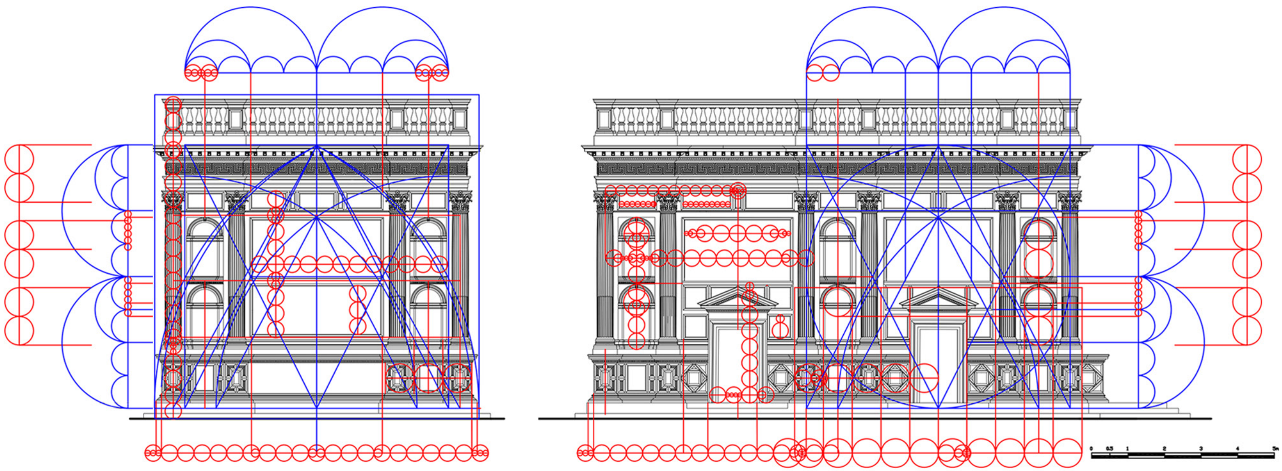
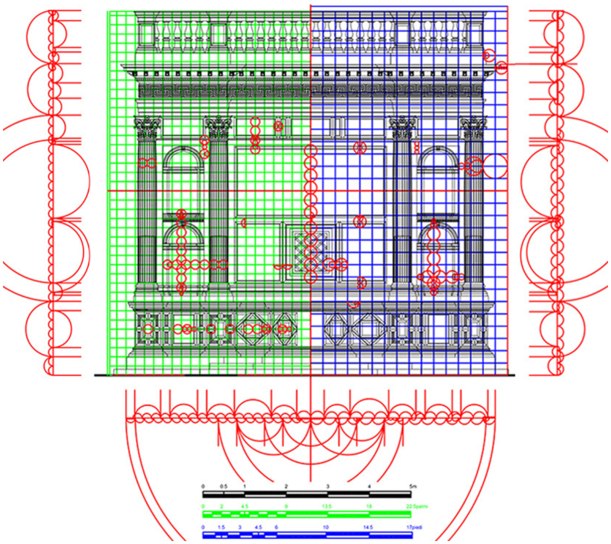


Fig. 9. Investigation into the ratio of correspondence between the elements of the minor façade composition and ancient linear measurement systems in spans (green) and feet (blue).



The analyses aimed to investigate the different meanings of the concept of measurement: in terms of the 'measurement module' (diameter of the bottom of the shaft) or proportions of the Corinthian order that define and 'size' the design of the elevations; in terms of the compositional partitions of the elevations, i.e. the repetition of themes (the 'rhythmic' alternation of two different inter-column spaces and the echo of the triumphal arch motif); in terms of physical quantities as a unit of measurement; in terms of the underlying geometrical relationships and the regulatory traces (sculptural panels).
Aside from evidencing how Bramante was an eminent connoisseur of the ancient world who drew inspiration from the models of the Imperial era, these studies overall seem to demonstrate that he granted himself licence with respect to the ancient prototypes [Frommel 2003, p. 100, 108], adapting certain proportions of the design of the Holy House to the particular situation. In other words, while at times conforming more with Vitruvius or more with Alberti, it is assumed that he aimed to give concrete form to his vision of 'old-fashioned' architecture through further invention [Frommel 1994, pp. 410-417].
Likewise, with regard to Sansovino, in the years in which he works at Loreto, treatises dedicated to the figurative arts such as *De Prospectiva Pingendi* by Piero della Francesca

Fig. 10. Analysis of the correspondence of the major façade with the sizing in spans (green), feet (blue), and other modular scans of the architectural composition.

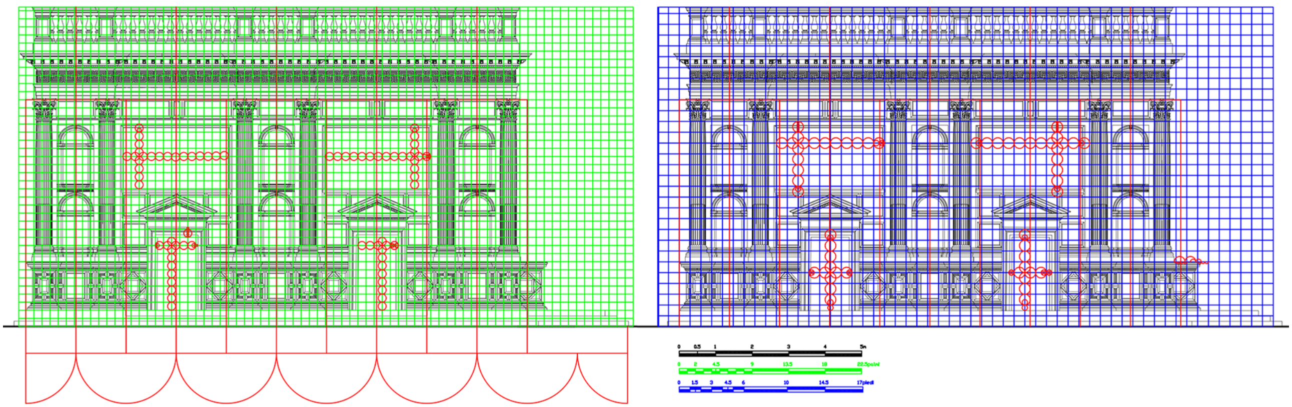
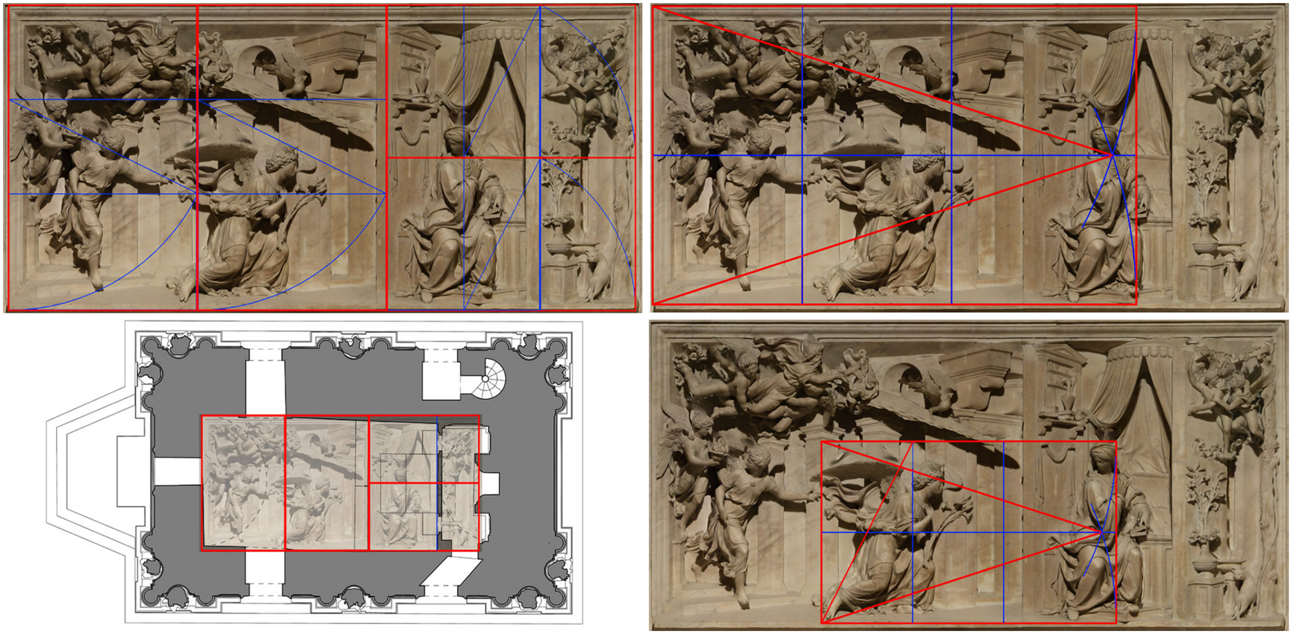


Fig. 11. The sculpted panel of the Annunciation: regulating traces in golden proportions of the frames of the scene, relationships of golden triangles between the characters, ratios between the low-relief dimensions and the interior space of the chapel.



and *De Pictura* and *De Statua* by Alberti had already been published. The analysis of the panel of the Annunciation seems to confirm not only the artist's knowledge of these writings, but also how much he succeeded in achieving that connection between the characters and the scenic spaces of the representation by applying underlying golden ratios and the dictates of perspective. These compositional expedients, although analysed for a specific panel, can be found in the planning of all sculptural panels that embellish the construction.

Notes

[1] According to ancient tradition, the interior of the Holy House constitutes the terrestrial home of the Virgin Mary, situated before a cave that is still venerated in the Basilica of the Annunciation in Nazareth.

[2] To cite a few: Niccolò Pericoli detto il Tribolo, Baccio Bandinelli, Raffaello da Montelupo, Girolamo Lombardo, Francesco di Vincenzo da Sangallo, Domenico Aimo. Then for the statues (sibyls and prophets), the brothers Giovan Battista and Tommaso della Porta and Aurelio and Girolamo Lombardi.

[3] ASSC Loreto, Depositario 4, 1516-1520, c.137 and c.174.

[4] Stored at the Albertina Graphische Sammlung in Vienna.

[5] GDSU 6770A. Frommel 1994, p. 609. Sheet 295.

[6] GDSU 1744A and 1746A: <https://euploos.uffizi.it/inventario-euploos.php> (accessed Octobre 10, 2020).

[7] The difference between the lengths of the opposite sides is of the order of 0.004 m (major elevations) and 0.007 m (minor elevations).

[8] This alludes to the funeral monuments that Sansovino created for Cardinal Manzi (Basilica of Santa Maria in Ara Celi) and for the cardinals Ascanio Sforza and Girolamo Basso Della Rovere (Church of Santa Maria del Popolo).

[9] For the span (great span), reference is made to the *palmus major* or *Dodrans* (¾ of a foot) which corresponded to the distance between the tip of the thumb and the tip of the little finger holding the fingers apart; a span was divided into 60 minutes.

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Drawings and Measures for the Knowledge and the Representation in the Eighteenth Century of the 'Isla Plana' (Alicante, Spain)

Andrés Martínez-Medina, Andrea Pirinu

Abstract

The historical cartography is an important documentary source for the knowledge of the places. An analysis of the representations of a territory in the medium and long term makes it possible to recognize its forms and its identity characters, understand the dynamics of transformation and preserve the memory of landscapes and architecture now definitively lost.
The study of the maps can lead to interesting results and offer a methodological contribution to the research if supported by a mastery of systems and tools for survey and drawing of the architecture and the territory. The use of the compass and astronomical measurements in support of a network of instrumental stations starting from the thirteenth century guide the territorial reconnaissance and the survey of the architectures. These procedures, widely tested during the sixteenth century, in the eighteenth century can rely on more precise equipment and are subject of a process of standardization of the methods of acquisition and graphic representation.
The eighteenth century's drawings made by military engineers for the description of the stretch of Spanish coast between Santa Pola and Alicante and for the project for a new fortified settlement in the 'Isla Plana' offer the opportunity to apply a research path focused on the analysis of the maps scientifically repeatable in other contexts.

Keywords: drawing and survey, historical maps, military engineers, Nueva Tabarca.

Surveying and drawing the territoty

Survey and representation of the territory have ancient origins and –over the centuries– are characterized by a constant improvement of methods and tools. In Europe since the thirteenth century (fig. 1) the introduction of the compass for the construction of nautical charts [Valerio 2012, p. 219] [1] starts a process of refinement whose results are evident in the quality of the Aragonese cartography of the Kingdom of Naples, from whose examination "it is evident the use of the compass in the survey operations or, at least, in the general orientation of the maps. What Leon Battista Alberti had proposed for the survey of Rome was applied by the Aragonese scientists to the topographic survey of an entire Kingdom" [Valerio 1993, p. 299] (fig. 2). This method, set to a polar coordinate system, at the beginning of the 16th century, is widely tested and in use in all of the main survey operations and urban planning [2].
In the sixteenth century the drawing acquires a great importance and the figure of the military engineer is able –through the direct knowledge of the places– to carry out an effective fortification work only after have visited the place and measured and evaluated through scientific methods the attitude of the territory to be modified and transformed.
The measuring instruments, based on the triangulation, will reach high precision in this era and will bring together in one the functions previously performed by several instruments.

The possibilities of measurement are collected by Cristóbal de Rojas in his fortification treatise edited in the 1598 [3] (fig. 3); the Spanish engineer, to overcome the difficulties in the use of the triangulation [4] and the square, suggests the instrument used by Tiburcio Spannocchi [5]. The training of military engineers, mainly entrusted in the battlefields experience, during the Kingdom of Philip II of Spain, with the establishment in the 1583 of the Academia de Matemáticas in Madrid direct by the royal architect Juan de Herrera, could rely on the scholastic teaching of the art of fortification.
Under the aspect of representation, between the sixteenth and seventeenth centuries there is a gradual abandonment of the physical model [6], accompanied by the plan and the profile, which leads to a progressive standardization, with the use of graphic codes and geometric scales until then not always present. It will be France, starting from 1670 [Muñoz 2016, p. 35], to first establish a regulation, soon adopted in the production of maps and published in the treaties [7]; this initiative is linked to the need to define a unique language that could be understood by all and avoid misunderstandings and delays in the approval of projects [Gómez, López 2016, p. 40].
In Spain, as a consequence of the creation of the '*Cuerpo de Ingenieros del Estado*' in the 1711, the spread of this system was entrusted to military treaties [8] and institutions as specified by the *Real Ordenanza and Instrucción de 22 July 1739* for the teaching of mathematics at the *Academia of Barcelona* about to clearly draw with the use of colors and the use of the necessary graphics models [9].

This 'revolution' took place at the beginning of the eighteenth century, during the Kingdom of Philip V [10], when the restructuring of the training courses and the reorganization of the corps of engineers entrusted to Jorge Próspero Verboom (1665-1744) began. Another aspect that characterizes the XVIII century is the greater accuracy present in the drawings. In the eighteenth century there was a need for a precise identification of the territory and of the natural and anthropic elements that characterize it, as well as the urgency of greater precision; all of this with regard to the planimetric description, because the orography is still a difficult problem to solve from the point of view of survey and in terms of representation [11].
The diversity of graphic scales, the complexity of the projects and the growing dependence on geometric models, determine a generalized use of the pantometer (or proportional compass), which will be gradually abandoned and replaced by the graduated semicircle.
The instrumental equipment generally included praetorian tablets [12], used for surveying in small areas, levels of various shapes, quadrants or quarter circle for medium-sized measurements, graphometers. However, commonly used instruments equipped with compass, circle and alidade still gave errors of more than two degrees in the measurements, and only later, with the introduction of precision turning and threading, was possible to improve the performance of them [13].
In the *Real Ordenanza and Instrucción* of July 22, 1739 the instruments that must be present in the Academy are listed and among these the semicircle and the dial

Fig. 1. The so-called 'Carta Pisana' of the thirteenth century, Bibliothéque Nationale de France: <https://catalogue.bnf.fr/ark:/12148/cb406673515> (accessed 2020, June 20).

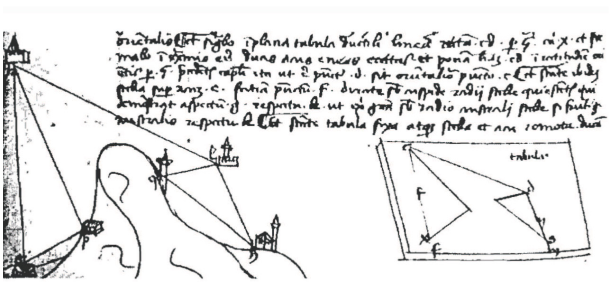


Fig. 2. Stations employed for survey operation as illustrated in the handbook 'De Trigono Balistario' f. 68v di G. Fontana [Battisti, Saccaro Battisti 1984, p. 17].

with glasses, levels, pantometer and compasses. Finally, in the work of the Zaragoza architect Antonio Plo y Camín, entitled *El Arquitecto práctico civil, militar y agrimensor*, published in Madrid in the 1767, the tools used in the 18th century are described, mainly the compass and the ruler for drawing, the graduated semicircle and square for drawing lines on the ground, and finally, the pantometer and level, of which, as more elaborate instruments, a detailed description of their manufacture and use is included.
The use of these tools and methods is clearly adopted in the procedures adopted in the eighteenth century for the description of the Spanish territory, as reveals an examination of the drawings made by military engineers for the description of the coast between Santa Pola and Alicante. In fact, the graphic analysis of the documents allows the recognition of the points chosen to structure the geodetic survey network, of the units of measurement and of the graphic codes necessary to represent the surveys, according to the required detail. The maps produced in the period 1721-1789 allow the collection and reconstruction of a considerable amount of historical and geomorphological data; their comparison with the current aerial photogrammetric surveys highlights an interesting quality of the techniques adopted which favors the application of a methodological path of analysis aimed of validating its repeatability in the scientific field.

The graphic analysis of the '*Isla Plana*' drawings: towards a method proposal

The Isla Plana, located not far from the city of Santa Pola near Alicante, is included in the 70s of the eighteenth century as part of a reconnaissance activity aimed at the defense of the coasts and at the foundation of a new fortified settlement called 'Nueva Tabarca' [Pérez 2017].
The engineer Méndez de Ras (or Rao), in charge of the design of the new works, made a survey in 1766 [Capel et al. 1983] for the construction of a '*torre fuerte*' and in the following years (1769-1779) executes several drawings that can be classified in four main themes: the geographical description of the territory, the urban project, the architectural project and the final state of the works carried out [Martínez-Medina, Pirinu, Banyuls I Pérez 2017].
However, a first representation, which goes beyond the simple geographical localization, is present in the '*Mapa*

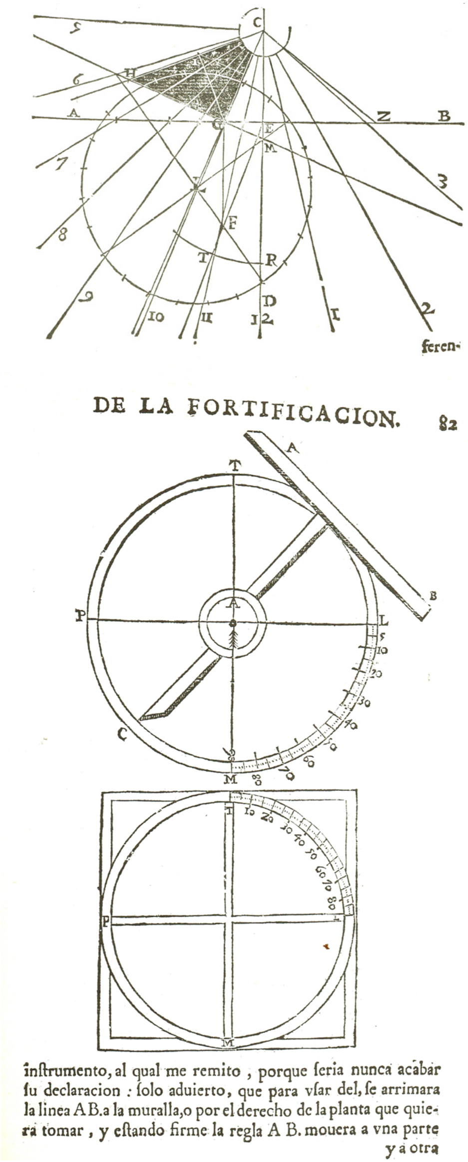


Fig. 3. Instruments and methods for survey operations [de Rojas 1598, p. 189, 198].

de la costa de la provincia de Alicante, desde el Cabo de Santa Pola hasta la playa de San Juan' dated 1721 (which has two versions: an initial made with ink and pencil and another final made with ink and watercolor [14]); it is a territorial survey that we will take as the starting point of our study. For the wealth of references to the procedures adopted in its construction, the map is an interesting document that exceeds a mere description of the 'form' of the Isla Plana.
The study of these two maps is structured on several levels. An initial identification of the graphic rules (orientation, metric scale, graphic codes) is followed by an accurate survey of the axes that connect the representative points indicated in the 'preparatory' version. This step, essential for an in-depth knowledge, is carried out by retracing and vectorizing [15] the document line by line with the aim of facilitating the recognition of the instrumental survey network and of allowing the rediscovery of the graphic passages lost in the transcription of the map on the canvas.
The 'final' version repeats the first drawing with some differences in the positioning of place names, of the compass and in the directions that depart from it and with the addition of the metric scale in tuesas, useful reference for the comparison of the map with the current cartographic databases.
The graphic analysis is therefore conducted on the 'preparatory' drawing taking into account the information offered by both drawings (fig. 4). A first important reference on the map is the use of the compass centered in the bastion of San Carlo [16] and of an instrumental base (alignment xx parallel to the east-west axis) created starting from the walled line and the pier of Alicante (fig. 5a). The apex of the bastion facing the sea is the place in which to hinge the oriented axes system that reaches some characteristic points of the coast, such as towers and promontories (listed on the edge of the map [17]) and allows the survey of a stretch of coast of about 25 km between the mouth of the Montnegre river in the north and the fort of Santa Pola in the south.
A second system of axes (the only indicated in the final drawing) is positioned in the sea three kilometres away far from the port of Alicante (pos. A) and rotated according to an angle of 16 degrees if compared to the first system; from it, according to precise angles, start the lines that reach some points further 'targeted' by the first 'origin', connected to each other and to the coastal towers (fig. 5b).
Additional graphical constructions complete the construction of the map. These are axes orthogonal to the lines that connect the stations to each other or alignments created to thicken the survey grid; they allow the survey of some elements that characterize the territory and their location on the latest digital maps (fig. 6) among which, from the south to the north starting from the 'Castillo de Santa Pola': the '*torre de las Caletas*', the '*torre del Cabo Jub*' (also called *Atalaiola* or *Atalayola*, the actual lighthouse), the '*torre del Carabasy*' (disappeared in the first half of the nineteenth century), the 'Torre del Agua Amarga' and, after Alicante, the '*torre del Cabo de Levante*' (also called the 'Cabo de las Huertas', the actual lighthouse). An extension of the oriented system, necessary to reach Santa Pola, is structured close to the '*Isla Plana*' where the ship probably stationed in positions B, C and D (fig. 7) for instrumental surveys and measurements of the seabed. The study of this sector arouses particular interest because reveals the points located on the island, such as the '*Cabo Falcon*', '*la Nave de la Isla*' and '*la Guarda*' [18], which we also will find in subsequent representations.
Some alignments are clearly showed on the map, others can be 'reconstructed'; a line crosses the *Cabo Falcon* and the *Nave de la Isla*, point on the '*Isla Plana*', but if we extend this line we observe that it perfectly crosses the *torre del Carabasy*, a place from which it possible that a measurement was made from in the direction of the island.
The next document examined is the drawing called '*Planos de la Ysla Plana y Cabo de S.ta Pola*' [19] (fig. 8). This map, oriented, with a metric scale and legend and dated 1766, signed by the engineer Méndez de Ras, describes the geographical characteristics of the island, of the cape of Santa Pola and the strait between them. The map describe the depth of the seabed [20], the presence of obstacles to navigation [21], identifies the landings, the morphological characteristics [22] and the coastal towers system [23]. The object of the reconnaissance is the realization of a strengthening of the coastal defense [24] with the construction of a tower on the highest point of the island; a solution replaced a few years later entrusting the defense to the crossfire of a battery on the '*Cabo di S. Pola*' and another one on the 'Punta de Tierra', western offshoot of the Isla Plana describe in the plan designed by the same technician in the 1774.
The information acquired is shown through the integration of the plan view with the north profile; this document describes the hill identified with the letter 'A' and

Fig. 4. Top: digitalization and graphic synthesis of the two maps (analysis and representation by Andrea Pirinu and Andrés Martínez-Medina). Bottom: the two versions of the 1721's map (ACEGCGE).

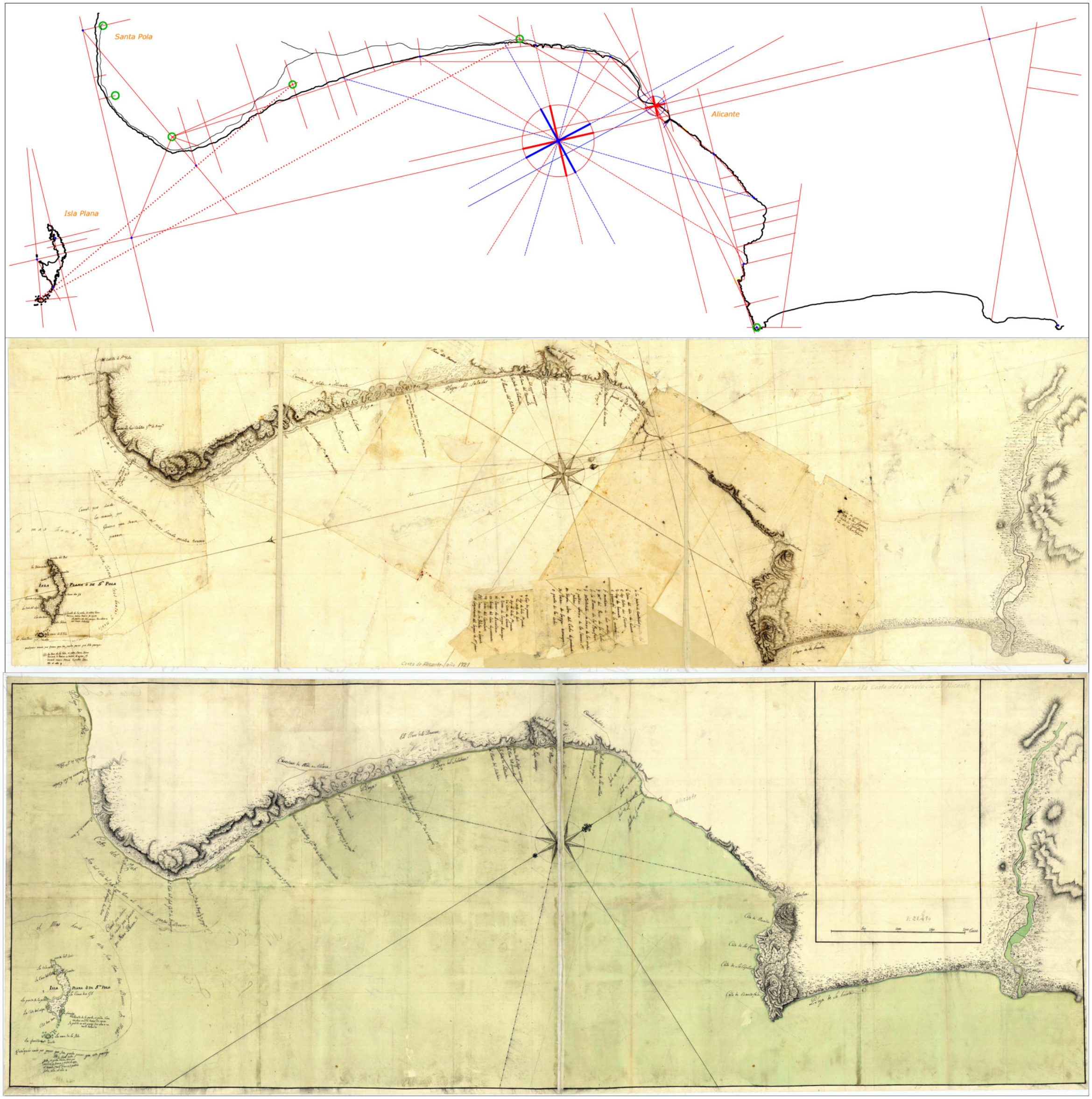


Fig. 5. Digital restitution of the 1721's map that highlights the construction of the survey grid that starts from the pier (Z) and the San Carlo bastion (Y) designed by Giovanni Battista Antonelli [Gonzales 2012] (graphic elaboration by Andrea Pirinu).

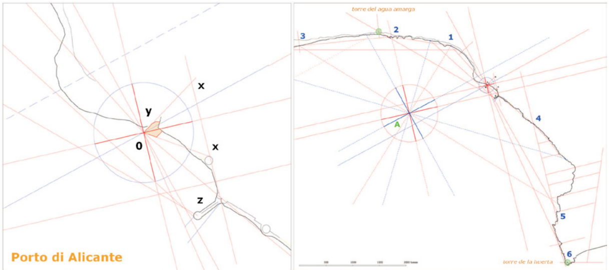


Fig. 6. Overlay mapping between the 1721's map and the DTM produced by the Institut Cartogràfic Valencià, Generalitat Valenciana: <https://visor.gva.es/visor/ (accessed 2020, May 20) (graphic elaboration by Andrea Pirinu).

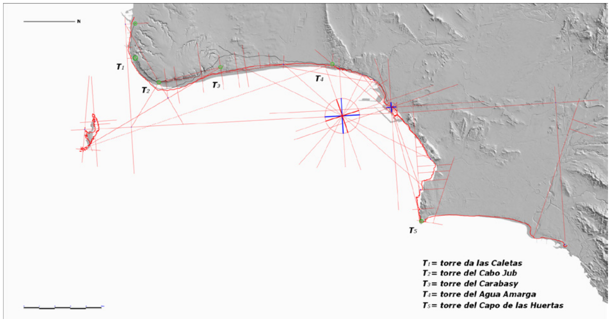
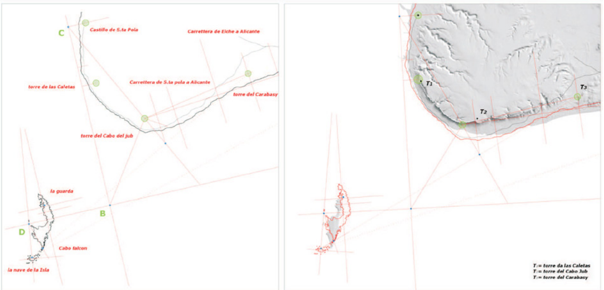


Fig. 7. Graphic elaboration and graphic overlay between the 1721's map and the 2009 DTM (graphic elaboration by Andrea Pirinu).



called 'la Guardia' (useful for '*los moros*' as a 'sentinel'), with the letter 'AA' the site in which to place the '*Torre Fuerte*' and some coves (BC and DD) including the '*Cala grande en la Isla Plana donde se refugian las Gal Galeotas de los Moros*' [25].
This drawing, supported by a metric scale in Castilian varas [26], French miles and tuesas [27], if compared with the latest digital maps (fig. 9), highlights a lack of correct restitution of the island dimensions and of the distance between the island and the cape of Santa Pola; the map also shown an 'artistic' drawing of the coastline used to complete the representation of a perimeter [28] of which the engineer have only a few points geographically located or perhaps aimed at emphasizing –with the description of numerous coves in which pirates find refuge– the need for a defense project. The drawing does not seem to take into account the excellent survey of 1721 and shows a use of graphic techniques linked to the sixteenth-seventeenth-century tradition, as the legend itself refers to with the term "Elevacion de los Planos de la Ysla y Cabo de Santa Pola en perspectiva â la Cavaliera, vistos desde Alicante". The territorial context appears compressed perhaps in an attempt to include in the map all the elements deemed useful [29], as in the case of the Castillo di Santa Pola, placed on the edge of the drawing.
The survey carried out in the 1766 precedes the design of the Nueva Tabarca settlement represented in the '*Plano de le Ysla Plana de San Pablo*' [30] (fig. 10) dated 1770, which focuses its attention on the island, leaving only a reference of the cape of Santa Pola in the margin of the map; it is the first drawing of the citadel inserted in its environmental context, the result of three years of work (1766-1769) necessary to elaborate the fortification project. The shape of the city walls is clearly identified together with the lantern and the additional works useful for the exploitation of the fields envisaged in the sector not built. In this new map no place names are present; the table is a rigorously technical project, oriented, provided with a metric scale and compatible with a recent aerial photogrammetric survey, because now it is necessary to record the true geography in order to design a small town and start the works. The method of graphic representation adopted is also different from previous documents: while the two maps of 1721 are drawn in a very technical and accurate way (with precision of shape and measurements) and the map of 1766 shows many islets and coves with their own place names and 'realistic' re-

presentation by means of watercolor, the latter drawing combines both characteristics (accurate representation of the shape, size of the island and realistic aspects such as the turquoise sea) adding the 'new' normalized codes for the building characterization, as the yellow for the new and red for the existing one, adopted in the following drawings of the citadel.
Another drawing examined is dated 1774 and also elaborated by Méndez (fig. 11). The size of the island and its distance from the coast are compatible with the actual digital maps. However, the description of the 'correct' form takes a step back from the 1770 map, probably because the only objective is to show the precise placement of the citadel design, well described in subsequent drawings produced between 1771 and 1779 [Martínez-Medina, Pirinu, Banyuls i Pérez et al. 2017], and the position of the military works located in *Punta de Tierra and Cabo di Santa Pola*, as suggested by the greater precision in the representation of the coastline that characterizes the project area.
The list of maps examined is completed with the last survey of the island performed at the end of the fortification works. This map (fig. 12) is realized by Antonio Ladrón de Guevara; the engineer in 1789 define an inventory of the defenses and of the buildings built in the citadel and proposed the construction of two towers. Now, the aspect on which we focus is the survey of the island's perimeter for which the technician does not perform a new

Fig. 8. 'Planos de la Ysla Plana y Cabo de S.ta Pola', 1766, Fernando Méndez de Rao (ACEGCGE: Ar.G-T.3-C.3-347).

measurement, but rather uses the 1770's data, however without reproducing them with the same precision, nor with the same graphic quality. This last drawing, poor in information and represented with a very simple graphic codes, reflects the fate of the island and its abandonment and will not contribute to its correct description that we observe at the end of the 18th century in the book *Atlante marítimo de Spagna* [Tofiño de San Miguel, Salvador Carmona, Mengs 1789].

Conclusions: historical maps for the knowledge and 'memory' of the territory

The examination of the documents highlighted the correct application of the procedures in use in the eighteenth century for the survey and representation of the territory, but also the use of graphic techniques linked to the sixteenth-seventeenth century tradition. The analysis of the maps produced in the period 1721-1789 for the description of the stretch of Spanish coast between Alicante and Santa Pola made it possible to verify the use of a geodetic network set on points, clearly visible even from a great distance, which could play the role of sights or instrumental stations [Valenti, Romor 2019].
The recognition of the methods adopted for the construction of the maps and the identification of the points "for which a correct graphic recording is conceivable" [Valerio 1993, p. 295] made it possible to apply a methodological path repeatable in the scientific field to other contexts. A gradual process of defining the forms of the coastline was observed: a first step with the design of a network of strong points on a territorial scale (1721), a second with the collection of geographical information of the island (1766) and a third with the survey aimed to design the fortified citadel (1770); each of these 'steps' was characterized by a graphic result functional to the survey scale: first step, a linear and monochromatic drawing, second step a colored perspective view and finally a detailed plan view that shows the graphic codes established for a military use. The other drawings (1774 and 1789) did not participate in the construction of a new knowledge of the territory.
A comparison between historical maps and aerial photogrammetric surveys has also made possible to analyze the forms of the territory and its own characters and to preserve the memory of landscapes and architectu-

res now definitively lost, such as agricultural crops, small hydraulic infrastructures and some costal towers. The quality and the precision of the work of the engineers has been verified and a landscape, rapidly transformed over the last three centuries, has been 'rediscovered'. In conclusion, the old maps, built with care and scientific precision, are, in a certain way, the memory of places and, for this reason, the illustrated method becomes a useful tool for their knowledge, protection and conservation.

Notes

[1] "These are maps whose purpose is the recognition of the coast and the possibility of navigating according to a predetermined route in the Mediterranean sea: in these graphic documents the shape and the course of the coasts are described, the place names are indicated through writings placed orthogonally to the coastline, rotating the map for their reading, while a dense network of lines was used for tracing the routes and for determining the ship's position. In short, we are faced with a real work tool": Valerio 2012, p. 219.

[2] "In 1529, on the occasion of the war and the siege of Florence by Pope Clement VII, the pontiff ordered, for strategic purposes, the survey of the city (and the elements that compose it) and of the surrounding area. The tool used to implant a grid, structured on physical elements such as towers, bell towers, peaks and stations, is a compass, which allows a precisely control of the distances between the key points": Guidoni, Marino 1983, p. 196.

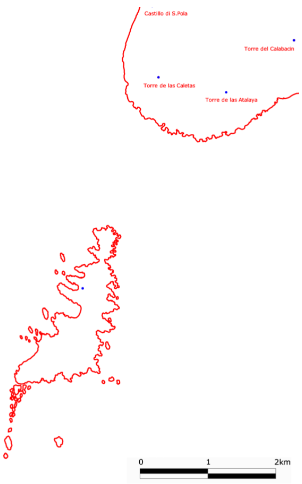
[3] *Teorica y Practica de fortificacion*, a compendium of the teachings of Cristóbal de Rojas at the Academia de Matemáticas de Madrid founded by Juan de Herrera (1530-1597).

[4] In terms of survey methodologies, a fundamental step occurred in Europe thanks to the contribution of W. Snellius who, between 1615 and 1622, carried out the first triangulation in order to determine the length of a meridian arc between Alkmaar and Bergen in Holland, at the mouth of the Schelda river.

[5] "Un ingenioso instrumento consistente en una regla en T de latón con brújula, que permitía medir ángulos y establecer la orientación de los paramentos": Muñoz 2016, p. 18.

[6] "*Las maquetas continuaron existiendo, pero más por interés didáctico o para expresión del poder real, que como instrumento de elaboración y transmisión del proyecto*": Muñoz 2016, p. 35.

Fig. 9. Comparison between the map of 1766 and the map of 1721 both digitized and integrated with the DTM (graphic elaboration by Andrea Pirinu).



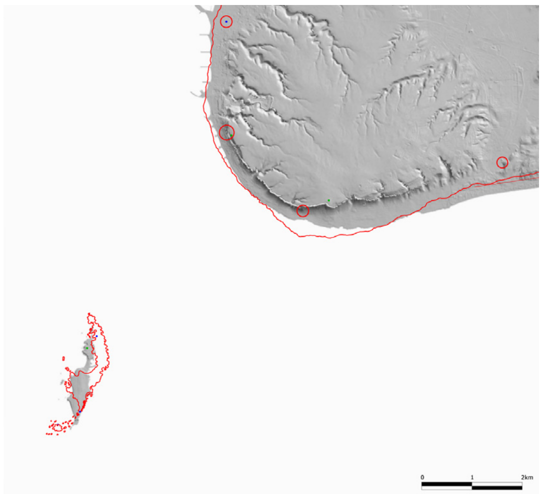


Fig. 10. Comparison between a recent aerophotogrammetric survey of the island and the 1770's map called 'Plano de la Ysla Plana de San Pablo', 1770, attributed to Fernando Méndez (AHM: SH, A-03-02, Madrid).

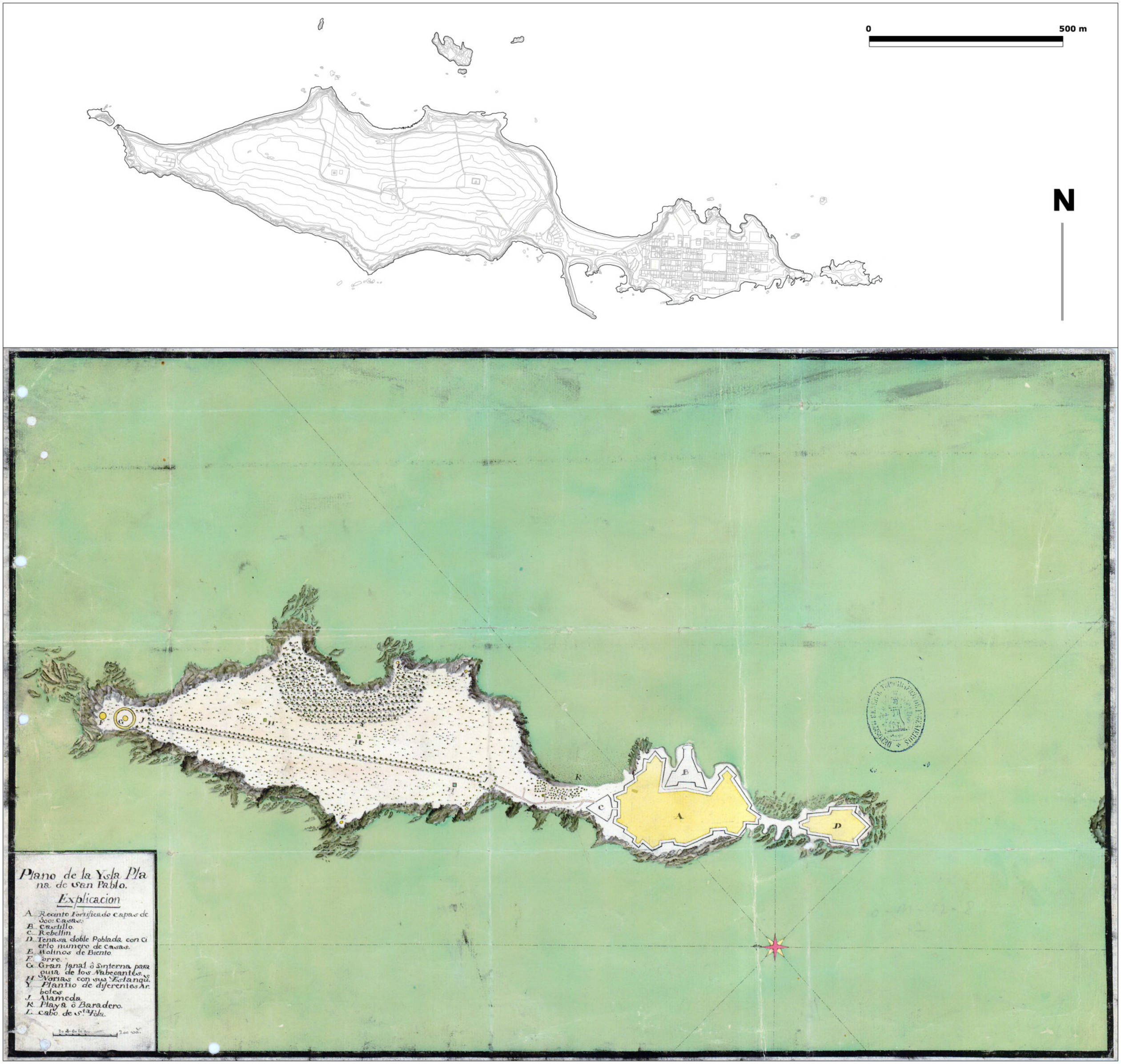
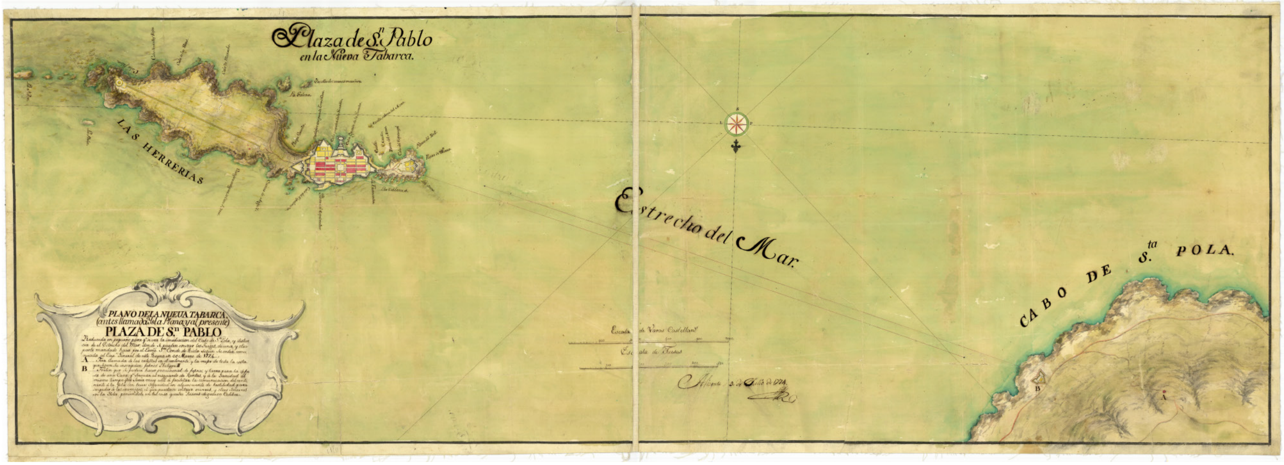
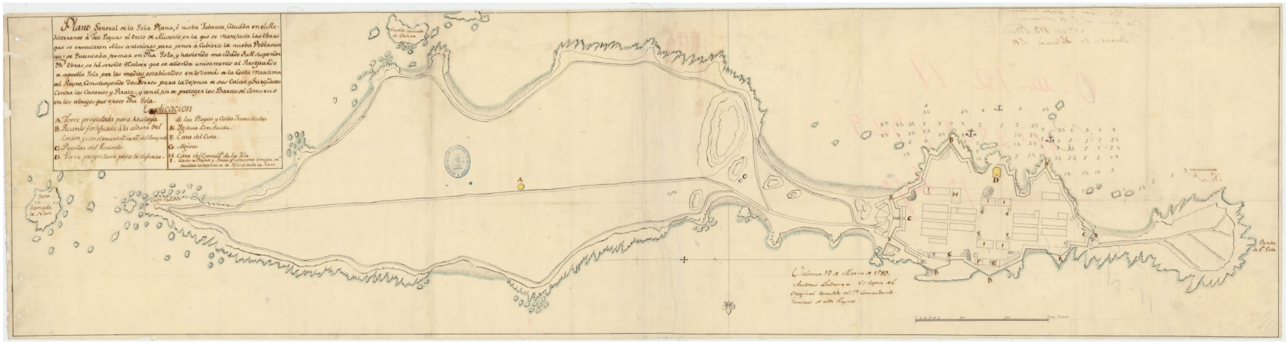


Fig. 11. 'Plano de la Nueva Tabarca (…) para qe. se vea la inmediación del Cabo de Sa. Pola (…), donde se pueden cruzar los Fuegos (…)', 1774, F. Méndez (ACEGCGE: Ar. G-T.3-C.4-350).

Fig. 12. 'Plano General de la Ysla Plana, ó Nueba Tabarca (…)', 1789, Antonio Ladrón (AHM: SH, A-03-04, Madrid).





[7] Among these: *L'Art de dessiner proprement les Plans, Profils, Elevations Geometrales & Perspectives, soit d'Architecture Militaire ou Civile* published by Henri Gautier in 1697 in Paris.

[8] Among these, in the Spanish area, the Tratado de Castrametación o Arte de Campar (1801) di Vicente Ferraz, a text that specifies the colors to be used for military architecture and follows the treaties of Alférez Medrano, who was director of the Royal and Military Academy of Brussels and wrote several texts for the training of military engineers, as: *El Ingeniero, primera parte* e *El Ingeniero, segunda parte que trata de la geometría práctica, trigonometría y uso de las reglas de proporción*, Bruselas 1687 and *El Architecto Perfecto en el Arte Militar. Dividido en cinco libros*, Bruselas 1700.

[9] "Se enseñará el modo de delinear con limpieza, y de aplicar los colores, según práctica, para la demostración de sus partes, su distribución y decoración, con los adornos pertenecientes a todos los Edificios Militares, haciendo a este fin sus respectivos Planos, Perfiles y Elevaciones": Muñoz 2016, p. 36.

[10] King of Spain during the period 1700-1746.

[11] Only at the end of the century this problem will be faced with conviction and instrumental possibilities, through the use of portable barometers to measure heights and the use of new graphic symbols for cartographic representation: Docci, Maestri 1993.

[12] In his *Istruzioni pratiche per l'ingegnero* published in the 1748, G. Antonio Alberti, proposed some innovations for measuring angles, making the Praetorian tablet an instrument capable of measuring distances in a indirectly way, reducing the need for a second station point: Dotto 2010, pp. 117, 118.

[13] At the same time, the research on a better use of the instruments goes on, thanks to Tobias Meyer, to whom we owe the idea of the method of repetition of the angles, which consists in measuring an angle in different sectors of the graduated circle, in order to reduce errors due to manufacturing defects of the appliance, a method perfected by the French J.C. Borda (1733-99), with the construction of the repeating circle (1775), for azimuth measurements: Docci, Maestri 1983.

[14] In the *Archivo Cartográfico de Estudios Geográficos del Centro Geográfico del Ejército* (ACEGCGE) are cataloged the preparatory drawing called 'Mapa de la costa de la provincia de Alicante, desde el Cabo de Santa Pola hasta playa de San Juan': Ar.G-T.3-C.3-314 and the final version called: "Mapa de la Costa de la provincia de Alicante: Ar.G-T.3-C.3-315.

[15] The digitization of the maps is necessary to carry out subsequent comparisons.

[16] Demolished in the second half of the nineteenth century.

[17] Among these, indicated with the n.16, the 'Campanario del lugar di S.Juan', traceable to the tower of the 'Monasterio de la Santa Faz' and located in the north of the urban center of Alicante.

[18] Further alignments, such as the one that crosses 'la Guarda' (so called in the 1721 and renamed 'La Guardia' in the 1766), are parallel to the compass axes.

[19] *Archivo Cartográfico de Estudios Geográficos del Centro Geográfico del Ejército* (ACEGCGE): Ar. G-T.3-C.4-347. In addition to this work, there are further drawings also dated August 15, 1766: one of the Cala Grande and an another relating to the project of a 'Torre Fuerte'.

[20] Through a grid measured in arms (braza in Spanish) equal to 1.6718 m.

[21] Among these it is reported an "Escollo" (an obstacle to navigation) called "la Losa".

[22] To describe the shape of the Cape of Santa Pola all the ravines (Barrancos in Spanish) that characterize the sea side are represented.

[23] Among which the Calabacin tower, consisting of two connected buildings.

[24] In addition to the use of the island as a hospital, as the report accompanying the map specifies.

[25] Well described in a view attached to the map.

[26] The *varas* are part of the ancient anthropomorphic system adopted in Spain until the metric system introducted by law in 19 July 1849. The *Gaceta de Madrid* on December 28, 1852 publishes the equivalences between the ancient measures in use in the individual regions and the new system. The size of the *varas* differs within the Crown of Aragon itself until that date and the Valencian *varas* in particular consists of 91 cm, the Aragonese one of 77.7 cm and the Castilian one is 83 cm.

[27] One *tuesa* is equivalent to 1.949 meters: Carrillo 2005.

[28] As observed during the re-drawing of the map.

[29] Numerous examples are known in the history of the representation of architecture such as the table of 24.9x34.3 cm engraved by Matthäus Greuter in the 1623 which reproduces the square of St. Peter in Rome and reports: "this urban space was made into a square for the smallness of the copper that can be done with a length of 30 Arcs at least for each part".

[30] "Plano de la Ysla Plana de San Pablo", 1770, assigned to F. Méndez, Archivo Histórico Militar (Madrid): SH, A-03-02.

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For defining a reason between thought and project

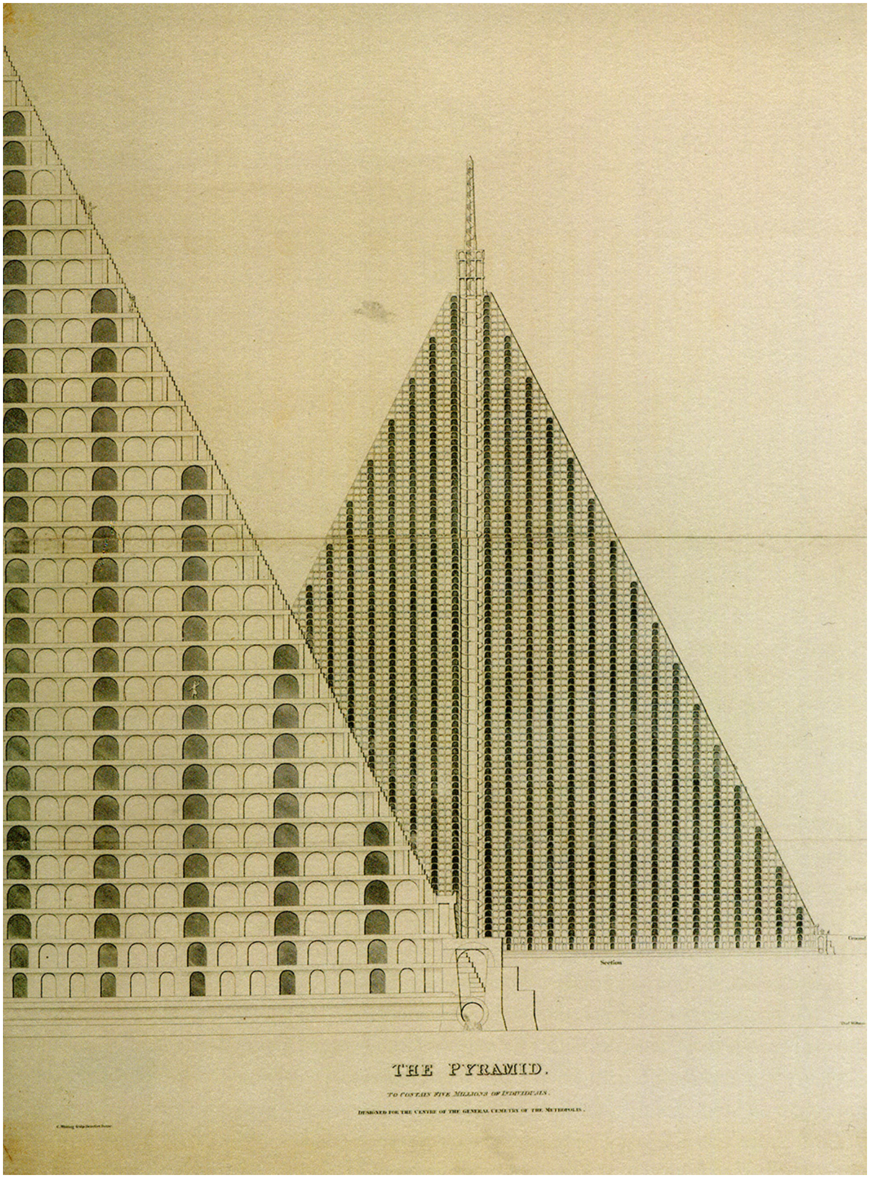
Drawing and Measuring to Define a Reason between Thought and Project

Riccardo Florio

Treating the genetic relationship between Drawing and measurement, without wanting to commit the references, albeit rich in meaning, that bring us back to Phidias and Polycletus and their preference for mathematical rules and geometric order as the necessary basis for any artistic expression, or to the Plato himself and his obvious impossibility of separating the doctrine of numbers, measure and balance from the arts, up to the conception of Saint Augustine which takes up the maximum Solomonic "*Ordo, pondo et mensura*" in his conception of God, origin of the beauty that contains in itself number, measure and harmony [cf. Ungers 1994, pp. 307-318], and to all the developments that have originated from these assumptions inherent in harmonic-proportional theories, it means investigating a subtle condition of balance, a horizon that moves towards the territories of knowledge and explains the principles that aim to permute the design in the dimension of the restitutive and planning double prefiguration.
"The theme of architectural representation consists of a set of concepts that [...] correspond to the Greek concepts of *μίμησις* [mimesis], *μέτρησις* [métrēsis], and *ποίησις* [poiesis]. In a very schematic way: imitation as an analogical and perceptual correspondence between reality

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. T. Willson, *Pyramid cemetery*, 1831 ca. [Wilkinson 2018, p. 83].

