proceedings IMMAGINI? MDPI

Proceedings

Perspective Applications for Interior Design. Planimetric and Altimetric Restitution of Pictorial Images †

Giuseppe Amoruso

Politecnico di Milano, Dipartimento di Design, 20158 Milano, Italy; giuseppe.amoruso@polimi.it

† Presented at the International and interdisciplinary conference IMMAGINI? Image and Imagination between representation, communication, education and psychology, Brixen, Italy, 27–28 November 2017.

Published: 17 November 2017

Abstract: "As soon as perspective ceased to be a technical and mathematical problem, it was bound to become all that much more of an artistic problem" (Panowsky, 1927). The solid perspectives of Bramante, Palladio-Scamozzi, Borromini and Bernini built a true architectural space, emphasizing its perceptual nature in relation to the ideal spectator. The research presents an application of "altimetric and planimetric restitution" of pictorial images to reconstruct spatiality through the realization of physical and digital models. From the perspective analysis of Arduino Cantafora's works, plans and elevation were drawn in order to build the physical model and visualize its formal qualities.

Keywords: perspective; solid perspective; 3d modeling; altimetric and planimetric restitution; interior design; representation

1. Introduction

"As soon as perspective ceased to be a technical and mathematical problem, it was bound to become all that much more of an artistic problem. For perspective is by nature a two-edged sword: it creates room for bodies to expand plastically and move gesturally, and yet at the same time it enables light to spread out in space and in a painterly way to dissolve the bodies" [1]. This assumption is still of extreme validity today by addressing the use of perspective representations by designers to visualize and communicate the spatial characters of their projects.

Robin Evans, before his death, wrote *The Projective Cast: Architecture and Its Three Geometries* where investigates about the relationship between geometry and architecture, drawing on mathematics, engineering, art history, and aesthetics to unveil processes in the imagining and design of architectural form. Geometry does not always play a stolid and dormant role but It is used as a strong tool between thinking and imagination, imagination and drawing, drawing and building. A theory of architecture, according to Evans, that is based on the multiple and possible interactions between architecture and geometry. *The Projective Cast* shortlists the geometry of designers, asking whether they are in fact the stable underpinnings of the creative, intuitive, or rhetorical aspects of architecture. History of architectural projection, intended as the geometry of vision, is granted for the fundamental role in the development of the "pervasive pictorial method of construction and that, until now, has played only a small part in the development of architectural theory". [2]

It is unknown in which way knowledge of geometry and psychology of vision, introduced by the Greek, Arab and Latin treaties of optics, very popular in the XIII and XIV, have generated techniques to experiment illusionistic sculpture and architecture, optical corrections and, about painting, systems of representation of the three-dimensional space of perspectival type, which developed precisely in this age [3].

During Renaissance the concept of architectural space often coincide, or at least is directly associated, with the central perspective or with the psychological and perceptive phenomenon, a mathematical artifice that had to produce a complete sense of wonder. A consequence was that the design intention "*was conceived on the basis of experience derived from the conceptual perception of an apparent world, as a result of the images artificially created according to the perspective representation*" [3]. A perspective, that had to be truthful, exact, rather than symbolic and full of meanings and that was to reassure mathematicians, artists and architects who described in detail the practical and universal methods; this is the perspective of treatises, from practice and also of art scholars who have highlighted its qualities in relation to the masterworks they generated.

The physical products of perspective interpreted as psychological issue by directing attention to the cognitive-perceptual processes that perspective representations trigger building perceptive universes with high spatial value.

This is the field of study that James Jerome Gibson called *picture perception*; he developed the idea that objects in motion are stimulating more vision than static ones. Among his contributions that of the perception unmediated by other mental processes which selects perceptual invariants which remain constant regardless of the perception variation [4].

Further interesting is the psychology of perspective, the link between the projective and geometric tool and the concepts that allows to transmit to its users; in this transformation process artists had the role of setting up specific processes of perception and experience of works creating a conflict between the experience derived from the painting observation, with that one derived from the observation of the environment in which the work was inserted [5].

From the apparent perceptual discontinuity introduced by the perspective work, comes the dialectic experience, namely the formation of the concept of use or fruition; the intrinsic space of the painting, immutable and related to the perspective projection, interacts within the space of the real environment in which you can move freely and where the point of view become the position of the observer.

Experimental researches in the field of cognitive psychology have outlined the "strength of perspective" concept, a topic already described by Leonardo. The demonstration of why perspective representations appear deformed and unexpectedly retain their spatial coherence, even if observed from different and far points of view not standing in the geometrically fixed eye-point, the unique observation parameter used for their construction. Further studies have revealed many cases of perspectives in which the spatial position of objects or depicted environments seem to change their orientation in depth according to the position movement of those who watch them, giving the idea that objects are seen to point in the direction of the observer even by following the movement.

2. Relief-Perspective and the Science of Appearance

In the researches carried out over the last 5 years, numerous examples of perspective-relief or solid perspective have been analyzed (Bramante, Palladio-Scamozzi, Bitonti, Borromini, Bernini); this is a perspective application for modifying the perceived architectural space. (Figure 1) These methods, nowadays almost unknown and which have been part of the long tradition of Italian perspective and scenography, can still be of great value both for education in the field of descriptive geometry but also for interior designers.

