Digital & Documentation V5

From virtual space to information database

edited by
Francesca Picchio

PROSPETTIVE MULTIPLE
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From Virtual space to Information database

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The volume consists of a collection of contributions from the seminar "Digital & Documentation: From Virtual space to Information database", realized at the University of Pavia on the day of September 19th, 2022. The event, organized by the experimental laboratory of research and didactics DAda Lab. of DICAr - Department of Civil Engineering and Architecture of University of Pavia, promotes the themes of digital modeling and virtual environments applied to the documentation of architectural scenarios and the implementation of museum complexes through communication programs of immersive fruition. The fifth Digital and documentation conference was also the inaugural event of the first Pavia DigiWeek, held from 19 to 23 September 2022 in Pavia.
The event has provide the contribution of external experts and lecturers in the field of digital documentation for Cultural Heritage. The scientific responsible for the organization of the event is Prof. Francesca Picchio, University of Pavia.

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This publication is made with the contribution of DICAr, Department of Civil Engineering and Architecture of University of Pavia, through the joint research of the experimental laboratories DAda Lab - Drawing Architecture Document Action and PLAY - Photography and 3D Laser for virtual Architecture LaboratorY.

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The event "Digital & Documentation, V.5" has seen the participation of professors, researchers and scholars from University of Pavia, Politecnico di Torino, University of Rome "La Sapienza", University of Palermo, University of Catania, Politecnico di Milano, University of Ferrara, University of Florence, University of Basilicata, University of L'Aquila, University of Salerno, Gdańsk University of Technology (Poland), Nanyang Technological University (Singapore), Universitat Politècnica de València (Spain), University of Salerno, University of L'Aquila, Lublin University of Technology (Poland), Cracow University of technology (Poland), University of Cordoba (Argentina).

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PART 1 - PERCEPTION: VIRTUAL SPACES, SIMULATIONS AND INTERACTIONS

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PART 2 - Information Databases and Information Systems for Architecture

Panelists

Flavia Camagni

University of Rome "La Sapienza"

Architect, Phd awarded in 2021 at the Department of History, Design and Restoration of Architecture at Sapienza University of Rome. During this training she has developed studies involving representation and in particular perspective, both in its historical and current aspects with particular attention to architectural perspectives and perspective wooden inlays. These studies are often conducted with the help of digital three-dimensional models based on the study of drawings, perspective restitution and survey data and aimed at the enhancement of the studied assets through the use of new technologies in the field of representation.

03 SPATIAL PERCEPTION IN ARCHITECTURAL PERSPECTIVES: VISUALIZATION THROUGH AR E VR SYSTEMS

Abstract

Those who observe a painted, drawn, carved, or sculpted perspective perceive three-dimensional spaces and environments that are not, however, present in reality. Similarly, the user using VR and AR systems perceives spaces and elements that are not physically tangible.
These technologies allow, through the use of three-dimensional models, to simulate scenarios and interactions with strong communicative power that introduce themes such as the perception of illusory spaces, thanks to their fundamental characteristics such as immersiveness and interaction, through which the user comes into contact with virtual scenarios.
The paper presented intends to reflect on this analogy, relating it to the suggestive aspect that quadratures could arouse in the viewer of the time, deceiving the eye and dilating space, and the interest that new technologies stimulate in the contemporary viewer.
This relationship allows us to make the most of the perceptual component of these experiences and to reflect on the contribution these technologies can have in the study of Architectural Perspectives.
This paper discusses some applications and consequent reflections arising from different case studies, which have different dimensional characteristics and made with different techniques.
In particular, it aims to bring to light the different types of interactions that the user can get from the use in new technologies if they are applied to the chosen theme. And again, understand how, through perceptual experience, illusory space can best be represented with the selected digital tools.
The use of these instruments for the study of Architectural Perspectives is intended to represent the innovative contribution that this study proposes, relating to the suggestive aspect that quadrature could arouse in the viewer of the past, deceiving the eye and dilating the space, and the interest that new technologies stimulate in the contemporary viewer, capable of astonishing and showing new realities.

Introduction

Perceiving space is a simple yet complex exercise involving the senses. This exercise is practiced every day and in every context because a right understanding of the environment around us is necessary. Therefore, when we are faced with systems that simulate spatial effects, our brain generates a response, which is always mediated by our experiential background.

