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Parametric Grammar: The Shape of Villa Giulia, between Cognitive Coherence and Data Enrichment

The research theme is the identification of a prototype procedure for the construction of parametric models useful for the communication of Cultural Heritage. The final result of the experimentation, applied to architectures marked by the presence of classical architectural orders and sculptural apparatus, has generated communicative artifacts. Reconstructing a conoscitive model of a real space has meant composing a navigation interface through which to convey and illustrate architecture with other potentialities, responding at the same time to specific characteristics of perceptive and geometric quality for the user.

Keywords:
Semantic language; Parametric blocks; Cultural heritage; Numeric model

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1. INTRODUCTION

For some years, digital representation has been enriched with new software dedicated to drawing the built heritage using tools that rely on new modelling paradigms to construct the parts of the building. While ordinary digital representation tools interpret the architectural form using geometric constructions (extrusion of curves, generatrices along curves, directrices, revolutions around axes, boolean operations, etc.), software dedicated to building modelling makes use of juxtaposed parametric blocks, that is modifiable objects compiled to shape the entire building. While cleansed of informational aspects and enriched with semantic language, this approach as used in the construction industry today is interesting for its insertion in a workflow used to quickly render buildings characterized by compositional elements that cannot easily be reproduced by architectural modellers. Hidden problems therefore exist related to the nature of the design tools used and the definition of an efficient operational path because they are aimed at producing a new numerical model to navigate the cultural object in real time. In addition to creating a new procedure, it is necessary to integrate the semantic content of the architectural design software with non-standardized elements (column blocks, bases, etc.). The integration of new parametric families leads to a search within the research that starts from elements described in classic treatises (Vignola, Palladio, Serlio, etc.), and ends with the procedural drawing of new parametric elements. The approach to procedural drawing uses VPL [1] to systematize the different models generated in the process presented below. The prototype of the procedure entails the creation of procedures and parametric models to build a new library that can be implemented with personalized objects and also the identification of procedures for knowledge about the shape of the building examined and its translation into a parametric architectural model. The proposed procedure holds temporal value, involving an initial and generalizable global approach (since they can be modified, the parametric objects defined are applicable to different buildings of equal complexity) and a local consecutive approach (defining a series of local actions to synthesize the building represented parametrically).
The global approach to the topic entailed the acquisition of information from architecture treatises that use the description of scriptographic algorithms to illustrate a parametric approach ante litteram. The scriptographic description was reproduced using the digital grammar of VPL, with which the non-standard parametric objects were modelled, introducing them in the digital environment.
The local approach entailed the design of multiple inter-operable models of the architecture examined. The models in the experimentation consisted of:

1. the first numerical model
2. the simplified geometric model
3. the parametric model
4. the second numerical model

The first numerical model
The experimentation began by gaining knowledge about the building of interest using digital photogrammetry.

The simplified geometric model
The first 'raw' [2] numerical model was used to obtain the simplified geometric model. This step occurred through the reverse modelling which was used to identify the one-dimensional synthetic geometries in the point cloud to be used as input for the subsequent parametric model.

The parametric model
The resulting architectural elements, already collected in the digital library, were positioned and varied parametrically in relation to the indications provided by the previous simplified geometric model. The result of this operation was the simplified semantic model of the entire building.

The second numerical model
This model can be used virtually on ICT [3] devices. The primary qualities of this model are its lightness in real-time navigation and its similarity to the real model.
For this purpose, the parametric model was discretized into a numerical model with different details to be inserted in the navigable digital scene in relation to the navigation. The 'light' numerical model was then given the textures produced from photogrammetry, thereby creating a photorealistic model of the cultural good to be used remotely. The use of the different models, each suitable for meeting particular needs, was preparatory to reaching the central node of the research, that is, the identification of a fluid path of representation in the phases of investigation that is quick to follow and thus facilitates the investigation of and knowledge about the situation.

2. GOALS OF THE RESEARCH

The first step was to create an effective image of the space in question by drawing its shape and rendering its colour. Researching the geometric and formal qualities of a real space to approximate them in effective synthetic models means investigating the geometric structure of said space, isolating its essential characteristics without the need for a complete architectural transcription in the digital realm (Ippoliti, 2011). The goal was not to slavishly duplicate what already exists, but to establish the shapes for proceeding with parametric compositional logic. To approach the complexity of the real architectural space, it was necessary to reduce the information into basic elements to facilitate the reading of the building through descriptive synthesis. Three-dimensional architectural modelling supported by VPL systems allowed the morphological/functional complexity to already be managed in the phase to juxtapose the architectural objects. The parametric approach made the composition of the objects adaptable and anticipated and resolved questions regarding the construction of the architectural space; an initial result was the construction of a hierarchical semantic model with a flexible internal structure deriving from a critical interpretation of the form (Fig. 1). This was translated synthetically in the diagram in Figure 2, which highlights the two large branches of the research: experimentation and knowledge.