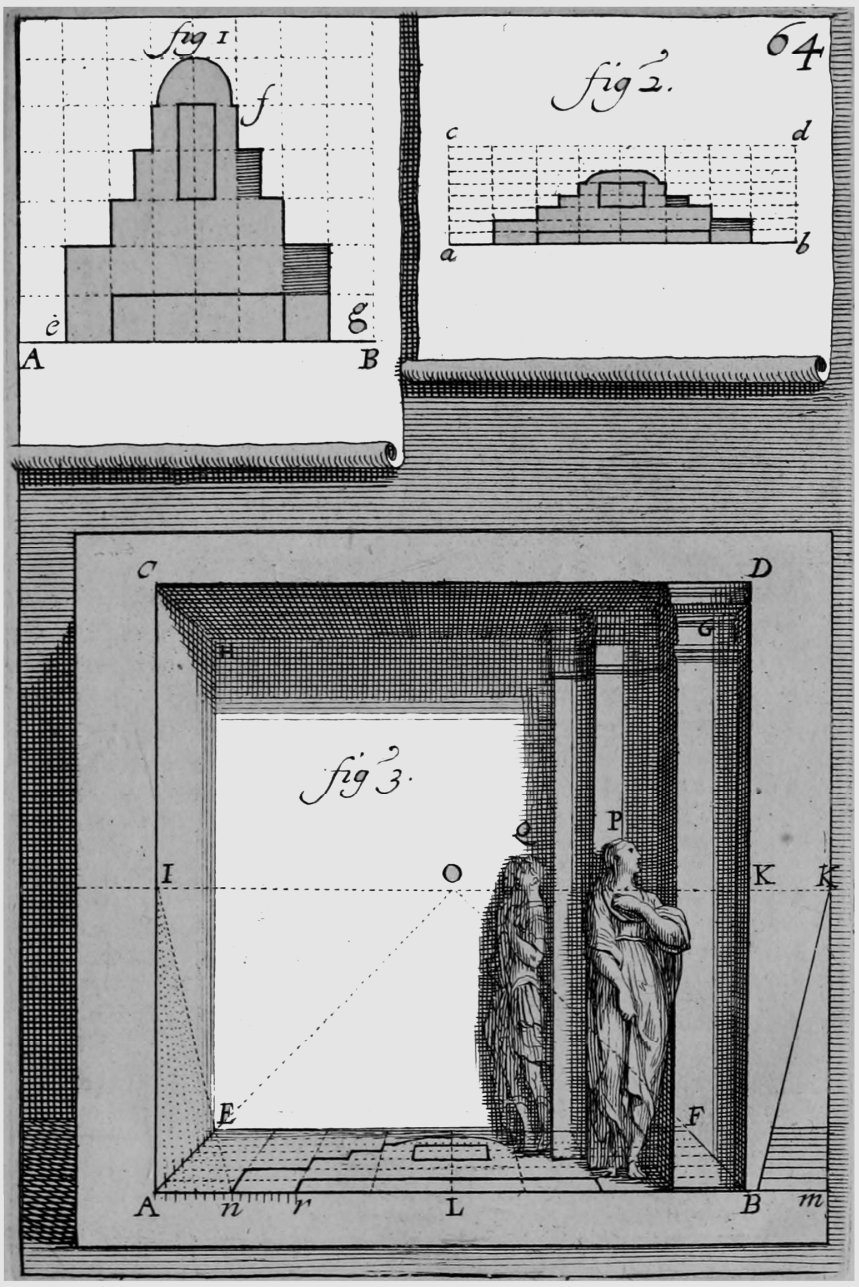

Figure 1. The projective system of the relief-perspective by Bosse that explains how to do the *echelles perspectives* (perspectival scales) in the relief-perspective according to the ordinary concept of *echelle fuyante* of the linear perspective. *Traité des pratiques geometrales et perspectives* by Abraham Bosse (1665), Planches 64.

The altimetric and planimetric restitution method has been applied to perspective concepts from sketches or paintings with the aim of reconstructing spatiality through physical and digital models. Perspective analysis has allowed to extract floor plans and elevations of rooms painted by Arduino Cantafora; subsequently, a 3D model was created to visualize the painted space, assumed as virtual or perceived environment.

In the *Histoire de la Perspective ancienne et moderne*, Poudra defines perspective as the *science des l'apparences* in continuity with the tradition of scientific studies about optics that was resumed in the popular medieval text *De aspectibus* attributed to the Arab scholar Ibn al-Haytham, known in the West as Alhazen (965- c. 1040 AD).

From the applications of plane perspective, the concept of appearance underwent a gradual evolution up to the dynamic and total involvement of the viewer through the material construction of spatial experience and the consequent perceptual effect. [6].

The research project identifies the illusory design parameters in relation to the use of perspective drawing and its material reproduction, from the concept to the perspective tools to achieve perceptual effects and architectural space experience, we can scientifically determine methods from the appearance and subsequently verify their reproducibility and building variations, and also the most appropriate operational and conceptual features, both by means of manual modeling and by using digital systems.

