SCIRES it
SCIentific RESearch and Information Technology
Ricerca Scientifica e Tecnologie dell'Informazione
Vol 8, Issue 2 (2018), 29-48
e-ISSN 2239-4303, DOI 10.2423/i22394303v8n2p29

PARAMETRICAL VITRUVIUS. GENERATIVE MODELING OF THE ARCHITECTURAL ORDERS

*Fabio Bianconi, Marco Filippucci, Federica Magi Meconi**

*Università degli Studi di Perugia, Italy.

Abstract

The Architectural Orders have always occupied a key role in architectural history, starting from the rediscovery of the Vitruvian text in Renaissance, when all of the most famous architects gave their own interpretation about the Orders composition and proportion. According to the importance of the theme for the Cultural Heritage but also the educational value inherent in the redrawing through this roles, the aim of the research is testing and defining a generative representation of the five orders parametrized in function of the most important authors, modifiable changing different parameters. The definition of a single digital model is interesting for the direct comparison between authors interpretation, to support their accurate representations, but also it is useful to aid in the interpretation of the actual artifacts shape, allowing us to hypothesize the author's style and, in case of restoration, to operate in a consistent way.

Keywords

Architectural Orders, Cultural Heritage documentation, drawing, generative modeling

1. *Introduction*

The aim of the study is testing and defining a generative representation of the five orders, parametrized in function of the different authors, useful for the study and for the preservation of ancient artifacts. Connected to other experiences developed by other group of research using different approaches (Apollonio, Gaiani, & Sun, 2012), the transcription of the rules handed down by historical treatises through the new language of generative design represents an act of documentation, analysis, and experimentation that can be exchanged for sharing the know-how in support of Cultural Heritage.

The generative design establishes itself as a significant and widespread representative form. Usually, the parametrical approach is connected to the contemporary aesthetic, a new language and a style (Schumacher, 2011), also for the revolution "in the making of architecture" (Oxman & Oxman, 2010, pag. 24). Instead, it is possible to show as this design approach is really close to the study of the Cultural heritage.

Leon Battista Alberti, in 1485, starts his treatment *De re aedificatoria* introducing the centrality of drawing: "it will be possible to represent the integrated designs in our thought and imagination entirely separate from matter, a condition derived by recording and pre-setting angles and lines to defined directions and connections. This being so, the drawing will be a defined and constant design, conceived in the mind, made by lines and angles, and carried out by a person endowed with intelligence and culture" (Alberti, 1443, pag. 2). The "*lineamenta*", the drawing, is a system of connected signs, the conscious use of this medium to understand the real. Drawing is the modeling and, in this conception, is forecast our contemporary idea of generative modeling, composed by links between simple algorithms to define a digital path. The representation, in fact, is a scientific code, "correct and unique", absolute, a way of joining and fitting together lines and angles.

The parametric revolution (Schumacher, 2011) is strongly marked to the extrapolation of logical connections in the construction of the form is based on the individuation of relations and dependences (Jabi, 2013), defining ranges of the possible input data to determinate the options.

"Variety is always a most pleasing space, where distant objects agree and conform with one another; but when it causes discord and difference between them, it is extremely disagreeable" (Alberti, 1443, vol. I, IX). *Ante litteram*, Alberti shows how parametric principles are the basis of architectural theory, founded in the composition of these relations, showing how also in this field difference is not diversity, in the unity of the model. Drawing conceived by the mind, is made of lines and angles, through geometrical elements but also through their relations, the edges. The representation is firstly interested to the deep structure, a linguistic expression that refers to a technical construct that seeks to unify several related structures, according to the requirements for the generative design to define relations.

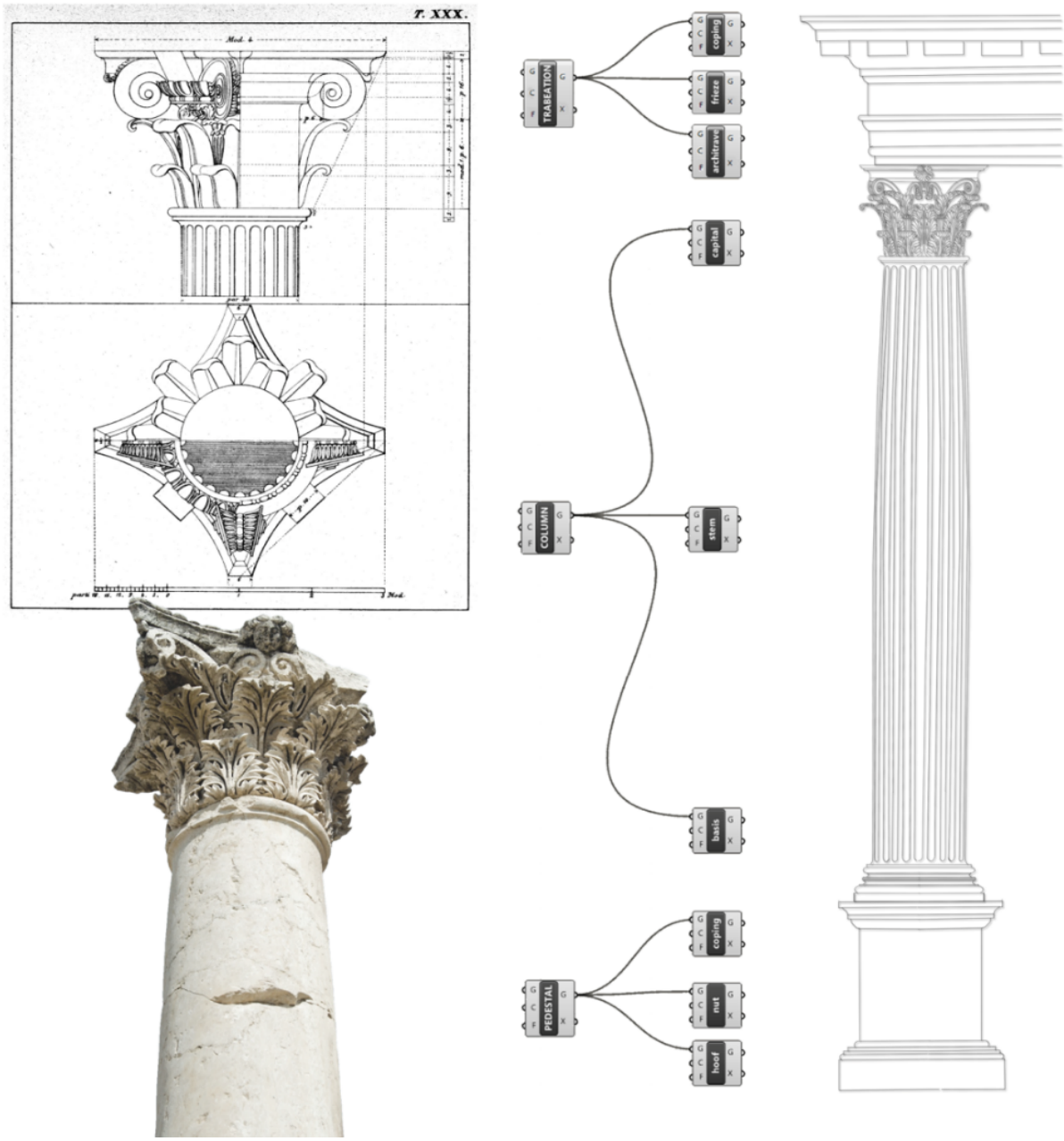


Fig. 1: Graphical abstract of the research about the corrispondence between architectural order grammar shape and the generative-based approach

Fig. 2: Comparison of Vignola's Order

In general, the parametric design is based on the subdivisions and on the hierarchical organization of the model, guaranteeing variable and dynamic representations (Apollonio et al., 2012, pag. 42). In particular, generative based approach reinforces the role of semantic, marking the centrality of the relationships. (Fig. 1)

In this context, the theme of architectural orders becomes one of the most interesting fields of application. The architectural orders define a shape-grammar approach in the deconstruction of the semantic elements. The treatises dealt with the elaboration of the "grammatical" rules, their structure of the architectural language (Morolli, Cantini, & Ente Cassa di risparmio di Firenze., 2013, pag. 43). and today too, through new digital tools (Filippucci et alii, 2016), the same classical path appears as ideal to show the parametric soul of their project, the real subject of the research (Migliari, 2004).

