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STRETCHING OF CURVILINEAR CANVAS OF RELIGIOUS PAINTINGS

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ABSTRACT

Religious art objects preserved in the form of curved canvas paintings present a very interesting subject for the research, both from technical and conservation points of view. The work concentrates on theoretical and experimental analysis of mechanically correct stretching of curvilinear canvas to avoid folding and buckling of paintings. It is shown that treating curvilinear canvas as a ruled surface might be a very promising solution. Reverse engineering can help to discover the ruled surface shape adequate to the individual curved painting.

Keywords: canvas, stretching, ruled surface, religious paintings

INTRODUCTION

In Baroque period, paintings on canvas reached enormous dimensions and became a decorative element closely connected with architecture. Sometimes canvas was even adapted to curved walls, curvature of bevels and even barrel vaults. Such an example is a giant vault decoration of the Hall of Mirrors in the Palace of Versailles, composed of the canvas cycle executed by Charles le Brun. In the XVIIIth century, various forms of curvilinear canvas, concave or convex, and of different radius of curvature were used. Curved paintings of religious themes played an important role in decoration of churches. One of the examples of such curvilinear painting is "Apostles discovering the empty tomb of Mary" by Camillo Procaccini from 1594, located behind the main altar of Basilica di Santa Maria Maggiore in Bergamo (Italy).

The concave shape of the canvas further emphasizes the theological dimension of the monumental vision – the supernatural character of the Assumption of Mary and the communion of gathered Apostles.

Another type of known curvilinear paintings are convex paintings placed on church pillars. In the St. Jacob church in Antwerp there are preserved two curvilinear paintings placed on the lateral pillars presenting St. Mary Help of Christians (Fig. 1) and St. Jacob Passion. Similar form has pair of canvas paintings exposed on the pillar in the Frauenkirche church in Nuremberg.

The presented research is to a large extent related to conservation works carried out in the Saint – Aubain cathedral church in Namur (Belgium), gathering a group of four large–size canvas paintings, presenting the scenes of the Christ's childhood by Mauritius Heinrich Loder. Two of them obtained an unusual form adapted to the shape of the apse walls. The canvas, being the object of conservation works is "Adoration of the Magi" with 3,70 m height and 4,50 m width. The painting is bowed in the horizontal plane and the sagitta of the arc of its stretcher frame is 37 cm [1].

The aim of the presented research was experimental and theoretical analysis of fundamentals of stretching of large curvilinear canvas to answer the conservators needs of rational shaping of stretchers for such religious paintings.

METHOD

It should be stressed here that the following analysis does not examine what are the adequate amounts of tensile forces to properly stretch the canvas. Only force directions are of our concern because this is a crucial point in stretcher frames design in the case of curvilinear paintings. Stretching forces can be more or less fitted during canvas fixing according to the needs if only an adequate stretcher structure is provided.

From simple geometrical considerations it is known that chord of an arc is shorter than the arc length. Thus pulling-out the arc ends diminishes its curvature and extends its chord. Hence, one may expect that any tension applied to the canvas in a direction other than that coinciding with tangent to the canvas surface will flatten the painting. In the case of flat canvases, any in-plane tensions have directions tangential to the canvas surface. Consequently, flat paintings can be stretched in any

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in-plane direction. In the case of curved surfaces situation is much different. Tractions acting at surface boundaries can be tangent to the curved surface at points of their application but not at the inner points of that surface. This means that stretching the curvilinear canvas in general case has to flatten its surface. There is however one special type of curved surfaces for which one can find straight lines tangent to the surface at every inner point. These are ruled surfaces [3, 4].

A ruled surface *S* is generated by continuous motion of a straight line (*ruling*) along a base curve (*directrix*). This means that for each point of *S* one can draw at least one straight line on the surface. Ruled surfaces can be described by a parameterization:

$$S(u,v) = \mathbf{a}(u) + v\,\mathbf{r}(u) \qquad (1)$$

where a(u) is the directrix, and r(u) is a unit vector providing direction of the ruling. Alternative representation is in the form [5]:

$$S(u,v) = (1 - v)\,\mathbf{a}(u) + v\,\mathbf{b}(u) \qquad (2)$$

where S is a point on the surface, a(u) and b(u) are two directrix curves. Straight lines connecting points on directrix curves in this case define the ruled surface.