The research has therefore pointed out the classification of the techniques for the practice of relief-perspective coming from the need to improve and correct spaces, known as optical corrections, to the beginning of scenography with the contribute of Donato Bramante, till the birth of a new field of design, the illusory project and the building of deception into architectural spaces. (Figure 2)

Perspective, despite being a tool more than effective for the representation of the real, especially for its ability to improve the perception of the third dimension, cannot be taken as a mere product of visual perception. It "*contributes only to create the evocative illusion of infinite spaces resumed in the synthesis of the correct geometric construction that can be performed on the plane (linear perspective) and in the space (scenographic perspective) or, according to the opposite approach already used in Greek architecture and, later theorized by authors such as Dürer and Serlio in the sixteenth century, to usefully slow down the vanishing effects in certain applications relating to architecture and urban design*" [3] (p. 18).

In the design practice, in different ages, they are documented examples in which, constructively, a three dimensional effect was used to improve its usability according to perception needs; after the initial state of wonder, the spectator can recognize the signs of accelerated or delayed perspective convergence compared to that one which occurs, naturally, in visual perception. The geometric principle to which these effects were inspired is the "relief-perspective", otherwise known as "solid perspective", built in the form of permanent stage or as a scenography and temporary installation, as the most popular field of adoption.

Filippo Camerota supports the unquestionable merit of Bramante, namely "to have first demonstrated the architectural potential of linear perspective that in the next two centuries would be expressed through the development of scenography, the quadraturism, illusory architecture and the theoretical reflections about the optical proportions of buildings".

And again: "... Here the architectura ficta and the built one are interpenetrated and mutually fitted. More precisely, the perspective ceased to be a problem of painting applied to architecture and became a full architectural tool itself: the prospectiva aedificandi. The choir is not prospectively solved pictorially but plastically, with the same materials which was in place in the building; nor is it a solution to the sculptural relief since it has its own structural logic and is designed, at least conceptually, as static and spatial support of the dome." [7]

The solution proposed by Bramante will become soon a widely used method in stage design and illusory architecture of the Baroque period, while remaining a unique case of whole architectural space built around an architecture perspective. Andrea Pozzo paid tribute to Bramante in his treatise on the architectural perspective and the illusory frescoes.