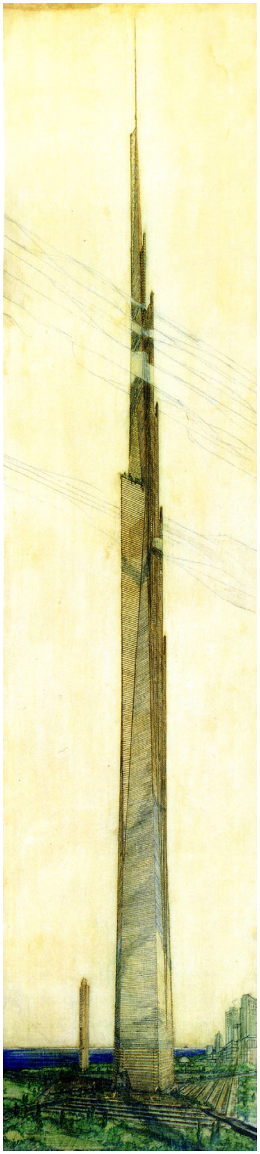


and its representation; the measure as a ratio and comparability; the poetic activity in the sense of production and design. And all this is organized and directed towards the project as a form of knowledge" [Ugo 2008, p. 1].
The object of the imitation-representation requires the definition of a model and a technical-operating system; model that will not be reduced to mere selection of the fundamental elements as parts of the work, but it must contain, in order to meet the needs of theoresis and knowledge, components relatable to the generality, universality and complexity of the phenomena and for this historically and critically recognizable [cf. Ugo 1992]. The model must possess seemingly contradictory qualities, since on one side it has to make explicit the particularity and uniqueness of a work, on the other hand it has to refer to a high degree of generality. "Forms themselves does not contain transcendent meanings or a priori. They are released from their previously 'given' condition. The meaning is in the relationship; architecture is among the signs" [Eisenman 1987, p. 19] [1] .
The construction of models, in the broadest sense, is one of the key actions in processuality history and culture that man has been able to establish. One of the most significant stages has been to create a unit of measurement to be understood as a model to compare different elements one to the other. The first step is given by the ability to abstract, from any set, the quantitative elements, numbering and counting them; the next one is the possibility of comparing these quantities on the basis of a reference sample. Whatever the unit of reference chosen, measuring means considering reality only in its apparently passable aspects of an objective analysis. "The quantitative language with which science approaches a world stripped of its subjective qualities is a powerful tool for predicting, explaining and controlling phenomena. But in superimposing a world of numbers on the quality world of sensitive experience, a series of precautions must be used to respect the conditions that limit and regulate this overlap" [Popper 1972, pp. 361-363].
Therefore, the measure expresses a precautionary principle, a precautionary action that appears to circumscribe, at first, only the fields of the dichotomous quantity/quality relationship, committing, however, intrinsically and significantly, the aspects purely referable to the interpretative dimension of the world.
The theoretical object of the drawing is to be understood as "the analysis of the 'transfer' of a building from its material dimension to its 'representation' and viceversa" [Purini 1992, p. 53], taking all the opportunities for deepening the knowledge and reflection that this continuous oscillation produces; the design thus takes on the role of an intermediary to trace the measure of diversity: in this way, a tiring and fascinating work horizon is outlined, which leads towards understanding the gap between an architectural program and an 'architectural thing', be it only designed or even constructed. Work as a transformation process that establishes an active relationship between man and reality, between man and nature [cf. Florio 2012, pp. 19-40].
Drawing becomes a differential device that is modulated on the ability to trigger a dialogue that challenges the quality of difference as a measure of the mystery to be revealed within it, which to match in tension the quality of our action, if relevant action and participates in the dialogue that manages to establish.
It must also be taken into account that quality cannot be considered as an absolute, historicized datum, a sort of linguistic category. "In our sensitive present we find it in the verses of the unknown of the canticle of songs, of Dante, of Eliot, of Ada Merini, we find it in the graffiti of Addaura, in the mosaics of Santa Apollinare in Classe, in the cretto of Burri in Gibellina. Quality exists in every inhabited place, the poet reveals it and makes it known to sensitive men. Faced with his duties, the architect, if he is educated to do it, reveals it with architecture" [Culotta 2006, p. 32].
In fact, in this world, things "have no power to exist in spite of everything, are simply subtle forces that develop their implications on condition that they gathered from favorable circumstances. However, if this is true, the identity of the thing in itself, the kind of personal stability, resting in itself, the fullness and the positivity that we recognized already go beyond the experience, they are already an interpretation of the second experience" [Merleau-Ponty 2003, p. 178].
An in-depth reflection concerning the act of drawing reveals its foundation as a complex operation of transposition of the different realities designed to make visually present what doesn't materially exist [2], and significantly insists on the persistent transcriptive action with which the necessary hermeneuse of cognitive aspects in order to oversee the continuous steps between the pre-figured and its replacement.
The elaborative parable that presides over the sign rewriting process within the architectural design finds a fruitful

Fig. 2. E. Horter, Crysler skyscraper under construction, 1933 [Tagliasco 1993, p. 25].

field in the synaptic junction that is established between the figurative gestation of the expressive models of the form and the architecture itself.
If it is true that the design derives its value and its quality by the intrinsic critical moment potential of synthesis and, therefore, communication and explication of the proximity ideational, it is true that this role through originates from the strength of its membership in the whole process of building architecture in prefigurative terms. "The project is up to the architect as the character of a novel is up to the author: he constantly goes beyond it. It is necessary not to lose it. The design follows him. But the project is a character with many authors, and becomes intelligent only when he is hired like this, he is obsessive and impertinent otherwise. Drawing is desire of intelligence" [Siza Vieira 1995, p. 51].
Of course, drawing cannot be considered as the equivalent or replaceable to architecture: it aims to clarify its theoretical structure, allows careful reflection on the architecture of history and memory, but also expertly measures the levels of desire and invention. "The drawings, preserving the architectural thoughts intact, give the possibility to save much of what would otherwise be lost in the architectural consumerism […] Creativity is manifested in its purest form; the visions, not debased by compromises, unfold more freely […] Architectural drawings become […] as precise as convincing professions of cultural faith […] an intellectual contribution to architecture" [Magnago Lampugnani 1982, p. 6].
Much more frequently, in the context of the representative elaborations referable to architecture, one feels pervaded by the configurative energy released by the architect's ideational translation translated into a succession of representations in which cryptographic syntax and autograph signs run quickly to decree one of the possible final configurations, the one that has seen its genetic process deeply and positively conditioned, not only by the static, technological and economic choices, but also by the intrinsic qualities and the creative incisiveness of the processing procedures and their semantic value. "Whoever draws at the moment of the delineation of a form immediately realizes how many it excludes, and how more and more numerous are the forms that will not come to light in the process of his work. The practical and visible reflection of this process can be seen in the so-called 'repentances'" [Pierantoni 1999, p. 128]. 'Repentance' which implies in its ethical meaning the reversal of the desire to extract a good form from chaos, in the indecision between different forms. "In drawing you stop going around the image: you stop at one point. And you contemplate" [Pierantoni 1999, p. 128]. Fortunately, what remains are the furrows traced by the sequences of the story, its uncertainties and difficult convictions, the ideational storytelling, the cultural references, the construction of hierarchies and, finally, the decision made.
The representation wants to be read, therefore, in its gnoseological function with respect to the intellect [cf. Contessi 1985, pp. 143-180], which first builds an articulated series of diaphragms, slowly, and then causes their demolition by means of incisions full of meaning which, once the codes have been decrypted, codes of initiations belonging to a graphic hermetism that first hides and separates [3], push towards dispensing horizons of new territories for measuring imagination, cognitive interpretation and ideational prefiguration.
Drawing, in its quality of 'figurative writing', denounces its point of origin, identifies a direction, marks a trace that guides the author's subsequent intentions at every moment. These directions, each time reworked on the new proposals, define the general trend, and the limits imposed on them determine the extent and intensity of the will. "And the drawing, 'common casing at points of equal function' keeps the evolutionary track of this desire, which will receive an extension fixed in accordance with the origin, the path and the arrival of her own. The highlight of the highlights of the route will culminate in the expression, and will stress, by virtue of their position and importance, the intensity of thought" [Magnago Lampugnani 1982, p. 6].
Its essential peculiarity of 'through' cannot possibly be separated by the force of his presence in the whole process that is established both in the operation of investigation of the constructed reality, and in that relative to the figuration of an architecture and, therefore, in the long path of its configurative definition.
With drawing and through drawing we are driven into the double condition of measuring the mystery of the structure of things and being able to glimpse all the different projections.
The fruitful process that incorporates the existing connections between the results of exploratory and restorative investigations and the programs of the project hypotheses is densified, in the clear awareness that "there is no judgment of analysis that does not determine in the architect […] a mental propensity towards a certain

Fig. 3. F. Lloyd Wright, Mile High skyscraper, 1956 [Brooks Pfeiffer 2015, p. 82].



design hypothesis" [Quaroni 1997, p. 43], establishing the "subjective time of the 'analyst'" [Purini 1992, p. 60] which, assuming the equivalence between the action of measuring and the deployment of the concept of measurement itself, perimeters with its interpretative tension fertile multiplicity of fields of investigation and project intervention.
As a system of signs, of form and function together, aimed at defining an architectural form-configuration, in substance of another system of signs, it is to be understood, rather than as language, as metalanguage: "paradoxically, the only character who does not speak the architectural language directly is the architect himself, because he actually expresses himself only on paper in a metalanguage composed of signs that merely symbolize (and even very partially) the architectural facts without building architecture they themselves" [Maldonado 1974, p. 122] [4]. In this sense it refers to a transitory coding code which can therefore be continuously expanded and transformed throughout the process of defining thought [5].
In this regard and on the relationships between the process established by the drawing and the difficulty of its expressiveness, in the relationship established with the project, as a recognizable language as well as the literary and poetic one, what Vittorio Gregotti wrote is very interesting: "Drawing is not for us architects, an autonomous language: it is a question of taking measures, of fixing internal hierarchies of the site that is observed, of the desires it generates, of the tensions it induces; it is about learning to see the questions, to make them transparent and penetrable by the project. In the end it is a matter of seeking, by the means of writing of drawing, a series of resonances which progressively function as parts of a whole, which maintain the identity of the reasons for their origin, but at the same time organize themselves in sequences, paths, stops calculated, which align themselves for discrete differences towards a process of necessary diversity that is not ostentatious, a dense grammar of spaces and forms of the specific project and its use" [Gregotti 2014, p. 22].
The measure also and necessarily imposes multiple diversification 'scales' with which the relationship between man and the world, between the body of man and the nature-universe is continuously re-established. A series of 'restless' measurement operations that continually recalculates the relationships between the physical environment and the human body in the sense of the ideal body, which becomes a prolonged body thanks to the progressive intermediation with which our cultural experience provides us,

producing a different perception of the world to promote the architecture modification action. "It is a matter of measuring internal differences in the landscape, […] measuring the state of affection in visiting its parts, measuring places and their possibility of offering themselves to a strategy of change, measuring positions, distances, font sizes and compliance of the new elements to be introduced" [Gregotti 2000, pp. 118, 119].
An action that often in recent years has entrenched itself behind it and media experience, preventing us from going through the deep layers of our cognitive awareness and decreasing our listening and interrogation skills. All this in architecture is reflected also in the fields of measurement, as frequently happens in the appeal to exaggerate the effects 'out of scale': "the obsessive repetition of the language […] the new weird as unnecessary, to language as caricature […] the imagination conceived as a regression of the imagination (the Grand Canal in Venice in Las Vegas); to a language, that is, tousled by the wind of air conditioning rather than the Benjaminian wind of the angel of history. […] A long, tiring path of crossing awaits us, beyond which we can find the resistance of things and with them the possibility of measured movements" [Gregotti 2000, p. 120].
It becomes almost inevitable, in synthetically tracing the relationship between drawing and measurement as we have done so far, to mention the notion of order, trying to free it from the historical heritage of the Vitruvian genera [cf. Procaccini 2018, pp. 107-127] to re-read it in the current light of a deep system within the architecture in which *eurythmia* and *symmetry* converge, the latter in the sense of commisuration (*sun* = with and *metron* = measure) [cf. Florio 2018, pp. 237-293], well aware that in the idea of architectural order the one of measure, "of repetition, of succession, has always been established of rhythm, of 'composition'" [Quaroni 1997, p. 172].

As Gregotti states again [cf. Gregotti 1994], the word order is an old-fashioned word, it refers us to restoration and to an imposing level of rules that leads to submission to forms of rationality that appear simplified today. But the architecture has the unavoidable task of reading the order in its historical sense and to propose a new order assumptions against the reification of chaos around us, in the belief that "the order is […] as […] it concerns a project, the law of constitution of the thing, the selection and organization of the elements that constitute it, but also the new system of meanings that it proposes and through which it is possible to look, that is to order the world in a new way" [Gregotti 1994, pp. 52, 53].
The order is "a level of creative consciousness that forever becomes the highest level […]. The order supports integration. From what the space wants to be the unknown can be revealed to the architect. From the order he will derive the creative force and the power of self-criticism to give shape to this unknown. Beauty will evolve" [Kahn 1955, p. 59].
Sometimes some architectures are sufficient to return new and valid meaning to the whole which they belong, in the awareness of being an active part of a particular context in which an order must be reconstructed. This possibility often occurs by resorting to measured actions of design grafts that perform an action that we could define as a counterfire with which the margins of containment of the urban dissolution are drawn against which elements of regeneration are inserted: "this technique risky, it requires a wise effort typical of artisan knowledge, an absolute attention to detail, which allows it to stop the progress of the building, not for quantity but for quality. Preliminary to the counterfire of architecture is a scrupulous relief of the existing" [Sciascia 2014, p. 35], followed by an equally scrupulous restitution of the reality investigated, in a field in which the dialectic drawing/design becomes a necessary expression of hermeneutic experience.

Notes

[1] The concept of "proportional movement" described by Nicola Emery appears very interesting and pertinent to the essential meaning of the relationship between the parts [Emery 2007, pp. 209-214].

[2] We are talking about what Vittorio Ugo indicates as the "Mediated (deferred) Experience" [Ugo 1991, p. 57]..

[3] "Writing has served, often and for a long time, to mask what was entrusted to her: she did not join men at all, but separated them, opposing those who knew how to encrypt and decipher those who were unable to" [Barthes, Mauriés 1981, p. 606]. See also: Bolzoni 1995 pp. 87-134.

[4] "We proposed to consider drawing, so to speak of art and architecture created as artistic languages […] and architectural drawing as a metalanguage, that is, a language above and at the service of another language: the architecture in flesh and bones" [De Fusco 1968, p. 136].

[5] As regards the relationship between drawing and coding and classifying system, in the express meaning of a flexible, expandable and transformable relationship [cf. Baculo Giusti 1992].

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From Suffering to Hope. The Survey of Rubble as a Measure of Resilience

Paolo Belardi, Giovanna Ramaccini

Abstract

As in the Japanese art of kintsugi*, where fragments of broken ceramics are recomposed using the gold dust insert, in the installation* Canapa Nera*, presented by the Regione Umbria at* Milan Design Week 2018*, the preciousness of the material was substantiated by an alchemical mix of the hopes that vibrate in the fibres of the black hemp of the Valnerina with the memories that permeate the rubble of the diruti walls of Norcia following the seismic events that in 2016 upset Central Italy.* Canapa Nera *was a long two-faced wall, characterised on one side by a polyptych of eleven large canvases of hemp inspired by the plots and colours of the annual flowering of the Pian Grande and on the other side by a chaotic explosion of variegated rubble, the recovery of which entailed both operational and interpretative difficulties, because they were linked both to the extraction and to the identification of the most suitable survey techniques. As part of the study undertaken, the measurement and graphic restitution of the individual rubble was aimed at enhancing its identity value, celebrated through the recomposition of a fragmented whole, scattered among voids. Making measurable the poetic space that marks the gap between suffering and hope.*

Keywords: earthquake, resilience, identity, rubble, measure.

Rubble is the conscience of history

"The sight of the ruins makes us fleetingly sense the existence of a time that is not what the history manuals talk about or that the restorations try to bring back to life. It is a pure, undated time, absent from our world of images, simulacra and reconstructions, from our violent world whose rubble no longer has time to become ruins. A lost time that art sometimes succeeds in finding again." [Augé 2004, p. 8]

The seismic events that shook Central Italy in 2016 brought highlighted the concept of resilience, not just in terms of the ability of a building to withstand the shock wave caused by a telluric shock, but also in terms of the ability of a community to react to the psychological annihilation caused by a seismic event. As Paolo Crepet pointed out, after a seismic event "we worry, rightly or wrongly, about material aspects. Which is right, but there is a loss of identity that is not taken into account in the same way. […] That is the most difficult part to repair" [Scianca 2016]. What follows is the need to start again from "what remains" [Teti 2017], with a proactive attitude that somehow finds a symbolic incarnation in the Japanese art of *kintsugi* in which the fragments of broken ceramics are recomposed through the gold dust insert [Santini 2018]. Although *kintsugi* is an artistic practice rooted in a distant culture, both from a historical and geographical point of view, Italian architects (but also artists) have always been sensitive to the evocative power of ruins (and rubble),

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Fig. 1. Norcia (PG), the Basilica of San Benedetto after the earthquake of 30 October 2016.

demonstrating a marked propensity for the reuse of what remains through the innovative recomposition of broken unity: from Leon Battista Alberti to Donato Bramante, from Antonio da Sangallo il Giovane to Carlo Fontana. Until Piero Bottoni, who in 1946, taking advantage of the need to remove and dispose of the rubble produced by the bombing of Milan during the Second World War, launched the idea of erecting Monte Stella (better known as the *montagnetta di San Siro*) within the QT8 district, accumulating the most intimate wartime evidence and surrounding it with a panoramic road that still provides an unusual panoramic view of the city [Bottoni 1995].

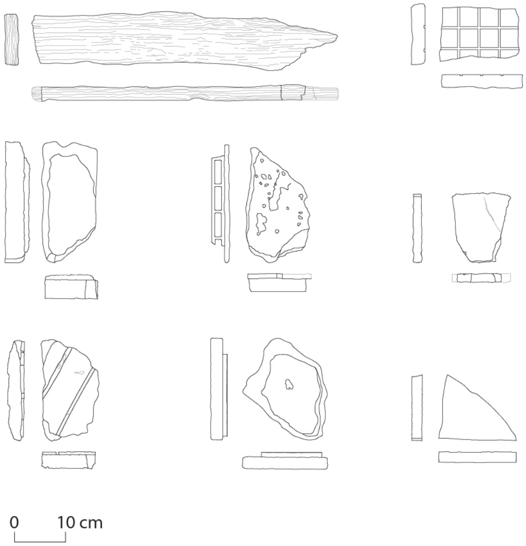
When it comes to the inventive reuse of rubble, Monte Stella represents an essential cornerstone, because Bottoni, transforming an icy environmental hygiene initiative into a pioneering work of land art, anticipated what happened more than twenty years later in Gibellina, when the most established artists of the time, accepting the provocative invitation of mayor Ludovico Corrao ("Let the flowers of art and culture grow in the desert of earthquake, fate, oblivion"), actively participated in the epic of post-seismic reconstruction: namely Nanda Vigo, who with her work *Tracce antropomorfe* (1978) reassembled in the heart of the Gibellina Nuova the finds

Fig. 2. Left, Souvenir from Shanghai (Ai Weiwei 2012), detail (photo Paul Lloyd). Right, Ningbo Historic Museum (Wang Shu 2008), detail.

Fig. 3. Norcia (PG), rubble deposited at the former quarry of Misciano (photo Giovanni Tarpani).

Fig. 4. Canapa Nera (Paolo Belardi, Daniela Gerini, Matteo Scoccia, Paul Henry Robb 2018), photographic documentation and recomposition of the rubble (elab. Giovanna Ramaccini 2018).

of 'spolio' taken from the rubble of the Gibellina Vecchia [Cangelosi 2013, pp. 120, 121], and Alberto Burri, who in the Grande Cretto "solidified the memory in a powerful image, freezing forever the ruins of the old settlement, a place of pilgrimage for the people, under a concrete shroud" [Pioselli 2015, p. 91]. Gibellina opened a new poetic field, animated by the awareness that rubble is the consciousness of history. The Norman arch of Nanda Vigo and the cement shroud of Alberto Burri, in fact, were followed by a long theory of works based on the inventive reuse of rubble. Both in the field of art and architecture. The itinerant sculpture *Souvenir from Shanghai* by Ai Weiwei springs to mind, a true anti-monument composed of the rubble of his own studio in Shangai framing a bedhead of the Qing dynasty [Galansino 2016, p. 136], and the installation *Kounellis Trieste* (2013), set up by Iannis Kounellis in the Salone degli Incanti of the former Pescheria suspending a swarm of rubble above the wrecks of old wooden boats [Kounellis 1993, p. 92]. Just like the face-to-face coverings of the *Ningbo Historic Museum*, made by Wang Shu using the wa pan technique to reassemble a multitude of material finds recovered from the ruins in Zhejiang Province [McGetrick 2009], and the temporary shelter for the Nepalese homeless, conceived by Shigeru Ban as an archetypal building made of bricks recovered from the rubble heaps of the buildings that collapsed after the devastating earthquake of 2015 [Corradi 2015]. Hence the reasons why, when the Regione Umbria decided to participate in *Milan Design Week 2018* with an installation aimed at expressing the desire to transform the suffering of loss into hope for rebirth, the designated interdisciplinary team took up the thread of memory, imagining the installation *Canapa Nera*, aimed at critically re-elaborating the seismic catastrophe by offering a second chance at life not only to the destroyed churches, but also and above all to the collapsed houses. And, with them, the identity of the Valnerina. Because, contrary to the *Direttiva per le procedure*



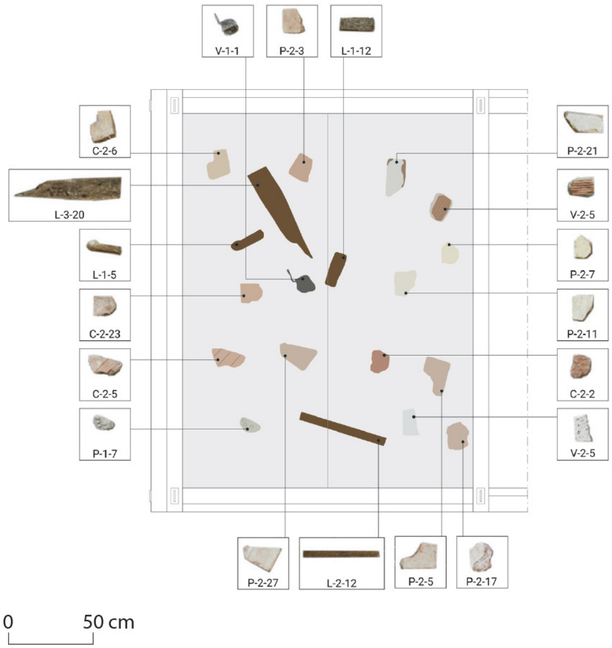


Fig. 5. Canapa Nera (Paolo Belardi, Daniela Gerini, Matteo Scoccia, Paul Henry Robb 2018), graphical restitution of rubble (elab. Giovanna Ramaccini 2018).

Fig. 6. Canapa Nera (Paolo Belardi, Daniela Gerini, Matteo Scoccia, Paul Henry Robb 2018), cataloguing and recomposition of rubble (elab. Giovanna Ramaccini 2018).

di rimozione e recupero delle macerie di beni tutelati e di edilizia storica issued by the Ministry of Cultural Heritage and Activities and Tourism on 12 September 2016, which classified rubble in a strongly hierarchical manner, the stones of the houses deserved the same respect as the stones of the churches [Ministero dei beni e delle attività culturali e del turismo 2016].

Measuring rubble

"A pulverised apple and a pulverised orange are finally the same thing, aren't they? You can't tell the difference between a good dress and a bad dress if they're both turned to shreds, can you? At a certain point, things disintegrate into muck, or dust, or scraps, and what you have is something new, some particle or agglomeration on matter that cannot be identified. It is a clump, a mote, a fragment of the world that has no place: a cipher of it-ness" [Auster 2018, pp. 33, 34]

The etymological analysis of terms is often valuable in revealing their deeper meaning. It is not surprising, then, that the introduction of the Italian word '*maceria*' is linked to the verb '*macerare*' [Bonomi 2004]. An origin which expresses the sense of indistinctness associated with the fragment and which is mainly linked to the loss of the unitary integrity of the original object, or the deprivation of an apparent usefulness. Nevertheless between the part and the whole there is a relationship of circularity and interdependence [Cacciari, 2000]. This is demonstrated by recent experiences arising from the disasters related to the war in Syria. While on the one hand, with particular reference to the monumental heritage, a philological approach is adopted, aimed at reconstructing the lost fragments in order to restore the original object [Denker 2017], at the same time, with particular reference to the ordinary heritage, the world of culture and scientific research opens up to an inventive approach, aimed at giving a new meaning to the rubble, interpreted as the memory of the lost

Fig. 7. Canapa Nera (Paolo Belardi, Daniela Gerini, Matteo Scoccia, Paul Henry Robb 2018), selection and setting up of the rubble at the Totem srl laboratory in Perugia (photo Giovanni Tarpani).

original [Engels 2016]. The part is what has been excluded, so far from the order of form that it is incomprehensible but, for this very reason, it represents an opportunity to build something else [Marini 2009, p. 255]. Thus, Kevin Lynch's exhortation, "take pleasure in discarding; do it skilfully; don't just minimize it" [Lynch 1992, p. 227], is an invitation to look at the discard as the alive matter of the project, an opportunity to look to the future [Ingold 2019, p. 43; Malanski 2015]. It is in this perspective that the study dedicated to the rubble of the houses collapsed following the seismic events of 2016 is placed. 'Ex-objects' observed adopting an 'archaeological' look, because aimed at rediscovering fragments produced, accumulated and 'buried', replacing them in time and space [Bianchi Bandinelli 2011, p. XXV]. But every activity of 'retrieval' and documentation presupposes a method of survey necessarily open to knowledge [Cundari, Carnevali 2005, pp. 70-74]. In this sense, the recovery of the fragments has led to both operational and interpretative difficulties. In fact, while it was bureaucratically complicated to obtain authorisation from the Ufficio Speciale of the Regione Umbria (Comune di Norcia, mat. 004/2018) to remove the rubble, it was even more complicated to identify the most suitable surveying techniques for measuring it. It is no coincidence that the preliminary operations took a long time and were implemented in subsequent phases. During the first phase, carried out in the field, by rummaging through the pile of rubble deposited at the former quarry of Misciano in Norcia, 120 fragments were removed. The delicacy of the operations made it necessary to act promptly. Each piece

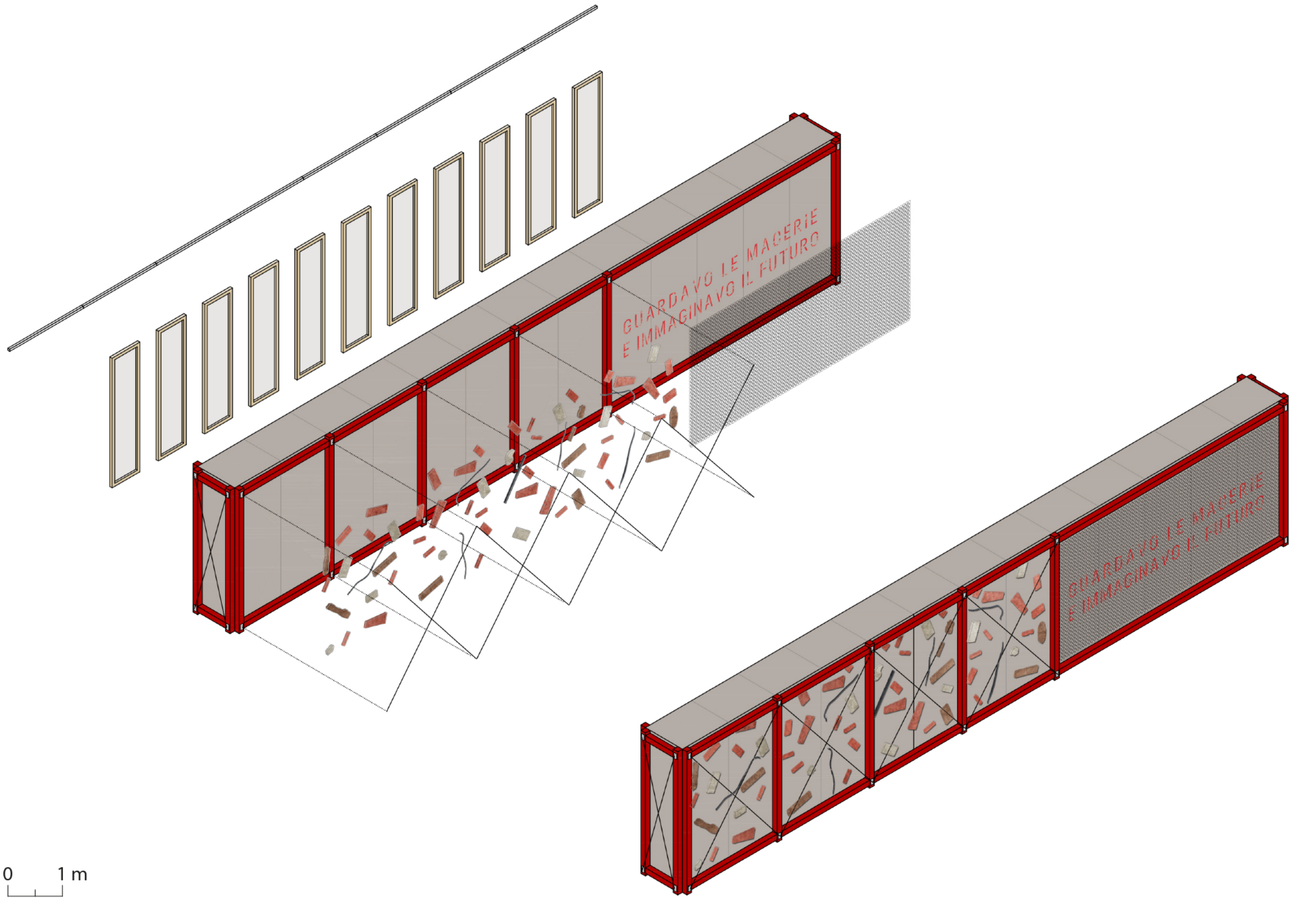


Fig. 8. Canapa Nera (Paolo Belardi, Daniela Gerini, Matteo Scoccia, Paul Henry Robb 2018), exploded axonometry.

Fig. 9. Canapa Nera (Paolo Belardi, Daniela Gerini, Matteo Scoccia, Paul Henry Robb 2018), installation in the Courtyard of honour of the University of Milan (photo Federico Monti).

was then signed and recorded with some photographic shots, and then transferred to the Totem srl laboratory in Perugia, where the elements were analysed. Once isolated, the fragments were documented through a capillary photographic documentation campaign, classified according to a comparative criterion based on material and dimensional parameters, and filed by defining an alphanumeric identification code that takes into account the recurring materials (terracotta, stone, ceramic, wood, iron, plastic, fabric, cement), the dimensional development (defining three ranges) and the relative number (defined with a progressive number). The measurement operations were aimed at detecting the morphological and material qualities as well as the state of conservation of the fragments, in order to obtain a consistent documentation, useful to give an overall reading in view of the subsequent exhibition project. Data acquisition activities saw the integration of different methodologies [Docci, Maestri 2010; Ippoliti 2000; Saint-Aubin 1999].

In fact, if on the one hand the possibility of exploring object allowed an immediate contact with its material and dimensional qualities, allowing the use of direct

Fig. 10. Canapa Nera (Paolo Belardi, Daniela Gerini, Matteo Scoccia, Paul Henry Robb 2018), installation in the Courtyard of honour of the University of Milan (photo Federico Monti).

Fig. 11. Canapa Nera (Paolo Belardi, Daniela Gerini, Matteo Scoccia, Paul Henry Robb 2018), installation in the Courtyard of honour of the University of Milan (photo Federico Monti).

Fig. 12. Canapa Nera (Paolo Belardi, Daniela Gerini, Matteo Scoccia, Paul Henry Robb 2018), installation in the Courtyard of honour of the University of Milan, detail (photo Federico Monti).

measuring instruments [de Rubertis 2011, p. 11], on the other hand, the complexity, irregularity and geometric heterogeneity of the fragments analyzed suggested the use of analytical photo-straightening instruments [Bianchini 2012]. The operations of direct survey have been developed taking into account a homogeneous level of depth, setting a scale reduction equal to the ratio 1:10 [Docci, Maestri 2010; Medri 2003]. Each fragment analysed was described through two-dimensional drawings, in orthogonal projection, with the creation of a frontal view and two side views (the latter ritually positioned to the left and at the bottom of the frontal view) graphically characterised, in order to restore the material quality of the surfaces and their state of conservation [Medri 2003, pp. 139-142]. Each fragment has also been represented with its own orientation, real or conventional, taking into account, where possible, the original 'position of use' [Pennacchioni 2004]. The restitution phase, developed through the use of homogeneous graphic conventions, was a necessary tool to return a coherent whole in relation to the information obtained, making it possible to compare the fragments analyzed and a synthetic reading useful for the design operations of the installation. 81 exemplary fragments were then selected with the aim of showing the multiple origins of the rubble: from the portions of building elements (such as beams or stones) to the architectural finishes (such as tiles or frames), visibly referable to the dimension of everyday living. Contrary to a traditionally intended archaeological approach, in which the measurement operations are mainly aimed at obtaining data useful for the identification of the missing parts, or for the compensation of the gaps, in the context of the study dealt with, the measurement and graphic restitution of the individual rubble were aimed at enhancing its identity value, celebrated through the recomposition of a fragmented whole, scattered among voids. Nor could it have been otherwise. Because just as the task of reconstruction is not only to return a house, but also to preserve an identity, the measurement activity cannot only return a material quantification, but must also return an immaterial qualification. Making measurable the poetic space that separates suffering from hope.

Macerie prime

"Rubble represents not only an end, but also a beginning"
[Kiefer 2008]

The installation *Canapa Nera*, conceived as an ode to resilience and solidarity written with the language of feelings, was set up in Milan from 16 to 28 April 2018 in the southern portico of the courtyard of honour of the University of Milan on the occasion of the exhibition-event *Interni House in Motion*, curated by Gilda Bojardi and organised by 'Magazine Interni' as part of *Milan Design Week 2018*, involving internationally renowned designers such as Mario Bellini, Aldo Cibic, Michele De Lucchi, Massimo Iosa Ghini and Piero Lissoni [*Interni House in Motion* 2018]. Sinking its roots in the deepest sense of *kintsugi* (where gold dust became an alchemical mix composed by mixing the memories that permeate the rubble of the diruti walls of Norcia with the hopes that vibrate in the fibres of the natural fabrics of the Valnerina), *Canapa Nera* looked like a long two-faced wall, made by the Totem Group of Perugia by assembling on site thirteen prefabricated modular elements in mdf wood, made solid by an internal structure in metal carpentry and painted with the grey colour of the typical Valnerina's stone [Belardi 2016, pp. 93-117].
The facade towards the courtyard, which was marked by a slogan visible in the background of a rockfall net ('*guardavo le macerie e immaginavo il futuro*'), was marked

by a chaotic accumulation of rubble taken from the former nursery quarry of Misciano in Norcia (iron bars, shreds of brick, pieces of stone, etc.), anchored to the load-bearing structure by means of threaded steel bars and framed by an apparatus of providential works made with wooden beams painted red.
While the facade towards the portico, in addition to the terminal parts dedicated to the illustration of the concept and the list of credits, was marked by a polyptych of eleven large canvases of hemp in which the Milanese artist Daniela Gerini was inspired by the plots and colours that every spring, on the occasion of the flowering of the Pian Grande, make the panoramic view of the inhabited of Castelluccio unique, scattered hands, spirals, lightning, labyrinths, stairs, hourglasses and eyes with the aim of celebrating solidarity and, with it, the yearning for brotherhood that one breathes in the deserted streets of Norcia.
On the other hand, as Claudio Magris sharply notes, "destruction is also an architecture, a deconstruction that follows rules and calculations, an art of breaking down and recomposing, or rather creating another order" [Magris 1986, p. 13].

Credits
The installation *Canapa Nera* was designed by an interdisciplinary team coordinated by Paolo Belardi (University of Perugia) and with Daniela Gerini (Atelier Daniela Gerini of Milan), Matteo Scoccia and Paul Henry Robb (Academy of Fine Arts "Pietro Vannucci" of Perugia). The activities of surveying the rubble were carried out by Giovanna Ramaccini as part of a post-doc research grant developed both at the Civil and Environmental Engineering Department of the University of Perugia and at the M&G Engineering studio in Spoleto.

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The Process of Surveying Maquettes in Car Design

Fausto Brevi, Flora Gaetani

Abstract

This work grew out of a desire to investigate the digital surveying process used in phases to define the concept of a morphologically complex product such as an automobile.
This investigation was conducted by analysing the final steps of the first ten editions of the Specialized Master course in Transportation & Automobile Design at Politecnico di Milano University. In analysing the procedures to create the presentation models starting with clay studio models, four protocols were standardized and compared. Following this, some suggestions and guidelines were summarized to ensure that faithfulness to the design intent during the process would not fail.
The ultimate goal of this work is to highlight the critical aspects of a process that is based on a quantitative method (the digital survey), but that requires a qualitative approach to be truly effective.

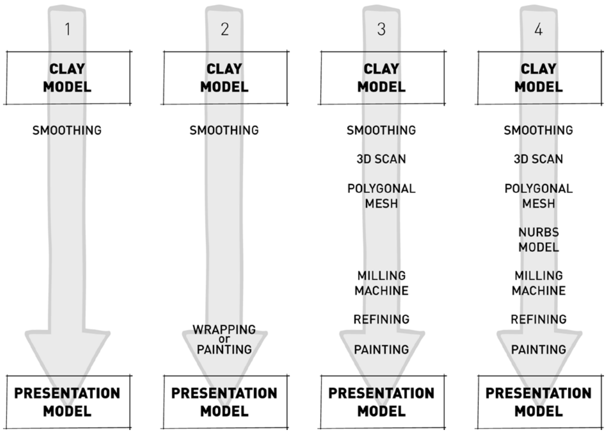
Keywords: 3D scan, car design, car concept, 3D modelling, physical modelling.

Introduction

Of all the industrial design processes, car design is one of the most complex and sofisticated. This is because automobiles are an industrial product in which design makes an important contribution to the project by attributing very clear aesthetic meaning to a product that is already very complex from the engineering point of view. Defining the design intent and remaining faithful to it throughout the design process is therefore a priority, in particular when the formal definition is still incomplete, that is when the concept design is being defined.
Given the complexity of the project and the economic implications for manufacturing companies, the concept phase is celebrated and brought to public attention at international motorshows. It is also investigated in the scientific realm in sectors such as design management as a tool for pushing towards the design of increasingly innovative products [Elmquist 2007].
It is therefore not surprising that, while car design teaching differs as a function of the national setting, school background, and chosen professors, the design output requested from students at all international schools is always a concept model in reduced scale [1]. The most common scale factors for creating physical models are 1:3, 1:4, and 1:5 [2] because they tend to be the best compromise for students when learning to deal with the complex form of the car as an object, while also maintaining a level of detail useful to fully understand the design intent.

In education, the process ends with the transformation of the maquette into a presentation model, while in business it is inevitably a longer, more detailed process in which the physical model intersects the digital model multiple times, with the resulting need to manage the conversion in both directions.
The need for an in-depth investigation of the relationship between the construction of the presentation model and the design intent as represented in the sketches, renders, and studio maquette still remains.
Experimentation in this sense was conducted by comparing the processes adopted by the Specialized Master course in Transportation & Automobile Design, which has been taught at Politecnico di Milano University since 2008, to develop projects realized by students for their theses at the end of their educational programme. This process has evolved over the years, moving from the direct transposition of the maquette into a presentation model to the conversion of the maquette into a three-dimensional digital model that then yields the presentation model.
The objective of this work is therefore to compare four different protocols so as to understand how to best preserve the design intent, as expressed through the drawing and studio maquette, in the presentation model of car concept designs.

Fig. 1. Description of the four protocols used during the ten editions of the Master's programme (graphic elaboration by Flora Gaetani).



To do so, the approaches and protocols used during the final steps of the ten editions of the Master course were analysed, with particular focus on the role of revising the project during the phases to define the concept and final model. The reviews were made considering sketches and renders in relation to the various phases of completing the physical model. The presence or absence of the above-mentioned design reviews within the process was also detected and always compared with the faithfulness to the design intent.
This faithfulness was observed while considering the geometric correspondence (style of the main surfaces, their convexity or concavity, position, shape, and character lines [3]) and their visual correspondence (maintaining the division between glass surfaces and body, paint colour with respect to the CMF project [4]).
In the ten editions of the Master's programme, the protocols were modified to refine the quality of the final presentation model and, despite the emergence of critical aspects, a much higher level of quality was achieved compared to the first protocols used. Not only that, the high quality required ensured that the projects also acquired a higher level of detail compared to the first years. The greater quality of the presentation model therefore led to a better definition of the project itself.

State of art

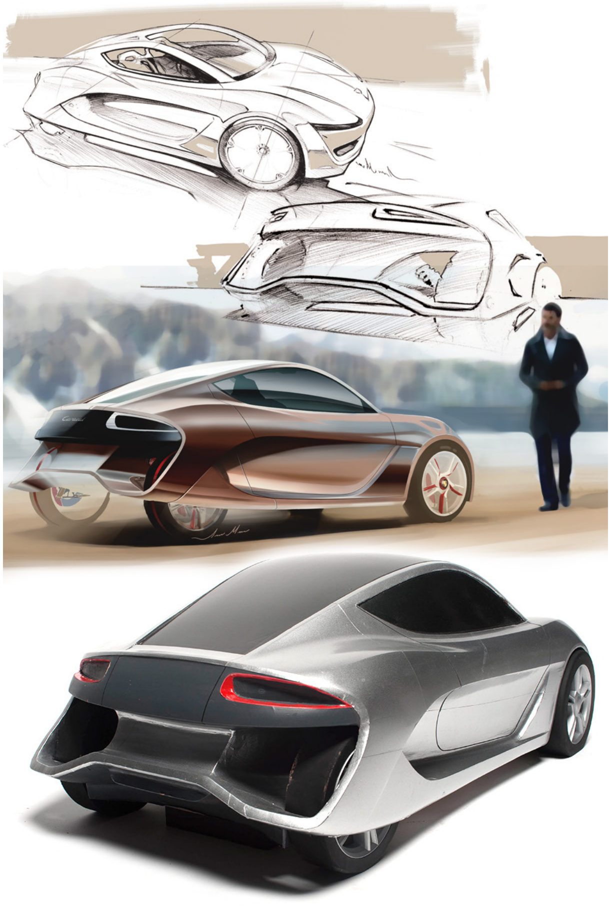
The teaching project underlying the Master's programme that we have investigated entails replicating what occurs in design centres at companies involved in car design, although only partially and with corrective actions aimed at favouring the correct preparation.
Historically, projects for vehicles have been developed on the dual tracks of drawings and the creation of physical models in progressively larger scales (from 1:10 to 1:5 to 1:1), without noticeable differences in the process from company to company [Bernobich, Chirone 1982, pp. 23, 24].
Today, the vehicle design process is considered by car manufacturing companies as just one phase in the entire project design and production cycle, in which its specific aspects shine through clearly. For this reason, small and large differences can be identified based on the size of the company, its history, the product characteristics, the profile of the target customer, and often also the management guiding it in a given period of time.

Literature on the process of transportation design is scarce, especially when compared to the enormous number of books on the characteristics of cars and prototypes [Krzywinski, Wölfel 2012, p. 269]. However, a specific common thread can be found in the project design process for road vehicles [5].
The design process always begins with a collection of ideas, the most typical expressive form of which is found through preliminary drawings. A selection of these is made to identify the most interesting and promising in terms of coherence with the project specifications. This also relates to the so-called 'package', that is, the set of geometric limits bounding the new project [6]. The drawings should therefore be reconsidered and refined to respect these limits so that the initial idea dictated by pure creativity may be effectively developed in industry.
Different types of drawings are associated with different phases of the design process. Of these, ideation sketches are used at the beginning of the process [Tovey, Porter, Newman 2003, p. 137]. The scientific value of drawing within the design process, whether in architecture or design, is that it is the main tool used to study the laws governing the formal structure of the project and to study the expression of the design idea, whose evolution and continuous rethinking was described by Bouchard and Aoussat as a progressive reconfiguration of a problem towards a solution. The design process consists in reducing the abstraction of the designer's mental representation through the use of different successive levels of representation that increasingly integrate the constraints [Bouchard, Aoussat 2003; Bouchard, Aoussat, Duchamp 2006].
Within the wider world of the project, in both design and architecture, the issue was already addressed by Giovanni Klaus Koenig when he wrote that "When something is designed, in the precise moment in which it is designed, it exists only in the architect's mind and precisely due to its complexity it must be studied, criticized, reprocessed, investigated, possibly transformed, reduced, or expanded before it is executed materially" [Koenig 1962, pp. 8, 9]. This was also looked at again more recently by Mario Bellini when he stated that "the creative idea takes shape […] through a conceptual flow that starting from the mind reaches the hand, transforming itself into expression on a sheet of paper" [Bellini 2019, p. 9].
Once the reference drawings have been defined, these should be able to communicate the author's design intent clearly and uniquely. In fact, the steps immediately following this see a shift from the primarily two-dimensional techniques of drawing to the three-dimensional techniques of modelling, aimed at ensuring full understanding of the effective perception of a large object conceived with articulated, complex surfaces in the three-dimensional space. The best projects identified from the drawings are then produced as physical models in clay [7], first in 1:4 scale and then in real scale, and as virtual models.
This process, from the drawing to the model, occurs in the company along parallel paths managed by dedicated personnel called "clay modellers" and "digital modellers" [8]. In the educational aspect of the Master course examined in this work, the choice was made to consider clay modelling as preparatory to digital modelling because it allows for a greater spatial understanding of complex shapes. This understanding is helped by the possibility of using touch in addition to sight and by avoiding the mediation of the computer screen, where the framework of perspective projection is put forth again, although usable in a different way. This leads to a misalignment of the two models in time, with the possibility of losing the perfect coincidence between physical and virtual models. This possible loss,

Fig. 2. Model and sketch to describe the Alfa Romeo Ascari, Ed. 1 (Luca F. Bovo and Iosef Fanizza, graphic elaboration by I. Fanizza).

however, is irrelevant from the educational point of view since the process to develop the final project of the Master course ends with the realization of these two models.
The way in which these two models are used in the presentation of the projects has varied over the years. This change was analysed here to understand the advantages and disadvantages of the different solutions adopted with respect to their ability to maintain consistency between the presentation model exhibited and the design intents narrated through the drawings.

Fig. 3. Sketch, render, and model with wrap film of Porsche Caracal, Ed. 4 (Adnan Al Maleh, Juan D. Cadena, Denis Pasquini, graphic elaboration by drawings by A. Al Maleh).



Methodology

The aim of this work was to determine the best way to maintain the design intent in the models when presenting the concept of an automobile in reduced scale.
As mentioned in the introduction, this objective was addressed by analysing the design results within the Specialized Master course in Transportation & Automobile Design at Politecnico di Milano. Observations of the dynamics during design rewies were made during the first ten editions of the programme, along with an analysis of the final work with respect to the iconographic material produced by the students (analogue and digital renders) that best expressed their original design intent.
Over the years, four protocols were used (fig. 1) to develop the final presentation models. The first three protocols were used in multiple years so that the results obtained were not influenced by contingent factors. The last protocol was implemented only in the tenth edition of the Master's programme; the COVID-19 pandemic prevented the completion of the physical models in the eleventh edition.
The elements common to all protocols are the clay maquette, the iconographic set, and the presentation model. The input model was always a clay studio maquette in 1:4 scale developed by the students during the Car Design Studio as part of the Master's programme; the iconographic set was always aimed at describing the phases of project, design intent, and final result.
Protocol one was used in the first and second years. The clay maquette developed by the students was sharpened by a professional clay modeller. This model was put on showcase.
Protocol two was used from the third to the sixth years. After the clay maquette was sharpened, the model was finished with wrapping or paint. This model, equipped with details such as glass surfaces and doors cuts, was put on showcase.
During protocol three, used from the seventh to the ninth years, refinement of the clay maquette was followed by surveying with a full-filled surface 3D scanner [Guidi, Russo, Beraldin 2010]. The scan thus obtained was aligned, optimized, and smoothed, and the polygonal model obtained

was sent to the milling machine. At this point, the physical model was finished and painted. The model, equipped with details such as doors cuts and graphics, was then put on showcase.
Finally, protocol four was used in the tenth year. Following refinement of the clay maquette, the model was surveyed with a full-filled surface 3D scanner. The scan thus obtained was aligned, optimized, and smoothed. At this point, the polygonal model was re-modelled with surface modelling software. The digital model thus obtained was sent to the milling machine, finished, and painted. The model, equipped with details such as doors cuts and graphics, was put on showcase.
The chosen methodology was made possible by the extensive observation of the procedures conducted by the teachers during the final phases of the Master's programme. The teachers chosen to support the students during the course of studies all have extensive professional experience in the field of car design and varied background. This ensured that the students would be confronted with different points of view, just as occurs within automobile style centres. Another similarity with the professional world was the structure of the Studio itself, which has changed continuously over the years and been refined to divide the various project responsibilities between both the professors and students. The areas are divided into: meta-design, exterior design, interior design, colour & trim, and presentation techniques. Everything was coordinated by a person in charge (a figure similar to a project manager in the professional world) and by the director of the Master's programme.
Just as it is necessary to consider the natural changes in the educational structure that have occurred in the editions of the Master, it is also clear how the human aspect was important throughout the phases of the research project, both in evaluating the final results and in assessing and modifying the intermediate steps. This human variable was expressed and generated its greatest importance during the design review, ensuring that the design intent was maintained.

The first years of experimentation

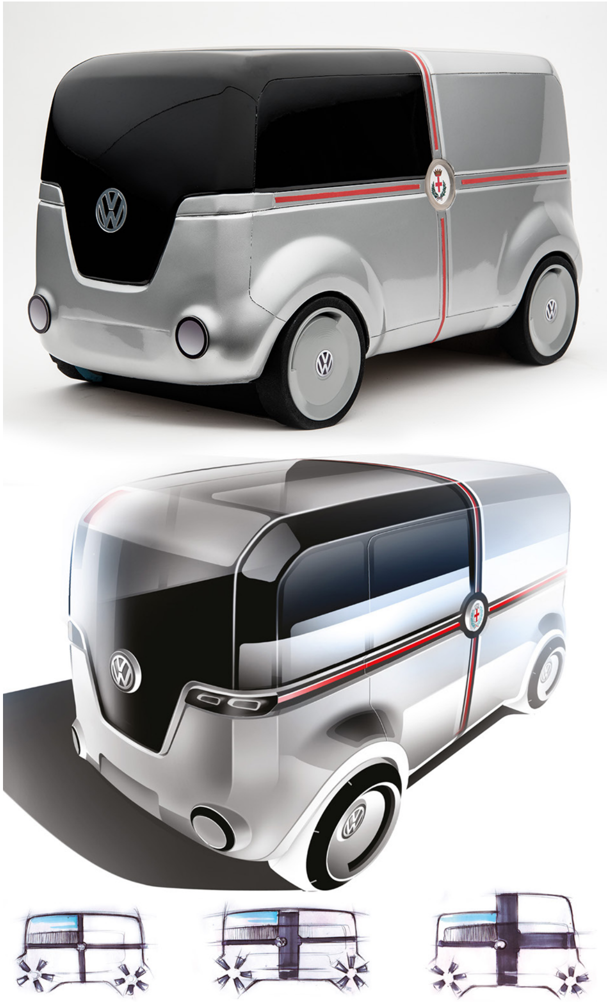
The description of the results follows the same division of the protocols in order to clarify the evolution of the entire project.

In the first protocol, used during the first and second editions of the Master's programme, the models exhibited remained in clay in 1:4 scale and were finished only from the formal, not the visual, point of view. The material used is optically diffusive and therefore does not exalt the shape details of the surfaces. The models exhibited consequently highlighted the non-definitive nature of the project. The tactile perception and visualization of the surface style was left to the supporting iconographic material (sketches and renders). The faithfulness to the design intent was rather good because the entire process occurred with continuous contact between teachers and students, but leaving the tactile perception to just the two-dimensional material was restrictive with regard to the expressive quality of the final result (fig. 2).
The second protocol was used in the next four editions. The finishing of the clay model was done externally by professional clay modellers. This led to some discrepancies and inaccuracies in the final models with respect to the design intent. From subsequent analysis with the professors, this discrepancy was revealed to be due to the poor definition of some of the models prepared by students,

Fig. 4. Model with wrap film displayed for the ten years of the Master's programme, Porsche Medhelan, Ed. 4 (Mario Antonioli, Matteo Tamini, Vander Zanutto).

which necessitated independent choices on behalf of the external professional.
The objective of this protocol was to lend greater tactile definition to the models by applying wrapping or paint.

Fig. 5. Painted clay model, render, and sketch of VW QB, Ed. 3 (Jonathan Bauccio, Josip Cupin, Ahmed Zayed Radwan, drawings by A. Zayed Radwan).



These two techniques, while falling within the same protocol, had different formal and visual characteristics.
Wrapping is a technique that is now widespread in the application of advertising graphics on car bodies. A similar tool is used in automobile style centres to cover clay style models in whole or in part so that the surfaces have optical qualities similar to painted car bodies [9]. Wrap film is an extremely thin film of cellulose resin [10]. This material has the ability to faithfully follow the surfaces on which it is applied, whether characterized by simple curvature (such as the sides) or complex curvature (such as the front). Its cling capacity highlights inaccuracies and discontinuities. In the professional world, it is used precisely to correct defects when modelling surfaces. In presenting the projects, it was shown to be a quick tool but with an inadequate visual yield. It is therefore good for intermediate work, but ineffective in presentation (figs. 3, 4).
The paint has a greater thickness, and an underlying layer is also added to isolate the clay from the paint. The final result led to an optimal visual effect, completely faithful to the paint on a normal car body. While nearly negligible on real-scale models, the greater thickness of this treatment on reduced-scale models could lead to geometric discrepancies due to a general increase in the fillet radii. In the model shown in figure (fig. 5), it is clear how the perception of some corners at the rear is reduced with respect to the reference drawings.
In addition, with both surface finishes, wrapping and painting, the models degraded quickly over time. This was due, in the first case, to the low resistance to abrasion and pressure and, in the second case, to the different heat resistances of the materials (clay and paint), which led to cracks in the paint (fig. 6).

Towards faithfulness to the design intent

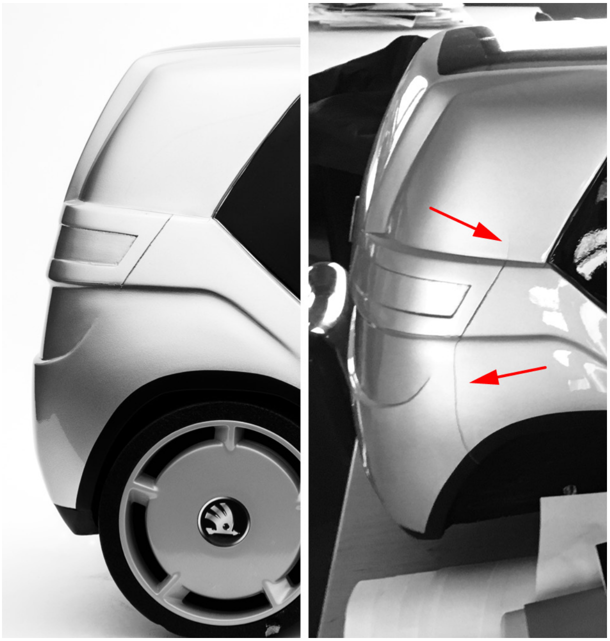
To remedy the degradation of the models yet maintain the visual quality of the paint, painted milled models began to be created in the third protocol, starting with a 3D scan of the clay model.
Therefore, starting in the seventh edition, the scan was inserted after finishing the clay maquette. The process to acquire and render a polygonal model suitable for milling entailed the classic phases of acquisition, alignment and cleaning, merging, and editing [Guidi, Russo, Beraldin 2010]. As can be seen in figure (fig. 7), the character lines of the

car door have practically disappeared in the final model, denoting a critical point in maintaining the design intent.
An analysis of the entire process shows that the most critical phase is editing, in which smoothing of the surfaces often coincided with simplification, leading to an excessive attenuation of some details. In this phase, the designers' review and control operations were less frequent due to the entire process being carried out externally.
The process was optimized starting from the eighth edition of the Master's programme: the clay model created by the students was only half modelled, relying on the intrinsic symmetry of cars. This greatly simplified the physical modelling process and ensured that the students concentrated more on defining the project.
In the last protocol used in the tenth edition of the Master, the polygonal mesh obtained from the scan of the clay studio maquette served as the reference for building a digital model based on NURBS-type polynomial parametric equations. This step was critical within the protocol because, without adequate intervention on behalf of the teachers (project manager) and students (car designer), the design intent changed notably. In fact, the operators' approach to the reconstruction was based only on the numerical variance between the NURBS surfaces and the scan. This meant that the reconstruction was quantitatively consistent with the overall acceptable tolerance of the total dimension of the model, but was inadequate upon qualitative inspection. With regard to the geometric faithfulness to the design intent, this translated into a comparison of character lines where they were not present in the original model, thereby changing the project.
These defects were corrected before painting thanks to a fruitful, intense collaboration between modellers and teachers. These corrections are clear from the photos (fig. 8), evidencing the position and trend of the character lines on the sides. The final result was therefore satisfactory, despite some differences that were not possible to fix (fig. 9).

Observations on the protocols

Following this long process to analyse the protocols, a series of results stand out about the treatment of the concept maquettes and their transformation into presentation models.
The qualitative verification by the professors was always important and decisive and always involved consultation of the drawings and renders made by the students, in addition to verification on the clay model. On the other hand, the protocols became progressively more complex while the time dedicated to them remained unchanged.
The debate conducted over these years highlighted a series of guidelines within the scope of supporting the work in the final steps of the Master's programme to achieve the best balance between faithfulness to the design intent and visual quality.
First, it is known that the more formal maturity a project has, expressed in varied ways of representation such as sketches, renders, and clay models, the more the finishing touches on the presentation model will be faithful to the original design intent. When this does not occur, steps to define the presentation model are used as an additional moment in the design process, increasing the difference between the final model and the original design intent. It is

Fig. 6. Cracks on a painted clay model. The same model after some time.



therefore always necessary to clearly define the deadlines to avoid prolonging the "design timing" and indecision.
Problems involving the correctness of the shape always regard the definition of the surfaces in the project. Analysis of their semantic division [11] [Cheutet 2007] is an important tool in the review phases to highlight and share the surface and character lines trends.
Critical aspects leading to errors in the digital model were detected at two different times: when editing the polygonal model deriving from the three-dimensional scan, and during NURBS modelling. In the first case, an excessive rounding of the fillets was detected, leading to a reduction in the character lines. In the second case, an increase in discontinuity was detected, with the consequent creation of character lines where they did not exist.

Fig. 7. Milled model, sketch, and render of Audi Jewl.in, Ed. 9 (Gianluca Raciti, Giancarlo Temin, Esteban Wittinghan Q., graphic elaboration by by G. Raciti).