Searching for the optimal stretching directions in case of curvilinear canvas should begin with finding the closest approximation by ruled surfaces. Similar approach is applied in architecture for finding structural design for complex shells [6]. Fig.2 presents an example of two stitched, ruled surfaces with parameterization given by equation (2). Directrix curves are placed in the horizontal plane and are defined respectively as polynomials of order two and three with different coefficients for upper and lower curve.

In order to provide a basic verification of the proposed concept, experimental analysis of fundamentals of stretching of large curvilinear canvas was done with aid of a simple string model. The aim of the experiment was to confirm the above considerations and to visualize the deformations of the warp resulting from tensioning of the weft or in directions inclined to the weft. The string model (Fig. 3a) is composed of a stretcher frame and elastic strings stretched between upper and lower stretcher's beams. Therefore, the strings simulate the warp of the canvas. The upper and lower beams are curvilinear to assure convexity of the model "surface" in one direction. A lateral tensile force action was simulated by using an additional stretching string fixed to the vertical elements of the model. The analysis was a qualitative one and it had been repeated with various positions of the additional stretching string and with various relations of stiffness of the vertical and additional strings.

RESULTS

Experimental results are illustrated in Figures 3b–d. Figure 3b shows deformations of vertical strings resulting after an additional horizontal string and hence horizontal stretching force was applied at the model centre perpendicular to the vertical strings. The next two pictures show deformations due to stretching in the direction neither perpendicular nor parallel to the vertical strings – diagonal stretching (Fig. 3c) and arbitrary inclined stretching (Fig. 3d). Observed deformations clearly show that any stretching in directions departing from that of vertical strings deforms these strings and produces buckling in the inward direction. Applying tractions at two points of a canvas results in a tendency of straightening of the segment between these points and flattening of the painting surface. This tendency is favourable in case of flat paintings. I case of curvilinear paintings however this is undesirable because reduces a wilful curvature of the painting unless the tractions are applied along lines which are intentionally straight ones.

Straight lines can be drawn at every point of the curvilinear painting only if the painting surface is a ruled surface [3, 4,5]. Thus, one may conclude that probably all large curvilinear canvas had to be originally designed by the masters as the ruled surfaces, otherwise it would have not been possible to stretch them along straight-line segments. These straight-line segments coincide with surface rulings [3].

CONCLUSIONS

The research shows that stretching of curvilinear canvas substantially differs from that of flat ones. The correct canvas shape without out-of-surface deformations can be secured under two conditions:

- canvas must have a form of a ruled surface, and
- external tractions applied to the canvas should be co-linear with surface rulings.

In such a case the curvilinear canvas will be able to sustain its dead weight and traction loads like a membrane of no bending stiffness without out-of surface buckling and folding.

Based on the above conclusion it is expected that nowadays high accuracy 3D measurement methods combined with reverse engineering calculations may allow us to discover the adequate ruled surface shape of the curvilinear painting prior to beginning of its conservation. Hence, the painting optimized stretcher shape and stretching directions would be correctly elaborated.

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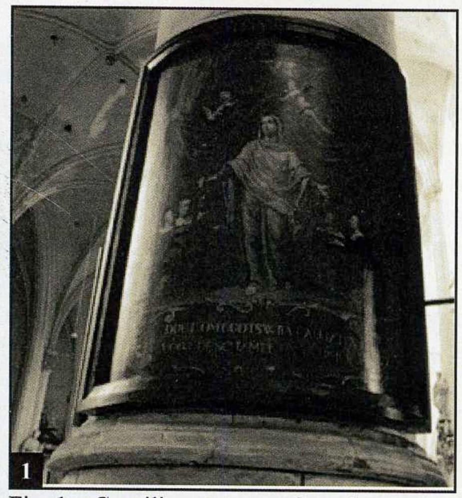

Fig. 1 – Curvilinear canvas from St. Jacob's church in Antwerp.

