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AUGMENTING PAINTED ARCHITECTURES FOR COMMUNICATING CULTURAL HERITAGE

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Abstract

The paper presents a research under development at the University of Trieste to analyze a painted architecture by Paolo Veronese and to present the results using AR systems (Augmented Reality Systems). The canvas was painted in 1573 and it is now at the Gallerie dell'Accademia Museum in Venice. The aim of the research was to transform a two-dimensional work of art in a three dimensional one, allowing all the visitors of a museum to enter the space of the representation and perceive it in a more direct way. After the geometrical analysis of the picture, we started the digital restitution of the perspective references and proceed to model the virtual scene using Boolean primitives and applying all the textures to render the scene in a very realistic way. The further step was to convert the model into a dynamic form with AR algorithms and associate it with spatial references to allow users to do a virtual experience of it.

Keywords

Perspective, Painted Architecture, Augmented Reality, Paolo Veronese, Digital Modeling

1. *A painted perspective by Paolo Veronese*

In 1573 Paolo Veronese realized a painting of great dimensions for the refectory of the Basilica of SS. Giovanni e Paolo in Venice, and commissioned by the Dominican friars (Fig. 1). It represented a supper with the figure of Christ in the middle and the apostoles and some other people around him, giving it the name of the 'Last Supper', considering what it was written in the Gospel. But due to the presence of some indecorous persons inside the composition – such as drunken people, buffoons, dwarfs – and their extravagant clothes, that could be related more to the customs of the Venetian patrician feats than to the well-known event that precedes the Passion of Christ, the Tribunal of the Sant'Uffizio asked him to explain about this strange way to present a sacred event. As Veronese did not accept the critical reflexions from it, decided to change the title of the painting without changing what he painted. The new title, accepted by the Sacred Inquisition, was 'The Feast in the House of Levi'. But who works in the field of drawing, and in particular on perspective analysis, finds this canvas very interesting, because it contains some architectural elements that show a scenographic description that seems to respect the perspective rules with great exactness.

So we decided to analyze it and try to understand the method used by the painter to realize the scene having in mind a double aim: to study the geometrical references and virtually reconstruct the architectural scenography; to transmit the research for dissemination in the field of cultural heritage, in order to extent to a large part of people the results of the investigation[1]. In fact we decided to used advanced systems of Augmented Reality (AR) to improve a way to transform the visitors of a museum, from a passive status to an active one, to feel themselves as a part of the painting, to enter virtually in the scene and to live in a more interactive way the experience of this work of art. Due to the large dimensions of it, the architectural elements and the people who are present on the canvas seem to be in a real scale (1:1) in

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reference to the human observer of the perspective.

2. *Acquiring the canvas*

The first step of the research was to acquire the canvas that as large dimensions: m 13.10x5.55. Thanks to a preceding restoration that was done by the Soprintendenza we had the possibility to work with a high definition digital acquisition made with professional camera, that allowed us to have a preliminary verification of the status of the painting. Then we collected all the bibliography on this work and all the previous research reports to have a general view of all the data. From these analysis we knew that the canvas was cut in three pieces, to preserve from a fire at the end of XVII Century, then after the fall of the Venetian Republic Napoleon brought it in France and only after 1815 the work was given back to Venice. During the World Wars it was moved to some other towns, such as Florence and Rome. Then after the Second World War it was located in Venice again and between 1979 and 1983 an important restoration brought colour and brightness to the work, joining the three pieces into one. The painting was analyzed with the infrared computerized reflectoscopy that revealed some "pentimenti" of the painter, both on the people, and on the architectural background. Then we had to identify all the architectural elements, because thanks to them we can proceed to study the perspective scene. The scene is inscribed in three levels of determined spaces, already analyzed by David Rosand, who suggested to consider the space as a theatre scene, divided in proscenium, stage and backdrop. In fact we can find in the front of the scene the proscenium characterized by the two staircases at left and right side; the stage, where there are the great part of the figures, the geometrical floor and the great porch based by the three arches with corintian columns; then there is the backdrop, in which there is an urban view with various palaces and galleries, and a dark sky at the end.

