METHODOLOGIES CAPTURE THREE-DIMENSIONAL HIGH-DEFINITION OF SIXTEENTH WOODEN FRAMES. THE CASE OF WORKS BY CORREGGIO.

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ABSTRACT:

The occasion linked to a large exhibition about the sixteenth century Italian painter **Antonio Allegri** said **Correggio**, has provided the opportunity to make a significant high-definition survey of **some wooden frames made by design of Correggio**.
Two oh these frames are currently preserved at the National Gallery of Parma and cover the painting known as "**Madonna of Scodella**", and the frame for the altar of the **Chapel Del Bono**; the third one, the frame of the "**Nativity**", is placed inside the church of San Prospero in Reggio Emilia.
The primary objective of achieving these **scans high-definition** is to obtain processed important metric on which to carry out subsequent **studies geometric proportional type**, in relation to the dictates of sixteenth-century treaties and to understand the fees and dimensional design used by Correggio to design **these real architecture in small scale.** In all of them, there are the elements that make up the classic architectural orders: studying the **rules for proportioning** and putting them in connection with the dictates of the treaties sixteenth you can assume knowledge of the artist than the architectural world and understand any links with architects or negotiations contemporaries with him. Another important purpose of high-precision is the need to know in detail elements of high artistic value, to a more appropriate cataloguing and preliminary studies related to their **future restoration**.

1. INTRODUCTION

1.1 The wooden frames of Antonio Allegri, known as *Correggio*

It was recently done at Parma a long exhibition dedicated to the work of Sixteenth-century painter Antonio Allegri from Correggio (1489 – 1434 about), one of the leading exponents of Renaissance painting, compared by scholars to genius such as Raphael, Leonardo and Michelangelo.
Among the various works by *Correggio* displayed at the National Gallery of Parma, home of the exhibition, two wooden frames have aroused particular interest: in the first painting, *The rest during the return from Egypt*, known as *Madonna della Scodella* commissioned before October of 1524 by the Pious Union of St. Joseph for his altar in the church of San Sepolcro in Parma, in which it was placed only in 1530, accompanied by dazzling frame planting classical wooden carved by Marcantonio Zucchi.
This painting (218x137 cm), with its frame, was a requirement by the government of Napoleon and transported to Paris in 1796, and only in 1816 it was returned to the city of Parma and placed in the National Gallery in which even today it is exposed, on a continual basis.
The second frame (425x240 cm size external dimensions; 197x152 cm internal dimensions), whose attribution is uncertain but it seems to be a work of a workshop of Parma first quarter of the Sixteenth-century, made of wood carved and painted gold and depicts died Christ in a cyma, while in parastas the Virgin Mary and the Gabriel angel.

Figure 1. Madonna della Scodella (Parma, National Gallery)

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Analyzing this frame interests the decoration of the chapel Del Bono, in the church of San Giovanni Evangelista in Parma, where *Correggio* worked significantly.

Figure 2. Pala del Bono (Parma, National Gallery)

The precious wooden frame is undoubtedly a work of high and complex design, and carpentry and carving.
On a blue alternate reasons elegant embossed gold, which forms ribbons, vases, rosettes, palm trees, eagles, and heads of angels are the result of a workshop on a date certainly ornamental repertoire that combines the ancient ideas with the free invention of classic taste.
At the base of the frame, there are two blazons, with abbreviated initials of Pietro and Placido Del Bono, presumably father and son, respectively, the founder of the chapel notary lived in the Fifteenth century and the developer of the work.
Until the Eighteenth, the frame stood behind the altar between of the two paintings by *Correggio*, one by hand, depicting the *Martyrdom of Four Saints* and *the Lamentation on Christ* and then it went into the church of Pedrignano before entering the National Gallery in 1983.

