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

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Abstract

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

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

Introduction

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

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

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

From drawing to measure

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

Inductive observations

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

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

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

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

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

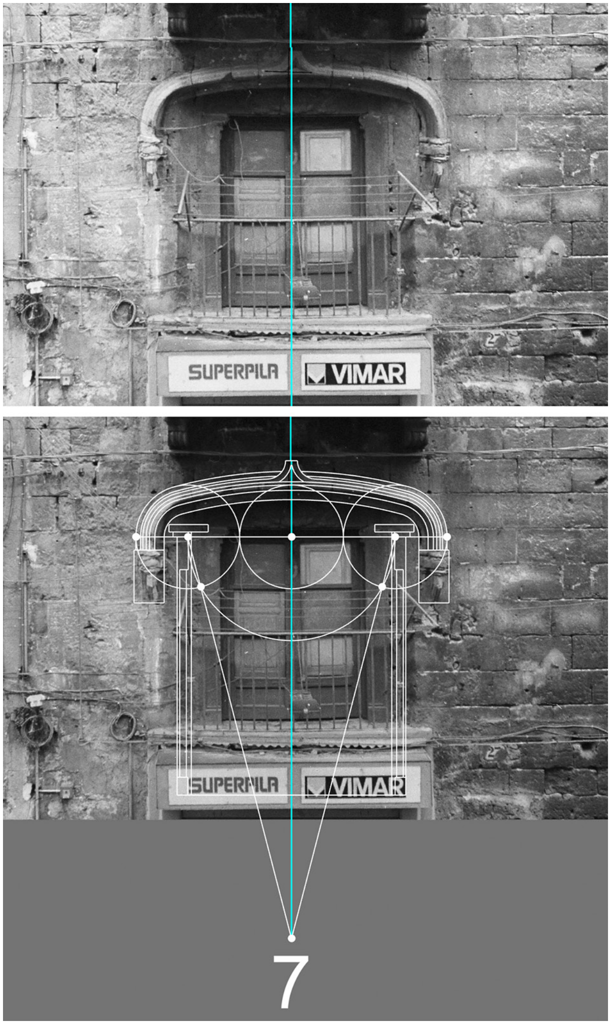
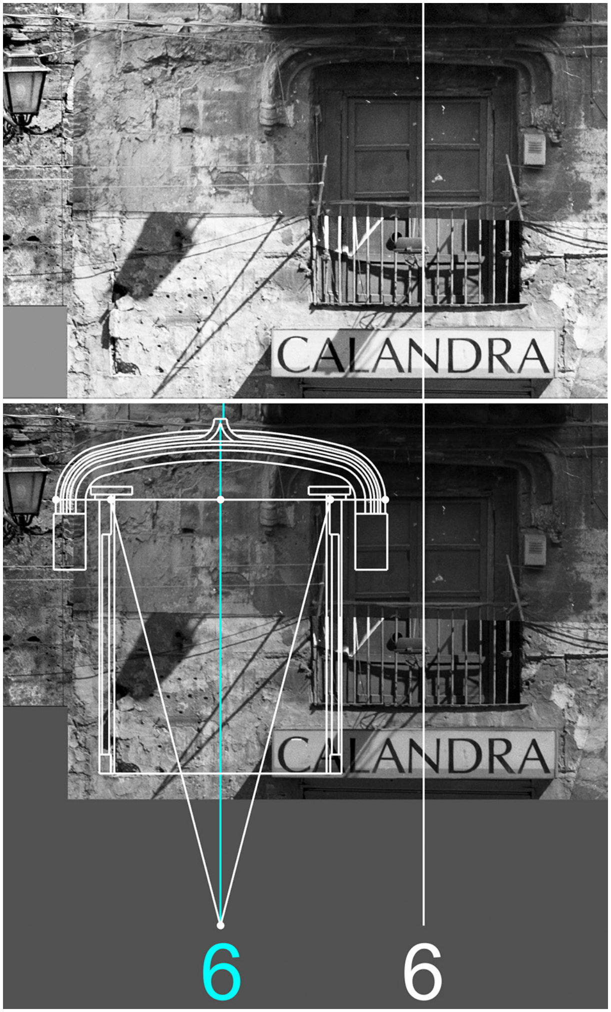
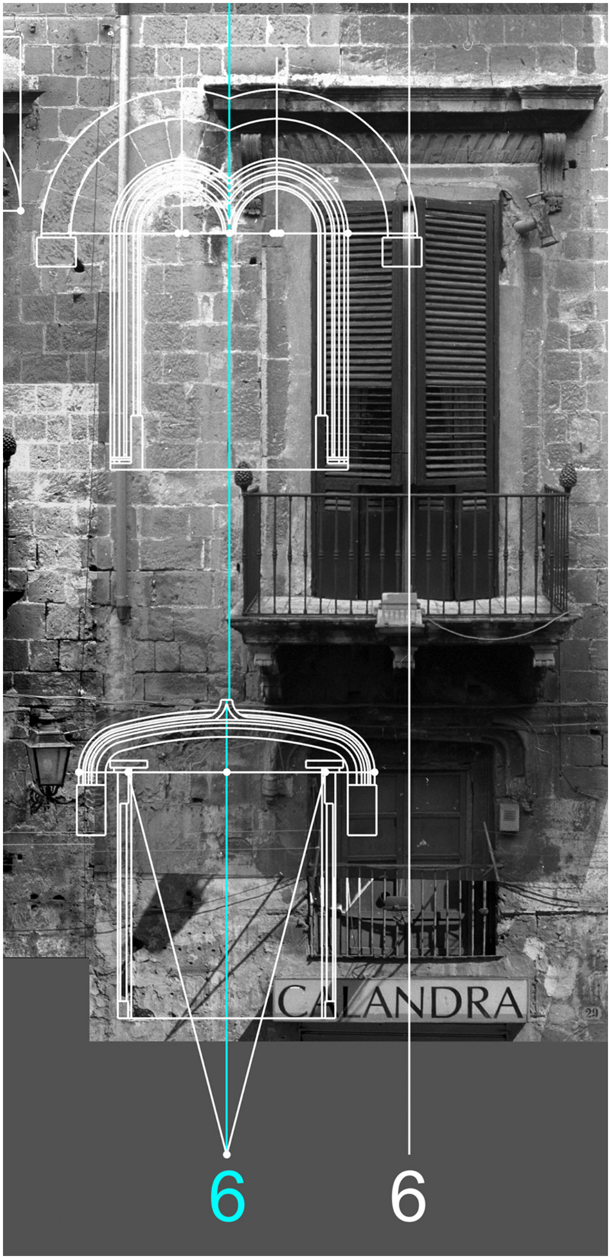