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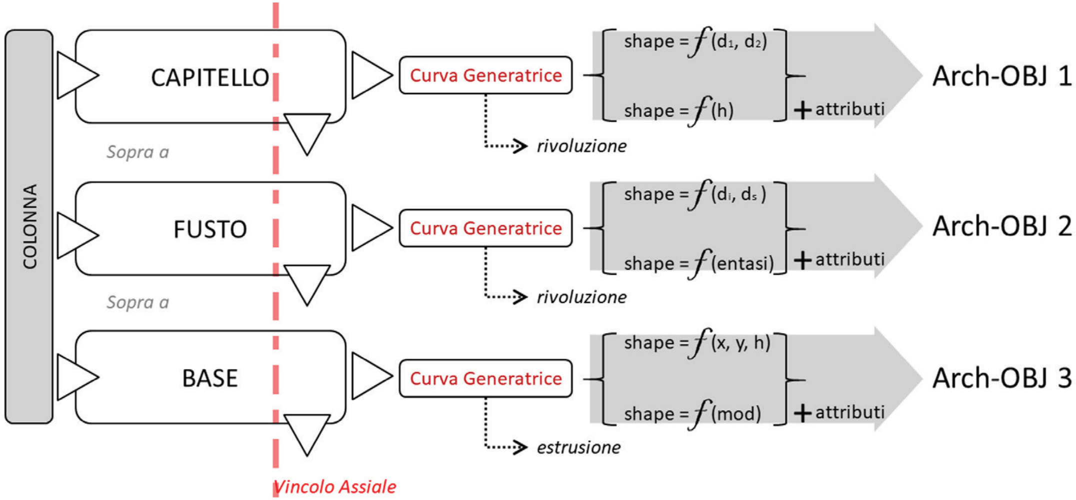
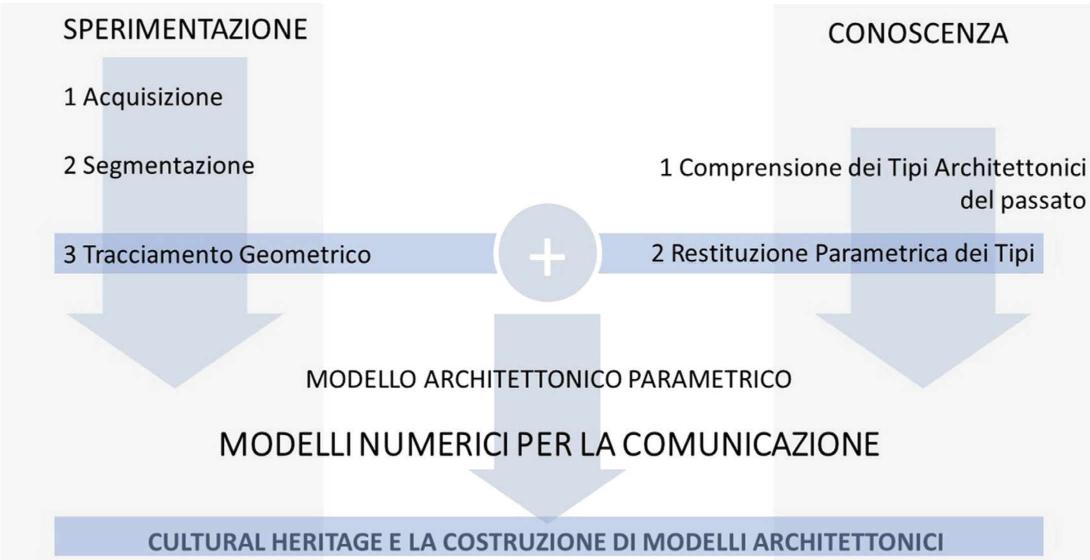


Fig. 1 - Decomposition of the real object in a semantic and hierarchical logic, for a subsequent parametric recomposition.

Fig. 2 - Summary diagram of the phases applied for the development of the procedure prototype.



These branches were divided in turn into strongly conditioned parallel operational phases. Before beginning the experimentation, a reflection was made on which building and important elements to select to favour the use of parametric architectural models and their typical operational logic, which in this experimentation was preparatory to managing the numerical models for real-time navigation.
The procedure investigated can be applied to buildings whose architectural imprint presents stylistic features typical of a given historical period, that is, non-standardized elements that make the building in question unique and which are not generally present in architectural modelling software. The work began by addressing the broad area of experimentation with photogrammetry of the real object and an understanding of its architectural particulars. It progressed with the phase to segment the point cloud [4], that is, critically interpreting the raw data that allowed the typical parts of the architectural structure to be recognized. This conceptual synthesis was applied as a tool to continuously calibrate the shapes to increase or decrease the quality of their topological information (number of vertices that define each element of the building), thereby making them as functional as possible for preserving the similarity of the final model in relation to the user's point of view during real-time navigation.
The segmentation phase overlapped with the knowledge phase. Based on the recognized architectural elements, architectural types of the past were identified and, using procedural algorithms managed through parameters, the types were translated into customized digital objects. The set of these parametric objects constituted an open library for the construction of future architectural models. After creating the library, it was necessary to define a scheme, a geometric trace [5] to associate with the parametric objects that shape the model. To translate the numerical condition of the architectural elements into mathematical elements, the point cloud was subject to reverse modelling to recognize the continuous one-dimensional entities that determined the geometric trace, the skeleton of the architecture surveyed. These geometries, now basic elements

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of the individual parametric objects, underlined the relationships that truly exist between the parts of the building examined; the experimentation revealed the geometric trace as an indispensable tool for locating the parts and assembling the pieces of an architectural frame, with respect for the proportions (Fig. 3). In modelling parametric objects, the individual element is no longer an exact copy of reality, but derives from a synthesis process that nevertheless maintains a high conceptual affinity with the real object. The architectural type was encoded through a series of parameters that defined the rules, and this condition enabled the construction of an unlimited number of variations of the type composing the unique real object. The experimentation involved another fundamental condition as well, that is, the construction of a light model suitable for real-time navigation. The digital model thus composed constitutes a cognitive architectural device featuring objects with typical formal geometric attributes built according to precise internal rules and represented in accordance with the objectivity that emerged from the theoretical analysis and reflection (Fig. 4).

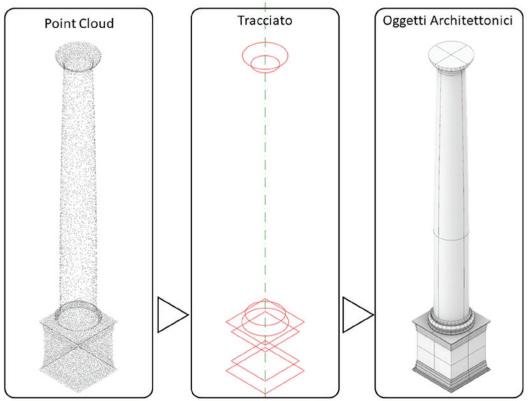
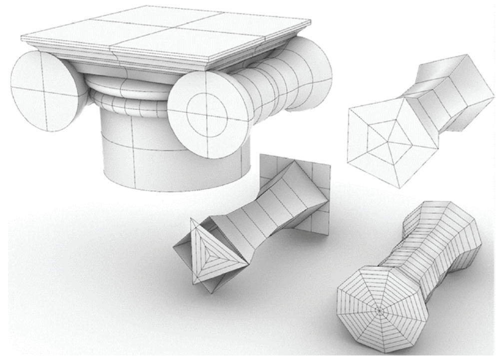


Fig. 3 - Graphicisation of the phases foreseen by the macro-areas of segmentation and knowledge for the manipulation of the architectural elements of the point cloud up to the custom parametric object that relies on the geometric layout.