Figure 3. The Hight (Reggio Emilia, Church of San Prospero)

Nothing attests to the fact that the frame may rise to a given program decorative of *Correggio*, and effectively the product of his workshop, although scholars still debate on the subject, and about date of completion.
The third wooden frame object of analysis is placed in the Chapel Pratonieri the church of San Prospero in Reggio Emilia and it was subject to a restoration ended recently, which led to the identification of engraving the date of gilding on 10 June 1530; the work of implementation have been concluded, however, by 1 June 1530 and started after the conclusion of the contract occurred in 1522.
The painting currently present within the frame work is a copy of Boulanger, while the original of *Correggio*, the paint with the *Adoration of the Shepherds*, named *The Night*, commissioned to *Correggio* in 1522 by Alberto Pratonieri for family chapel, was moved in 1640 in the halls of Palazzo Ducale in Modena, from where it left for Dresden in 1746, where it is still preserved at the Gemäldegalerie.
The reason why these wooden frames have major importance is the testimony of the interest of *Correggio* for architecture, and particularly the architectural treatises and the old, which is manifested mainly in the frame of the *Madonna della Scodella* and in *The Night*.
The study of these precious and special wooden frames has articulated its research on the method of proportioning followed by *Correggio* in the design of the various component parts, in connection with the requirements contained in the main treaties

of architecture and, therefore, in the different elements (ovules, garlands, scrolls, etc.)..
Because of the peculiarities of the size and the shape of the wooden frames, came the need to obtain a study very precise and careful about what we could make any subsequent operation of graphics and proportional analysis.
To meet this need they have been made any surveys of shapes and dimensions using high-definition equipment and different technologies for the two frames stored at the National Gallery of Parma and for the one kept in the church of San Prospero in Reggio Emilia.
These studies, conducted by professors Paolo Giandebiaggi, Chiara Vernizzi and Andrea Ghiretti from the Department of Civil Engineering Environment, Territory and Architecture of the University of Parma, have as their objective the creation of a digital data bank aimed to study the morphological and proportional wooden frames, through the' application of new technologies related to high-tech mechanical and to Reverse Engineering that starting from morphological and metric data of a physical element to achieve a 3D model which is the starting point for further processing.
Highly effective and interest it is especially the application of a series of advanced technologies, previously used in other areas, including the study of the Italian artistic heritage and, above all, of unique items such as wooden frames made and designed by *Correggio*.

2. THE SURVEY

2.1 The survey of *Madonna della Scodella* and of Del Bono Chapel frames

The on-site surveys of wooden frames kept at the National Gallery of Parma were made through the technology of Reverse Engineering, because it helps to generate a file that describes three-dimensional objects scanned in any detail. Starting from this type of file we can make a virtual object found in volume and size and we can generate from the model, various views and sections, but also perform comparisons between different files of the same object measurements obtained from one another apart in time, useful in monitoring the state of conservation of the cultural object of study.

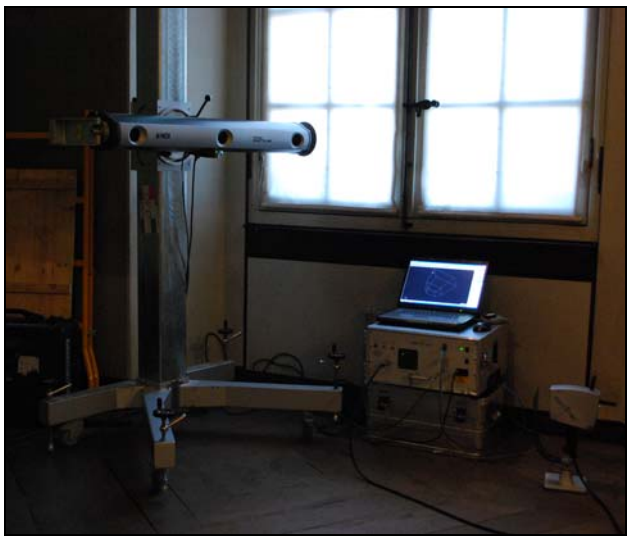
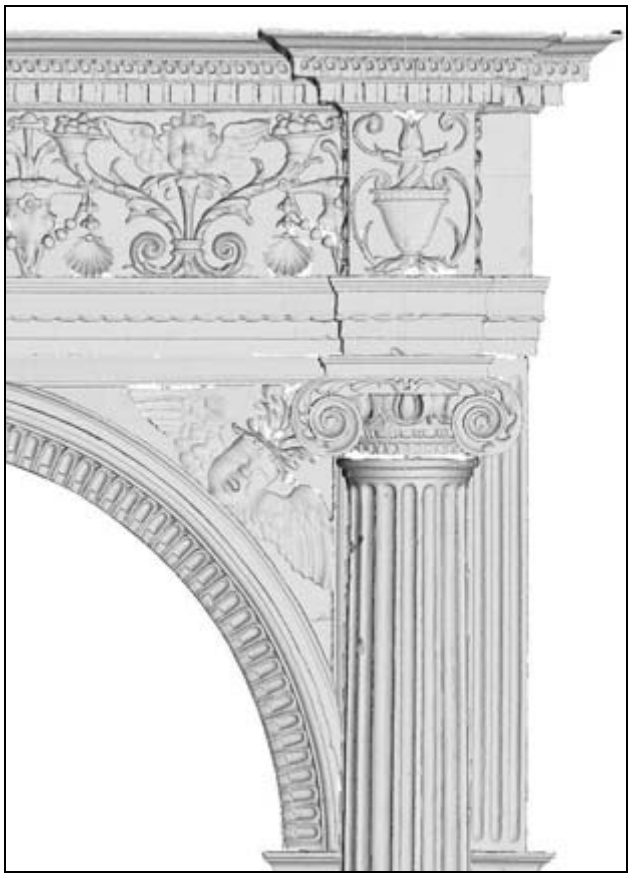


