

Handbook of Research on

Visual Computing and Emerging Geometrical Design Tools

Giuseppe Amoruso



Volume II

Handbook of Research on Visual Computing and Emerging Geometrical Design Tools

Giuseppe Amoruso
Politecnico di Milano, Italy

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Giuseppe Amoruso
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Section 1

Geometric, visual and projective tools for design and assessment of space: descriptive geometry, computer vision, perspective based design tools, architectural perspective, anamorphosis, oblique projection, parametric design, BIM, digital heritage.

Chapter 17

Interpretative Reading of an Illusory Painted Wall: A Survey and Analysis of a Work from Antonio Galli Bibiena in Bologna

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ABSTRACT

*This study concerns architectural representation, and it focuses on the *Quadratura* issue: an illusory architecture painting where perspective creates the illusion of spatial depth on a flat surface. The main subject of this work is the study of the perspective scenes frescoed in the yards of historical building, during the 18th century in northern Italy, especially in Bologna; they represent architectural scenes, placed at the end of a promenade through the building. One of the most interesting example of these perspective frescoes in Bologna has been designed in 1761 by Antonio Galli Bibiena in Palazzo Vizzani's yard. This study aimed to approach a digital 3D-reconstruction of the scene, based on an accurate documentation and a combination of architectural survey techniques. Finally the digital reconstructed scene can be video-projected on the wall: it can simulate a viewer's eye guided across the building towards and inside the scene.*

INTRODUCTION AND FRAMEWORK

The perspective scenes frescoed on the courtyards of some of Bologna's historical buildings are a particular "framing" of cultural heritage. This essay talks about the knowledge of cultural heritage, in particular of perspective-frescoed walls, focusing on the best ways to portrait them and communicate them to the people. This is of specific importance because the majority of these pictorial works are either unknown or placed in hidden locations. Also, many of these scenes have been lost through the years, due to the exposure to the elements and due to human neglect.

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After having screened several examples of perspective-painted yards, frescoed in the city of Bologna between the 17th and the 19th centuries, the study targets the perspective fresco created by Antonio Galli Bibiena in Palazzo Vizzani; the goal was to build a digital 3D-reconstruction of the lost scene, using a previously-executed accurate analysis and a combination of different architectural survey techniques.

These kinds of perspective canvases, placed at the end of a *promenade* running through the building and mimicking the wings of a theatre stage, are to be considered a sort of urban stage design. These buildings were mainly senatorial buildings, located on the main streets, and they represented an expression of the local power. The aristocratic families of the times used to hire artists to paint the yards and the apartments of their buildings, with the aim of creating a unique, customized-looking building within the city scenario.

It was important to understand how the author created the entire composition, and how in the 18th century people were attracted inside the building, how they were encouraged to explore a semi-public area (such a courtyard), passing through a perspective telescope, to admire, in the end, a frescoed wall. Once the viewers arrived in front of the fresco they could see a space without boundaries, in a rhythmic succession of spaces.

The Quadratura genre is an illusory painted architecture where the perspective creates a trick of spatial depth on a flat surface by employing the technique of proportional foreshortening and by using a realistic rendering of light. The author needed to have extraordinary painting skills and knowledge of optics and geometry.

In a perspective composition objects are scaled in relation to the viewer and everything converges to the vanishing point: the beholder, by standing in the centre of the perspective projection, can imagine a limitless space, where real and fictional worlds merge. A particular but effective definition of the power of perspective might be:

The convention of perspective centres everything on the eye of the beholder. It is like a beam for a lighthouse [...] Perspective makes the single eye the centre of the visible world. Everything converges on to the eye as to the vanishing point of infinity [...] every drawing or painting that used perspective proposed to the spectator that he was the unique centre of the world. (Berger, 1972)

For centuries, especially from the Renaissance, many scholars were intrigued by the power of perspective applications, and many of them wrote treatises that helped to understand this kind of works: for examples those of Sebastiano Serlio, Jacopo Barozzi da Vignola, Andrea Pozzo and (most important all for this case study) the treatise of Ferdinando Galli Bibiena (Galli Bibiena, 1711). By analyzing these treatises it is possible to understand the enigma of perspective projection, guessing how the entire artistic work was created.

The subject of this work was selected from several perspective scenes, including many of them in critical conditions; have been found about fifteen examples of painted yards in Bologna, usually framed by an arch or painted on an entire wall, such as the yard of Palazzo Monti Salina and the yard of Palazzo Vizzani, painted by Ferdinando and Antonio Galli Bibiena.

At the time Bologna was a vibrant environment: it was the headquarter of both the *Archiginnasio* and the *Accademia Clementina* (The Academy of Fine Arts) and therefore many artists could receive commissions from the aristocracy and from the royal Courts.

The Bibiena dynasty paved the way for a unique cultural *koinè*. They were architects and stage designers working during the 18th century, and they became very famous for their unique skills.

Interpretative Reading of an Illusory Painted Wall

Antonio Bibiena in 1761 realized the illusory painted architecture in Palazzo Vizzani's courtyard, carefully designed and with a dramatic representation; it was the perfect fusion between architecture, stage design and decoration, aiming at a total participation of the viewer.

The Palazzo Vizzani's scene represented a triumphal arch with columns and decorations, introducing the viewer to another virtual courtyard; here is clear an obvious analogy with the *proscenium* arch of a theatre stage.

Antonio Bibiena intended the scene as a real construction, with plans and elevations, and for this reason he designed the scene in all of its details before painting it in perspective. The scene was strictly linked to the building and to its morphology, and it has been key to understanding the geometrical relationship between real and illusory architecture. Unfortunately a huge part of the scene has been lost through the years, and for this reason it has become necessary a virtual reconstruction of the painted wall (Figure 1).