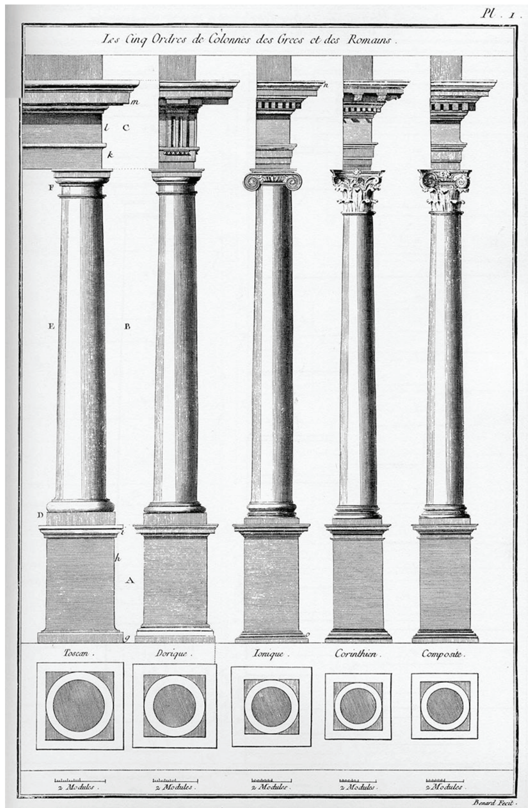


Fig. 4 - Graphing of the steps provided by the macro-areas of segmentation and knowledge provided for the meshing of sculptural surfaces.

Fig. 5 - The five architectural orders as given in Diderot and D'Alembert's En-cyclopédie, 1751.

3. PARTICULAR ASPECTS OF THE REAL OBJECT

Treatises from the 1500–1600s present the work of illustrious writers who, using the tools of drawing, parametrized the architectural orders. With their work of taking apart and reassembling the parts that compose the elements, the architects of the past described algorithms *ante litteram* that were capable of encompassing different levels of detail (Fig. 5). The solution to the problem of details and parametric representation of shapes in classical architecture is sought in the intersection between the treatises and new tools of parametric representation. Basically, the translation of the constructive graphical language (graphical sign) into an algorithmic programming language (VPL), was one of the assumptions in the research. This process of translation entailed an initial phase to interpret and construct the parts (making the models semantic) and a second phase to combine the parts themselves in an established parametric system (Bianconi et al, 2018).

4. FROM THE SIGN TO THE ARCHITECTURAL OBJECT

In architecture, the concept of parametric model arose in the past following the need to transfer confirmed architectural writing styles through places and time. At a time when knowledge about statics and the science of construction was still very rudimentary, geometry combined with proportions represented the only way to control the buildings; the designer used a balanced base to personalize the work with the rhythms, measurements, and ratios between the parts. In contrast to contemporary projects, the buildings of the past better clarified the rules binding the construction of the parts, recognizable in plan and elevation under their morphological and topological appearance.

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An original algorithmic explanation of the classical elements composing the buildings was developed by *W. J. Mitchell in The Logic of Architecture: Design, Computation, and Cognition* (1990). The author expresses the need to establish a grammar of the form, proposing a graphical language that ties the form itself to the relationships between the architectural parts. Using computational logic, Mitchell clarifies systems of rules using diagrams (Fig. 6).
The new means of modelling allow the different steps to be bound in a continuous flow that leads to the objective that in the present case regards the construction of an architectural organism composed of recognizable parts. Starting with the rules in the treatises and moving through the grammar of the form, the step to contemporary parametric logic was immediate.
The capacity of the past to express a grammar of the parts through proportions and transformations can be easily described today using VPL systems (Fig. 7), whose added value lies in the possibility of building a continuous and changing informational flow by adopting variable parameters.
The modeller's attention moves from the output to the process, leading to the generation of predetermined objectives. A single code gives rise to multiple images of the model and the process is designed explicitly in the digital environment. *Explicit design* implies the procedures useful for representing the algorithms that allow 3D models of dynamic parametric entities to be constructed (Calvano, 2019). The explicit digital representation in the procedure enables a focus on the generating archetype and not just on the final architectural object. Contemporary techniques of explicit digital drawing using a VPL allowed the parametric processes of the past to be digitized, leaving open values (parameters) to model architectural objects not present in architectural design software. For example, the research used some architectural elements present in Vignola's treatise and to construct some objects, the parametric semantic modelling was based on the capacity of each architectural element to establish topological and morphological relationships with the three-dimensional objects. This approach to managing the

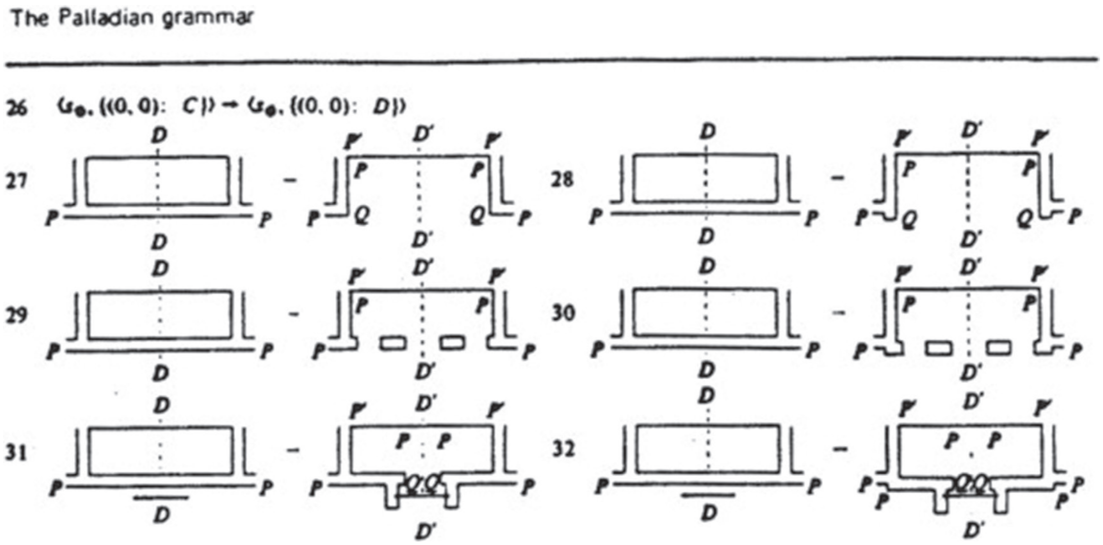
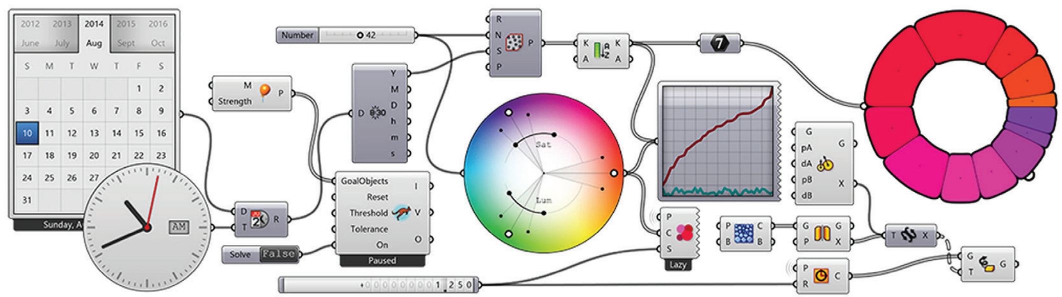