"The language of the columns is composed of the mouldings such as vowels, the elements as consonants, the portions as phonemes: to then arrive, with further, more articulated aggregations, to the members who would thus assume the value of words of meaning accomplished" (Morolli et al., 2013, pag. 17). In the architectural order, the metric created has a purely linguistic character: as Giuseppe Zander observes, there is an analogy between the succession of moldings and the succession of syllables in Latin poetry. The metrical foot jamb (*iambus*) consists of an unstressed syllable followed by a stressed syllable, the same condition that happens in moldings composition and alternation.

The same idea of order codification can be read as an "algorithm", the basis also of generative design (Migliari, 1991; Migliari & Romor, 2015): the sequence of operations arranged in such a way to obtain a certain result, the concept on which the programming of computers is based. All the treatise-writers aim was to give general rules to proportionate the architectural orders. Their algorithms define the relationship between parts, independent by the measure, in the same definition of proportion as the comparative relation of the parts to a whole. (Fig. 2)

The deconstruction of elements, fundamental also for parameterization, together with the representation of connections and structures, clarifies the mutual positions of algorithms. Digital revolution has strengthened the requests of rigorous with its own syntactic alphabet, purely mathematical, able to procure synthetic elements and morphological patterns, a network of nodes and connections considered ideogrammatic morpheme of contemporary hypertext communication (Bianconi, 2002, Bianconi, 2005).

Generative modeling becomes an instrument to reinvigorate the union of the graphical representation of space and digital space, a

process that explains what a form is made of and not what form it is. If the order codification reinforces the value of modeling as "mental and graphical operations, instead of the final result" (Migliari, 1991, pag. 54), also the generative design shows the same aim, in the interpretation of architecture as something hybrid, "constituted by the drawing and in the construction" (Alberti, 1443, pag. 2).
Representing the logical net, the parameterization of the elements is a consequence, an opportunity of digital descriptive text to regain possession of its infinite potential and dynamic heuristic, analysis of a path, understanding singular elements of digital syntax. In this way, it is possible to have a "critical analysis of digital representation's performance", as descriptive geometry discipline required (Monge, 1789, pag. 2). The algorithm, in the order codification as in the generative design, "verifies the definition and it permits, in some way, to appreciate the quality of the relation, whereas the algebraic expression, in its utmost synthesis, gives us directly a result, of which the meaning might even be lost", in the centrality for the drawing of the order of the operations (Migliari, 1991, pag. 53).

In the construction of the system of relations and dependencies, the generative design is a "representation of a representation", a "square representation", able to amplify in an "exponential way" the passage form logic of model, linking geometry and computer syntax. This drawing form appears very close to the Renaissance visual transmission of proportional measurements, so important for the for the dissemination of the treaties (Carpo, 2003, pagg. 451–453) based on a representative synthesis able to condense the multiple rules in a single drawing (De Paoli, 2011, pag. 95). But Marshall McLuhan learns us that "the medium is the message" assumption (McLuhan, 1964). Therefore, the parametric model changes the way to study and develop shapes and objects, combining complex drawing and spatial understanding and questioning. The digital language of parametric modeling can be thus expressed by a visual interface translating software procedural logic that would otherwise be formulated through strings of codes that are usually hard to understand by the average designer.

In the modeling process, then, the attention focuses on the represented form, and the interface allows understanding its morphogenesis and the geometric rules that structure its digital development.

Fig. 3: Representation of the Doric capital and of its integration in the trabeation according to the Vignola interpretation

Fig. 4: Representation of the Corinthian capital and of its integration in the trabeation according to the Vignola interpretation

As Riccardo Migliari writes, in 1991, "the drawing of the order teaches one to appreciate the proportions which exist between the metrical quantities, which are by themselves unimportant". Moreover, "the drawing of an order teaches architecture's internal hierarchy and hence guides the selection of the parts to be surveyed and represented, in relation to the scale on which they are depicted, reveals the play of the relations and unveils the interplay of the ancient units of measure. Therefore, it would appear opportune to study the treatises from the point of view, decidedly special, of who wishes to learn to draw the classical order: to design, that is to say to learn. In addition, in pursuing this study one realizes that there is still a lot of work to do. The process of construction, or, if you like, the planning of the order would appear to have turned its back on Vitruvius's transparent logic of subsequent partitions in favor of Vignola's obscure rule of submultiples of the Modulus" (Migliari, 1991). After more of a quarter of a century, these words sound really close to generative modeling: hierarchies, relations between parts, logics, subsequentialities, partitions, submultiples, are all term connect to the parametric semantic.

Drawing architectural details of the orders, also through generative tools, helps to understand the role and the logic inside architectural design, its graphics language, the roles of composition, the three-dimensional construction of the model. In generative design, the representative logic expressed, the same that is the foundation of our thought reveals itself in its description capacity, to let know the project process.

The application of generative design to the classical order is connected to the same criticism addressed to this approach, that it “all looks the same” (Sakamoto & Ferré, 2008). In the case of the classical order, this condition represents the real object, the definition of a canon. (Fig.3-4)

The generative approach is different from the parametric representation (Apollonio et al., 2012), as it shows the important case of the "Renaissance Revit" (Aubin & Milburn, 2013). In this book the author wants to test the value of BIM instrument according also the value of maintaining proportions, the application of the generative approach to the classic marks the potentials of associative parametric design for affecting significant changes in thought process, in design process, and in technological processes in architectural practice (Gerber, 2007). The relations between the parts and their connections replicate the same research approach proposed in the definition of a canon, in the centrality of not related to the measure but to proportion and metrics. Generative design supports the representation of the variation in the interpretation of the classic, the research of model that defines the born of the scientific approach to the architecture through the drawing and the architectural survey.

2. Materials and methods

2.1 Digital processes and instruments

Generative modeling seems to be the best way to reach the goal, based on 3D digital semantic models organized as cognitive systems with geo-object items in a 3D Information System. Traditional 3D modeling allows creating models that transmit only in a spatial simulation. This is measurable in all their parts but does not give any information about the graphics rules and the process used by the designer. Instead, the result of a generative modeling is an element that contains various information. The results of generative modeling are comparable to a treaty, the model contains both the rules and the final object. Moreover, the algorithms could be continually adaptable and can evolve into countless new forms as a digital tool to create a family of objects with similar features.

The models of this project were developed with Grasshopper software, a Visual Scripting in Rhinoceros environment. The algorithm is a way of troubleshooting, to compute a path leading to the final solution from the question and the initial information. The process of the algorithm leads to a set of instructions that repeated, always with the same input data, and give the same result. This condition guarantees the easy translation of the order interpretation according to the possibility to define a general procedure and it has allowed coming up with an order common genesis and at the same time to determine the main differences.

At the basis of the drawing is the NURBS curves, but the representation doesn't derive from interpolation of points, rather from classical drawing rules, a composition of simple forms actable by compass and ruled and for these reasons the process doesn't lose any geometric information.