SURVEY OF A PAINTED WALL

It's important to get a scientific approach, useful in this case study and also for similar painted walls in ruins, by finding an experimental method that can recreate the artistic work as it revealed itself to the viewer of the 18th century.

First is possible to start with some information on the painting and on its author, so understanding how the pictorial work was created, how the author had chosen the right position to admire it (the centre of the perspective projection), who were his references among the ancient scholars of perspective, where the strict geometrical rules of perspective projection came from.

Figure 1. A present picture of the perspective fresco in Palazzo Vizzani



The proposal is a virtual reconstruction of the scene, starting from some visible signs on the painted wall, and simulating also the original fresco's colors. After having understood the scene using documented history, and having compared it to other similar Bibiena's sketches in the aforementioned treatise, it is possible to plan out a combination of different architectural survey techniques, such as GPS-total station, orthophoto images, 3D laser scanning and infrared thermography.

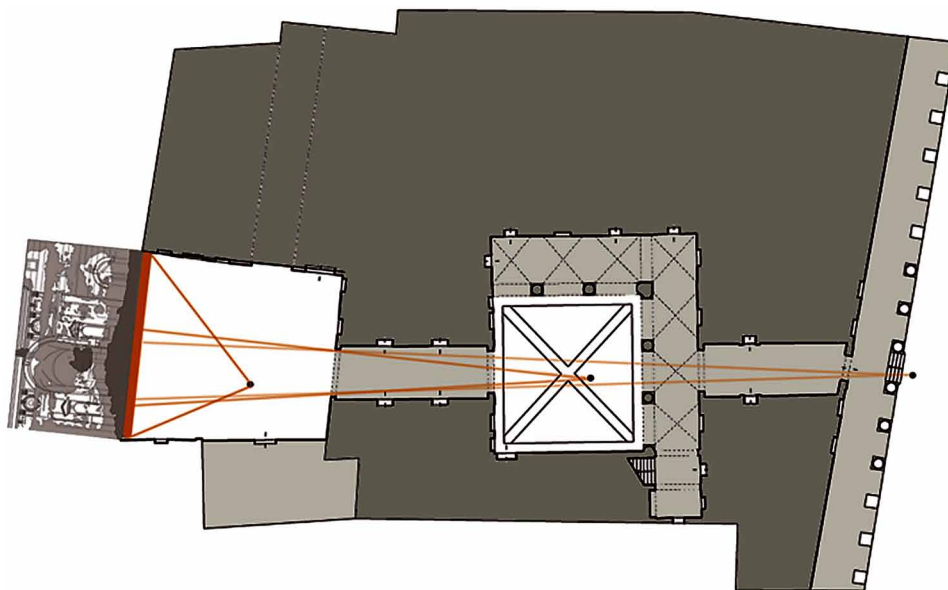
The courtyard of an historical building, as the one in Palazzo Vizzani, is a space of transition between the public space of the city and the aristocratic private residence, and it shows a flowing succession of scenography settings against the painted backdrop, where everything becomes part of an illusory project. For that reason it is essential to make a survey of the entire perspective telescope of the building, including the painted wall: by drawing plans and sections and by making a solid modeling of the building's perspective telescope, it's possible to include the scene (the illusory architecture) within the real architecture; research findings have proved that there was a close relationship between the illusory painted architecture and the real space that enclosed it (Figure 2), (Figure 3).

The Palazzo Vizzani's fresco depicts an asymmetrical composition in respect to the wall: the *proscenium* arch with its huge cross vault is aligned with the building entrance, and also with the perspective telescope, and it guided the beholder's sight from the entrance towards another virtual courtyard; only once the viewer has arrived in front of the painted wall it is possible also to see, on the right of the triumphal arch, a painted façade, textured with *bugnato*.

The arch and the façade seem to belong to two different planning schemes, or perhaps they could belong to different authors.

It's important to remember that an illusory painted architecture shows a double nature, both pictorial (tangible) and architectural (conceptual), and this leads to a double analysis:

Figure 2. The plan of the building's perspective telescope: it represents how the viewers perceive the scene from the entrance to the painted wall



Interpretative Reading of an Illusory Painted Wall

Figure 3. The sections of the building's perspective telescope: it represents how the viewers perceive the scene from the entrance to the painted wall