Fig. 4. Reconstruction of the mezzanine window 6.

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





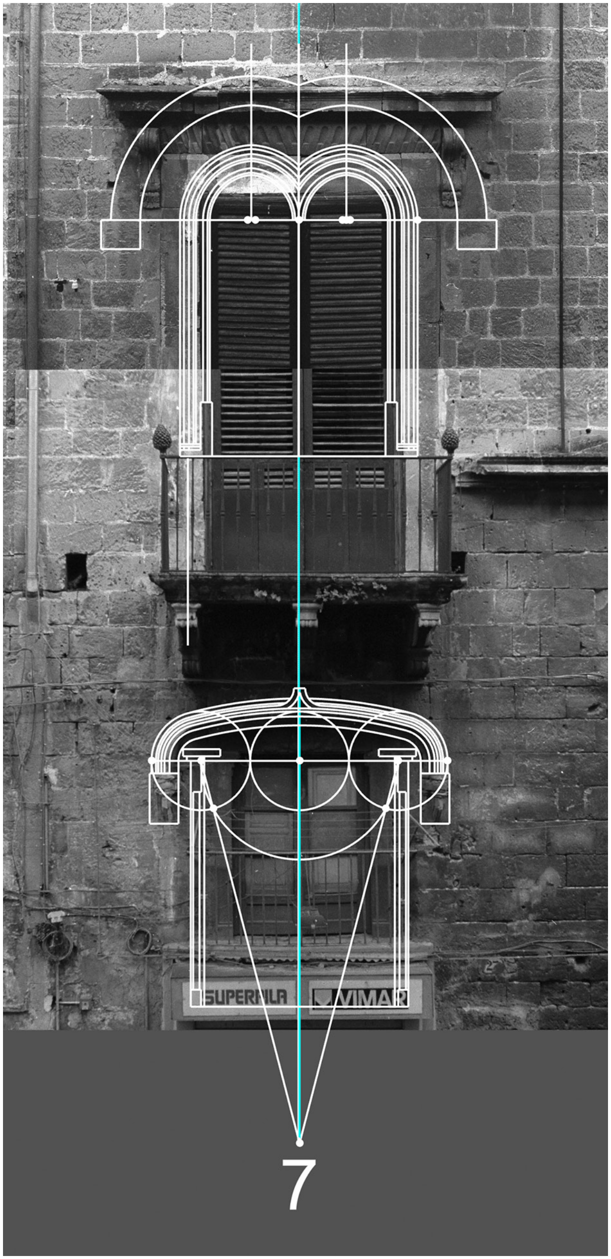


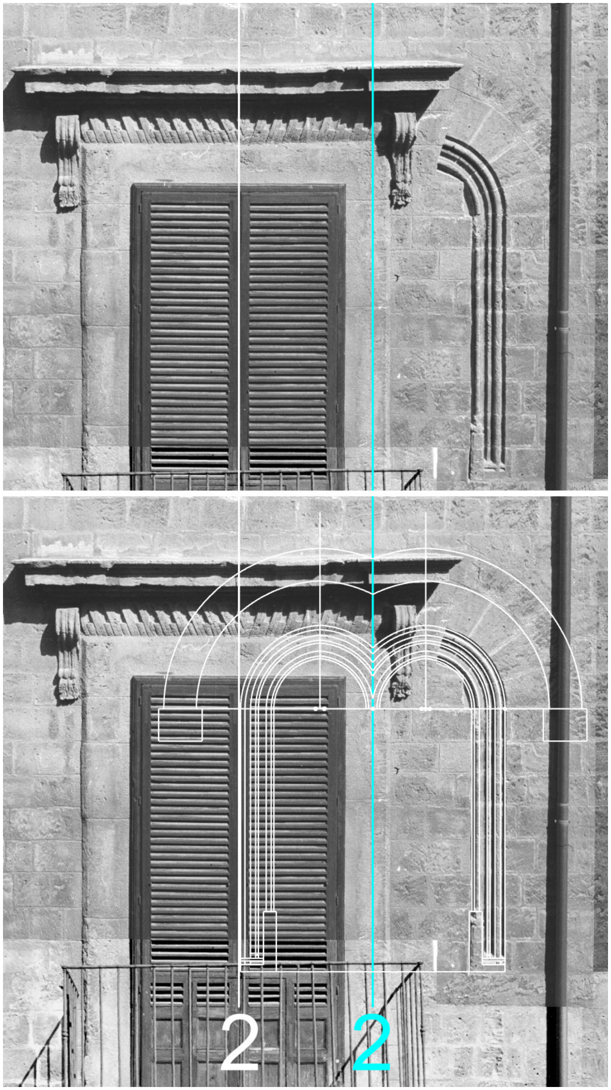
Fig. 6. Drawing of window 7 at the mezzanine and at the piano nobile.

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

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

Fig. 8. Drawing of the mezzanine window 2.