Figure 4. Components of the optical system 3D T-Scan



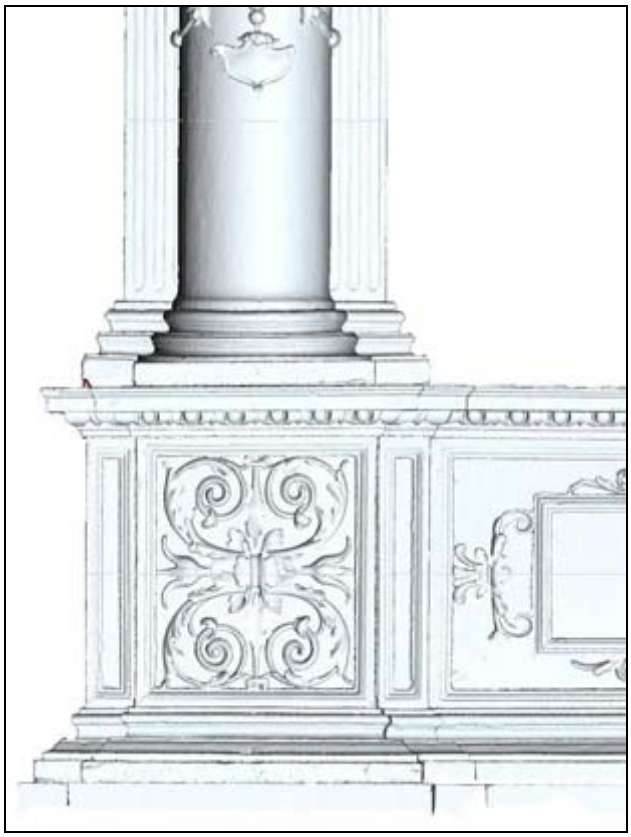
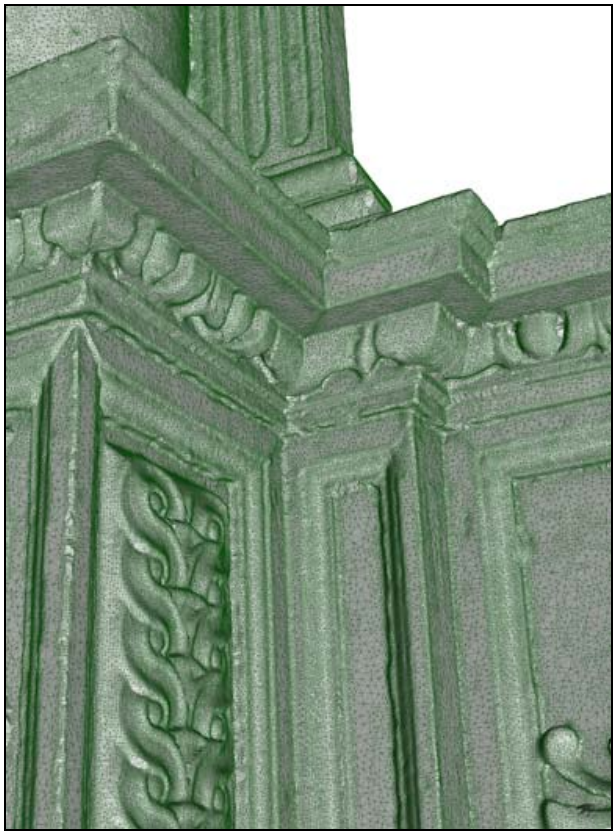