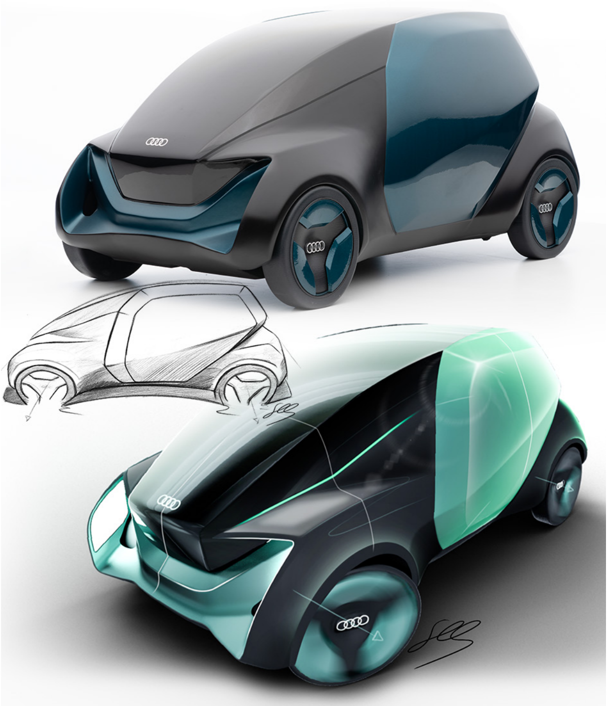
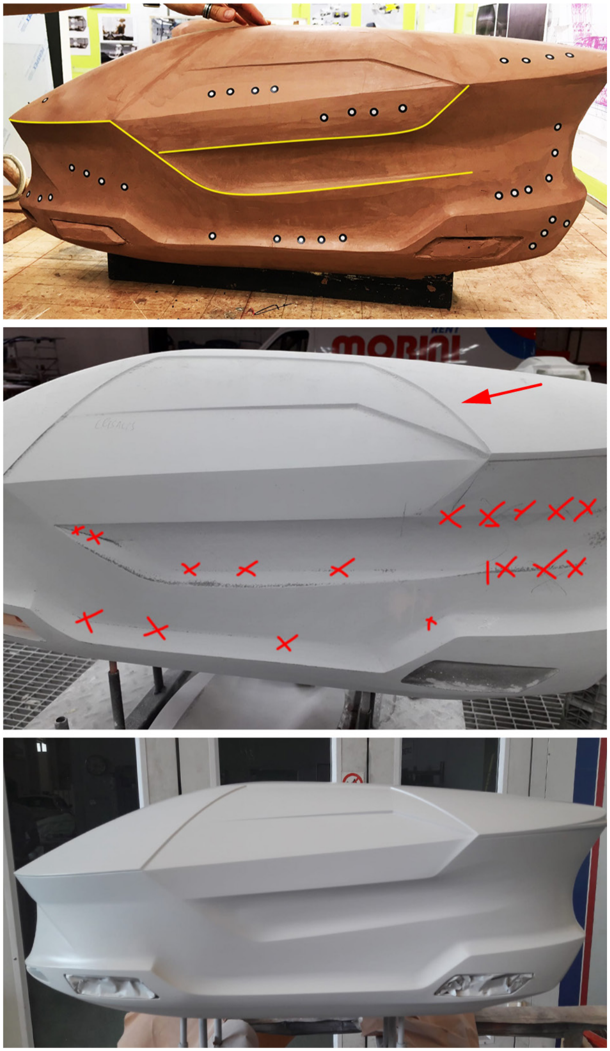


Fig. 8. Photos of the model revision phases. From the top: clay model, milled model to be corrected, and corrected version.



Conclusions

Among possible ideas for improvement, we can consider some tied to the process of creating the digital model and others tied to the means of using the iconographic material. Together with the design review, this material served as the most effective tool for guaranteeing faithfulness to the design intent.
With regard to the model, a possible solution would be to integrate the two modelling methods (NURBS and polygonal surface editing) in order to use the best of both approaches. The milled model should also be developed directly by the students, diversifying the approach among the various projects according to the level reached. In this sense, it may be useful to achieve a certain level of definition for the main surfaces in the clay model and then move on to a reference scan, followed by the definition of the project exclusively through digital modelling.

With regard to the iconographic material, it should always be present in support of every step, precisely to maintain the intent, also supporting the scans so that the operators do not rely solely on the quantitative assessments tied to them.
It is certainly necessary not to lose sight of the fact that we are always dealing with a design concept and not a definitive project, and that the time available to develop the presentation models is limited by teaching deadlines. Different representation tools say different things in the narrative of design activities, so they should not necessarily reach the same level of definition. What is important is to clarify the narrative and purpose of each tool.

Credits

The present paper is the result of research and results obtained by the authors together. However, the first and second sections and conclusions were written by Fausto Brevi; the other sections were written by Flora Gaetani.

Notes

[1] In some schools, the final model is in 1:1 scale, but students involvement is normally only marginal.

[2] The scales of the physical models do not follow the standard scales of representation in industrial technical drawing.

[3] Character lines are the lines determined by the intersection of the main surfaces defining the volumes of the car. These are edges that will not exist in reality because they will later be rounded, but they describe the "character" of the shape of a car and define the formal DNA of a brand.

[4] Colour Material & Finish. This is an area in the automotive world (also called Colour & Trim) dealing with the design of colours, materials, and surface finishes. Its epistemological origins lie in fashion design, with the adoption of its languages and tools.

[5] For the design process in companies, see The design process: <https://bit.ly/365dGmG> (Mercedes, accessed 2020, October 22); <https://bit.ly/37ahodV> (Jaguar, accessed 2020, October 23).

[6] These limits include the general dimensions, respect for obstructions due to the technological components, ergonomics, and legislative safety standards.

[7] The composition of car modelling clay material allows it to be spread out after heating and mould removing material.

Fig. 9. Render and model of Audi Crisalis, Ed. 10 (Filippo Batavia, Jean P. Bruni, Edoardo Trabattoni, Pietro Tranchellini, graphic elaboration by F. Batavia).

[8] 'Digital modellers' are sometimes also called 'surface modellers' or 'Alias modellers' after the name of the most common software used for this purpose.

[9] As a reference, see the site of Jaguar design process: <https://bit.ly/37ahodV> (accessed, 2020 October 23).

[10] Its composition and application are described on the distributor's website: <http://www.chavant.com> (accessed, 2020 October 24).

[11] Semantic division is the definition of primary and secondary surfaces, and also the position and radii of the fillets.

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Drawing, Measurement and Movement. The Representation of Space in Urban Maps (an Interdisciplinary Analysis)

Rosario Marrocco

Abstract

Urban maps represent the simplified drawing of a complex world (urban space) where material and immaterial phenomena, problems and solutions coexist; they are a tool used by individuals to perceive and act in space.
In our current socio-urban context these representations are particularly interesting, above all due to the complexity of contemporary metropolises. Maps accompany us in our complex "urban" life more as maps of complexity than maps of the city.
The contribution tackles this issue from the point of view of representation and the individual. It illustrates an interdisciplinary study that analyses the complexity of represented space, i.e., of the urban (such as spatial and social concentration, anthropological expression and system) and the problems linked to the complexity of its representation (i.e., the complexity of urban maps) which is solved by simplexity. It also analyses man's capacity to act and move in real space (linked to the vital impulses of the organism, propriocetion and kinesthesia and the wonderful and extremely plastic ability to move in the environment) and thus the possibility of an individual to act and move in space through representation – linking his action to represented space and exploiting his brain's ability to foresee movement in the drawing, i.e., in the map.

Keywords: urban maps, urban drawing, urban space, movement in space, perception and action.

Introduction. Space, representation, individual, action

From the point of view of representation, urban maps represent the drawing of a simplified complex world (urban space) where material and immaterial phenomena, problems and solutions coexist.
From the point of view of the individual, maps are a tool with which to perceive and act in space.
If these two viewpoints are broken down into their essential terms – space, representation, the individual, perception and action (movement) – I could end my introduction right here, with these two or three lines. Without wanting to be or able to be exhaustive, I could add that I will try to tackle the subject of maps from both points of view, by (literally) combining them in an interdisciplinary study on the representation of space and the relationship between representation, space and the individual in urban maps.
However I will continue this introduction with short but necessary considerations about some of the concepts related to the relationship between the individual, space and representation; these concepts are the cornerstone of this study justifying an interdisciplinary approach.

Space
First of all, I need to emphasise the adjective of space, i.e., "urban"; I will try to show how both representation and the individual have to deal with its complexity.

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Action in real space

According to Alain Berthoz, professor of physiology of perception and action at the Collège de France, our brain projects our own perceptions, hypotheses and interpretations on the world so as to anticipate the consequences of an action [Berthoz 2011, p. XI].

This happens everyday and applies to all our actions, even when we have to act in the space of the city. When we move, we perceive, measure and interpret it, creating the right conditions for each of our actions and each movement.

Through action we bind ourselves to space. We somehow appropriate it. Berthoz writes that action is an immediate data of consciousness, and that anchoring notions of space in an action eliminates the gap separating abstraction from reality [Berthoz 2011, p. 131].

Man's ability to act in space is behind this individual-space-action triangulation (an individual moving in space). As stated by Carmela Morabito, a historian of psychology and cognitive neurosciences, the motor paradigm defines a new image of the organism developed on action, "and also produces a new image of man whose species-specificity is not to be found only in reason, consciousness and willpower, as it has generally been from Descartes onwards, i.e., in what has been defined as 'superior cognitive functions', but instead naturalistically identified – first and foremost – in the vital impulses of the organism, in propriocetion, in kinesthesia, in the wonderful and extremely plastic ability to move effectively in an environment" [Morabito 2020, p. 16].

So, individuals move in space based on how they perceive themselves: through their own propriocetion they perceive, measure and adapt their bodies in relation to space. Sherrington called it "our secret sense, our sixth sense", "that continuous but unconscious sensory flow from the moveable parts of our body (muscles, tendons, joints) by which their position and tone and motion are continually monitored and adjusted, but in a way which is hidden from us because it is automatic and unconscious" [Sherrington 1906, pp. 336-344; Sacks 1985].

Even if we perceive and measure space using Marr's visual mechanism [Marr 1982], without this sixth sense individuals would not be able to move and act in space. Oliver Sacks describes one of his patients who did not have this sixth sense as "disembodied... condemned to live in an indescribable, unimaginable realm-though 'non-realm', 'nothingness' might be better words for it" [Sacks 1985].

Individuals use action and behaviour in the space of the city to establish relationships with the outside world and other individuals, while the brain codifies, elaborates and preserves the emotionally-developed data linked to memories, circumstances and spatiality. When an individual walks down a street he is able to relate it to another street or place; he measures it and gradually recognises its depth, width, deviations and then the structures, colours and heights around it. Using unique procedures and coding systems that are specific to every individual, he establishes a relationship between the places and full and empty spaces in the city. This is how he thinks of space; he assigns the city measurements, proportions and relationships he did not actually detect. A sort of unconscious urban drawing.

Action in represented space

One of the main functions of the brain is to foresee. It is a machine that anticipates and simulates reality before acting "in the extremely short space of time preceding action" [Berthoz 2011, p. 173]. "Like a biological machine [...] the brain is considered as a sort of 'anticipator', foreseeing the motor possibilities of an organism in an environment" [Morabito 2020, p. 14].

In this respect, an individual's action in real space can be anticipated in represented space thanks to a prevision (simulation) of the action his brain performs in the representation. This happens when we use a map, i.e., a drawing – simplex and useful [Berthoz 2011].

This not all. The brain goes further: "using our mental processes it does not simulate only tangible routes or the map of a city. It also divides space in many different ways depending on our affiliation to multiple communities" [Berthoz 2011, p. 141]. In other words, the brain simultaneously selects the physical and social extension of space. In fact, space is a house, a city, a village, but also a region, a country, a continent [Berthoz 2011].

"Space is not only what we cross in a labyrinth, a garden, when we travel 'around our room' or in our city" [Berthoz 2011, p. 141].

It is something that is increasingly complex, even to represent.

The "urban" and its representation

The study and drafting of city maps as complex systems representing the "urban" and communicating all its data primarily require the involvement and interpretation of the characteristics and phenomena that make up the urban itself.
As stated by the anthropologist Ariel Gravano, we can consider the urban as the phenomenon of spatial concentration; its expression par excellence is the city made up of an ensemble of physical, spatial and social infrastructures [Gravano 2016, p. 51].
This ensemble identifies and physically represents the city; the phenomena that broaden the urban concept are linked to the city. Gravano writes that in fact the urban appears to be a problem when talking, for example, about the conditions of the traffic, houses and service while it appears as an urban crisis when these problems are grouped together and characterise a typical lifestyle adopted in cities [Gravano 2016, p. 50]. In addition, he states that the urban emerges as a demand when there is a lack of the basic urban infrastructures that guarantee a "dignified" life while instead it appears as a reform because the urban is a spatial form designed and created as a renovation, as an alteration compared to the non-urban landscape or previous urban landscape; it appears as utopia, as an ideal, when one imagines or designs the desired city, the city one wants to build and live in [Gravano 2016, pp. 50, 51].
So the urban appears as a complex ensemble of spatial and social characteristics and phenomena, continually renewed by welcoming innovations and stratifying transformations and information.
On the other hand, Gravano also states that throughout history the city has always embodied progress and a break with the natural, with what is not artificial, with what is given, and what is prescribed [Gravano 2016, p. 51]. According to Lewis Mumford, the city is the point of maximum concentration for the power and culture of a community; it is the form and symbol of an integrated social relationship, where human experience is transformed into visible signs, symbols, patterns of conduct, systems of order [Mumford 1970]. Paul Ricoeur states it is a place where man perceives change as a human project [Ricoeur 1978, pp. 123-136].
Gravano also writes that in the twenty-first century the city is like a problem that can be solved by several different disciplines [Gravano 2016, p. 50], where the guiding principle, as stated by Berthoz, is complexity [Berthoz 2011, p. VII] and its representation in a map follows and illustrates the transformations of its form as well as urban complexity.

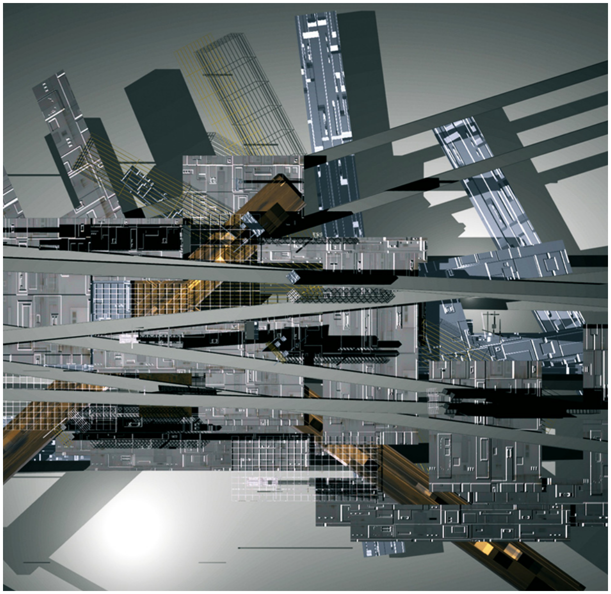

Fig. 1. Rosario Marrocco, Urban Map, 2020. Mixed technique (60 x 40 cm).

Representing urban complexity

Managing and representing the complexity of urban space as well as elaborating and communicating the increasing amount of data contained in the city means it is crucial to achieve simplified representation. Simplification does not involve eliminating or reducing the data, but maintaining its visibility and making its complexity decipherable. Graphic and symbolic systems are normally used in urban maps to represent this complexity.
As a result, maps are a figurative mix of complexity and simplicity, of simple representation and the complexity of (urban) space.

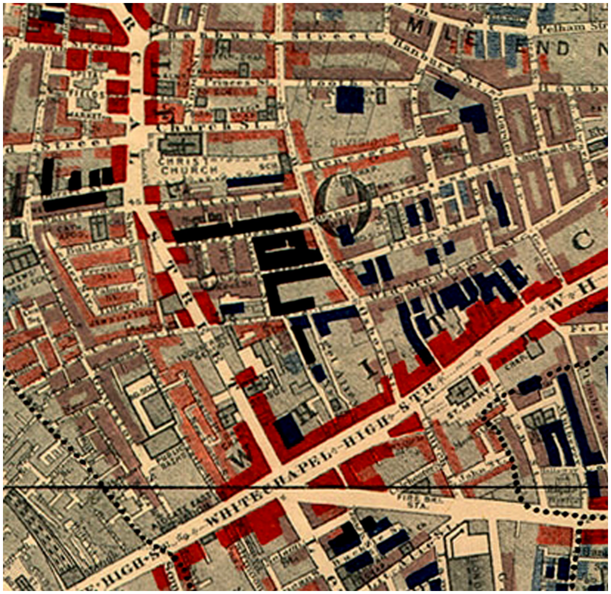

Fig. 2. Charles Booth, Maps of London Poverty, 1889 (Booth 1889).

Before discussing representation I will briefly focus on urban complexity.
Generally speaking "complexity is, by its very nature, difficult to define [...] Nor does a univocal method exist to measure its complexity" [Bertuglia, Vaio 2019, p. 21]. As stated by Philip Warren Anderson, Nobel Prize for Physics, it is present in those "systems [like cities] that are so big and intricate they display an autonomous behaviour" [Anderson 2011, pp. 364, 365]. The complexity of a system, considered as "an organic aggregate structured by interacting parts" [1], is perceived when its component elements are not only side by side – i.e., not as a simple sum of single parts [Bertuglia, Vaio 2019, p. 21] – but interact.
This occurs in the urban system where complexity is perceived by the quantity and close interrelation (also formal and functional) of its elements, which can either be physical-spatial (buildings, roads, networks, etc.) or social (citizens) [Bertuglia, Vaio 2019, pp. 25, 26].
Every element contains and expresses its own complexity that interacts with the complexities of other elements, thereby determining the complexity of the urban system and city system.
By representing each element (either physical-spatial or social) it is possible to represent urban complexity, acknowledging in each element the interaction it generates with the other elements in the system. This also occurs in urban maps where a single element – nearly always physical-spatial – represents the complexity of urban space.
Let's now go back to representation. For the purposes of this study we can establish a classification [2] of the physical-spatial elements of the city system, a thematisation generally used in urban maps:
a) urban drawing, places and services;
b) transportation;
c) commercial and tourist structures.
A physical-spatial element of the city is represented in each of the maps analysed below (figs. 3-10). The cities are located in Europe, Asia, Latin America, North America and Oceania.
More specifically: as regards transportation (b) figures 3-5 show the maps of the current subway systems in Tokyo, New York, Berlin and Paris (figs. 3-5) and figure 6 presents a sixties' map of the railway networks in the Province of Buenos Aires [3].
As regards commercial and tourist structures (c), two maps show the city of Sydney (the *Map Walking Tours*, fig. 7) and Tokyo (the *Akihabara Map Electric Town, Shop Guide*, fig. 8). Overall maps of urban drawing, places and services (a) are instead illustrated in the maps of two small cities in Argentina: Olavarría and Salta (figs. 9-10) [4].
The maps of the subways in Tokyo, New York, Berlin and Paris (figs. 3-5) provide the information people need to move around and have clearly been drafted for this purpose. But they also represent the contemporary complexity of big metropolises, in this case caused by the density of the above and below ground transportation networks.
The city's production level is represented in the network by the quantity of lines, both above and below ground, that ensure the movement of people, goods and services and enable work, trade, tourism and exchanges which in turn increase competitiveness and fuel the fabric of the urban economy.

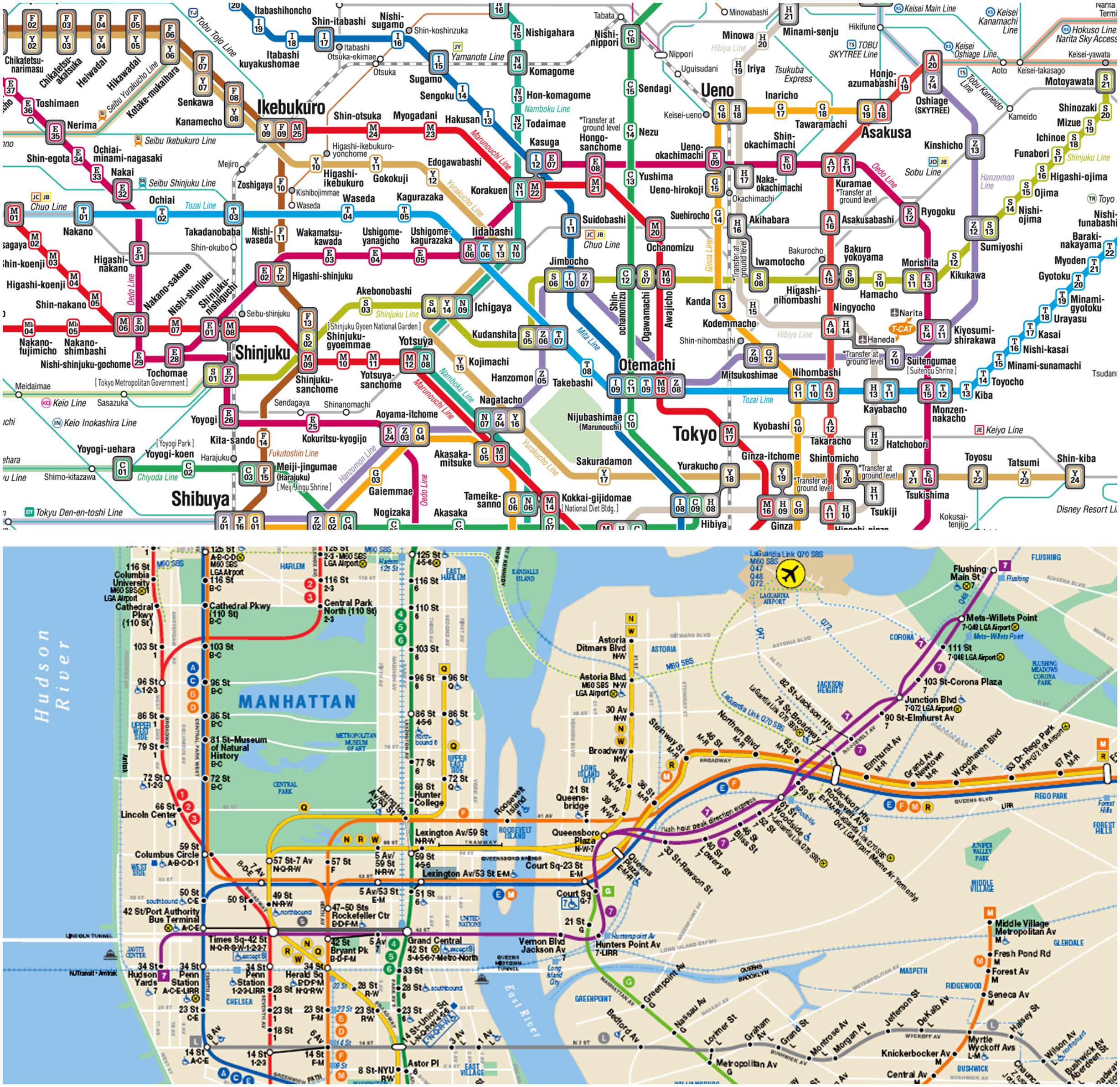

Fig. 3. (above) Tokyo Subway Route Map (06/2020). Source: Tokyo Metro. Bureau of Transportation, Tokyo Metropolitan Government. (below) New York Subway Map 2020 (11/2020). Source: MTA, Metropolitan Transportation Authority.

Fig. 4. BGV. S-Bahn / U-Bahn Berlin (10/2020). Source: Berliner Verkehrsbetriebe (BGV).

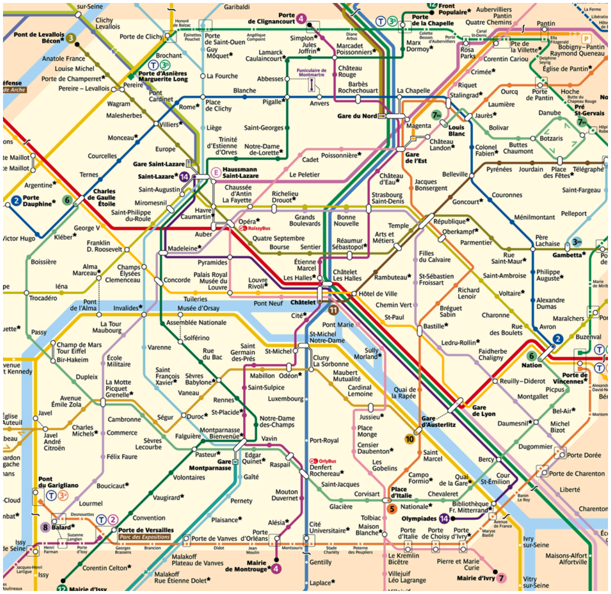

Fig. 5. Paris Metro-RER-T- Map (10/2019). Source: RATP (Régie Autonome des Transports Parisiens).

The network also shows part of the spatial and social phenomena of the urban, for example: the size of the urban area that usually corresponds to the range of the subway lines (fig. 4), or the concentration of the urban fabric and therefore of the demographic density which generally corresponds to the concentration of the lines and stations (figs. 3-5).
Likewise, the territorial networks represent the production capacity of a region, province or country. The map of the railway lines in the Province of Buenos Aires (fig. 6) represents the growth, radication and connection of the urban in the territory, i.e., the complexity of the relationship between the city and the territory.
Some maps use urban complexity to represent anthropological complexity. In other words, in the real world social elements interact so intensely with physical and spatial elements they ultimately configure anthropological phenomena, also reflected in the representation. In these cases the map is also an anthropological image, a map of possible actions not only in space, but also in the society that lives in and creates that space.
The map of *Akihabara*, a district in Tokyo (fig. 8), is one example; the spatial information regarding trade, tourism and services illustrated in the graphic grid showing the urban fabric reflects lifestyles, consumption patterns and human relationships.
Another important example of representation of anthropological and urban complexity dates to the late nineteenth century when the sociologist Charles Booth used representation to illustrate the socio-economic and urban complexity of London.
According to Booth, it could easily solve a complex phenomenon such as poverty. The sociologist also transferred the problem of destitution into space and tasked the city and its districts to represent the phenomenon, "suggesting that what an individual called 'home' [could] influence not only his standard of living, but also his behaviour" [Garfield 2016, p. 221].
The poverty map (fig. 2) Booth published in 1889 [5] was an attempt to provide an answer to three com-

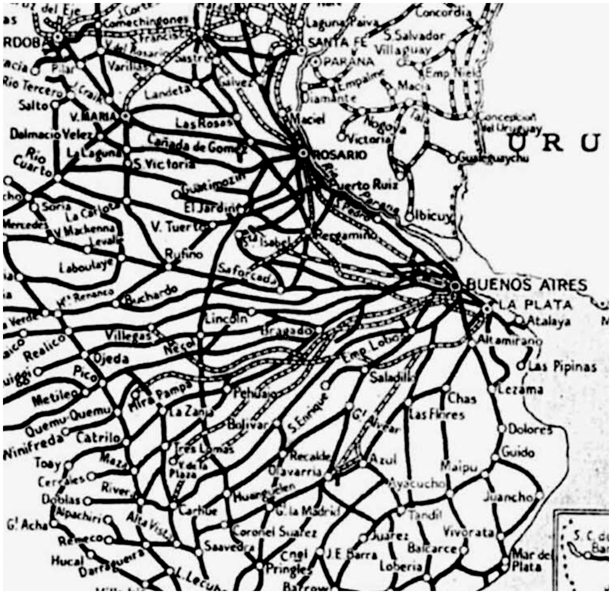

Fig. 6. The Argentina Railway Network, c. 1960. Source: Uncertain.

Fig. 7. Map of Sydney, Walking Tours. Sydney, 2017. Map, property of the author.

plexities: social poverty; places of poverty; representation (and diffusion) of the phenomenon. It was a very controversial answer, even ethically, because rather than just identifying and representing poor areas, he assigned specific social classes (from semi-criminal to the upper classes) to the urban fabric (using colours). This turned the poverty map into a map focusing on poverty. A sort of socio-urban graphic-alert.
The "simplicity" with which Booth mapped London not only dealt with, but also clashed with a complexity that obviously did not originate and exist only in space (since space is the effect of poverty and not the cause) and could not be tackled using this conceptual approach.
The map illustrated the historical context of a city that tried to pinpoint the reasons and methods of a transformation in its drawn representation; in fact it is cited as a "historical" example of the use of representation as an approach to socio-economic and urban complexity.
Now I'll focus on another example of complexity: the maps by Olavarría and Salta (figs. 9, 10).

Considering the origin, location and size of the two cities, it's certainly difficult to imagine urban complexity. In fact, spatial simplicity is reflected in the representation, in the two maps portraying the urban drawing with its places of historical interest and services.
Nevertheless, it is ontologically interesting due to the simplicity of the urban drawing and orthogonal grid which, quite apart from its history, recalls a possible method with which to transform the Earth, again using drawing present in every map. From the small to large human scale.
Regarding this issue I'll briefly comment on the second plan of Buenos Aires made by Juan de Garay in 1583 (fig. 11). A simple division of land; a map of the lots assigned to the founders of the city. A map showing the human radication that triggered the change mentioned by Gravano: from a landscape to an urban landscape [Gravano 2016, pp. 50, 51] based on the relationship between man, space and representation.

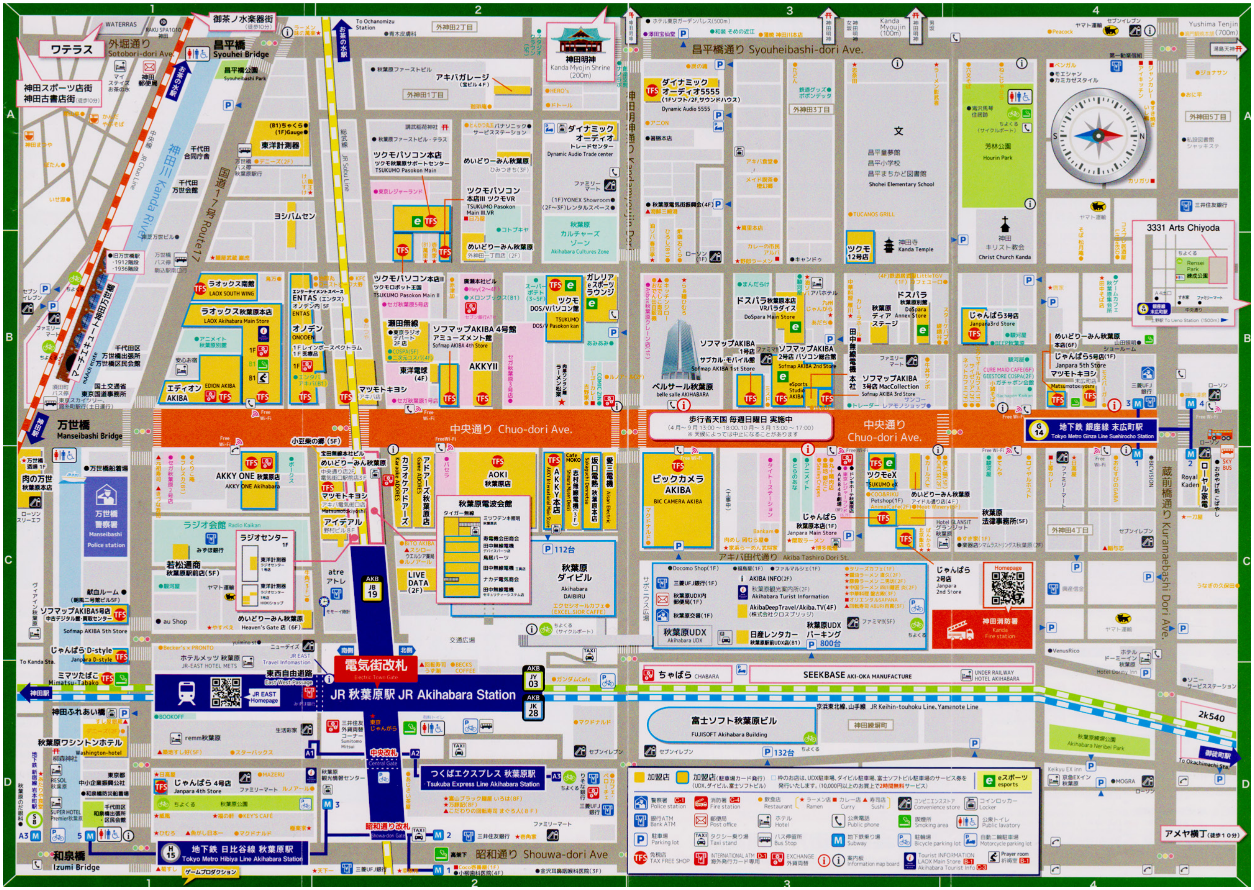

Fig. 8. Akihabara Map Electric Town. Shop Guide 2019. Akihabara, Tokyo Japan. Map, property of the author. (above) Detail of the area around the JR Akihabara Station.

The complexity of representation. Simplexity

After focusing on maps as representations of urban complexity, I will now concentrate on the complexity of representation.
Two complexities are evident when studying the maps: one relating to space and the other relating to representation, i.e., relating to the way in which space is represented in a map.
First off, in the previous paragraph a reader may have already recognised the representation of space as something simple rather than complex.
But now we're focusing on another issue.
Earlier I said that the complexity of urban space is "managed" in maps by the simplicity of its representation. A simplicity which, by deciphering urban complexity, allows an individual to understand its complexity and "use it", i.e., use the map. This use can be defined as the first level of use of a map.
Now I will analyse a second, more in-depth psychological use that allows individuals to perceive space and interpret it, linking their action to the represented space.
In this second level of use, the complexity with which space is represented determines a different involvement of the individual; this involvement increases gradually when simplicity is superimposed on complexity until it becomes a "complicated simplicity", in other words a simplexity [Berthoz 2011, p. XI].
The criteria that can be adopted is still that of simplicity, focusing on a complexity-simplicity crasis, this time based entirely on representation.
The result of this (second) crasis is a representation that can be defined as "simplex", reminiscent of Alain Berthoz's theory of simplexity [2011].
Berthoz writes that simplexity is therefore a decipherable complexity, i.e., it is *complicated simplicity* because it is based on a rich "combination of simple rules" and that this neologism indicates one of the most amazing inventions of living organisms, applicable at various levels of human activity, from the molecule to thought, from the individual to intersubjectivity, and on to consciousness and love [Berthoz 2011, pp. VII, XI].
I would like to point out that I consider simplexity as a theoretical paradigm; the multiple references to space and architecture made by Berthoz himself [Berthoz 2011, pp. 151-155] appear in an interdisciplinary form-problem that can be solved using simplexity.
In fact, when Berthoz writes that the corner of a street is a place where simplexity should dominate, that the roof is "a simplex gesture" or that stairs represent a symbol, a relationship, a transition between the inner world and the outer world [Berthoz 2011, pp. 153, 154], he talks about the simplexity of space (corner, roof) and its social and psychic perception (stairs). But this is not all he talks about.
He also explains how space becomes simplex (e.g., a space-corner). He writes that the corner [of a street] can be cut, thus allowing vision, that always anticipates a change in direction, to guide the way, so that we do not come face to face too abruptly with someone else [Berthoz 2011, p. 155].
(By trying to summarise I come closer to simplex representation).
When a person turns a corner he determines a complexity of space that can be simplified by cutting the corner. This simple "cut" makes space simplex.
So, if a physical "cut" simplifies the complexity of real space, how is it possible to simplify the complexity of representation, and make it simplex?
Clearly Berthoz does not offer direct answers but references to that "combination of simple rules" on which simplexity is based.
References he promptly provides. In fact he writes that in a complex world simplification is never simple and requires instead that we choose, refuse, connect and imagine [Berthoz 2011, p. XI].
While bearing in mind that every map represents the drawing of a complex (urban) world (space) that must be simplified, the above are the keywords needed to create urban maps in which material and immaterial phenomena, problems and solutions coexist.
According to Berthoz, drawing is in itself "a simplex mental tool" [Berthoz 2011, p. 143], and in this case its simplexity is required to involve the individual who links his action to the represented space.
The next paragraph will present two examples of simplex representations.

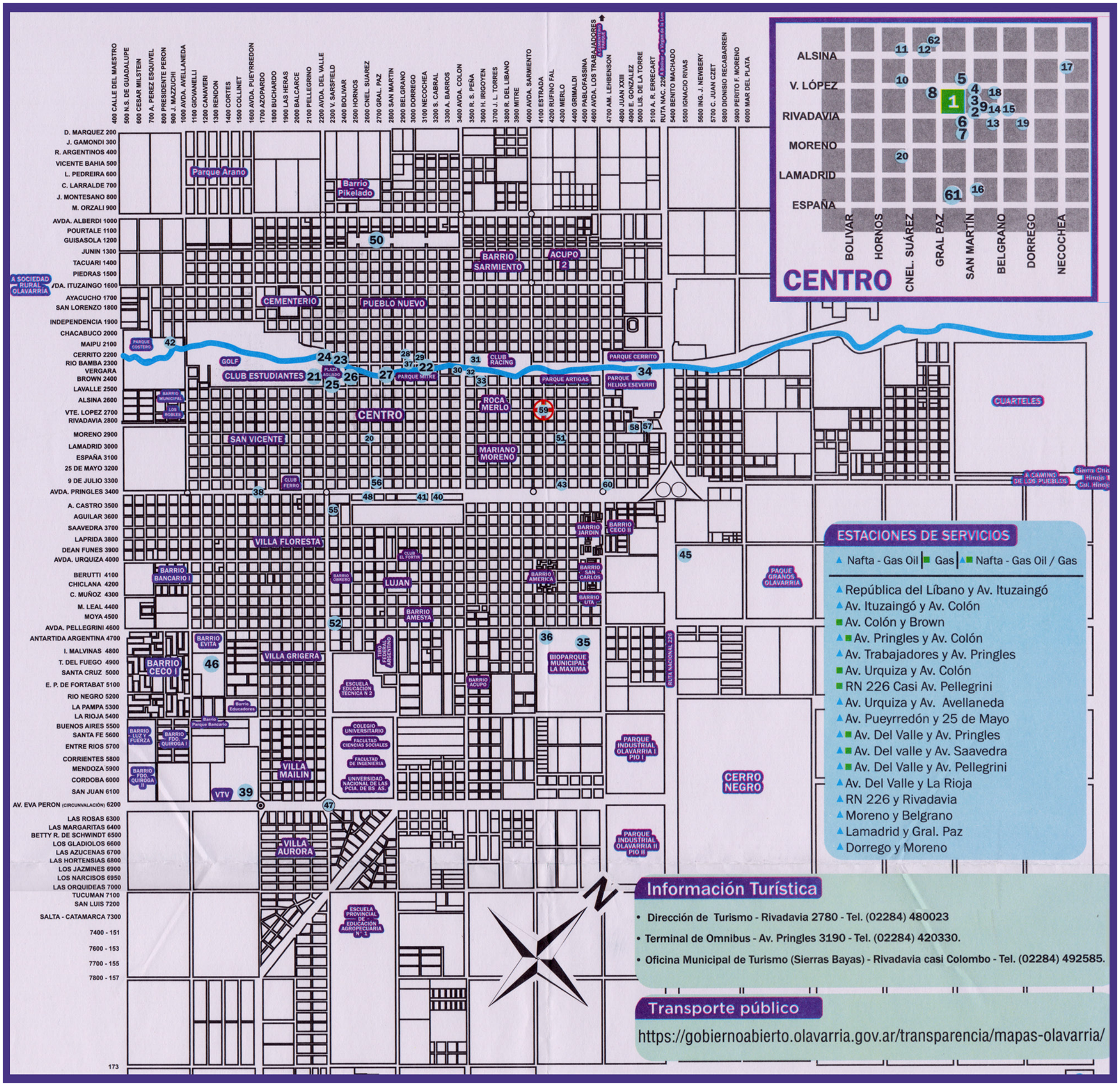

Fig. 9. Olavarría, Tourist Map, 2019. Olavarría, Province of Buenos Aires, Argentina. Map, property of the author.

"Simplex" representations

One example of simplex representation is the map of the New York subway drawn by the designer Michael Hertz in 1979 [6] and still used as a basis for the current map (fig. 3).
Hertz superimposes the numerous subway lines on the form of the city, but he also reveals its fabric. By introducing several physical-spatial elements in New York into the map (urban drawing and transportation) he represents a greater level of complexity.
However, Hertz's graphic strategy (reinterpreted using Berthoz's words: choose, connect, imagine) allows an individual to interpret and use the complex transportation system as well as identify his position underground compared to the space above ground. Hertz transforms the underground network into a surface network, turning what is actually more complex into something simpler and more decipherable. This involves psychologically simplifying representation by removing the uncertainties and fears associated with being underground. This idea is confirmed by the psychologist Arline Bronzaft who worked with Hertz on the map: "It was the 1970s [...]. people were fearful of going on the subways. [...] We wanted people to use the map to see the sights of New York" [Bronzaft, 2004].
A graphic and methodological revolution broadening the map's objectives and encouraging individuals to relate to their actions in space (movement in the subway).
The map was innovative even compared to the previous map drawn by the designer Massimo Vignelli in 1972 and now in the MoMA in New York [7]; in Vignelli's map the subway lines are represented over a simplified and chromatically abstract urban form.
In most cases, the standard, up-to-date maps of the subway system isolate the lines from the city's fabric (also to avoid graphic overload); as a result the urban form and the size of the city can be interpreted and perceived thanks to the greater or lesser number of lines. For example in the map of the Tokyo subway (fig. 3). It is another simplex representation where the dense network of underground routes, drawn against a completely white background, renders the complex urban density above ground and also illustrates another space (underground); the complexity of this latter space is created by the links between places, identified by their name and reciprocal proximity.
The map not only provides the extensive information required for people to use it, it makes that information visible by using abstract graphics which, semiologically speaking, are entrusted to plastic elements: i.e., colours, lines and space; the map also succeeds in deciphering the complexity above ground (as urban density) and representing the complexity under the ground (as connection). The fact there is no urban drawing appears to be a graphic strategy to encourage individuals to think of the underground as a structured and defined layer of the city. Another city with which to relate: the underground city.
In actual fact, apart from the objective graphic and functional features required to interpret subway network maps, the absence or presence of the urban drawing in these maps can become a conceptual choice regarding the city's structure; it can be designed and represented either in levels (e.g., the map of Tokyo) or as an ensemble, like a level that shows everything (e.g., the map of New York) (fig. 3).
Obviously in some maps, e.g., tourist maps, the urban drawing is crucial and necessary. The *Map Walking Tours* of Sydney (fig. 7) is one such map where three routes are illustrated and represented in the urban drawing.

Space-representation-the individual-action

It doesn't matter what kind of map is used (as illustrated by Hertz's work), an urban drawing allows individuals to decipher the geometries of space and associate them with the action they are performing, whatever that action may be (in Hertz, movement underground, in the map of Sydney, movement above ground). According to the mathematician Henri Poincaré "to localise an object in such a point of space simply means that we represent to ourselves the movements that must take place to reach that object" [Berthoz 2011, p. 131].
All this means greater interaction between the individual and the representation because it becomes an integral part of the individual's action.

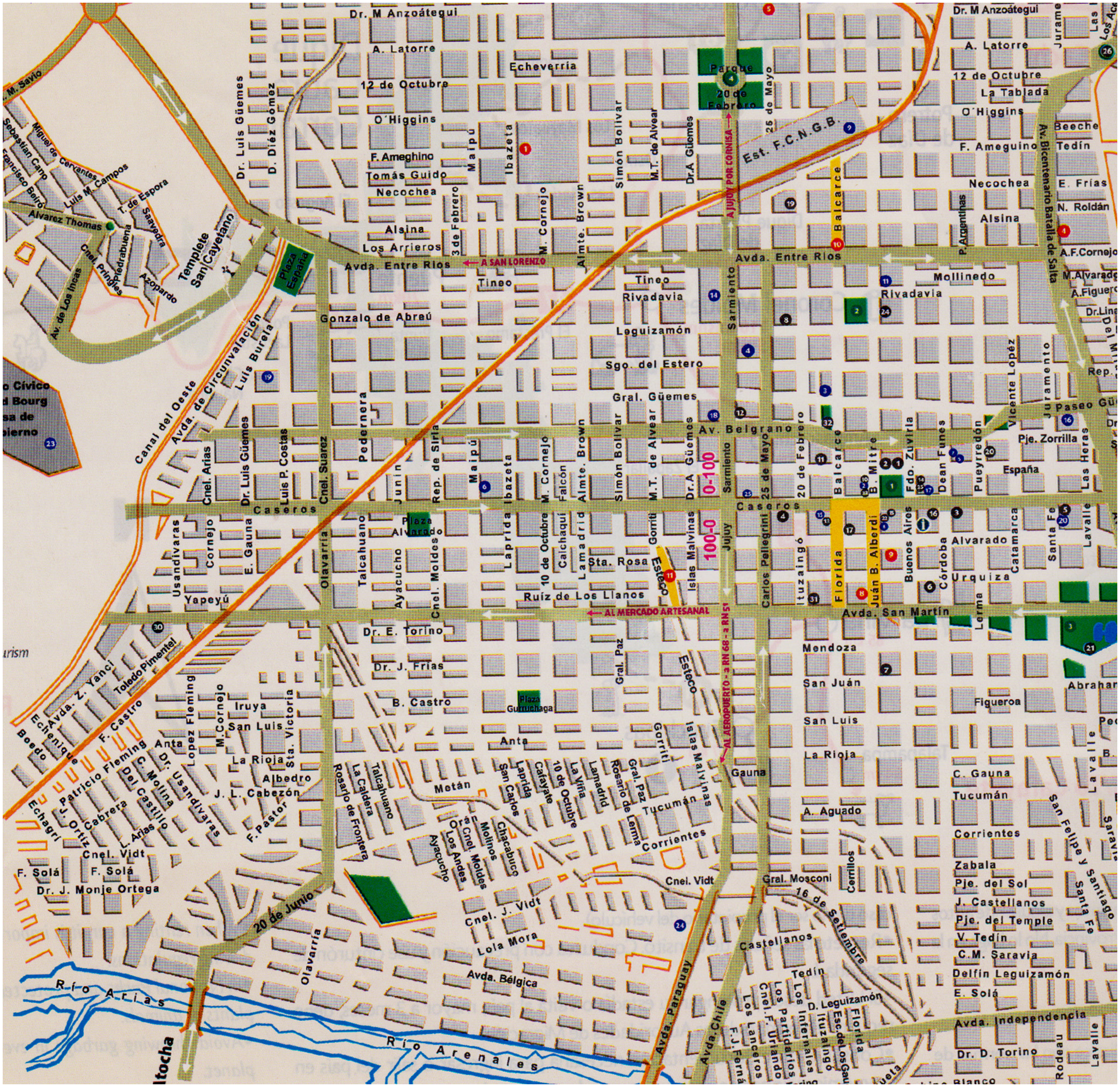

Fig. 10. Salta, Tourist Map, 2018. Salta, Province of Salta, Argentina. Map, property of the author.

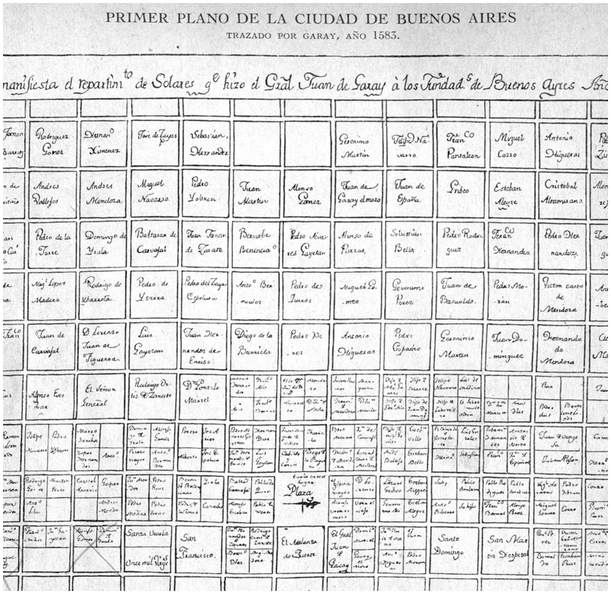

Fig. 11. Second foundation of Buenos Aires. Division and distribution of the lots by J.de Garay to the founders of Buenos Aires, 1583. Taullard 1940, s/p.

As mentioned in the introduction, man's ability to act in space is behind the individual-space-action relationship; it involves the vital impulses of the organism, propriocetion and kinesthesia as well as the wonderful, plastic ability to move in the environment [Morabito 2020, p. 16].
As concerns maps, these vital impulses are "managed" by the brain that performs a (spontaneous) pre-vision of the movement in space through its representation, allowing and triggering the kinaesthetic process.
(Please refer to my considerations at the beginning of this article regarding foresight as one of the brain's main functions).
The brain interacts directly with the map as if it were a real space; it uses space actively and not passively, because space, in real life – as per Merleau-Ponty's phenomenological tradition – is a dimension actively elaborated rather than passively received [Merleau-Ponty 2003].

Although linking the action to space through representation seems obvious, for psychological reasons (e.g., Hertz's map) or functional reasons (e.g., the map of Sydney, where space is the object of the action), deciphering the geometries of space can be linked, as stated by the philosopher and psychoanalyst Miguel Benasayag, to "processes of what we call 'geometric thought' [that] correspond to existing forms, bearing in mind that, in line with the definition by the French epistemologist Jean Petitot (1980), 'form is the phenomenon of the organisation of matter in general'. This means that [...] we process the reality of the forms [...] in the sense of what is manifest as forms in relation to other forms" [Benasayag, 2016, p. 132].
Then again, the urban, as a form of organised matter, is a complex of forms in relation to other forms; the reality of these forms is absorbed (processed) using the 'geometric' or 'topological' thought "that western tradition calls 'instinct'" [Benasayag, 2016, p. 131].

Conclusions

Conceptually speaking the representation of space in urban maps emerges as a solution to the spatial, social, psychological and anthropological phenomena and problems that coalesce and interact in the complex relationship (physically concentrated in the urban system) between space, representation, the individual and action. Within the framework of these representations, this can prompt further studies and interdisciplinary researches.
From a formal and functional point of view, the complexity of the urban system and city system – as an ensemble of interacting physical-spatial and social elements – is represented in the maps using simplified representation, i.e., using a figurative crasis between complexity and simplicity leading to simplex representations that interact directly with the brain and are capable of communicating all the data regarding the aforementioned physical-spatial elements in the maps (urban drawing, transportation, trade-tourism).

Notes

The original text of this essay is in Italian. English translation by the author. All the quotes from Italian books, books translated into Italian, or other Italian language sources, have been translated by the author from Italian into English.

[1] Item: Complexity. In Treccani. Online vocabulary, <https://www.treccani.it/vocabolario/complessita/> (accessed 2020, December 10).

[2] Certainly not exhaustive, neither for space nor for maps.

[3] These are details of the maps, useful for the analysis.

[4] The maps of Sydney and Salta only show part of these cities, while those of Tokyo-Akihabara and Olavarría show the whole city.

[5] Charles Booth, Maps of London Poverty. East & West 1889. London.

[6] With his studio Michael Hertz Associates.

[7] M. Vignelli, J. Charysyn, B.Noorda, Unimark I.C., NY, *New York Subway Map*, 1970-1972. See: https://www.moma.org/collection/works/89300 (accessed 2020, December 10).

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For communicating the complexity of images

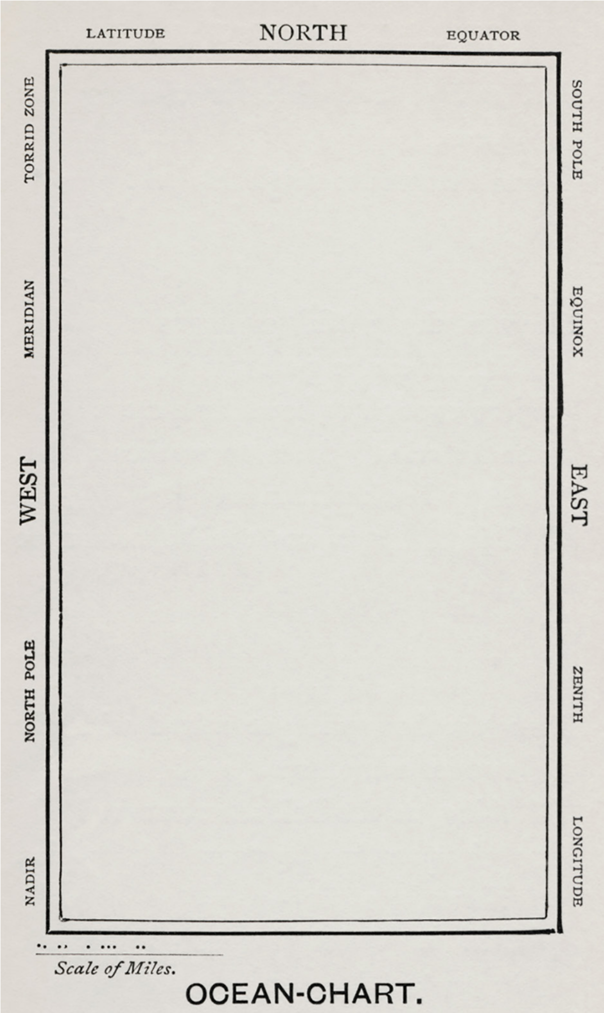
The Sense of Measure and Graphic Communication. Three Pranks, Two Studies and a Consideration

Edoardo Dotto

"*A buon intenditor poche parole*"; "A word to the wise (is sufficient)"; "*À bon entendeur, demi-mot (suffit)*"; "*mezza parola*": in practically every language (and in many dialects) there is a saying of analogous meaning. The meaning is clear: to communicate effectively with those who are experts, with those who are well versed in something and have a precise competence, very little is needed. No need to get lost in long speeches or detailed descriptions. 'A half word' is enough for the wise.
The theme of measurement and communication allows for reflection on this topic. The measure does not have –as lucidly pointed out in the call of this issue– an exclusive quantitative prerogative. Its qualitative connotation appears in many cases infinitely more relevant, especially when it comes to measuring –forgive the quarrel– the amount of information necessary to communicate clearly, without sacrificing complexity.
During a *Seminario di Primavera* in 1985, Franca Helg, with perfect synthesis, noted that "size is the foundation of form" [Helg 1988, p. 159], linking each graphic expression firmly and intrinsically to the measurement. There is no way to define a shape in the abstract. Its description covers the scope of the measurement and it is always declined in the field of measurability. Despite this, the number of measures

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. H. Holiday, Ocean Chart [Carroll 1876, pl. 4].



necessary to define it –which could be very high– can only be strictly limited. Describing through drawing is a complex matter. Being able to ensure that the graphic representation effectively communicates the shape is the result of the convergence of procedures, conventions, capabilities, even inspiration. Risking to relegate the description of the shape to the slavish rendering of its measures and to believe that the greater their number, the better the description we get, is one of the dangers that run in these years, in which it is easy to be blinded by the charm of the technical dimension of the graphic representation. Submerging a shape in the definition of its measures is likely to make us lose its meaning and make its communication ineffective.

In this note I would like to reflect precisely on this topic, that is, on the need to communicate precisely, without getting lost in the 'sea' of dimensions, details, to avoid that the narrative is fragmented and that the shape –be it graphic, spatial or other type– end up 'fading' and overshadowing. Recently, there is an increasing tendency to focus on mensural precision –which is quite different from the accuracy [Calvino 1993]– and we should probably ask ourselves why the spread of a modality that sometimes proves to be redundant and intrusive. In other words, the need to resort to the 'sense of measure' –however vague this expression may be– in the context of graphic communication will be considered.

The breadth of the theme requires reductive choices and the arguments used will be mainly analogical. In the following pages we will take into consideration some emblematic cases, two examples of conscious and clear management of the sense of measure and three blatant transgressions in this field. If the former concern the well-balanced practice of two expert architectural scholars, the others are examples drawn from the substantially graphic repertoire of writers, designers and humourists who, precisely because of their natural attendance with oxymoronic thinking, are able to show clearly how much the lack of sense of measure determines the collapse, the disaster in the communication.

Three pranks

Regarding the narrative scheme of Conan Doyle's stories that have the most acute Sherlock Holmes and the distracted doctor John Watson as their protagonists, Carlo Ginzburg noted how nothing allows us to understand well how much seeing someone who does not understand [Ginzburg 1986]. Allowing the reader to witness an explanation, studded with doubts and specific questions, manages to make the logical path that leads to the discovery of the truth clear. In a similar way it can be useful –while remaining far from the intention to pursue any rigid truth– to consider three funny inventions, three cases described by writers, illustrators, designers, united by their ease in the territories of humour and sagacity. Our three authors, who obviously understand very well, pretend not to understand how necessary an adequate relationship is necessary between the act of measuring and its object, between the description and the thing described, precisely through measurement, generating three paradoxical situations.

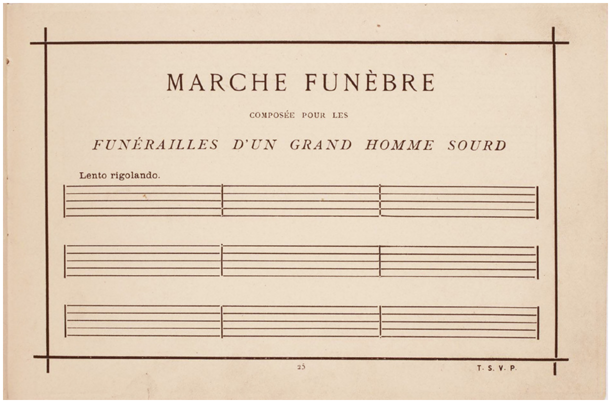
The ocean of Holiday

In 1874, at 35 years of age, the Pre-Raphaelite painter Henry Holiday, illustrated The Hunting of the Snark, a satirical poem of surreal taste written by Lewis Carroll [Carroll 1876]. Of the ten beautiful woodcuts depicting monstrous figures and caricatured characters, the fourth, an incredible map of the Ocean, is particularly surprising (fig. 1). Within a box dotted with scale and orientation indications that are inconsistent and contradictory, there is a completely empty field. The illustration, which simulates a geographical map, is composed of a free, perfectly white field. Although the frame evokes indications of measurement and location, the image is completely devoid of object. The representation of places is converted into the representation of non-place. The graphic 'liturgy' of measurement and orientation which in geographic maps generally occupies a prominent place –metric scales, compass roses and so on– expertly suggested in the frame, coexists with the lack of the measured object. A chess game without a chessboard seems to be taking place. It reaches the 'zero degree' of that relationship between the thing and its description which makes every representation theory indispensable and unavoidable. I have already used this illustration as a stimulus for reflection on other [Dotto 2011] topics –as proof of how emblematic and stimulating a 'zero degree' representation can be in different areas– and I think the amazement, the vertigo that this image is capable of generating lunges above all in its ability to make reference points and scale lose, not to allow deciphering –even accepting that it is an image of an ocean– any indication of the vastness or limitation of the field represented and, together, not to allow the observer to recognize his own measure with respect to what the author wants (or pretends to) represent.