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



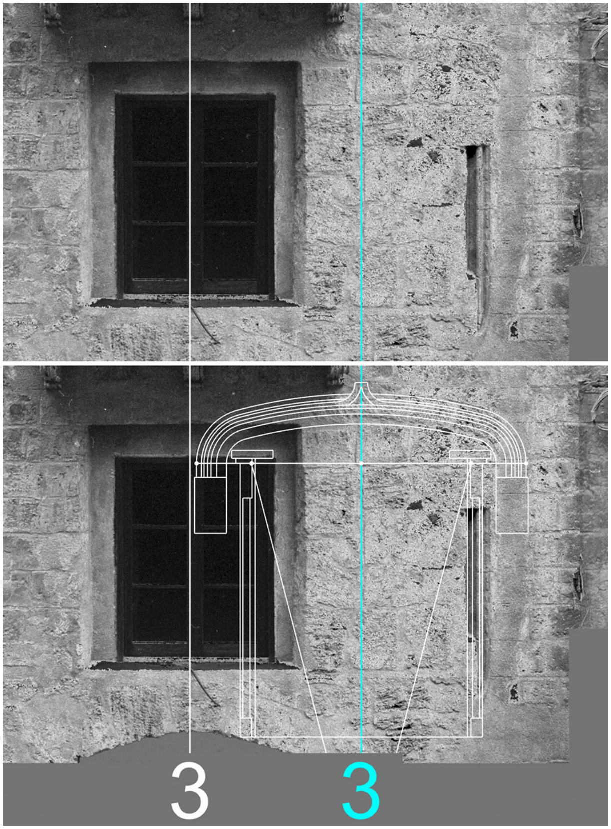


Fig. 9. Drawing of the double-arched window 2 at the piano nobile.

Fig. 10. Drawing of mezzanine window 3.

between windows 4 and 5, is greater than the 16 palms distance between windows 3 and 4.

The arrangement of windows at the mezzanine and at the *piano nobile* does not match the layout of the seven single-arched windows at the attic, framed by a three-centered cornice.

New openings with balconies replaced attic windows 1, 2 and 3, but clearly visible traces supported their reconstruction; windows 4 and 5 seem unchanged; windows 6 and 7 have been extended downwards.

The spacing of attic windows is almost regular and amounts to about 22 palms, double the 11 palms width of the three-arched cornice that frames the windows; the 24 palms distance between windows 4 e 5 is slightly greater.