Figure 5 – 6. Details of STL files generated from point cloud surveyed on the frame of *Madonna della Scodella*

From this type of file we can also create, through technologies of Rapid Prototyping, copies of the model, the true scale or reduced, but also create virtual galleries in which the objects and their details are displayed three-dimensionally, we can navigate through rotations, zoom and panoramic views.
The surveys and the graphic elaboration of the frames of the National Gallery of Parma have been made thanks to the collaboration with the CRP Technology srl of Modena, the Italian leader for over thirty years in the field of Race Engineering, Rapid Prototyping and Rapid Manufacturing, through coordination by the engineer. Livia Cevolini, and operators ing. Mauro Giordani and Eng. Andrea Pasqualetto.
To scan both frames it has benne used the optical system "Steibichler T-SCAN", comprised of a laser gun, an optical drive Optotrack infrared light, a portable work station for data management, a controller for the transfer Data acquired and the software Polyworks 3D 9.0 for the total management of the data until the last file in STL format.
This system can detect objects of medium-large due to the volume of measurement equal to about 20 cubic meters; this volume is determined by space framed by an optical infrared cameras.
In this volume you can move without any physical constraint, with a "gun" supported by the laser whose position is detected by the device drive.
All digitized points are aligned within a reference system by eliminating the need to conduct operations to bring various clouds of points gained through other software.
The measure of the intensity of the reflection of the laser on the surface of objects being digitization, and the resulting self-power laser is performed automatically by the software acquisition Polyworks 3D.
This avoids special treatment of surface preparation, even if the elements are highly reflective or dark. These treatments, however, normally used in the purchase of models of industrial design, are obviously not possible in the context of cultural heritage.
The frames subject of the present survey, pale gold and dark blue, have a surface that would create problems in many other optical scanning systems.
Since this is a type of laser class 2, no type of measure is needed to operate this equipment, nor are they required personal protective equipment for the operator or other persons assisting the survey.
The dim light in this room of the National Gallery of Parma, was an ideal environment for the use of optical scanners. One observation made in full daylight would have been, in fact, the more difficult because of the lack of contrast between the band scan projected on the surrounding environment.
Inside the museum, the only difficulties have been generated by the light of the spotlights focused lighting that disturbed the communication between the gun and the infrared tracker, for this reason, during the scan has been modified orientation.
The vision in real time on the monitor of points obtained, allows the operator to verify what is captured at the same time as you work.
This allows immediate control to correct any errors and complete any missing areas, so as to change the density of the points where appropriate.
It is possible, when the data acquisition is coming, to set in software during the scanning, a scale of values on the density of points allowing you to change the speed of acquisition of the points, so as to increase and decrease according to the morphological characteristics of surface, optimizing, already under significant, the size of the files collected.