This kind of response is obtained when looking at Architectural Perspectives[1], a figurative genre, which aims, through the use of perspective, to trick the eye by representing three-dimensional environments.

Just as perspective, which found its codification and wide use in artistic production in the Renaissance[2], aimed to surprise the viewer by deceiving the eye and arousing awe, Virtual Reality and Augmented Reality[3] also want to surprise the user by catapulting him or her into virtual scenarios (Fig. 1).

Because of the vast heritage that makes up the genre, case studies will be used that differ in their characteristics and peculiarities: the *Sala dei Centro Giorni* (Fig. 2a), painted by Giorgio Vasari in 1546[4], is a large frescoed room; created in the same period are the wooden inlays of the choir of San Domenico realized by Fra Damiano Zambelli (Fig. 2b), composed of individual images of more modest dimensions[5]; even smaller in size are those of the perspectives contained in Andrea Pozzo's treatise (Fig. 2c), which, by date is situated later in time, 1700[6].

The viewer observing live perspective images is strongly influenced by what their eye perceives as a dilated space, i.e., a virtual space; this also occurs in other similar ways in AR and VR applications in which the viewer is convoluted by virtual three-dimensional content. So, the purpose is to explore the relationship between quadratures and immersive systems, reflecting in particular on the perceptual implications they have.

But in addition to this function, the use of these tools, in the proposed research, aims to the investigation and deep understanding of the relationship between real and illusory space through the creation of a digital model[7] representing both (Fig. 3).

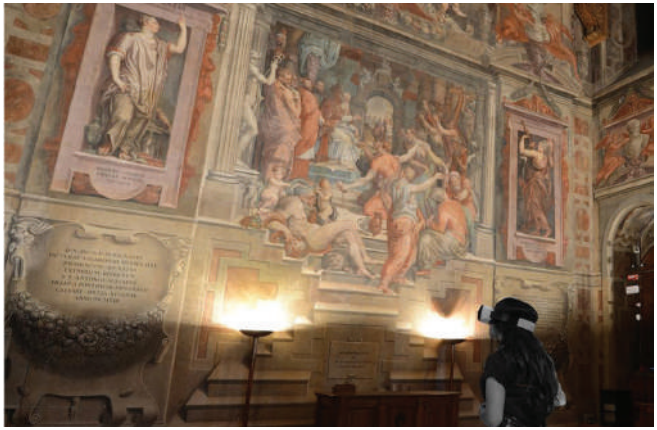
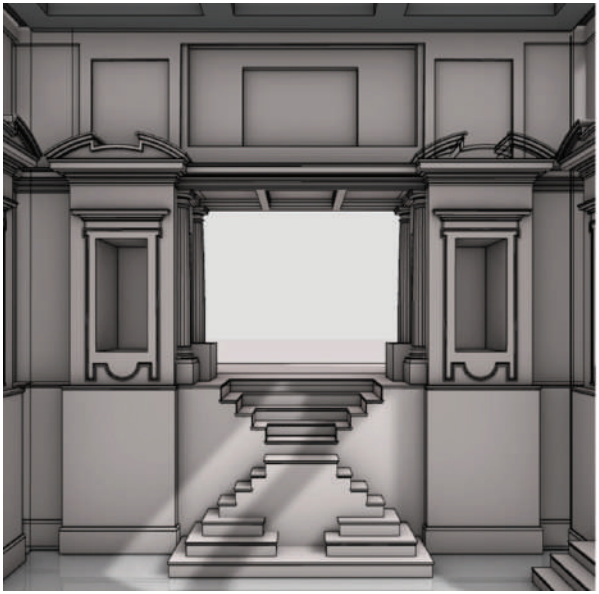


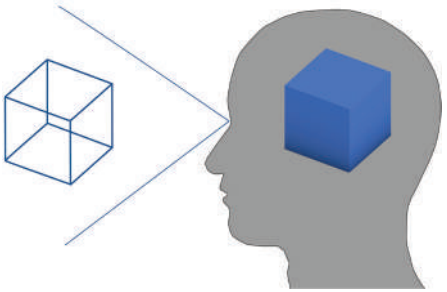
Fig .1 - The viewer inside the Sala dei Cento Giorni (left) and the user viewing the same Sala in Virtual Reality.
Fig. 2 - The works chosen as case studies: a) Sala dei Cento Giorni, Palazzo della Cancelleria, Rome; b) sixth inlay of the Dossal of the Choir of San Domenico, Bologna; c) Figure 81 of the second volume of the treatise Perspectiva pictorum et architectorum by Andrea Pozzo.
Fig. 3 - Three-dimensional model representing the perspective space of the case studies.



