LE RAGIONI DEL DISEGNO
THE REASONS OF DRAWING
Pensiero, Forma e Modello nella Gestione della Complessità
Thought, Shape and Model in the Complexity Management

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A CURA DI
STEFANO BERTOCCI
MARCO BINI

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The tree of life in the southern porch of the Cathedral of Palermo: survey and geometric analysis

Fabrizio Aguella*, Mirco Cannella*

This study focuses one of the most puzzling works of art made in Palermo at the end of the medieval age: The Tree of Life, a rich geometrical decoration with animal and human figures in the southern porch of the Cathedral of Palermo. Topographic and SfM photogrammetric methods produced a detailed orthophoto of the porch. Images collected during restoration have been rectified and superimposed to the orthophoto. The geometrical analysis of the decorative patterns reveals a complex design and meaningful links between the decoration and the general architectural layout of the portico.

Keywords: Medieval geometric patterns; Tree of life; Cathedral of Palermo; Digital surveying and representation.

The renovation of the Cathedral of Palermo in the XV century
The foundation of the Cathedral of Palermo dates back to the first Norman kingdom in Sicily (XII century). The Norman cathedral took the place of a mosque that was built during the Arab domination (IX-XII century), on the site of an older Byzantine church. The main front of the Cathedral faced a medium-sized street westward, according to the usual orientation of Christian churches; the northern and southern fronts faced two narrow streets. The church was not distant from the main axis of the historic center of Palermo, the so-called Cassaro.

In the XV century, when Sicily was subdued to the Spanish crown of Aragon, King Alfonso promoted a great urban transformation, to provide the Cathedral with a wide-open area for religious and popular celebrations. The buildings, which filled the area stretching from the southern front of the Cathedral to the Cassaro, were demolished and the new wide area, named il Piano, was paved. The new urban space literally changed the orientation of the Cathedral and the southern front became the new façade of the church. This occurrence demanded an architectural and decorative renovation; the most relevant episode in such renovation program was the construction of a porch leading to a richly decorated portal, which became the new entrance gate. Antonio Gambara, who led the corporation of craftsmen of the Cathedral in the third decade of the XV century, was appointed to the realization of both works.

The tree of life in the southern porch of the Cathedral
Three pointed arches, leading to the entrance portal, feature the front of the porch; the central arch is oversized. A frieze and a tympanum, richly decorated with carvings echoing gothic flamboyant decorations, make the upper end of the porch. Two small towers, whose elevation slightly overcomes the level of the frieze, flank the porch (fig. 1).

The flat area almost 18 meters long and delimited by the lower edge of the frieze and the cornices of arches, appeared blank until 1982, when restoration works removed the secular dust and revealed a rich geometric pattern populated by animals and human figures. The co-presence of rich geometric interfaces, and of human/zoomorphic figures, suggested identifying this decoration as a tree of life. Two pinnacles, aligned with the vertical axes of the inner columns of the porch, divide the tree of life into three sections: left and right sections are congruent, whereas the central section is wider but narrower at the top, due to the oversize of the arch.

The re-discovery of the decorated strip gave impulse to new studies, which mainly focused on the symbolic references of zoomorphic and human figures; up to now, no specific study has addressed the geometric interpretation of the decoration.

The geometric figures are made of interlacing tapes, delimited by thin and precise grooves, carved in the limestone blocks. The geometric tapes and the figures are not colored, whereas the background was painted blue, to make drawings more prominent. Red spots highlight specific parts of the figures.

A preliminary exam of the geometric interfaces reveals that a sequence of circles, named Girali, structures the decorated strip. The Girali are perfectly tangent to each other and to the delimiting lines of each section.

The size of Girali varies in order to fit the available area; what appears evident is the intention to cover with decoration the entire area of each section, according to the attitude, named horror vacui, which characterizes most decorative patterns in medieval art. The decorative patterns in the tree of life echo traceries from late medieval Spanish art.

The survey
The prerequisite in geometric analysis of works of art is the accurate documentation of their actual size and form. With reference to the subject of this study, a mosaic of rectified images could be a proper solution; nonetheless we reputed that geometric analysis of the decorated strip should be extended to the entire porch, in order to check eventual connections with the decorations in the tympanum and with the layout of the front.

The first step addressed therefore the creation of an orthophoto of the front of the porch (fig. 2). Photos were taken from the ground with a reflex full frame camera equipped with 28mm, 50mm and 135mm calibrated lenses. The photogrammetric model was oriented and scaled with control points that were measured with topographic methods.

The decoration is today badly preserved; many tapes and most figures appear dimmer than in 1982. Luckily, a rich photographic documentation of the tree of life was acquired during the restoration...
campaign. Control points measured on the orthophoto allowed to rectify these images (fig. 3); finally, registered rectified images were superimposed to the orthophoto with an accurate referencing (fig. 4).

**Geometric analysis**

The first step in geometric analysis addresses the geometry of the pointed arches. Simple geometric constructions show that the segments of circle composing the pointed arch center on points that are symmetrical with respect to the vertical axis of symmetry of the arch; the distance between the centers equals the fifth part of the arch’s span.

The distance $m$ between the vertical axes of the arches equals the span of the central arch; a horizontal line, whose distance from the upper edge of the decorated strip is $m$, aligns the capitals of columns and the cornice at the base of the second level in the small towers flanking the porch. Three red circles, with radius $m$, center on the points where the vertical axes of symmetry of arches intersect such horizontal line.