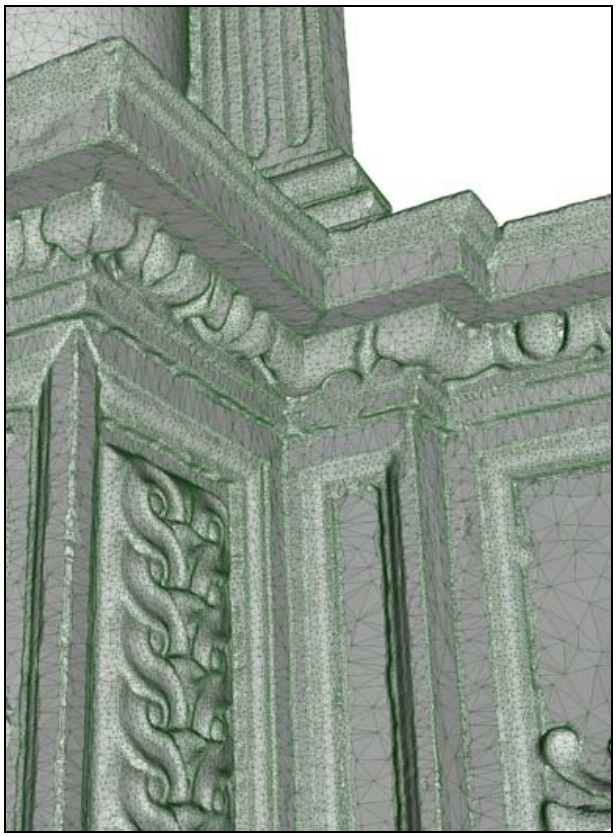


Figure 7 – 8. Top: the file with a tolerance of 0.02 mm. Bottom: the file “lightened”, with tolerance of 0.2 mm.

Figure 9 – 10. Perspective view of the STL file. Top: Madonna della Scodella. Bottom: Pala Del Bono.

Within the volume of measurement you have, at worst, accuracy equal to 0.1 mm.
The result of the scan consists of a cloud of points in space that describes the visible surface of the object.
The system offers the possibility of adjusting the density of the acquisition from 0.1 mm to 10 mm, making it possible to fit the speed of acquiring, adapting to the geometry and dimensions of the object and the amount of information needed.
The survey operations were carried out during normal business hours to the National Gallery, and the acquisition process in any way obstruct the visit of the frames, despite the presence of a small scaffolding, set up to reach the highest points of the frames.
The scan requires that the laser gun to operate at about 80 mm from the surface to survey, so it was essential to get in close proximity to all parties and easily put the cover of the gun and the laser tracker.
To scan all visible surfaces of the two frames were needed about 30 hours working on divided into three days.
Some of these were used for the development of the scanning system in the proximity of the frames and for the movement of all devices in the elevation (two different scales, in addition to the small scaffolding).
The presence of at least two technicians on the ground was necessary in order to check in real time the quality and completeness of the data collected and to be able to switch two different "hands" in the use of the laser gun.
The size of the laser gun and positioning "wall" of the two frames prevented the survey of some small details in shadow, but these small shortcomings were irrelevant for the purposes of this study.
The three-dimensional point cloud, with density scan shares to 0.75 mm, thus obtained and that describes the visible surface of the object was post-processed to obtain three-dimensional optimized file and eased through the use of all appropriate filters 's use of software dedicated to Reverse Engineering.
The different clouds of points, corresponding to different scanning sessions were aligned in the same reference system, then, points recorded several times, during the scan, were eliminated.
The file format is the standard mesh STL (a file that plays the 3D scanned area through a series of small irregular triangles). Each of the two surveys has been transformed with a tolerance of 0.02 mm, in a STL high resolution file.
From this file other files lightened were, then, created, with tolerance of 0.2 mm, making the phases of three-dimensional study on the PC easier in terms of graphics and memory management.
In this file has obtained a three-dimensional model that allowed to extract, with a high degree of accuracy, all measures of the frames.
The level of detail of the survey is able to view, and possibly quantify, small damage over time, as small holes due to aggression of woodworm and areas in which the frieze is incomplete.
Starting from a representation in the prospectus, on a scale of 1:20, of the two wooden frames, we tried to understand the proportioning of the parts and then the compositional rule followed by *Correggio*, as described below.

2.2 The survey of the *Night* frame

The scan of the frame named *The Night* was performed using a different survey equipment, more suited to the measurement of scale architectural elements that do not detail.
The survey and the graphic elaboration were made in

collaboration with architect Lorenzo Pio Massimo Martini of the University Mediterranean of Reggio Calabria, using a system Leika HDS Scan Station 2, a time of flight laser scanner, that led to the establishment of a three-dimensional point cloud outcome of the continuous survey.