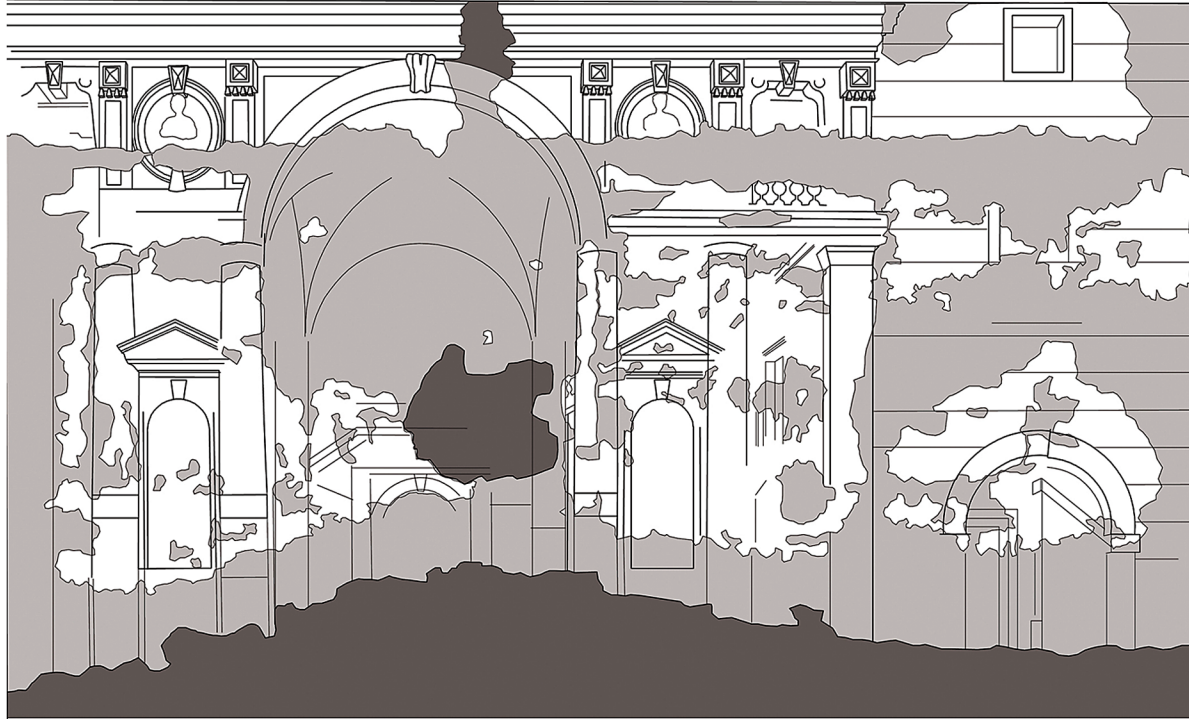


- A material reading of the fresco.
- A perspective restitution of the central projection.

The material reading involves direct and instrumental survey techniques: with the help of a 3D laser scanning and orthophoto images, the study proved that water and structural damages have caused important losses of the fresco; by interpolating points, gathered with the scanner, it shows how the painted wall, viewed from the top, has a variable shape. Thanks to the data acquisition it is possible to watch over the structural integrity of the wall.

The existence of original layers of plaster was recorded by drawing the elevation of the frescoed wall and by marking every lacks in the painting: thanks to the infrared thermography it was made a stratigraphical analysis of the fresco and three layers of plaster were highlighted, as the ancient treatises described (Figure 4). By carefully observing the fresco's elevation it can be noticed that underneath the

Figure 4. The digital reconstruction of the painted wall's elevation: Dark grey areas are total losses, light grey areas are partial losses



colored plaster there were clear tracks of the painting's figurative layout, and this helped to understand its originating concept. Surely Antonio Bibiena used different transposition techniques to transfer the painting to the wall, maybe using pasteboard for the figurative layout and direct engravings for the architectural layout.

Subsequently it was made a survey and documentation of the fresco's original color, using the watercolors, a traditional painting technique, to represent the current state of the fresco; by picking similar color hues and by comparing this fresco to other Bibiena's pictorial works and to some treatises like the Andrea Pozzo's *Perspectiva pictorum et architectorum* (Pozzo, 1693-1698), it was created a reference abacus for coloring, useful to the digital 3D-reconstruction (Figure 5). Color registration does not intent to show the original fresco's aspect, but it can register its chromatic appearance at the moment.

RECONSTRUCTING THE SCENE BY PERSPECTIVE PROJECTION

To truly understand Antonio Bibiena's pictorial work it can be examined from a purely geometric point of view, considering the frescoed scene as a geometrical plane surface measuring about 15 x 10 meters; the intent was to study the various possible ways in which the projective procedure was used by the author, through the means of inverse perspective.

Interpretative Reading of an Illusory Painted Wall

Figure 5. A watercolor sketch of the current state of the fresco, at the bottom the reference abacus for coloring