The silence of Allais

The last part of the *Album primo-avrilesque by the comic author Alphonse Allais of 1897, reported by the Marche Funèbre Composée per le Funérailles d'un grand homme sourd*, two pages of pentagrams [Allais 1897, pp. 25, 26] on which no note stands out (fig. 2). The image is suggestive and fun and feeds on the absurd causal relationship that links the need for funeral music not so much to the funeral pump set up for the guests as to the auditory sensitivity of the deceased. Although the musical key is also missing from the score, its function would be to provide a reference for reading the notes –non-existent, in fact– the song is divided into 24 bars (which are also called 'measures') and also reads an unusual indication of time, "*lento rigolando*". Allais makes us imagine the solemnity of a sumptuous funeral –let's not forget that a grand homme is celebrated– in the silence of the execution, marked and measured by a precise duration with a slow tempo. Incidentally, after 55 years, in a completely different world, John Cage conceives a similar piece, *4'33"* written in 1952, and proposes its performance in concert halls, showing how the measure of silence hypothesized by

Fig. 2. A. Allais, Marche Funèbre Composée pour les Funérailles d'un grand homme sourd [Allais 1897, p. 25].



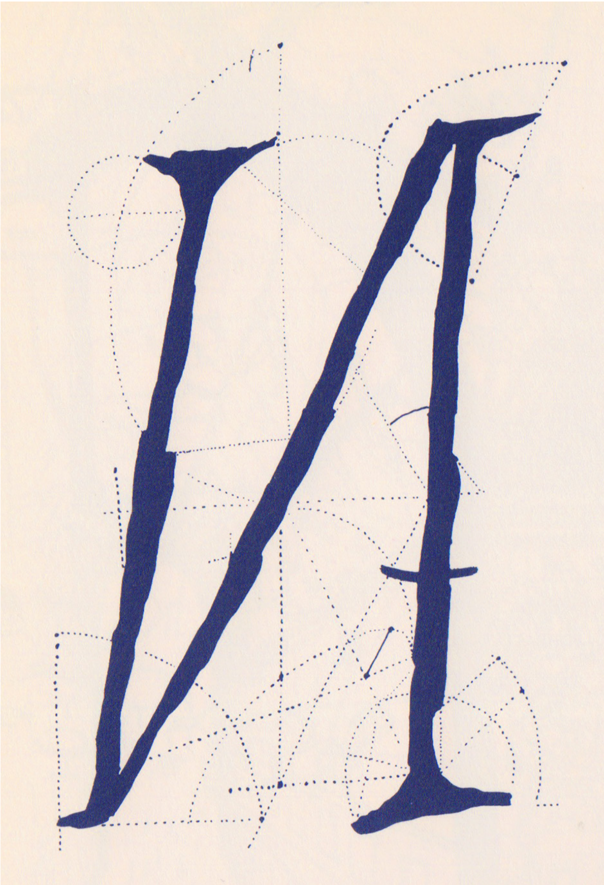


Fig. 3. S. Steinberg, untitled [Steinberg 1949].

Allais and described as a refined *boutade* will be able to support other reflections and above all how that silence, precisely because measured, detailed and shared, can be configured in a different way each time. From a musical point of view the invention of Allais and the piece by Cage –however, we have to distinguish– including the measure of time, exclusively connote a temporal context that would otherwise have been dissolved in the oblivion of common days and which instead paradoxically listened a trace of unrepeatable density. These pages of Allais are the precise image of the measure itself, the outcome of the act of measuring itself, the tangible sign of the measure regardless of the measured object which, like any silence, cannot have an occasional and at the same time casual connotation, undefinable; this is precisely what will not be able to characterize any programmed sequence of sounds or any structured musical form.

Steinberg's letter

Among the hundreds of drawings, photographs, photomontages that the Romanian designer Saul Steinberg composes in his volume *The Passport* of 1949 [Steinberg 1949], towards the middle –the pages are without numbering– a strange shape appears, a letter 'N' traced backwards with unsteady hand, incoherent sticks, deformed graces (fig. 3). A little more than a gouge, in a proper sense. The shape, however, is literally surrounded by dotted dials, thin segments, hatching, which describe a deep attention to the metric and angular measurements of that letter. Surrounded by so much attention, the gouging appears even more unworthy, deformed. The oxymoron formed by the collapse between the obsessive attention to the measurements and a shaky sign supports the comic effect and opens the door to a trail of reflections –as it always happens in Steinberg. Is it possible that the letter, if surrounded by so much interest, is less ugly than it appears to us? Is it possible that the punctual interest is deserved and that any apparent deviation is desired? Could it be that it was traced precisely on the basis of that dense conglomeration of measures? Of course not. We are definitely seeing an immense attention to sizes, an oversized interest. Steinberg's drawing shows a misplaced pedantry, a meaningless effort, an empty obstinacy aimed at describing characteristics without any quality. An effort driven by a prejudicial interest, perhaps, whose effectiveness is null and whose end is untraceable.

Two studies

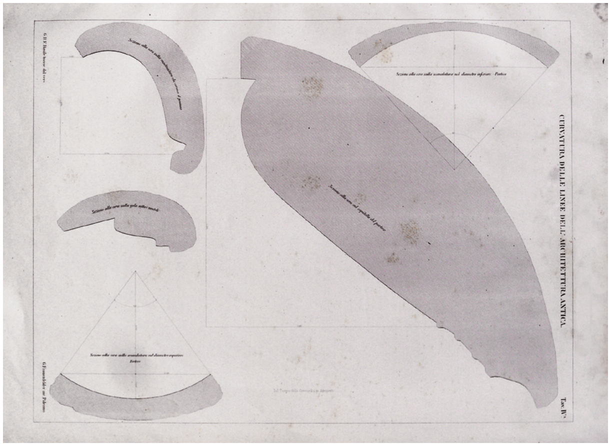
In reality, probably nothing allows us to understand as well as looking at two authentic masters at work. Over the years I have repeatedly come across the work of two characters of extraordinary calibre. The one is a great nineteenth-century architect from Palermo, Giovanni Battista Filippo Basile, also known as a scholar of ancient Greek architecture. The other is a Sicilian intellectual, passionate about medieval architecture, Domenico Benedetto Gravina, who completed an extraordinary work on the Cathedral of Monreale. They are two authentic experts in their field, two scholars who have left an indelible mark on the historiography of Sicilian architecture. We will consider only two episodes of their work, two details unsuitable to describe the importance of their commitment but which are useful within our reflection on the appropriate use of measurement in graphic communication.

The continuous line in Basile's surveys

In 1884 Giovanni Battista Filippo Basile published *Curvatura delle linee dell'architettura antica con un metodo per lo studio dei monumenti*. Epoca dorico-sicula [Basile 1884; Dotto 2012], a work in which he studied three monuments in the Agrigento area focusing his work –in the wake of the pioneering works of Joseph Hoffer, John Pennethorne and Francis Cranmer Penrose of a few decades earlier [1]– on the study of the curvature of the lines in Greek architecture. Basile illustrates in detail some ingenious methods for detecting the sections of these curves he himself experimented. He proposes, among other things, to create wax casts on the surfaces, to cut the casts according to a plane that –for the capitals, for example– passes through the axis of the stems of the columns and to trace these perfectly coincident sections on paper, after a patient work, with the shape of the volume generators. The attention paid to the survey of the measures is tangible and Basile is interested in taking into consideration the shapes "in their actual size, without any alteration, that is, the exactly true, autographed lines traced by the Greek artist during the construction time" [Basile 1884, p. 3]. Many details are drawn '*al vero*' in the large format plates that accompany the short volume of text and the floor plans of the temples are quoted in millimetres. The object of the study is the monument in its real form, protected from idealizations that can lead us to build abstract models, seductive as fallacious. On this Basile it is extremely clear: his purpose is to measure elements which really exists, without forcing in any way the survey in order to obtain perhaps more captivating drawings that do not represent the real monument.

In the period in which Basile writes, the survey technique benefits from the diffusion of many innovative tools. Traditional instruments are revised in the light of new technological acquisitions that allow unprecedented precision and are made on the basis of those for the celestial survey. Basile however –while exhibiting a *nonchalant* competence also on new instruments– continues to use, substantially, ruler and level, exploiting them with acumen and patience. The material with which most Sicilian Doric monuments are built, a beautiful golden and porous limestone, does not allow to enjoy smooth surfaces, especially thousands of years after the building phase. Basile is consequently found to detect surfaces full of imperfections, gaps, abrasions, washed-out and corrupt parts. Attention to the millimetre, in this condition, can only appear pleonastic. The interest in the monument and its authenticity, in its physicality, in the graphic restitution of the survey, in the construction of the plates, in the communication of the results must leave room for a more complex vision, far from rigid and prejudicial, towards the forms detected. In fact, his drawings do not show stunted shapes, interrupted by the natural fractures of the stone surface but

Fig. 4. G. B. F. Basile, "wax" survey of details of the Temple of Concordia in Agrigento [Basile 1884, pl. VII].



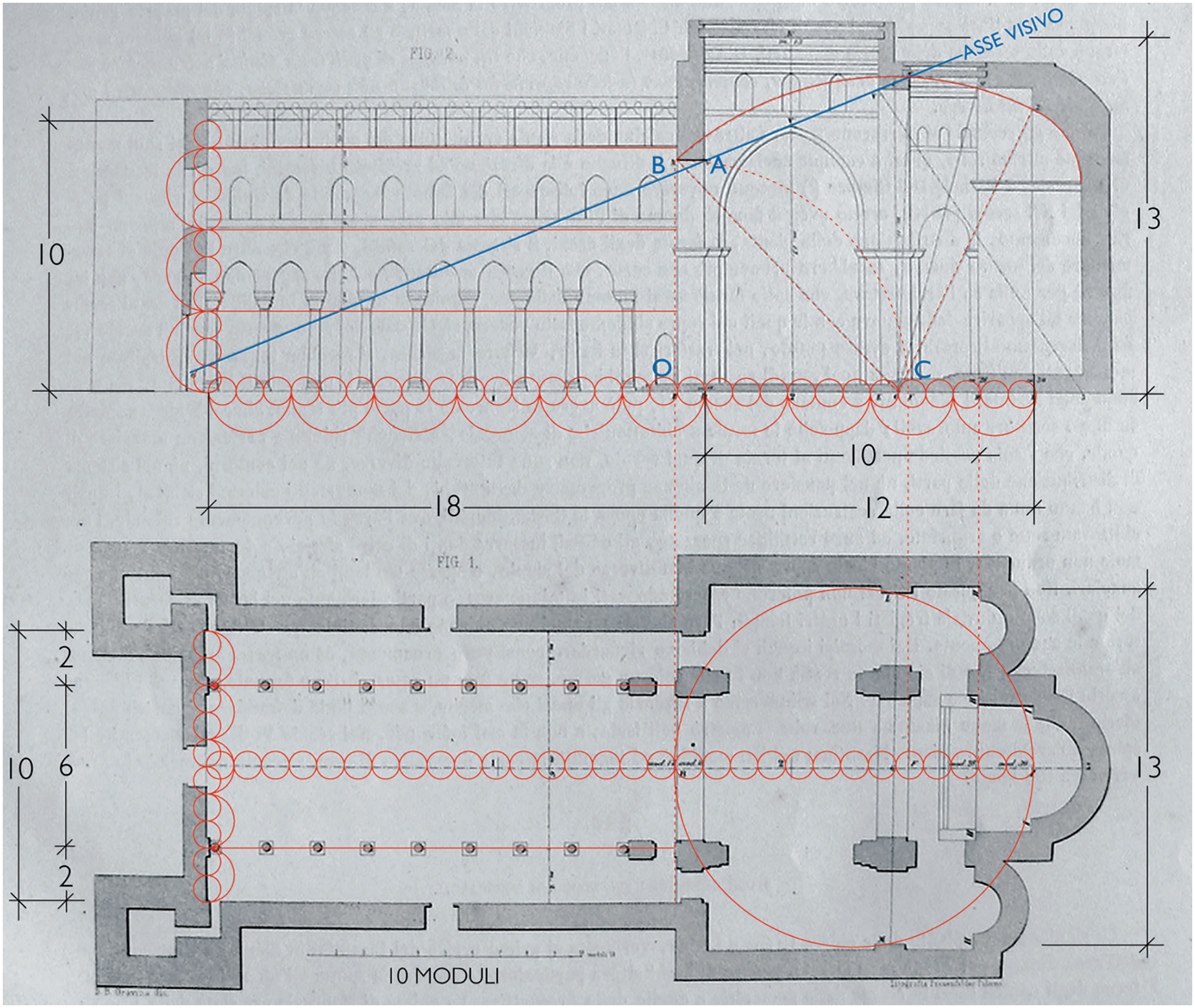
rather continuous, fluid and elegant lines (fig. 4). The ambition to propose the results of a survey that is as impersonal and mechanical as possible is broken by the need to provide a coherent reconstruction of the forms, so much so that if it is not possible to "find the entasis, the capital in a well-preserved column, the grooves and more" [Basile 1884, p. 42] it is necessary to compose elements of different parts to obtain an accomplished design. In the same way in graphic restitution of the intercolumns it may happen that it is necessary to put aside the precision of the survey and "correct some slight defect in execution, which can always happen in human works" [Basile 1884, p. 42]. Basile faces similar situations in the redrawing of the entasis –"by adapting the rule near the point we see that only a millimetre is missing so that the inflection will vanish" [Basile 1884, p. 34]– correcting the survey by the means of drawing.
Are Basile's surveys false or incorrect? Absolutely not. Basile's approach shows a disciplinary maturity that allows him to finalize his careful –even pedantic– approach to taking measures. In communicating the results of his studies he appeals to all his culture, his acumen and his experience and proposes readable and pleasant, intense and mature plates, in which, even more than his respect for precision, a deep sense of measure emerges in knowing how to balance study and story, clarity and precision, intention and outcome.

The prudent analysis of Gravina
When between 1859 and 1870 in Palermo the work of Domenico Benedetto Gravina Il Duomo di Monreale, *Illustrato e riportato in tavole cromolitografiche* was published [Gravina 1859-1870; Dotto 2009], the interest in Sicilian medieval architecture and in particular in those belonging to the so-called Arab-Norman vein has already produced dozens of significant studies and surveys, so as to constitute an episode of great interest in Sicilian historiography. Gravina dedicates a monumental work to the study of the Cathedral of Monreale, directing one of the most amazing masterpieces in the history of Italian publishing. To achieve it, he recruits and trains dozens of young and talented designers, gets a seat of the Neapolitan chromolithography Richter & Co. opened in Palermo, promotes the creation of a complete and original survey. The large-format work includes 90 color plates in which the most diverse and modern methods of graphic communication are explored. Of this varied and generous work that deserves much more consideration, we will consider only one aspect, rather reduced. On page 53 of the text volume there is a black lithograph of the plan and the longitudinal section of the Cathedral (shown here with the overlap of some geometric constructions and metric scans) that Gravina uses to illustrate a passage of great importance (fig. 5). As a profound connoisseur of Sicilian architecture and metrology, Gravina also dedicates himself to the modular reading of the plan and section of the Duomo and measures its proportions with intelligence by putting forward some effective and convincing hypotheses on the geometric layout, carrying out what we would now call a graphical-geometric analysis. He proposes a reading for the layout of the section which provides for the construction of an ascending visual axis that crosses the building in depth and which precisely determines the height of the arch of the presbytery. What is important remarking is that although Gravina possesses a very precise survey –for those times, obviously– and therefore has the dimensions of each part and element, he manages to resist the temptation to deepen and decline the analysis up to consider minor details. Gravina writes: "Various other less interesting investigations, and more subtle observations, we believed to neglect them, both because of less interest, and not to be accused of minuteness, or even idealism, in things that could be reputed due to chance, and never to the depth of science. What was said is enough to give the reason for the architectural beauty of a monument, in which a softness of style reigns, and a harmonious severity as a whole" [Gravina 1859-1870, p. 53]. Gravina succeeds where sometimes many of us fail: he develops an in-depth analysis and shares only the most convincing part of it, he stops after reflecting on the general system, he avoids "minuteness" and "idealism". In essence, he elegantly identifies the limit beyond which the hypotheses become confused, the clarity is less and the anxiety of completeness –a true enemy of good graphic analysis– takes over and risks tarnishing the results. In other words, he shows his ability to consciously use his sense of measure.

A reflection

What is the difference between the three pranks and the two studies? What makes the two studies exemplary cases and the three pranks paradoxical situations?

Fig. 5. D. B. Gravina, graphic analysis of the Cathedral of Monreale, with overlapping (by the author) of modular schemes and measures [original drawing in Gravina 1859-1870, p. 53].



Our three humourists ostentatiously flaunt an unconscious and obtuse attitude. Holiday shows that he cannot represent the object of his drawing and ends up not even knowing the orientation of his map, suspending us in a scalar limbo, leaving us without references and making us float in absolute indeterminacy. Allais pretends not to have understood the relationship between measure (time) and the measured object (music) and shows us how measurement, the act of measuring, can even be independent of its object, how measurement can constitute a sort of theme in itself, autonomous, not dependent on the quality of what is measured (which does not exist in the present case). Steinberg, on the other hand, pretends not to understand that the obstinacy in studying the dimensions of the doodle is completely superfluous and that the distance between the act of measuring and its object, between the gouging and the fury in measuring it, shows –in this case excessively, while in Allais the opposite happened– that the relationship between form and measure does not naturally arise in a harmonious way but rather that it must be meditated and evaluated. This is only possible by appealing to your sense of measure.
The two scholars, on the other hand, show great competence in their fields and manage to impeccably dose the relationship between measure and measured object, bringing communication on a level of effectiveness and absolute common sense. The use of dimensions –the basis of the representation of the curves of the temples or of the analytical reflections on the shape of the Duomo– is absolutely adequate, exact, and aimed intelligently.
Similar conclusions could also be reached by exploring different areas. Until a few decades ago, cooking recipes were indistinctly dotted with the acronym Q. s., '*Quantum sufficit*', usually referred to salt, spices, however to ingredients whose quantitative contribution is very delicate and can transform delicacy into disaster. It was sufficient to recall the chef's skill and sense of measure without going into precise quantitative descriptions (8 grams of salt, a shaved coffee spoon). They made direct appeal to his experience, his knowledge and his manual skills. The recipes that an ancestor of mine, a baker, pinned on his notebooks were resolved in a few lines: a list of ingredients, the temperature of the oven and, sometimes, the cooking time. The recipes written for the offsprings, generally profane, were extensive descriptions of the gestures to be made to prepare the doughs, of their sequence, of the intermediate stages and even reported the risks that are run if you work differently than recommended. Years ago I heard a shipwright, a boat builder, claim that the projects consisting of drawings accompanied by precise measurements are made for the ignorant and that he was able to make a boat, exactly as desired by the client, only using wisely a small instrument –the 'mezzo garbo'– which he used to shape the planking and therefore to give shape to the hull. The communication between the client and the manufacturer took place verbally, at most indicating two or three measures of the boat, and this was enough. Something similar happened in the construction of architecture when the language of architectural orders was used. The architects and the stonemasons often referred to the knowledge of a common lexicon, perhaps taken from an architecture manual or a treatise, often Vignola's or Palladio's one. There was no need to communicate the shape of the mouldings, to draw the Ionic volutes, the Corinthian acanthus leaves. Each stonemason knew perfectly how to operate from essential indications. A good connoisseur, few measures.

Conclusions

In a paragraph of Il sipario dedicated to the nineteenth-century Austrian writer Adalbert Stifter, Milan Kundera frames an essential aspect of modernity that has to do with the "existential meaning of bureaucracy" [Kundera 2005, pp. 143-145]. The bureaucratic organization –says Kundera quoting one of Stifter characters– is such as the result of a system that "ensures that the necessary operations were carried out despite the heterogeneous competence of the officials distorting or weakening it". In other words, the fragmentation of knowledge and skills, the redundancy of functions and procedures is a passive defence against the possible incompetence of some element of the complex mechanism of the functioning of the state, whose understanding can –and perhaps must– escape to each individual.
With the support of renewed technologies, graphic communication, in fields ranging from medical research to the survey of architecture, seems to have taken a similar approach with conviction. Partially automated data capture procedures provide multidimensional matrices whose reading eludes common procedures. In many cases an automated data skimming is indispensable, perhaps with the support of modern algorithms. The taken data are so

many that in their apparent homogeneity they can appear silent and distant, unable to communicate any knowledge of reality. In this way, the knowledge that we outline, in fleeing the risk of an inadequate interpretation, ends up by not suggesting any. By supposing that we are freeing ourselves from the risks of personal discretion and from the arbitrariness of subjective interpretation, we end up delegating responsibility for understanding things to schematized procedures. In different fields –from evaluation procedures, to quality assurance practices, to the drafting of architectural projects– protocols are created which, in an attempt to avoid the intrinsic risks in the discretion of the intellect, promote the application of methods of taking and communicating measures which reduce our control over procedures. This mode has certainly shown its strengths several times. From the construction of legal strategies based on extensive repertoires of trial data to the search for procedural methods for the creation of vaccines, the assumption of formidable quantities of measures whose processing is entrusted to the computing power of generative algorithms has already produced convincing results. As a slogan of Comscore [2] says, a leader company for communication strategies on the web, "Making Measurement Make Sense". There is no doubt that this method constitutes the most promising path to follow for the construction of knowledge that has effective repercussions in the operational sphere. What worries is the although absolute impossibility of knowingly and autonomously managing stocks of such large measures, at least without delegating their reading to automated procedures.

If the use of the sense of measure determines effective communication and allows a profound understanding of the phenomena –specifically those described through the graphic signs– that is rooted in the competence and awareness of individual people, standardized procedures that start with immense data acquisitions constitute, in fact, the renunciation of understanding and a sort of institutionalization of our individual ignorance. The accumulation of measures beyond any apparent need –as in Steinberg's drawing– risks not only to remove any relationship with the object of measurement –as in Allais' music– but also to transform the field of our actions into a silent, impenetrable place, without references points –like Holiday's map.

In the Stifter novel quoted by Kundera, the protagonist renounces his role as a senior public administrator and moves to the countryside to attend only places, people, situations of which he has full knowledge and personal awareness. Rather than an escape of this kind –an epic and twilight response together– the challenge facing us and that concerns the sense of our modernity is to find a complex synthesis, a virtuous balance between the abysses of the fragmentation of knowledge and the fullness of individual awareness, between the application of shared procedures and the assumption of responsibility for judgment. And even in this case the solution can only benefit from our sense of measure.

Notes

[1] Sisa J. (1990). Joseph Hoffer and the Study of Ancient Architecture. In *Journal of the Society of Architectural Historians*, vol. 49, n. 4, pp. 430-439; Pennethorne, J. (1844). *The Elements and Mathematical Principles of the Greek Architects and Artists*. London: Pennethorne, J. (1878). *The Geometry and Optics of Ancient Architecture, London: Williams & Northgate*; Penrose, J. C. (1851). *An investigation of the principles of Athenian Architecture, Or The Results Of A Recent Survey Conducted Chiefly With Reference To The Optical Refinements Exhibited In The Construction Of The Ancient Buildings At Athens, By Francis Cranmer Penrose, Archt. M.A., Etc. Illustrated By Numerous Engravings. Published By The Society Of Dilettanti*. London: Printed By W. Nicol, Shakspeare Press, Pall Mall. Longman and Co., Paternoster Row, And John Murray.

[2] <http://www. comscore.com> (accessed 2020, June 24). On the topic of the collection, automatic processing and impenetrability of computer data, see the recent and essential Zuboff 2019.

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Measuring the Immeasurable. Communicating Perspective-Based Painted Spaces to the Blind

Barbara Ansaldi

Abstract

This paper deals with the challenge of making perspective-based painted spaces tangible and accessible, and therefore measureable, by those who cannot rely on sight. Is it possible to do so by means of alternative channels? The answer to this question can be found in the tools of representation: the space obtained through the reversed procedure of linear perspective allows the creation of a three-dimensional model of such space that can be explored through touch. Architectures painted according to the principles of perspective have been historically translated into tactile language by resorting to the bas-relief. The research presents a reflection on such didactic device, suggesting the application of accelerated solid perspective to the restituted space. In this way, distortions and convergences resulting from the application of the rules of perspective can become tactically perceivable. An educational model based on the comparison between the three-dimensional model of the actual restituted space and the one deformed by solid perspective is thus proposed, presenting the painted architecture of the Feast of Herod *(ca 1462-65) by Benozzo Gozzoli as a case study. The multisensory approach represents an extremely inclusive strategy: indeed, the communicative-didactic apparatus based on the involvement of extra-visual senses must be imagined and conceived as accessible for a diverse audience. As a consequence, any user can add a surplus value to their own experience, changing their own yardstick regarding the work of art and discovering a new way to relate to it.*

Keywords: blindness, perspective, touch, multisensory communication, painted spaces.

Introduction

"Measure what is measurable, and make measurable what is not so". Galileo Galilei

We mainly rely on sight to "capture reality", to grasp its features, to analyze its details, to measure its components. The supremacy of sight over all other senses is centuries-old, especially when we need to relate to the complexity of images or to resort to the privileged means of studying the visible: drawing. Most of the art produced since the Renaissance is crossed by the hidden lines of perspective, which serves as its frame, its scaffolding and its supporting structure. For instance, the position of the vanishing point guides our gaze, establishing the prime location of the observer; in addition, the convergence of vanishing lines mimics the functioning of sight, chasing the axiom of visual realism. Perspective rules the composition while unifying time and space in a *continuum*. Perspective-based painted spaces are geometrically constructed, therefore they can be fully measured: it is consequently possible to translate them into three-dimensional models that can be explored through touch. Reflecting on the accessibility of perspective-based paintings by a visually impaired audience does not simply mean to design a mere compensatory measure addressed to a minority of users who cannot rely on sight. Being able to 'touch' the distortions resulting from the application of the rules of perspective can be rather seen as a chance of knowledge enrichment also to sighted users, who discover they can see more –and better– through a new, alternative way to experience the work of art. For centuries, the museum environment has been regarded as the "empire of sight" [Stewart 1999, p. 28] and as a place of contemplation, therefore we are not used to employ other senses in our relationship with art. Designing an educational model for the 'translation' of perspective into haptic language actually means to design an innovative way to experience artworks which fully embodies the spirit and the truest, most authentic meaning of inclusion. Inclusion intended as a process of re-arrangement and re-organization of the context that, triggered by the request of someone who is "outside", 'forces' those who are "inside" to re-negotiate lexicons, procedures, institutions. In the *17 Sustainable Development Goals* (or *Global Goals*) of the 2030 Agenda, inclusion of people with disabilities is often mentioned in relation to different issues, including the participation in cultural life and the fruition of cultural heritage. Dealing with a disability can be compared to art making: in both cases, community rules are subverted, repressive and paralyzing norms must be shaken and expressive means and cognitive processes are constantly reinvented, revealing the unpredictable fragility of the human condition.

From reality to its representation: blindness and perspective

Whether it happens through touch or sight, the aesthetic experience is "imaginative" [Dewey 1951, p. 128] and it consists of the mental image that each one of us creates on an intellectual level. Assuming that people with disabilities can live an aesthetic experience [1], the main issue to investigate is the relationship between perspective (or, more in general, projective geometry) and visual impairment. The debate over this problem is still open and controversial and, according to Mazzeo, there are two main psychological theories: the first one is the *visuo-amodal* theory, supported by John M. Kennedy, according to which there is a visual component in human perception of space which substantially cannot be eliminated, as if it was *a priori* category or an invariant of human species; the second one, the *synesthetic hypothesis*, believes instead that space can be acknowledged by blind people only through the remaining senses and in its volumetric and tri-dimensional nature [Mazzeo 2008, pp. 117-118]. The Canadian psychologist Kennedy claims that non-sighted people access perspectival representations basically just like sighted individuals do, as he observed in both early and late blind individuals' drawings the ability to reproduce features that are typical of visual perception, just like perspective, which depends on a viewpoint and on distance. According to the scholar "perspective is an ever-present influence on perception, tactual as well as visual, but how it operates is not always well understood" [Kennedy 1993, p. 180] and the most significant example he brings in support of his assumptions is the case of Esref Armagan, a congenitally blind Turkish painter whose artworks show the ability of mastering one-point and two-point perspective [Kennedy, Iuricevic, 2007]. It follows that also a congenitally blind person can comprehend and master the principles of perspective as a way to represent reality on a bidimensional support. However, it is also true that Armagan has practiced drawing for a long time, developing and refining his ability to understand and to reproduce features that belong to the functioning of sight. A blind user visiting a museum has hardly been trained to intuitively understand these spatial aspects, especially because, as de Rubertis points out, "non-visual thinking strongly refuses projective concepts, such as interposition and the apparent form of an object which changes depending on its position in relation to the viewer" [de Rubertis 2006, p. 7]. Therefore, a representation designed for an 'extemporaneous' fruition of a painting must be both educational and synthetic, as we cannot take for granted that a blind visitor has prior knowledge of perspective or that he has even practiced it. Consequently, the aim must be to make intelligible the scientific-geometric process, that, by imitating the functioning of sight, allows the transcription of a tridimensional space 'as we see it' on a bi-dimensional support, without assuming that a visually impaired user can intuitively understand and handle perspective projections. After all, even sighted people face difficulties when dealing with the transition from *perspectiva naturalis* to *perspectiva artificialis* on their own, even though they constantly experience the first one in their daily life. It is indeed remarkable that a discipline concerning operations that take place in a three-dimensional space can be explained and learned only through plane and bi-dimensional representations of spatial processes, to the point that this "is an obstacle also to sighted people, since that those who do not possess an innate sense of space find it difficult to handle images representing, in their projective distortions, the projective mechanisms causing the same distortions" [de Rubertis 2006, p. 7]. Geometrical-optical linear perspective can be understood only through a conscious cognitive process: it's a skill that must be learnt, like reading and writing, no matter how obvious the optical illusion of perspective convergence can be in the Western world, where it is generally considered the paradigm of pictorial realism. A 'scientific training' to linear perspective is instead necessary to acknowledge its value and correctness, as this does not depend uniquely on the physiology of vision and on rough data perceived through sight. In geometry education for blind people, it is widely known how to make spatial invariants such as parallelism and perpendicularity comprehensible [2]. Yet, what happens when such geometrical 'certainties' are questioned and measures are altered by perspective distortions? Just like pre-school children have not yet developed spatial categories to accurately interpret perspective-based representations, blind people lack the references to understand projective invariants, such as the concept of lines –which are parallel in real life– converging to one or more vanishing points in the perspective transposition. These concepts must be therefore conveyed on a different level by making them tactically perceptible through an educational effort which allows blind people to access a wide range of sensations that otherwise would be denied.

Seeing through hands: touch and its cognitive function

As a matter of fact, touch and speaking become the units of measurement of reality for visually impaired people, since they cannot rely on sight to interpret images. While touch decodes forms by means of haptic exploration, measuring their features and properties through a series of specific gestures, speaking –with its strong evocative and representative power– co-operates with the former, carefully avoiding to fall into deleterious literalism. Touch is thus the main compensatory sense for all visually impaired people (early-blind, late-blind and low vision subjects) and the only one which is able to recognize shapes. It is then necessary to recall the essential distinction between early and late blind individuals: early-blind subjects, who never had any visual experience or they only had it for a very limited time, are more adept at fully exploiting their tactile-manual system to interact with the external world. However, perception and representation of space are way harder for them compared to late-blind individuals, as they could not or barely benefit from visual images [Hatwell 2006, p. 79]. For blind people, learning how to efficiently use the remaining senses to acknowledge formal and spatial values is an essential training that echoes in the emotional and intellectual sphere. At the same time, empowering and expanding sensoriality reinforces the awareness of perceptive and cognitive abilities in sighted people, teaching them to see things more in-depth. *Hands-on* approaches are in-

Fig. 1. Herbert Bayer, Lonely Metropolitan, 1932, photomontage.

deed among the most efficient educational strategies, even for those who normally relate to art through sight: learning to explore objects with our hands teaches us how to organize the comprehension of the artwork starting from shapes, composition and perspective-based space to reveal its content and meaning. Touch can therefore "facilitate imitative decoding and add "feeling" to the visual experience" [Ruggeri 2006, p. 47], making possible to share linguistic, technical and semantic codes that enriches communication and integration between sighted and non-sighted people. Learning to 'see more' thanks to the analytical support of touch opens up to a reflection on the real potential of sight and on the power of the inner eye. Indeed, the depth of our gaze is measured from the capability to relate to the various aspects of intellectual and physical life, whose combination builds the perception of reality. It is thanks to this synergistic co-operation between senses and mind that every experience can be encoded and decoded, so that "sight means feeling and feeling means knowing" [Secchi 2010, p. 13]. If we do not practice 'feeling' by involving all of our senses in our relationship with reality, we risk to falsify vision itself. As Maddalena Mazzocut-Mis argues: "touch doesn't lie, hide or deceive but it creates instead a world on a human scale, without chimeras or false illusions. Images can lie, while the hand that touches and recognizes contours and borders does not. Images are a quick glance at the world, while touch slowly caresses things: touch is then the only true form of apprehension beyond the illusions of the senses" [Mazzocut-Mis 2002, p. 13].

Translating paintings into haptic language: the bas-reliefs from the Anteros Museum

In the case of paintings, a tactile fruition of the original artworks is, of course, impossible and the problem of accessibility for people with visual disabilities presents unquestionable difficulties. It is therefore necessary to resort to tactile representations and models to support the original artwork. Kennedy affirms that "not only can space can be represented in different ways; each way can be translated into another" [Kennedy 1993, p. 211]. Perspective bas-reliefs are currently the most employed devices to translate pictorial works into tactile language for blind people, in continuity with the tradition of Renaissance and Neo-classical bas-relief, originated during the XV-century in Florence. Differently from tactile diagrams, bas-reliefs are characterized by a greater resemblance and coherence compared to the bi-dimensional original artwork, since they respect its formal and compositional values, given that the original artwork itself suggests the idea of three-dimensionality. Tactile bas-reliefs are not merely copies of the original paintings but instead they "facilitate the perceptive and cognitive acquisition of concepts such as foreshortening, perspective space, space-time relationships between different elements, contour, volume, surface, expressive and aesthetic values of form" [Secchi 2004, p. 64]. Such features make it the most 'readable' and significant device for blind people, whose manufacturing process involves a complex and delicate 'translation' operation of bi-dimensional images into similar three-dimensional forms –which is essential for tactile exploration– currently carried out by skilled professional sculptors. The Anteros Museum in Bologna, directed by Loretta Secchi, creates refined perspective bas-reliefs resulting from a pioneering research project started in 1995, which gave a significant contribution to the development of museum educational services dedicated to visually impaired visitors. The collection is made of handcrafted tactile bas-relief transpositions of pictorial masterpieces, whose main feature is the undercut (*sottosquadro*), a technical device borrowed from traditional Renaissance bas-reliefs through which figures and volumes emerge from the background. The undercut simulates perspective planes receding towards the vanishing point, as if they were theatrical backdrops, building a bridge between sculpture and painting. The scale of a model is chosen according to the level of complexity of the painting and its tactile readability: dimensions can either correspond to the original ones or it is possible to use a larger or smaller scale, always taking into account tactile tolerance thresholds universally shared in the field of haptic perception and visual impairment [Secchi 2010]. In addition to the perspective bas-relief reproductions of famous paintings and copies of Renaissance reliefs, the Anteros Museum collection includes preparatory perspective boards (fig. 2), which try to unfold the projective operations for the creation of perspectival images to a visually impaired audience. Indeed, perspective construction lines are in relief and tangible: they inscribe the figures in order to highlight the convergence of parallel lines towards the vanishing point located on the horizon line. This eventually explains the alteration of perspective forms compared to the actual figures located below the ground line [3].

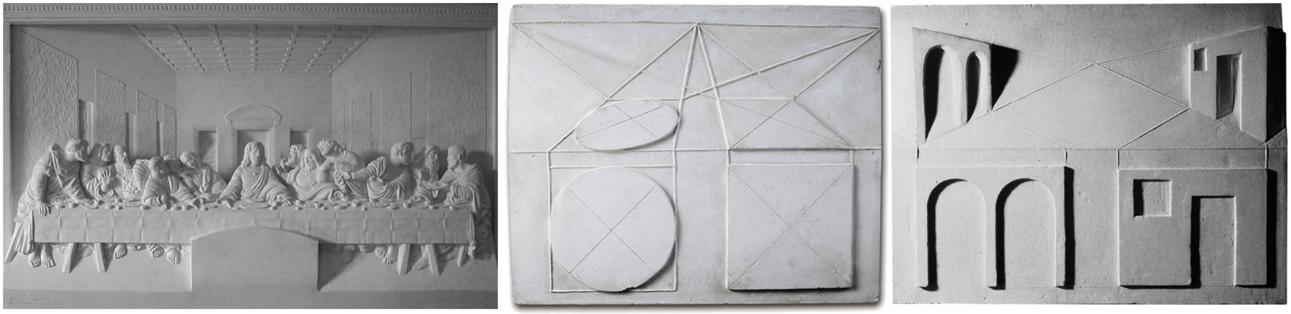
'Unveiling' the perspective-based painted space of *The Feast of Herod* by Benozzo Gozzoli

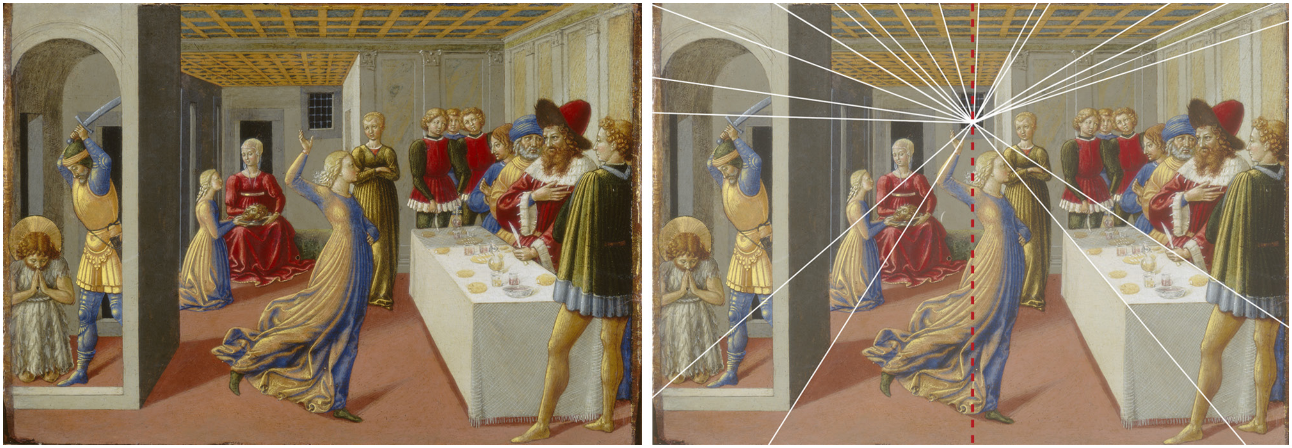
The Feast of Herod by Benozzo Gozzoli (fig. 3) was chosen as case-study because it well suits the research goals. The painting is indeed characterized by a simple and substantially regular one-point perspective with a strong symmetry with respect to the vertical axis, in which the main events of the narration and a number of extra-visual stimuli (e.g. smells, tastes, sounds, music etc.) are all condensed in the spatial-temporal *continuum* of a single static picture. As in many Renaissance narrative paintings, Gozzoli unifies three temporally distinct scenes (fig. 4) in the same perspective-based space. The spatial-temporal reading must be done starting from the foreground and moving towards the background: *Salomé's Dance* is the first event to have happened so it's

Fig. 2. Perspective bas-relief transposition of The Last Supper by Leonardo da Vinci and two preparatory perspective boards of the Anteros Museum in Bologna.

Fig. 3. Benozzo Gozzoli, The Feast of Herod, tempera on panel, ca 1461-1462, 23.8 x 34.5 cm, Samuel H. Kress Collection, National Museum of Art, Washington. Photo credit: National Museum of Art di Washington. On the left, perspective layout with the principal point falling on the vertical axis of symmetry of the painting.

Fig. 4. The three different moments of the narration, highlighted in chronological order.





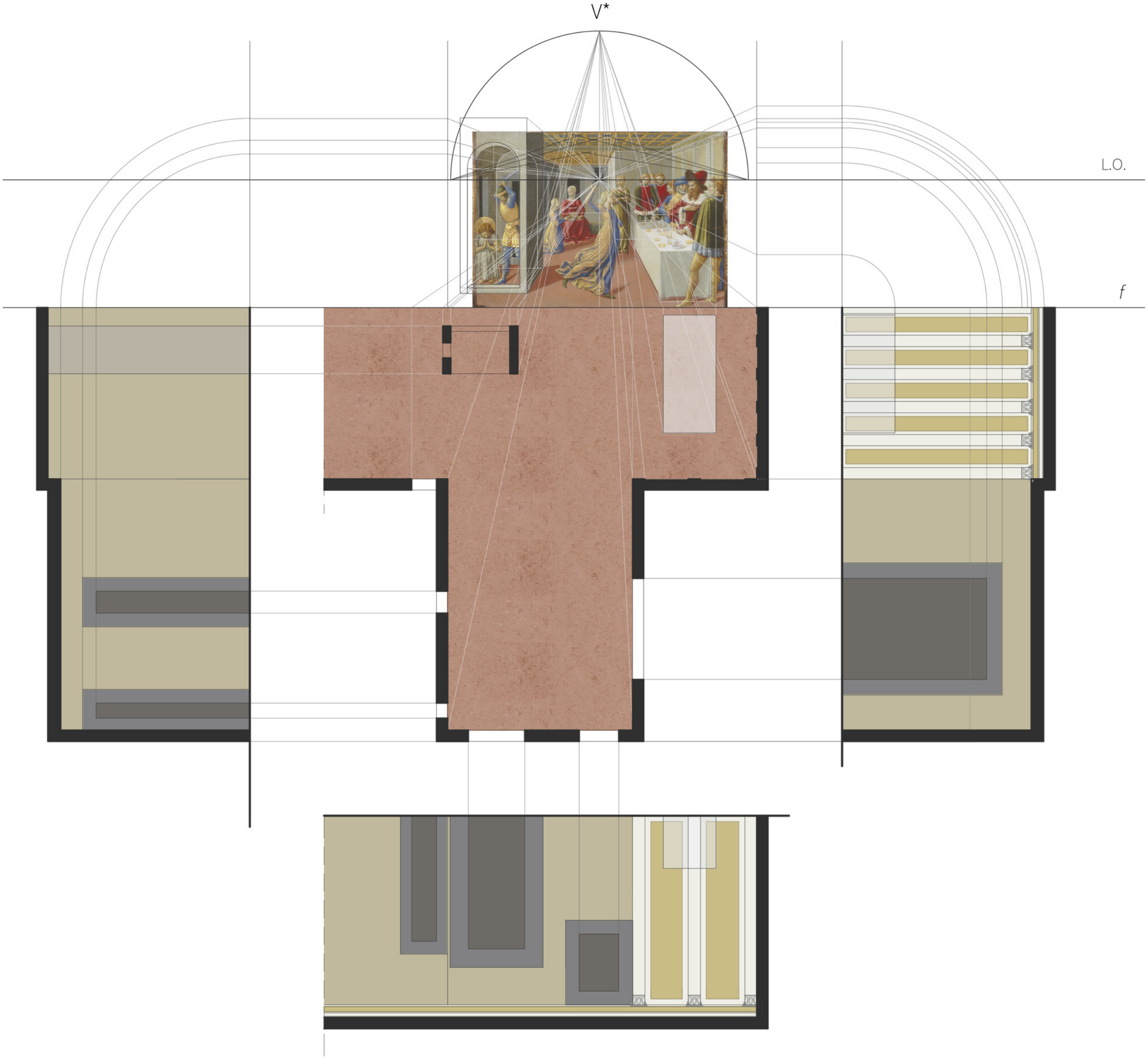


Fig. 5. Perspective restitution of the painted space.

also spatially closer to the viewer; the *Beheading of Saint John* is the second next and it is indeed located on a middle plane; the *Presentation of the Baptist's Head to Herodias* is the last event in the timeline and it is consequently located far away from the viewer, at the very back of the painted space but in a setting that can be considered as an extension of the banquet room. The transition from one scene to another is underlined by architectural elements which, despite the spatial continuity, clearly separate the events; for instance, an *edicola* on the left side of the painting –which recalls of medieval *luoghi deputati* [Pagliano 2005, p. 13]– frames and isolates the execution of Saint John the Baptist, highlighting the most dramatic moment of the macabre episode which deserves intimacy and solemnity. In an artwork like *The Feast of Herod*, perspective represents and measures both space and time: it traces the timeline and arranges all the narrated events, unifying them in a spatial grid in which different temporal dimensions coexist. The research methodology can be divided into the following phases: 1) Geometric restitution of perspective of the painted space; 2) 3D modeling of the restituted space; 3) 3D Modeling of the perspectival bas-relief through accelerated solid perspective; 4) 3D printing of tactile models; 5) Educational model to support the comprehension of perspective; 6) Verbal narration of the painting to support the haptic exploration of the 3D models; 7) Multisensory experience: sounds, smells, tastes, moods.

The perspective restitution of the painted space and the three-dimensional model

The perspective restitution of Gozzoli's painting (fig. 5, 6) has been carried out through the reversed procedure of linear perspective and it revealed the choices made by the artist when planning the space designed to host the events narrated by the Gospels. In spite of the apparent coherence of the perspective layout and beside the minor imperfections due to the brushstrokes and the difficulty of execution on a small format, Gozzoli intentionally made a number of deviations from the rules in favor of the aesthetic value of the final image. Indeed, the final overall effect is always given priority over the formal rigor of painted architecture (*architectura picta*). In the philological restitution, the consistency of the spatial unity was restored by operating a 'correction' of the image to make it perfectly adherent to the perspective's coordinate system and to obtain a regular space, also in view of preparing drawings for the following 3D modeling. Therefore, perspective restitution proved to be other than an automatic translation of a perspective image into plans

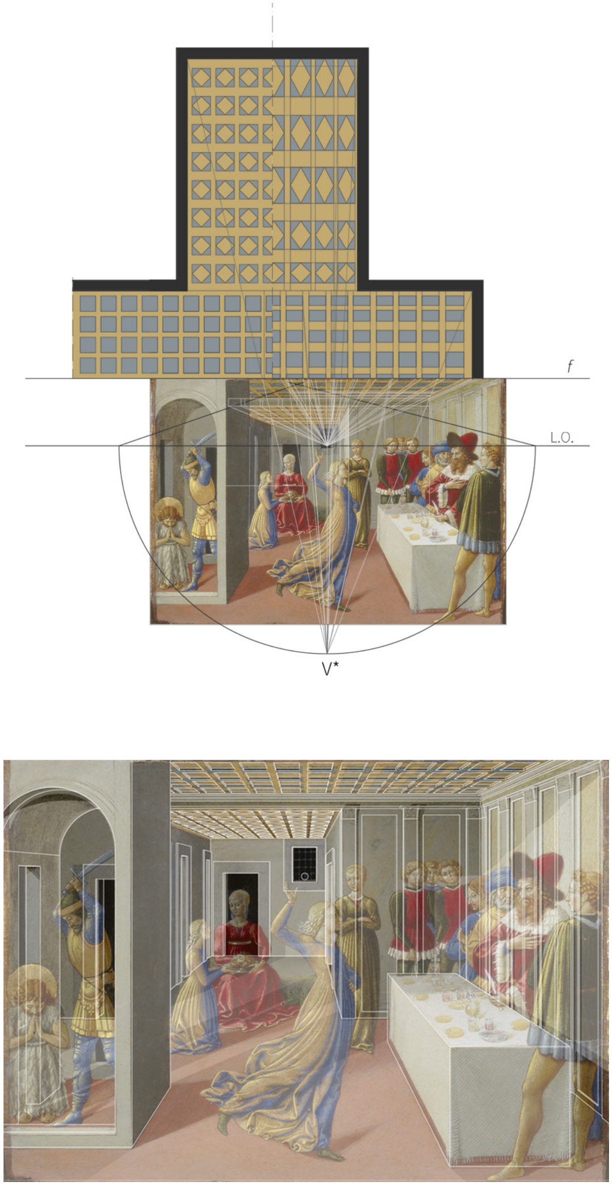
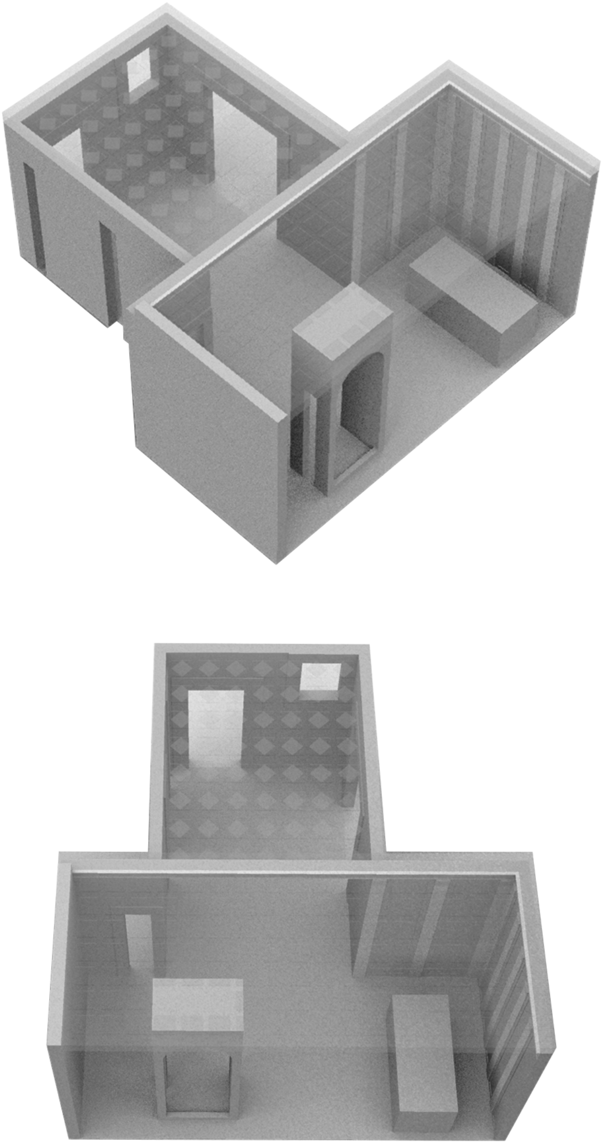


Fig. 6. Perspective restitution of the coffered ceiling compared to the philological restitution. On the bottom, comparison between the original painting and the digital model.

Fig. 7. 3D digital reconstruction of Gozzoli's painted space.



and sections: it is, instead, a true interpretative act capable of revealing incongruences, artistic licenses and deviations from rules. The three-dimensional model digitally constructed starting from the plan and sections obtained through the philological restitution (fig. 7) is quite simple and suitable for a tactile exploration since the painter himself did not overload the image with excessive details and decorations. As a matter of fact, excessive detail would have been an obstacle for the correct tactile comprehension of the spatial system.

The perspective bas-relief

The perspective bas-relief was digitally modeled through the application of accelerated solid perspective (fig. 8) within the depth of the support. It is no coincidence that solid perspective was originally known by the name of 'relief perspective': it was indeed an actual three-dimensional perspective where "a reduced space gave the illusion of a greater depth: such technique was destined to be employed for the creation of sculpted bas-reliefs and theatrical sets" [Sgrosso 2002, p. I]. In this study, the perspective bas-relief was intended as the accelerated solid perspective of a space because such technique allows to erase parallelism, successfully underlying perspective convergence of parallel lines towards the vanishing point, rendering the different depth planes and preserving the centrality of the point of view. Differently from traditional bas-reliefs, the model obtained through accelerated solid perspective is in the round: such choice, besides making the interpretation of the perspective-based space easier for non-sighted people, appears to be more appealing even for a sighted audience. Indeed, it provides a more powerful spatiality and allows the exploration of a space whose 'distortions' and 'foreshortenings' can be perceived through touch. This represents a new way of 'entering' the perspective painting, a new cognitive experience for both sighted and non-sighted people. Such model is thus a more explicative one rather than a *diminutio* compared to the original. Thanks to 3D printing, multiple copies of a perspective bas-relief can be manufactured so that the three different moments of the narration can be isolated and then presented all together in a single synthetic vision (fig. 9). The narrated events are therefore temporally separated, indulging the exploratory modalities of touch and introducing an additional ideal dimension, movement, as if the characters entered the stage in different acts of a theatre performance. 3D printing makes prototyping and experimenting relatively easy and quick as the models can be tested promptly in order to identify issues and improving their features to provide an optimal tactile experience (scale, level of detail, surface textures etc.)

Fig. 8. Application of accelerated solid perspective to the space obtained through the reverse perspective technique.

Fig. 9. Multiple copies of the perspectival bas-relief –each one highlighting a moment of the narration–, the complete bas-relief and a perspective section. Colors can be preserved for sighted users.

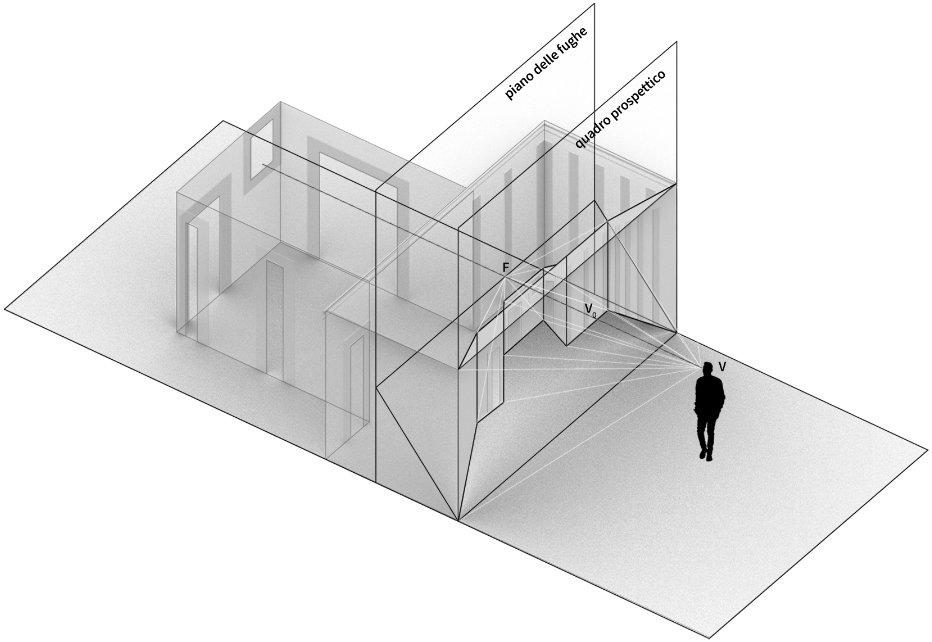
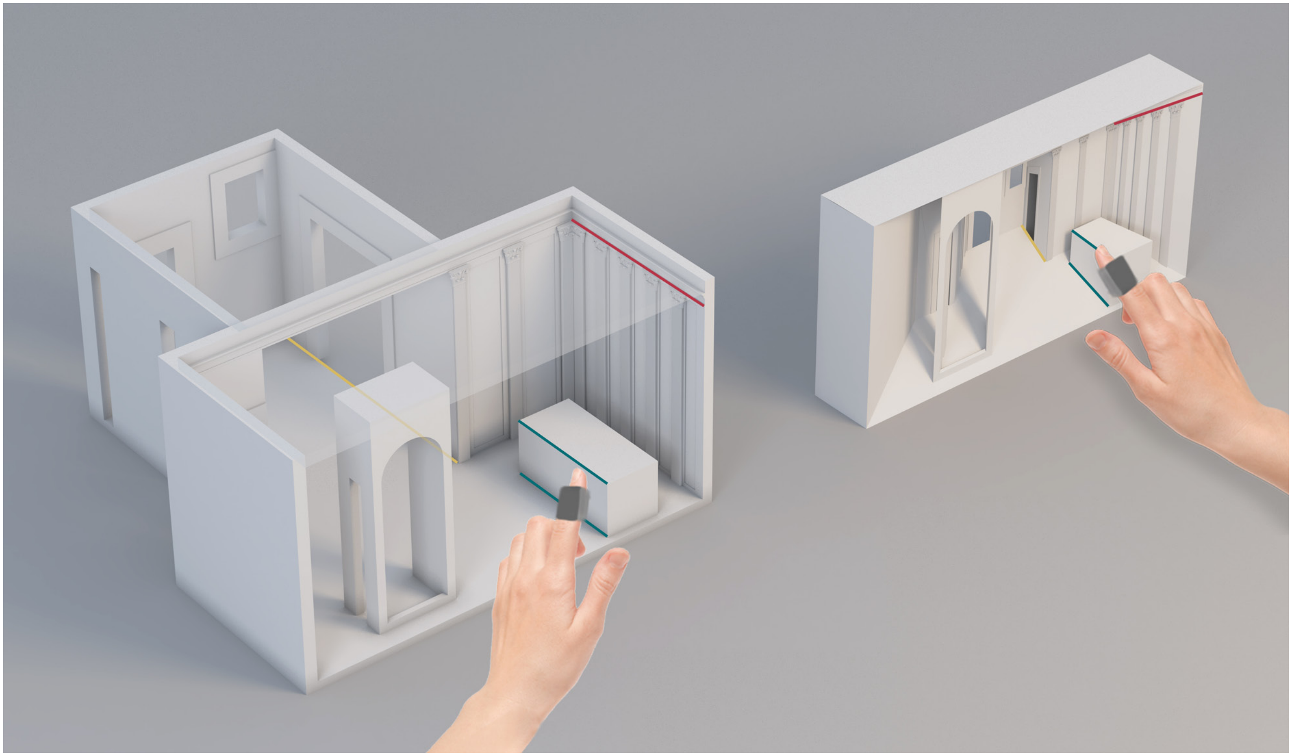
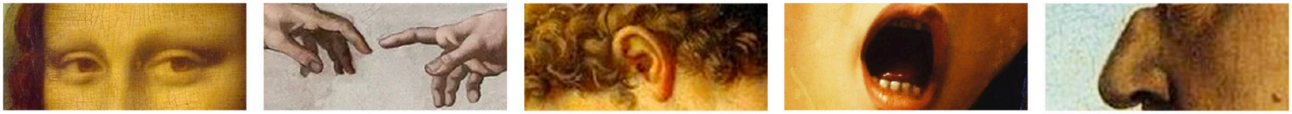


Fig. 10. The comparative educational model.