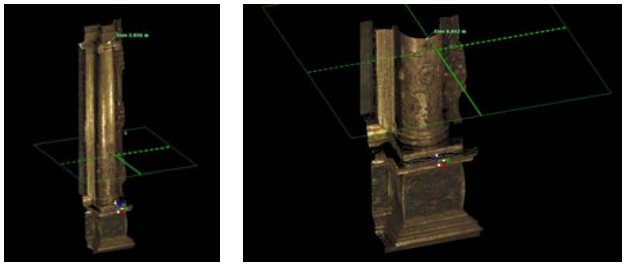


Figure 11 – 12. The Night. Point cloud of the column.

For the survey of the frame it was made only one station, placing the instrument at the center of the frame, for a height of about 1.72 m, which led to a survey with a projection center for man's height, with minimal shadows.
It was performed only one scan with a pitch of 2 mmq, with a radius (probe) of 4.5 meters and sent a cloud of about 13 million points (13613272).

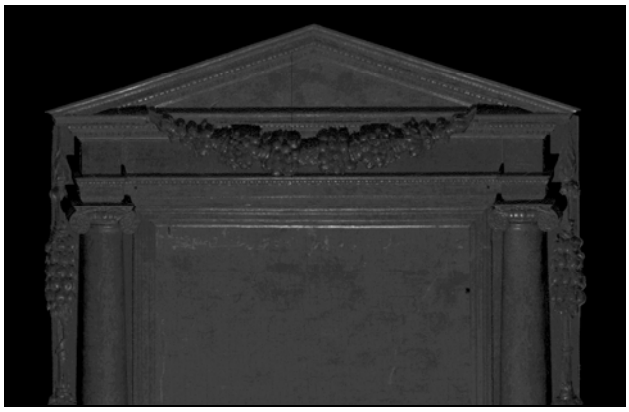


Figure 13. The Night. Detail of 3D point cloud model.

The control and processing software used is Cyclone in version 6.0.
The different transverse and longitudinal sections made on the cloud of points obtained, but especially in the prospectus in 1:20 scale have allowed the graphical analysis on the frame. It was also carried out a virtual re-painting dall'Allegri, the *Adoration of the Shepherds*, now kept at the Gemäldegalerie in Dresden, in order to complete the reading of the frame. The scanning system used for *The Night*, certainly more appropriate to the scale architectural significance (representation in scale 1:50) which is not the scale of detail (1:20, as in this case) was more appropriate because of the place of the frame inside the chapel Pratonieri of the Church of San Prospero, which is not allowed to get closer to the frame as it would be necessary with the optical system "Steibichler T-SCAN."
The ability to do the scans by a less close than the location of the frame has led to the choice of instrumentation and of a different technology, to check specific peculiarities of the two instruments, through the identification of methodologies better suited to high-definition survey, content elements dimensionally but also formally very complex, to reach final processing for making a series of subsequent studies ranging from graphic-proportional items, to the assessment of the state of conservation of the objects found.

Figure 14. Perspective view of 3D point cloud model.

3. THE GEOMETRIC-PROPORTIONAL STUDY

3.1 The *Madonna della Scodella* frame

The original frame, which was supposed to have been executed on design by *Correggio*, bears the inscription: DIVO IOSEPPO DEIPARAE VIRGINIS CUSTODI / FIDISS COELITUSQ DESTINATO HVIVSCE / ARAE COMUNI AERE ERECTORES DEVOTI / ALACRESQ EREXERE / DIE II IVNII.
Giorgio Vasari talks about it in the second edition of *Lifes*, talking about Girolamo da Carpi, which was studied in the Church of San Sepolcro: as said before, the painting remained there until 1796, when it was requisitioned by the government of Napoleon and transported to Paris, from where it was returned in 1815 after the defeat of Napoleon at Waterloo, and it was placed in the National Gallery of Parma.
In 1893, on a proposal by Corrado Ricci, it was reinserted into the original frame.
For the realization of the painting it is commonly proposal dated 1529-1530: Cecil Gould believes that only angels at the top of the canvas have been executed in these years and for the

bottom of the paint, however, have been executed in the middle of the third decade of the XVI century (Adorni, 2008).
Starting from a representation in the prospectus of the frame in scale 1:20, we searched the proportioning of the parties and the composition rule followed by *Correggio*. The criteria for proportioning the classical orders used by the treaty of the Sixteenth century, to follow the procedure for dividing the subsequent partitions.
Starting from the form, usually the diameter of the column measured at the bottom (ie the extreme bottom of the barrel of the column) (Docci, 2002), taken as the unit of measurement, you could size through proceedings exquisitely graphics, all elements, up to several minutes.