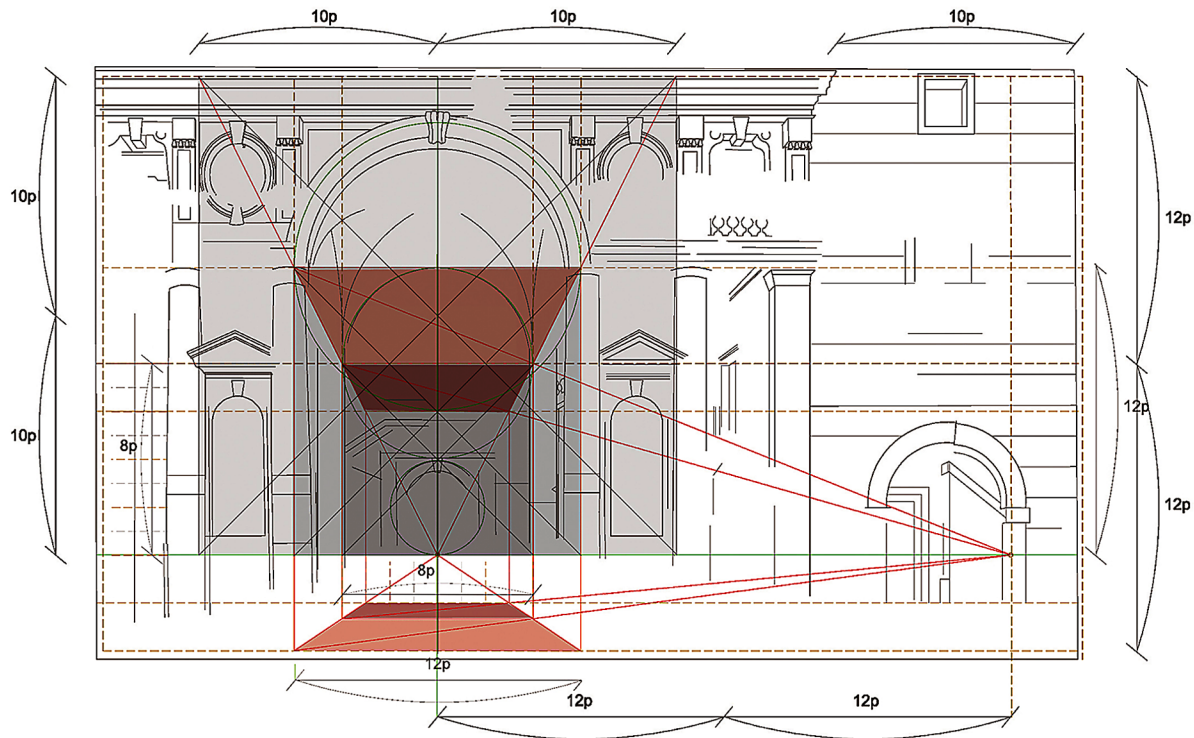


The aim was to identify the principal axes and the basic lines of the architectural drawing, in the elements that were still visible, such as the cross vault, the columns and the area above the highest part of the fresco, where usually the author started to paint by drawing its perspective grid.

By following the painter's *modus operandi*, it is possible to guess where the vanishing point was collocated by the author, and where the viewer was supposed to be standing in order to be struck by the breathtaking sight of the illusory scene; in other words the mean was to determine the horizon line and the distance point where they were originally placed by the author. The study identified some tracks of the axis of symmetry, which divided clearly the *proscenium* arch of the scene, and also some tracks of the horizon line at about 1.7 meters above the floor, the height of a human's eye. The vanishing point of the entire central projection is located in the intersection between the axis of symmetry and the horizon line, within the cross vault, focus of the scene, which is visible from the building's entrance. That area is the origin of the scene's composition and it is aligned along the main axis of fruition of the space.

It was possible to define a perspective grid based on a module, the Bologna foot (corresponding to 0.38 meters), which the author probably used as the basic measure to proportion and to transpose the whole scene, starting from the axis of symmetry and the horizon line. Every elements of the scene is in proportion to the Bologna foot and there is a strong mechanism of interconnection: there are three circumferences, two of them that formed the cross vault, that belonged to the perspective arches of six feet and four feet radius, and the third one that belonged to the background of two feet radius. The three

Figure 6. The perspective restitution of the fresco: is possible to see the vanishing point, the horizon line, the distance point and their proportional interconnections to the Bologna foot



circumferences draw a big triangle of twenty feet, with vertex on the vanishing point and with base on the entablature of the *proscenium* arch. The impost of the arch on the foreground belongs to a line, which measures a twelve feet distance from the horizon line, where the author engraved the perspective grid to proportion the whole scene.

The distance point has been determined on the horizon line, by using the forty-five degrees lines of the vault's impost: distance point measures a twenty-four feet distance, about 9 meters, from the vanishing point, the same dimensions as the total height of the wall (Figure 6).

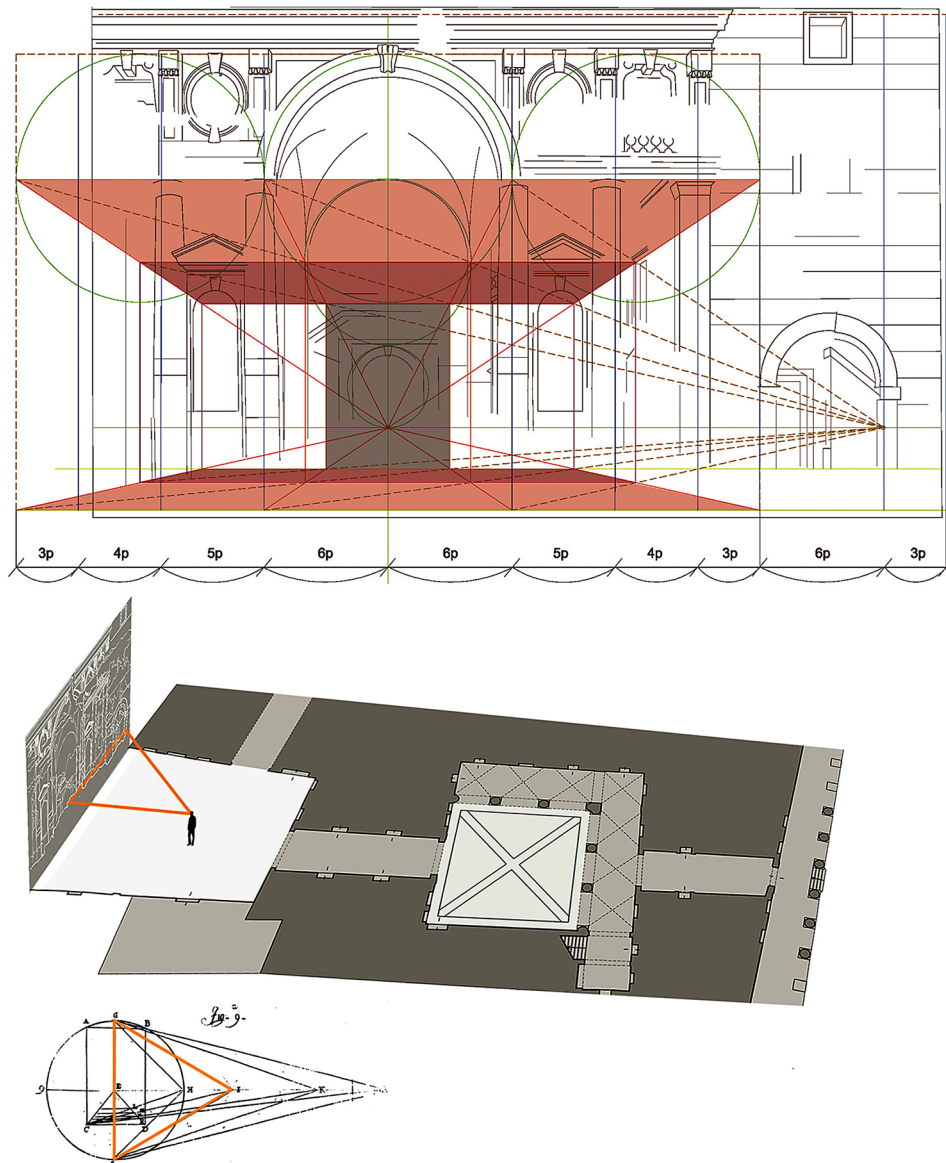
It was also estimated where the viewer was supposed to be standing, by turning the distance point in front of the scene: there is a single spot, at a twenty-four feet distance from the wall, where the viewer could admire virtual and real architecture together as one. This is the single viewpoint where the perspective provides the illusion of spatial continuity, that it is the centre of perspective projection (Figure 7).