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

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

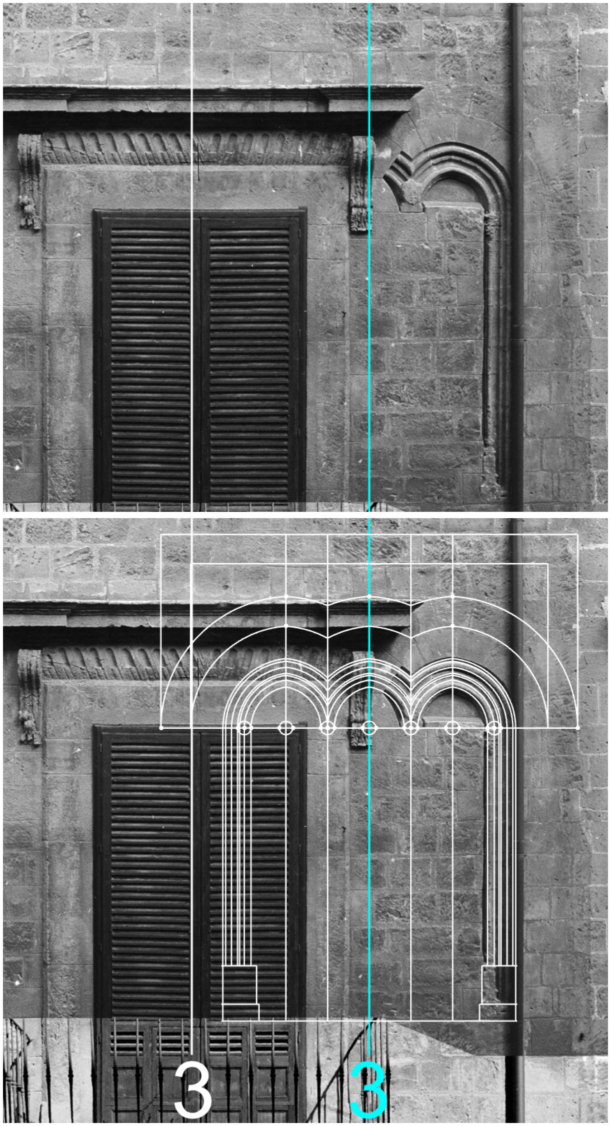
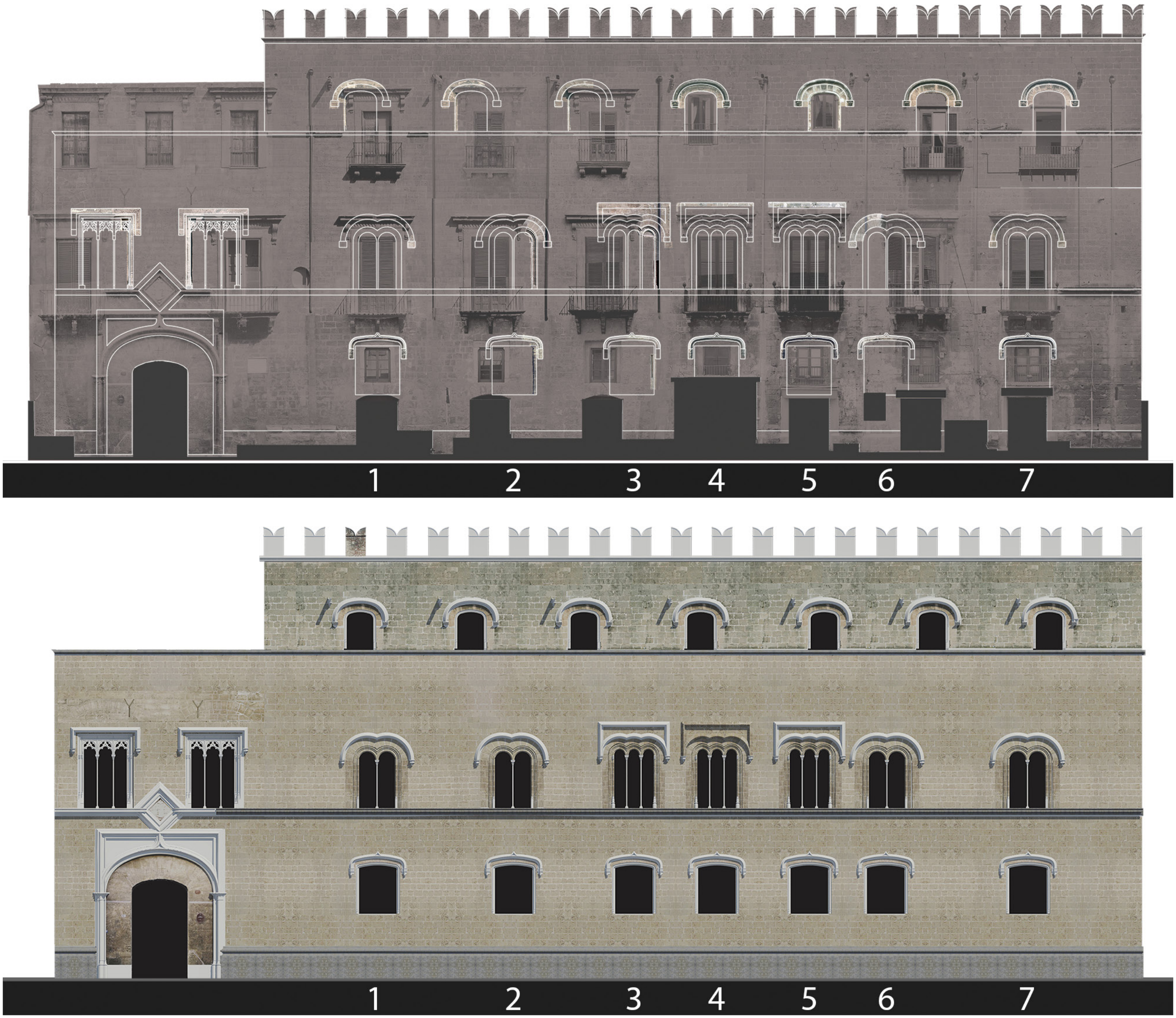


Fig. 12. Reconstruction of Matteo Carnilivari's design.



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

Conclusions

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

Notes

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

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

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

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

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

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