The right and left circles are tangent to the external vertical edges of the small towers; the length of the porch therefore equals $4m$. A further magenta circle with radius $2m$, centered on the middle point of the baseline, meets the vertical axis of symmetry of the porch at the higher vertex of the tympanum. Such circle passes through the vertices of the base of the inner triangle of the tympanum as well (fig. 5).

A common feature in the three sections of the decorated strip is the presence of great circles placed in the upper corners of each section. Such circles are tangent to: a) the upper horizontal edge of the decorated strip; b) the vertical lines delimiting the sections; c) the profile of the arch. The craftsman had therefore to face one of the problems that Apollonius solved in his treatise on tangencies:

- the construction of a circle that is tangent to two straight lines and to a further circle.\(^4\)

Apollonius’ solution has been tested on the left circle in the left section; the construction is explained in five steps (fig. 6):

Step 1: the straight lines are red colored; $C$ is the center of the magenta circle whose radius is $r$; Step 2: two blue lines are the offset of red lines at a distance $r$; Step 3: a cyan circle, centered on $C$, is wide enough to intersect blue lines in points $P_1$, $P_2$, $Q_1$ and $Q_2$; two further circles, orange colored, are drawn: the circle through points $P_1$, $P_2$ and $C$ is named $p_c$; its center is $C_p$ and its radius is $r_p$; the circle through points $Q_1$, $Q_2$ and $C$ is named $q_c$; its center is $C_q$ and its radius is $r_q$; Step 4: this step addresses the construction of the straight lines which are tangent to both orange circles; the minor circle $q$ is temporarily reduced to zero, that is to the point $C_q$; the bigger circle $p$ is reduced to a concentric green colored circle whose radius is calculated as the difference $r_p-r_q$; the tangents from $C_q$ to the green colored circle are traced; the radii from $C_p$ to the tangency points are thus determined; the point where such radii intersect the circle $p$ are named $T_p$; the tangential lines are copied to the points $T_p$; such lines, named $t$, are tangent to both orange circles.

Step 5: $A_1$ and $A_2$ are the points where one of the lines $t$ intersects the cyan circle; the black colored circle at through points $A_1$, $A_2$ and $C$ is traced. The center of circle $a$ is $C_a$. The circle centered in $C_a$, having a radius equal to $r_a$, is the circle tangent to the arch and to the red lines.

Each Girale circumscribes a different geometric pattern, whose orientation appears random: the Girale placed on the upper right end of the left section, which echoes models from northern Europe,\(^1\) shows

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no horizontal or vertical reference line. Such occurrence suggested a closer look at the decoration in the tympanum, whose traceries show similar puzzling features.

With reference to the left section, graphic analysis shows that the centers of the Girali placed in the upper corners are not horizontally aligned, nor symmetric with respect to the axis of symmetry of the arch (fig. 7); a white circle, concentric to the circle with radius $m$, passes through these centers. Such white circle provides therefore an effective solution to the questions posed by the puzzling features in decoration. The white circles pass through the centers of the intermediate Girali as well. Furthermore, the radial lines through the centers of Girali are the axes of symmetry of their inner decorations (fig. 8).

With reference to the decorative tracery in the tympanum, graphic analysis has revealed that the axis of symmetry of some traceries are aligned with magenta straight lines passing through the lower endpoint of the vertical diameter of the magenta circle with radius $2m$.

The last step in geometric analysis focuses the Girali in the upper corners of the left section. A hexagonal geometry structures the inner decoration of the Girale placed in the upper left corner (fig. 9). The intersection points of the diagonals of the blue hexagon inscribed in the Girale, are the vertexes of the dual green hexagon. Eighteen arcs of circle, whose diameter equals the diagonal of the dual hexagon, depict six petals. Green circles, which center on the vertexes of the green hexagon, make the two of a petal that are symmetrically arranged about the diagonals of the blue hexagon. Blue circles, centering on the vertexes of the blue hexagon, make the third part of the petal. Each petal frames three equal circles centered on the bisectrix lines of the equilateral triangle inscribed in the petal.

The inner decoration of the Girale placed in the upper right corner features three squares 45° rotated and inscribed to each other, according to a widely diffuse scheme in decorative patterns in ancient and medieval art (fig. 10). With reference to the Girale,
a black square (circumscribing the circle) and two 45° rotated squares (blue and green), are drawn. The lines passing through the vertexes of the black square and through the points where blue and green squares intersect, meet the diagonals of the green squares thus detecting the centers of the magenta circles. Such circles are tangent to the Girale.

**Conclusions**
The study evidences the skills in geometry of craftsmen working on the renovation of the southern porch of the Cathedral of Palermo in late Medieval age. The geometric analysis of elements that seemed puzzling revealed a very sophisticated framework, involving both decoration and architectural layout. Further inquiries will focus the analysis of the entire group of Girali in the tree of life and interdisciplinary scholarships will be involved to highlight probable links between geometric and symbolic features. The method discussed in this study offers an affordable reference for the progress of the research work.

**Notes**
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2. Arch. Guido Meli, who was responsible for the restoration, was the first one who proposed such identification (Meli 1991, p. 25).
3. Many similar and coeval traceries appear both in Spain and in France.
5. Garavari 1921, p. 81.
6. The authors wish to thank Prof. Doris Behrens-Abouseif for pointing out right similarities between the geometry of the Girale and the decoration of some Islamic works of art.
8/ Orthophoto of the left end of the porch. Magnified images, compared to a figure from Garneri's book on ornament (Garneri 1921, 81), put into evidence the slanting axis of symmetry of the upper right Girale in the left section and of a decorative element in the tympanum.
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