Fig. 6 - Example of architectural decomposition according to W.J. Mitchell's Shape Gramar rules. Mitchell, 1990.

Fig. 7 - Typical Visual Programming Language structure, consisting of parameters and components to create an automated process.



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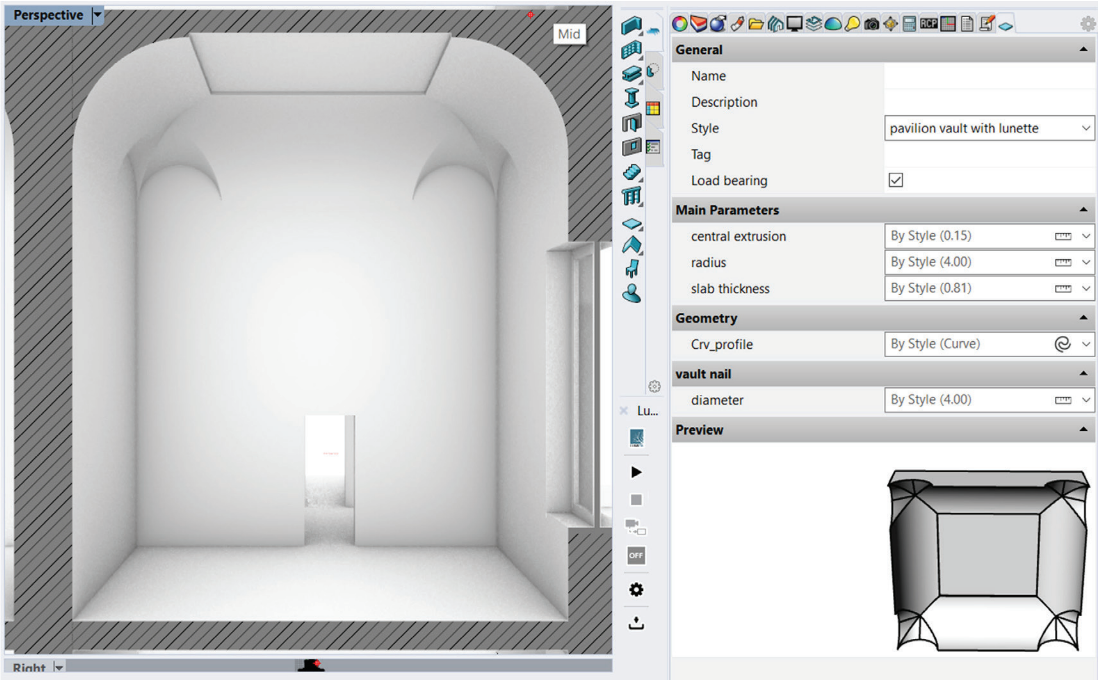

models introduced two problems: communication of the content and the level of detail of the shapes (the first influenced the second). To reach the research objective of quickly building navigable, cognitive models of architectural spaces, it was necessary to optimize the geometry of the model by creating parametric elements that were not exact copies of the real object, but derived from the simplification process necessary to easily manage the model itself (Apollonio & Giovannini, 2015). The new objects thus constructed pertain to an open library necessary for representing the cognitive model of the artefact in question. The libraries were equipped with graphical interfaces to visualize the architectural forms and strings for the parameters (Fig. 8).
This part of the text provides details about the construction of the parametric objects customized using the VPL for integration in architectural modelling software libraries.
For the construction of the parametric column Using the synthetic geometric trace as a reference, there were two inputs for constructing the column: the point where the column was inserted, which corresponds to a chosen point at the bottom of the shaft and the diameter of the bottom (Fig. 9). Using the VPL, the relationships that unite the diameter of the bottom and top of the shaft and the diameter of the entasis were therefore defined. The latter was introduced within the parametric structure of the 'column' object already present in the architecture modeller. In this case, therefore, the existing parametric object was integrated with the information necessary to make the object useful for composing the final model.
For The base of the Ionic Order and its Variations the process continued by analysing the treatise regulating the construction of the base of the order, respectively alternating the 'fillet', 'torus', and

Fig. 8 - Graphical interfaces that make up the open library of custom parametric objects. Calvano, 2019.

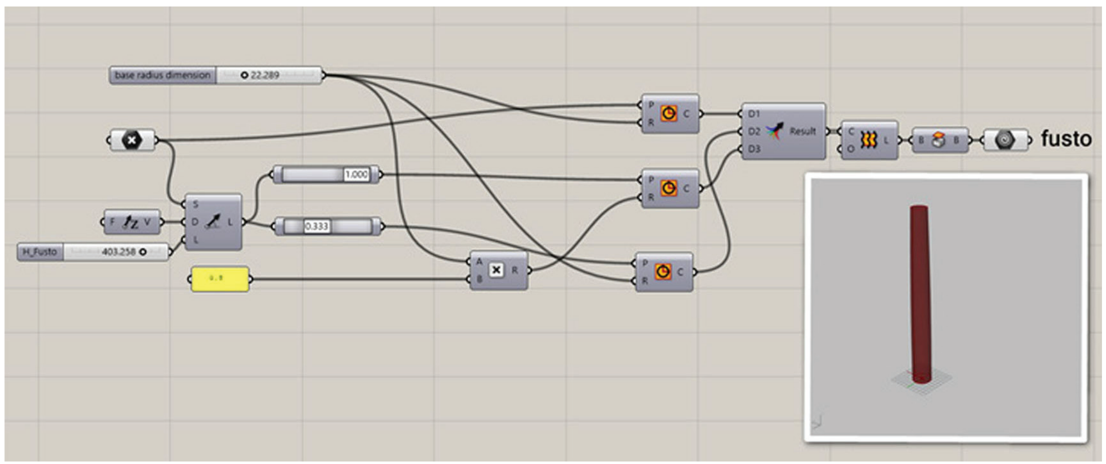

Fig. 9 - Algorithmic definition for the construction of the new parametric object, the column. The three variables are: entasis, imoscape, and summoscape.