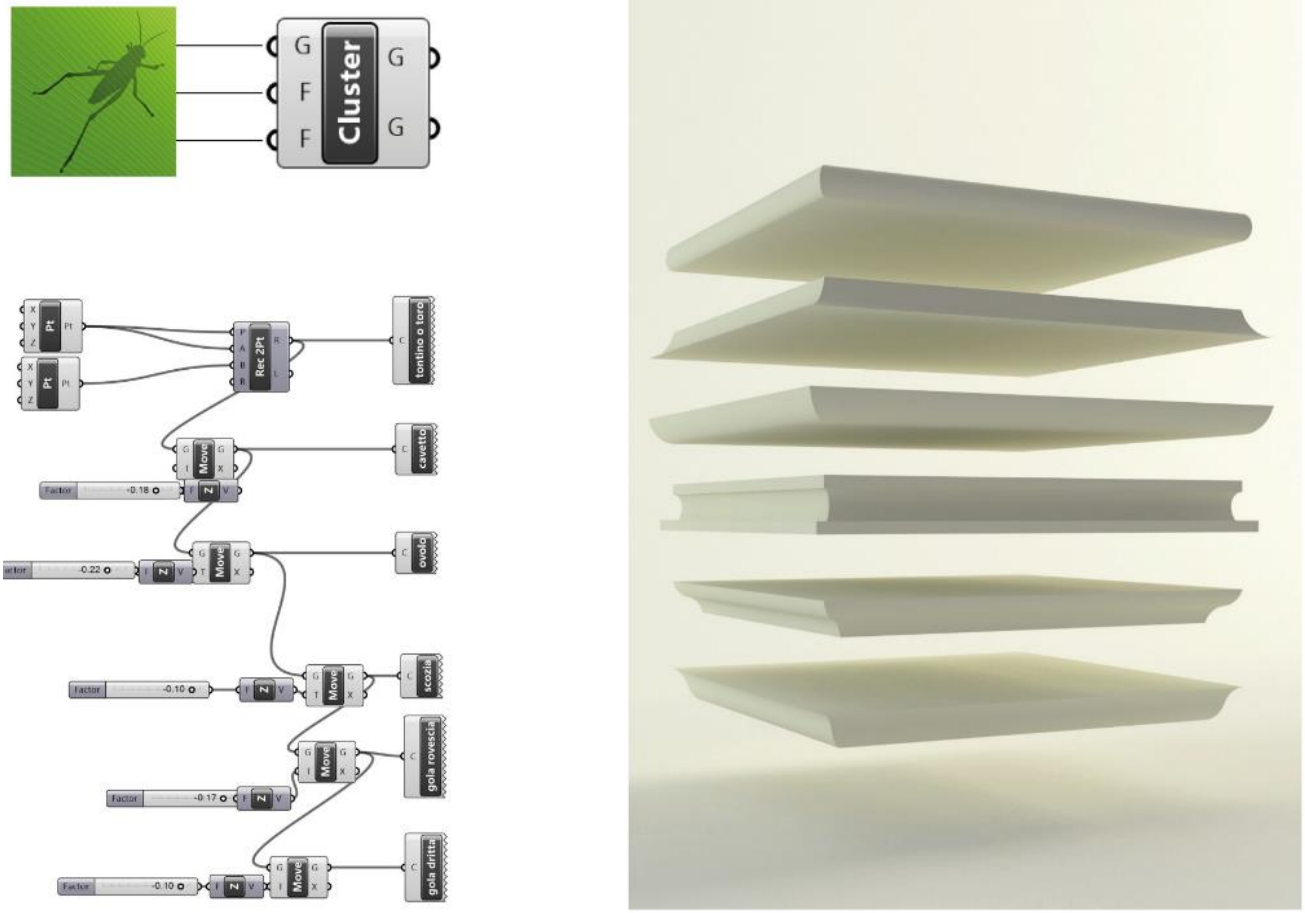


Fig. 5: The logic of the moldings Cluster

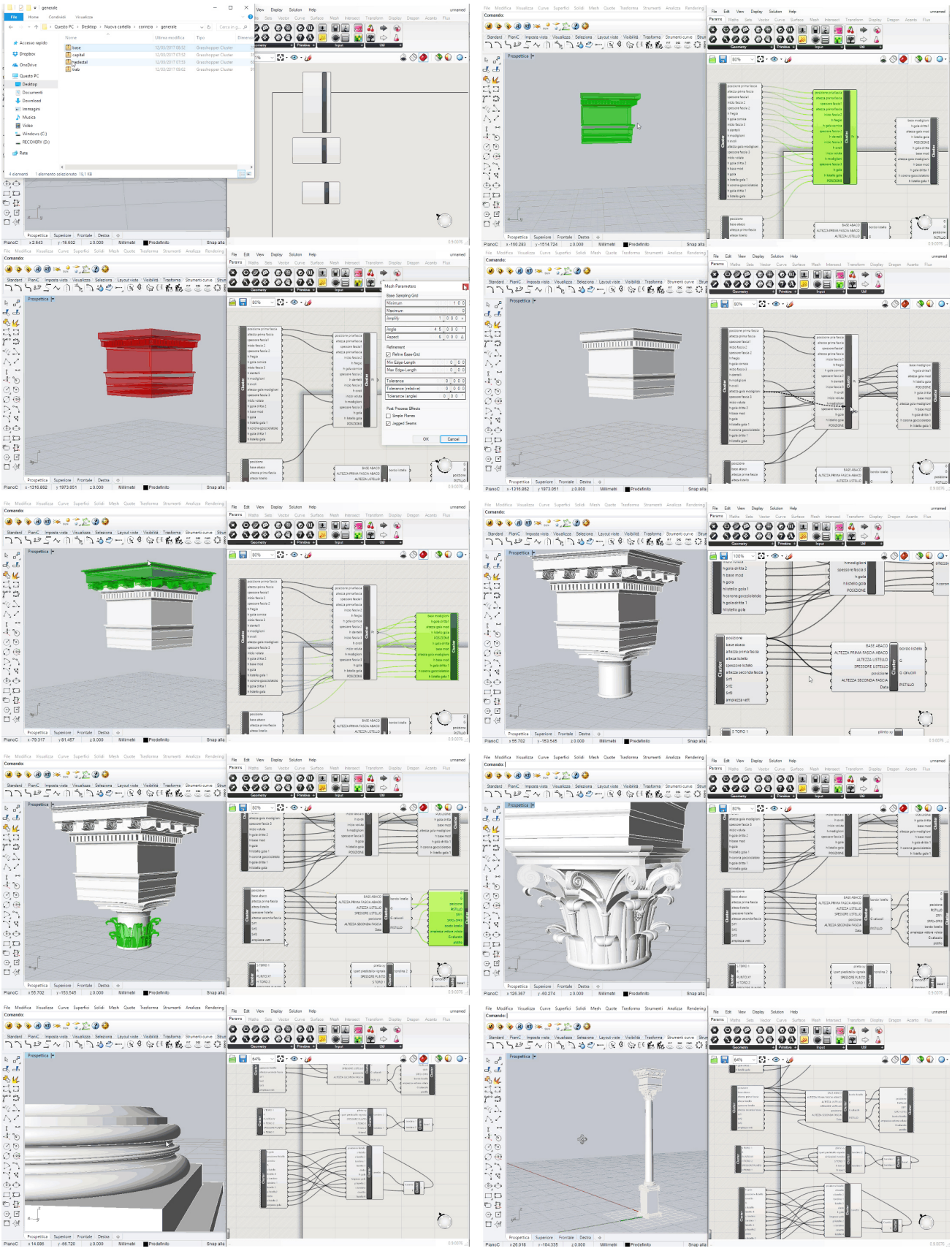


Fig. 6: Parametrization, connections and visual node-based interface in the generative design approach

The association between the parts defines the different elements of the orders, the modeling. As in generative representation, starting from the smaller parts of these elements as vocals that make up the words, the parts generate sentences and different combinations of moldings give different parts and different meaning.

The parts of the architectural orders created by putting the generative algorithms in the clusters, this grasshopper function allows having a slimmer finale algorithm composed cluster that works as an independent tool. Therefore, the final algorithm of the entire order is the positioning of the various clusters of the moldings opportunely scaled. (Fig.5)

The smaller decorations compose the larger parts the base, the column the capital and then the trabeation. Each of these clusters was put into another cluster.

All the features, that diversify the orders, are identified and linked to the major clusters. These inputs of various kinds, numeric or geometric, composed new clusters divided in function of the authors. (Fig.6)

All the system is linked to a numeric tool that rules the diameter dimension of the column base.