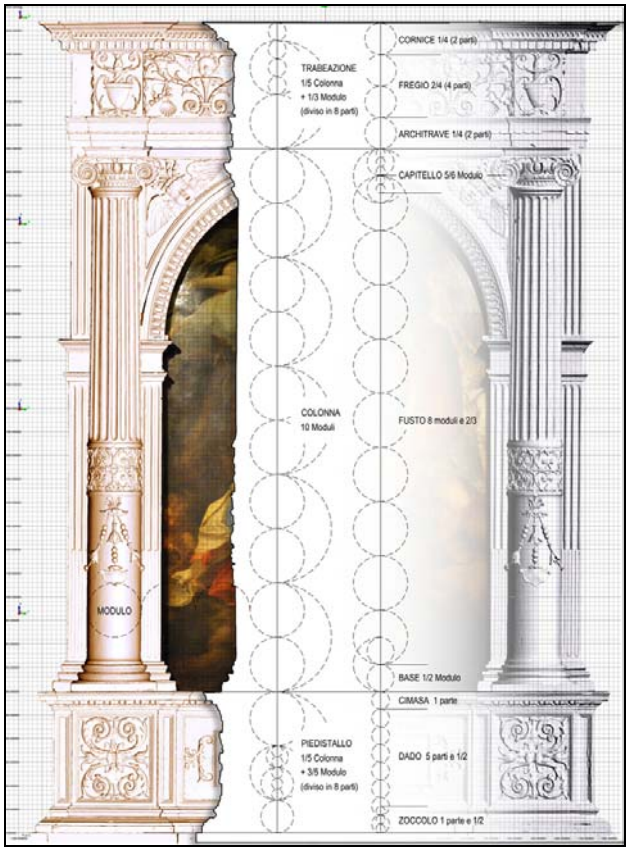


Figure 15. Madonna della Scodella. Graphical analysis.

This method, when applied to the ionic column of the frame, has made it possible to read the compositive rules and then compare them with those dictated by the Treaties (mainly Fra Giocondo and Cesariano) which are considered to be known by *Correggio*. In particular, the column is of 10 modules, which is higher of two modules compared to Serlio criteria, who is 8 modules precisely and ¾ module compared to the ionic one on pedestal of Vignola module, which is 9 1/4 (18 1/2 for Vignola, who considers that the form equal to the radius of the column).
Compared to Jonic style of the board of architectural orders to folio LXIII of Vitruvio of Cesariano, it is higher by about one form, being that of about nine modules.
The ionic style described by Fra Giocondo (1511) varies depending on the engravings by about 8 ½ to 9 modules, then the column of the frame is still higher than at least 1 module. The entablature of this frame is much higher than that of table folio LX front of Cesariano, and Serlio (1537) and Vignola. While the pedestal are the lower than both.
The comparison is not possible with Fra Giocondo and Cesariano.

3.2 The *Night* frame

The graphical analysis carried out on the representation by prospectus of *The Night* frame, in order to identify the proportioning of the parties and the rule of composition design was carried out by successive parts division, on the cloud of points obtained from the continuous survey.
As module for the graphical analysis it was used the half diameter of the column.
The system was divided in its three constituent elements of entablature, column and pedestal.