Fig. 11. Suggestions for a multisensory experience around Gozzoli's painting.





Sight

Augmented Reality

Virtual Reality

Inviting users to see the 3D printed models from the perspective point of view

Touch

Haptic exploration of tactile models

Braille captions

Touching objects or fabric depicted in the painting

Hearing

Verbal description

Sounds evoked by the picture

Music of the Dance of Salomé

Taste / Smell

Smells and tastes of 1st century BC Jersusalem typical food served at the feast.

Body

Inviting users to reproduce the characters' poses and gestures with their own body

The comparison between the returned three-dimensional space and the perspective bas-relief: an educational model to explain perspective

In order to understand the transition from the three-dimensional form of the painted space to its bidimensional perspective image, it was decided to apply the principles behind the aforementioned preparatory perspective boards created by the Anteros Museum in collaboration with the Francesco Cavazza Institute. As Loretta Secchi argues, "this consists of a sort of brand new literacy on the way reality is visually represented" [Secchi 2018, p. 24]. The comparison between corresponding lines on the two plastic transpositions of the painted space (true-form three-dimensional model and perspective bas-relief) enables the visually impaired to recreate a mental model of the painted architectures, justifying the distortions resulting from central projections that 'build' the perspective image and allowing them to identify the actual spatial location of perspective lines. In this way, the visually impaired, whose knowledge of the world mainly rely on tactile perception of forms, can touch and understand the distortions which take place in the process of translation of a space to a plane, discovering that they have a precise and valid significance (fig. 10). It is therefore possible to learn new geometric definitions and experience them first hand through touch. Such path of knowledge must be accurately planned, indulging time and modalities of haptic exploration [4] which is assisted by the remaining senses and supported by an efficient kinesthetic activity. The summation of stimuli provided by volume, texture and hand movement shapes the mental image that, for those who can't see, is the object itself. A 3D model alone is certainly not enough to convey all the values that 'build' the identity of an artwork. Tactile reading needs to be complemented, guided and supported by a verbal description, in order to ensure a correct decoding of forms as long as the iconographic and iconological understanding of a painting. For a blind person relating to a pictorial artwork, the evocative and iconoclastic power of speech is an essential and irreplaceable resource that needs to be carefully calibrated in order to avoid falling into the trap of verbalism. A correct integration of sense and intellect, through which the blind individual can imagine reality and access a real aesthetic experience, can take place thanks to the synergistic relationship between language and tactile reading: speech guides imagination so it can get where hands cannot touch. So, "if *ekphrasis* is defined by Ermogene as a 'descriptive discourse that efficiently makes the object perceptible to the human eye', it is possible to talk about an *ekphrasis* sui generis that must be able to efficiently make the object perceptible not to the human the eye but to the hands" [Sòcrati 2018, p. 34].

The multisensory experience

Nowadays, museums are no longer places were artworks are simply housed and preserved for future generations; the museum experience can become a multi-dimensional journey, involving proprioceptive, sensory, intellectual, aesthetic and social aspects. Touch is the main sensory compensation to sight since it's the only one which is able to explore and recognize form. Nevertheless, touch and sight are not the only resources that our body can count on to establish a relationship with objects and especially with the work of art. Furthermore, modern neurosciences argue that inner representations of reality are intrinsically multisensory. While observing a painting, "it is not true that visual features are central and all other qualities are placed around them as if they were ancillary. Nothing could be further from the truth" [Dewey 1951, p. 150]. In the artistic experience, the different sensory features indeed overlap, intersect and interact; touch, color, smell, light, taste are constantly combined, stratified and connected in the body of who is living the experience.
In the case of the *Feast of Herod*, the subject already provides many inputs and suggestions for an exhibition strategy which enhances the knowledge and accessibility of the artwork by engaging more than one sense. Experiencing the painting becomes a multi-dimensional 'immersive' journey, in which stimuli produced by hearing, touch, smell and taste and their bodily resonance can reveal new meanings and unexpected sensations. The table shown in fig. 11 presents a few suggestions for a multisensory experience based on *The Feast of Herod*.

Conclusions

Blind people can certainly experience an authentic aesthetic experience, even if through a different path outlined by the needs of tactile exploration. However, their relationship with *perspectiva artificialis* is more controversial since perspective itself has its roots in optics and therefore it is deeply connected with the physiology of human sight (*perspectiva naturalis*). Despite being unable to directly experience it as they do not possess an intuitive or innate biological predisposition, blind individuals can understand the functioning of perspective by learning the graphic-geometric process behind perspective-based painted spaces through a special education which does not require the use of sight. Traditional techniques of descriptive geometry (geometric analysis, philological restitution) along with modern digital technologies (3D modeling, 3D printing) and supported by a multisensory program for the artwork storytelling can provide an educational multi-modal model to convey –to everyone– the whole 'world' contained in a bidimensional image. As Howes states, "the experience of a painting need not be mediated by sight alone, as if its visual surface were the only sensory dimension that mattered. The painting itself may represent a transposition of an auditory or tactile experience into a visual one [...] and even if it doesn't, there is no intrinsic reason not to enlist other sensory channels in one's perception of it by constructing a multisensory model of its topology in the intervening space between the painting and the perceiver" [Howes 2014, p. 297].

Notes

[1] Cfr. Secchi 2004; Arnheim 1990; Grassini 2016.

[2] Cfr. Nasini 2006.

[3] <http://www.cavazza.it/drupal/it/node/335> (accessed June 9, 2020).

[4] For further reading about touch modalities, see: Hatwell, Streri, Gentaz (eds.) 2003.

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Catoptric Anamorphosis on Free-Form Reflective Surfaces

Francesco Di Paola, Pietro Pedone

Abstract

The study focuses on the definition of a geometric methodology for the use of catoptric anamorphosis in contemporary architecture. The particular projective phenomenon is illustrated, showing typological-geometric properties, responding to mechanisms of light reflection. It is pointed out that previous experience, over the centuries, employed the technique, relegating its realisation exclusively to reflecting devices realised by simple geometries, on a small scale and almost exclusively for convex mirrors. Wanting to extend the use of the projective phenomenon and experiment with the expressive potential on reflective surfaces of a complex geometric free-form nature, traditional geometric methods limit the design and prior control of the results, thus causing the desired effect to fail. Therefore, a generalisable methodological process of implementation is proposed, defined through the use of algorithmic-parametric procedures, for the determination of deformed images, describing possible subsequent developments.

Keywords: anamorphosis, science of representation, generative algorithm, free-form, design.

Introduction

The study investigates the theme of anamorphosis, a 17th century neologism, from the Greek ἀναμόρφωσις "riformazione", "reformation", derivation of ἀναμορφόω "to form again".
It is an original and curious geometric procedure through which it is possible to represent figures on surfaces, making their projections comprehensible only if observed from a particular point of view, chosen in advance by the author-designer.
In the application of the theoretical-practical fundamentals of the scientific method, the fortunate union between geometry, art and architecture is openly manifested, and is presented in design approaches and scientific and empirical research, provoking amazement in the observer.
The resulting applications require mastery in the use of the various techniques of the Science of Representation aimed at the formulation of the rule for the "deformation" and "regeneration" of represented images [Di Paola, Inzerillo, Santagati 2016].
There is a particular form of expression, in art and in everyday life, of anamorphic optical illusions usually referred to as " catoptric " or " specular ".
The in-depth study presented here focuses on this type of anamorphosis, which, as is well known, requires the additional presence of reflective devices that allow the deformed image to be deciphered.
The geometric phenomenon of anamorphosis has been known since the 14th century and finds its place in the

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broadest treatises on perspective [Accolti 1625; Baltrušaitis 1969; Gardner 1975]. Applications of this technique can be found in the works of painters such as Piero della Francesca and Hans Holbein the Younger [Di Paola et al. 2015; De Rosa et al. 2012].
The discipline was perfected in its scientific rigour in Europe, between the 15th and 17th century, as a result of the progress made in the fields of projective geometry and optics.
In recent times, the same principles have been applied in the realisation of temporary and permanent installations, on a multitude of supports and at different scales. Among the artists in this sense are Leon Keer, François Abelanet and Felice Varini.
Over time, interest in the technique grew because it was profoundly connected to the theme of illusion, paradox, oxymoron and the deception of ambiguous duplication of projection and, above all, with the "radical" metaphor that recognises the visual experience, and not only the artistic one, as essentially "spectatorial" in nature [Ugo 2002, p. 89]. When writing treatises, entire chapters describe the geometric genesis of such "illusions".
One of the most interesting protagonists of this complex conjuncture is the French mathematician and theologian Jean-François Nicéron, who entered the order of the Minims of St. Francis of Paola at an early age and devoted himself just as early to the study of optics and perspective [Nicéron 1638].
Experiments to date have focused on small-scale applications consisting exclusively of reflecting elements of a simple geometric nature (regular, ruled surfaces: straight cones and cylinders, planes or spheres).
This limitation of the devices used at the time is justified mainly by a number of factors. Firstly, the construction of a catoptric anamorphosis, using a free-form surface or one of a complex nature, generates a distorted image that can be several times larger than the apparent image, depending on the curvature of the surface.
Furthermore, this type of device necessarily requires the observer to be in a position opposite and above the surface or surfaces on which the distorted image is rendered.
Finally, a virtual image that is too large would be difficult to appreciate, thus failing to achieve the desired optical-perceptual effect.
The theory and practice of catoptric anamorphosis could offer numerous ideas for interdisciplinary research in the field of geometry applied to architecture, the figurative arts, visual perception and design.
Today, in fact, in contemporary architectural applications, the use of complex reflective forms using free-form surfaces with variable curvature is becoming increasingly widespread.
There are variable scale interventions already installed that could lend themselves to applications that exploit the anamorphic projective procedure, highlighting its potential applications, both from an expressive point of view and from a design point of view.
The use of this technique makes it possible to compensate for the aberrations typically caused by the curvature of reflecting elements, obtaining intelligible virtual images usually obtained with flat mirrors.
Using this expedient, the building envelopes could be more integrated in the surrounding context, avoiding the alienation of the user and ensuring the possibility of recognising non-aberrated shapes on a curved reflecting surface.
On the basis of these considerations, it is of interest to investigate and experiment new strategies that extend the field of application to free-form surfaces with the use of innovative digital representation tools.
Therefore, the essay introduces the projective method of the catoptric anamorphosis, through geometric-descriptive schemes, highlighting the theoretical principles and the peculiar characteristics of the optical-perceptual phenomenon.
The proposed methodology is introduced and defined, with the objective of extending and implementing the geometric method of the catoptric anamorphosis with digital tools and algorithmic-parametric control of the design process, which generalises the application to architectural elements of significant extension and of any geometric nature composed of reflecting surfaces.
In conclusion, in order to better explain the value and the perceptive impact of the observer and to validate the methodological path started, the discussion continues by presenting multi-scale application cases.

Catoptric anamorphosis: state of the art

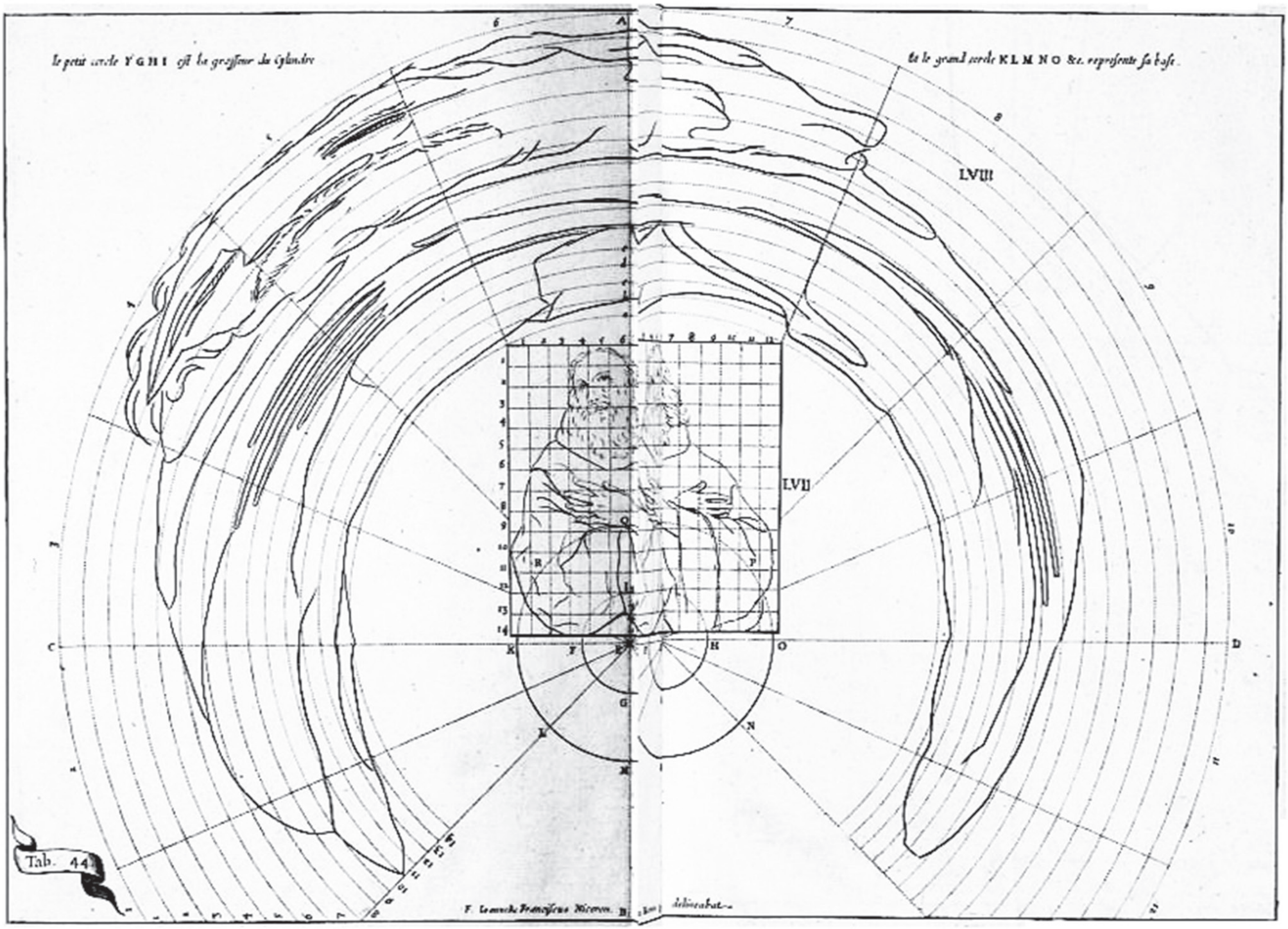
An image projected from its own specific projection centre onto one or more flat or free-form reflecting surfaces or generated by reflection in a deforming mirror (e.g. cylindrical, conical or pyramidal in shape) is perceived, by an observer standing at that viewpoint, without deformation. The optical aberration of the reflection compensates for the deformation of the anamorphic design and makes it proportionate and recognisable [Di Lazzaro, Murra 2019, p. 16].

The artifice of optical illusion is understood with marvel by the spectator as soon as they assume any observation position, at which point they perceive the represented figure as somewhat distorted and incomprehensible.
Graphic constructions are based on the laws of reflection and a peculiarity of this type of anamorphosis is the possibility of observing both a 'distorted' graphic and the 'correct' reflected image from the same point of view.
The introduction of the mirror as reflection, inversion and doubling makes the interplay of actor/spectator, reality/representation even more exasperated and intense. Vittorio Ugo effectively describes the typical nature of the phenomenon of observing "from the outside": "the only real artifice that makes it possible to represent in a single context the seen, the seeing and the vision is the referral operated by the mirror: a surface reflecting the real in a virtual image" [Ugo 2002, p. 88].
The use of devices made with curved mirrors, which historically have consisted mostly of ruled surfaces, such as right circular cylinders and right cones, polyhedral elements or, less frequently, spherical surfaces, has been documented since the 16th century. One of the precursors to deal with catoptric anamorphosis was J.L. Vaulezard in 1630, introducing empirical and illustrative experiments using cylindrical and conical reflecting surfaces. In the middle of the 17th century the Jesuit fathers, in the person of Gaspard Schott and his teacher Athanasius Kircher, dealt with the subject, laying the foundations for the spread of the phenomenon of perspective [Schott 1657]. In the 18th century, the theme became an essential practice to be discussed in treatises on perspective; an authoritative example is Ferdinando Galli Bibiena with his treatise: *L'architettura civile preparata su la geometria e ridotta alle prospettive. Practical considerations*, 1711 [Càndito 2010, pp. 71, 72].
More recent experiences are moving towards large-scale applications of catoptric anamorphosis [Čučaković, Paunović 2015] and towards the definition of non-two-dimensional deformed images, through the use of CAD programs, simulations with physical rendering engines and ad-hoc created codes [De Comité 2010; 2011; De Comité, Grisoni 2015].

Catoptric anamorphosis: geometric-descriptive schemes

The definition of distorted images was initially done by eye, and it was only after the first experiments that sufficient geometric knowledge was attained to allow their rigorous construction.
The catoptric anamorphosis, to allow the interpretation of the distorted image, requires the correct positioning of the reflecting device as well as the position of the observer.
The additional complexity due to the introduction of a reflecting device entails, therefore, the need to understand its geometrical characteristics thoroughly, also in relation to the mechanisms of light reflection and the rules of catoptrics, which can be schematised by means of linear rays.
Such information was acquired by treatise writers from the earliest evidence of the use of this type of device: however, only reflecting surfaces with rather simple geometries and almost exclusively for convex mirrors were described, while the few texts on concave mirrors generally resorted to simplifying hypotheses.
In 1638, the aforementioned Jean-François Nicéron published his treatise *La Perspective Curieuse*, in four books, devoted entirely to anamorphosis. In the third book, he delves into the subject of catoptric anamorphosis, describing the phenomenon through graphic examples.
The construction of the catoptric anamorphosis, known in the literature, involves drawing a reference anamorphic grid, on which the distorted image is then defined by hand. By way of example, we will focus in particular on analysing the construction of reflective anamorphic perspective projection on a convex cylindrical ruled mirror surface with a vertical axis.
In the projective space, in most cases, the projection setting, which generates the anamorphic image, must use an auxiliary plane perpendicular to the visual ray conducted by the point of view and projection centre V, on which the figure in true form is shown. Auxiliary planes not perpendicular to the direction of the visual ray would generate an image perceived in foreshortening, or would otherwise require additional artifices to compensate for this foreshortening.
Comparison with tables from treatises and drawings from the literature shows that various graphic devices are used to simplify the resolution process; these provide geometric approximations of the optical phenomenon which are compensated for by direct observation of the device with bi-ocular vision [Hunt, Harding MacKay 2011].
The exemplifications lie in the choice of the spatial position of the real grid and the distance of the observer from the reflecting surface (equivalent, in Nicéron's construction, to a projection from an infinite point of view) (fig. 1).

Fig. 1. J.F. Nicéron, orthogonal projection of a reflection anamorphosis on a cylindrical mirror surface of a human portrait (Nicéron 1638, Tab. 44, pp. 428, 429).



In the following we compare two representations of the anamorphic process made in two different configurations. From an angle "outside" the device, it is possible to observe: the centre of the projection *V*, the virtual figure *c*, a reference grid in true form placed on the auxiliary plane β, the anamorphic figure c^* on the horizontal plane α and its reflected image $c^V\sigma$ on the cylindrical reflecting surface σ with respect to the point of view *V*.
It should be noted that if the auxiliary plane β, to which the curve *c* belongs, were vertical and passing through the axis of the cylinder, the geometric construction would be easier to solve graphically, but the result would be less rigorous. In this way, the reference grid in true form, constituted by straight lines perpendicular to each other, would be deformed with approximation in a grid constituted by segments and, in the generality of the cases, by arcs of ellipses that can be easily traced (fig. 2).
If, on the other hand, the auxiliary plane β lies inclined with respect to the axis of the cylinder and orthogonal to the visual radius λ, the resulting network of the real grid would consist entirely of curvilinear profiles (fig. 3).
For both cases, the anamorphic procedure is defined as follows. Given a right-axis cylinder of known height, with a circular directrix of assigned diameter and resting on a horizontal reference plane α, a point of view of the observer *V* is fixed.
Once the auxiliary plane β is defined, a circle in true form *c* inscribed in a reference grid is drawn on it. The grid is placed in such a way that a pair of sides is in the same direction as the line t_β, intersection line of the plane α with the auxiliary plane.
Having chosen a point *P* belonging to the curve in true form *c*, a visual ray λ is drawn joining *V* with *P*. The ray intersects the cylindrical reflecting surface σ, in view with respect to *V* at the reflected point $P^V\sigma$.
According to the laws of reflection, for $P^V\sigma$ the tangent plane of reflection δ to the cylinder is represented. The anamorphic image P^* of point *P* on the plane α is determined by means of the counter-observer V^*, placed in symmetry to the plane δ with respect to *V*.
Iterating the procedure and moving the point *P* on the curve in true form *c*, two loci are described: c^* which represents the anamorphic projection of the assigned curve and $c^V\sigma$, the non-planar curve belonging to the reflecting cylindrical surface.
In order to obtain the image of the original drawing, i.e. the circumference and the circumscribed grid free of de-

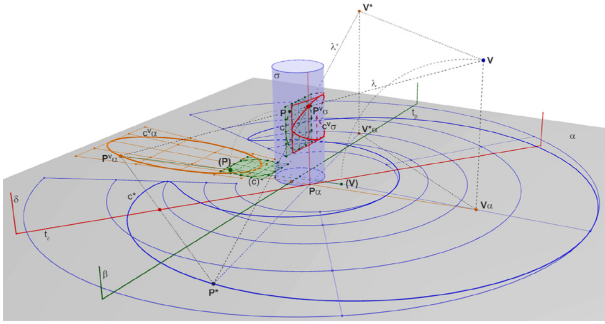


Fig. 2. Perspective view of the catoptric anamorphosis procedure with a cylindrical reflecting surface. Virtual figure c belonging to the vertical auxiliary plane β (authors' drawing).

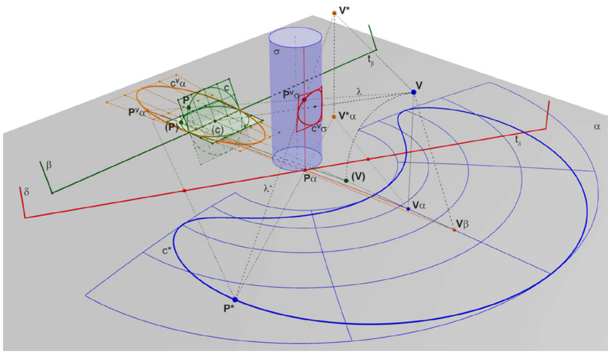
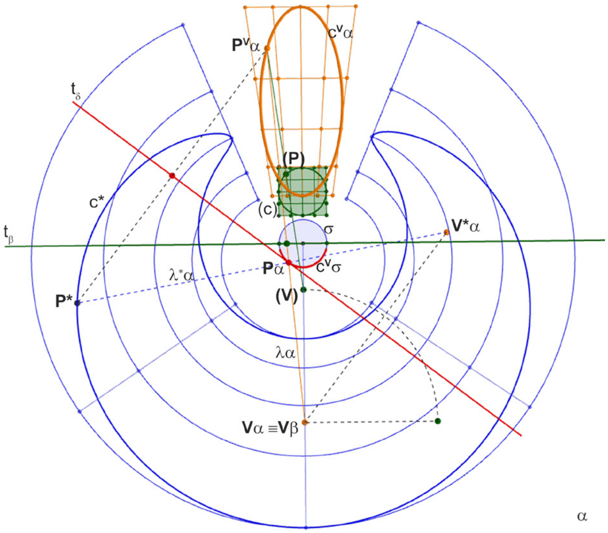


Fig. 3 Perspective view of the catoptric anamorphosis procedure with a cylindrical reflecting surface. Virtual figure c belonging to the oblique auxiliary plane β (authors' drawing).



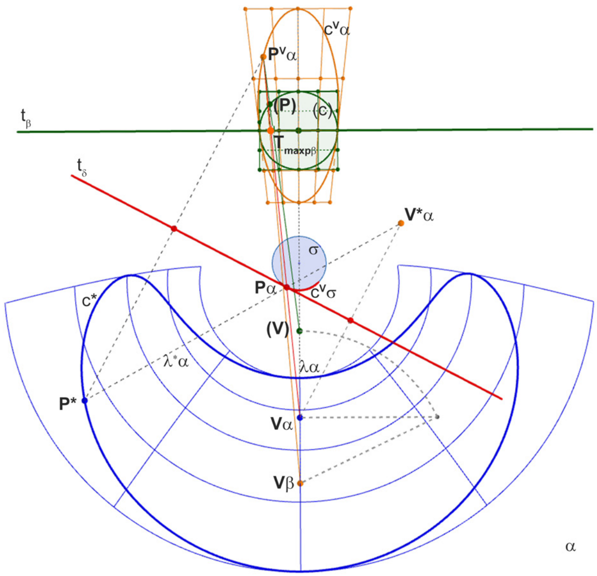


Fig. 4. Orthogonal projection of the catoptric anamorphosis procedure with a cylindrical reflecting surface and a vertical auxiliary plane β. Geometric construction with a ruler and a compass (authors' drawing).

Fig. 5. Orthogonal projection of the catoptric anamorphosis procedure with a cylindrical reflecting surface and a oblique auxiliary plane β. Geometric construction with a ruler and a compass (authors' drawing).

formations, it is necessary to observe the anamorphic curve reflected on the cylindrical mirror from the observation point *V*; by doing so, the circumference *c* will be superimposed on the non-planar curve $c^V\sigma$.
The comparison of the two approaches shows the different geometrical nature of the resulting anamorphic curves, according to the above-mentioned observations. This second approach, of general validity, which takes into account the rules of catoptrics, will be used for the algorithmic implementation described in the next paragraph.
In the proposed digital graphical constructions, the methods of representation of descriptive geometry are employed, applying traditional procedures of plane transformations of geometric entities with straightedge and compass (figs. 4, 5).
By overturning the auxiliary plane β on the plane α, around the intersection line t_β, a homology is established that puts the two superimposed planes in bi-univocal correspondence.
The point *(V)*, the overturning of the point of view *V*, the trace t_β, the overturning hinge of the auxiliary plane, and the point *(P)* belonging to the overturned curve *(c)* are identified.
We define, then, V_β as the projection of *V* on the plane α according to the direction of the line of maximum slope of the auxiliary plane β. We define $T_{maxp\beta}$ as the trace point of the line of maximum slope of the plane β on the plane α led by *(P)*. Finally, we determine $P^V\alpha$, as the intersection of the straight lines $V_\beta T_{maxp\beta}$ and *(V)(P)*.
A homology is then established with the following elements: homology centre *(V)*, homology axis t_β, and a pair of corresponding points *(P)* and $P^V\alpha$.
Given the fundamental properties, corresponding points in a homology are aligned with the centre and distinct corresponding lines secede on the axis. The point $P^V\alpha$ describes the ellipse locus $c^V\alpha$ at the variation of *(P)* on *(c)*.
Running a line through $V\alpha$ and $P^V\alpha$ we determine: the point of intersection $P\alpha$ belonging to the circular directrix of the cylindrical reflecting surface σ, the line t_δ, tangent to the directrix and, by axial symmetry to the latter,

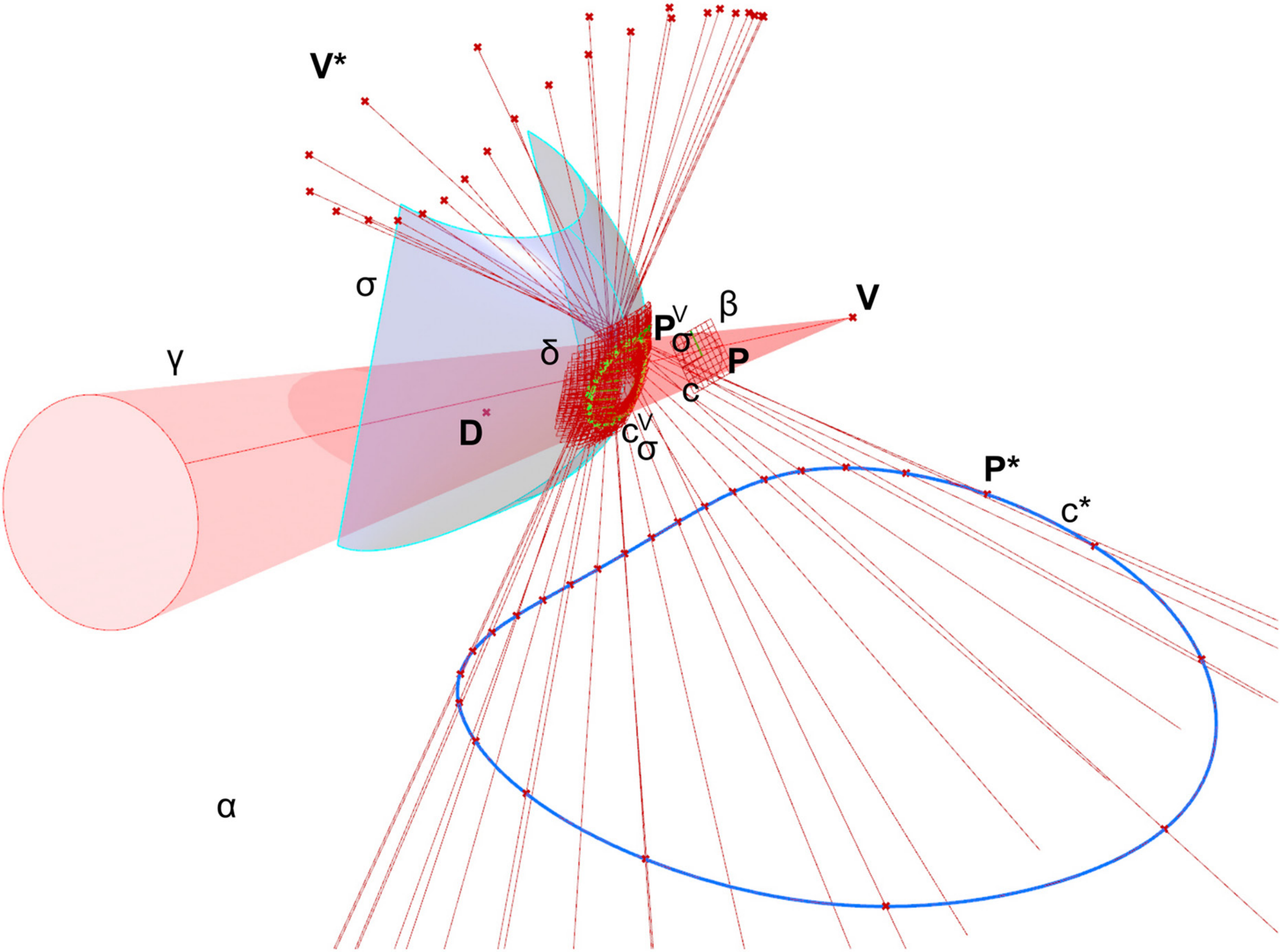


Fig. 6. Simplified scheme illustrating a conventional arrangement to reproduce the illusory process of catoptric anamorphosis on convex surfaces (authors' drawing).

the point P^*, symmetrical to $P^V\alpha$. The point P^* describes, when (P) moves along (c), the locus c^*, the deformed anamorphic curve.

Catoptric anamorphosis on variable curvature free-form surfaces. Method, instruments and case studies

As anticipated, the methodology employed in this study assumes considerations related to the physical phenomenon of the reflection of a visual ray. In particular, the reflection mechanisms on a planar mirror and on curved mirrors with regular geometries (concave and convex spherical mirror, parabolic mirror) are considered known from the state of the art. By analogy, the reflection mechanism on cylindrical and conical mirrors, historically used in the realisation of catoptric anamorphosis, is considered known, as described in the previous paragraph.
This simple tracing is no longer possible regardless of the chosen viewpoint if the reflecting surface does not have known and easily defined geometrical properties. For example, a generic double-curved NURBS surface without symmetry planes will cause a nonequivalent controllable deformation of the elements of the reflected grid [Eigensatz et al. 2010; Flöry, Pottmann 2010; Wallner, Pottmann 2011].
Realisations of catoptric anamorphosis using complex and/or composite reflective surfaces are uncommon and usually the result of an empirical procedure in which the author –predominantly an artist– calibrates the desired result by successive approximations with little or no geometrical rigor.
An algorithmic point-by-point procedure is proposed to define the distorted image by loosening the constraints given by the geometric characteristics of the mirroring surface [Buratti 2012].
Using the phenomenon of determining the reflected image of a point from a planar reflecting surface by determining a counter-observer, the procedure is iterated for the points constituting the true-form curve, then interpolating the resulting anamorphic points.
The specular plane for each point is identified in the plane tangent to the reflecting surface at the virtual point lying on this surface, as outlined below.
The possibility of generalising the realisation of the catoptric anamorphosis makes it possible to extend the field of application beyond the small scale typical of this type of phenomenon, such as for architectural scale realisations.
In the context of the use of this algorithmic procedure by a designer, the following significant elements are identified: the point of view or observer V, the direction of the visual ray given by the destination point of view D, the curve in true form c, the reflecting surface σ, and the receiving support α.
In addition to these significant geometric elements, two further values are used: a homothetic scaling coefficient of the curve and the number of sampling points (resolution) (figs. 6-7).
Once the direction of the visual ray has been defined, the curve in true form c is positioned perpendicular to it on an auxiliary plane β representing the perceptual result of the anamorphic procedure. We define a generic cone γ having as directrix the curve in true form, as vertex the observer and as generators the visual rays. This cone γ intersects the surface σ defining the virtual curve $c^V\sigma$.
For each sampling point P on the σ surface, the mirroring plane δ tangent to the σ surface is then defined. Each δ plane is used in the determination of the counter-observer V^*, reflection of point V with respect to the plane, for each of the sampling points (in some particular cases, distinct sampling points have the same counter-observer, but this is not true in general and there is a biunivocal relationship between sampling points and counter-observer).
The line joining each counter-observer V^* with the corresponding sampling point P is identified.
Where this line meets the surface α, the anamorphic point P^* is determined.
The procedure thus described is repeated for each of the sampling points $P_1 ... P_n$.
Once the anamorphic points have been determined, the anamorphic curve is reconstructed by interpolation.
In order to highlight the educational, popular and artistic-expressive potential that the technique could offer in current contexts, some examples of applications with different quadric and free-form surfaces of different complexity are presented: a small-scale application, such as a mathematical machine for educational and museum use (fig. 8); a reflective geometry similar to the land-art piece 'Cloud Gate' by the artist Anish Kapoor [1] (fig. 9); a possible large-scale application using the curvilinear reflective surfaces of the Palazzo della Regione Lombardia in Milan by Pei Cobb Freed & Partners (fig. 10); and finally a model of the free-form reflective surface of the

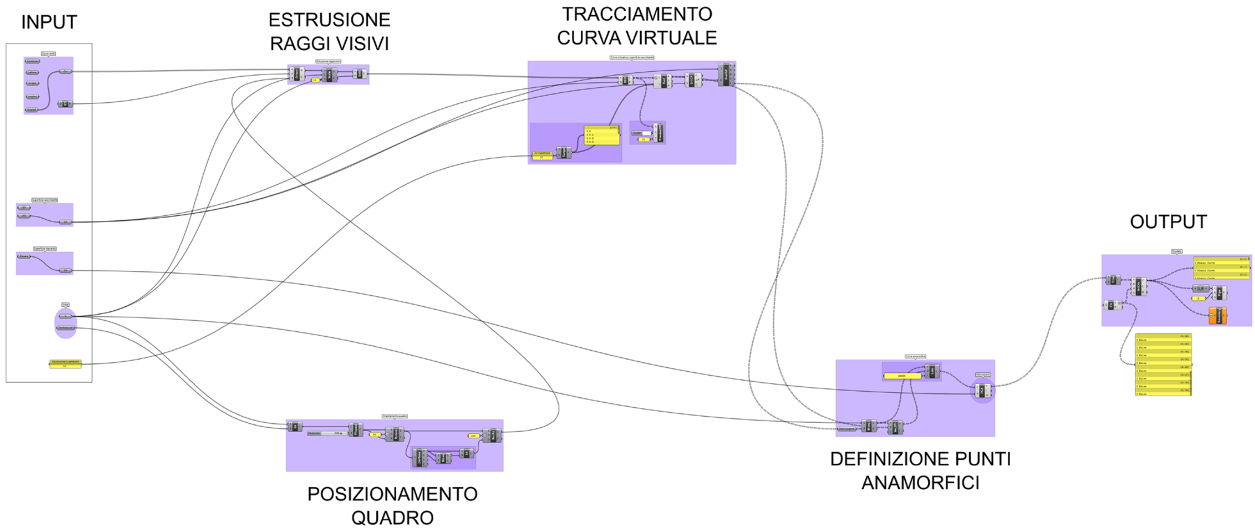


Fig. 7. Definition of the structure of the visual algorithm controlling the generation of the illusory process in the Grasshopper plugin workspace (authors' drawing).

Boijmans Van Beuningen Museum in Rotterdam by the studio MVRDV (fig. 11).
For each of these examples, a visualisation from the privileged viewpoint of the observer and isometric views representing the anamorphic curves in true form are shown.

Conclusions

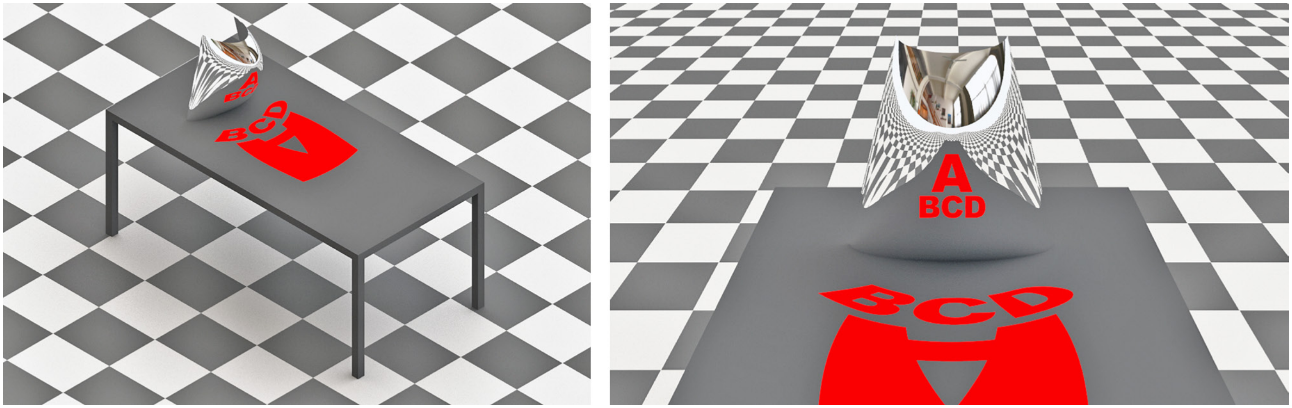
The proposed methodology offers the possibility of implementing geometric processes of catoptric anamorphosis of remarkable expressive potential in multi-scalar design contexts with reference to reflecting elements of relevant extension and geometric complexity with a generalizable parametric control [Rossi, Buratti 2017; Saggio 2007].
In particular, in the use of generic free-form surfaces, the defined method guides the designer in the construction of the anamorphosis, allowing rigorous measurement of the deformed figures and the corresponding reflected images on the reflecting surfaces, predicting, with reference to the chosen point of view, the outcomes of the projective phenomenon [Bianconi, Filippucci 2019].
The algorithm developed makes it possible to determine the catoptric anamorphosis for almost any surface or portion of a convex surface, but does not return an equally reliable result if the surface is concave or presents a change of concavity. This is due to the physical-optical characteristics of the light reflection phenomenon, which in the well-known examples of reflection in spherical concave and paraboloid mirrors presents, in the general case, an inversion of the reflected image.
In the case of a fully concave surface, the resulting image is more difficult to manage, while in the case of a change of concavity, the inversion of the reflected image makes it impossible to determine an unambiguous anamorphic image.
This is true for both free-form and ruled surfaces with these characteristics.

Notes

[1] <http://anishkapoor.com/> (accessed 2020, 10 November).

Fig. 8. Catoptric anamorphosis, example of small-scale application, mathematical machine of teaching laboratory; on the right, rendering of the privileged viewpoint (authors' drawing).

Fig. 9. Catoptric anamorphosis, example of medium-scale application, the inscription "Diségno 2020" reflected on a geometry similar to the land art work "Cloud Gate" by the artist Anish Kapoor; on the right, rendering of the privileged point of view (authors' images).



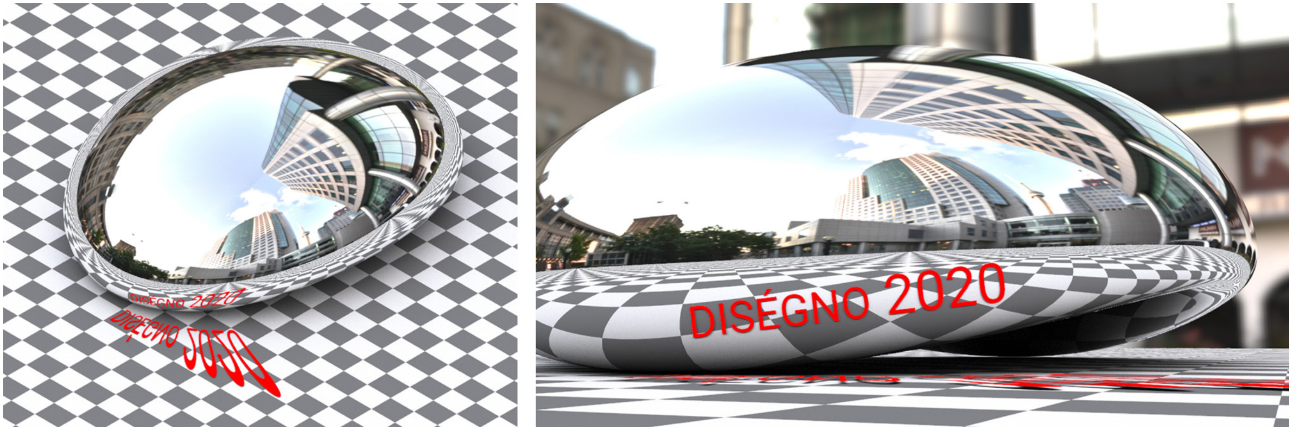
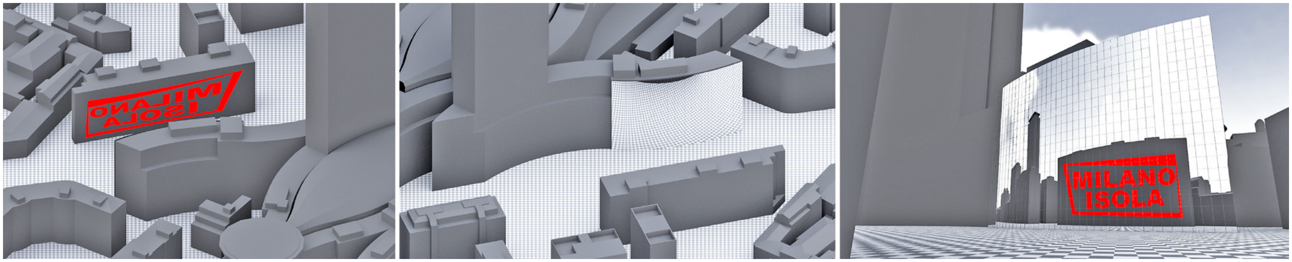
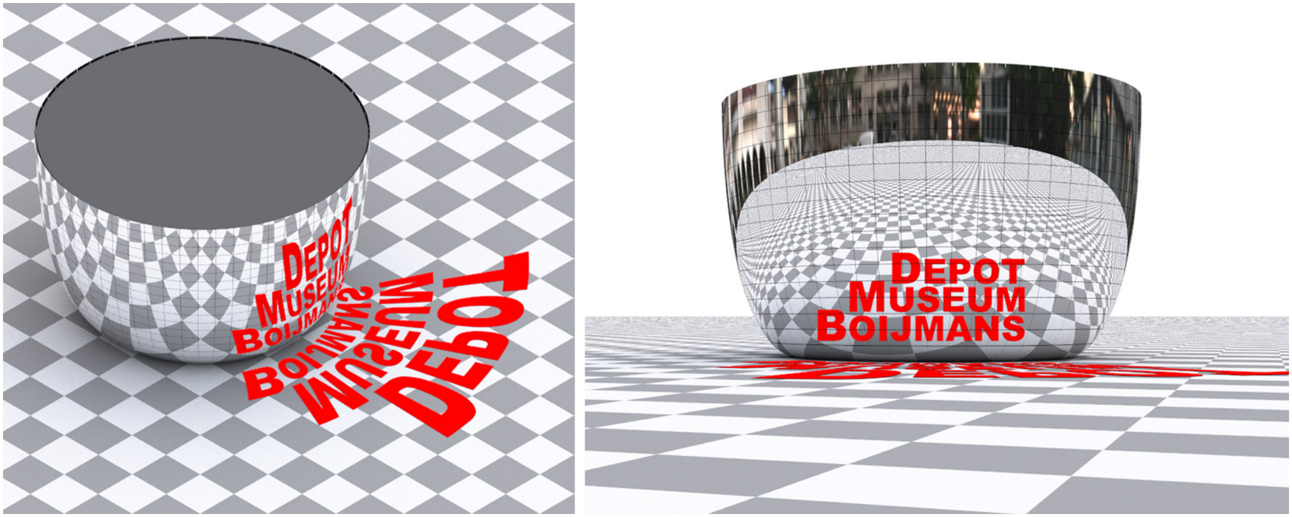


Fig. 10. Catoptric anamorphosis, example of a large-scale convex surface. Render reproducing the reflection on a building elevation; on the right, privileged viewpoint. Reproduction of the shape of the main elevation of the Palazzo Regionale Lombardia, Milan. (image by the authors).

Fig. 11. Catoptric anamorphosis, example of a large-scale complex surface. Render reproducing the shape of the Boijmans Van Beuningen Museum, Rotterdam; on the right, privileged viewpoint (authors' image).





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The Value of Measurements, in Desgodets and Palladio

Francisco Martínez Mindeguía

Abstract

In 1682, Antoine Desgodets published Les édifices antiques de Roma dessinés et mesurés très exactement, *confirming the imprecision of the data published by the Italian architects of the previous century, singularly by Palladio in his* Quarto libro dell'architettura*, whose errors he does not cease to denounce in his book. This is a question that raises the confrontation of two attitudes in the face of the knowledge of antiquity that refers to the very objective of architectural representation. Between the indisputable value of data and the ambiguity of intuitive knowledge. Between Desgodets's drawings, of unquestionable quality, but limited to what he can verify, and Palladio's compositions, of an almost radical abstraction, capable of incorporating what Raphael understood as "seeing as painters", without renouncing the orthogonal drawing of plant, section and elevation.*

Keywords: Antoine Desgodets, Andrea Palladio, fragment.

IIntroduction

In 1674 Antoine Desgodets was sent to Rome to measure its ancient buildings. The commission came from the Minister Jean-Baptiste Colbert, who three years earlier had created [1] the *Académie royale d'architecture*, with the aim of establishing the official doctrine of good architecture. Desgodets' specific mission was to accurately measure the ancient buildings of Rome, as they were then, in order to resolve the discrepancies that had been detected between the data provided by Sebastiano Serlio, Antonio Labacco and Andrea Palladio, and denounced by Roland Fréart de Chambray, in his *Parallèle de l'architecture antique avec la moderne* [Fréart de Chambray 1650]. Colbert aspired to build a system of fixed rules and concrete models that he could apply in state-building policy and that would build on the undisputed prestige of ancient Roman architecture. Colbert aspired to build a system of fixed rules and concrete models that would be based on the policy of state building and that would be based on the undisputed prestige of the architecture of ancient Rome [Herrmann 1958, p. 23]. Desgodets's exact surveys should allow the proportions of the correct architecture to be deduced, surveys that would be the closest thing for "owning" the building, similar to have plaster copies of the sculptures.

Desgodets's work, which was finally published in 1682 [Desgodets 1682], was a radical change from previous surveys, both for its rigor and for the engravings with which he illustrated the results, and for a long time was a model of reference of similar studies. The precision of his

measurements evidenced the errors made by the preceding authors and particularly by Palladio [Palladio 1570], whom he accused of an incomprehensible carelessness and an apparent lack of rigor, while at the same time that this undermined the theoretical basis on which the studies of some of the leading academics were based [Herrmann 1958]. But the knowledge of the exact measurements of the buildings did not change the valuation of them, nor did it affect the prestige of these authors. Nor was the ultimate goal pursued by Colbert achieved because antiquity was not such a perfect system, reducible to precise rules and concrete models, and Colbert continued without "having" the buildings of ancient Rome, nor the rules of "great architecture" [Gros 2010, p. 25] and had to rely on the *pensionnaires* sent to Rome to experience what made them remarkable buildings.
Faced with this apparent crisis, it is worth asking what value the measures had or what was left out of them. The aim here is not to reproduce the analyzes already made on Desgodets' criticisms of Serlio or Palladio, nor on the coherence of the proposals of these authors, but to see how the drawings they published allow us to understand the objectives of their research, comparing some drawings by Desgodets and Palladio, since it is to the latter that the main criticisms of the former are directed. Before starting, two important issues should be considered, so that the formal aspect does not affect the result. First of all, it would not be fair to compare the drawings without taking into account the conditions in which they were made. In the case of Desgodets, it was a specific commission, made in a short period of 16 months, in which he surveyed 49 monuments, although only 25 were published, when he was 21 years old [Lemonnier 1917, p. 216]. In the case of Palladio, as in that of other Renaissance architects, it was the result of a complementary activity to the professional one, dilated in the time, that many began without arriving to complete. A work that Palladio redone when he was already advanced, that he could mature and that he published when he was 62 years old and was already an architect with recognized prestige. Secondly, it must be taken into account that they were published with different engraving techniques, with copper plates, the work of Desgodets, and with wooden plates, that of Palladio, the same technique that was used by Serlio, because, in Venice, the use of woodcut went on longer than in Rome or Paris, which earlier adopted the use of copper plates, with burin or with acid.

The Pantheon

In addition to the accuracy of the measurements, Desgodets's work is much more extensive, with 302 pages in total, excluding the dedication, the preface and the index, which he uses to show 25 buildings, while Palladio's *Il quarto libro dell'architettura* [2], occupies a total of 123 pages, without considering the prologue or the theoretical introduction, and shows 26 buildings. If, to better understand the differences, we look at one of the buildings, the Pantheon, which both consider the most important [3], the former uses 60 pages to describe it, while Palladio uses only 12. This difference should also be nuanced.
In the 60 pages of the Pantheon, Desgodetz contributes 23 plates, of which 6 occupy two pages each (fig. 1). The remaining pages are of text, although this does not occupy them completely and much of it is used to compare their data with those of Palladio, Serlio and Roland Fréart de Chambray, pointing out their errors and omissions. In no case, nor in the other buildings in the book, does he combine text and image on the same sheet. As in the rest of the buildings, the images are complete orthogonal projections, except for the details of the orders, which, according to the convention, are compositions of parts. These plates are: the ground floor, which includes the drawing of the pavement, the upper floor, composed of the halves of two different levels (that of the attic and that of the beginning of the vault, with the coffering), a front elevation, a lateral one, the longitudinal and the transverse section, in which it composes two halves of opposite orientations (towards the inside and the outside). These are the plates that occupy 2 pages each. Another 2 plates contain the cross section of the portico and the elevation of one of the interior altars, and the remaining 15 are details of orders and ornamental elements. The engravings are of a high graphic quality, with a good definition of contours, an expressive chiaroscuro and a good use of solar shadows, with which curvature and depth are suggested, taking advantage of the capabilities of engraving with copper plates. In some details of capitals, he adds a zenith plan (from below) that he composes with different rooms, in which he removes layers to better understand their composition (fig. 2). In this way, he follows the models that Jacopo Barozzi da Vignola published in the *Regola delli cinque ordini de l'architettura* [4], with the same operation that he applies in the compositions of the upper plans and the cross section. All

Fig. 1. The 60 plates of the Pantheon. Desgodets 1682.

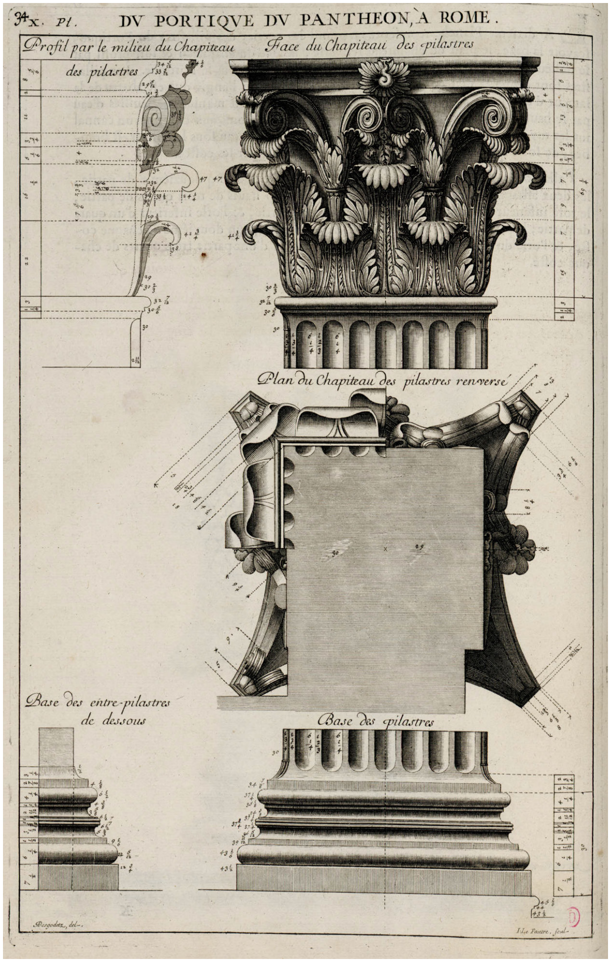


Fig. 2. Pilaster of the portico of the Pantheon. Desgodets 1682.

the projections completed with abundant measurements, excessive according to its critics, taking into account that it also provides a graphic scale and a drawing of precise contours. Overall, it is a good example of what the drawing of the academies was: the culmination of a process begun in the Renaissance to recover the perception of three-dimensionality that orthogonal projection drawing prevented.

For his part, Palladio does not begin his exposition with the Pantheon and moves it to position 15. Of the 12 pages he uses, 10 are plates with images (fig. 3) and 2 only with text, the first of these with the description of the building and the second with the index of the plates and a concise title for each one. With this reduction of the text, Palladio fulfils what he already announces at the beginning of the *Primo libro*, of avoiding the excess of "words" [5], following the laconic style that Labacco and Vignola had used before. These plates are: the plan, the symmetrical half of the main elevation, the opposite half with the cross section of the portico, the side elevation of the portico and its connection with the cylindrical body, the longitudinal section of the portico and its connection with the interior, the symmetrical half of the cross section, a fragment of the interior elevation, centred on one of the interior altars, and two plates with capitals and other parts of the decoration. As in the rest of the plates in the book, there is limited use of shadows, used to suggest curvature and some change in depth. The incorporation of measures is moderate, taking into account the size of the drawing, except for the plates of the orders, in which they are abundant.