To compare a model and a real artifact, the real diameter dimension is set on the numeric tool, to have a form in the right scale. It is also possible to change all the elements heights to the real dimensions.

This path represents a kind mechanical path to model the architectonic orders, a measurable representation without deep knowledge of modeling and proportional rules, an instrument usable by everyone.

2.2 The generative elements of the classic architecture: the paradigmatic example of ionic capitol cluster

To explain the role of generative modelling algorithms, it could be useful describing a paradigmatic cluster. This description can show the multiplicity of solutions that define a cluster.

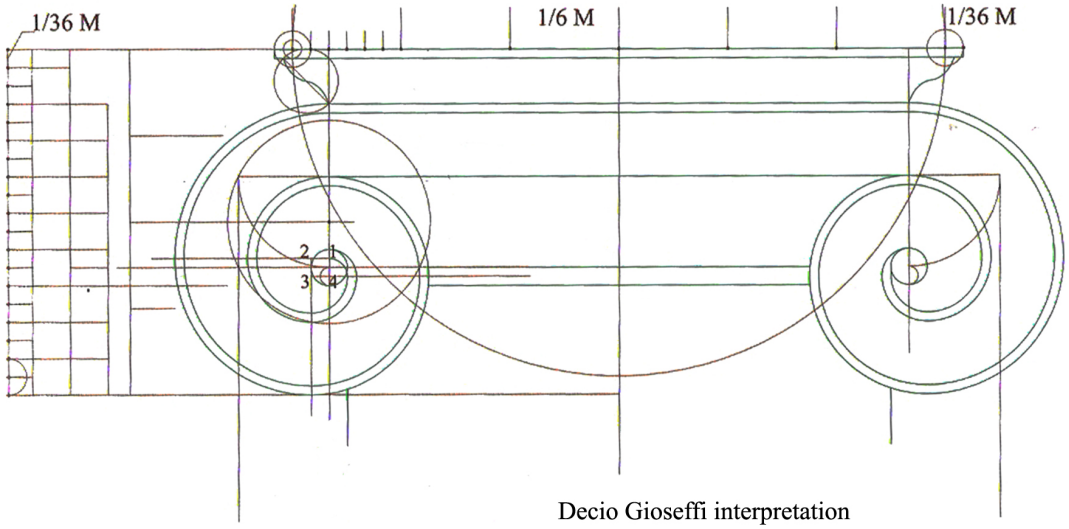
If simple moldings as torus, canaliculus, gulula and undula compose the classic order, a cluster is also used for decorative elements with more complicated geometry.

The study case of the ionic capital helps to comprehend the detailed study on descriptive geometry, which required the representation of each element and the guaranteed possibility of generative modeling to contain in the same path multiples solutions and interactions. (Fig. 7)

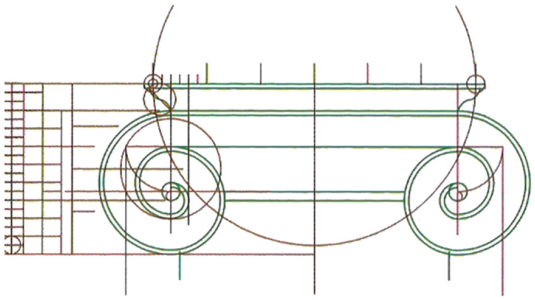
This case study is paradigmatic for its complexity and peculiarity, but also for its fine elegance in simplicity, recalling on "the slenderness of a female body" (Vitruvius, IV, 1, 7). An abacus decorated with volutes characterizes the ionic capital, and its geometric construction represents one of the famous Vitruvian crux. The Vitruvian passage clearly indicates height and length proportions of the volutes, while it is not easy to obtain their form due to "the difficulty of interpreting the text, and because the literal application of the passage it contrasts with the most of the testimonies, the monuments of the roman age" (Migliari, 1998, 45).

About the abacus, it is wide 1 modulus +1/18, so 19/18, while the capital height including the volutes is equal to half the length, which means 1/2 modulus +1/36, so 19/36. The abacus is tapered by an upturned cyma molding whose upper edge is 38/36, 19/18 of the modulus, while the lower edge is 32/39, which is 16/18. It is then possible to trace the volutes' cathetus. The cathetus is a vertical line that starts from the highest edge of the abacus and its length equals the capital's height, which means 19/36, of which 3/36 belong to the abacus and 16/36 are dived in eight parts of 2/36 each. The center of the volute is in the point with a distance of four parts and half from the bottom of the cyma molding; the eye will have a diameter of 2/36 of the modulus. Then it is possible to design the horizontal cathetus, which passes through the center of the eye, dividing the volute in four quadrants.

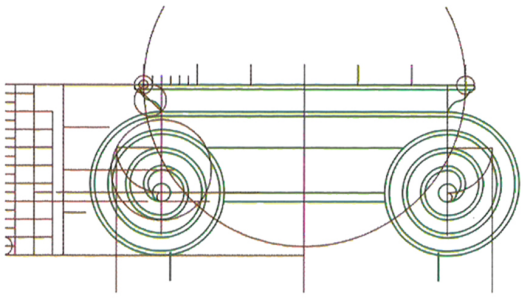
The construction of the volute is "among the darkest and controversial concepts of the entire Vitruvian work" (Migliari, 1998, 47), for this, it is important to recall on Riccardo Migliari reference rereading. It is important to explicit this fundamental condition because of the interpretative ambiguity of the described procedure, which leads to substantial formal transformations according to the interpretation made by Barbaro (1567), Cesariano (1521), Amati (Morolli, 1989, 33) or Gros (1997), that it follows.



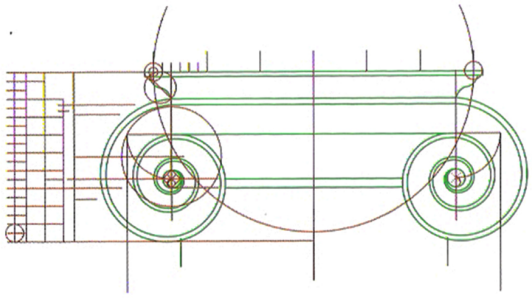
Decio Gioseffi interpretation



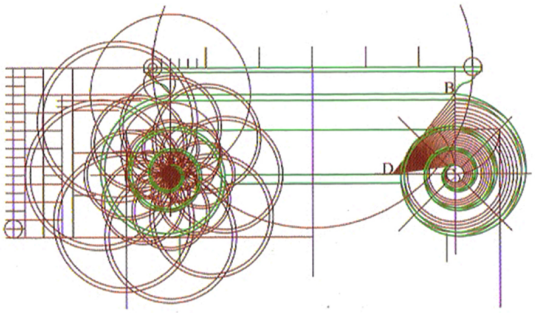
Alberti interpretation



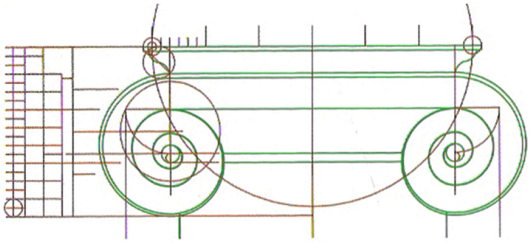
Cesariano interpretation



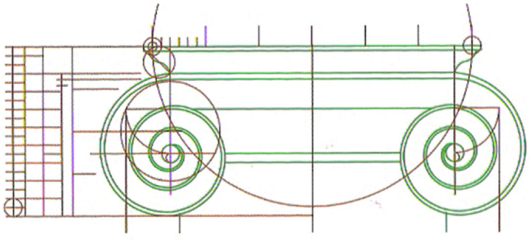
Vignola interpretation (first method)



Vignola interpretation (second method)



Serlio interpretation (first method)



Cataneo interpretation (first method)

Fig. 7: Parametrization of solutions in ionic capitol cluster

Vitruvius, in fact, gives a synthetic description to support a design set at the end of the third book, the explicitly written in the text, but unfortunately, it went lost together with the others.