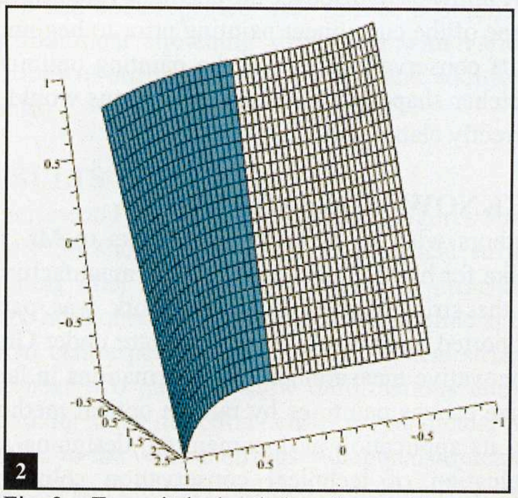

Fig. 2 – Two stitched, ruled surfaces with second and third-order polynomial directix

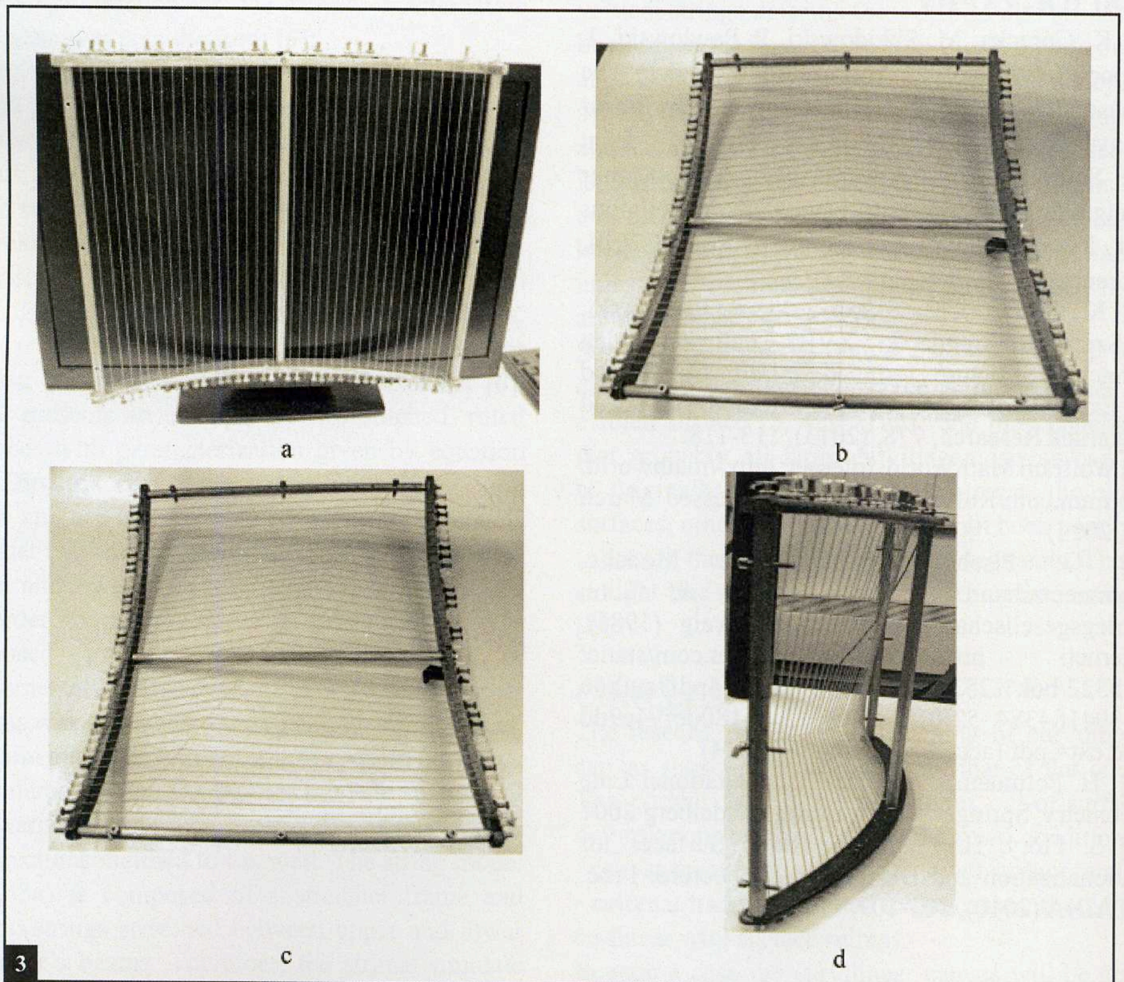

Fig. 3 – a) String model of a curvilinear canvas, b) model deformation – force applied through its center perpendicular to the strings, c) model deformation – force applied through its diagonal, d) model deformation – force applied at some arbitrary angle to the strings