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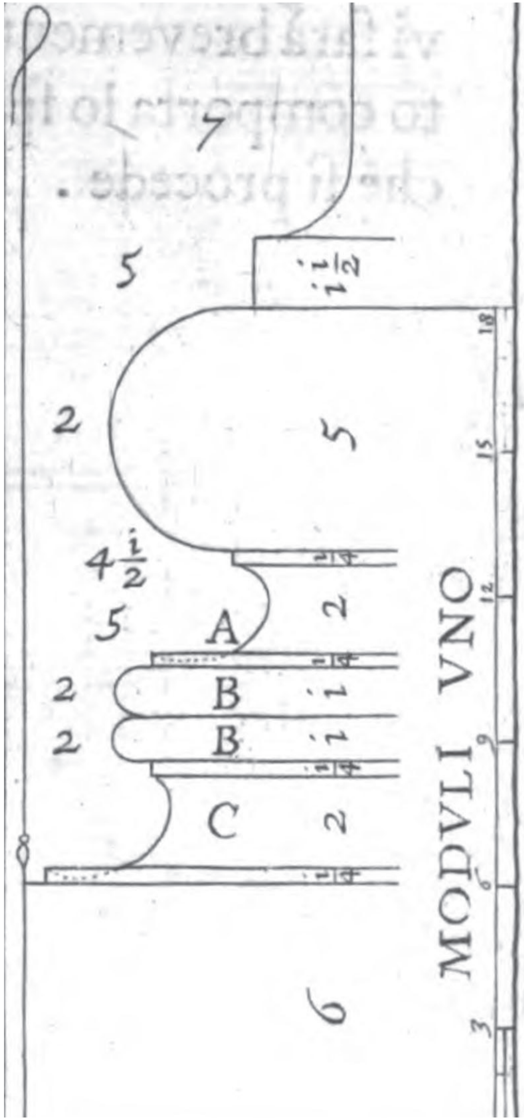

Fig. 10 - Portion of table drawn extracted from "Regola delli cinque ordini d'architettura", of the base of the Ionic capital. Vignola, 1562.

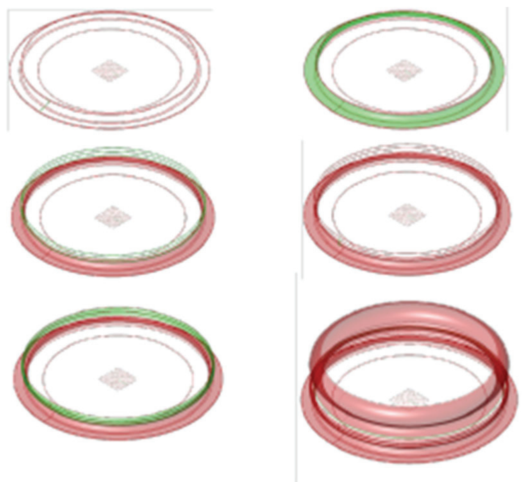

Fig. 11 - Definition of base construction geometries: synthesis of the generative process.

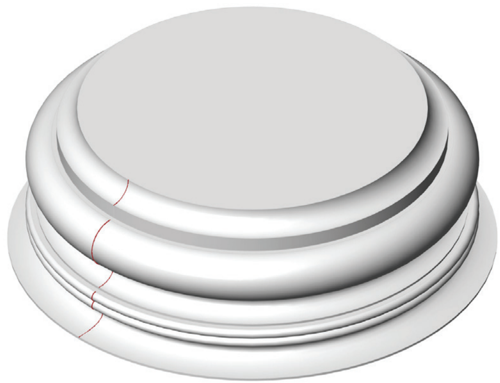

Fig. 12 - View of the created parametric object.

'scotia' (Fig. 10). The reconstruction of the parametric process starting with the data provided in Vignola's table guaranteed a large number of images of the same model, thereby making the object a type of family.
Construction levels of the object were identified for the base of the column (Fig. 11). To define the first fillet in the base, a circle with a diameter equal to the bottom of the column was drawn on level 0, followed by an offset curve on the same plane. The dimension of the latter was defined by Vignola a 6 ¾ units. The circle thus generated was projected on the first construction level which is offset from the origin by ¼ of a unit, and together with the previous curve, the new curve generated delimited the surface of the first element of the base, the fillet. The operations to construct the scotia were the same: a curve with an offset from the main curve of 4 units was drawn, the curve was projected onto construction level 2 (upper limit of the scotia), thereby generating new curves. The same operations were used to progress to construction level 5, alternating concave and convex forms and thereby completely parametrizing the base (Fig. 12).
By varying the algorithm described to build the base of the column, it was possible to construct the base of the pilaster and rather than basing the genesis of the form on the circumference of the bottom of the column, the square profile of the pilaster was used.

5. REVERSE MODELLING FOR ARCHITECTURAL OBJECTS

The path described thus far involved the presence of two levels of representation: semantic and geometric. Integrated together, the two levels subsequently defined a continuous parametric model composed of the collection of parametric architectural objects built in the previous phases and inserted in the vocabulary of new architectural families. The semantic level led to conceptual recognition of the important elements already present in the point cloud and, once recognized, the second geometric level of representation