More than the numbers, the important difference between the two approaches is the composition of the plates. Desgodets determines the scale of the projections on the first sheet, the ground floor, leaving an acceptable margin between the projection and the page boundaries. This scale is the one that applies in the rest of the projections of plans, elevations and sections, except in the cross section of the portico, in which the scale is smaller to take advantage of the available space, allowing the drawing to be larger. This portico appears isolated, as if it were an autonomous piece, without references to the main body of the building that could be seen behind. Posed in this way, the projections are more or less centered on the plate [6], with a perimeter margin that is used to locate the dimensions, a graphic scale and the titles. It is a composition that could be

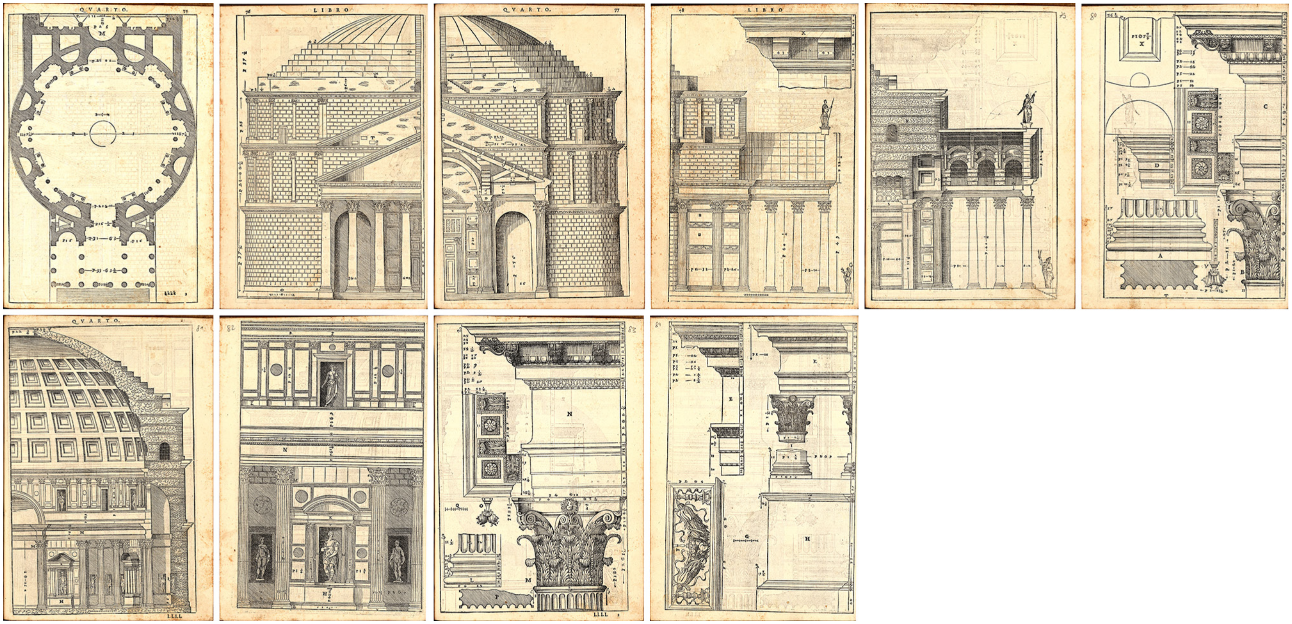


Fig. 3. The 10 plates of the Pantheon. Palladio 1570.

considered conventional. In the plates of the orders, he follows the Vignola model, even in the drawing of the alignments between projections and in the incorporation of a schematic profile of the capital that facilitates the placement of the dimensions.
For his part, Palladio reduces the scale of the projections to the maximum, trying to make the drawing as large as possible, reducing to a minimum the perimeter margin, and draws a rectangular frame adjusted to the final size of the projection, in such a way that sometimes it coincides with the projection lines. Outside this frame is only the title of the book and the page number. In this way he constructs the plate of the Pantheon plan, which shows completely, with the frame "glued" to the lower and upper limits and with the sides tangent to the circle of the plan. The frame appears to make more sense in following plates, with the halves of the front elevation, in which the frame coincides with the "cutting" limit of the projection. By using the page space only for half of the elevation, it achieves that the drawing dimension larger, and by placing the two halves on facing pages of the book, it offers the reader the complete image of the elevation. This compositional solution had already been tried by Palladio in Daniele Barbaro's edition of *De architettura* in 1556 [7], solving the problem of composing the two projections in the same drawing [8]. Apparently, Palladio had qualms about it, due to the confusion it could cause in the reader and, when he had to compose them, he did so by faking a break in the façade wall that exposed the interior, which was an image that the reader could understand (fig. 4). A proof that confirms these objections is a drawing from the reissue of *De architettura* by Daniele Barbaro, from 1567, in which a combination of this type was solved by adding two letters over the projections, with a comment that clarified that one part was the elevation and another section (fig. 5) [9]. Unlike Desgodets, Palladio shows the cross section of the portico with the elevation of the rear body of the building, and not isolated, which he could have dispensed with because it already appears, symmetrical but identical, in the previous sheet.

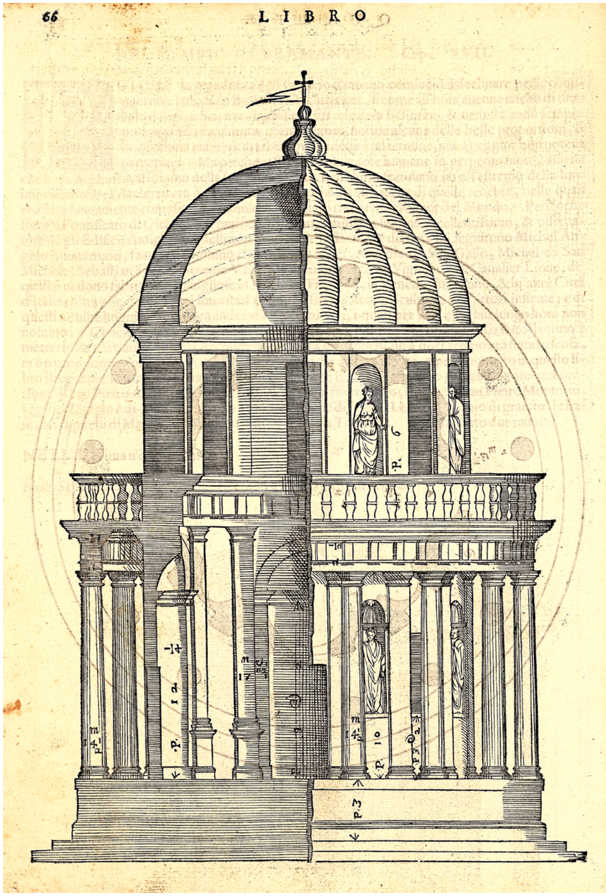


Fig. 4. Bramante's Temple. Palladio 1570, IV, p. 66.

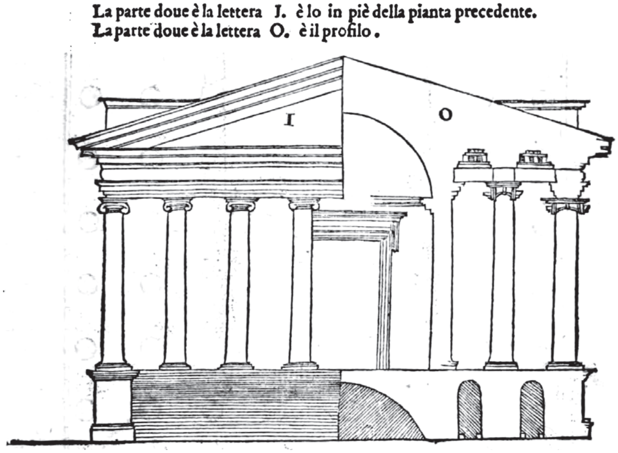


Fig. 5. Elevation and section of a temple. Barbaro 1567, p. 32.

If in the plan and in these elevations, the frame coincides with characteristic limits of the projection (one end or the axis of symmetry), in the next two plates (the side elevation and the longitudinal section of the portico) the projection is not the one that determines the contours of the frame: its dimension and the scale of the projection are those of the previous sheet and, instead, it is the frame that sets the limit of the projection, without coinciding with any singular element of it. Strictly, the frame delimits a fragment whose limits we could consider undefined. Like Desgodets, in the plates of the capitals it also follows the models of Vignola's *Regola* [10].
The graphic exhibition of the plates is consistent with the will to show large images, but with an extreme abstraction that does not soften to adapt the drawing to the usual conventions, despite the originality of the solution, which manages to resolve with an undeniable appeal.

The fragment

The only cases in which Desgodets shows fragments are, in reality, either buildings that were incomplete by partial demolition, in which he valued showing what was still preserved, or buildings with buried parts that he could not fully measure. But even in those cases what he shows on his plates are full projections. These are cases that should

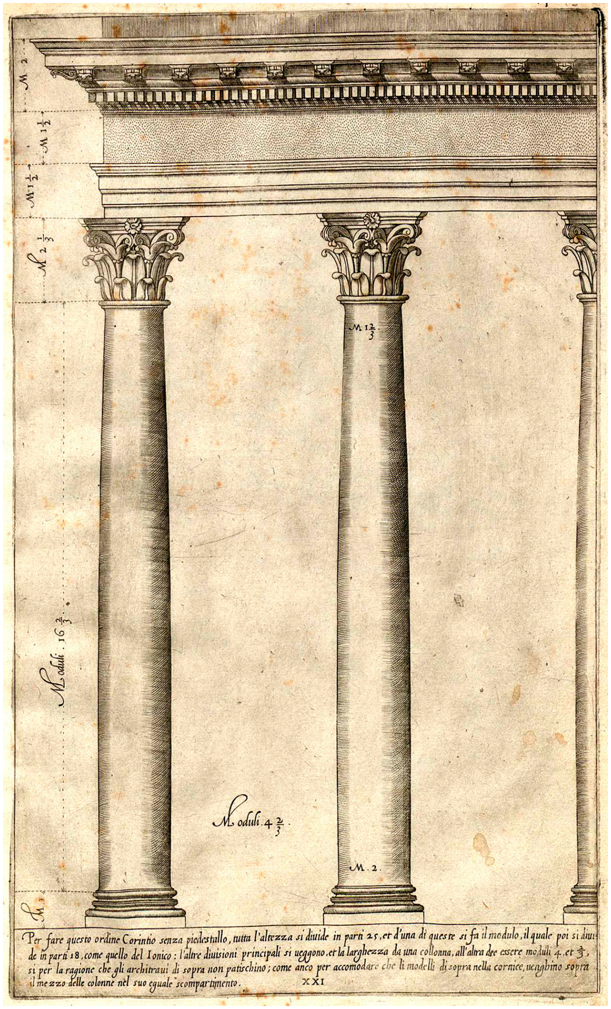


Fig. 6. Corinthian order. Vignola, Regola, lam. XXI.

Fig. 7. Colonna 1499, p. 75

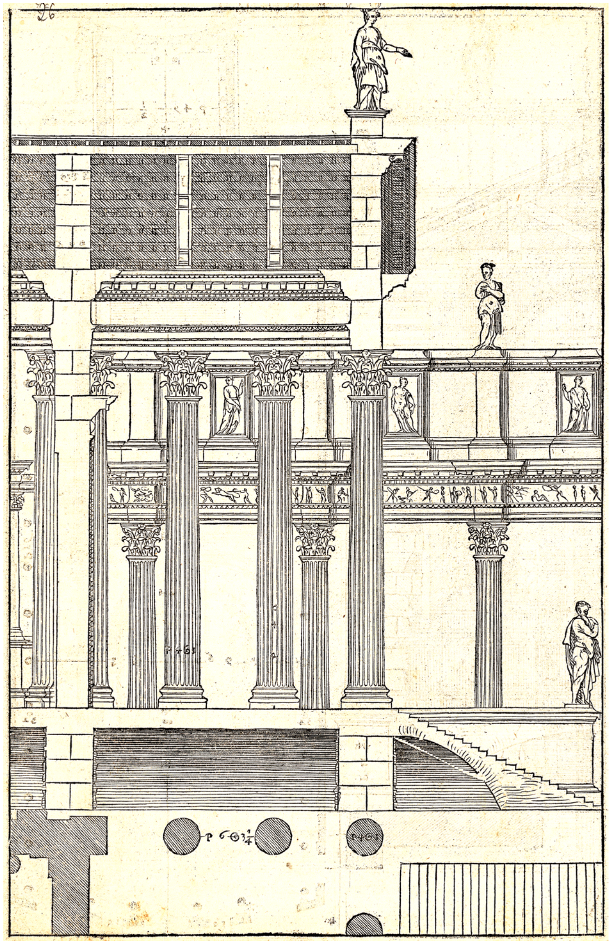
not be considered as fragments, in the sense that we are giving here. By contrast, in Palladio's case, the fragment has a singular value that should be noted.

Possibly, due to the long elaboration of *I quattro libri*, all its plates are not resolved in the same way, although they always have a careful composition, which pretends to be uniform in the plates of each book. However, there are some features that are common in most plates, such as the relationship of the frame with the drawing it delimits, the composition of the different projections on the plate and the role of the fragment.

The frames to delimit the drawings had already been used in the editions of Vitruvio's *De architettura*, by Giovanni Gi-

Fig. 8. Colonna 1499, pp. 153 and 154, faced.

ocondo, in 1511, and Cesare Cesariano, in 1521, although perhaps the most decisive influence was from Vignola's *Regola* [11] (fig. 6), which must also have influenced Palladio's interest in the composition of the sheet, as a fixed system, solid in its construction and effective for communication. Although, strictly, the frame adjusted to the measurements of the drawing has an earlier precedent, in the engravings of the *Poliphili Hypnerotomachia*, by Francesco Colonna, of 1499 [12] (fig. 7), which also contained engravings bound on facing pages that, together formed a single image (fig. 8).
The *Quarto libro* is perhaps the most irregular, with 99 plates of drawings, of which 7 also have text and 83 have frame. Of these 99 plates, 29 are of details of capitals and ornamental elements, 35 plates are conventional plates, with complete images of plan (19), elevation (5), elevation-section (3) or composition of projections (8), and 35 are plates with incomplete projections (fragments). Of the latter, 20 are dihedral compositions of elevation or section with a fragment of the plant that helps to understand them better. I would like to draw attention to 11 of these last plates, in which, to the description of the temple, the environment that surrounds it is added [13]. It should be clarified that they are temples that Palladio rebuilds based on what is preserved and what he knows about them, but that he could not see complete or standing.
One of these plates is the longitudinal section of the portico of the temple of Nerva Traiano, which Palladio titled *Diritto del fianco del portico, & per gli intercolunnij si vede l'ordine delle colonne che erano intorno la Piazza*, pointing out the two aspects to consider in it (fig. 9) [14]. The temple stands at the end of the Foro de Nerva, or Foro Transitoro, a rectangular "piazza", long and narrow, bounded by a perimeter of columns and a continuous wall behind them (fig. 10) [15]. The plate shows the section of the portico and a fragment of the plan placed below, with no separation margin. The frame coincides with the beginning of the access staircase and extends beyond the wall of the *cella*. As the title makes clarifies, behind the columns of the portico you see the perimeter columns of the square, but the floor plan is not provided: they are only the background that "you see" behind the portico. It is a fragment of the temple in front of a fragment of the perimeter wall, superimposed in an image without depth that, despite the austerity of the graphic resources, compose a drawing that is understood and attractive. It can be deduced that they are entities that complement each other, that exchange reciprocal qualities that make up the same aes-



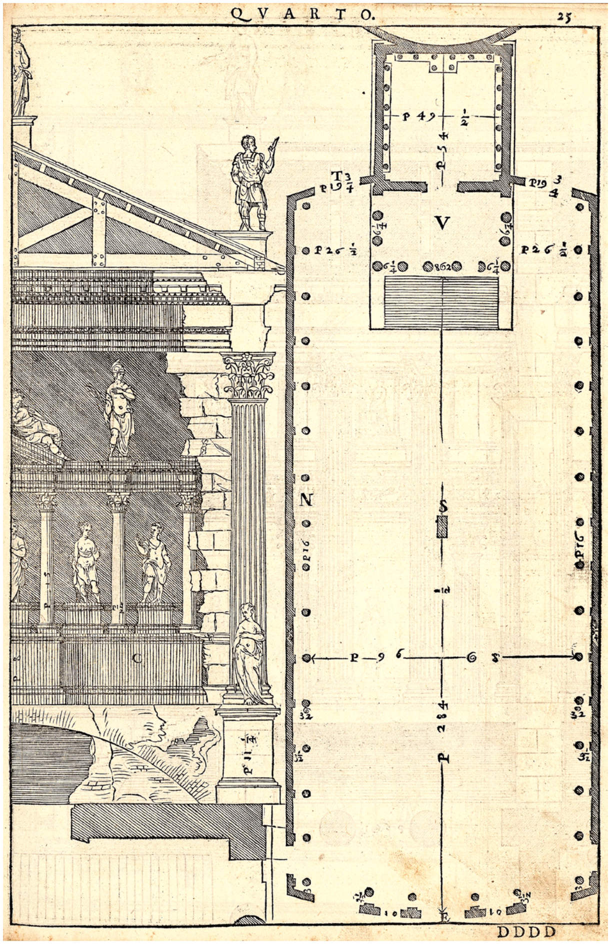


Fig. 9. Portico section of the Minerva's Temple. Palladio 1570, IV, p. 26.

Fig. 10. Elevation of the portico of the temple and plan of the Forum of Nerva. Palladio 1570, IV, p. 26.

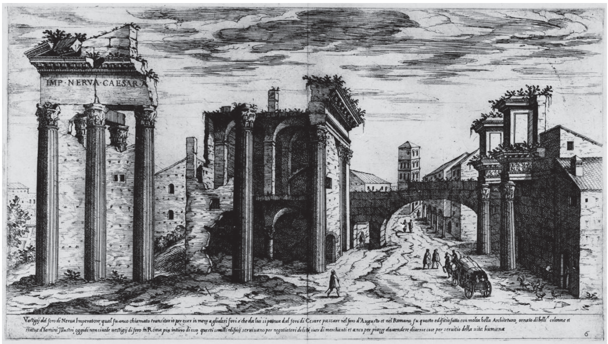


Fig. 11. Forum of Nerva. Dupérac 1575, lam. 6.

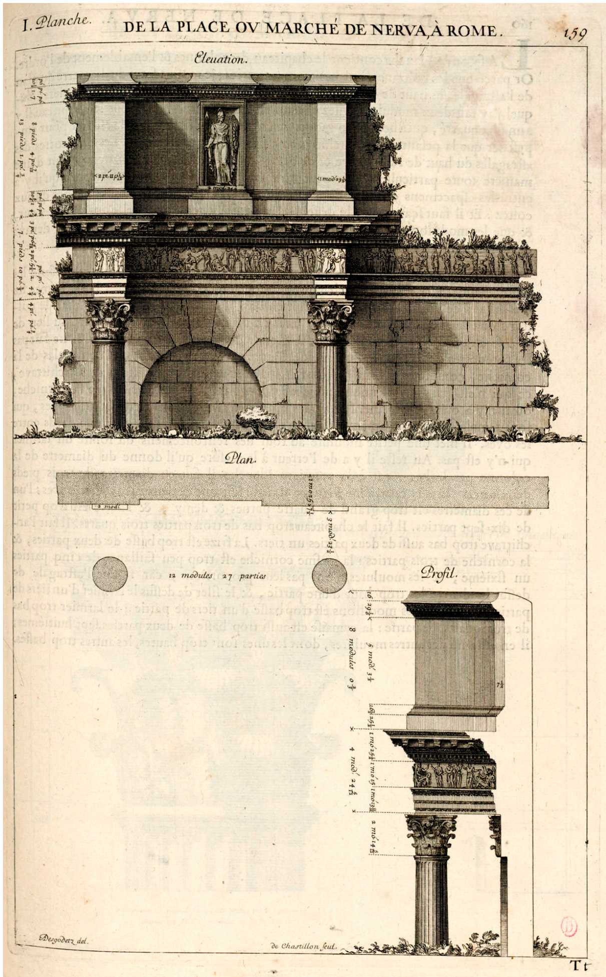


Fig. 12. Forum of Nerva. Desgodets 1682.

thetic experience. Stated in this way, the incorporation of the environment in this section translates the "look of the painter", to which Raphael referred, into a drawing that does not lose its architectural character. Raphael's comment was contained in the letter he addressed to Pope Leon X, in fulfilment of the commission that he had given him, around 1515 [16], to draw and measure the buildings of ancient Rome, to deduce how it must have been what had been lost and, from there, try to rebuild it. In the letter, Raphael justifies that he draws them like the architects, in plan, elevation and section, in order to have the exact measurements of the buildings, but that he also does it in perspective, to better understand the distant parts, recommending that this own method of the painter be used also by architects because with it they can better imagine buildings [Bonelli 1978, pp. 482, 483]. It was a comment that was justified in the difficulty of "seeing" the buildings with the architect's drawings, and in an attitude that had the support of Cicero, who said *that painters see in the shadows and with clarity what others do not see* [17]. But Palladio was an architect and could not literally apply that recommendation. "Seeing as the painters" implied incorporating the presence of the environment, the idea that it conditions the perception and valuation of the building, but also the ability to "see" from the fragments that determine the field of vision, extracting from reality a fragment that allows transmitting the aesthetic content of a relationship.

Currently, of the Foro Transitorio, only two perimeter columns remain, but Palladio could see part of the temple of Nerva (or Minerva) partially standing, as it appeared in the drawings by Maerten van Heemskerk, Bernardo Gamucci [Gamucci da Gimignano 1565, p. 52] or Étienne Dupérac [Dupérac 1575, p. 6] (fig. 11), before the interventions of Pio V and Paulo V had just brought it down. Desgodets could only see the two current columns and it is the only thing he drew, such that he announced that he would do at the beginning of his book (fig. 12), avoiding venturing the original state. For his part, Palladio, in *Proemio ai Lettori del Quarto Libro*, says that, in a general way, from the remains that are standing of the buildings, from the study of the foundations and with the teachings of Vitruvius, he will deduce how "they must have been when they were whole " [18]. His objective was not to make an exact survey, but to show the shape and ornaments of these temples "so that each one can know in what form the churches should be made and with what ornaments" [19]. His interest was not the antiquity as it stood but "the imagined antiquity" that survives eternal [Gros 2010] and that can continue in modern activity. Based on the knowledge he had of ancient architecture and in view of the parts that were preserved, Palladio could not help deducing what the building must have been like and drawing it, as he says in the prologue of the *Primo libro*: "understand [the building] and in drawing reduce it" [20]. Palladio's gaze seems to see beyond what the remains show: it is a critical gaze, which interprets what he sees.

Conclusion

As Desgodets explains in the prologue to *Les édifices antiques de Rome*, it is very likely that Palladio did not believe that the value of these buildings depended on that precision [21] and that he was looking for something different in them. For Desgodets they were models that he had to measure exactly and in their scrupulous compliance lay the merit of his work. They were the exemplary models that were to allow the rules of good architecture to be set. For Palladio, they were the remains of an incomplete puzzle that could be put back together, the starting point of a reflection that had to allow continuity (Gros 2010, p. 25). The antiquity of Rome was for the most part fragments, buildings in ruins or buried, and the imagination was necessary to put the process back together. As if they were pieces of a "non finito", which activates the curiosity to discover what is missing.

Notes

[1] Formally the founder was King Louis XIV, on the initiative of Colbert.

[2] Palladio 1570, divided into four books, the *Quarto* is the one that Palladio dedicates to the ancient temples of Rome.

[3] "le plus entier & le mieux exécuté de ceux qui sont restez jusqu'à notre temps", according to Desgodets, and the "più celebre […] che ne sia rimasto più intero, essendo ch'egli si veda quasi nell'esser di prima quanto alla fabbrica", according to Palladio.

[4] Although the data does not appear on the cover, it has been possible to deduced that it was published in 1562 [Thoenes 2002, p. 333].

[5] "Et in tutti questi libri io fuggirò la lunghezza delle parole"; en Palladio 1570, I, p. 6.

[6] For some reason, the projections are not placed at the same height on all pages.

[7] Barbaro 1556, p. 22 and 23. Palladio is supposed to have drawn the plates.

[8] It must be taken into account that "seeing" the buildings from images as abstract as the plan, the section or the elevation was not easy initially and combinations of this type were only assimilated from the beginning of the 17th century.

[9] Barbaro, 1567, p. 32. The reissue of 1567 led to a reduction in the format of the pages, from *in-folio* to *in-quarto*, and a reduction of the images. This image replaced two separate ones that, in the 1556 edition, were bound on facing pages.

[10] To the point that one of these plates, the penultimate, is a copy of plate XXVI from Vignola's *Regola*.

[11] The influence is very evident in the *Primo libro*.

[12] Colonna 1499, a Vitruvian commentary in the form of a novel and the first book related to architecture to be printed with illustrations. Originally written in Latin, around 1467 (Dinsmoor 1942, p. 59).

[13] They correspond to the temples of Marte Vendicatore, Nerva Traiano (or Minerva), Antonino e Faustina, and Giove nel Monte Quirinale.

[14] This is the temple that we now know as Minerva, which was in the Foro Transitorio.

[15] Palladio could see part of the temple of Nerva standing, as it appears in the drawings by Étienne Dupérac or Maerten van Heemskerk,

but currently, from the Forum Transitorium only two columns remain of the perimeter, since Pope Pius V demolished it in the decade from 1560.

[16] The exact date of the commission is not known, but in 1515, the pope appointed him prefect of Rome's antiquity. Before that date he had commissioned Marco Fabio Calvo to translate the book of Vitruvius and the letter to Leon X appears to be from 1519-1520. Between these margins the commission must have been produced.

[17] "Quam multa vident Pictores in umbris et in eminentia quae nos non videmus¡" [How many things painters see in the shadows and with clarity that we do not see!], Cicero, *Academica*. Lib. II, VII.

[18] "dovessero essere quando erano intieri": in Palladio 1570, IV, p. 3.

[19] "dimostrar in questo libro la forma, e gli ornamenti di molti Tempi antichi, [...] accioche si possa da ciascuno conoscere con qual forma si debbiano e con quali ornamenti fabricar le chiese": Palladio 1570, IV, p. 3.

[20] "per potere interamente da quelle, quale fosse il tutto, comprendere, et in disegno ridurlo": Palladio 1570, I, p. 5.

[21] Desgodets's comment contains a certain irony, the result of the "pedantry" with which he exposes his achievements.

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Measure of Architectures on Paper: Graphic and Analytic Practices of a Student of Architecture around 1787

Martino Pavignano

Abstract

The essay critically investigates some drawings elaborated by Giovanni Battista Cipriani during his architectural studies with Giuseppe Palazzi, in the 1780s in Rome. Relationships between these drawings and their known graphic sources are studied and can be traced back to some plates of the first Libro primo Scielta di varii tempietti antichi di Giovanni Battista Montano *(Rome 1624) in the edition of 1684. These drawings have a double meaning for the history of Representation, as they are the results of an eidetic practice that acts an interpretative process of a given graphic source – which has become a building on paper to be surveyed and synthetically redrawn – or as the final result of a process of partial reconfiguration with heuristic values, at least as regards the use of drawing as a tool for representing architect's ideas and projects.*
From this point of view, Cipriani's works become interpreting tools for the practice of surveying drawing and graphic sources, as well as symbols of the value of drawing intended as an expression of the memory of its author, as it happened when re-annotated on the Libraccio o miscellanea di memorie spettanti alle belle arti *(1801 e seg.), the model of the 'opera omnia' representing Cipriani's concept of eidetic knowledge.*

Keywords: Giovanni Battista Cipriani, architectural education, graphic source, critical interpretation, graphic analysis.

Introduction

Drawing, here intended as "a cognitive and creative place where the idea is born and reveals itself in its potential" [Purini 2010, p. 12], is at the basis of the practice of architecture. Similarly, drawing is the result of those transformations that affected the various civilizations and their respective cultural climates, leading to the multiplication of occasions that allowed "to arouse those stimuli and those communicative opportunities that extended the practice of representation to all human activities, especially to those relating to the use of the image both as a qualified objective of aesthetic communication and information and as a design tool for all sorts of artifacts" [de Rubertis 2018, p. 24].

Likewise, architecture has always been linked to the concept of measurement, here understood as an essential element for the formalization of architectural geometries or as the result of a process of dimensional analysis of the same [Ippoliti 2000, pp. 51-68]. Indeed, if we consider the latter as one of the possible expressions of geometry, of which Guarino Guarini remembered the founding role for architectural practice [Guarini 1737, p. 3], then it is clear how much this connection is elevated to the role of supporting structure for, not just subjugated by, architecture, as for design and analysis purposes. Then, the architect, and student, must know how to decline the measure according to its applications, to reach a critical knowledge of the

world around him [Docci, Maestri 2009]. Therefore, the architect's training must deal with the concept of measurement itself, mainly in its practical declination as outcome of instrumental operations which is functional to the metric knowledge of an artifact or a context whose prerogatives must enter into be part of the cultural background to be structured before any heuristic process having architecture as main goal [De Simone 1990, pp. 224-226].
In this context, the contribution proposes an analysis of some drawings made by Giovanni Battista Cipriani (1765-1839) during his training as an architect, in the last quarter of the XVIII century in Rome.

Giovanni Battista Cipriani

Born in Siena, Cipriani studied Architecture and became draftsman, etcher, and perceptive surveyor [Pavignano 2019, pp. 94 and 145]. He first undertook fine arts studies in Siena, with the sculptor Giuseppe Silini and, perhaps, technical studies with the engineer Bernardino Fantastici. In the early eighties of the XVIII century he had the opportunity to move to Rome where he undertook architectural studies with Giuseppe Palazzi [Debenedetti 2006, p. 235]. In this context, maybe thanks to the guidance of Palazzi, Cipriani got in contact with the cultural circle headed by the philosopher Leonardo de Vegni [Debenedetti 2015, p. 208] and, consequently, with the "cultural circle of Francesco Milizia" [Olschki 1940, p. 8]. Thanks to these cultural 'connections' Cipriani will turn his interest more towards drawing, representation and communication of Architecture, rather than architectural design [Pavignano 2019, pp. 52, 53]. Here, I cite his first important work as an 'illustrator' of the architectural fact, which occurred through the collaboration with Giandomenico Navone for the *Nuovo metodo per apprendere insieme le teorie, e le pratiche della scelta architettura civile* [Navone, Cipriani 1794].
Cipriani developed his professional activity around to provide adequate tools – both for graphic quality and for communication synthesis – mainly for architectural education and dissemination. Examples are the three volumes of *Monumenti di fabbriche antiche estratti dai disegni dei più celebri autori* [Pavignano 2019, pp. 68-71, 78, 96-98], the vedute of the *Edificj antichi e moderni di Roma* [Debenedetti 2017; Pavignano 2020] or the *Itinerario figurato di Roma* [Pavignano 2019, pp. 145-147].

This contribution proposes a renewed critical inspection of the *Taccuino Lanciani 33*, preserved at the BiASA in Rome, whereas I do not discuss here the overall values of Cipriani's corpus of original work [Pavignano 2019].

Methodological approach

The analysis is structured in several phases, consequential to each other and removed from the consolidated practice of the discipline of Drawing. First, I identified the drawings of interest contained in the *Taccuino Lanciani 33* (personally retrieved at BiASA, table 1) [1], then I carried out a comparison with the possible graphic sources used by Cipriani. In this regard, I chose to use the edition of Montano's *Raccolta de Tempii, e sepolcri disegnati dall'antico* dated to 1684 (acquired through the central object database Arachne), identified by Pasquali [Pasquali 2002] as the source of the captions written by Cipriani [2]. Having recognized the used plates, I collected in table 2 the data relating to: title of the object drawn by Cipriani, volume and table of Montano 1684 and related captions. There, I provided a specific comparison with Montano's *editio princeps* [Montano 1624] (personally retrieved at BNTo). In this way, it was possible to define a first synoptic framework of drawings and respective graphic sources. Subsequently, I processed the images acquired using CAD software to define the proportions of some of the Cipriani's buildings, then I proceed with a critical comparison between the work of Cipriani and that of Montano, on the basis of retrieved data on the survey of the drawings. This phase was carried out following what has been stated regarding the study by Ursula Zich of Palladio's *Quattro libri di Architettura* [Zich 2009].

Taccuino Lanciani 33

The *Taccuino* consists of sixteen bounded papers (cc. 1r-16v) and three loose papers (cc. 17r-19v), of medium format 242 x 184 mm (fig. 1) and has been previously noted [Pasquali 2002; Debenedetti 2015]. All the sheets, often signed 'GBC', can be dated between 1786 and 1791, due to annotated dates, and is introduced by a cover with the drawing of the façade of

Tab. 1. Taccuino Lanciani 33 contents.

Soggetto	Titolo	Carta	Disegno
0	Chiesa di San Crisogono	1r	Facciata (prospetto)
		1v	vuota
1	Sepolcro di forma quadrata fuori; e dentro tonda, ornato di Corintio, di cui vedonsi i vestigj fuori di Porta Maggiore a mano dritta in Roma. Copiata per istudio, e fattone quest'abbozzo per notarvi le misure a parte	2r	Pianta
		2v	Membri in grande (particolari)
		3r	Alzato (prospetto)
		3v	vuota
2	Tempio di Bacco fuori di Porta Pia in Roma	4r	Pianta
		4v	Alzato (prospetto con particolari)
		5r	Spaccato (sezione con particolari)
3	Tempio antico	5v	Alzato (con particolari)
		6r	Pianta (con particolari)
		6v	Spaccato (semi-sezione con particolari)
4	Tempio antico vicino Tivoli	7r	Metà d'una pianta
		7v	Alzato (mezzo prospetto con particolari)
5	Sepoltura fatta dagli antichi d'Ordine Dorio, e Corintio	8r	Pianta
		8v	Elevazione (mezzo prospetto)
6	Edificio antico non definito	9r	Pianta (mezza pianta)
*	Appunti vari	9v	Testi
7	Tempio Antico, Copiato dal Compagno	10r	Pianta (con particolari)
*	Appunti vari	10v	Testi
8	Tempio Antico che vedesi fuori di Roma molto Rovinato	11r	Pianta (mezza pianta)
		11v	Facciata (mezzo prospetto con particolari)
9	Tempio Antico d'Ordine Corintio nella Campagna Romana fuori di Porta Pia	12r	Metà della pianta (mezza pianta con particolari)
		12v	Alzato (mezzo prospetto con particolari)
10	Tempio Antico	13r	Pianta (pianta con particolari)
		13v	Elevazione (mezzo prospetto con particolari)
11	Tempio Antico	14r	Pianta
		14v	Elevazione (mezzo prospetto con particolare)
12	Sepolcro fatto dagli Antichi a Palestrina d'Ordine Corintio	15r	Pianta
		15v	Membri dell'Architrave, Fregio, Cornice (particolari)
		16r	Facciata (prospetto)
13	Tempio Antico	16v	Pianta
		17r	Spaccato e Alzato (metà sezione e metà prospetto con particolari)
		17v	appunti vari, con indicazione di «Il dì 25. ottobre mandai gli altari ideati / al G. S. F. / GBC»
14	Nicchia nell'esterno del Vaticano. Architettura di Michelangiolo Buonaroti	18r	Prospetto
15	Palladio Ordini d'Architettura, Capitello lucidato da altro fatto / da Mauro Tesi (capitello corinzio in prospettiva)	18v	Prospettiva
16	Indice del Libretto	19r	fabbriche a <…> / contenute in questo Libretto (elenco errato dei contenuti del Taccuino)
*	Appunti vari	19v	Testi

Tab. 2. Comparison between objects in Cipriani [1789-1791] and Montano [1624; 1684a; 1684b].

Cipriani 1784-1791		Montano 1624	Montano 1684			
			Libro secondo		Libro terzo	
Soggetto	Titolo (da didascalia)	Tavola	Tavola	Didascalia	Tavola	Didascalia
1	Sepolcro di forma quadrata fuori; e dentro tonda, ornato di Corintio, di cui vedonsi i vestigj fuori di Porta Maggiore a mano dritta in Roma. Copiata per istudio, e fattone quest'abbozzo per notarvi le misure a parte				XXV	Di questo sepolchro con forma quadrata fuori, e dentro tonda, ornato di Corintio si vedono anco i vestigij fuori di Porta Magio a' mano dritta.
2	Tempio di Bacco fuori di Porta Pia in Roma	58	39	Tempio di Bacco fuori dalla Porta Nomentana detta Pia, dedicato a S.a Costanza		
3	Tempio antico	61	42	Tempio antico fuori di Porta Maggiore		
4	Tempio antico vicino Tivoli		28	Tempio antico vicino Tivoli		
5	Sepoltura fatta dagli antichi d'Ordine Dorio, e Corintio				XXIV	Sepoltura fatta dalli Antichi di Ordine Dorico e Corinthio
6	Edificio antico non definito	21	14	Tempio antico presso Pozzuolo		
7	Tempio Antico, Copiato dal Compagno	14			XXVIII	Sepolcro antico vicino l'antecedente fuori la Porta Celimontana
8	Tempio Antico che vedesi fuori di Roma molto Rovinato	60	16	Tempio antico posto anche dal Serlio il quale dice di averlo disegnato nella Campagna di Roma	XX	Tempio Antico
9	Tempio Antico d'Ordine Corintio nella Campagna Romana fuori di Porta Pia				XVII	Tempio Antico di Ordine Ionico nella Campagna di Roma fuori di Porta Pia. la figura di questa pianta è triangolare, composta di quadrati e tondi.
10	Tempio Antico				X	Questo Tempio dicono essere stato edificato in Campidoglio quando li Galli Scoperti dal stridor delle Oche volevano per tradimento pigliare la Rocca di esso, per la poca guardia delle Sentinelle; una delle quali per castigo fù gettata dalla sumità di essa Rocca.
11	Tempio Antico				II	Tempio della Fortuna Virile
12	Sepolcro fatto dagli Antichi a Palestrina d'Ordine Corintio				XXIII	Sepolcro fatto dagli Antichi a Pellestrina di Ordine Corinthio
13	Tempio Antico	8	8	Tempio antico a Palestrina, di mattoni arrotati		
14	Nicchia nell'esterno del Vaticano. Architettura di Michelangiolo Buonaroti			Nessun riscontro		
15	Palladio Ordini d'Architettura			Nessun riscontro		

the church of *San Crisogono*, attributable to the studies of Giovanni Battista Soria, a pupil of Giovanni Battista Montano [Debenedetti 2015, p. 208]. All the drawings are traced with dry technique on paper and subsequently brushed with dark ink, as well as variously watercolored.
Without counting the *San Crisogono* for the analysis, Cipriani represents thirteen ancient buildings in Rome, in the Roman countryside, in Palestrina and Pozzuoli, drawing more or less complete sets of quoted 2D views (or half-views): plan, elevation and section.
Table 1 summarizes the contents of this *Taccuino*.
Objects 2, 3 and 13 have a complete description with all the three types of views; objects 1, 4, 5, 8, 9, 10, 11 and 12 are represented by means of a plan and an elevation; objects 6 and 7, the latter with no dimensions, are only described by a plan. All the drawings are quoted in Roman palms (fig. 1). With regard to the use of half-views, it is evident that in the Roman cultural context – already pervaded by the neoclassical spirit on the behalf of Milizia's idea – the representation of ancient buildings could not fail to highlight their symmetries, making a building even only half drawable and not only for just saving time [Spallone 2004, p. 68]. In this regard, even if the views describing the same building are not directly and geometrically correlated together, as they are drawn on separate sheets, the combining on the same page half-section and half-elevation would allow not only to highlight the symmetry Montano's model, but to create a link between the such representations. Unfortunately, in the only one case where a half elevation and a half section are placed side by side on the same page this correlation is not that evident, due to different scales (fig. 2).
Cipriani drawn a large amount of architectural details for each example, labelling and recalling them on elevations and sections with letters. The *Taccuino* is completed by some papers bearing various notes, a perspective of a composite capital, with a notation about Palladio Orders of Architecture […] Capital traced from another made by Mauro Tesi and a recess of a building in the Vatican, designed by Michelangelo, as well as an incorrect index of the contents of the *Taccuino*.
The interest raised by this manuscript is mostly due to the presence of objects that take the form of representations drawn from works by other authors, as already recalled [Pasquali 2002. P. 18]. Most of them – or all of the objects analysed – are inspired by the work of Montano [Montano 1684], or from his editions of 1638 or 1681 [Debenedetti 2015, p. 209].
In table 2 propose an intersection of the data related to the objects drawn by Cipriani and the respective Montano's plates.
As example of object described by means of three views, I show the object no. 3, *Tempio antico* (fig. 3).
The same object proposes a critical observation regarding the representation of the staircases (fig. 3b). Cipriani showed interest in the conformation of the stairs, of which he redrawn the detail. In fact, he does not fail to specify the distributive role of the stairs and tended to insert typological elements attributable to ramps where Montano did not indicate their presence, for example in object 4, *Tempio antico vicino a Tivoli*, c. 7*r*, where the author added few steps to access the heads of the exedra behind the temple in doors (fig. 4b). Similarly, he changed the structure of the stairs in the plan of the object 7, Tempio antico copiato dal Compagno, c. 10*r*, drawing a C rather than L disposition (fig. 4c, 4d); furthermore, in the plan of object 12, *Sepolcro fatto dagli Antichi a Palestrina d'Ordine Corintio in Palestrina*, c. 15*r*, Cipriani took the opportunity to analyse the symbol of the spiral staircase inserted inside the wall, by means detailing the representation with quotes (fig. 4f).
As for the objects described by means of a plan/half plan and half elevation accompanied by a semi-section, for example no. 10, *Tempio antico* shown in figure 5b, c, with the corresponding Montano's plate.
Cipriani explicitly indicated few objects as copied by other authors, such as no. 7 by an unspecified "*Compagno*" (mate) and 15 as reproduced on translucent paper by another drawn by Mauro Tesi, with the specification that it is an architectural order by Palladio. In this case the drawing is in fact traced on a piece of paper glued on the sheet (c. 18*v*). Perhaps Cipriani referred a drawing by the painter and architect Mauro Antonio Tesi, whose collection of drawings was published in Bologna right in 1787. It should also be noted that the practice of translucent paper, represented here by the copy of the composite capital, would have been proved to be very common, if not fundamental, in the graphic work of Giovanni Battista Cipriani.

Fig. 1. Synoptic framework of the Taccuino Lanciani 33.

In fact, we find many pieces of this paper, filled with significant signs – now the temple plan, now a bas-relief, now a detail of a window in other notebooks by the Author – for example in the 1828 manuscript *Dei Tempj antichi di Roma e altri monumenti raccolti dopo le recenti escavazioni* (BAN 1580/4), c. 7*v*, or at c. 67*v* of the 1834 manuscript *Itinerario figurato negli edifici di Roma* (BAN 1698).
It is interesting to note that the author cited only one source for his drawings within this *Taccuino Lanciani 33*, without highlighting the 'graphic debts' to Giovanni Battista Montano. Nevertheless, he will cite this work in the *Libraccio*, object 436, *Mole o Mausoleo di Adriano*, adding the sign: "dal Montano" [Cipriani 1801 et seq., c. 65*v*].
Among the sheets of the Taccuino it should be noted that there are some quotations taken from the text of Girolamo Fonda, c. 9*v*. Cited texts refer to the *Traiana* and *Antonina* columns that would have been at the objects of a proposal for publication by Cipriani himself. He never completed such book, but we can still read the handwritten drafts in the 1823 *Delle Colonne Trionfali* (BAN 1602/9).

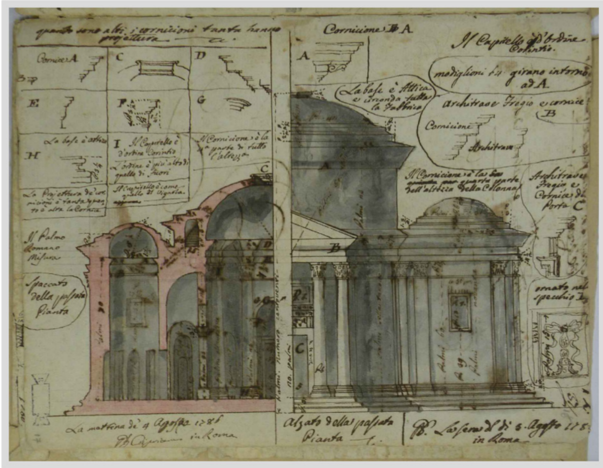
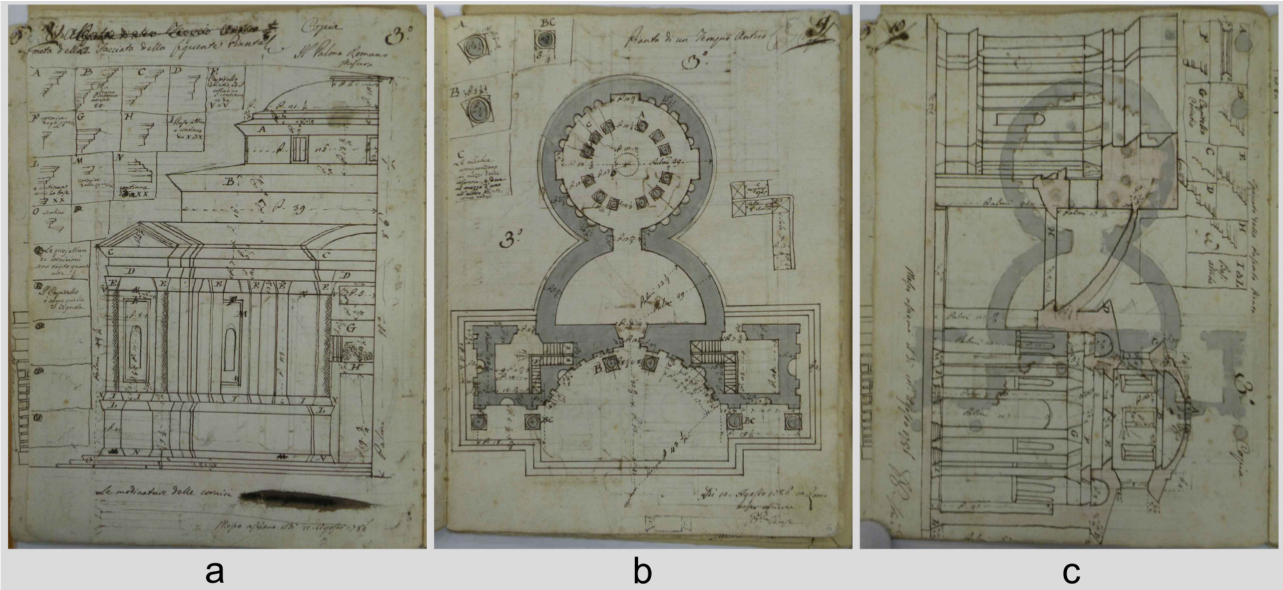


Fig. 2. Half section and half elevation of a Tempio antico, Cipriani [1786-1791, c. 17r].

Copy and interpretation, proportions and traces

Previous analysis of the documents of the *Taccuino Lanciani 33* noted how Cipriani operated the copy of graphic sources only for building plans, but not for the façades [Debenedetti 2015, p. 209]. I will add elements in partial confirmation of this thesis in the next section (see figs. 8 and 9). It is immediately clear that the Cipriani's drawings were not configured as an unoriginal imitation of a reference model, but as a pseudo-design interpretation, or rather as a re-signification of the envelope-signifier of the buildings. In a sense, Cipriani redesigned that part of artifact, real or virtual, which is configured as an element of conjunction between the internal and the external space and the external [De Fusco 2001, p. 159]. This pseudo-design operations were fact based on the reassignment of dimensions (in Roman palms) to the individual drawn elements, varying them from what could have been measured on Montano's plates. Moreover, it is clear how the individual details designed by Cipriani are configured as applications of the Vitruvian rules [Debenedetti 2015, p. 209] and as free interpretations of graphic sources [Pavignano 2019, p. 61].
Cipriani's graphic elaborations are thus attributable to the prerogatives of renewal of the teaching of architecture carried out also within the cultural circle of Milizia [Gambutti 2014]. Furthermore, they also prove to be graphic exercises designed to divert the difficulties related to the reading most of the perspective sections by Montano. These drawings, in fact, although generally identifiable as frontal vertical picture perspectives, were traced in an approximate manner. This could be confirmed by the comparison with a couple of drawings directly attributed to Montano and referrable as preparatory schemes of many published tables [Dallaj 2014, p. 145, fig, 29 and p. 146, fig. 30]. Even here, it is possible to notice the precise execution of the plans, with rigorous geometric grids, in open contrast to the approximative realization of the perspective views.
It is however interesting to note how Montano's plates, obtained through a process of translating drawings into engravings, show many traces of the geometric construction of the plans [3], such as construction lines, centres of circumferences, etc., i.e. highlighted with numbers from 1-3 in figure 6.



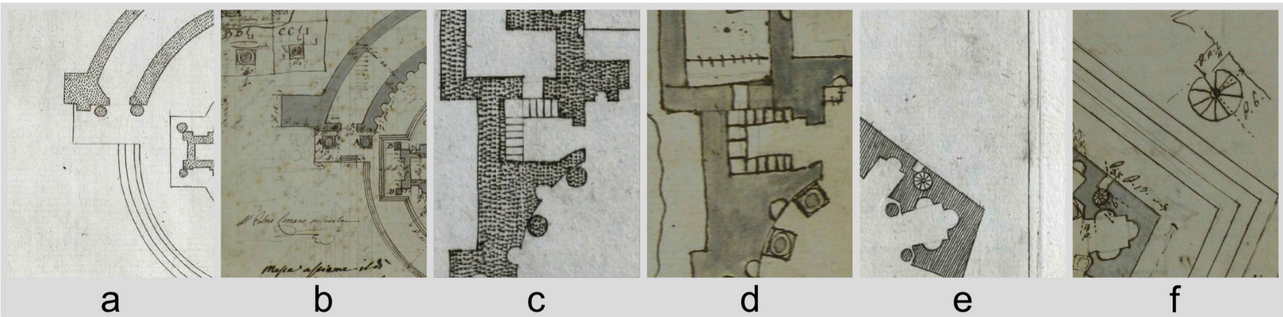


Fig. 3. Tempio antico. a) half elevation with details; b) plan with details; c) section with details. Cipriani 1786-1791, cc. 5v, 6r, 6v.

Fig. 4. Examples of Cipriani's interpretation of staircases. a), c), e) details of Montano: Montano 1684a, tav. 28; 1684b, tav. XXVIII; 1684a, tav. 8. b) d) f) details from drawings by Cipriani: Cipriani 1786-1791, cc. 7r, 10r, 15r.

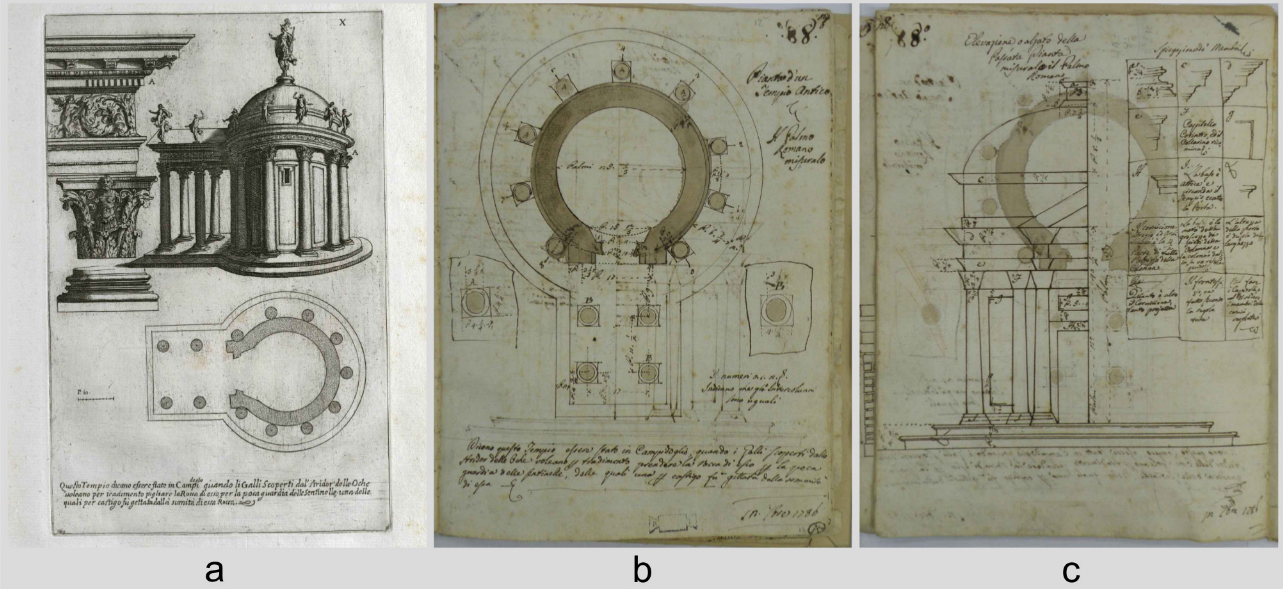


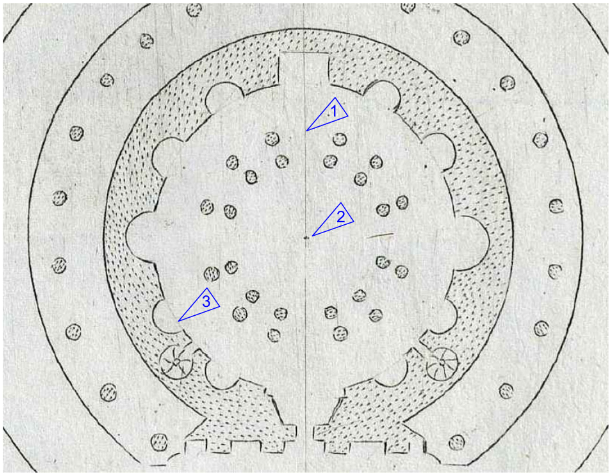
Fig. 5. Tempio antico [in Campidoglio]: a) Montano's description: Montano 1684b, tav. X; b) GBC, plan; c) half section with details: Cipriani 1786-1791, cc. 13r, 13v.

This information, perhaps of secondary importance for a common reader, was probably of great help for the work of Cipriani and other Architecture students who, like him, undertook the interpretative coping process, described above.

All Cipriani's drawings were traced mainly freehand, but there are traces of signs made with the aid of tools used to describe the main lines: i.e. we find the of use of a compass for tracing the circumferences of greater diameter. If we analyse the plan of the object 2, *Tempio di Bacco fuori di Porta Pia in Roma*, c. 4*r*, the lines drawn in graphite can be clearly observed. The author could have drawn them to define the main alignments of part of internal steps and external wall next to the main hall. In addition, there are also traces of compass, being used to define the thickness of the wall of the circular hall, the positioning of the axes of the columns and the rise of the outermost step (fig. 7b). Here Cipriani generally maintained the correct proportions between plan and elevation (except for the intercolumns of the portal), however he significantly increased the width of the section, while decreasing its height (fig. 7a). Perhaps this is due to the size of the paper used.

Survey and restitution of graphic source

The dimensions on Cipriani's drawings are explanatory of his personal interpretation of the graphic source. If we take object 1 as an example, we can try to verify the author's dimensional assumptions. Starting by defining the basic square in which to inscribe the building plan, having a side equal to 130.5 palms, then the internal diameter of the cell with a circular base is defined, equal to 42.5 palms. Already at this point, we highlight a discrepancy between Cipriani's drawing and its relative: in fact, by redrawing these lines on the drawing, we can see how the diameter roughly corresponds to that of the external



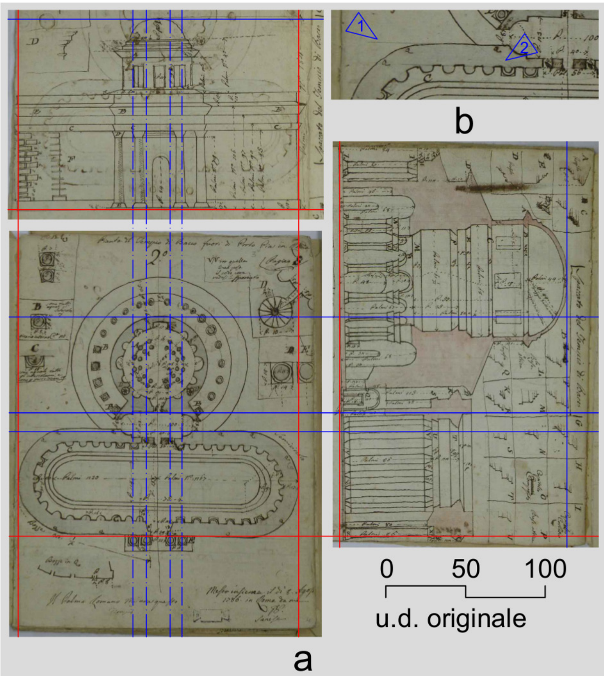
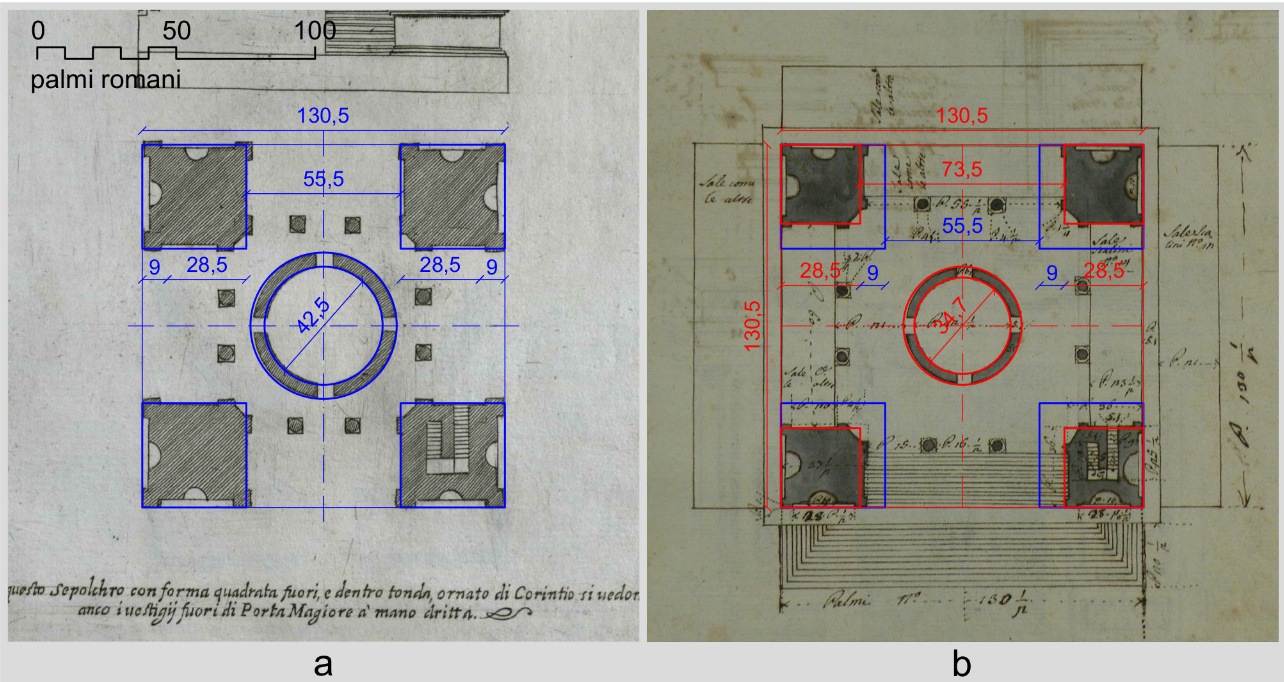


Fig. 6. Traces of geometrical constructions in Montano: Montano 1684a, tav. 42 (graphic overlayer by M. Pavignano).