The dimensions of every part of the scene are linked to the harmonious proportions: for instance the *proscenium* arch has a thirty-two feet width and a twenty-four feet high, a 4:3 ratio, prompted by Ferdinando Bibiena's writings as the right proportion of a theatre stage.

The distance point allows to determine the real depth of every single elements painted in perspective in a proportional foreshortening, therefore after having drawn the plan and the section of the scene, as a real construction (Figure 8), it was possible to build it as a three-dimensional model. It's important to highlight how a perspective-painted architecture can't represent something that is effectively possible to build; therefore has been drawn a conceptual 3D model where the elements on the foreground

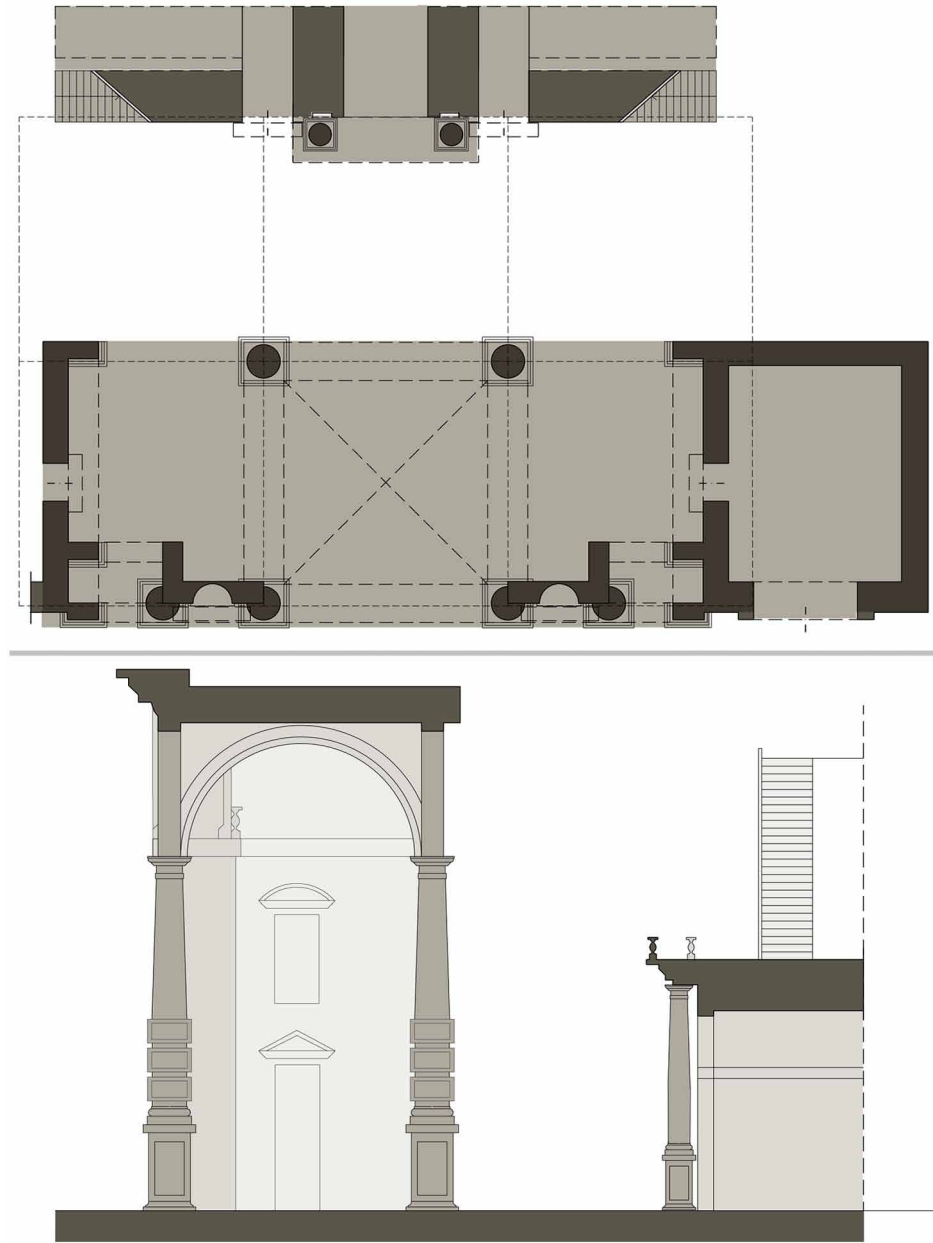
Interpretative Reading of an Illusory Painted Wall

Figure 7. The center of perspective projection, compared to Ferdinando Bibiena's treatise at the bottom



(the *proscenium* arch) and the elements on the background (the stairway) belonged to two independent architectural systems. The treatise of Ferdinando Bibiena, *L'Architettura Civile*, helped to proportion every single element in the scene; to recreate the same perceptive trick have been made some tests on the right distance between the *proscenium* arch and the stairway on the background (Figure 9). The model of the *proscenium* arch is structured with six symmetric square bays with each side of twelve feet; it is a conceptual reconstruction, compared also to other similar sketches by Ferdinando Bibiena's treatise. The influence of stage design on Bibiena's works is shown by the structural symmetry that pervades each part, from the scene as a whole to the smallest details.