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followed to build parametric architectural objects for use in the final architectural model (Fig. 13).
The research analysis extended not only to acquiring the geometry of the architectural apparatus in the case study, but especially to the disclosure of the same, focusing on the relationships between the real space and the represented space. In this process, the geometric/cognitive analysis involved a comparison between the real environment and the one represented, and the construction of the digital model was managed by a geometric trace of fundamental lines and points used as 'hooks' for the personalized parametric objects as a function of the recognized geometries. Analysis of the architectural elements involved the recognition of architectural types, the identification of basic geometries and rules of reconstruction considering the directrices and generatrices of each element according to the principles of reverse modelling, without necessarily working on each individual element as a whole. From this analysis of the architectural parts, attention shifted to defining the parametrized architectural types.
In Figure 13, the point cloud is a single entity that virtually envelops the real object. The numerical data return no information about the semantic characteristics of the real model acquired, so it was necessary to implement procedures to segment the cloud into portions referring to elementary architectural objects. The actions pertaining to the decisive algorithm are:
• Segmentation of the cloud
• Extraction of the synthetic geometries (reverse modelling)
• Use of the geometries as input for standard and customized architectural objects
Since the building of reference is a classical structure, the cloud was segmented without recourse to the typical automation in software dedicated to reverse modelling used to identify basic shapes for interpolating points and returning simple entities. Indeed, the objective was to replace segments of the cloud with parametric objects that have a type value composed of coordinated parts (column, shaft, base, and plinth).
Figure 14 highlights the main architectural lines of the 'column' element recognized through its parts. The base starts with the plinth. To render the most appropriate parametric architectural object corresponding to it, it was necessary to extrapolate the plinth from the point cloud and follow the operations to synthesize it with a textual graphical system, the input of the object. The textual and numerical attributes tied to the insertion geometries were functional for the parameters required by the standard and customized objects previously inserted in the library of parametric elements. The plinth in the figure is composed of a body, upper edge, and lower edge. The body of the plinth, similar to a parallelepiped, was described by the coordinates of an insertion point (the centre of the base), its dimensions in plan, height, and rotation around its axis. The reverse modelling operation applied to the portion of cloud was anomalous

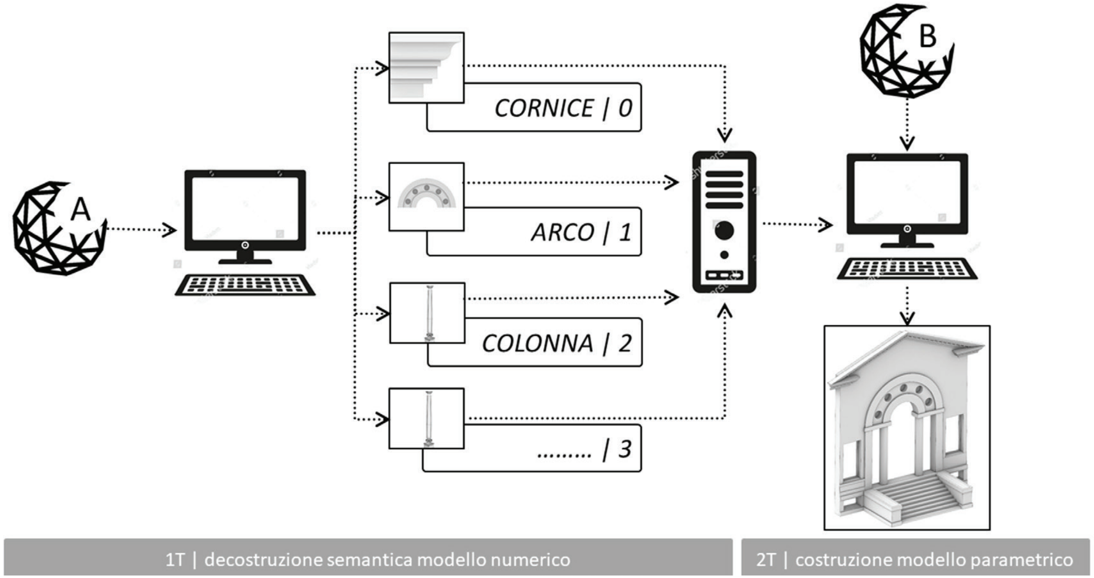

Fig. 13 - Scheme exemplifying the process of construction of the semantic model for the Cultural Goods. In a first time of job (1T) the new parametric objects are constructed. In a second time of job (2T) the examined architecture is composed integrating standard parametric objects and customized parametric objects.

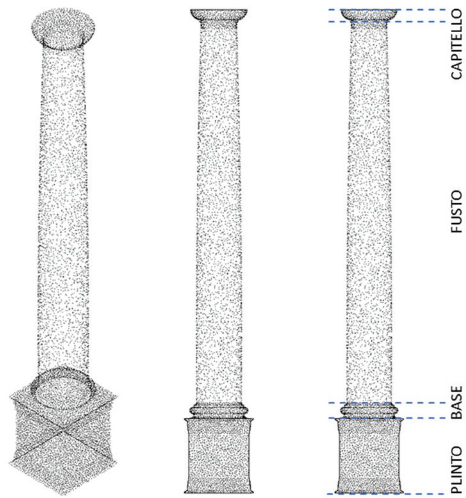

Fig. 14 - Segmentation of the point cloud into recognizable architectural parts.

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because it was not aimed at returning a continuous model, but at detecting the basic shapes and point-like attributes, which were useful strictly for generating the individual parametric object.
To detect the point of insertion, the *bounding box A* of the portion of cloud of interest was built, extracting from it the centre of the base (Fig. 15) and thereby identifying the height of the object. The limiting parallelepiped constructed and corresponding to the portion of cloud examined, could not be used to identify the dimensions of the base of the plinth because the cloud also describes the decorative system (the upper and lower edges). The missing data, the plan dimensions of the plinth, were obtained by creating a second *bounding box B* around a band of cloud extracted from the middle along the height of the plinth. The synthetic geometries of this architectural entity were then extracted, which further directed all the morphological parameters of the plinth.
Also for the base necessary to construct a limiting parallelepiped for the base of the column. The centre of the upper and lower faces determined the ends of the vertical axis of the object. The type element resting on this axis has a complex moulding (torus, scotia, fillet, etc.) with parameters that vary in height and distance from the axis. The representation of these parameters was obtained by extracting the profile of the base, which was used to measure the necessary parameters to generate the object type (Fig. 16).
The shaft is mainly a surface of revolution whose profile is determined by the type of column, and parameters useful for its modelling were likewise determined (Fig. 17). The limiting parallelepiped deduced from the cloud allowed the central points of the upper and lower faces — the start and end of the column axis — to be identified. Using a plane