Fig. 7. Tempio di Bacco fuori di Porta Pia in Roma. a) analysis of the proportions between views; b) highlithing traces of contructing lines (graphic overlayer by M. Pavignano).

circumference and not to the internal one. But it is in defining the reciprocal position of the pillars that we notice the first difference between Cipriani's and Montano's plan (fig. 8).
In fact, if we keep the reference dimension, equal to 55.5 palms, we he would obtain a situation very similar to that drawn by Montano, but Cipriani's drawing betrays this intention by indicating a clearly greater distance. Furthermore, if the measurements related to the widths of (two) pillars, equal to 28.5 palms by two, therefore 57 palms, are added to that of the light between them, 55.5 palms, we obtain 112.5 palms: a difference of 18 palms with the declared width of the side of the base square, 130.5 palms. If we assumed the width of the external step tangent to the pillars equal to 9 palms, one could think that this difference of 18 palms is relative to this element, however the Author measures it with a measure equal to 5.5 palms, or 11 palms in total and not 18. Similarly, if we start from Montano's plan, it is possible to notice how, by imposing the size of the basis square equal to 130.5 palms and the width of the pillars equal to 28.5 palms, we obtain a discrepancy of 9 palms per side, so 18 palms in total. Here, therefore, that the relationship between graphic source, its survey, redrawing, and measurement is immediately clarified: Cipriani really surveyed the Montano's plan, but immediately implemented a process of re-composition (if we exclude errors of interpretation).
A similar example is suggested by object 11, *Tempio Antico* (or *Tempio della Fortuna Virile*, following Montano's caption). In this case, Cipriani's plan clearly assumed to the role of eidotipo (technical sketch) for the survey of the reference model (fig. 9).
The measurements shown are basically those of Montano's temple plan, however, also in this case Cipriani carried out a process of re-composition of the object studied. In fact, he added data related to a possible *podium*, including an access stairway to the stylobate floor. Also this second example on the one hand confirms what has already been highlighted by Pas-

Fig. 8. Survey of graphic sources, 1. Sepolcro di forma quadrata fuori; e dentro tonda, ornato di Corintio, di cui vedonsi i vestigj fuori di Porta Maggiore. a) Montano 1684b, tav. XXV; b) Cipriani 1786-1791, c. 2r (graphic overlay by M. Pavignano).



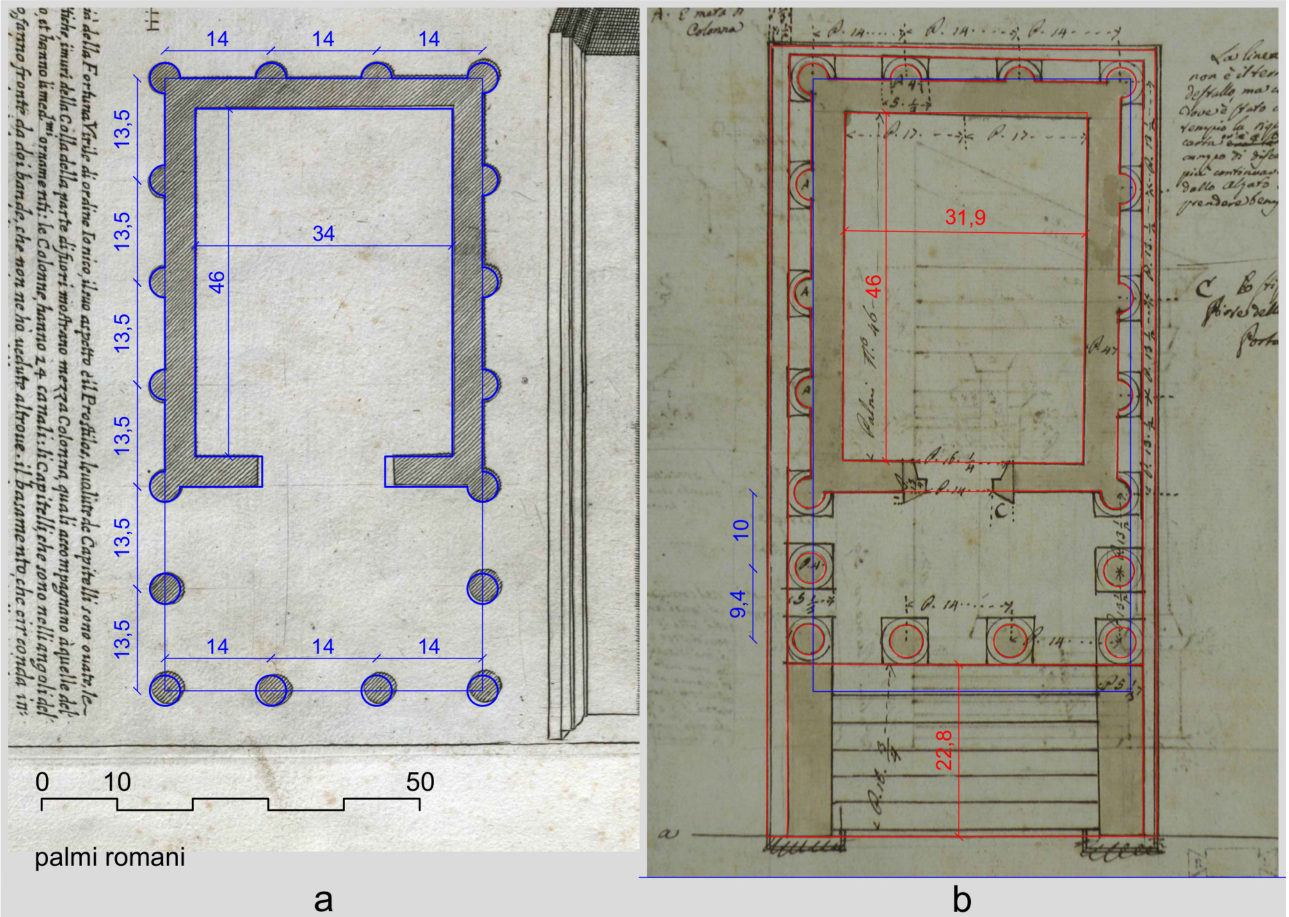
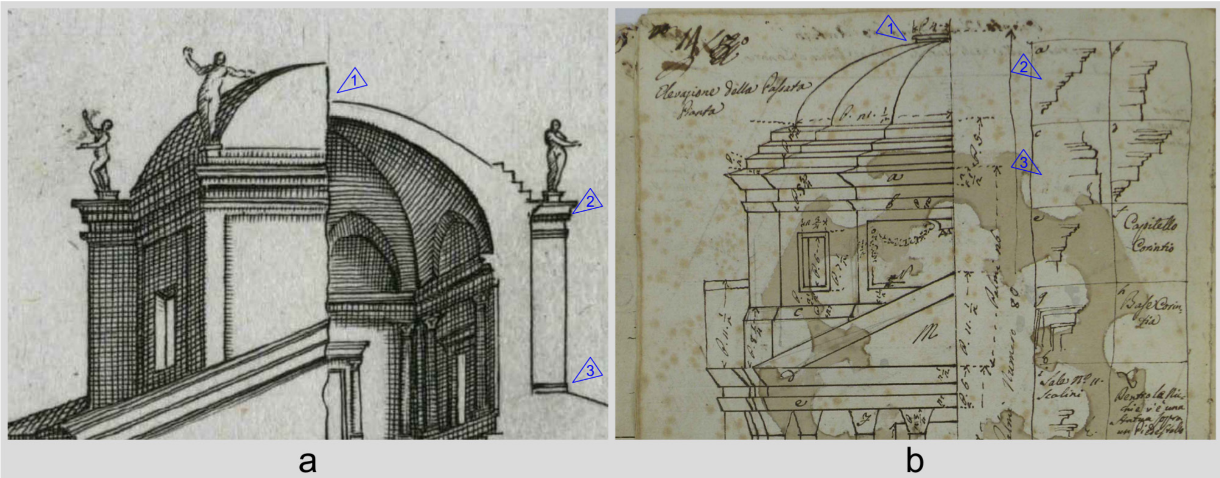


Fig. 9. Survey of graphic sources, 2. Tempio antico. a) Montano 1684b, tav. II; b) Cipriani 1786-1791, c. 14r (graphic overlay by M. Pavignano).



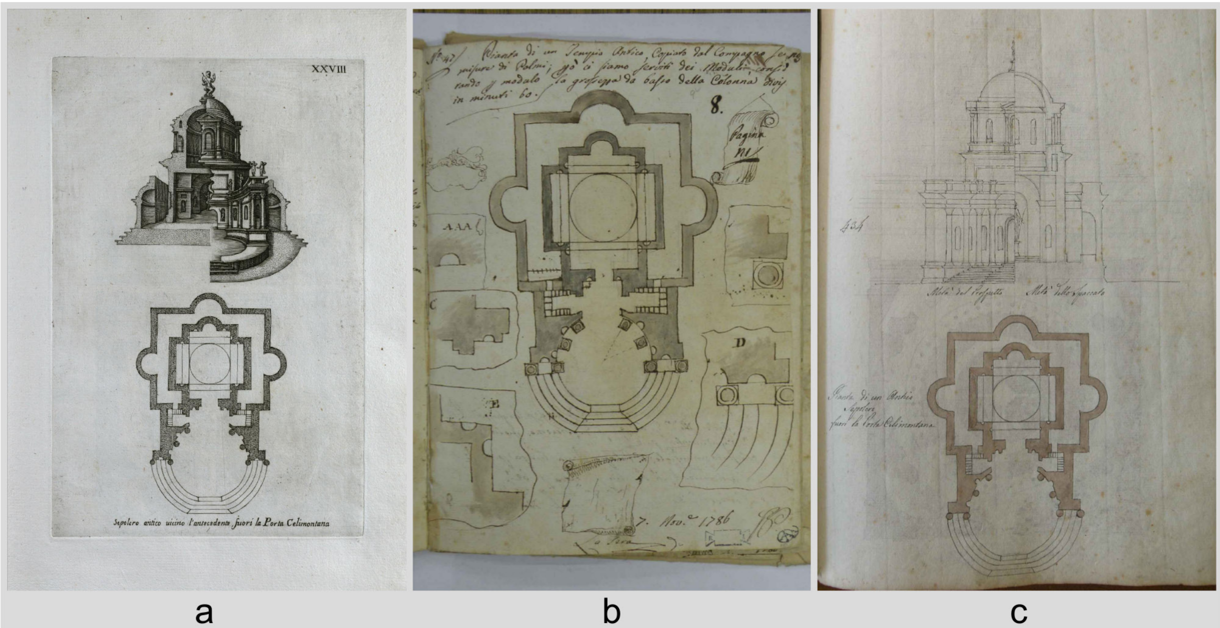


Fig. 10. Survey of graphic sources, 3, architectural mouldings. Details of the Sepoltura fatta dagli antichi d'Ordine Dorio, e Corintio. a) Montano 1684b, tav. XXIV; b) Cipriani 1786-1791, c. 8v (graphic overlay by M. Pavignano).

Fig. 11. Tempio Antico, copiato dal compagno. A). Montano 1684b, tav. XXVIII; b) Cipriani 1786-1791, c. 10r; c. Cipriani 1801 et seq., f. 65r.

quali [Pasquali 2002] and Debenedetti [Debenedetti 2015], on the other it suggests a more complex process of surveying and reworking the artefacts starting from the plants, not limited to elevations only.
Then, the author proves to enter the merits of the critical analysis of a reference graphic model within the descriptions of the details. In fact, the process of interpreting Montano's sparse descriptions is evident for example in the object 5, *Sepoltura fatta dagli antichi d'Ordine Dorio, e Corintio*. Here Cipriani restored the complexity of architectural mouldings (see 2 and 3 in fig. 10a, 10b), with the attempt to respect the general indications of the source, however, he also added new ones (see 1 in fig. 10a, 10b).
In the end, I propose a comparison between work representing object 7, *Tempio Antico, Copiato dal Compagno*, which is the only building described in the *Taccuino*, c. 10*r*, by means of a single view, lacking any dimension (fig. 11a, 11b). Cipriani's dual function of the drawing is thus evident: as an *eidotipo* (technical sketch) on which noting the dimensions retrieved on the Montano tables via direct measurement [Montano 1684b, pl. XXVIII] and as a tool for exploring the formal languages of neoclassicism, for example with regard to the formalization of the relationship between free columns and façade. Furthermore, by comparing the same drawing in the *Taccuino* with the object 436 in the *Libraccio* [Cipriani 1801 et seq. 65r] (figs. 11b, 11c) we can introduce Cipriani's third declination of the function of drawing, that is to explicitly materialize the value of eidetic memory [Pavignano 2019, p. 91].

Conclusions

Giovanni Battista Cipriani's work promotes an awareness of the close relationship between architecture and measure, articulated through the re-signification of predetermined graphic images. These provide the pretext for a critical reinterpretation of the models provided by them, passing through the abstraction of the measure in Roman palms, here risen to a sort of dimensionless module of the entire and, perhaps, suggesting a real practice of survey of the graphic source, at least for the plans of each model. Therefore, it is possible to assert that Montano's plates provide models acting as much as an objects to be copied, the *paradéigma* of classical memory [Scolari 2005 pp. 131, 132], as well as mental models that, when properly elaborated, can lead to the definition of new compositional constructs that give life to that "imaginative dramatization" which is fundamental for the teaching of architecture [Gay 2020, p. 73]. In other words, Cipriani's experience configured the practice of surveying a graphic source, or the analysis of the dimensional characteristics of a drawn artefact, as a fundamental step for the constitution of the student's/architect's memory. In fact, this was one of the first steps of a long professional path that, even if never related with a professional practice of a compositional nature, was ideally concluded with a process of physical sedimentation of the idea of architecture and measurement in the eidetic memory of the Author. The *Taccuino Lanciani 33* expresses statement and the *Libraccio* [Cipriani 1801 et seq.] recalled the function of Juvarra's *pensieri*.
There is a fundamental interconnection between student's exercise and the professional activity which involved Cipriani as creator of graphic contents for the study of Architecture, aimed at the perceptual analysis of the built for its dissemination to wider audience possible, by means of the small images of the *Itinerario figurato di Roma*, 1835, as postulated through the analytical sketches preserved in Cipriani's last *Taccuini*.
At this point we are encouraged in interpreting the eidetic nature (fundamentally and perhaps fortuitously) of the training path that here I have tried to outline. It is clear how the same path was at the basis of many of the graphic reasonings that Cipriani implemented with assiduity throughout his professional career, constantly pondering the relationship between reference models and its critical re-interpretation, with purposes that are not always comparable.

Notes

[1] Abbreviations used in the contribution. Arachne: iDAI.objects Arachne. Central object database of the German Archaeological Institute (DAI). BiASA: Biblioteca di Archeologia e Storia dell'Arte Polo Museale del Lazio. BNCRm: Biblioteca Nazionale Centrale di Roma. BNTo: Biblioteca Nazionale Universitaria di Torino.

[2] This is not the place to discuss the various editions of G. B. Montano's works, since the 1684 edition contains all the graphic references used by Cipriani. For a critical overview of the seventeenth-century editions of Montano's works see Dallaj 2017.

[3] Such traces are present both in the editio princeps [1624] and in that of 1684, which I consulted. It is likely that these are the traces left on the copper plates by a metal stylus capable of scratching the copper in a phase of pre-transposition of the drawing on the copper plate. This practice could "also make use of compasses, rulers and squares" as indicated in Dallaj 2017, p. 85.

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RUBRICS

Readings/Rereadings

Reading/Rereading

Ludi Matematici by Leon Battista Alberti

Ornella Zerlenga

Along with his humanistic interests, Leon Battista Alberti (1404-1472) was attracted to the world of scientific knowledge both during his youth, while studying physics and mathematics, and when he definitively returned to Rome in 1443 following Pope Eugene IV (1383-1447) and started to study these subjects in greater detail [Bertolini 2004, pp. 246, 249]. It was while in Rome, that according to recent studies, historiography would erroneously place at 1450-1452, Alberti composed a manuscript in the vernacular entitled *Ex Ludis Rerum Mathematicarum*, better known as *Ludi Matematici*.

The original text of *Ludi Matematici*, which was lost, was handed down through 13 different copies of the manuscript, now kept in the libraries of Cambridge (n. 2), Florence (n. 6), Genoa, Ravenna, Rome, Rouen and Venice (n. 1 each) [Saletti 2008, pp. 120-122]. The first printed edition with the title *Piacevolezze matematiche (Mathematical Pleasures)* was published in 1568 by the Sienese typographer Francesco Franceschi in the collection *Opuscoli morali di Leon Batista Alberti gentil'huomo firentino […]*, translated and partly corrected by Cosimo Bartoli (1503-1572) [Bertolini 2014, p. 131]. For this rereading, in addition to the most recent printed versions published by

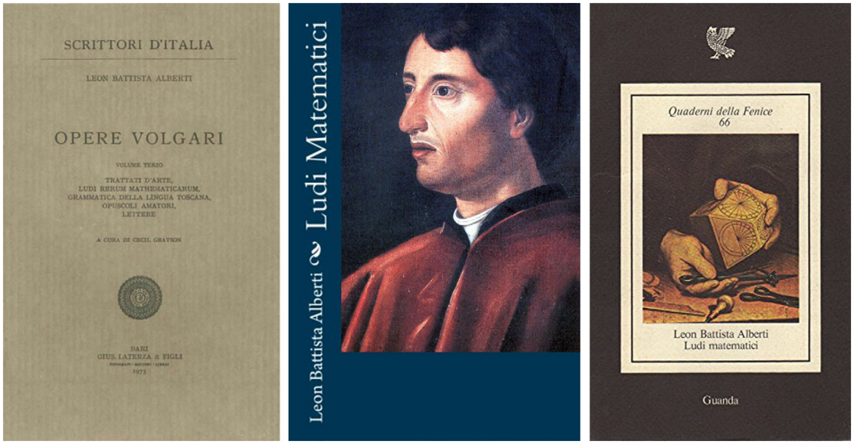

Fig. 1. Covers of the critical editions edited by Cecil Grayson (Laterza 1973 and current commercial version) and Raffaele Rinaldi [Guanda 1980].

Grayson in 1973 and Rinaldi in 1980 (fig. 1), reference was made to two copies of the manuscript currently available online: the first, in 39 sheets, kept at the Houghton Library of Harvard University in Cambridge, Massachusetts [Alberti 1450-1452]; the second, in 36 sheets, at the Bibliothèque municipale de Rouen [Alberti 1401-1500].

Based on recent research, the scholars Francesco Furlan and Pierre Souffrin [Furlan 2006a; Furlan, Souffrin 2001] as well as Beatrice Saletti [Saletti 2008] believe that the dating of the Albertian manuscript must be brought forward to September 1450. Saletti bases the hypothesis on the analysis of the dedication with which the *Ludi* matematici begins. This dedication (*LEONIS BAP. ALB. AD ILLUSTRISSIMUM PRINCIPEM D. MELIADUSIUM MARCHIONEM ESTENSEM. EX LUDIS RERUM MATHEMATICARUM*) is present in most of the manuscripts as well as the printed version (*Allo Illustris. P. Melladusio Marchese d'Este*), while in the manuscript preserved at the Houghton Library it seems to have been deliberately dele-

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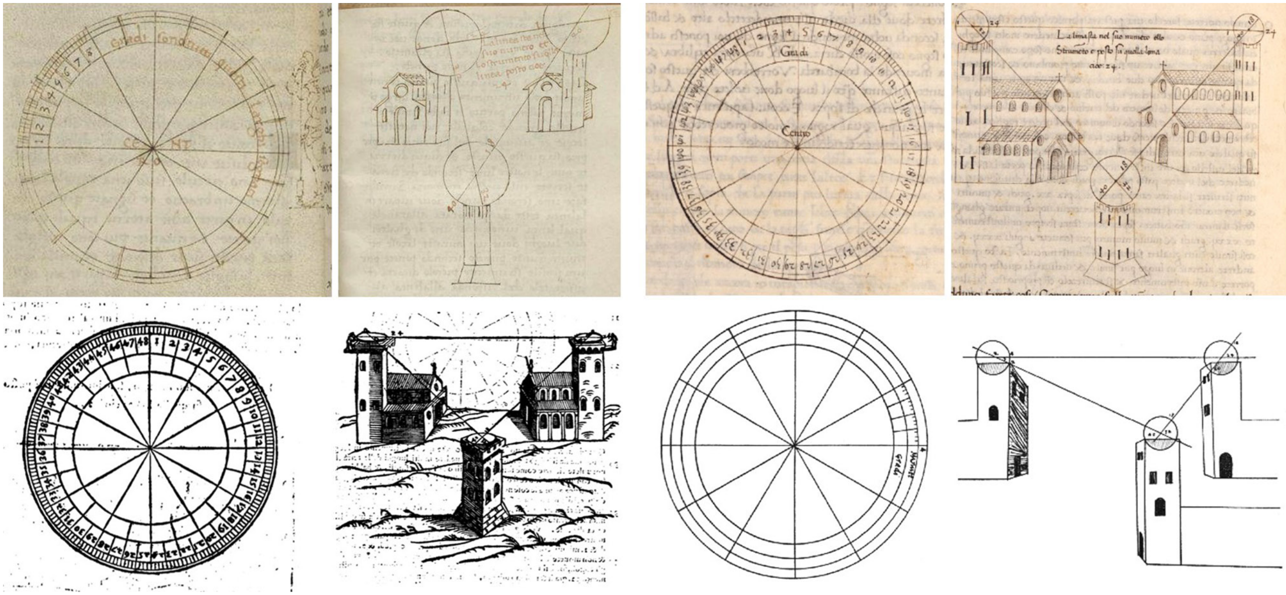
ted. Placing itself in the epochal context affected by the dedication, there is an inaccuracy in its content since Meliaduse d'Este (1406-1452) never held the role of marquis. Meliaduse, the illegitimate son of Nicolò III d'Este, was forced to pursue an ecclesiastical career by his father. Upon becoming commendatory abbot of San Bartolo in 1425, he held the office until he resigned in 1450. On the contrary, his brother Leonello d'Este (1407-1450), equally illegitimate, succeeded his father in 1441 as Marquis of Ferrara until his death when the third brother Borso (1413-1471) took over. At first glance, the dedication formulated by Alberti would reveal a "gaffe" but, thanks to the philological analysis carried out by Saletti [Saletti 2008, pp. 135-136], it is possible to anticipate the dating of the manuscript to September 1450 when, given that was Leonello dying, Alberti hastened to complete the manuscript and, apologizing for the delay, dedicated it to Meliaduse, whose contemporary resignation from the ecclesial office prompted him hastily to consider him as the future Marquis of Ferrara. It is likely that with Leonello's sudden death, the relationship between Alberti and the Este family would have ended and Alberti wanted to ingratiate himself with Meliaduse, believing him to be the future Marquis of Ferrara. Alberti had met Leonello in Ferrara in 1438 during the council and he, known for his cultural patronage, had probably commissioned *De Re Aedificatoria* [Portoghesi 1966, p. XII].

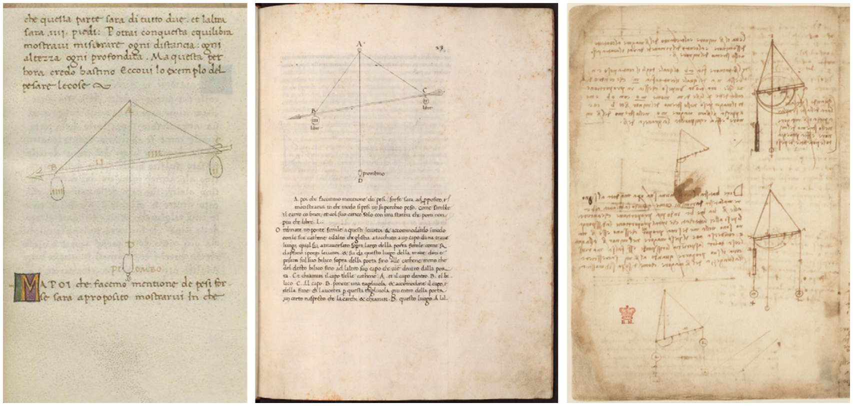
According to Saletti, *Descriptio urbis Romae and De Statue* [Saletti 2008, p. 119] can be both dated to around 1450, the content of which confirms the interest of the essayist in scientific subjects as well as the understanding and use of measuring instruments. During his first stay in Rome (1432-1434) [Bertolini 2004], Alberti had begun to take an interest in the study of architecture through the method of measuring the ruins of the ancient city learned from Filippo Brunelleschi (1377-1446) during his stay in Florence [Grayson, Argan 1960]. Later, these 'measurements' were the object of the short composition *Descriptio urbis Romae* in which Alberti reconstructed the topography of ancient Rome through a system of coordinates that allowed the shape of the city to be graphically restored. Furthermore, the theme of measurement also characterised the Latin work *De*

Fig. 2. "Instrument [to] commensurate the site of a town" in the manuscripts of Cambridge and Rouen and in the printed versions by Bartoli (1568) and Grayson (1973).



Statue [Pfisterer 2007] where, with the help of tools (often of his own invention), Alberti anticipated the culture of 'scientific representation' by determining the proportions of the human body [Collareta 1998].
These works, in addition to dealing with the theme of 'measuring' in the various fields of knowledge and drawing, showed how much Alberti's scientific interest had matured in an epochal context in profound transformation and how much the birth of a new thought linked the mathematical sciences to the humanities, supporting an increasingly operative 'knowledge' [Fabietti 1975]. A position, this of Alberti, which anticipated the relaunching of the cultural season of 'practical geometry', which from the second half of the sixteenth century characterised the production of treatises in the fields of civil and military architecture [Zerlenga 1994, pp. 59-74, 75-100].
In the *Preface* to the re-edition of the *Ludi Matematici* edited by Raffaele Rinaldi [Rinaldi 1980, pp. 7-11], Ludovico Geymonat (1908-1991), a multifaceted figure among the most distinguished of the Italian twentieth century, believes that this work is one of the most representative of the time as "in the fifteenth century, despite the absence of, at the forefront, mathematics underwent one of the most profound transformations in its history; it was in this period that it unquestionably emerged from the medieval phase –in which mathematics like all the sciences was conceived as a secondary speculative activity (secondary to the 'central' problem of the salvation of the soul)– entering a new phase, in which science is interpreted as a fully autonomous activity and mathematics assumes the essential role […] of great mediator between science and technology as well as between science and art" [Rinaldi 1980, pp. 7, 8].
In the *Introduction* to the critical edition of *De re aedificatoria* edited by Giovanni Orlandi, Paolo Portoghesi also believes that "[Alberti's] attitude towards technique is an attitude of lively curiosity and documents not only a prodigious knowledge of classical sources, but also an experience of the artisan tradition, also demonstrated by other writings such as the *Ludi Matematici* or *Descriptio urbis Romae*; an attitude that anticipates, due to the breadth of interests, Leonardo's work "[Portoghesi 1966, p. XXIV].
The fifteenth century is a historical period that passes from a medieval culture, static and contemplative, to a decidedly new one, of dynamic and operational rebirth. Geymonat believes that Leon Battista Alberti, "although not a 'mathematical genius', was undoubtedly one of the main protagonists of the transformation" [Rinaldi 1980, p. 8] so much so that the purpose of *Ludi Matematici* was to "illustrate to the largest number of educated people, the very interesting tasks that mathematics can perform as well as the ingenious tricks that it is able to suggest to us in the most varied concrete situations" [Rinaldi 1980, p. 9]. This was the new spirit that animated the presupposition of an adequate knowledge of this subject of 'measurement' and 'description'. Mathematics was not just speculation but became fundamental for the progress of a nascent new civil society, providing a valuable contribution both as a tool for ingenious technical innovations as well as a tool for the highest artistic creations. Thus, in the scientific panorama of the fifteenth century, Geymonat believes that, better than any other work, "the rereading of the *Ludi*" instils the meaning of this innovation of thought [Rinaldi 1980, p. 11].
The field in which Alberti demonstrates the greatest scientific importance is that of geometry aimed at architectural drawing and art. In the chapter "Geometry in aid of painting" (contained in the trilogy *Storia delle Matematiche*) Gino Loria states that Alberti "was not exclusively a great artist; he was one of the great thinkers of the Renaissance who knew

Fig. 3. Drawing of the "Equilibra to measure every weight" in copies of the manuscript (Cambridge and Rouen) and in the Codex Arundel of Leonardo da Vinci.



how to embrace the whole knowledge" [Loria 1929, p. 445]. Whereas, in *La Geometria nella imagine*, Anna Sgrosso recalls how "Alberti's greatest merit was that of having clearly posed the problem of reducing space to the floor, and of having solved it by means of the *section of the Euclidean visual pyramid*" [Sgrosso 2001, p. 40].
In this context, the experience of Leon Battista Alberti's *Ludi Matematici* anticipates the nascent humanistic position according to which mathematics represented a useful language both for solving practical problems as well as expanding personal culture. Conceived and structured in this way, *Ludi Matematici* has a pedagogical intent and constitutes a collection of problems applied to several fields of human knowledge (civil and military architecture, topography, mechanics, astronomy, navigation, hydraulics) to answer questions relating to the measuring of quantities physical (heights and widths, depths, time, flat surfaces, weight, distances) through the 'practical' knowledge of geometry. In architecture, these problems of applied science concern the rules that Alberti sets out to measure "only by seeing" (or 'at sight'), heights, widths and distances, that would have otherwise been inaccessible such as the height of a tower or the width of a river (for which he applies the Thales theorem and the similarity between triangles through the proportionality of homologous sides) or to "commensurate the site of a town", using "a thread with a plummet" and a sort of horizontal protractor, to be placed on top of towers and/or bell towers and with which to survey a territory or a city with a method, that of polar coordinates, which, according to Luigi Vagnetti, Alberti used before others (fig. 2) [Vagnetti 1972, p. 240].
With the spirit of introducing the reader to a "very delightful game", Alberti also tackles other geometric problems, which concern the measuring of depths (wells, reservoirs) and flat surfaces (rectangular, triangular, curvilinear, irregular straight or mixtilinear). For the latter, in addition to claiming to have referred to the practical geometry of ancient Roman writers (such as Columella) and the more modern ones (such as Fibonacci), Alberti resorts to the construction of a measuring instrument, a square with the shape of a right-angled triangle, which he invented and founded on the application of the Pythagorean theorem.
However, the practical problems dealt with by Alberti are not entirely original. Loria considers the collection of *Ludi Matematici* a testimony of Alberti's interest in pure geometry, while stating that "the rules set out by Alberti were neither exact nor original, but that they authenticated the author's knowledge" [Loria 1929, p. 446] demonstrating his vast scientific culture in the application of rules based on the relationships between similar triangles with which Alberti determines the measuring of inaccessible points. However, as can be read in *Ludi*, Alberti would not only have recourse to the determinations of Thales from Miletus or Pythagoras of Samos but also to a previous culture of 'practical geometry', spread by Leonardo Pisano known as Fibonacci (ca. 1170-1242), Tommaso della Gazzaia (d. 1443), Gaetano da Montepulciano (XV century) and by others who in the XIII-XIV would have divulged mathematical assumptions as parts of a game. In this sense, according to D'Amore, the title *Ludi* mathematici would find reason when placed in a literary tradition of formulating "mathematical games" to capture the curiosity and attention of the reader towards problems notoriously difficult to learn (such as those of mathematics and geometry), proposed as tempting games [D'Amore 2005, pp. 63, 64]. This tradition persisted even in the sixteenth century so much so that around 1512 the cultured merchant Piero di Niccolò d'Antonio da Filicaia published a manuscript entitled *Giuochi mathematici* with a direct inspiration to the Albertian *Ludi* and in particular with the visual calculation of the height of a tower [Palmarini, Sosnowski 2019].
Another rather significant aspect of the cultural result of *Ludi Matematici* is the use of simple tools, provided by the practical tradition (rods, wax to mark the quotas, darts, ropes, poles, bowls, mirrors) to solve the complex measurement problems, as well as the invention of mechanical devices including the *equilibra*, a pendulum level built with rope and dart [Mercanti, Landra 2007, pp. 39-42]. Due to this attitude to use and invent measuring instruments, Alberti is considered a reference for the sixteenth-century printed treatises dedicated to techniques and instruments for surveying architecture, cities and territories [Stroffolino 1999, p. 16] as well as the precursor of Leonardo da Vinci. Regarding the latter, as can be seen from the consultation of the Madrid Codex (c. II-3r) [Leonardo's Library], in describing the list of books held "in the safe of the monastery" Leonardo also mentions "a measuring book by Bta. Alberti" while in some folios of the Codices Arundel (cc. 31v, 32r, 66r) and Atlanticus (c. 675r) as well as in those preserved at the Institute de France, codices F (c. 82r) and G (c. 54v), we learn that for his studies of mechanics and motion Leonardo repeatedly consulted *Ludi Matematici*, citing the source: "Batista Alberti says

in one of his works entitled *Ex ludis rerum mathematicarum*" [Leonardo's Library, Arundel, c. 66r] or, at times, criticizing their assumptions. This is the case of sheets 31v, 32r, 66r of the Codex Arundel where Leonardo takes up Alberti's description of the *equilibra* to "measure every weight" [Alberti 1450-52, c. 23v], giving his own version: "Batista Alberti says in one of his works given to the noble Malatesta of Rimini how, when the scale *a b c* has the arm *ba* and *bc* in double proportion, it still weighs them attached to it, that they dispose of it in such a proportion, they are in the same proportion that they are the arm; but it is converse that is the greater weight in the minor arm; since experience shows it to be false, but its proposal will succeed when the minor arm is the length of the main arm as shown above" [Library of Leonardo, Arundel, c. 31v]. In the aforementioned sheets, Leonardo discusses the Albertian assumption accompanying his demonstration with several autographed drawings, which clearly refer to the copy of the manuscript he consulted and which are compared here with the copies kept in Cambridge and Rouen (fig. 3) [Alberti 1450-1452, 24r; Alberti 1401-1500, p. 23].

Leaving the comparative study of the assumptions between Alberti and Leonardo to another occasion, in the rereading of the text of the *Ludi Matematici*, the analysis of the drawings that accompany Alberti's manuscripts is of particular interest. It is well-known that the original manuscript by Alberti is currently given as missing and, therefore, it is evident that, like the written text, the drawings were also copied by other writers directly from Alberti's original or from copies, to the point of having different representations of the same subject as, for example, in the case of the *equilibra* in the Cambridge and Rouen copies. Furthermore, it is reasonable to believe that the original could have been devoid of drawings since it is well known that Alberti's treatise production is characterized by the presence of only the written text and, according to current historiography, Alberti would have left only very few drawings and sketches to posterity, among which, according to Furlan, those representing a detail of the double volute of the Malatesta Temple in Rimini and the plan of a *thermarum* building [Furlan 2006b, p. 210].

According to Furlan, the relationship between scientific texts and figures would be affected by the epochal context, which established the superiority of writing over drawing. Referring to *Ludi Matematici*, Furlan draws the reader's attention to the punctual precision of Alberti's literal descriptions which, therefore, would not have needed any drawing to be understood but which, on the contrary, would have allowed any reader to gradually follow the description and personally produce some drawings, which would have illustrated the assumption. A sort of instructions for use in written form, whose descriptive precision allowed anyone to independently produce graphic illustrations. The omission of graphic illustrations in the drafting of a scientific text, such as that of *Ludi Matematici*, however, would not have concealed the adherence to a purely ideological question (summarized in 'writing vs drawing') but, according to Furlan, would have found reason in the consistency of *Ludi Matematici*, or in their being a manuscript and non-typographical product and, therefore, subject to considerable risk of error during the copying.

In the comparison made here between the two copies of the manuscript *Ludi Matematici*, consulted online, there are many differences both in the drafting of the drawings as well as in the correspondence of the written text. These differences in writing could be attributed to bad transcription by the copyists or to their attempt to correct some lacuna due to homeoteleuton [Furlan 2006b, p. 203], i.e. by repetition of the same or similar words at the end of different lines or proximity of words of the same termination in the same line of the text. This would lead to the hypothesis that the original copy of

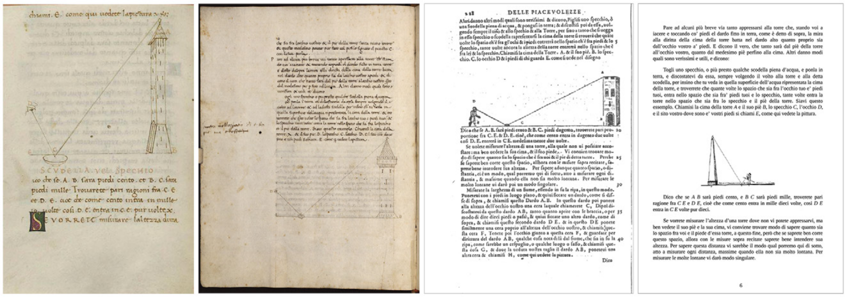


Fig. 4. Comparison of graphic style (writing and drawing) between the Cambridge and Rouen manuscripts and the printed versions by Bartoli (1568) and Grayson (1973).

Ludi Matematici could have been produced by Alberti without any graphic illustrations (perhaps since it was intended for private use) as happened for the other works elaborated on the theme of 'measuring', *Descriptio Urbis Romae* and *De Statue,* and, more generally, *De Re Aedificatoria*. This hypothesis is reflected both in Alberti's own exhortations, contained in the work *De Statue* where he invites "the reader – and with him the 'sculptor'– to record the series of data thus collected '*non picturæ modo sed litteris et commentariis*': 'Not with a drawing, but in writing and with annotations'" [Furlan 2006b, p. 208], which in the long-standing research (which has still not given any positive results) for the existence of a possible topographical map of Rome drawn up and attached by Alberti to the *Descriptio Urbis Romae* [Vagnetti 1974], which especially in the method adopted by the author to reduce the description of the city map (scientifically detected through measuring instruments) to a series of coordinates provided in the text only.
Nevertheless, if this is the critical panorama that accompanies the reproduction of the Albertian manuscript of *Ludi matematici* in its many manuscript copies, the one linked to its printed edition appears equally complex. As previously mentioned, in 1568 Cosimo Bartoli printed a collection of works by Leon Battista Alberti, including *Ludi matematici* which, for the occasion, were entitled in the index "Mathematical Pleasures" and, in full, "Of the pleasures of mathematics" [Bartoli 1568, pp. 242-271]. In his work as an erudite philologist, in 1550 Bartoli had already translated "into the Florentine language" and published *De re Aedificatoria* by Alberti [Bartoli 1550]. Aware of land surveying and geometry, in 1564 Bartoli published (again at the Franceschi printing house) a work entitled *Del modo di misurare le distantie, le superficie, i corpi, le piante, le provincie, le prospettive, e tutte le altre cose terrene, che possono occorrere a gli huomini, secondo le vere regole d'Euclide, e de gli altri più lodati scrittori.* Among the writers used by Bartoli, there is also Leon Battista Alberti, to whom he referred in the First Book to describe the indirect measuring of the height of a tower [Bartoli 1564, pp. 1-49]: this is a theme extensively treated by Alberti in his *Ludi*. Bartoli's training in these fields of human knowledge led him to become familiar with *Ludi* matematici and to carry out the first critical operation of passing from a multiplicity of manuscripts to a printed edition. It is not known which manuscript edition (or editions) Bartoli referred to [Bertolini 2014, pp. 133-136]. In the dedication that introduces *Ludi* in *Opuscoli*, Bartoli refers to the "many incorrectnesses" contained in the manuscripts and the "various and varied copies, which, thanks to my friends, have come into my hands" of which, however, he does not quote the sources [Bartoli 1568, p. 224]. It was certain that Bartoli innovated the lexicon in an even more modern version of the Florentine vernacular, returned the iconographic apparatus with the typographic style of the then scientific illustration, replaced the word 'booklet' in the dedication with that of 'operetta' and, as in the handwritten copy kept in Rouen, he omitted Alberti's recommendation to Meliaduse d'Este for his brother Carlo.
Currently, the most recent and authoritative printed edition that divulges Leon Battista Alberti's *Ludi Matematici* is not that by Cosimo Bartoli but rather that of Cecil Grayson (1920-1998), an English scholar of Italian literature who in 1973 reprinted it in a collective work regarding the correct identification and reproduction of the original text and drawings (fig. 4). According to Furlan, the version published by Grayson does not derive from any critical analysis and comparison of the various copies of the manuscript, presenting wide margins of approximation [Furlan 2006b, p. 200]. Saletti states that Grayson was not even aware of the existence of the thirteen copies of the manuscript but of only eleven [Saletti 2008, p. 120].
In this sense, and moving towards some conclusions, the current historiographical framework still leaves open many questions of a purely philological nature on the exegesis of the text as well as on the determination of a method of approach capable of reconstructing a possible 'correct' copy of the original manuscript by Alberti. Therefore, in compliance with the operation of 'rereading' the text, the subject of this contribution seems, rightly so, to ask other questions and ask for the reasons that make, even today, the rereading of the *Ludi Matematici* in areas not strictly of mathematical relevance [Williams, March, Wassell 2010, pp. 9-140]. Compared to the rich and complex epochal context, to which the theme opens, and the variety of events that have taken place, there are numerous answers as well as the points of view from which to observe this rereading. Meanwhile, there seems to be an affinity with the field of architectural and environmental surveying, especially in the context of the indirect determination of the metric measure, such as the height of a tower or the distance from it or from a city. This is an aspect of great interest when considering the critical panorama of the numerous studies carried on architectural surveying methods for the knowledge and protection of towers and/or bell towers through

contemporary criteria, methods and instruments offered by the application of digital photogrammetry and the use of laser scanners and drones for data acquisition [Zerlenga, Iaderosa]. In addition, remaining in this subject area, the central question of drawing as a tool of mental imagination for the illustrated verification of a written text is still relevant. Just as is the role of scientific awareness in the resolution of practical problems for the determination of measuring, which allows to manipulate the use of the tools well and, on the contrary, not to be manipulated by them as Alberti himself demonstrates in *Ludi Matematici* solving problems difficult to measure with the use of simple tools but resorting to determinations of cognitive logic based on the study of geometry. In this regard, it is worth reporting the recommendation that Alberti dedicates to the reader upon opening his 'booklet': "Perhaps I will satisfy you, when in these things *iocundissime* collected here you will take delight in considering again in practicing and using them. I tried to write them very openly; yet I should remind you that these are very subtle matters, and they can be treated badly so slowly that it is not convenient to be careful to recognize them" [Grayson 1973, p. 133]. This clarification also invites to understand the concept of 'measuring' not referable only to the metric dimension but extended to an increasingly multidimensional contemporary thought. Finally, in a world that is running faster and faster, there is the importance of knowledge and the conscious acquisition of one's own disciplinary roots or sources: an assumption that is valid for Alberti, in his time, as well as for every period that wishes to progress.

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Reviews

Reviews

Giovanna Spadafora
Fondamenti e applicazioni di geometria descrittiva
Franco Angeli
Milano 2019
192 pp.
ISBN 9788-88-917-8879-5

The scheme of the architectural representation process, and therefore its theoretical basis, is all enclosed, even today, in the famous passage written by Marcus Vitruvius Pollio, the Roman architect of the Augustan era, which takes up and fixes literally, in organic form, a tradition already consolidated for centuries, and not only within the Roman civilization.
In his treatise *De Architectura*, Vitruvius identified the modes of architectural representation as *Ichnographia*, *Orthographia* and *Scaenographia* (I, 2, 1). These, essentially, consisted of a two-dimensional method capable of identifying the future spatial realization, codifying the elements that constituted the *dispositio*, that is, the correct positioning of the architectural elements in a well-structured whole. The ways in which the latter had to be realized (but also those representations corresponding perfectly to precise moments of construction) were based on proportions and geometry, as is easily deduced by reading the treatise, which accurately describes the proportional and geometric elements for all the parts of a building and its whole.
The procedure described by Vitruvius was confirmed in the following centuries as well, progressively enriched with contents going beyond the brief description given by the architect from Fano.
Leon Battista Alberti, in his *De re aedificatoria*, written around 1450 but printed in Florence only in 1485, transcribes it impeccably, thanks to his literary and legal studies in Padua and Bologna.
But it was around 1520, in a text destined to become famous as the "Letter to Pope Leo X," that Raphael Sanzio and Antonio da Sangallo the Younger formalized the system of rational representation of architecture through drawings in plane projection of plans, elevations and sections, reworking the core of the Vitruvian and Albertian theory [Thoenes 1998]. Since then, for five hundred years, architects have used these tools to solve the conceptual problem of having to represent on a sheet of paper, in two dimensions, and using only a drawing instrument, a building that, in reality, extends in space. The system described by Raphael and Sangallo is sophisticated, because capable of interpenetrating representative method and constructive practice much the same as the Vitruvian formulation, and at the same time simple, because based solely on the reduction of 3D to 2D and on the use of geometry as a technique for the construction of the drawing/project. In this way, it definitively confirms a union that has also been fundamental to the architect's activity for centuries, as indicated confidently in the *incipit* of the *Livre de Portraiture* by the medieval Picardian master builder Villard de Honnecourt: " *en cest livre pue on trover grand consel de le grant force de maconerie et des engiens de carpenterie et si troverez le force de la portraiture, les trais ensi come li ars de io-*

metrie le command et ensaigne" [Villard de Honnecourt 1225-1235, pl. II].
Geometry, therefore, not only fulfilled the essential role of a tool for "dealing with" forms, but also played the role of a graphical-mathematical system of reference for constructing on paper the conformation of the spaces and other configurations of a building [Quaroni 1977, pp. 150, 151]. Later, the progress of studies in this discipline provided a unifying scientific substrate and the generalization to an eminently practical system, allowing its codification as a means of design with wide uniformity in time and space.
Even if the introduction of digital systems to the representational process of architecture has had, as James Ackerman wrote, an "importance comparable perhaps to that of the introduction of paper" [Ackemann 2003, p. 256], and digital three-dimensional modelers have called into question the basic operational scheme based on the reduction of 3D to 2D, nevertheless, the two-dimensional approach remains, because, however the digital visualization of the project, it is nothing more than a projection of geometric entities onto a plane (screen or printer) and the manipulation of these entities follows geometric processes conceived graphically, even if calculated numerically. Moreover, and perhaps even more so, our conceptual and practical heritage of architectural discourse is still based on the Vitruvian scheme which therefore continues to be, by similarity or by difference, our main experience on which to base the new.
Giovanna Spadafora's *Fondamenti e applicazioni di geometria descrittiva* lies within this framework. It is a text comprising lessons on parallel projections preceded by elements of projective geometry addressed to students enrolled in the first year of the Degree Course in Architectural Sciences.
A didactic volume that, due to a series of choices made by the author, is at the heart of today's debate between consolidated traditions and the effects of digital technologies and of that - today probably of greater importance due to the effects of the global pandemic that has been going on for a year now - between the permanence of traditional didactic methods and new teaching methodologies.
If the centrality of the text in relation to the first *querelle* has already been acknowledged, justifying the permanence of the volume's topic within a context that is still at the heart of the "knowledge" that forms an architect, its role within the second question, regarding our discipline, is the one that, in my opinion, provokes greater interest, because capable of proposing interesting answers to the most compelling questions.
First of all, the question of the expositive form.
The most widespread form of transmission of the "knowledge" of the representative disciplines is traditionally given by a great number of manuals, volumes well known to the community of reference. The main reason for this can be found in the very definition of a manual as a work that gathers together the essential aspects of a given discipline or subject, generally in function of the divulgative or didactic needs of the public to whom it is destined, summarizing the theoretical and, above all, practical aspects, which constitute most of the knowledge necessary for an architect.
Spadafora's book fits into this context in a new form. As astutely noted by Vito Cardone in the presentation of the volume, "While clearly a text for exercises, in many ways it is halfway between a theory book and a collection of solved exercises". The "corpus" of "knowledge" and connected "know-how" is achieved by proposing a hybrid system for the construction and application of knowledge. The traditional expositive form for drawings and text on paper is flanked by one for navigable digital models that puts the student directly in contact with the spatial formulation of the problem and, at the same time, with its two-dimensional solution, restoring the course necessarily disrupted in the two-dimensional reproduction of the "translation" from 3D to 2D.
Concretely, the structure of the text is based on one of the classical approaches to teaching the discipline: problems of position (condition of belonging, parallelism, perpendicularity), notable problems, objective configurations, representation of solids, plane sections of solids, section between solids etc., all solved using the canonical form as well as the so-called technical form. Furthermore, axonometric projections, which follow the chapter on orthogonal projections, are also treated using the tri-orthogonal triade of planes as a system of reference, thus linking in a logical didactic sequence the reasoning performed in the orthogonal projections with that performed in the axonometric projections. The difficulty of presenting the solution of the various problems by breaking down movements and projective operations in space into graphic constructions on the plane of the drawing sheet is diminished through the use of navigable digital models, contained in the pdf downloadable from the website of the publisher, Franco Angeli (Multimedia Library area) [1]. These, as the author notes, "on the one hand are functional to the description of the operations to

be carried out and on the other help to trigger in students the habit of thinking about geometric elements in their mutual spatial position".
Fondamenti e applicazioni di geometria descrittiva, therefore, describes consolidated knowledge using an original form capable of exploiting the didactic effects of the techniques of interactive three-dimensional digital visualization for restoring continuity to an expository technique in which the necessary discretization of the analog form had certainly not served to facilitate learning nor favored the formation of a specific *"foma mentis"*. In this sense, the book originally placed itself in the path that Riccardo Migliari, the forerunner of the use of navigable models to explain three-dimensional themes of descriptive geometry, had already indicated more than ten years ago: "Yet, to date, […] there is no reference manual that can open the way to a new structure of the discipline. Perhaps this, instead, is precisely the goal we should reach, working together" [Migliari 2007, p. 171].

Marco Gaiani

Notes

[1] <www.francoangeli.it> (accessed 2020, December 10).

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Reviews

Alessio Bortot

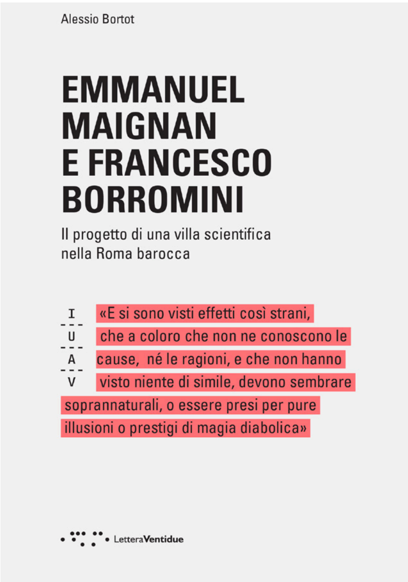
Emmanuel Maignan e Francesco Borromini. Il progetto di una villa scientifica nella Roma barocca

Lettera Ventidue

Siracusa 2020

273 pp.

ISBN 978-88-6242-412-4



This beautiful book by Alessio Bortot on the project, imagined but never realized, of a 'scientific villa' in baroque Rome is a fascinating example of the 'circumstantial power' of Drawing, when it is a document, and of the irresistible 'power of figuration' and 'morphogenesis' that it assumes when configured as an investigative process that, through the structures of geometric thought, generates and induces the design gesture.

It would be a *diminutio* to affirm that the work of feverish and meticulous investigation, carried out by the author on the traces of the singular project of the Villa Doria Pamphilj, can be circumscribed to the dimension of philological and historical-critical reconstruction, even if fascinating, of the events that have seen united in the same projectual intent two extraordinary minds like those of Francesco Borromini and the minimal friar Emmanuel Maignan. On the contrary, we would like to imagine that the whole investigative process, as "every making happen what from non-presence passes and is evidenced in presence", considered by Heidegger as an act of "*poiesis*", or rather of "production" [Heidegger 1985, p. 6].

Undoubtedly, this is an intriguing work of unraveling that starts from relatively weak traces: two technical drawings (a plan and an elevation offered in two solutions, accompanied by a letter) attributed by Paolo Portoghesi to Borromini and some manuscript sheets upon which there is a detailed list of 'scientific games' that should have been placed inside the villa, whose authorship is attributed by Portoghesi to Emmanuel Maignan. The rest is a refined game of cross-references between what is a trace and what is an 'invention', in the broadest sense that the term '*invenire*' hides in itself, in a process aimed at reconstructing not only the work that was never realized, but rather the cultural, philosophical, scientific, aesthetic and finally human conditions through which it is possible to understand its complex genesis. The numerous rivulets in which the author's arguments unravel, tense threads from the very first lines along which the arguments develop with expositive clarity and uncommon scientific depth, are in reality the plot and the warp of a text that can be read 'like a novel'.

At the beginning, the author narrates how Virgilio Spada, secret almoner and superintendent of the papal buildings, entrusted Borromini with the task of "building the villa as the future residence of the cardinal nephew Camillo Pamphilj", with a not marginal digression that critically frames the idea of the "villa" in the context of an architectural typology that oscillates between the "fortified villa" and the "wunderville". The happy intuition of the author is, however, to present with a rhetorical stratagem of an expert narrator, from the beginning the real protagonists of the story, thus providing the reader, even the less experienced on the

topics covered, the tools to easily orient themselves in the theoretical arguments, sometimes complex, which frame the story, allowing him beyond the more in-depth dissertations, to recognize the meaning and role in the broad horizon of the story.
Therefore, *vacuo*, *optics, photurgy* and *phonurgy*, understood as categories of scientific thought and scripts of which Borromini and Maignan–with many other protagonists of the story–are interpreters, immediately make their entrance on the scene, presented to the reader, described and used, as the author himself admits, as a "terrain of dialogue in which Borromini, Maignan, Descartes, actors and spectators of the artistic and scientific production of the Baroque era, meet" (p. 30). In reality 'pneumatics', 'optics', 'gnomonics' and 'acoustics'–to whom we owe the mirabilia imagined to make the Villa Doria Pamphilj "admirable not so much for the magnificence or grandeur of the construction, but rather for the curiosities that could be placed in it and in its gardens"–represent those that, at the time of the facts narrated, were the areas of reflection and scientific, philosophical and theological speculation of some of the most eclectic personalities of Baroque culture, through whose works our author competently sketches the scientific-experimental thought of the time.
Athanasius Kircher, Jean François Niceron, Girard Desargues, Réné Descartes, are only the main authors cited by Bortot, who investigates their scientific thought through the vast heritage of their treatises–on *Perspective*, *Optique*, *Dioptrique*, *le Meteore*, *Perspectiva Horaire*…–and, above all, through their practical-application experiments, with the clear intent of outlining that animated speculative debate in which perception (visual perception, first of all, but not only) opened up to a new philosophical statute and inaugurated the scenario of the optical wonders that crowded the baroque scene. The same figure of the architect Borromini, to whom the beautiful chapter *Borromini, the optical chisel and the point of view of light* is dedicated, aims to identify his relationship with the scientific and cultural climate of his time and interpret his production essentially for those aspects that can help define it as 'optical architecture' in which there are echoes of lenses, microscopes and telescopic visions and in which the architectural machine 'magnifies' the celestial dimension. What interests our author the most–because it is functional to the continuation of the story–is to underline how much Borromini's production is closely linked to the Cartesian concept of the materialization of geometric space and how in Borromini "the form is conceived more than ever in function of the perceptive capacity of the observer who in such a way is introduced into the architecture participating and determining the same spatiality" (p. 76). And this not only for the aspects of light and visual perception, but also for the acoustic perception and propagation of sound through the void.
The vast preamble of a historical-critical nature, which therefore occupies the first five chapters of the volume (*Francesco Borromini and Father Emmanuel Maignan*; *The statues of the scientific memorandum, personifications of the natural order*; *Photurgy and optics*; *Borromini, the optical chisel and the point of view of light*; *Photurgy, phonurgy and vacuo: observing sound through light*) is but the premises of the real coup de thêatre represented by the digital reconstruction of the architecture imagined by Borromini and the punctual analysis of the Maignan memorandum. An analysis carried out with the aim of reconstructing with care and scientific rigor the spatial and geometric conditions of the epiphany of spectacular 'scientific games' that would have made Villa Pamphilj admirable. Between confirmations and betrayals–to use the words of our author–the digital reconstruction of Borromini's project is a circumstantial path on the tracks of the most convincing solution, among those proposed in the project drawings, because more suitable to contain the twenty-one points of the memorandum, an objective that justifies choices, omissions, suppositions. But the true goal of the entire volume is in the eidomatic reconstruction, in the rooms of the villa, of the twenty-one "mirabilia" to which the entire last chapter is dedicated, entitled *The Memoir of Emmanuel Maignan: a precise analysis*. We have become accustomed, in this era seduced by technology, to consider "augmented" a reality on which we are able to superimpose, thanks to the widespread use of digital media, multiple levels of information that involve our sensory and cognitive apparatus in various ways. The more the narration of the surprising and apparently often magical effects of the scientific games described by Maignan unravels, the more the all geometric-projective modalities of the perceptive conditions are clarified, suggested with the clear intent of inducing wonder in the visitor, the more the foundations and the scientific principles find resonance in an artistic dimension and correspondence in the experimented dimension and in the infinite ingeniousness, the more our idea of 'augmented reality' pales in comparison with an ability to induce surprise and wonder by staging real installations, for the eye and all the senses, that fear no comparison due to their ability to reconcile art and science, blurring the boundaries between one discipline and the other.