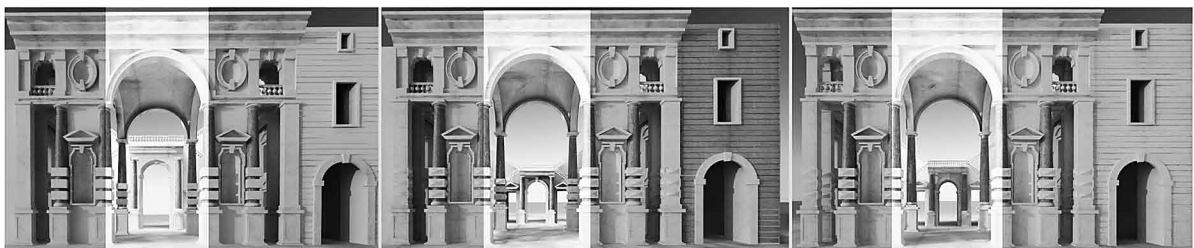
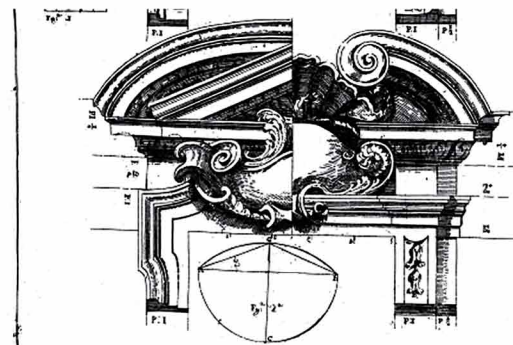
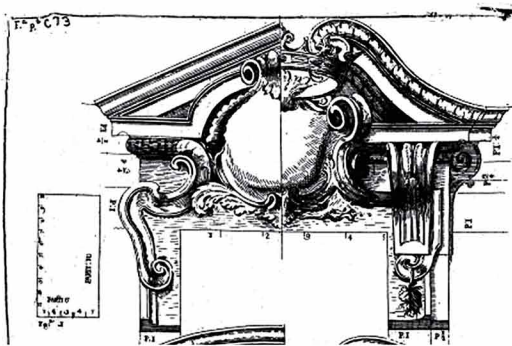
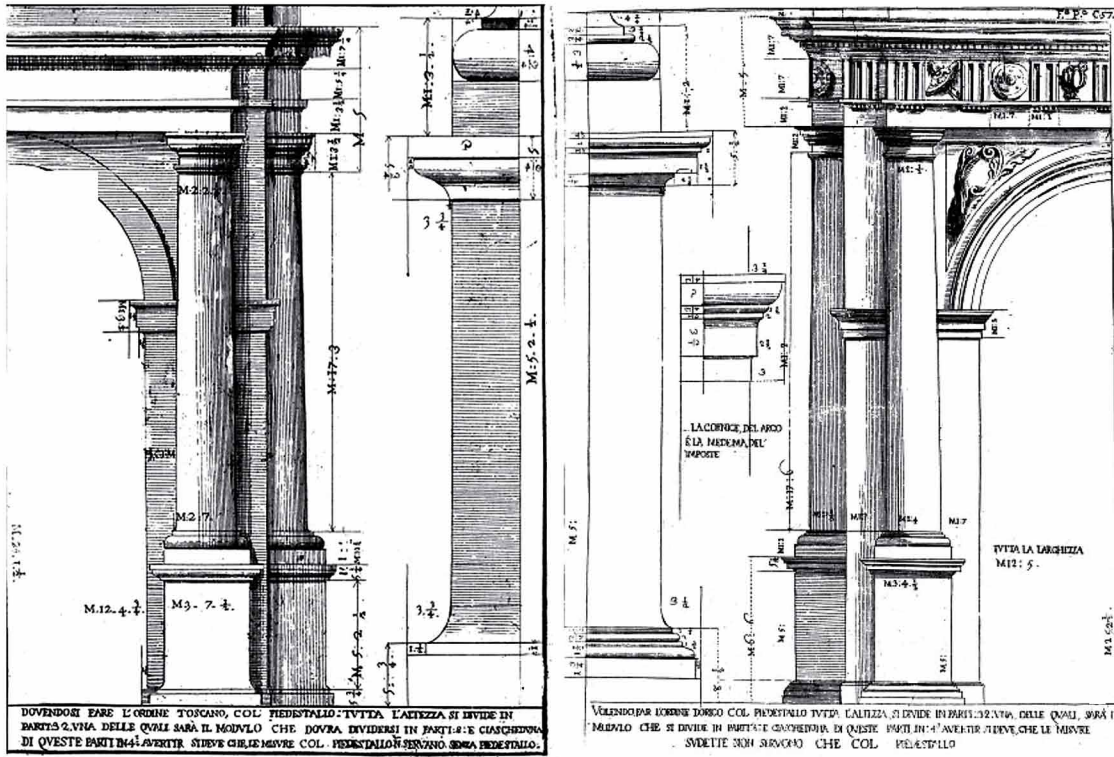
Figure 8. The plan and the section of the reconstructed scene