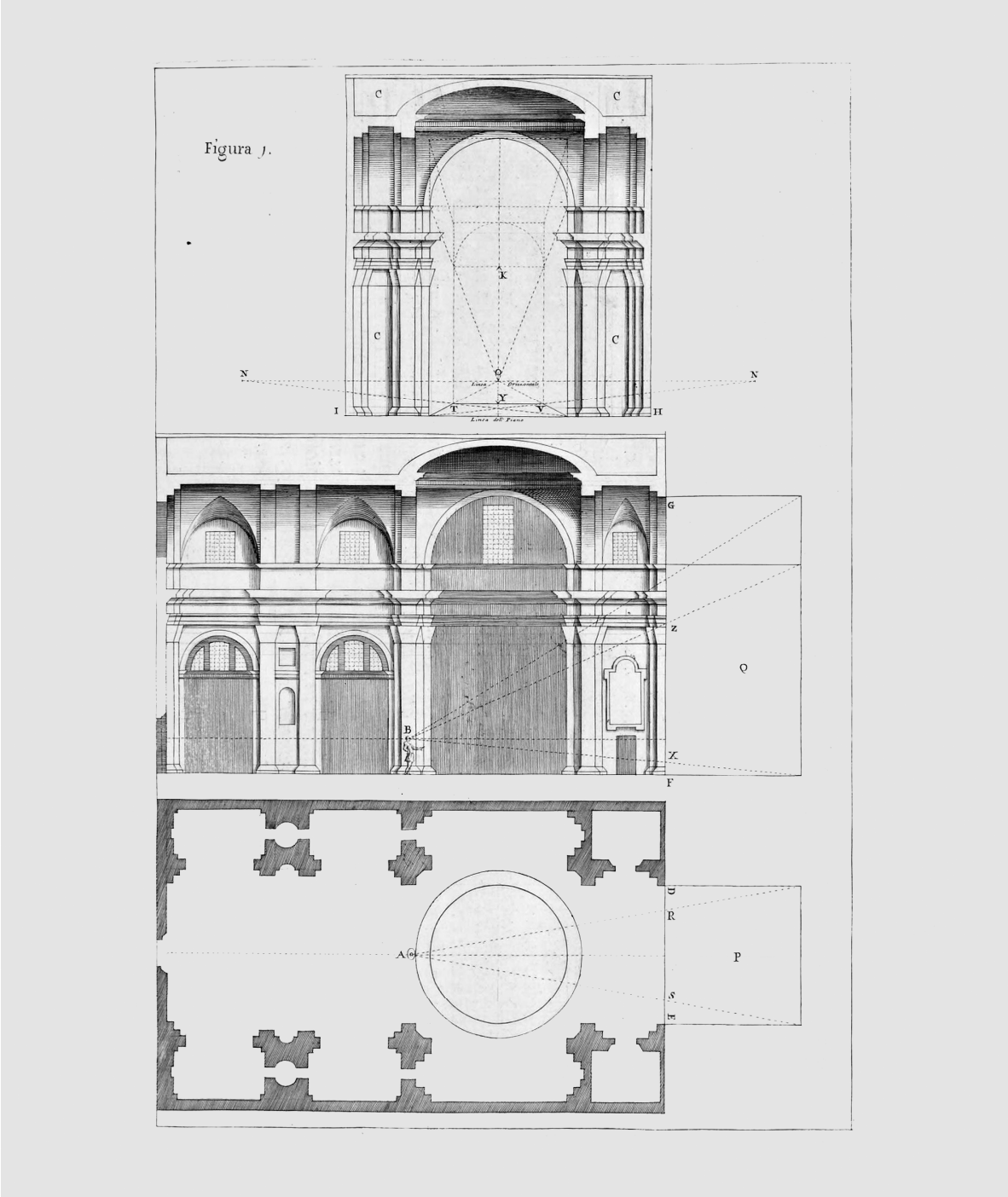

Figure 2. Andrea Pozzo in the first illustration of his treatise *Perspectiva architectorum et pictorum*, published in Rome in 1697, quotes Donato Bramante and its relief-perspective application to "extend" the choir of Santa Maria at San Satiro church.

The scientific theory of perspective, since the Renaissance, has evolved through practical applications primarily in the field of painting where painters had introduced the use of the principal point and also of the horizon line, the perspective of the grid and the diagonals of the ground floor; further applications were about methods of construction of perspectival scenography or technical design of scenes.

Camerota describes these achievements as "material" perspective that mark the transition from the pre-baroque space, in which the projective methods are used to "correct the deceptions of vision to safeguard the proportional order of the architectural elements", to a new concept of space where

the design address a "*deception research by creating imaginary spaces that go beyond the physical limit of the built environment*". [7]

Unlike what occurs in the case of linear perspective, in which the three-dimensional effect is obtained by projecting its image on the picture plane, the graphic construction of the perspective is located in the real space according to the position of the picture plane; this surface is integrated into the architectural environment and it is related to the point where the viewer is located enabling the correct use of the illusory design. This homology is, in fact, the perspective of figures that inhabit the objective space, projected on a second space superimposed on the first.

The projective geometric procedure of graphic correspondence is based on considerations relating to the correspondence of points, lines and planes according to the solid homology whose center is represented by the point of view; therefore, the construction of the three-dimensional perspectival image starts from axis-plane, on which the proportional scale is true, and it is developed in the space between this and the so-called limit-plane, locus of points at infinity of objective straight lines belonging to the above mentioned space. This methodology, a real method of representation of the three-dimensional space, it was necessary to build scenographic systems that had to be reduced to the limited size of a theater stage; it was improved the projective-graphics system to draw and build the transformed ground floor of a theatrical stage in order to give the illusion of a great depth in a much smaller space. The originality of such scenic design was not only in the architectural design, but in the innovation of building a great system in accelerated perspective, fitting in every part the observation issues and developing a practical design application according to the rules inspired by the studies of optics. (Figure 3)

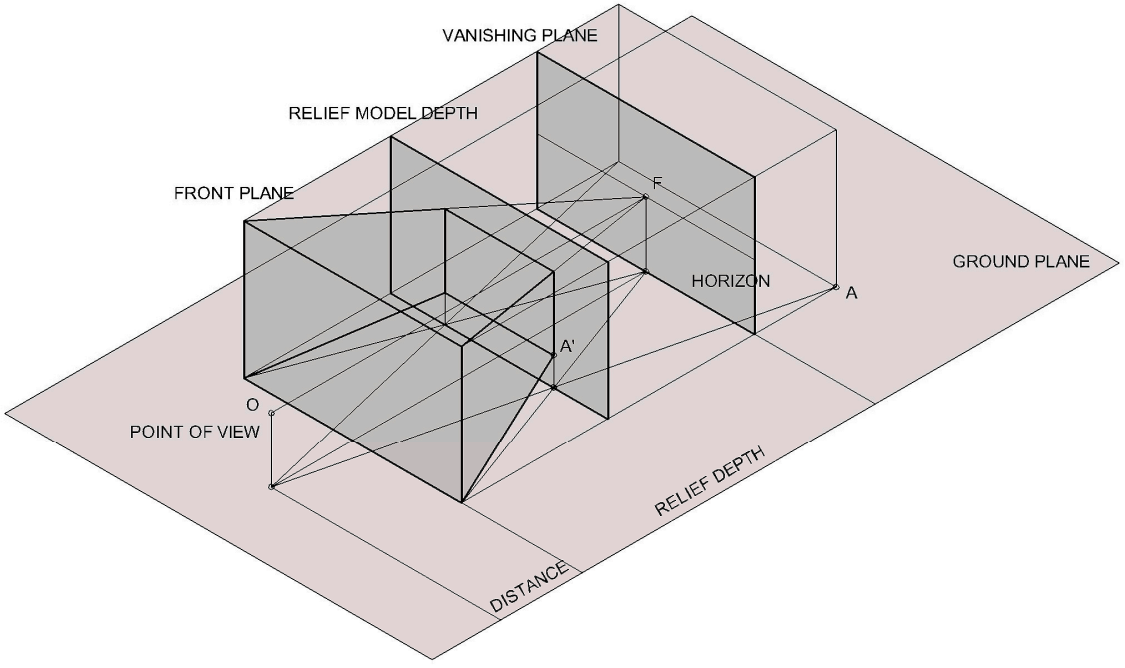

Figure 3. The projective system of relief-perspective.