Fig. 1: Paolo Veronese, The feast in the house of Levi, 1573 (Gallerie dell'Accademia, Venezia).

Starting from these considerations we began to analyze the perspective references of the canvas using the rules of Descriptive Geometry, and trying to reflect on the methods used by the painter to realize the scenographic layout.

3. *Perspective analysis*

The first step to understand the rules of construction of the perspective was to calculate the internal and external orientation of the projective references. For the first one we have to find the main elements that characterize this projection: the vanishing poit V_0, the Horizon line *o*, the main distance *d*, as it is a one-point perspective on a vertical front plane. It is important to note that we can't consider this work as a regular geometrical perspective, because of its large dimensions, and the difficulties to construct the perspective as if it was

done on a small piece of paper; but also because, being a work of art, the painter solved some visual aspects modifying the references in order to obtain the best vision to create an illusion of the reality. Without any doubt the element that can help us in determining the perspective reference is the floor which is based on a series of regular octagons (Fig. 2). As we know the octagon can be inscribed into a square, so that the two diagonals of it allow to calculate the true form and transform the perspective square into a planar square.

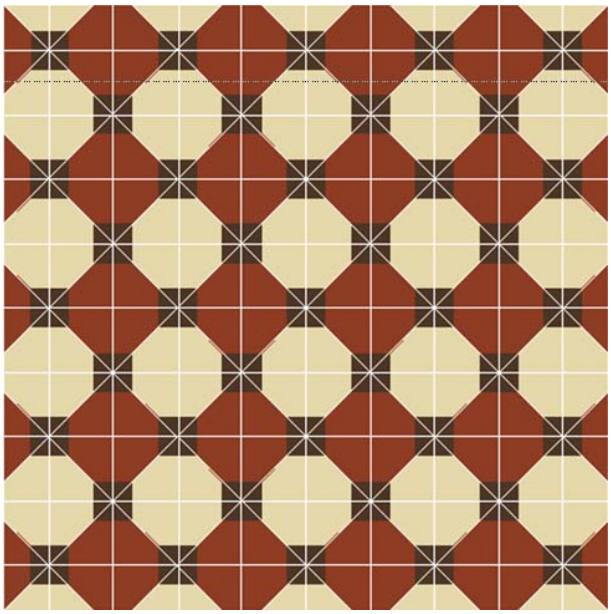

Fig. 2: The geometrical floor after the restitution phase.

If we extend all the lines of the squares inscribed into the octagons, not parallel to the projection plane, we can identify a vanishing point in the middle of the canvas – exactly on the face of Jesus Christ (Fig. 3)– for which the horizon line passes. Extending, then, the diagonals of the squares we can identify the two distance points on the horizon line, necessary to fix the position of the main distance *d*.

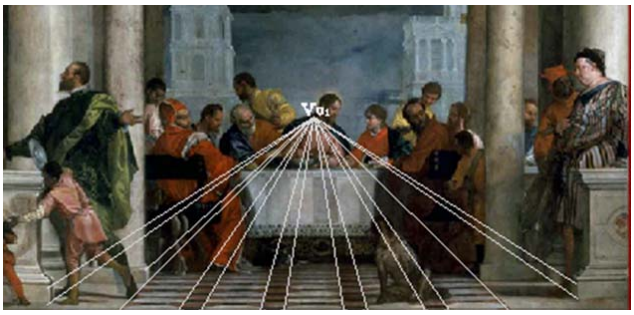

Fig. 3: Identification of the first vanishing point of the scene

Transferring the data using the omology, we can have the planar description of the floor, in which we can find also the position of the architectural columns. Continuing with the phase of perspective restitution, we have found another vanishing point proiecting the upper part of the arches, exactly redrawing the geometries of them. The second vanishing point is located on a second horizon in a lower part of the canvas, between the floor and the table (Fig. 4).