This led to a new phase of the study: the simulation of the original color of the painted scene. Once understood and drawn the abstract model of the scene, it has to exploit its strong perceptive wonder by inserting real lights and materials. By analyzing the fresco *in situ* and comparing it to other Bibiena's documented works (such as Palazzo Costa Trettenero in Piacenza painted by Ferdinando Galli Bibiena, Palazzo Ferrari in Verona painted by Antonio Galli Bibiena and Palazzo Fantuzzi in Bologna painted by Francesco Galli Bibiena), it was possible to choose the textures for the model: travertine for the entire structure and colored marble for the columns. A realistic light hit or reflected off the different surfaces of

Interpretative Reading of an Illusory Painted Wall

Figure 9. Some pictures from Ferdinando Bibiena's treatise, which helped to reconstruct the 3D-model of the scene; at the bottom some tests on the right distance between the proscenium arch on the foreground and the stairway on the background



the model, creating also shaded areas, mimicking the Bibiena's *chiaroscuro*. The light and the materials emphasized the plasticity of every elements of the scene. That point was essential to give it a realistic perception in the rendered view from the exact centre of projection (Figure 10).

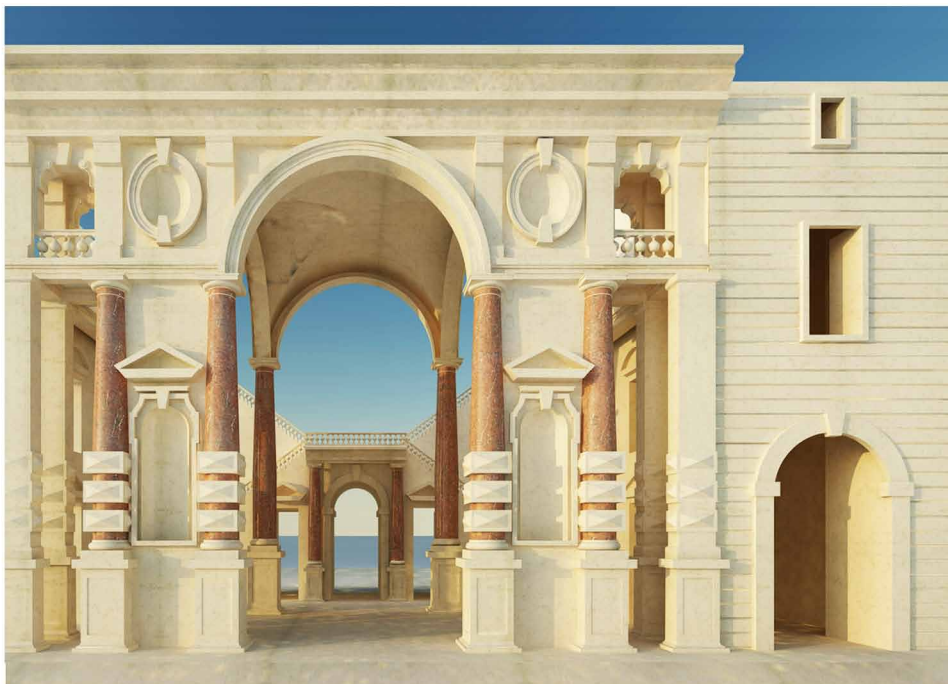
VIDEO MAPPING OF THE PAINTED WALL

The word “perspective” comes from Latin *perspicere* that means “to see through” and also “to perceive”. The second meaning relates to the most important feature of this drawing technique, because the linear perspective allows us to portray and above all to perceive an imaginary world, and to merge it with reality.

Every frescoed yard in ruins, as the one in Palazzo Vizzani, can't communicate its historical memory to the people anymore; therefore it is important to bring back its perceptive power through the computer graphic technology. The idea is to make a projection mapping of the reconstructed scene upon the very surface where it belonged, with the hopeful intent of creating a virtual *promenade* by night, available to everyone in the city of Bologna.

In the last few years the projection mapping technique has been used for many famous artistic performances: instead of projecting on a flat screen, the light has mapped to any kind of surface; it turns objects, such a building façade, into interactive displays, often with a background music as complement. Thanks to powerful projectors and to a strong perception trick is possible even to overturn, for instance, the morphology of a building, by projecting computer graphic pictures on its surface.

Figure 10. The 3d-model of the reconstructed scene, rendered from the centre of perspective projection



Interpretative Reading of an Illusory Painted Wall

During a video mapping process is important to merge carefully the virtual image with the building: the projected picture will be distorted and stretched, so by warping it previously on a computer, using special software, we can match the virtual data to the real object. So when physically the image will be projected on the wall it will appear to be undistorted.

To plan out a video mapping process we need:

- One or more powerful projectors. The most important aspect of a projection mapping is the projector itself, with its characteristic, such as: the brightness (how much light the projector put out); the resolution (a higher resolution will require higher-quality source data, we have to avoid to produce “pixelation”); the lens of the projector that influence the size of the projected image at certain distances.
- A computer with a good graphic card and the source data.
- Special software of video mapping. There are many programs to choose from, and free programs also are available.
- The real surface, that is the screen where I want to project the image.

One of the most innovative architectural firms skilled in video-mapping on architecture, the German *Urbanscreen*, uses diverse artistic tools such as: architecture remix, virtual lighting technology and virtual theatre; their aim is to wonder the viewers, providing a spatial augmented reality, exactly as the baroque artist used to do in the 18th century with an illusory painted scene.