Starting from the *stiacciato* technique, popular in the field of sculpture, Bramante developed an architectural application called solid perspective or perspective-relief from the established term in use in the artistic production of bas-reliefs. According to Poudra "*the perspective-relief is an extension of the perspective plane, or rather the linear perspective is a special case of the perspective-relief. While this one applies, in general, in all the arts of imitation, linear perspective is convenient for painting and drawing*". In his treatise Poudra speaks about a new application of descriptive geometry and he makes an appeal to those who study this science, more specifically those people who deal with the arts of imitation, as well as sculptors of bas-reliefs, painters of decorations and stage scenery, and builders of diorama

and panorama; he also argues that "*finally architects will find the tools to change advantageously the interior or exterior appearance of buildings*" [8] (p. 1–2).

So this application has a specific practical aim but also a geometrical reason which lies in the projective process which, by means of the rules of perspective, transforms objects of the space according to a collineation process; it creates a solid homology between the real space and the space that undergoes the transformation and then the perspective contraction.

The passage from the three-dimensional (or solid) image to the planar one as usual in the perspective of descriptive geometry takes place simply by reducing, until nullify it, the depth of the space that is supporting the image.

The distance between the two planes, that is a specific parameter of the solid perspective because it generates different reliefs starting from the same real space, is called anisotropy, i.e. can be described as the gradual compression of the scenographic space in-between the two plane and its expansion outside them.

Migliari has shown that the projective understanding of the solid perspective actually unifies methods, projective and mathematical, and that such representation methods both use the solid perspective to generate the images of the represented objects and that this projection can be expressed through several way, according to the specific method in which it operates [9] (pp. 22–29).

3. Methodology and Results

The research has proved particularly interesting points, since very often parallels and feedback have emerged among the works of Bramante, Bitonti, Borromini and Bernini and between what it has been found in written documents as in the Poudra treatise and what was actually been built.

The methodology applies the altimetric and planimetric restitution method as in use in the scenography to build scenes from perspective; is a method that belongs to a long cultural tradition that, for example, has been the protagonist of an entire family and dynasty of artists such as Bibiena family in Bologna. Therefore, this is a projective project (or cast) so that the scenic image can be placed inside the stage or become part of an interior; it does not represent space as it is in reality but represent it in its projective construction.

Perspective architectures and scenographic installations made throughout the sixteenth century, such as the Bramante perspective chorus in Milan, testify that design application for prospective restitution was largely in use. Despite this remarkable practical diffusion, only in the *Perspectivae Libri sex* by Guidobaldo del Monte (Pesaro, 1600, libro II) and in the *De Perspectivis* by Simon Stevin (Leyda, 1605) will be described the method then outlined more modernly by Brook Taylor in the *Principles of Linear Perspective* (London, 1715).

According to Ricchelli, "perspective restitution has numerous disciplinary and didactic interests. [...] Restitution of an object in its real form completes the understanding of the Renaissance perspective methodology by one point outlining, through the legitimate construction and the reconstruction of visual pyramid, two fundamental concepts. Perspective as result of the planar intersection and its correspondence (in geometric and projective terms) to the graphic transcription of the visual phenomenon of perception of depth of field and the consequent information." [10] (p. 102)

From the image drawn in perspective, the restitution allows to graphically describe the three-dimensional configuration and the original metric values of the depicted space including the description of objects.

To build the spatial concept it is used the perspective directly built on the picture plane, which in the case of a theater, has the proportions of the proscenium, 8:5 ratio. [11] Then it possible to draw directly on the stage designer or painter sketches: in the case here presented, perspective images are from a series of interior paintings by Arduino Cantafora. The goal is to build the analogous model that represents the space depicted in the painting and makes the pictorial work perceptible and accessible in direct or scenic mode. The concept of fruition can be extended if the model, besides being physically realized, is also modeled with digital tools.

The perspective picture plane is split halfway through the axis of symmetry, whose position does not coincide with the principal point. The view point is placed on the axis of symmetry, ideally at a distance from the ground line equal to one and a half times the width of the proscenium; the ground line overlaps to the top edge of the perspective view.

In the restitution of the ground floor plan, the depth line is established parallel to the picture plane, at a one-third of the stage depth distance. The proscenium edges are extracted by tracing the perpendiculars on the picture plane of the ground floor plan, and in the same way, the perpendiculars of the points x and y are traced which meet the picture plane at the points x1 and y1.