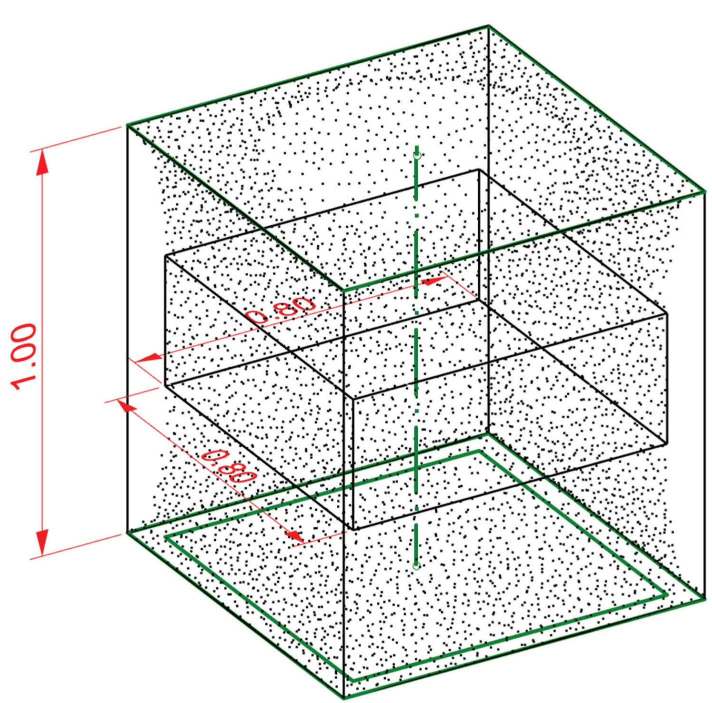

Fig. 15 - Extraction of parameters useful to inform architectural elements: the “plinth”

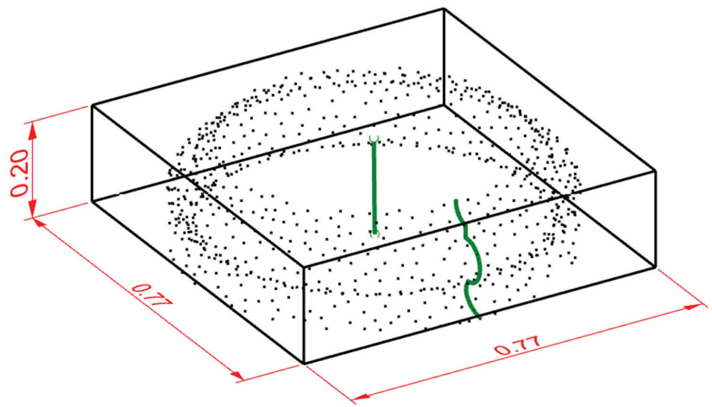

Fig. 16 - Extraction of parameters useful to inform the architectural element the “base”.

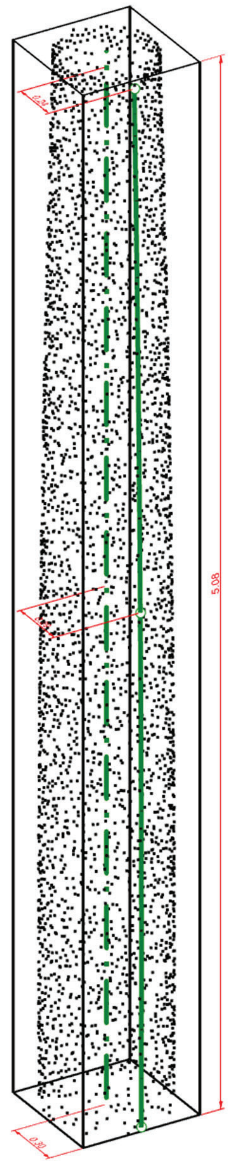

Fig. 17 - Extraction of parameters useful to inform the architectural element the “stem”.

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passing through the axis, it was possible to intercept the portion of cloud used to draw the profile curve; the data useful for directing the parametric object were the initial point of the profile, the end point, and an intermediate point. Proceeding in an orderly manner, the initial point projected on the axis identified the radius of the top of the column and the end point projected on the axis returned the radius of the bottom of the column. The intermediate point was identified in relation to the position of the entasis of the column. The elements extracted provided the few indications useful for directing the parameters of the family of columns to be used for the continuous representation of the architectural object.

6. MODEL WITH VARIABLE PARAMETERS

To achieve the lightness of the model that guarantees its dynamic management, maintaining its shape and perceptual characteristics, the original point-cloud data was not automatically downsampled, but the parts of the model were restored through parametric tessellation. The method yielding a fully understood form of the real object presented as a point cloud was parametric semantic modelling, which may be defined as a set of operations, the fruit of a clear and rigorous conceptual scheme previously formulated by recognizing the important elements of the real object in question. Therefore, the parametric semantic modelling was based on the capacity of each architectural element to establish topological and morphological relationships among the three-dimensional objects. The library implemented by these objects was decisive for representing and managing the cognitive model of the real phenomenon investigated. Beyond the parametric logic reserved for classical architecture, there is a particularly delicate theoretical question tied to the issue of parametric modelling used to represent and communicate the historical/cultural heritage in general. The process to build the digital model and its parts occurs on slippery terrain. On the one hand is the desire to use parametric modelling to define particular conformations and unique aspects typical of the architectural structure in question. On the other lies the possibility of using parametric logic to understand the real object through its critical synthesis. Uniqueness and critical synthesis: intrinsic qualities in the very nature of the question (Bianchini et al., 2016). Therefore in the search to communicate reality through parametric modelling, it was necessary to balance the need to critically synthesize the real object with the erroneous conviction of being able to translate all the unique aspects that characterize the existing heritage, especially the historical/cultural heritage, in the parametric environment. In this experimentation, a balance was sought between the model's efficiency and fluidity through continuous reverse engineering, where the architectural organism was broken down into its constituent parts and then rebuilt.

7. CASE STUDY

The experimentation presented falls within a context of revisiting the approach to building a digital model useful for popularizing a prestigious architectural place, Villa Giulia. Today, this is one of the most prestigious museums dedicated to the culture of civilization in Lazio in the pre-Roman era, an institution that displays important material from systematic excavations. Villa Giulia is a historic building with its own urban value, open to the public and adapted as a museum, a place with a recognized heritage that presents itself as a container of collections. Nevertheless, the Villa only partly communicates its architectural presence and it therefore needs greater communicational attention facilitated by processes to present it virtually. The Villa is located in the Parioli quarter of Rome, Italy and was built by Pope Julius III in

Fig. 18 - The hemicycle, entrance to the first courtyard. Image taken from the web.