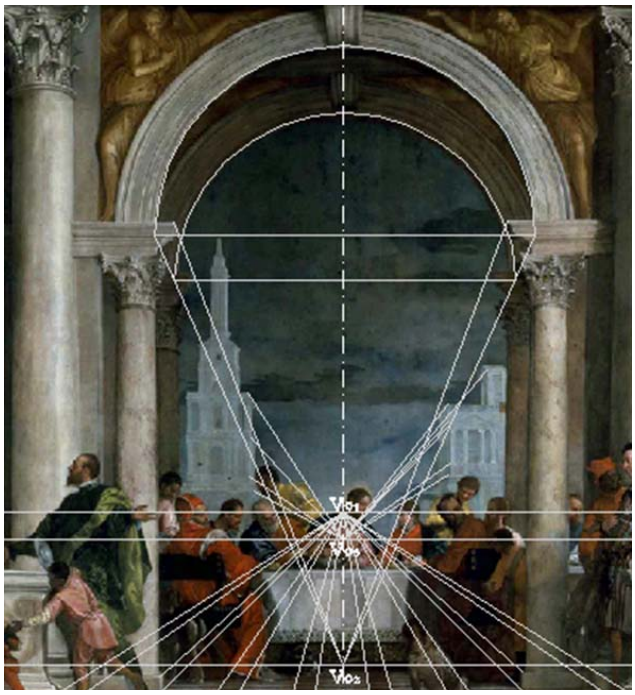

Fig. 4: Identification of the second vanishing point.

Probably it is due to the necessity for Veronese to show all the details of the large scene, deforming a bit the structures, in order to optimize the visualization.

After this phase, we started to analyze the external orientation, which allows to put in real scale the planar drawing obtained.

To adapt the plan to the human measure, we have to identify the base-line, which is called usually the fundamental line, to overturn the perspective into a planar drawing. As in this case we do not have sufficient information about the real position of the fundamental line, we decided to locate a fictitious line in correspondence with the beginning of the tiling floor with octagons. The factor of scale reduction will be in this case arbitrary. The further step was to identify the elevation of the architectural elements, considering that the kind of perspective the

painter used was a frontal one, which maintains the true form of the objects. We made another

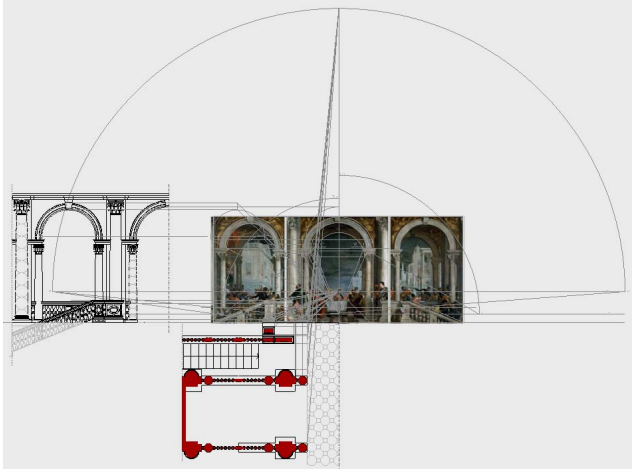

Fig. 5: Perspective restitution of the painting with plan and elevation of the scene.

consideration after having found that the three arches of the loggia have different dimensions: in detail, the two exterior ones are smaller than the central one. And in particular the two side arches are exactly based from a semicircle, instead the one in the middle is a segmental arch, geometrically less than a semicircle (Fig.5).