To find the corresponding points to x and y, it is drawn a straight line from the view point, passing by x, and then a second line that passes by y, until intersecting the bottom line respectively in x e y restituted (named as x1 and y1): this is the operation that is defined "targeting" i.e. projecting a point on the restituted ground floor plan through a projecting ray that originates from the viewpoint. The graphic process concludes by joining point A with x1, and B with y1 and tracing the perimeter of the ground floor plan or scene footprint on the stage. (Figure 4)

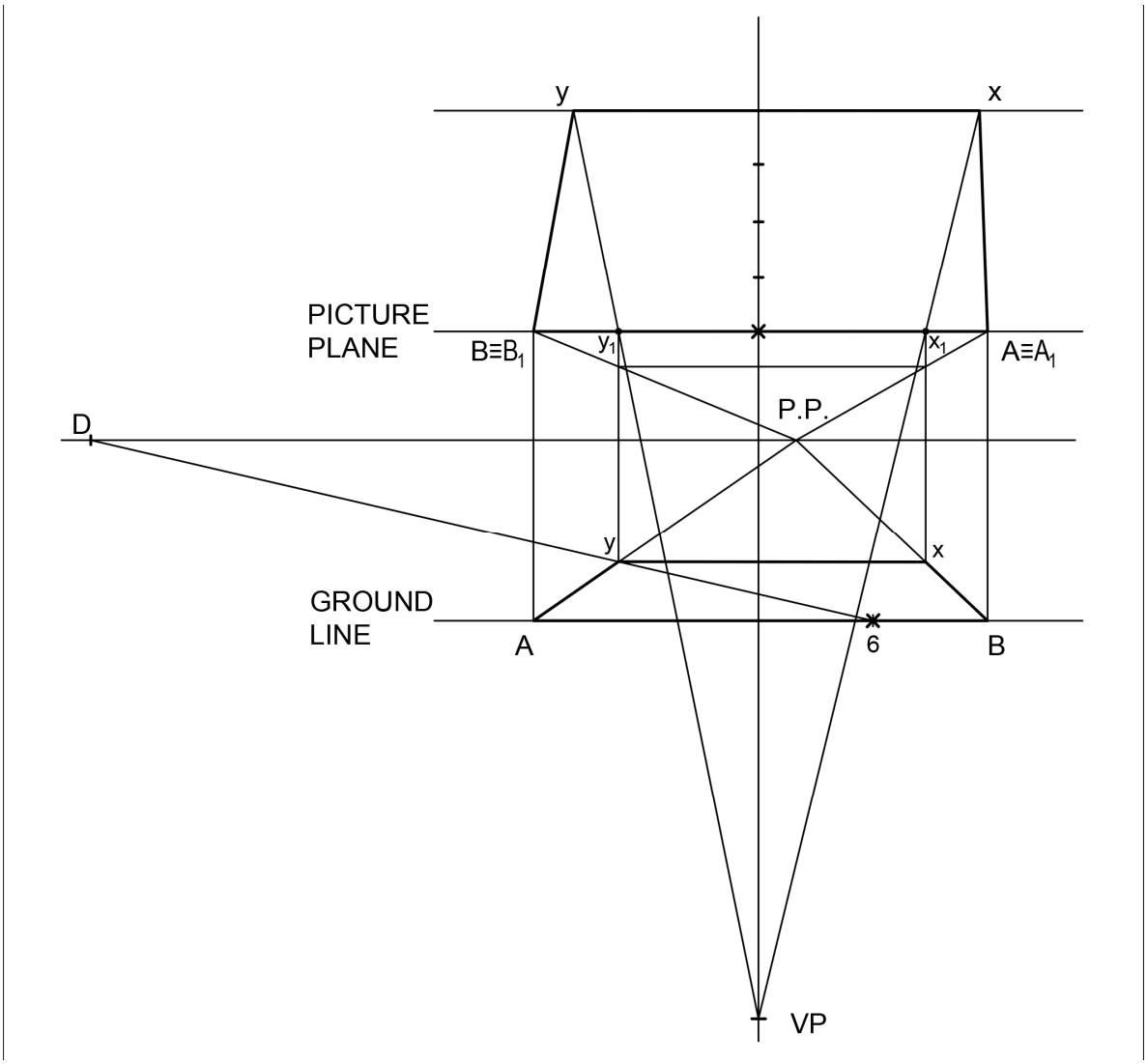

Figure 4. The perspective built directly on the picture plane is the preliminary operation to draw the restituted ground floor plan of a scene or of an interior design concept.

The three-dimensional model becomes the environmental synthesis of the concept that helps the designer in verifying and evaluating design key features, or make possible to build a perspective space that then becomes a stage or theatrical setting. From Cantafora paintings, the process makes available a line drawing of image perspectives, the first phase before operating the restitution. The

restitution parameters are related to the depth of the model that according to the design of sceneries technique corresponds to the size of the stage and therefore the practicable area where the scenes can be built. Another preliminary issue to the construction of the model concerns the size of the proscenium or the perspective picture intended as a rectangle characterized by base and height. It is necessary to know the picture plane dimensions and the depth of the scene to follow the workflow and fix the viewpoint; these parameters allow to draw the restitution as shown in the example. The restitution works geometrically on the perspective allowing to draw the profiles of the walls to be constructed as scenery flats or sections. Subsequently, projective operations are carried out to obtain the dimensions of architectural elements such as doors, windows and stairs. (Figure 5)