AR and VR for the study of cultural heritage

AR and VR technologies are part of the ITC a macro-group that includes the set of information technologies; but more specifically they are part of those immersive technologies that focus on the user experience and we find them along with other types of tools such as Spatial Augmented Realty, Video Mapping, and Mixed Reality just to name a few[8]. These tools are in the context of Cultural Heritage conventionally and increasingly used for communication and valorization phases. AR and VR make it possible to simulate scenarios and interactions with strong communicative power that introduce themes such as the perceptual contribution of the viewer to the artworks. This is because their key feature is the immersiveness and interaction through which the user comes into contact with the virtual scenarios. Neurobiology states that the nervous system developed as a response to input from the surrounding environment[9]; the objects around us we see through countless perspectives, under different lighting conditions and at ever-changing distances, nevertheless, we are able to understand their absolute form because it is the mind that actively contributes in vision by providing "added value" to the images we receive from the outside world. A similar process happens when viewing two-dimensional images, whether painted or drawn or the result of virtual projections, that simulate three-dimensional spaces (Fig. 4). Just as the artist knows that they cannot take for granted the understanding of the imagined space in their mind and therefore must always reiterate it, through visual method[10], in the same way those who approach the use of new technologies must always take these rules into account for effective perceptual impact. Much has been written[11] about the use of these technologies applied to Cultural Heritage by framing the topic and emphasizing the potential that these tools have with in the communication. There are many researches that make use of these tools for the representation and enhancement of Cultural Heritage, such as the work done on the basilica of Santa Maria di Loreto[12] in which different strategies are introduced to delve into different aspects of an architectural monument; in this study different technologies are used to highlight, in a systematic and visual way, information of various kinds. Or again, in the work[13] done on the Scoletta del Carmine in Padua, the potential of different Virtual Reality tools are tested, with different degrees of immersiveness, on the painted perspectives within the environment. The two systems presented possess different characteristics in terms of the degree of immersiveness and thus in the way one interacts with and perceives the dilated space (Fig. 5).



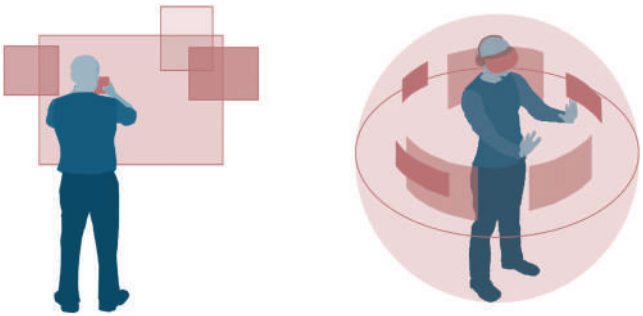


Fig. 4 - A two-dimensional image can be interpreted as three-dimensional.
Fig. 5 - AR systems (left) have low immersiveness compared to VR systems (right), because in the latter case digital content surrounds the user.

Perception in AR systems

The quadraturist work, with its different levels of reading, makes it possible to study the relationship between two-dimensional and three-dimensional elements, as is the case, for example, in experiments that make use of Augmented Reality, overlaying the two-dimensional perspective image with the three-dimensional model it represents. Taking advantage of this type of technology and associating it with architectural perspectives, the relationship between 3D information content and target becomes fundamental, the latter represented by the work itself becoming part of the model, without which the information content would lose relevance. The perspective image used as a target represents an added value in this reading: the use of the target is no longer just a recognition marker, whose function is therefore no longer just relegated to the orientation of the digital content with reference to the camera.

In systems that exploit Augmented Reality, interaction is always mediated by the device that stands between the real environment and the augmented experience. In this case the user manages the point of view with which the models are shown and visual contact with the source work is possible, which in the analyzed cases becomes the activating target of the technology. The three-dimensional model arises from the perspective image and is in continuity with it and is its spatial transposition. This reinforces the link between perspective and AR that sees the centre of projection as the virtual chamber, the picture plane, on which the image is formed, as the target, and the model as the augmented content (Fig. 6).