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the middle of the 1500s. Today it is the most representative Etruscan museum and an exquisite example of mannerist work from the Renaissance. It was designed by A. Vasari and revisited by M. Buonarroti. Its definitive completion was the work of J. B. da Vignola, while the decorations are attributed to B. Ammannati and G. Vasari. The urban façade of the Villa reaches up two storeys and is characterized by the triple rhythm of a triumphal arch. The rear part of the building has a concave façade that defines the first of three courtyards ending in a large loggia (Fig. 18).

8. CONCLUSIONS

In recent years, digital-induced transformations have involved the entire planet. The technological invasion, if at first it seemed to produce identity crises in many areas, has not weakened the will to understand cultural heritage. Evocative "virtual travel" in architectures of the past, ideal places that through technology are transformed into places of affection. This is the model of contemporaneity and if on the one hand the excess of information may have in some cases weakened the authentic values of a place of culture, on the other hand it has diminished the critical distance between the cultural heritage society and its representation. These considerations determined the purpose of the research, that is, to investigate the constructive possibilities of verisimilar parametric digital models with which to translate particular places of value to be navigated in real time (Fig. 19). The semantic approach chosen to investigate architectural places, determined a decomposition of architectures into two macro-categories, that of standard architectural elements and that of cus-

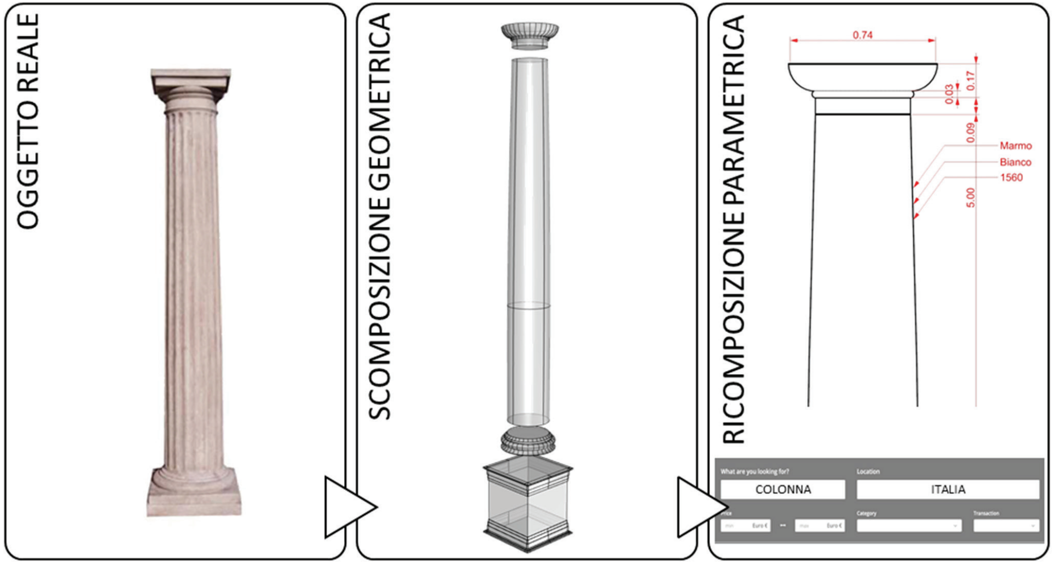

Fig. 19 - Decomposition of the real object in a semantic and hierarchical logic, for a subsequent parametric recomposition.

Fig. 20 - Villa Giulia courtyard: application of bitmap textures from photogrammetry and use of procedural textures where the photographic data is not sufficient to cover the custom parametric object.

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tomized architectural elements. The standard elements were identified among those already present in the architectural modelers, the customized ones were built from scratch or by implementing the standard elements themselves. The semantic analysis applied to the architectural space has been essential to the understanding of the complexity of reality achieved through its adequate simplification. The construction phases of the digital model, from the conceptual one to the parametric objects, have been managed by VPL which has facilitated the introduction in the digital environment of information present in the texts of the treatise writer J. Barozzi. da Vignola. In this scenario, wanting to confront an architecture of the past qualified by rigorous construction processes, the algorithmic modeling has been the cognitive means of that architecture and of the original ideas that generated it. Semantic analysis and custom parametric objects inserted in an implementable library, have identified a expeditious procedure with which to manage the construction phases of a verisimilar and navigable 3D model of a historical architecture (Fig.20). The search introduced can be in fact a way in order to define a database of objects dedicated to the construction of models informed and finalized to the popularization of some Cultural Goods; the database can be enriched in the time and can be used for the construction of historical architectures (Casale et al., 2012). The experimentation is therefore not only the attempt to schematize a set of phases, but above all the tool to ask questions before proceeding with the construction of a verisimilar parametric model.
The BIM software uses a direct modeling that does not make explicit the construction steps of the architectural elements therefore, for a control more inherent to the type of model proposed, it was appropriate to choose the VPL that allowed to list the construction steps of the parts allowing the model to be continuously improved both in formal and informative aspect. In this search for informed model it has meant a model that did not return information of textual and dimensional type, but information of perceptual type useful to the understanding of the form.
If, on the one hand, parametric modeling has solved many problems related to the representation of forms, without sacrificing the right level of verisimilitude with reality, on the other hand, the geometric constructive solutions of the ornate parts require an even more reliable and rapid schematization.
The study did not propose to give a solution to the question but was an attempt to express a logical, fluid path to simplify the construction phases of a model that would maintain the relationship between the object and the representation of its image. In particular, a procedure was identified to build models of buildings with geometric and plastic components that morphologically lend themselves well to deconstruction operations. Therefore, some problems have arisen related to the nature of the design tools used and to the definition of an efficient operational path because aimed at the production of a new numerical model for real-time navigation of the Cultural Heritage.

NOTE

[1] Visual programming language based on icons and graphical objects to develop a program. Its programming context includes icons, symbols, and connes¬sion arrows to represent the input and output of each step. VPL as an explicit modeling method is discussed in Calvano, 2019, pp.15-18.

[2] Data acquired during the photographic acquisition, therefore an unstructured mesh to be verified.

[3] Information Communication Technology.

[4] Process of subdivision of an object; in a numerical model it means the decomposition of the point cloud into homogeneous regions by an initial recognition of simple geometries.

[5] Set of geometric primitives useful for the construction of parametric elements.

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