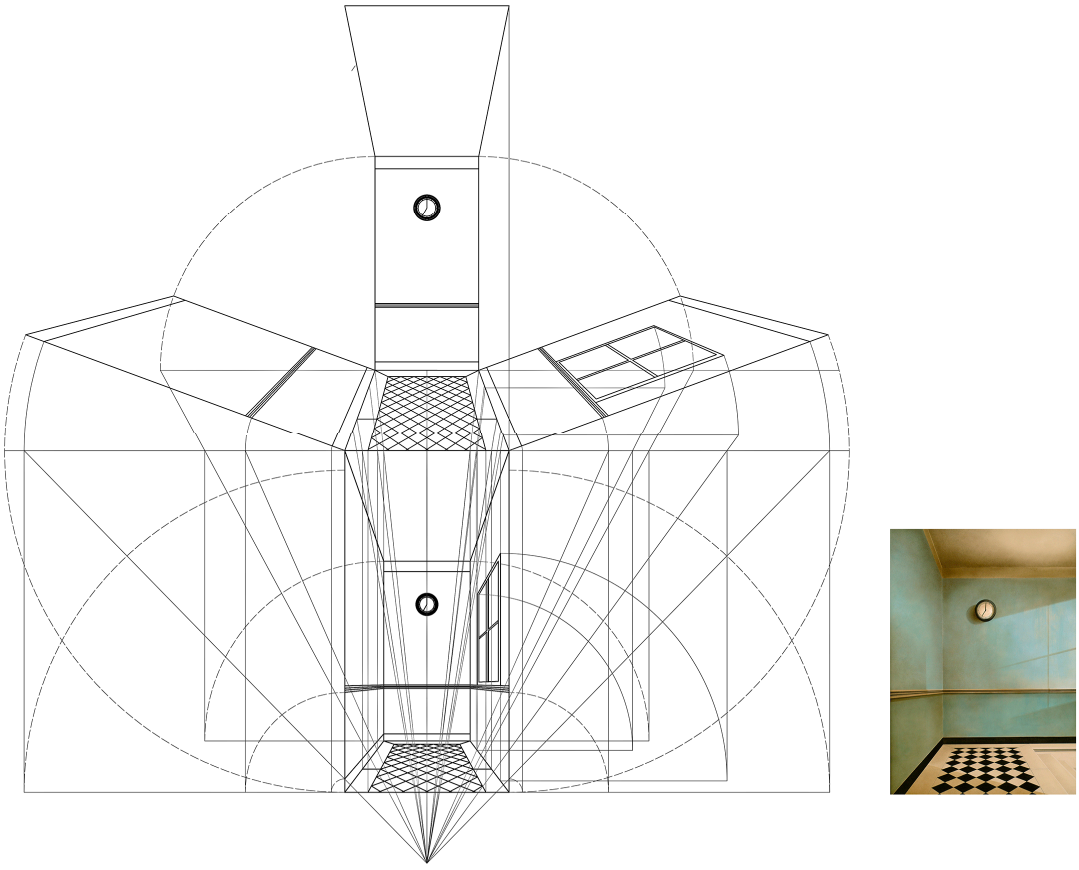

Figure 5. Planimetric and altimetric restitution method of the perspective of a painting. Arduino Cantafora, Avec le Temps I, 2016, vinyl and oil on table.

The methodology is undoubtedly laborious, in the past it was executed manually by extracting the scenery flat profiles for each prospective plan. Today, the use of digital representation tools has certainly privileged its rediscovery, and digital modelling allows to study their assembling, production and installation. After this phase, the application followed two operational methodologies, on the one hand, the construction of a verification model according to the traditional techniques, made of vegetable cardboard shaped according to the prospective scenes obtained from the restitution and then hand-colored with watercolor layers for characterize its surface appearance. (Figure 6).

Figure 6. Physical model of the planimetric and altimetric restitution.

Similarly, in the other case, the digital modeling of the perspective interiors has been carried out, developing the graphic exploitation of the parameters mentioned above. The digital model can

also be animated and then used for the assessment of materials, textures, illumination and perception of the scene if , for example, has to be placed inside a stage or a theatrical space. (Figure 7)