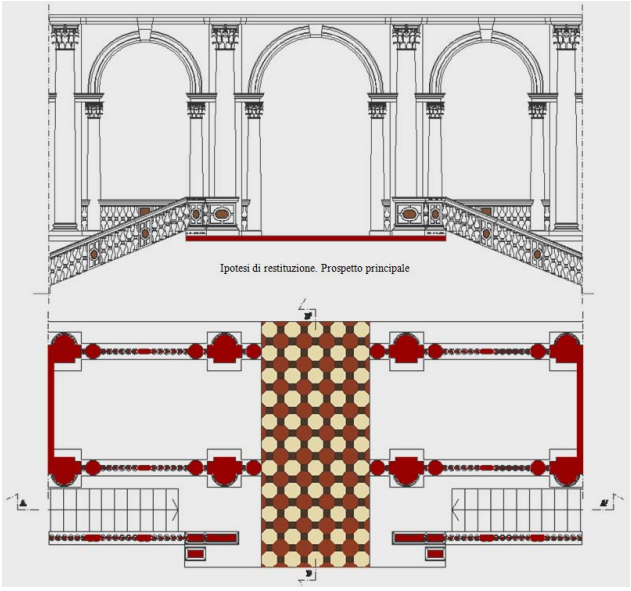

Fig. 6: Plan and elevation of the scene after the restitution.

The proportions of the orders are based on the rules we can find on the treatise of architecture, both the 'Ten books of architecture' by Marco Vitruvius Pollio, and the various treatises of Italian Reinassance, which were based on the Vitruvius' one.

4. *Digital modeling of the architectural elements*

After having found all the two dimensions of the main architectural obiects of the scene (Fig. 6), we started to model the single morphology of the parts: the balustrade of the staircases, the colums with enthasis, the corintian capitals, the arches. The Boolean primitives used in this case were integrated with some advanced procedures, such as the loft algorithm, the patches primitives, some NURBS geometries, and so on.

Before starting to replicate all the figures of the context, we decided to verify the correctness of the point of view, identifying the point from the restitution phase, and seeing the scene as if we were in the same position (Fig. 7).

We find a correspondance of the main elements, while the one based on the secondary vanishing point resulted a bit more deformed, even if the difference between them were in the order of a minimal range.

In fact the loggia was constructed starting from an interpolation of data: first of all the information coming from the perspective analysis and the internal orientation; then from the frontal geometries in true form of the elevations; in the end all the data were compared with the location of the plan generated thanks to the first vanishing point layout.

Fig. 7: Perspective of the digital model from the same point of view of the picture.

As one of the aim was to disseminate the research on cultural heritage inside museum, we considered also the aspects which probably will attract the visitors more than the architectural elements, that is the presence of human and animal figures inside the space. As it was very difficult to render all the three dimensional men with the richness of their clothes, we decided – for the moment – to use a simplification of the

representation, that is the application of a two dimensional texture on a planar surface which describe the silhouette of every figure. So they are in reality flat, but, as we can see at the end, the use of Augmented Reality bypass the problem, giving the user the perception of three-dimensionality of the elements themselves.

5. Reconstructing the refectory scene

As the painting was done for the refectory of the Basilica of SS. Giovanni e Paolo in Venice – which now is part of the Hospital of Venice – and the work is now at the Museum of the Gallerie dell'Accademia for public permanent exposition, we want to reconstruct the original set in which the canvas should have to be placed. To help us there is a painting by Francesco Guardi, done in 1782, which reproduced the space during the visit of the Pope Pio VI to the venetian doge (Fig. 8) and some information about the dimensions of the room.

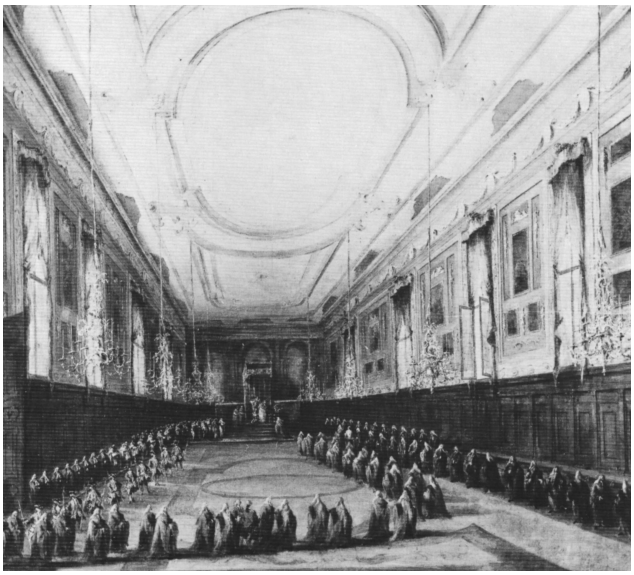

Fig. 8: F. Guardi, The visit of the Pope to the doge, 1782.