On this we can reflect on the position of the model with respect to the picture plane, which in the classical perspective can take on infinite positions, but which we can trace back to three cases, whereas in the default AR the model always projects in front of the target (Fig. 7).

In order to achieve a perceptual effect similar to the second case, in which the model straddles the picture plane, it is

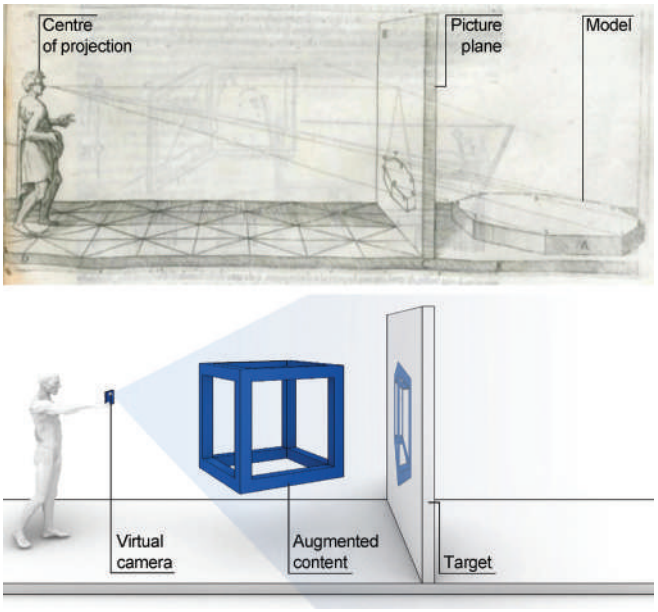


Fig. 6 - Comparison between perspective (top) and Augmented Reality (bottom).

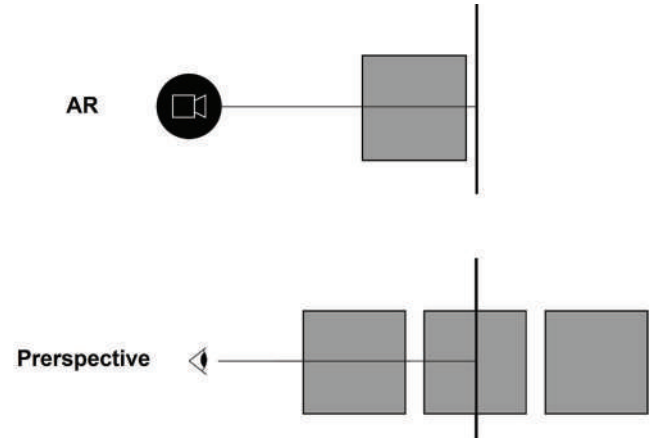


Fig. 7 - Comparison of spatial configurations: in perspective the model can be ahead or behind the picture plane, in AR it automatically projects in front of the target.

possible to integrate parts of the target into the virtual model so that they serve as a perceptual reference. This occurs in the *Sala dei Centro Giorni* model in which the parts in the model coincident with the partitions have been textured, in the true-form parts where the model is on the picture plane. This allows us to perceive the staircases in front of the target and the scene behind (Fig. 8).
Again in an inlay of the choir of San Domenico in Bologna, the urban scene seems to unravel within the wooden framework of the backrest. Without modification by projecting Augmented Reality the model would seem to come out of the perspective image. In this case, in addition to integrating part of the target within the model, the backside was screened as is done in photographic sets and a front screen was created that extends beyond the frame (Fig. 9).
These two strategies thus make the impression that the model of the urban scene develops beyond the frame. The sense of perspective breaking through is thus possible if one fully exploits the relationship with the target by integrating parts of it within the model (Fig. 10).

Fig. 8 - AR experiment on the Sala dei Cento Giorni.

Or the experimentation conducted on figure 81 of Andrea Pozzo's treatise, which through AR makes explicit the perspective decoding by revealing the position of the observer in space. It is possible to exploit the potential of the tool by designing interactions that allow the user, once the device is placed in the centre of projection, to appreciate the collimation between perspective image and three-dimensional model (Fig. 11).
Augmented Reality represents an overlay of content of the existing reality. In this case, the "additional" information that is added to the reality of the work will be precisely those contents processed by means of the interpretative phase and in particular the relationship between the two-dimensional image of the fresco and three-dimensional space restituted. If Augmented Reality always maintains contact with reality, so it has a type of interaction that is not very immersive, Virtual Reality is the type of technology that guarantees the gratest immersiveness and is able to involve to a greater extent the perceptual aspects in the observation of perspective images and three-dimensional models.