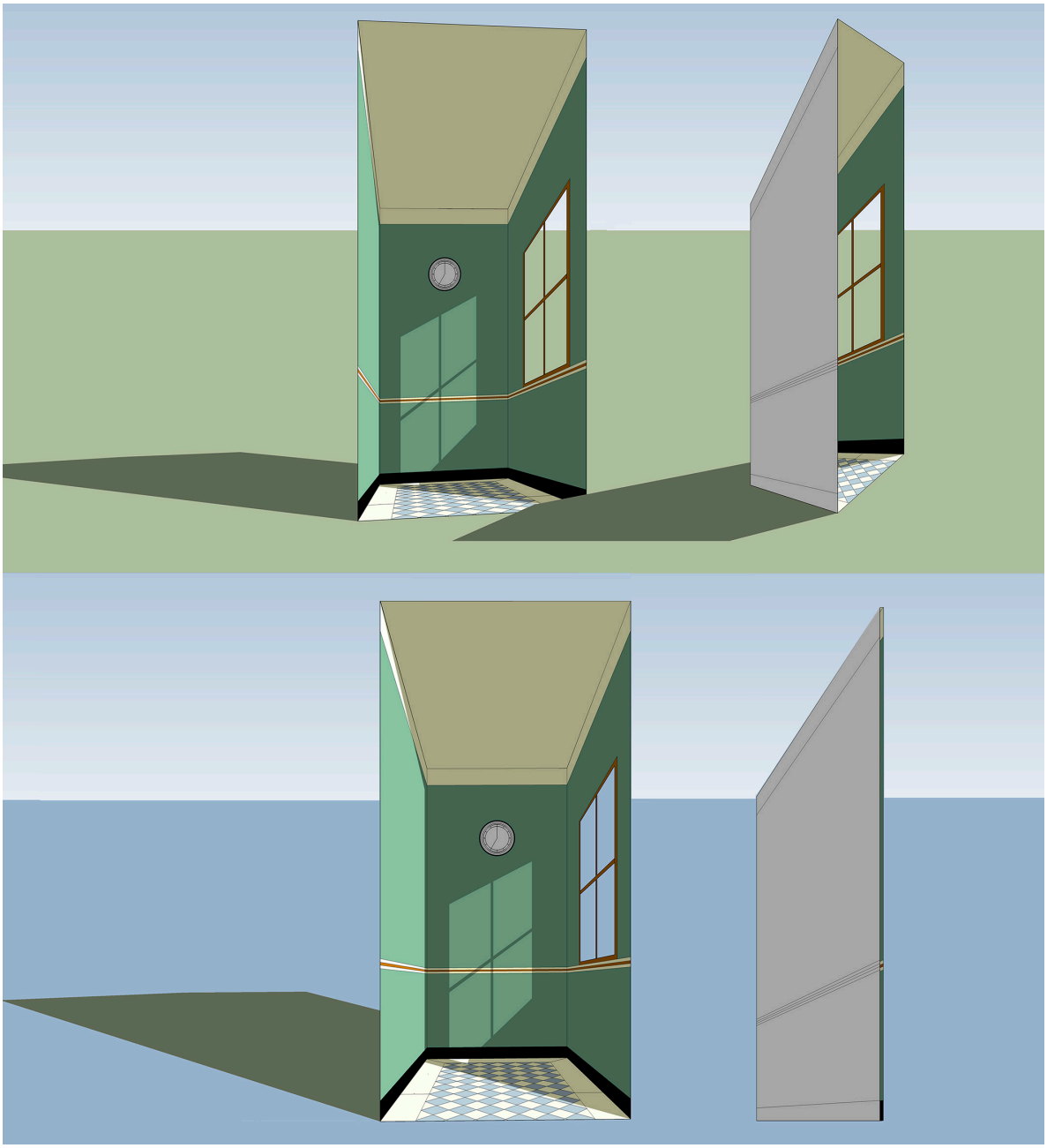

Figure 7. Digital model of the planimetric and altimetric restitution. Preparatory sequence for animation and assessment of the projective model.

4. Conclusions

The classification of illusory techniques for design of interiors, according to a specific process of graphic analysis, has proved to be operations aimed at highlighting the fundamental and universal principles that still can guide the creative process of the interior design.

The challenge is to make the role of representation more effective and attractive if we pinpoint knowledge and practical solutions coming from treatises and traditional practices. In the contemporary age digital technologies give a strong support to rediscover and improve projective methodology and the formation of images. In this directions is challenging to build physical models from images drawn in perspective and to model and print perspective interiors in a short and effective loop. The simulation of environments through the projective transformation of images,

drawings, perspectives allow to make representation closer to the spatial and physical understanding of reality.

The research here presented is demonstrating, one more time, how design representation can intervene, adding value, in the processes of concept development in the practice of interior design; representation and graphic approach consolidate its role, identity and value even through the study, documentation and transmission of such graphic methods. One more direction of research will be to set up a graphic repository of perspective techniques as found into the studied treatises unifying graphic conventions and glossaries introduced by designers, artists and mathematicians.

Conflicts of Interest: The author declares no conflict of interest.

References

1. Panofsky, E. *Perspective as Symbolic Form*; Zone Books: New York, NY, USA, 1991.
2. Evans, R. *The Projective Cast. Architecture and Its Three Geometries*. MIT Press: Cambridge, MA, USA, 2000.
3. Fano, G. *Correzioni ed Illusioni Ottiche in Architettura*; Dedalo: Bari, Italy, 1979.
4. Gibson, J.J. *The Perception of the Visual World*; Riverside Press: Cambridge, MA, USA, 1950.
5. Kubovy, M. *The Psychology of Perspective and Renaissance Art*; Cambridge University Press: Cambridge, MA, USA, 1986.
6. Poudra, N. *Histoire de la Perspective Ancienne et Moderne*; J. Corréard: Paris, France, 1864.
7. Camerota, F. *La Prospettiva del Rinascimento. Arte Architettura Scienza*; Electa: Milano, Italy, 2006; pp. 249–250.
8. Poudra, N. *Traité de Perspective-Relief*; J. Corréard: Paris, France, 1860; pp. 1–2.
9. Migliari, R. Drawing in Space/Disegnare nello spazio. In *Disegnare Idee Immagini* n° 38/2009; Gangemi Editore: Roma, Italy, 2009; pp. 22–29.
10. Ricchelli, G. La restituzione prospettica. In *Teorie e Metodi del Disegno*; Scolari, M., Bertan, F., Boraso, S., Filippi, S., Ricchelli, G., Trevisan, C., Borgherini, M., Eds.; Città Studi: Milano, Italy, 1994; p. 102.
11. Lenzini, P. *Lo Spazio Figurato. Breve Itinerario Dall'antichità al Rinascimento*; Editrice Press-Coper: Bologna, Italy, 1989.