Then, the Venetian Soprintendenza, did a superposition, with traditional technique, using a photograph of the space and the painting by Veronese. Starting from these kind of information we defined a virtual room to locate both the painting and the three-dimensional model to simulate the real position of the canvas, thought by Veronese (Fig. 9). So the general vanishing point resulted to have an height of about twice the eye of a human figure, confirming that the stratagem of using multiple vanishing points was due also to reduce these differences of viewpoints.

6. Augmenting the painting

The last part of the work was finalized to prepare all the research data for the transmission to an ideal visitor inside a museum.
As the use of Augmented Reality needs an optimization of the geometry of 3D model, we needed to interpolate the most complex form – such as the capitals – with the LOD (Level of Details) algorithm, to have a final 3D interactive model which could be easily explored in space.
As we know the difference between Virtual Reality and Augmented Reality is in the different way to perceive the space by the user.

Fig. 9: The reconstruction of the refectory with the scene.

In VR the subject is the human eye that is put inside a virtual scene, giving the impression to be into a real space. In AR the scene is virtually transformed into a small object into the hand of the user, who can see it as if it was a small maquette. It is also true that if we approach to it, we can have the illusion to be part of the scene.

The AR algorithm uses the QR code to load the virtual model inside the memory of the computer and then we can switch from the reproduction of the painting, shown to the cam, to the digital scene in three dimensions. But the potentiality of the AR systems is that we can use also a tablet or a smartphone to navigate and explore the interactive model. Thus, the visitor of a museum can point the painting on the wall and, instead of taking a picture of it, he can have an added value from the work of art, transforming it in 3D and perceiving the real configuration of the space (Figg.10, 11,12).

Fig. 10: The virtual model of the scene using Augmented Reality algorithm.

Fig. 11: The AR interactive set with all the figures.

We tried to experiment this kind of new perception by common people during an event that took place in Trieste some months ago, in occasion of "Trieste Next – European Show of the Scientific Research", from September 26th to 28th, 2014 (Fig. 14), in which we presented the system inside the space called "Architecture and Augmented Reality" organized by the Course of Study in Architecture, of the Department of Engineering and Architecture of the University of Trieste. The simplicity of the method to explore the model was tested by all kind of persons – from children to old ones – having a very impressive results from them.

Fig. 12: Perspective visualization of the AR scene.

7. *Conclusions*

The research focused on the canvas titled "The Feast in the House of Levi", painted by Paolo Veronese at the end of XVI Century. We used the perspective restitution to understand the procedure used by the author, to find the geometrical references of the architectural elements in order to construct the digital model and simulate the space.
The rigorous of the analysis allowed us to find some incongruences in the number of the vanishing points of the perspective, so to consider the projective space as a superposition of more than one perspective. The final step was dedicated to convert all the 3D scene into an AR system, in order to permit the navigation of the digital space to common people during an exhibition or inside a museum.

All the procedures are codified and can be used for some other work of art that have as main subject an architectural perspective.

Fig. 13: The presentation of the AR system at Trieste NEXT

8. *Acknowledgments*

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In detail Chapters 1 and 7 were written by Alberto Sdegno, Chapter 2 was developed by Paola Cochelli, Chapters 3, 4, 5 belonged mainly to Silvia Masserano, who drew also Figg. 2-8, Chapter 6 was developed by Denis Mior with the collaboration of Eleonora Gobbo. A preliminary analysis was done by Francesco Dario (Fig. 10) with his graduation thesis in Representation at the Faculty of Architecture of the University of Trieste, supervisor Alberto Sdegno, tutor Silvia Masserano, during Academic Year 2012-13. We would like to thank the Soprintendenza per I Beni Architettonici e Paesaggistici di Venezia e Laguna, and the Polo Museale Veneziano, for having given all the documents and support necessary to develop this research.

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