Among the different interpretations, Decio Gioseffi's operational reading is based on an approximation with Archimede's spiral (Gioseffi, 1980).

The construction begins with the design of a square with the side of the same measure of the volute radius. The square is set with a side tangential to the eye vertical diameter form the most external part, and the half of the side is aligned with the eye half. Following figure 7 numeration, a radium with the same measure of the distance between point 1 and the inferior vertex of the abacus, it is possible to trace 1/4 of circumference, with center in point 2, and from there it is possible to design the second square. The process has to be repeated until the volute ends on the eye in the internal quadrant under the abacus. "This tracking respects the whole Vitruvian text, without adding anything", but it has also the advantage of a logic corresponding to generative modeling, with which it was represented.

Other authors, as Alberti (1433), show that is possible to comprehend how the description can simplify the construction by using just two centers, set at the extremes points of the vertical diameter. In this way, the volute makes only two rounds and it looks inclined towards the inside. Vignola (1562) proposes two different methods that lead to similar results. From the procedural description proposed by Riccardo Migliari (Migliari 1998, 48), he wrote it in generative algorithms, to propose the description of the first model, which is the same of Cataneo (1554). Cataneo improved Serlio's procedure, and proposed volute of 12 rotation centers, set along a square diagonals, where the square is inscribed in its eye circumference. The 12 centers are not aligned, so the curves are welded in an irregular way with the spiral that wraps around itself for three rounds.

The second method that Vignola proposes is more complex and founded on the curve discretization, the determination of the points through which it has to pass, then the identification of curving centers, to divide the space occupied by the volute in eight parts, dividing the quadrants formed by the cathetus together with their bisectors. The design defied by relations easy to parametrize, set on the triangle BCD, whose cathetuses measure the distance between the eye center from the highest and the lowest points of the volute, so 4 parts plus ½ and 3 plus 1/2, a process still complicated and not considered by Barbaro (1567) and Palladio (1570).

Palladio, studying the Serlio's model, presents a volute designed from a square inscribed in the volute eye circumference, with a rotation of 45°. The square is then divided with straight lines that join the middle points of the opposite sides, then each line is divided in six parts, to obtain 12 rotation centers that take the model to the previous case study.

With the possibility of representing the many proposed solutions, it is possible to identify a volute sub cluster and to represent each one in an autonomous way, but still related to the echino. It is possible to show in the parametric transcription Migliari's observation (Migliari, 1998, 48) that "if the echino is built according to the accepted interpretation of Vitruvius's passage, its volume intersects the volutes, more or less at the palmettes height, interrupting them in an unacceptable way, which was never found in the testimony of the past" (Migliari, 1998, 49-50).

Considering the three hypothesis to reduce the object, to substitute superior and inferior curves from circumferences to polycentric, and on refining curves/sections (Migliari, 1998, 52), it emerges that the echino cannot be described as a rotation surface. This condition lead to pursue the profile correction, obtaining as a result a representation that leaves free the volutes field, respecting at the same time the indication given by the treatises.

According to the three hypotheses of corrections related to the reduction of the overhang, the replacement of upper and lower curves from circumferences to polycentric curves, and related to the refinement of the curves/sections (Migliari, 1998, 52), it emerges that the echinus can not to be described as a rotation surface.

This condition has therefore pushed to pursue the correction of the profile, obtaining a shape that does not intersect the volute, respecting at the same time the indications given by the treatises.

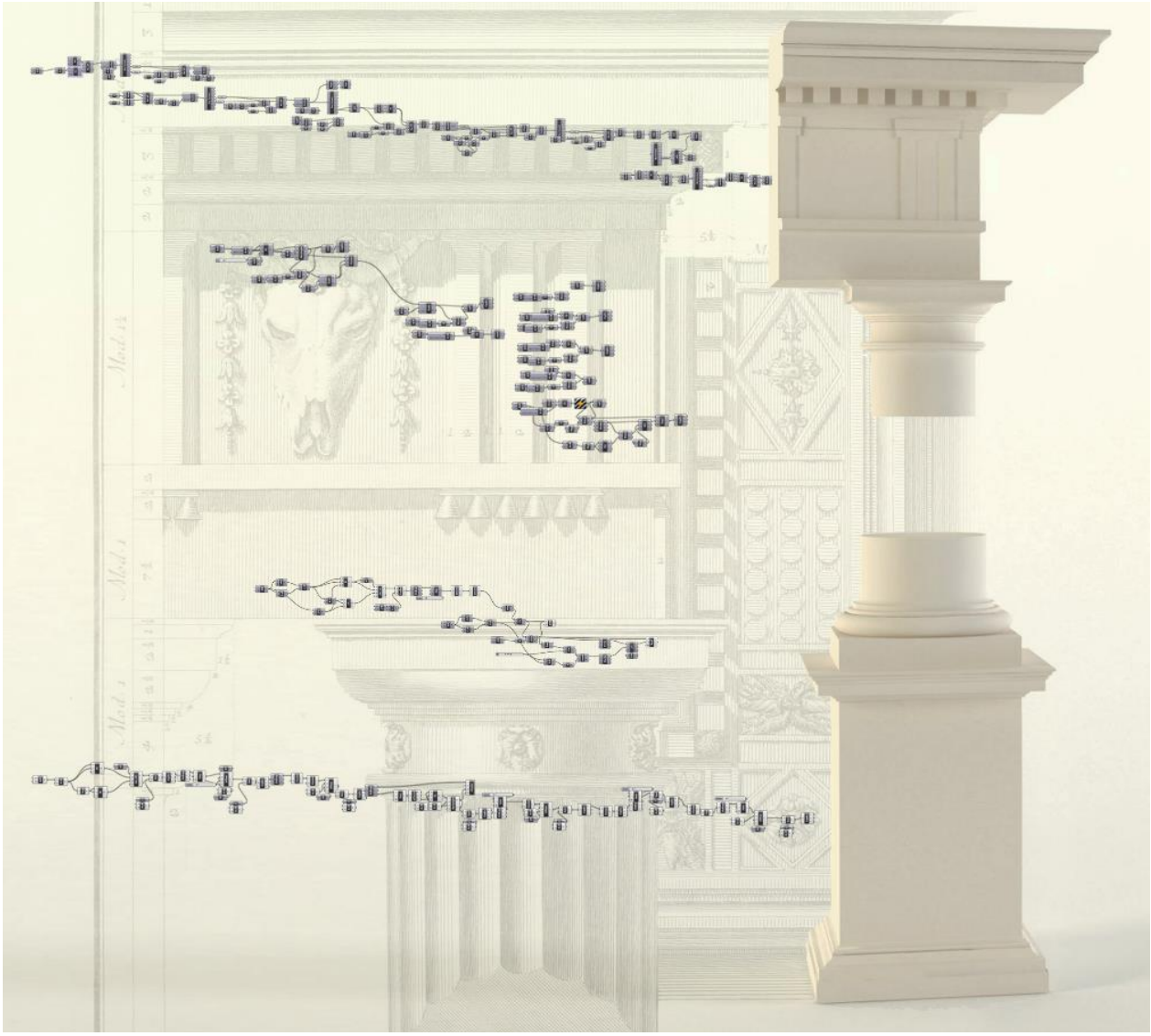


Fig. 8: Vignola's Doric Order

2.3 Theoretical coordinates

The research starts with the study of the classical Orders' Treaties: the Vitruvius' "De Architectura" (30-15 BC), the Alberti's "De re aedificatoria" (around 1450), the Vignola's "La regola delli cinque ordini d'Architettura" (1562), the Palladio's "I quattro libri dell'Architettura" (1570).

According to the Vitruvius teachings (IV, 7), the column diameter at the bottom (imoscapo) is the key measurement and sets all the others dimensions. A process like that lets the designers make a representation unlinked to the used metric system, this is the idea that has always charmed architects (Fig.8).