Fig. 9 - Stratagems used to simulate perspective breakthrough.
Fig. 10 - AR experimentation on the inlay of the choir of San Domenico.

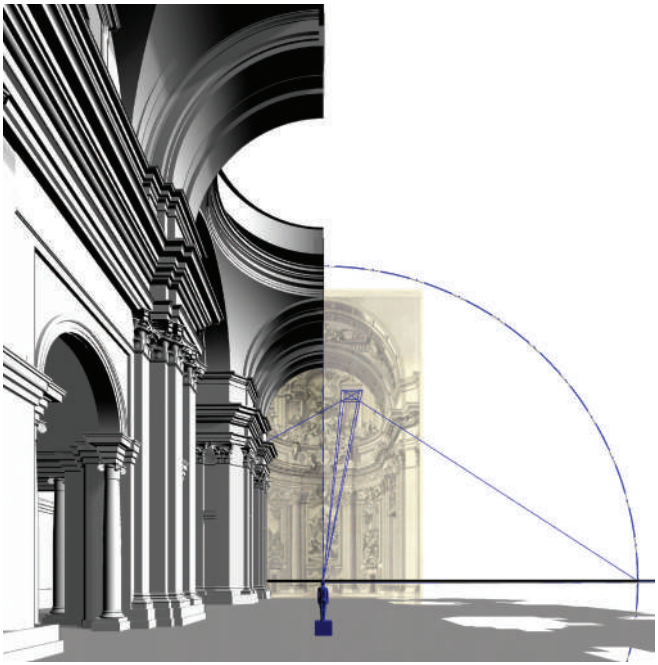


Fig. 11 - AR experimentation on the page of Andrea Pozzo's treatise.

Perception in VR systems

Speaking of VR refers to a type of immersive technology, enjoyed through a visor, glasses or helmet, with which it is possible to observe virtual environments with a 360-degree view. Two types of experiences can be distinguished; the first exploits panoramic images and the second allows spatial interaction within a three-dimensional model.
Both systems, however, are mediated by the use of a visor. This element generates a series of reflections related to the perceptual aspect: basically, the type of technology tends to want to trick our brains, and for this reason there can often be a feeling of estrangement or disorientation for the user; the experiments conducted also reflect on this aspect.
The *Sala dei Cento Giorni*, due to its characteristics, i.e.,

perspective images surrounding the viewer on the four walls, is the perfect subject to conduct the experiments and test the differences between the two systems.
The features focused on during the applications are the particular characteristic of the *Sala*: it, in fact, has a very high horizon compared to that of a viewer. This aspect strongly influences the perception of the painted architectural space because when observed, the planes that our brain would like to interpret as horizontal appear slanted to us (Fig. 12).
For this purpose we make use of two versions of the three-dimensional model of the illusory spaces. Thus obtaining two models: a realist one, more closely matching an ideal model, and a surrealist one with slanted planes, more similar to what the user of the room perceives in the frescoes (Fig. 13). These two versions of the model subsequently were visualized through VR systems to understand the different perceptive implications.
Obviously, perspective is the method most comparable to human vision; the VR comparison becomes immediate in which the viewer is tricked by an image that simulates the sensation of being in a three-dimensional environment.
Thanks to the use of 360° images, acquired on site and digitally created with the help of the three-dimensional model, it is possible to experiment in Virtual Reality, the perceptive aspect that the observation of the perspectives and the model of the illusory space causes in the viewer in different notable positions.
The experimentation consists of setting up a panoramic tour through specially created spherical images, each with the purpose of highlighting specific reflections on aspects of the *Sala*: the possibility of observing and comparing different configurations, moving from one version to another in which the different models replace the frescoes allows for a deep understanding of the relationship between the parts. Or again, it is possible to observe the models and frescoes from certain points of view, such as from the viewer's height or the horizon height of the perspectives (Fig. 14).
What is noticeable is that the VR project with panoramas needs a clear reference system for navigation to help the user not only move from one configuration to another but also to predict the

Fig. 12 - The horizon of the painted perspective, in red, and the horizon of an observer in the Sala, in blue.