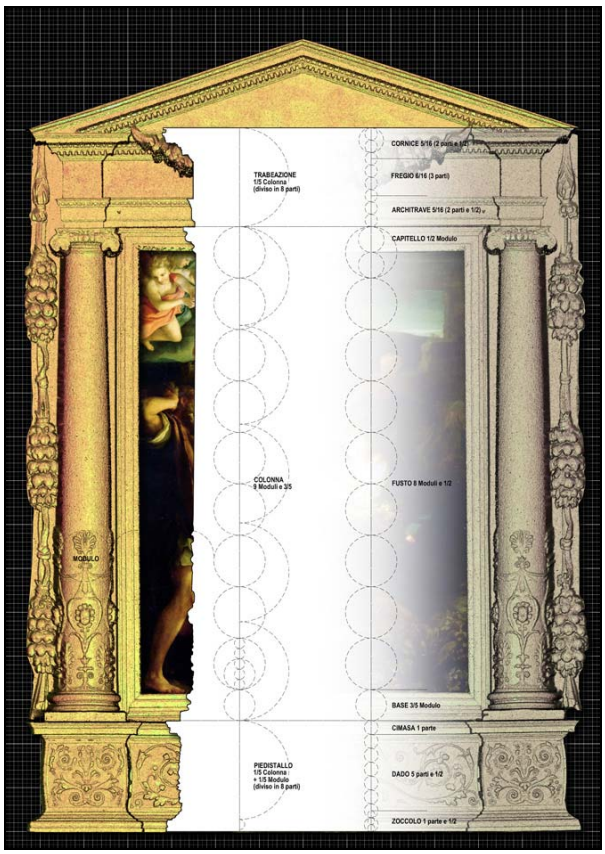


Figure 16. The Night. Graphical analysis.

The pedestal is high 1/5 of column and 1/5 of form; the column is high 9 modules and 3/5 (very close to the proportion, who preferred Vitruvio, to 9 1/2) while trabeation measure 1/5 of the column.
In particular, the pedestal is divided into 8 parts, divided among components.
The column is decomposable into several components: the base height of 3/5 module; the stem, high 8 ½ modules; the capital, a height equal to half of the module.
Finally, the entablature, is also split into several parts that are so dimensioned: lintel, with a height of 5/16 module (2 shares and 1/2); frieze height equal to 6 /16 form (3 shares) and the frame, high 5/16 modulo (still 2 ½ parts).
The comparison between the height of half column of *The Night* and of those of the *Madonna della Scodella* frame shows that the first one is about half module shorter than the second one.

4. CONCLUSIONS

The experiences of survey described above allow you to make some reflections on the tools and technologies most suitable for high resolution measurements of three-dimensional objects smaller than the architectural scale but, at the same time, bigger than a design object, for which it is necessary identify the most appropriate method in relation to both dimensional and shape aspects and at their location.

As in case of architecture, in fact, the wooden frame were not transported from the place of exposure, so it was necessary to approach them with the most suitable for the performance of a major three-dimensional high resolution, whose graphic representation, precisely through 3D models size, was adequate to restitution scale departing from 1: 20 and may reach up to 1:1 scale.

It is immediately evident the great difference between the final three-dimensional graphic achieved, especially in relation to the more minutes details.

It should be noted that the graphic representations of the surveys made with the instrumentation "Steibichler T-SCAN" are results of a re-engineering that led to the creation of a triangular mesh model, starting from point cloud produced by the scans, while the cloud of points obtained by the survey made by the laser scanner Leika HDS Scan Station 2 has not undergone the same treatment, because it is limited to smoothing operations performed on the cloud of points, without going to the next stage of definition of the 3D model mesh.

This is because this step would lead to an excessive approximation of the 3D model obtained to the detriment of the necessary resolution on the particular shape of the detected frame.

The graphical elaborations of the frames of *Madonna della Scodella* and of Del Bono pale, from the National Gallery of Parma, present themselves as the most appropriate outcome for the representation of elements such as these large frames, also in order to constitute a kind of database on the preservation conditions, to be monitored over time, but especially for the opportunity to obtain scans with details on the tenth of a millimetre, which are obviously three-dimensional models of the same detail.

Objects such as wooden frames, dating from the Sixteenth century, of great sensitivity to the material used and aged, made with skilled craftsmanship and with a number of details of great value, certainly require the identification of an appropriate instrument to measure and represent any minimum dimensional and shape feature that defines and thus making it unique.

Great potential is has also the possibility, related to the definition of the STL file format, to make physical copies through the three-dimensional printing (Rapid Prototyping) in the true or reduced scale of the analyzed items or individual components, in order to proceed with the establishment of missing pieces in any operations of restoration or replacement.

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