All the proportions rules could be sum up in three different groups (Migliari, 1991; Revesi Bruti, 1627):

- the following partitions process;
- the submultiples process;
- the decimal metric process.

The first one takes every dimension from the previous one, used by Vitruvius, Alberti, and Palladio, this process has got considerable benefits in the in the context of hand drawing and lets never lose the order complex (Migliari, 1991, pag. 51). For example, "Alberti did not give the proportional measurements of the parts of the base. Instead he provided a method, itemizing the steps of a process (in contemporary computer parlance, an algorithm) that, if carefully carried out, generates the right proportional

relationships among the parts ... Alberti described a chain or sequence of geometrical con structions. The overall process is broken down into a sequence of formally identical operations, each being the division of a segment into a number of equal parts" (Carpo, 2003, pag. 450).

The second one, the submultiples process, used by Vignola, divides the imoscapo radius in a number of smaller parts, called minutes, which act as submultiples, a number of the divisions variable depending on the treatisewriters's order interpretation. Condition of complexification for hand drawing, this process allows a very accurate picture. Vignola, mixed up both the processes, fixing the proportion 4:12:3 between pedestal, column and trabeation, he dimensioned every single element trough the radius division (Morolli, 2003). The latest process, the one used by Chitam, is the most criticized, it is the least practical one. He defines every element separately eliminating all the links to the whole construction and so going against all the compositional process of the architectural orders.

The models, as the algorithm, has been build following the Vignola process and later, thanks to the similitudes, converted to the others version (Fig. 9).

3. Results

The generative representation of the orders is itself the result of the research. In the deepen value of the academia, it could be considered as culture for the culture. Also today, the classical order represents a central didactic path in the renewed of the contemporary formation of the architects (Bianconi, Filippucci, 2016). The path is a digital translation of a defined canon, of a codex, of a language, of a style, of the art of the architecture. The orders itself is full of meanings, but because the medium is the massage, the generative transcription redrawing in a different way the value of cultural path. In this sense, the drawing was the aim of the research and it do not need to have "usefully" applications.

Anyway, it is possible to open perspective regarding a possible use of this result, inserted in the potential comparison the representations of the models idealized by the treatises with real cases. Through examples also not so quite meaningful, it is possible describing as the study could become also an instrument to making assumptions about some elements, like the author's identity and consequently getting, for example, information about the construction

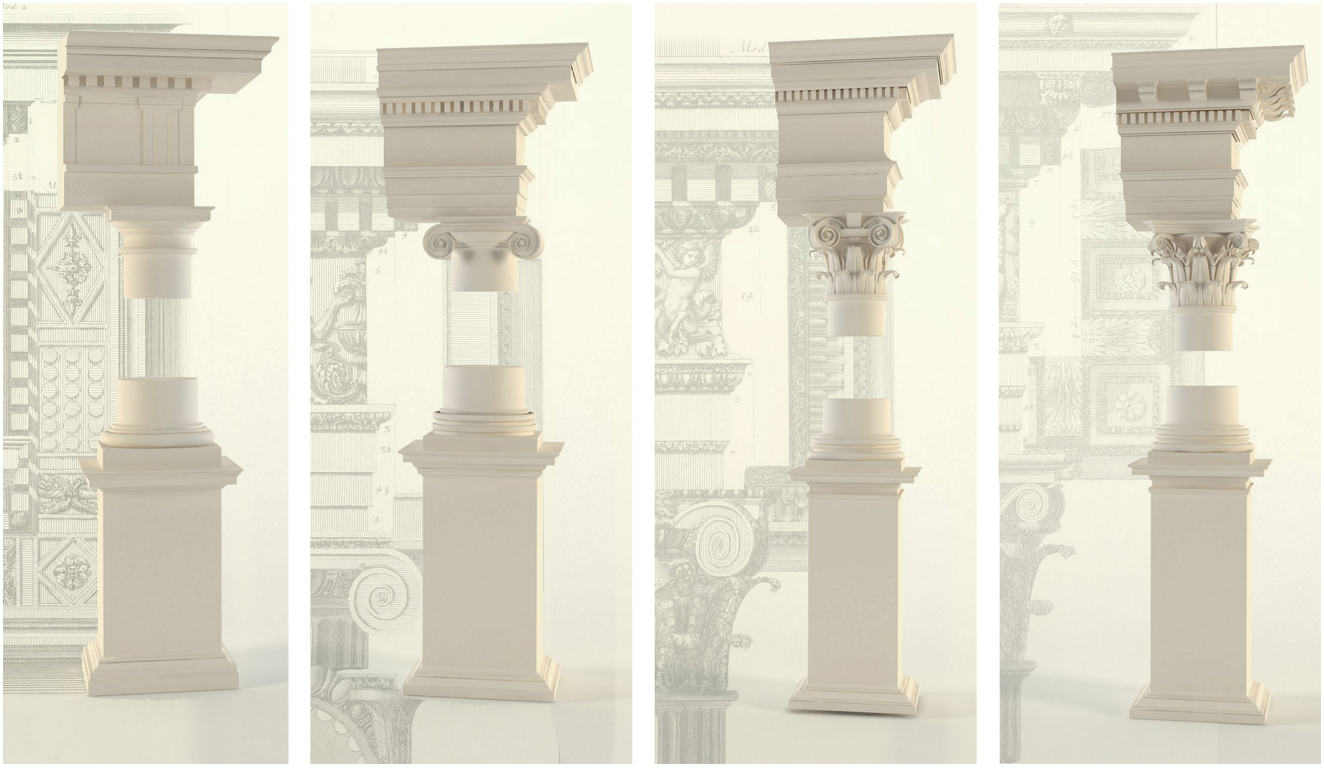


Fig. 9: Vignola's Orders comparison

techniques used and the construction process of the entire factory. These data are fundamental in case of restoration and consolidation of the analyzed artifacts, enabling to design an intervention as consistent as possible with the identity of the work.