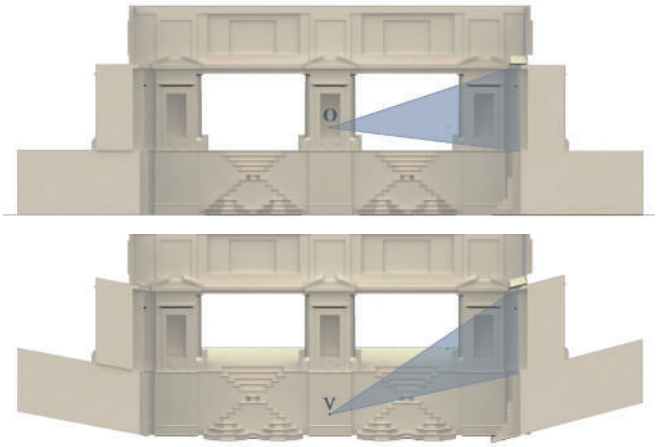


Fig. 13 - Realist and Surrealist model of the Sala dei Cento Giorni.

simulated movement, or change in the model that interaction with hotspots produces.
In this type of system, since these are static images, focusing on details or certain aspects is favored. Even by graphically editing on panoramas (Fig. 15).
Then there are the dynamic VR applications that take advantage of real-time rendering technology to be able to navigate three-dimensional models; in this case the user, in addition to wearing a visor, is also equipped with sliders or joypads that allow them to manage movement within the model. Interaction is greater

Fig 14. Panoramic exploration of the Sala, the image shows a configuration in which the model of a wall is inserted into real space.

because it is possible to move within the digitally created space, thus allowing for multiple points of view (Fig. 16).
By navigating the realist model at the two altitudes, it is clear how at the viewer's altitude the horizontal plane in which the scenes take place would not be visible. Although the second assumption is more fitting with the painted perspective images, the viewer has a strong sense of estrangement because they perceive that they are walking on an invisible plane or possess an unrealistic height.
On the other hand, if one wants to try to climb the sloping steps of the surrealist model this will not be made easy by the system that simulates physical laws to mimic the effect of gravity. The realist steps, however, are walkable, coming to observe the illusory space model as if the user were one of the characters in the stories.

Conclusions

The decision to exploit the potential of these two technologies, AR and VR, is motivated by the recognition in these tools of a direct connection with perspective: both are obviously related to the concept of projection, but in addition, Augmented Reality has similarities between its elements (camera-centre of projection, target/picture plane) that it is useful to deepen and highlight or again in Virtual Reality where the

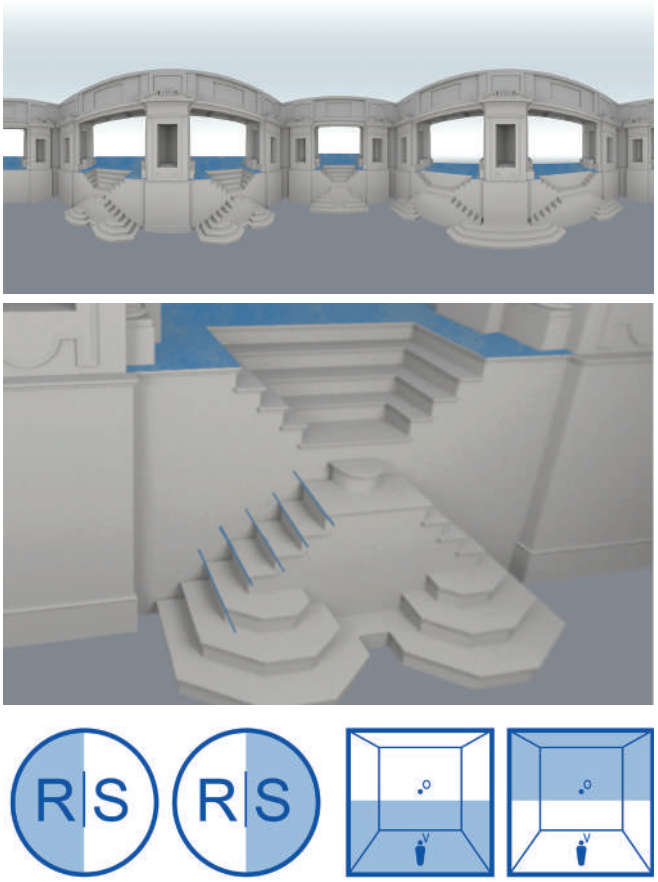


Fig. 15 - Graphical elements that aid in the perception of the navigable models.