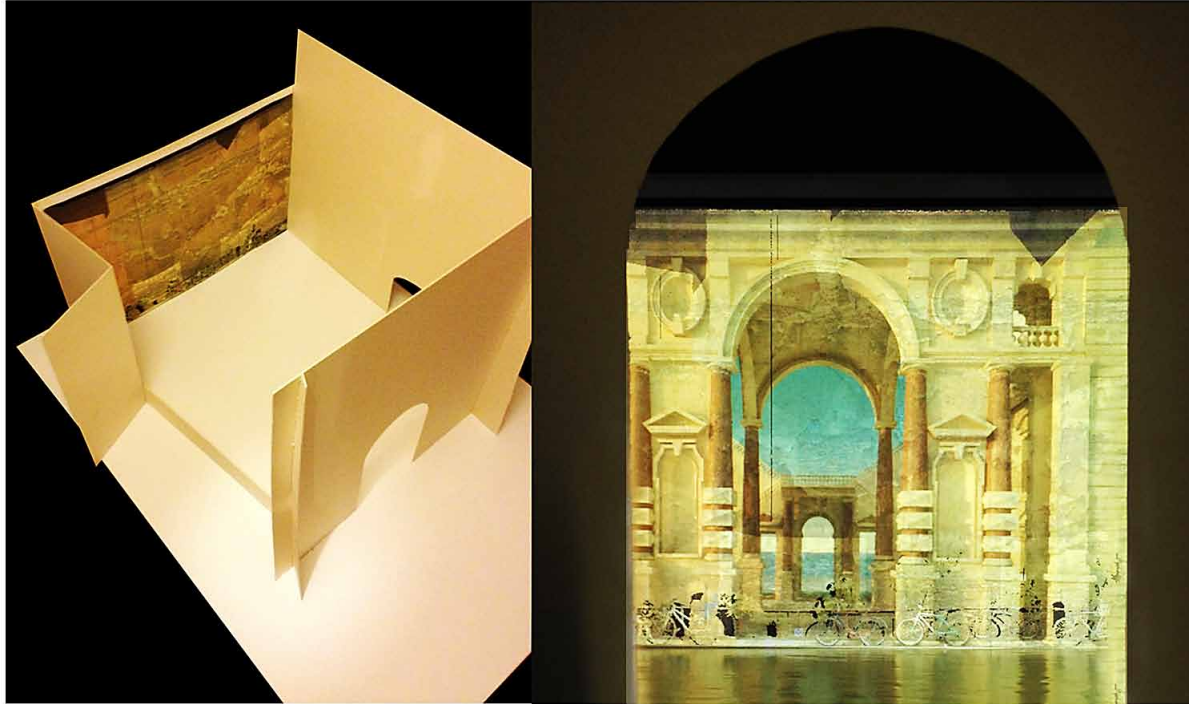
The video mapping technology can be used to entertain but also to inform people about the historical memory of a cultural heritage; for instance some ancient world scholars tried to recreate a three-dimensional reconstruction to preserve archaeological heritage.

Despite the diversity of cultural heritage application scenarios is important to highlight the computer graphic role on the enhancement of cultural heritage preservation. In that way is possible to giveback to the cultural heritage its perceptive power, but with some variations: in a video mapping process the viewer will perceive the illusory architecture by night, so the pictorial and tangible feature of a fresco will be lost; but anyway people in front of the scene will be astonished too. It’s like a sort of “metaphor” of Antonio Bibiena’s work.

It is essential to consider the video mapping limits in a scientific approach, wondering how to choose the right projector, where the projector could be placed, how sensors and monitors could transform the source chromatic data.

It couldn’t be possible to make physically the video-projection on the painted wall in Palazzo Vizani; therefore to make a truly simulation of the scene’s video mapping has been created a *maquette* of the building’s yard, where the painted wall measured 75 x 50 centimeters. After having included the orthophoto image of the painted wall to make it similar to the real wall, the four phases of the experimental method have been projected on it, in a four-frames sequence: the survey of the wall, the digital drawing of the fresco’s elevation, the perspective restitution of the scene and finally the reconstruction of the three-dimensional model (Figure 11). The image has been warped by using a special software (*Resolume Arena*) to match the projection to the *maquette*. The sequence has been projected from the right position, the aforementioned centre of perspective projection, where the viewer was supposed to

Figure 11. On the left the yard's maquette with the orthophoto of the scene, on the right the video projection of the reconstructed model of the scene



be standing to admire the perspective illusion. The video mapping must be visible from the building's entrance, with the aim of attracting people inside the building and with the aim of making once more the building unique and customized-looking in the city scenario.

By using this method people could be intrigued and motivated to know the history of a long-forgotten cultural heritage. It is important to find a new communication strategy, able to re-establish a direct dialog between the frescoed wall and the viewers, aiming at promote an appropriate preservation of the cultural heritage.

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KEYTERMS AND DEFINITION

Center of Perspective Projection: In linear perspective we can simulate a three dimensional space on a two dimensional surface and it depends on a single point of view, the center of perspective projection; it is the eye of the viewer, where visual rays converge from all objects. The viewer by standing at the centre of perspective projection could imagine a space without boundaries.

Interpretative Reading of an Illusory Painted Wall

Chiaroscuro: It's a pictorial technique; it consists in a particular treatment of light and shade in a drawing with the intent of bringing out a three-dimensional perception.

Inverse Perspective: It's an inverse operation, thanks to the perspective rules it's possible to draw plan and section of an object painted in perspective, starting from its vanishing point and its distance point.

Projection Mapping: Also known as video mapping, is a projection technique where instead of a flat screen the light is projected on real objects as a building façade. Thanks to this technique is possible to merge a virtual content with physical objects.

Quadratura: Quadratura genre is an illusory type of architectural painting that uses the perspective technique to create the illusion of a three-dimensional space on a plane or vaulted surface. It has its roots in both art history and perspective technique, since its executors needed to have not only extraordinary painting skills but also knowledge about optics and geometry.

Vanishing Point: Or "point at infinity", in a perspective composition is where parallel lines seem to converge; it lies on the horizon line.

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