We are met by the *mirabilia* described in the memorandum and Bortot's refined eidomic reconstructions, step by step, free them from their exclusively literal dimension and reveal them to our gaze in their fantastic chase through the rooms of the building: the statue of Innocent X welcomes us, self-propelled thanks to ingenious artifices of hydraulic physics; we are amazed by the series of episodes in which the queen of *perspective curiueuse*, the anamorphosis, gives a good demonstration of itself by 'stressing' to the point of making the laws of Renaissance perspective cryptic (on the walls of the rooms; on singular cylindrical or conical mirrors in the reflection of which it indirectly recomposes graphic elements in visual unity; through devices equipped with polyhedral lenses capable of generating images of a cryptographic nature…); and then there is the chapter of the complex reconstructions of the solar clocks through the *perspectiva horaria*; and then it is the turn of the description of the motion of the stars and the planets in environments with mobile walls in which, in the guise of ante litteram planetariums, an attempt is made to reproduce the movement of the astro-bodies; and then again, it is the turn of the propagation of sound and the construction of acoustic prodigies capable of generating surprising effects of echo and Sybils caught in the apparent act of giving answers…

For each of the "wonders" described in the memorandum, Bortot reproduces, in a digital environment, the entire process of spatial genesis. He begins by hypothesizing for each one the correct collocation in the environments of the built space, of which nothing is said either in the memorandum or Borromini's letter. If on the one hand, the digital reconstruction is faithful to the description in the memorandum, on the other, it is the result of a series of conjectures and suppositions that make it a project in all respects. The complexity of the projective genesis that governs the entire corpus of scientific experiments is retraced with absolute rigor and effectively rendered with a "narration" through clear images in which the process of projective genesis is made explicit, obviously making use of the potentialities of eidomatic representation, but without ever lingering on the technique itself, making sure that in the digital drawing, as Agostino De Rosa says in the introduction, the "analogical soul of the drawing" [p. 11], its procedural sequentiality and its temporal dimension, resounds clearly; attributes that make drawing the incredible creator of narrations, discoveries and creative gestures. The refined iconographic apparatus, the exhaustive and coherent bibliographical references, the clear and fluent reading add further value to a volume that will undoubtedly be a pleasure to read for scholars of representation… and not only!

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Reviews

Starlight Vattano
Didattica del segno, percorsi didattici
Franco Angeli
Milano 2020
252 pp.
ISBN 978-88-351-0550-3

Francesca Fatta in the *Preface* of the book *Didattica del segno, percorsi pedagogici* by Starlight Vattano, published by Franco Angeli in the open-access edition, writes that children drawing "can visibly and durably express the imagination, emotion, sensation and thought of the person who performs it, almost as if to draw a tangible sign of himself". Communication of the world and themself is an important topic in the disciplines that deal with representation. When the subject is the child, this topic becomes interdisciplinary specificity since in addition to the graphic expression, all the processes of expression that affect cognitive development are triggered. It is in this topic that the need to research for didactic methodologies that educate and lead to the vision of reality and to the manifestation of one's ego lies.
The topic of child drawing, of the process of building an image (of the world and of themselves) and the educational research, is treated in a systematic and methodical way through the fascinating pedagogical studies described in the first chapters of the book.
In the first chapter titled, *Evoluzione del disegno infantile*, the phases of graphic-figurative development of the child are explored, from the construction of the line "in simple structures around a center" [p. 21] to control the 'space' of the drawing, to recognize one's own drawing which thakes place by repetition of the same sign.
Studies around the 'scribble' show how it is not only the first instinctive form of expression but the first communication test with the outside world.
The research for a pedagogical code is investigated through the study of figure deduced from the graphic vocabulary of childhood. The investigation of the phases of visual realism and the representation of the world are treated through a careful and detailed analysis of studies on the visual and representative perception of the child in different developmental stages. The author, scrupulously, analyzes how the sign, from a communicative expression (replacing the verbal form), becomes mimesis of reality (visual realism) and finally aesthetic expression. She investigates the processes of ambiguity that are configured in the reading of the form and in its interpretation.
The construction of the graphic message, from the 'big head man' to the way of placing all objects within a continuous line "confirms the priority of information on spatial relations over those relating to the draughtsman's point of view" [p. 51].
Even the construction of the alphabet letters, first received as a graphic element "repeated and placed on the sheet with the primary aim of obtaining a decorative drawing" [p. 52] is intended as a graphic-symbolic element with the aim of expressive communication towards the observer, even before verbal communication.
Children's drawing is compared with the works of artists and analyzed in the declination of the sign present in art of the adult.

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diségno ISSN 2533-2899

We cite the comparison and analysis of some Paul Klee's drawings, in which the process of synthesis and selection highlights the simplification of the world in the symbolic dimension of the sign "intended as a synthetic form of investigation of reality" [p. 56].
To conclude with a summary of the considerations of the cognitive and gestaltic sciences and to affirm with Arnheim that every trace marked portrays the vision that the child (but also the adult) has of the world.
The second chapter titled, *Disegno infantile e codici figurativi*, deals with how the perceptions of the self-observer are transferred into the dimension of the image through figurative codes capable of narrating the external world. The author analyzes the works of Edward Hopper and Marc Chagall looking for the emotional dimension that leads to represent one's own image of the world, through the space-experiential theses of Arnheim and Gombrich opposed to those of the Swiss psychologist Jean Piaget who claims "that the child draws what he knows and not what he sees" [p. 71], while the Froebelian and Pestalozzian processes lead to the simplification of nature through the gradual recognition of the primary components and the geometric elementarization aimed at disassembling "the order of the elements to focus them, observe them, and rethink them more clearly" [p. 85].
The different types of representation, emphasized proportions, lines that connect objects, open and closed lines, overturned objects, forced three-dimensional objects, are indices of the emotional research that pedagogy investigates to decode the emotional relationship that the child establishes with the world.
In research of a pedagogical code analyzed in the first part of the book, the following two chapters deal with the research for teaching methods suitable for leading the child towards the construction of figurative languages that manifest the expression and creativity of each young individual.
The author skillfully searches for references in the teaching methodologies of the technical schools that led to the birth of the artistic Avant-Gardes of the XX century. The innovative teaching methodologies where the study of visual experimentation, the fragmentation of reality and the recomposition of the form, bring the image back to the communicative connotation.
In the third chapter titled, *Il metodo pedagogico Vchutemas e Bauhaus*, the topic is the "pedagogical principles through which it would have been possible to outline a process of univocal study of the artistic disciplines" [p. 92].
It is a detailed description of the Vchutemas Technical-Artistic Laboratories where the reform of artistic education implements didactic experiments in which the production is the main purpose of the preparation of "new type of artists" [p. 93].
The theory of color, visual perception, light, volume, geometry are studied "trying to bring the most current acquisitions of technique closer to artistic production" [p. 94]. The didactic model, based on composition and construction, proposed the integration of individual disciplines for design resolution and product production.
The didactic phases, of the Russian school, first envisage a theoretical-cognitive type of instruction, while the second phase concerns the realization of the object. The author identifies in this didactic method a "real pedagogical manifesto" in which "the line, the geometric shape, the color, the structure and the movement constituted the grammatical elements through which to construct an abstract art aimed at formulating laws own, but on a scientific basis" [p. 98]. She explains it in the description of the exercises conducted by the illustrious teachers of Vchutemas. The same one who moved to the Gropius Bauhaus years later. "When we talk about Bauhaus pedagogy we are referring to those aspects relating to the teaching of applied art, the planning process and design that have defined new visual values, which can be found in the synthesis of art, architecture and industry" [p. 106]. In Rudolf Bosselt's synthesis, the pedagogical training system of the Weimar school is explicit: if art is not teachable then all the technical activities to produce it must be taught.
Compositional awareness is achieved through the transdisciplinary organization of pedagogical units and didactic methodologies that favor the ability to break down the form into graphic units to exercise the understanding of geometry and the exploration of space, and recompose "the image to reach its possible transcriptions".
The fourth chapter titled, *Allegorie di-segni*, shows figurative didactic paths based on three macro-themes: surfaces, texture, space. The visual experimentation passes through the fragmentation in abstract schemes of forms drawn directly from nature, through allegorical compositions in which there are words and images, photomontages that involve the treatment of surfaces, photographic experiments in which the reconfiguration of the image passes through expressive sound fields and verbal.

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Events

Events

The 18th International Congress of Expresión Gráfica Arquitectónica *EGA 2020* *El Patrimonio Gráfico. La Gráfica del Patrimonio*

Francesca Fatta

The 18th International Congress of Graphic Design in Architecture was held on September 24 and 25, 2020. This event is organized every other year by the teachers of Graphic Design of the Higher Technical Schools of Architecture in Spain. This year, the Scientific Committee designated Zaragoza as the organizational seat, on the general theme of *The graphic heritage. The graphics of heritage*.

The Congress was initially planned as an in-person event to take place on June 4, 5 and 6 of this year, but after repeated postponements, it was decided to hold a virtual event on the online Meet platform at the end of September, after the UID Study Day. Several meetings were held between UID and the organizers, represented by Luis Agustín, President of the Organizing Committee, before the respective UID and EGA conferences; it was agreed that both September events would be characterized by the strong bond existing between EGA and UID, and inviting me, as President of UID, to present the inaugural greetings.

During two days of remote work, it was possible to appreciate the solid tradition of the EGA congresses that, since the mid-1980s, have continued to boast an experience and an organization acknowledged by all Spanish schools of architecture.

The Congress allowed us, despite the limitations dictated by distance, to meet a large and motivated community and to exchange experiences, cultivate affinities of interests and maintain productive contact between professors who, even though working in distant places, express the need for cultural and experiential growth given by the exchange of ideas with other colleagues from different institutions and different countries.

The international level of the Congress was outstanding, and to our particular pleasure, there was a large presence of Italian colleagues.

The theme discussed proved to be very topical, given the very high number of contributions received both from Spain and from the many foreign countries present in the program and, in the context of cultural heritage, the various topics served as the focus of the round tables and plenary conferences of the Congress.

The Congress's being organized as a remote event made it possible to view, on the YouTube channel, more than eighty video-recorded contributions divided among the five topics.

After the opening of the Congress by Luis Agustín and the customary greetings, the *Opening Conference* was entrusted to Rafael Aranda, a member of the RCR Arquitectes architecture firm, winner of the 2017 Pritzker Architecture Prize. The title of the communication, *RCR Shared Creativity*, was a stream of words and drawings of great beauty and expressiveness, giving us all the pleasure of enjoying a graphic narrative of great interest on the theme of museums, the city and the participatory use of cultural heritage.

On the first day of the Congress, round tables were held on the first three of

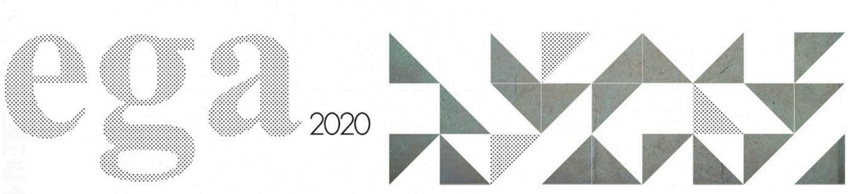

Fig. 1. Cover of conference.

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diségno ISSN 2533-2899

the five topics proposed by the organizers; an Italian colleague from UID always participated in each of these as a sign of attention to the climate of agreement that had been established. The first round table, *Heritage* and *History*, was moderated by Salvatore Barba, José Calvo, Antonio Garcia-Bueno and Jorge Llopis; the second, *Analysis and Representation*, by Carlos Marcos, Roberta Spallone, Noelia Cervero; and the third, Concept and Creation, had as moderators Stefano Chiarenza, Javier Raposo, Manuel Rodenas and Aurelio Vallespin.
The Plenary Conference of Ascensión Hernández, professor of Art History at the University of Zaragoza, who discussed the theme *Mutant monuments in the era of fake news*, was also very well attended.
On the second and final day of the Congress, the other three round tables were held, again on topic 1, *Heritage and History*, the subject that had received the most contributions, moderated by Ernesto Echeverria, Mercedes Linares, Rossella Salerno and Luis Agustín; the round table on topic 4, *Mapping, Cartography and Landscape*, moderated by Eduardo Carazo, Pilar Chías, Andrea Giordano and Miguel Sancho; and finally, topic 5, *Teaching Innovation*, for which Mario Docci, Iñigo León, Ernest Redondo and Angélica Fernández were called to moderate.
The Plenary Conference of the second day was entrusted to Antonio Almagro, Academic member of the Royal Academy of Fine Arts of San Fernando, on the theme of *Drawing (knowing) heritage*.
The debate that followed each round table addressed the topics in a very open and attractive manner, always obtaining a high number of online connections. This once again highlighted the relationship of Drawing with the history of places, with the identity of a people, developing its capacity for the knowledge and analysis of artifacts. Drawing and technological innovation, as well as non-verbal narration were dealt with and, finally, the great theme of the capacity for inclusion that Drawing possesses when it is addressed to cultural assets.
Moreover, the exchanges and discussions generated were useful in broadening the perspectives and fields of application of the disciplines of representation in the panorama of cultural heritage, even in relation to other sectors, especially for the consolidation of new technologies such as interoperable models, BIM, Photogrammetry, Laser Scanner, GIS and Augmented Reality, as can be appreciated in the video presentations at http://eventos.unizar.es/31205/section/26624/xviii-ega-international-conference.html
At the end of the second day of the Congress, the organizing committee launched a proposal for the future of EGA, involving me, as President of the Unione Italiana per il Disegno, to speak on the theme of Teacher organizations, discussion forums, promotion of the area of knowledge, organization and the Future. This intervention was decided after a few meetings between the President, Honorary President and Vice President of UID and the EGA committee, for the purpose of promoting, within the scientific community of Drawing and Graphic Design, the creation of a Spanish scientific association similar to ours.
During my intervention, I illustrated the main points of the organization of the Società Scientifica Italiana dei Docenti di Disegno, which now has 40 years of history behind it. I illustrated its functioning and described the possible advantages for the constitution of a similar association in Spain, on the model of the Italian statute approved last year in Perugia.
I also pointed out that there are many ideas that the UID has borrowed from EGA, the most important ones being: the choice of a traveling Conference for the Spanish locations, and a journal in Class A, which is a point of international excellence.
Thus, in analogy with EGA, the UID conferences have been held in itinerant form since 2012, and our association's journal *diségno* was founded in 2017.
In conclusion, I am sure that this union between Italy and Spain can be strengthened with the birth of another Spa-

Fig. 2. RCR Arquitectes, Pierre Soulages Museum, Rodez, France, 2015 (drawing by Raphael Aranda).

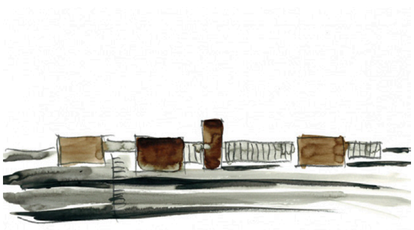
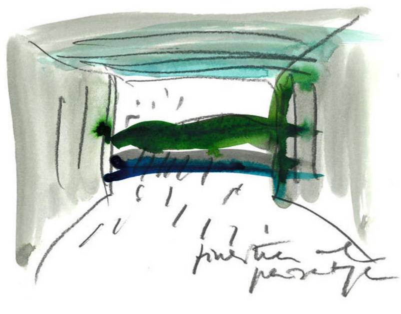


Fig. 3. RCR Arquitectes, La Lira Theater, Girona, Spain, 2011 (drawing by Raphael Aranda).



nish Association for Drawing, with which to confront and support each other, imagining that this network can then extend even further, for even more fruitful coordination.
I know that this is a project that has been maturing for some time among our Spanish colleagues, and we at UID intend to make ourselves available to facilitate this realization.
At the end of my talk there was a debate with many questions and just as many answers. One of them was "Why is it important to have a scientific society of reference?"
It is important because it creates belonging, scientific identity, implementing a fundamental ground for both educational and research exchange. It facilitates relationship opportunities for the organization of events and collaboration that embrace broad and diversified fields of research, making it possible to establish a research network widely distributed throughout the entire national territory, within which hundreds of researchers and scholars can work. Even where tenured scholars are very few or even alone, the UID can give support to research and to a cultural policy that can give guarantees of development for the youngest scholars.
And yet another question: "What can EGA's mission as an association be?"
The mission of an association like the one we hope EGA can become is to carry out, promote and disseminate scientific activities in a coordinated manner in all locations, with a credibility acknowledged by the highest institutions. Thus, just as we were inspired by EGA, it is now up to our Spanish friends to draw inspiration from UID and to found their Association.
The Congress website, http://eventos.unizar.es/31205/detail/xviii-congreso-internacional-de-expresion-grafica-arquitectonica.html contains all useful references and a gallery of the recent publications representative of the scientific field of Architectural Representation written by members of the Congress.
The next appointment with EGA will be in 2022 in Cartagena.

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Events

UID Study Day

Valeria Menchetelli

The unexpected need for distancing that characterized 2020, deeply influencing the habits of individuals and society, also affected the scientific community of the Unione Italiana per il Disegno which, after 41 consecutive annual meetings, had to postpone to next year the ritual meeting that every year sees teachers and scholars in the disciplines of representation interact in a fruitful exchange of studies and experiences. While waiting to return to the possibility of an in-presence meeting and not willing to renounce to present in public and collective form the many initiatives carried out by the scientific society in the last year, a UID Study Day was organized, an opportunity for remote discussion aimed at celebrating the incessant activity of the members of a lively community such as that of the Drawing. Thus, at 9 a.m. on 18 September 2020, using the telematic link set up by the Padua University, the UID President, Francesca Fatta, started the Study Day, divided into three consequential parts.

The first part was symbolically introduced by the two academic groups responsible for the synergetic organisation of the scientific programme of the Study Day, through the joint greetings of Mario Docci, UID Honorary President, and Luis Agustín, President of the organising committee of the XVIII International EGA – Expresión Gráfica Arquitectónica Congress. The title assigned to the seminar aimed to deepen the dynamic and constantly evolving role of Drawing through three keywords: *Drawing: languages, distances, technologies* was the theme within which the three scientific speeches of the Study Day were inserted. The introductory speech, given by Maurizio Ferraris (University of Torino), listed, specifying its philosophical value, the main "senses" that define Drawing, identifying five significant meanings: It is "figure" because it embodies an authentic form of thought, it is "writing" because it possesses the capacity for symbolic abstraction, it is "memory" because it acts as a support to memory but also allows the organisation of knowledge in a mnemotechnical sense, it is "scheme" because it synthesises the form of entities and objects, and finally it is "project" because it becomes the plan that guides human action. In the wake of the suggestions provided, a real duet began (inspired by the homonymous occasion in Perugia which in 2005 saw Gaspare De Fiore and Alfred Hohenegger as protagonists) in which the voices of Agostino De Rosa (Università IUAV di Venezia) and José Marìa Gentil Baldrich (Universidad de Sevilla) alternated. De Rosa's speech, which ended with a dedication to Anna Sgrosso, woven a connection between language, starting from the comparison between the opposite semantic meanings that characterize Eastern and Western languages in the definition of the acts of seeing and feeling, distance, overcoming the geographical extension and demonstrating how the cave space in the Platonic myth reproduces the inside of everyone's heart (Jan Saenredam, *Antrum Platonicum*, 1604), and technology, describing a dystopian but at the same time poetic future in which digital technological excess cannot replace the need for analogical meetings between men (Sion Sono, *The whispering star*, 2015). Gentil Baldrich's speech, opened by a memory of Vito Cardone, was a reflection on the Spanish Expresión Gráfica Arquitectónica area, conducted through a critical synthesis of the results of the EGA congress (21-25 September 2020), from which emerges once again the central role that the representation of architecture, in the rich articulation of its languages, plays and will continue to play.

The second part of the Study Day was dedicated to the presentation of the activities of the Unione Italiana per il

Fig. 1. Jan Saenredam, Antrum Platonicum, 1604.

Fig. 2. Sion Sono, The whispering star, 2015, frame.

Disegno: from the traditional annual events to the new initiatives organised in the last period. The attribution of the *Targhe Gaspare De Fiore 2020*, coordinated by the commission chaired by Mario Centofanti and composed of Edoardo Dotto and Fabrizio Gay, saw the mention of PhDs Raffaella De Marco, Marika Griffo, Martino Pavignano and Chiara Pietropaolo, and the awarding of PhDs Matteo Bigongiari, Veronica Riavis and Simona Scandurra. The prestigious award of the *Targa d'Oro UID* was given to professors Eduardo Carazo Lefort (Universidad de Valladolid) and Secondino Coppo (Politecnico di Torino).
The programme continued with the presentation of the proceedings of the 42nd UID conference *Connecting: drawing for weaving relationships*, which is an important step from the editorial point of view, not only because for the first time it is configured as an open-access volume, published by Franco Angeli and aimed at guaranteeing free access to scientific products, but also because it inaugurates the new UID series *diségno* (whose graphic design, completely renewed, is coordinated with that of the homonymous journal of the scientific society) conceived as a further opportunity for the publication of research results, seminars and symposiums of national and international character organized within the framework of the activities promoted or sponsored by UID. The illustration of the contents of the book of proceedings was carried out by the scientific responsible of the two previous editions of the UID annual conference. In Rossella Salerno's speech, after some summary data on the essays presented and a reaffirmation of the topicality of the theme of connection, understood not only

as of the link between knowledge and disciplines but also as the ability to unite the local and global dimensions (all the more so at a time when physical distance can be cancelled by technology), the four topics of mythological inspiration were illustrated which the contributions proposed a reading of: *Prometheus* (theory and technique), *Metis* (the mutation of form), *Mnemosyne* (the construction of memory) and *Hermes* (the story of places and things). The reading of the contributions offered the opportunity for a general reflection on the urgency of the thematic reorganization of the scientific-disciplinary sectors, also in the light of the need to frame competences in the sectors defined by the European Research Council, in which the tools and methods of representation, although pervasive at an interdisciplinary level, do not seem to find a clear identification (and visibility). Paolo Belardi's speech, starting from the considerable variety and richness of themes and approaches emerging from the contributions presented in the proceedings, reaffirmed the central role of Drawing in contemporary scientific and artistic culture, which constitutes an unequalled potential of the disciplinary scientific field. In particular, two aspects that distinguish the discipline of Drawing, namely the importance it attributes to the recovery of manual skills and its multifaceted and transversal vocation, find emblematic synthesis in another mythological figure, *Hephaestus* (*Vulcan*), interpreted as artisan-artist-designer par excellence. In this sense, it seems physiological to add a new topic to the four already identified, which finds its philosophical reason in the urgent need to humanize the technique, which emerges especially in some specific areas of application of the field (including BIM): only through the identification of a deep meaning the application of the technique can be fully placed in the most authentic sense of Drawing. Moreover, the future of the area appears increasingly oriented towards pervasive dissemination of skills in the most diverse scientific fields: a trend that is already evident and destined to be further consolidated.

The presentation of the volume was followed by the presentation of further initiatives organised within the activity of the scientific society, starting with the one entitled *#iorestoinaula #iodisegnodacasa. Reflections on the didactics of drawing between direct and mediated communication*, born in March following the necessary redefinition of the teaching methods after the spread of the Covid-19 pandemic, but which is proposed as an approach harbinger of further future potential. Sprouted in the wake of the reflections being elaborated by the UID Education Commission, it has become an instrument of investigation on the numerous meanings of the word "drawing" and has become an opportunity to carry out a mapping and a census, in an open and implementable way, of the distribution of the teachings of the representation area in the degree courses of Italian Universities. The dynamic map that collects the outcome of the initiative (subsequently presented in a widespread way during the seminar *Reflections on Didactics in the SSD ICAR/17 - Drawing* held on 30 October 2020) provides an overview in which it is possible to research in an interactive way, taking advantage of a further analysis tool aimed at understanding the evolution taking place in the disciplinary field, in

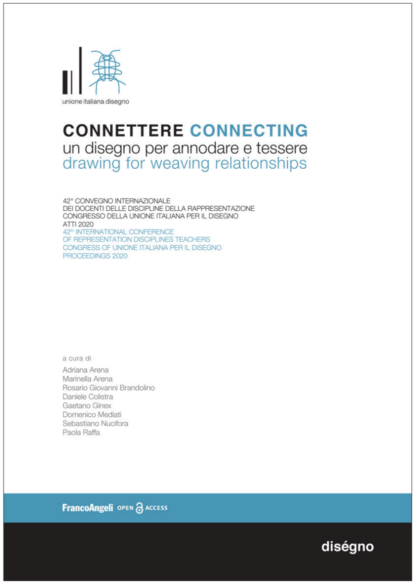

Fig. 3. Cover of the book of Proceedings of the 42nd UID Conference.

the sign of sharing knowledge and expanding the network of contacts.
Finally, the results of the first edition of the *Premio UID Giovani Vito Cardone* were presented, an initiative addressed to the adherent members of the UID, which received wide participation of interdisciplinary groups belonging to different Universities, who were able to connect their skills and experiences in a fruitful exchange of knowledge. Among the nine proposals submitted, the International Commission chaired by Chiara Vernizzi and composed of Pilar Chìas Navarro, Carlos Montes Serrano and Caterina Palestini, conferred the award to the project *Know, communicate, connect: for a UID 3.0 App*, coordinated by Jessica Romor (Sapienza Università di Roma) and developed with Cristian Farinella and Lorena Greco (Sapienza Università di Roma), Raissa Garozzo (University of Catania) and Martino Pavignano (Politecnico di Torino). The project aims to create the prototype of an application conceived as a space of relationship and sharing in which UID members can connect their research activities but also know the present and future events of interest to the scientific community.
The *UID Study Day* had its natural epilogue with the annual Assembly of members, at the end of which the President launched the appointment in 2021 in the Stretto di Messina area for the *42nd International Conference of Representation Disciplines Teachers – Congress of the Unione Italiana per il Disegno*, considering the previous focuses as well as a fifth that relaunches and celebrates the theme of this Day: *Drawing: languages, distances, technologies*.

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Events

REAACH-ID Symposium *Representation for Augmented Reality and Artificial Intelligence*

Cristina Càndito

The REAACH-ID symposium (Representation for Enhancement and management through Augmented reality and Artificial Intelligence: Cultural Heritage and Innovative Design), originally scheduled in Turin on 26 and 27 May 2020, took place in virtual form (13 and 14 October 2020), to which events are converting due to the known needs produced by the pandemic. The formulation was particularly effective and compatible with the topics covered, allowing more immediate transitions between the different forms of digital content presented by the speakers, without preventing the sharing of analysis and critical considerations.

At the beginning, the president of the UID Francesca Fatta underlined the transdisciplinarity that characterizes the applications of Augmented Reality and Artificial Intelligence and the ability of the Drawing field to respond to this challenge, through the sharing and development of knowledge and of the methodologies that are its own.

The need for the contribution of representation is recognized by the first keynote speaker, Mario Rasetti, professor emeritus of Theoretical Physics, who emphasized the essentiality for the pursuit of one of the main purposes of Augmented Reality: achieving maximum effectiveness in communication. Images make up about 70% of the volume of digital data which, as we know, is increasing exponentially. Mario Rasetti underlines how each representation filters reality through creativity: a selection that on the one hand subtracts elements from reality in order to add meanings through interpretation. Reality, inherently indefinable, allows the image to preserve the centrality of its role in identifying the essence and foundations of the content to be communicated.

The symposium was attended by six other keynote speakers who provided a vast panorama of the opportunities currently offered by Augmented Reality and Artificial Intelligence in various fields of knowledge and contemporary life, thanks also to further developments in technologies and processes.

The second session was inaugurated by Claudio Casetti, Computer Science teacher at Politecnico di Torino, who illustrated the progress of the various generations of the mobile network up to 5G, whose evolution is not limited to greater speed, but presents new potential through the collection of data of individual users. Casetti described a new generation application that establishes a renewed relationship with the monuments of the city of Turin, favoring virtual tourism, but also the detection of people's flows with the aid of sensors: one of its applications, aimed at collecting data on the museum attendance, resulted from a collaboration with a research group in the drawing area.

Michele Bonino, Composition teacher at Politecnico di Torino, inaugurating the third session, presented Eyes of the City (Hong Kong and Shenzhen Biennial of Urbanism/Architecture, 2019), an exhibition experience capable of representing the potential of Artificial Intelligence applications. An overview of the installations reveals a great interest in the logic of Design Intelligence, aimed at incorporating the transposition of data flows into the design process. Within the exhibition, a platform for facial recognition and identification of visitors' movements suggested elements of critical discussion on the impact of new technologies on architecture and urban planning. Bonino concluded with the presentation of some works by Philip F. Yuan that exemplify the orientation towards a use of technologies that does not overshadow creative freedom.

Simone Milani, Computer Science teacher at University of Padova, opens the fourth session describing recent solutions and open problems in Mixed Reality for Cultural Heritage and Building Information Modeling. Milani stressed that MR is spreading in many sectors because the interaction estab-

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lished with the user, thanks to the mixture of virtual and real elements, makes it effective for the knowledge of Cultural Heritage, but also for the simulation of emergency situations. In this regard, the virtual reality helmet designed with the Politecnico di Torino is mentioned, which allows any rescuers to view virtual dangers in a real context. Milani also highlighted how the solutions offered by Machine Learning technology largely depend on the quality and quantity of the data provided. The problems encountered are those that are commonly generated in images, as happens for photographs of the same subject which, if strongly differentiated in light exposure, make automatic recognition difficult. An implementation can be provided by Deep Learning technology, which can lead to the identification of visual characteristics capable of allowing a more constant identification of the subject.
The fifth session is opened by Fabrizio Lamberti, teacher and director of Grains (Graphics and Intelligent System Group) at Politecnico di Torino, who offered an interpretation of the relationships between Computer Graphics, Computer Vision, Human-Machine Interface (HMI) and Artificial Intelligence. The convergence of CG, CV and AI technologies is described through the exemplification of different applications involving various sectors, from marketing to Virtual Care. Lamberti stressed that, for a better diffusion, technologies must become easier to approach even outside the specialized sectors and reduce processing times. One of the most challenging phases is the preparation of the images, which can derive from scans of reality or from creative processes. A significant case is that of the creation of animated characters and their use in AI technologies, which can rely on Body Tracking to capture the movements of a real character equipped with sensors. Lamberti presented research that focuses on the optimization of working times by eliminating the phases that show little influence on the final result or by selecting the actions to be assigned to the character. The applications described also include those related to the assessment of learning, with the examination of some technical and perceptual aspects acquired by students in the creation of three-dimensional animated images. Other application fields involve Action Recognition to be used in sports training, proving how, through Computer Graphics, it is possible to create useful images for the training of machines in Artificial Intelligence modes.
Eleonora Grilli inaugurated the sixth session and presented a shared contribution with Fabio Remondino on the state of the art and possible developments in the sector of 3D Modeling for Cultural Heritage. Grilli showed the applications of Machine Learning techniques to the interpretation of 3D representation, through a classification of architectural elements that should make use of procedures that are as automatic as possible. The difficulties obviously reside in the quality of the objects subjected to analysis, which are distinguished precisely by their uniqueness and which, therefore, are not easily assimilable to each other, without careful critical examination. The techniques were subjected to validation in the comparison between the results obtained with the tools and through visual examination. Furthermore, methodologies that can be extended to stylistically similar cases have been identified, specifying new perspectives offered by Deep Learning in preparing datasets of architectural elements.
The seventh session is opened by the designer Alberto Tono with a variety of experiences in the application of Augmented Reality and Deep Learning techniques for the definition of architectural design solutions. Tono compares the analogical methods with softwares that integrate the sketches and photograph-

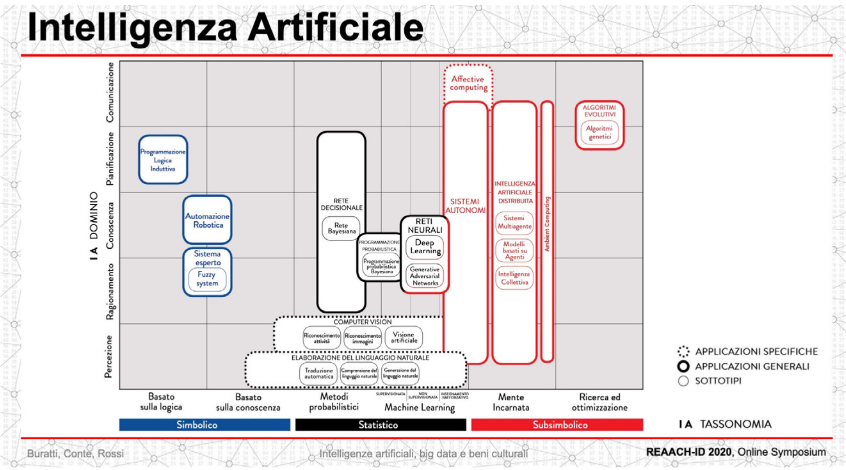

Fig. 1. Classification of AI application fields, logic and technologies (Giorgio Buratti, Sara Conte, Michela Rossi).

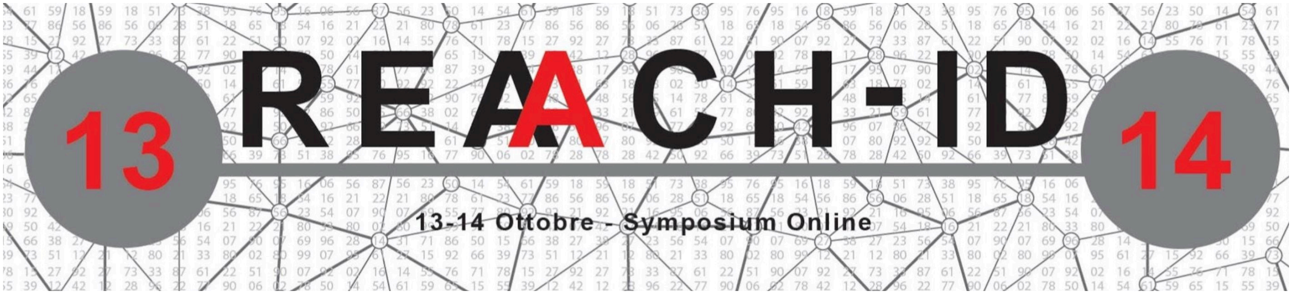

Fig. 2. Logo of the event.

ic shots present in the current widely used tools, and then illustrates possible specific implementations in architectural design, such as the possibility of carrying out formal Real Time modifications and analyzes in a parametric environment. Tono described the potential offered by virtual collaborative design, which allows the people involved in the process to be placed at the center, with their emotions and expressions, thanks to the visualization of the AR. It is also possible to eliminate interruptions in the design flow in the transition between the phase of formulating an idea sketch and its translation into a three-dimensional model, thanks to the interpretation of the first through an abacus of shared tools. The admixture of images with real elements can enter the service of inserting creative elements into the urban environment, using photographic image repertoires available on web and their use for the generation of 3D videos. Many solutions are taking shape within some of the most important software production houses, which make the design process more fluid and communicative.

The heterogeneity of membership and scientific characterization of the symposium promoting committee (Andrea Giordano, University of Padua; Michele Russo, Sapienza University of Rome; Roberta Spallone, Polytechnic of Turin) and of the scientific committee (which counts, in addition to the promoter committee: Salvatore Barba, University of Salerno; Marco Giorgio Bevilacqua, University of Pisa; Stefano Brusaporci; University of L'Aquila; Francesca Fatta, University of Reggio Calabria; Alessandro Luigini, Free University of Bolzano; Cettina Santagati, University of Catania; Alberto Sdegno, University of Udine) contributed to articulating the formulation of the call and, consequently, of the contents presented at the event.

The vast response to the REAACH-ID symposium call, with thirty-six speeches and forty online videos, demonstrated the need for the drawing area to participate in a highly topical critical debate, which the event allowed to feed, also at transdisciplinary level. It is not possible to mention all the interventions of the eight sessions and not even all the universities to which the speakers belong, but as a whole it has been possible to recognize how the Drawing sector has shown not only the ability to understand the extent of technological innovations, but also to provide an important contribution in the fields of its own pertinence. There were innovations susceptible to further developments resulting from the traditional ability of the sector to dialogue with various disciplines that converge in studies related to the investigation and design of architecture, urban spaces and the environment, in addition to research on Cultural Heritage.

Augmented Reality has revealed various ways of its communicative power but also its ability to become a cognitive tool of three-dimensional elements, which can be better understood if contextualized in the context of Mixed Reality. Artificial Intelligence, in turn, has developed in the various sectors in which the application of automatisms allows the operator and researcher to reserve unreliable critical activities for the machines.

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Events

XVI Color Conference

Daniele Calisi

For many years the Color Group has been promoting theoretical and practical sector research, with an increasingly interdisciplinary outlook. The organization, founded in 2004, but which traced its roots back to 1995, has always fulfilled the tasks it had set itself during the drafting of the statute: a) promote the study of color in all its aspects, including aspects relating to vision; b) offer the various people and / or groups of people who have to do with color in its various aspects, scientific, industrial, aesthetic or didactic, the opportunity to meet and communicate their problems; c) launch the necessary or desirable activity to raise a representative opinion on the various problems of standardization, specification, nomenclature and all other aspects that the Group will consider necessary to assist the research; d) encourage and promote the investigation of color phenomena and color measurement and the attempt to ensure that Italy is aware of the developments taking place in other countries of the world; e) assist in the dissemination of knowledge of color.
It is no coincidence that I propose these points again. I find it very interesting that knowledge, promotion, and dissemination of knowledge are the basis of these principles. But the group also sets itself the task of offering all those interested in the subject the opportunity to meet and communicate. It was a year, 2020, which put a strain on this last aspect, but together with it also all the previous ones, because without the meeting and comparison there cannot even be growth.
The task of the Department of Engineering and Applied Sciences of the University of Bergamo was doubly difficult. And, personally, I would like to thank them for allowing all of us, who follow the color group, to see each other, albeit telematically, to exhibit individual sector researches, and to listen to interesting and quality interventions, as always.
The 2020 edition of the Color Conference, the sixteenth, was held on 3 and 4 September and for the first time was held electronically on the Teams platform, using virtual classrooms corresponding to the various sessions of the program. This modality allowed all the participants to attend the conference with extreme ease and, above all, in a way completely similar to the one in person.
The international relevance is also evident thanks to the collaboration of other associations, the Associação Portuguesa da Cor, the Comite del Color Spain, the Deutsche Farbwissenschaftliche Gesellschaft and finally the Swedish Color Center Foundation. The international presence has always been considerable in previous years, but it must be admitted that the telematic possibilities have made the number of interventions from other countries even greater this year.
The science of color has a centuries-old history, first based on perceptual aspects, and later on experimentation and theorizing. However, it is only since the last century that this science has embraced multiple disciplines that have made color theories their own and specific. This variety can be clearly seen in the numerous thematic sessions in which the conference has been divided for years, guaranteeing the richness and at the same time the interdisciplinary nature of this science.
Already from the Invited lectures the multifaceted factor of the conference is denoted: Michael Robinson exposed the international and interdisciplinary dimension of color in Car Design; Rosella Cilano, for years engaged in research and experimentation on natural color, instead presented a speech on the use of natural dyeing for fabrics, ranging from purely chromatic to ecological factors; Riccardo Zanetta, an architect who deals with the design of color in historic centers, such as for the historic center of Bergamo upper city,

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instead introduced the importance of a scientific competence in color management in the historic city.
The multiplicity of themes anticipated by the Call itself, first, and then also by this rich introduction to the convention, is realized in the twelve sessions that touch numerous sectors of the most disparate.
In this regard, denouncing my academic preparation in restoration and representation, I must confess a propensity for certain themes rather than others, but the purely subjective interest does not influence the high judgment of interventions that are always well centered, focused on the topics, clear and of extreme academic and scientific interest.
The oral sessions, in Italian and English, were divided into 2 channels. On this telematic occasion, we must confess that being able to follow all the interventions in which each of us is really interested was much easier and less intrusive: the possibility of being able to enter and exit a Teams channel or the other has made everything very more fluid and non-invasive.
In recent years, interest in chromatic aspects in different disciplines has become increasingly intense and, in many cases, new technologies have made it possible to put into practice new experiments and consequent theories. In memory of the UID 2012 Conference on *The praise of theory* and the importance of practical experimentation, it was surprising to hear how, in many of the interventions of this 16th Color Conference, applied experimentation was essential, both for research in scientific-engineering subjects as in socio-psychological ones.
Of great relevance, undoubtedly, is the topic that has been dealt with several times, on the chromatic aspects in public places and hospitals, especially for children, to which is also added the educational aspect of color in children's games. However, the influence of color on moods is also the basis of much research in the field of architectural design. But the interest of most of the studies in the architectural field falls on the historical and restoration aspects, ranging from contemporary architectures such as the Casa del Fascio by Giuseppe Terragni (contrary to the common imagination that wants it monochromatic), to those of Lina Bo Bardi and Oscar Niemeyer (with particular attention to red and its meaning). Also worth mentioning are the studies on the Casa de Micheli, an Art Nouveau jewel whose colors are to be analyzed and preserved, and finally, the interior design with chromatic studies on both furnishings and upholstery and colors, up to historical architecture.
Interest in heritage can have different meanings. There is that linked to the aspects of the restoration, with the interventions on the Cathedral of Piazza Armerina and the characteristic curtain wall lined with raw brick, or to the wall colors incredibly preserved by the Vesuvian ashes in the *Capitolium* of Pompeii, or even towards the research on the colors of the post earthquake construction in Central Italy.
A second value refers to cultural heritage in a broader sense. Research is discovered on street art and color as an element of urban regeneration through

Fig. 1. Thumbnail of the XVI Conference of Color - Bergamo 2020.

perceptive redevelopment plans, or on the colors and geometries of Portuguese azulejos, emphasizing the method of color composition, the perceptual aspects connected to it and indicating a method for evaluating reflectance of the facades of buildings adorned with majolica.

Or, it is possible to rediscover the historical studies of the sector, with a careful analysis of ancient texts and treatises, a reinterpretation that always leads to new and fascinating deductions: the *Tratado* di Diogo de Carvahlo and Sampayo, little known in Italy, in which the the author introduces the linear chromatic scales, which is also appreciated and cited by Goethe; or the interesting study on the design treaties of green spaces from the early 1900s in the middle of the Art and Crafts period, especially those by Gertrude Jekyll, *Color in the flower garden* (London: Country Life, 1908) and *Color schemes for the flower garden* (London: Country Life, 1919) in which the techniques and color combinations at the base of the author's "flower borders" were explained; a different study on the texts by Imre Pal, from the 1960s, in which the anaglyphs generated for the three-dimensional vision of descriptive geometry models are analyzed, focusing attention on the didactic importance of an immersive vision together with the chromatic tools of anaglyphic vision.

The interest in the historical, artistic or architectural heritage, today, focuses not only on direct interventions, but increasingly tries to analyze, catalog and use this heritage in a digital environment, as for the immersive path with multimedia technologies of the Villa Farnesina in Rome, or as the project of documentation and digital management of the floor mosaics of the Church of the Nativity in Bethlehem, with metafiles that enrich the dimensional data with chromatic, geometric and conservation ones.

But all these interventions that we could define more tangible are flanked by as many scientific studies on Hyperspectral Imaging (HSI) which allows to measure the continuous spectrum of light for each pixel of the scene with a high resolution of the wavelength, both in the field visible spectral but also infrared (NIR); or the analysis of the Euclidean formula for color difference applied to small to medium color differences in the log-compressed OSA-UCS space.

This brief overview of some of the issues addressed does not do justice to the varied series of research presented at the conference. However, most of the interventions have converged in the volume of the proceedings, which has just been published, and which is clear evidence of the quality of the works presented and confirms the great professionalism of the participants but above all of the entire organizing committee.

Fig. 2. Opening at the NOW Gallery in London, Slices of Time by Emmanuelle Moureaux.

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Events

3D MODELING & BIM
Data Modeling & Management for AECO Industry
A virtual meeting for real scenarios

Adriana Caldarone

At the present time, connection, collaborative work and digital management tools are becoming increasingly important: in a sort of rush to digitization, in different and various fields, new technologies and strategies become mature. In the construction industry, as well as in the design word and in cultural heritage valorization, it is necessary to use digital and advanced tools and processing, which are based on digital modeling, in all its forms.

Digital management of an architectural work, whether it is a new building or an existing one, cannot do without information modeling (based on Building Information Modeling processes) and without systematization of data. This in fact optimizes remotely exchange of information, it increases data reliability, it simplifies planning phases, it improves safety for staff and workplaces, respect of the times and of quality workmanship. If before BIM protocol was an opportunity, today, more than ever, it becomes a necessity, also in view of the mandatory introduction of BIM in public procurement, as indicated by Legislative Decree No. 50/2016, as provided for by Law Decree No. 109/2018 and as confirmed by the recent Law No. 120/2020 containing "*Misure urgenti per la semplificazione e l'innovazione digitale*". To this panorama we must add the need to resort to digital tools for the cataloging, valorization and communication of bulit heritage. I am talking about both HBIM and virtual reconstructions, which often represent an adequate response to the remotely accessibility and management, of the tangible heritage, transporting it to an intangible level.

In this context it is appropriate to talk about the 3D Modeling & BIM Workshop, organized by the Department of History, Representation and Restoration of Architecture of the Sapienza University of Rome, the Faculty of Architecture, the Master in Heritage Building Information Modeling and the BIM Master of Sapienza, with the collaboration of the *Ordine degli Architetti Pianificatori e Paesaggisti e Conservatori* of Rome and Province and with the *Ordine degli Ingegneri* of the Province of Rome (whose president of the BIM Commission, Massimo Babudri, present at the meeting, also held the position of BIM Manager of ISTAT).

The congress, directed by Tommaso Empler, reached its sixth edition and was concentrated in a single day, on May 14 2020.

The congress was held in a virtual classroom which represented a successful meeting place between scholars and industry professionals in design and construction fields, as evidenced by the presence of the two keynote speakers Francesca Fatta (President of the Unione Italiana per il Disegno) and Christian Florian of Permasteelisa Group, respectively representatives of academic and professional world.

The participation of Francesca Fatta, as well as the introduction of Carlo Bianchini (both as scholar and as Director of Department of History, Representation and Restoration of Architecture) are emblematic in underlining centrality of scientific disciplinary sector ICAR-17 in the theme of the conference: it is clear from the debate the central role of digital processing and modeling, both as a modeling process (and / or reverse modeling that represents, from visual communication point of view, a design idea and that enhances the formal values of architecture and built heritage), and as an engineering process (and / or reverse engineering, in which you investigate the construction processes, which form the structure of the architectural organism).

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Fig. 1. Event flyer.

The interventions were divided into three main topics: Computer Graphics and 3D Modeling, Digitalization and Data Acquisition and Building Information Modeling.The contribution deriving from didactic experiences was very interesting and underlined the aim to make students understand methodological principles of processes (BIM, HBIM, modeling and representation), instead to make students understand instrumental and software principles.
If we analyze all the contributions, we note that the approach to the issues is changing from previous editions, and it passes from more philosophical topics to more operational problems. In particular, if we talk about BIM and HBIM, it seems that we are close to using a shared protocol, which uses different processes of conscious modeling.
However, critical issues still emerge regarding the so-called interoperability, around which resolves the comparison between the procedures. This is a feature that BIM models have always aspired to. In fact, the use of the IFC format has no expected results, due to the software houses are still too focused on keeping their data structure for purely commercial reasons, forcing users to take that proprietary format as a standard.
This is still an open topic on which, I believe, future editions will have to focus: the interoperability of a system, i.e. the ability to exchange information without data loss, cannot be resolved in an output format, on the contrary it is necessary to work with a series of input formats and software that interface each other to ensure that all information, geometric or not, is not lost during the process. In order to overcome this problem, procedures are oriented towards responsive or adaptive models that provide for an open, modifiable and implementable process with new information entering the workflow.
The evolution consists in a constant integration between computational design, data modeling, BIM, ICT, cloud platforms tools and data sharing.
It is in fact clear that the figure of the computational designer or the use of generative algorithms and visual programming assume value in the panorama of parametric modeling, and it is clear that they are proposed as a consolidated practice to give solutions to complex problems, especially in the field of built heritage.
This fact becomes relevant if we consider that the tendency is to act (I would to say almost exclusively) on the built heritage: even in the BIM field, the project takes a medium and long-term vision, which determines the importance of the maintenance of an architectural object. Massimo Babudri, during his presentation, in fact proposes an integration or modification of the BIM acronym, introducing Management as a fundamental component of the process, however he underlines that, in our field, there is still a great distance between UNI standards and the *Codice dei contratti pubblici*, and there are no guidelines from MIT and from *Ministero dei LL.PP*.
From the debate we deduce there is a tendency to go beyond the concept of BIM as traditionally understood, even not by studying a single architectural object, but also by studying urban context and infrastructures. In fact, there was some contributions that analyze urban shape modeling, which manage information and model both common buildings and the emerging building within the urban fabric. The process just described serves to determine useful tools for administrations and for urban planning, and it allows

continuous collaboration with all the players in the process, and not only with those who work directly in the construction industry. Some scholars based their research on the digital representation of the city for the enhancement of urban spaces. They investigate the perceptual aspects and the relationship between the observer and the image of the city with completely innovative methods: through generative algorithms, heterogeneous data, deriving from cognitive, spatial, and psychological-emotional investigations, become information that can be viewed in a three-dimensional model.
A consideration is born thanks to all the research presented: the three-dimensional model, (parametric or not) which represents a real or prefigured space, becomes more and more as an interface to access other information; it becomes a place to enter data and the interpretation of data, in order to create integrated documentation, management and communication systems. The creation and management of these models goes beyond the procedural approach and, although we are slightly far from identifying standard process, a never ending dialogue between all the players of the process is profitable to reach real scenarios based on parametric, semantic and interoperability.

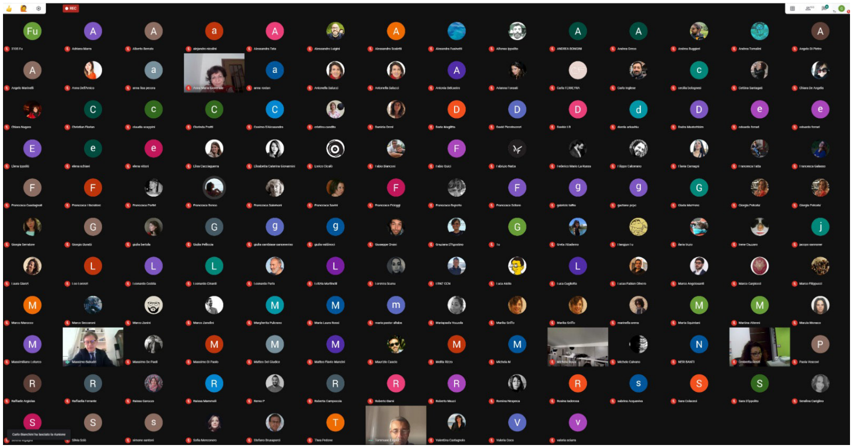

Fig. 2. Screenshot of participants on google meet platform.

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Events

After the Damages: an International Summer School for Risk Prevention, Management and Design

Luca Rossato

The first edition of the Summer School *"After the Damages"* ended in July 2020. The initiative aimed at increasing both the resilience capacity (natural and anthropic) and the mitigating and management aspects in case of catastrophic or calamitous events.
Starting from the assumption that the damages caused by such situations and their consequences, which generally have a major impact on society, cannot be quickly solved, the training course worked on the limits of tolerance to their effects, aiming at their possible increase in order to reduce the level of potential disaster.
The course was organised by the Department of Architecture of the University of Ferrara, through the DIAPReM research centre (Centre for the development of integrated automatic procedures for the restoration of monuments), the LaboRA research laboratory (Architectural Restoration Laboratory), the LEM research laboratory (Building and Environment Maintenance and Management Laboratory) and the TekneHub industrial research laboratory (Technopole of the University of Ferrara). The course was carried out in collaboration with the University of Parma (Department of Engineering and Architecture), the University of Modena and Reggio Emilia ("Enzo Ferrari" Department of Engineering) with the support of the Unione Italiana per il Disegno. Moreover, the initiative has received the important support of the Agency for Earthquake Reconstruction 2012, the MiBACT Archaeologic Superintendence for fine arts and landscape, ofthe metropolitan city of Bologna and the provinces of Modena, Reggio Emilia and Ferrara and the IBACN (Institute for Artistic, Cultural and Natural Heritage of the Emilia-Romagna Region).
In this first edition, in the form of Summer School (which took place between 1st-15th July 2020), the event was a great success in terms of participation, collecting 62 participants from 18 countries and 4 different continents. The participants were guided during the two-week intensive course by experienced teachers in the different areas of emergency management, reconstruction and innovative intervention on cultural heritage affected by catastrophic events. Notwithstanding the current pandemic limitations that led to online teaching, participants had the opportunity to experience an active confrontation via an effective distance learning system capable of making people divided by even 10 hours of time zone work together. The seminars dealt with issues such as resilience, national governance and international regulations, socio-economic impacts, inclusiveness and participatory actions in support of communities, integrated digital documentation, monitoring, digital modelling, vulnerability analysis, and risk mitigation, integrated design and related technologies applied to the conservation of historical buildings and cultural heritage.
The course offered intensive training for different categories of actors involved in emergency management: public administration managers, government personnel, agencies, international organizations, researchers, professionals and specialists.
The Summer School was also an opportunity to discuss and launch an International Academy aimed at promoting an interdisciplinary and integrated approach to risk management with reference to existing heritage.
Capitalising on the experience gained in the recent earthquake in Emilia-Romagna in 2012 and the related reconstruction process by the involved partners, the project brought together an interdisciplinary group of Italian and international experts with the role of lecturers and members of the scientific and technical-scientific committee, including some members of the *Unione Italiana per il Disegno* who have contributed to the documentation of cultural heritage. The aim was to highlight recent

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innovations in the field of post-disaster management by providing more up-to-date expertise with the objective of enabling participants to play an active role in disaster risk management and responding more effectively through mitigation strategies.
The project, funded by the Emilia-Romagna Region in the framework of the Call for proposals for three-year advanced training projects in the cultural, economic and technological fields, is part of Emilia-Romagna's strategy of smart specialisation, implemented in collaboration with the High Technology Network, the Clust-ER BUILD, the Technopoles of Ferrara, Parma and Modena. The training project has a high-level Scientific Committee composed of experts from Italy, Morocco, Brazil, France, Ecuador, China, Armenia, Spain, Greece, Belgium, Germany, Denmark, Turkey, India and Slovenia.
Through the Summer School, international approaches on the topic were shared at different scales, using a wide audience of experts who revealed case studies, research and results of their work in the academic and professional fields.

Fig. 1. Flyer of the Summer School "After the Damages" 2020. Photocredit After the Damages.

Fig. 2. Some images of the case studies analysed during the course. Photocredit Claudia Pescosolido / After the Damages.

Among the most interesting topics, it is possible to highlight the vulnerability of the cultural heritage of some Asian regions due to natural and man-made events that have caused both wonderful architectural complexes and the rich local vernacular heritage to suffer. Experts from India and Nepal emphasized how the concept of intangible cultural heritage can play a fundamental role as a form of local post-disaster resilience, thus supporting the need to increase activities related to intangible culture, also as a channel of social support to the community.
The interventions dedicated to technologies useful for risk prevention and management have focused attention on the use of sensors for remote control and tools capable of returning point clouds with high geometric consistency and high precision for the restoration and analysis of seismic vulnerability of buildings but also of entire historic centres, with case studies from Mexico, UK and the 2012 earthquake area in Emilia-Romagna. Once again, the reliability of documentation and representation of heritage plays a fundamental role in the processes of management and rapid intervention on buildings endangered by unexpected and sudden events.
The inclusive approach to the resilience of cultural heritage has been the subject of debates and interventions among various experts and researchers in the sector, who have highlighted the need for a holistic approach based on community participation and the idea that heritage should be maintained in order to resist to damage but also respects the pillars of sustainability (economic, social, cultural and environmental). In these terms, an interesting discussion was launched on the innovative theme of identity documentation for the construction of immaterial resilience in historical urban contexts, a subject worthy of further development.
During the course there was also space for a more technical comparisons on methods and strategies of intervention on the heritage damaged by catastrophic events, especially starting from the Italian experience in Emilia-Romagna, Abruzzo, Tuscany and Umbria, with interesting insights on the mechanisms that can lead to the loss of portions of buildings during an earthquake, the various masonry behaviours, and first aid interventions to counteract further subsidence or losses.
The risk of coastal erosion and flooding has also been the subject of dedicated focus on the theme, which has shown how the implications of climate change are putting entire coastal cities at risk. Therefore, a case-by-case assessment through targeted policies and specific urban and environmental analyses appeared extremely important.
The involved experts highlighted and showed participants how low-cost interventions to maintain or increase future flexibility in responding to climate change must be identified and implemented as part of an integrated approach to coastal management. Again, on the subject of hydro-geological risk, the discussion shared interesting examples from the experience of natural disasters in Brazil that have endangered entire historic towns in the country whose reconstruction has placed the focus on safety, but also on selective choices about "what to keep".
One of the emerging themes of the Summer School related to the possible solution of the financial fragility of cultural heritage was the concept of cultural ecosystems based on connections and interactions among different actors

in an integrated perspective. Cultural ecosystems can be key factors to enable the valorisation of the potential of cultural heritage and increase its resilience to calamitous events.
The guided tours included in the initial educational project were also carried out through virtual tours of the four case studies, one for each province (Ferrara, Modena, Bologna and Reggio Emilia) affected by the 2012 earthquake in Emilia. Among the visits in Ferrara, there were the virtual tour inside the Palazzo Schifanoia, which highlighted the consolidation of the wooden structures and the restoration of the walls, and the on-line visit to the Cathedral of Mirandola, the most extensive reconstruction work of the entire crater in Emilia.
The last days of the initiative were dedicated to a final workshop among the participants, engaged in a project action able to simulate possible interventions starting from the knowledge acquired during the course. The subdivision of the participants into groups of 5-6 components supervised by a reference teacher, led to 12 final proposals that showed how the participants of the initiative have effectively expanded their knowledge on the central theme of the Summer School but also on digital documentation techniques.
"*After the damages*" will be implemented through a new call for proposals also for the 2021 edition, but in the meantime for the month of December, three events called winter focus (1, 2 and 15 December) have been planned. During these three webinar thematic case studies related to governance, comparison with companies in the sector and BIM technologies for existing assets will be presented and discussed.

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The UID Library

The UID library

2019

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