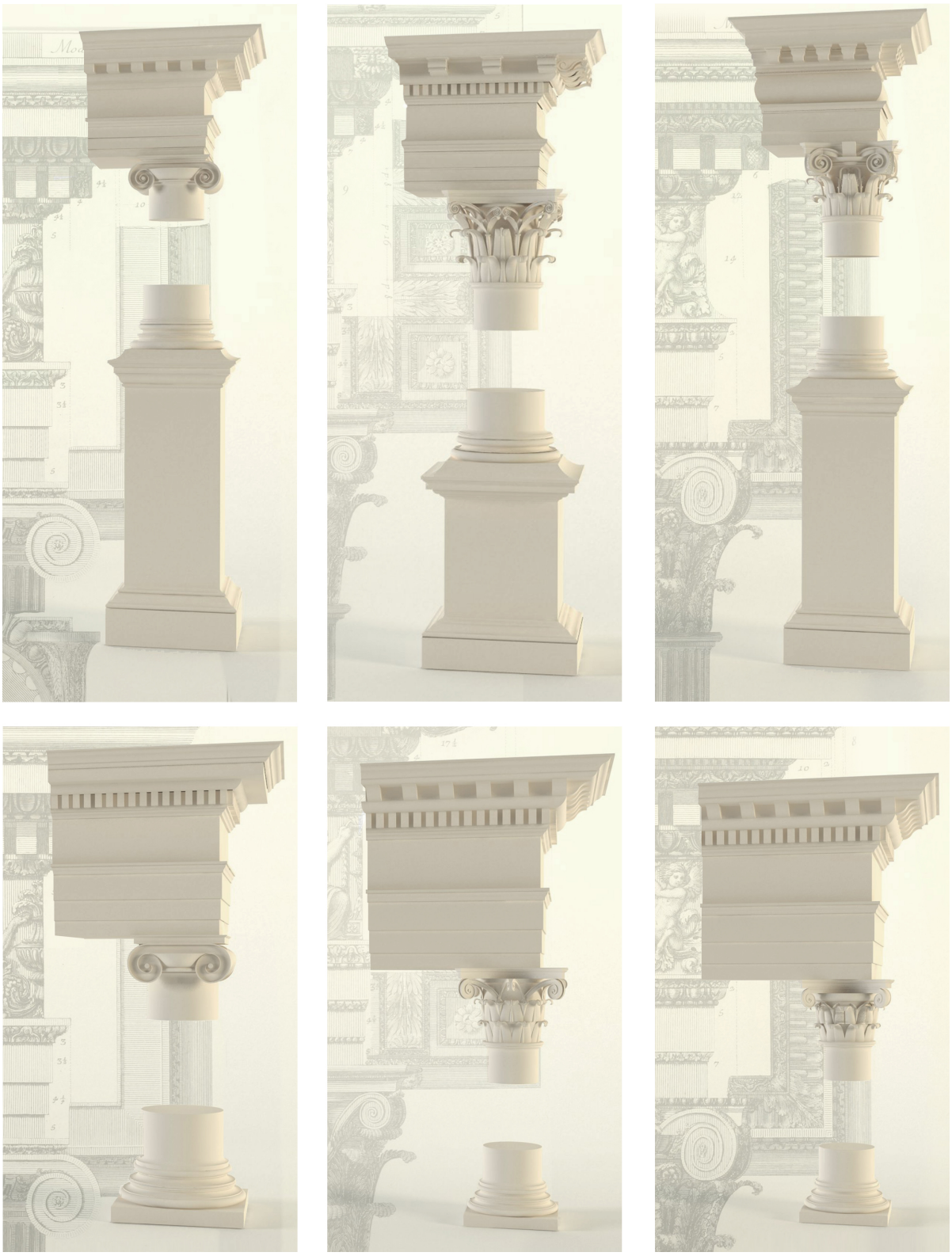


Fig. 10: Comparison between Palladio's (top) and Alberti's (bottom) Ionic, Corinth and Composite Order

3.1 The comparison

It was possible to create four different models for each order starting from the same algorithm. Then these models have generated the comparison images, to emphasize differences in shape and geometry inside the descriptions of the authors. (Fig.10-11-12)

For example, it could be seen the lack of the Vitruvian Composite order, because of the death of the author before of the birth. This order -with the Tuscan one before- is a Romans creation and it was the fusion of the Ionic and the Corinthian Order.

Furthermore, the Vitruvian orders do not present any pedestal, according to the Greeks way. The same characteristics are also in the Alberti's version who blindly follows the Vitruvian rules.

Alberti has some more differences, he does not describe the Tuscans Orders and he has some different kinds of decoration specifically in the Corinthian and Composite capital.

The others authors have two kind of folia, the prima folia is half of height of the secunda folia and both start from the bottom of the cylinder. Alberti draws the secunda folia like the prima folia with the same dimension and put them over the finish of prima folia. This author does not have Culiculum, but only Helices that he calls *medium cauliculi*. He also use a different geometry to represent the volute, theme that would be worth studying further.

After these general considerations were carried out also a dimensional analysis, every orders version model including a table where there is every thickness expressed with the authors format, to commensurate the different version and simplify the drawing.

Fig. 11: Comparison of Tuscan Order

Fig. 12: Comparison of Ionic an Doric order interpretations

3.2 Graphic rendering of an existing historical artifact

The first application comes from the survey, taking a few measures, you will be able to generate an accurate digital model of the reality. (Fig.13)

Chosen the most similar model to the real case, it is necessary to change some value of the algorithm, like the imoscapo radius (the circumference at the base of the column) and the final height to obtain a full graphics restructuring.

It was chosen to study the columns of St. Peter's Stars Courtyard in Perugia, designed by the architect Galeazzo Alessi (Milizia, 1785; Rossi, 1873), a modern architecht of two of the treaties analysed in this project, Palladio and Vignola.

Doric columns, the subject of the first application developed, surround the square courtyard. It was also used the technique of photomodelling, that allowed to realize a 3D model in real scale to measure the highest parts. The photomodelling technique (Filippucci, 2010; Bianconi et alii, 2017) is a useful and fast tool but in this case it did not produce complete results. The column is an object of considerable size and full of details, with an economic instrumentation it has not been possible to obtain an accurate survey in all its parts.

The photo-modeling generates a cloud of points whose graphics can not be left to be made only by the computer, need a graphic editing by a subject instructed about object measured, a model also exportable in a BIM environment (Lo Turco, Santagati, 2016; Barazzetti et alii, 2016; Quattrini et alii, 2015). The product of this project aims to provide an instrument that follow the rules of classical architecture to skip the reprocessing phase.

Fig. 13: Modelling of an existing historical the columns of St. Peter's Stars Courtyard in Perugia, designed by the architect Galeazzo Alessi

Fig. 14: Reconstruction of the order interpretation from the Amelia museum's historical artifact

3.3 Reconstruction of a historical artifact of which there are only remains

The second application was to create a hypothetical reconstruction of a column from its ruins (Fig.14).

The starting element is an Ionic capital of Amelia museum, from late Republican age, which presents an echino almost intact, the volute, even if consumed, stills indicate the form and it appears to be very close to the Vignola's one. The channel of the volutes, below the abacus, is completely absent; no analysed treatises reports this case.

There would be various hypothesis, including that what was interpreted, as abacus, also from the specification of the museum, is actually the volute channel. However, this is only a hypothesis.

In the interest of providing more information, two models were created, one with and one without the channel of the volutes, maintaining the unaltered propositions. Again, the photo-modeling technique guarantees a measurement without touching the artifact.

The 3D model was developed with Vignola model, applying the appropriate changes in the case of capital without the channel.

4. Conclusion

The classics represent our cultural DNA and are the clearest synthesis of the idea of techne, the balance between art and science, which has come down to us and which we now update and project into the future through the first exercises of artificial intelligence. An exercise that translated from analogical to digital can be ideogramised with Vitruvius' triangle, in which in addition to beauty (art) and stability (science), it is possible to add the third vertex that is the usefulness of artificial intelligence, the next development of research.

By a careful analysis of some of main Orders treaties, in particular the works of Vitruvius, Alberti, Vignola and Palladio, it was highlighted the interest of creating a unified genesis of the Orders interpretation in order to create a single model that could be laid down into the different and most famous versions.

This project led to the consultation of multiple sources and the implementation of the rules derived from them.

In the first part of the project, according to Vignola, were designed the five starting algorithms, through the plug-in Grasshopper for Rhinoceros. To complete this process was necessary to determinate the algorithms that adaptable to the different versions, after that the algorithm was separated in a few number of cluster to give the user a simple way to use it.

This project has been useful also to develop a critic analysis of every version and to highlight the difference between them.

The result is kind of a digital tool for representation every actual and study case.

Our proposal is a support for the measurement to create accurate products from a few key measurements usable also by someone without deep knowledges.

Our aim was to spread, in a practical, way the results of the studies of four of the most old and important Architectonic tracts, resolving some problems linked to the difficult of rappresentation of the Orders.

The models proposed let us also possible to make a comparison with actual artefacts to hypothesize what treaties inspired the author, maybe who was the architect and age of built.

The algorithm applications are actually wider, those results used for the reconstructions of now lost elements, and in this process there could be potential developments in archaeology. This study could expand to the architectural rules of classical buildings, to develop, from the remains, a plausible digital representation of entire constructions.

Digital culture, parametric geometry and the potential of its algorithms have opened up inexhaustible avenues of research. The ability to analyse data and to construct new interpretative models have amplified the tools and offered new meanings to several research fields. In this sense, the idea of designing orders extends its usefulness not only to the knowledge of a culture or a constructive method, but also to the creation of new processes of investigation that lead to research fronts that have not yet been investigated.

There is a link between classical and digital architecture in operationalist culture. If Percy Bridgman's approach (Bridgman, 1959) is fully in line with the constructive logic of the classical order (Migliari, 1999), this same case happens in digital parametric logic, for which the process leads to disassemble and recompose signs and analogical meanings. Ideally, it obtains in its recomposition an infinitely large number of pieces to combine and offer solutions sometimes unexpected and often harbinger of new hypotheses to be included in interactive processes.

Why draw orders? A question that recalls Calvino's exhortation who, in 1981 from the pages of the Espresso, invited Italians to read the classics. An exhortation to draw the classics in the digital age that, for several reasons, compared to the Calvinian one. It is possible to draw classics in digital, so it became paradigmatic parameters and tools for comparison and investigation. Because the classics carry on them the trace of the readings that preceded ours (think of the treatise writers) and behind them, the trace that they left in the culture they went through, as well as their revitalization through a digital soul that will offer us new visions and new images. Because a classic has never finished saying what it has to say. Because it is classic what tends to relegate current events to the rank of background noise, but at the same time it cannot do without this background noise.

REFERENCES

Alberti, L. B. (1443). *De re aedificatoria*. Florence, Italy: Nicolai Laurentii Alamani.

Apollonio, F. I., Gaiani, M., & Sun, Z. (2012). BIM-based Modeling and Data Enrichment of Classical Architectural Buildings. *SCIRES-IT - SCIentific RESearch and Information Technology*, *2*(2), 41–62.

Aubin, P. F., & Milburn, A. (2013). *Renaissance Revit: Creating Classical Architecture with Modern Software*. Scotts Valley, California: CreateSpace Independent Publishing Platform.

Barazzetti, L., Banfi, F., Brumana, R., & Previtali, M. (2016). Creation of parametric BIM objects from point clouds using NURBS. *Photogram. Record.* 30(152), 339–362.

Barbaro, D. (ed.) (1567) *Vitruvio. I dieci libri dell'architettura*. Venice, Italy: Francesco de' Franceschi & Giouanni Chrieger.

Bianconi, F. (2002). Tetraktis. Strumenti, luoghi, materia, rilievo. Perugia, Italy: Digital Point.

Bianconi, F. (2005). Segni digitali. Perugia, Italy: Morlacchi.

Bianconi, F., & Filippucci, M. (2016). The parameterization of complex surfaces for engineering solutions. In Le ragioni del Disegno / The reasons of Drawing (125–130). Rome, Italy: Gangemi.

Bianconi, F., Catalucci, S., Filippucci, M., Marsili, R., Moretti, M., Rossi, G., & Speranzini, E. (2017). Comparison between two non-contact techniques for art digitalization. Journal of Physics: Conference Series, 882(1), 012005. https://doi.org/10.1088/1742-6596/882/1/012005

Bridgman, P. W. (1959). *The way things are*. Cambridge, UK: Harvard University Press.

Cesariano, C. (ed.) (1521): *Vitruvio. I dieci libri dell'architettura*. Como, Italy: Gotardo da Ponte for Agostino Gallo and Aloisio Pirovano.

Carpo, M. (2003). Drawing with Numbers: Geometry and Numeracy in Early Modern Architectural Design. *Journal of the Society of Architectural Historians*, *62*(4), 448–469.

Cataneo P. (1554), *I primi quattro libri d'architettura*, Venice, Italy: In casa de'figliuoli di Aldo.

De Paoli, M. (2011). *Il disegno degli ordini architettonici. Letture degli elementi connotativi*. Calcinato, Italy: Acherdo.

Filippucci, M. (2010). Nuvole di pixel. La fotomodellazione con software liberi per il rilievo d'architettura. DISEGNARE CON..., 3, 50–63. https://doi.org/10.6092/issn.1828-5961/2081

Filippucci, M., Rinchi, G., Brunori, A., Nasini, L., Regni, L., & Proietti, P. (2016). Architectural modelling of an olive tree. Generative tools for the scientific visualization of morphology and radiation relationships. Ecological Informatics, 36, 84–93. https://doi.org/10.1016/j.ecoinf.2016.09.004

Gerber, D. J. (2007). *Parametric Practices: Models for Design Exploration in Architecture* (Doctoral dissertation). Retrieved from Harvard University, Cambridge, MA, USA. (AAI3269720)

Gioseffi D. (1980), I disegni dei "Quattro Libri" come modelli; modellistica architettonica e teoria dei modelli. *Bollettino del Centro Internazionale di Studi Architettura Andrea Palladio*. XII, 47-64.

Gross, P. (ed.) (1997): *Vitruvio. De Architectura*, Turin, Italy: Einaudi.

Jabi, W. (2013). *Parametric Design for Architecture*. London, UK: Laurence King.

Lo Turco, M, & Santagati, C. (2016). From SfM to Semantic-Aware BIM Objects of Architectural Elements. *Euro-Mediterranean Conference*. Cham, Switzerland: Springer,

McLuhan, M. (1964). *Understanding Media*. Berkeley, California: Gingko Press.

Migliari, R. (1991). *Il disegno degli ordini e il rilievo dell'architettura classica: Cinque Pezzi Facili*. Rome, Italy: Gangemi Editore.

Migliari, R. (1998). Il capitello ionico classico e gli esiti inaspettati di un suo modello numerico. *Disegnare idee immagini*, 17(VIII), 45-58.

Migliari, R. (1999). Principi teorici e prime acquisizioni nel rilievo del Colosseo. *Disegnare idee immagini 18/19*, 33–50.

Migliari, R. (2004). Per una teoria del Rilievo architettonico. In *Disegno come Modello – Riflessioni sul disegno nell'era informatica* (pp. 63-64). Rome, Italy: Edizioni Kappa.

Migliari, R., & Romor, J. (2015). Perspective: Theories and Experiments on the Veduta Vincolata (Restricted Sight). *Journal for Geometry and Graphics*, *19*(1), 57–77.

Milizia, F. (1785). *Memorie degli architetti antichi e moderni*, Venice, Italy: Remondini.

Monge, G. (1789). *Géométrie descriptive*. Paris, France: Boudouin.

Morolli G. (ed.) (1989). *L'architettura di Vitruvio nella versione di Carlo Amati (1329-1330)*. Florence, Italy: Alimea.

Morolli, G. (2003). Il 'fiore della regola'. Le componenti modanari e il proporzionamento dei 'Cinque Ordini' di Vignola. In C. L. Frommel, M. Ricci, & R. J. Tuttle (eds), *Vignola e i Farnese:: atti del convegno internazionale Piacenza 18-20 Aprile 2002* (pp. 174–203). Milan, Italy: Electa.

Morolli, G., Cantini, C., & Ente Cassa di risparmio di Firenze. (2013). *La lingua delle colonne: morfologia, proporzioni e semantica degli ordini architettonici*. Florence, Italy: Edifir.

Oxman, R., & Oxman, R. (2010). Introduction. In R. Oxman & R. Oxman (eds), *The New Structuralism: Design, Engineering and Architectural Technologies* (pp. 14–24). Hoboken, New Jersey: Wiley.

Palladio (1570). *I quattro libri dell'Architettura*, Venice, Italy: Domenico de' Franceschi.

Quattrini, R., Malinverni, E.S., Clini, P., Nespeca, R., & Orlietti, E. (2015). From TLS to HBIM: high quality semantically-aware 3D modeling of complex architecture. *Int. Arch. Photogramm. Remote Sens. Spat. Inform. Sci.,* 40(5/W4), 367–374.

Revesi Bruti, O. (1627). *Archisesto per formar con facilità li Cinque Ordini d'Architettura*. Vicenza, Italy: Amadio.

Rossi, A. (1873). Di Galeazzo Alessi, architetto perugino: memorie attinte dai patrii scrittori ed archivi. Perugia, Italy: Boncompagni.

Sakamoto, T., & Ferré, A. (2008). *From control to design : parametric/algorithmic architecture*. New York, NY: Actar-D.

Schumacher, P. (2011). *The autopoiesis of architecture : a new framework for architecture*. West Sussex, UK: John Wiley & Sons.

Serlio S. (1537), *I sette libri dell'architettura*, Venica, Italy: Marcolini.

Vignola (1562). *La regola delli cinque ordini d'Architettura*. Bologna, Italy: Lelio dalla Volpe.