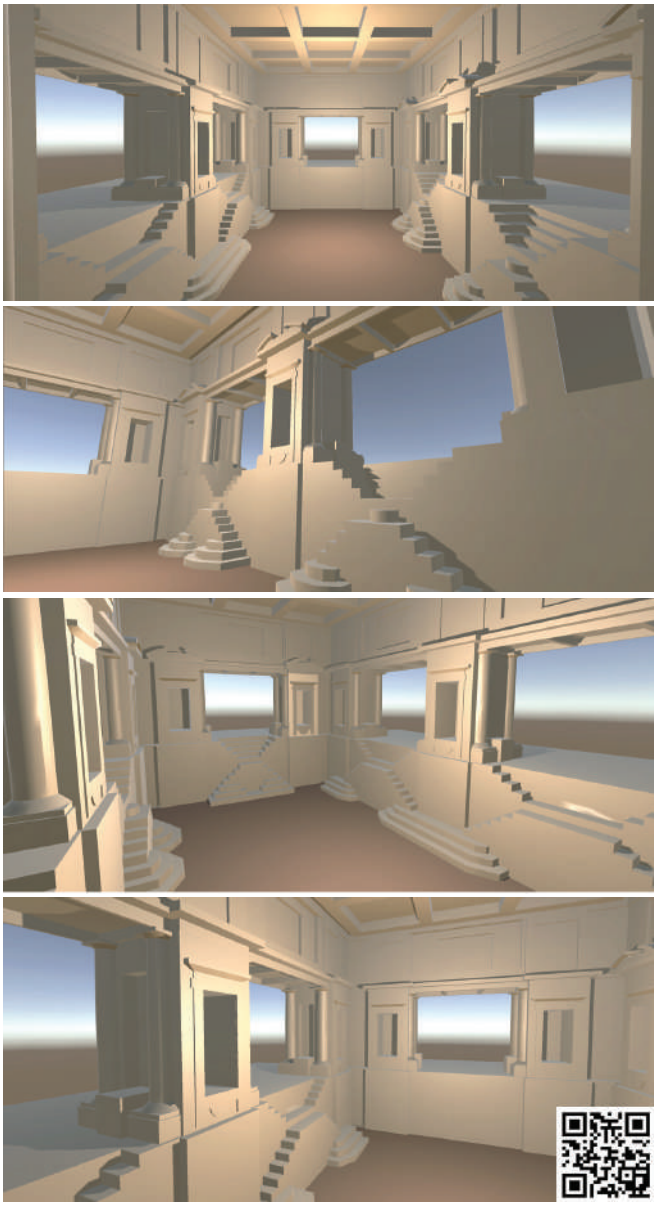


Fig. 16 - Views of the model exploration in real-time mode.

role of the observer- centre of projection can be deepened. These experiments are strictly designed to interpret and provide new keys to interpret the architectural perspective, therefore, not posing themselves with the sole purpose of valorization, considered as the final and communicative phase of the whole project, but mainly as a tool for understanding the phenomenon, allowing to explore, in the true sense of the word, and to interact, although this is done virtually, with the different instances of the works under consideration. In conclusion, we can say that Virtual Reality and Augmented Reality have suitable characteristics for the exploration of architectural spaces, but the perceptual implications of the applications need to be kept well in mind. In addition, it is shown to be necessary that the perspective characteristics of the works be well understood to create efficient applications.

Notes

[1] Valenti, 2014, 2016.

[2] Camerota, 2006.

[3] Li et al., 2018.

[4] Fasolo, Mancini, 2014.

[5] Fasolo, Camagni, 2020.

[6] Fasolo et al., 2021.

[7] The models presented in this contribution are obtained by prospective restitution. For a more in-depth discussion on this methodology, see Inzerillo 2014.

[8] Of course, with technological advancement, the definitions of these technologies are becoming more and more blurred, and often the various experiences overlap.

[9] Casale, 2018.

[10] Arnheim, 1986.

[11] Among the many, they include Ippoliti, Meschini, 2010 e Luigini, Panciroli, 2018.

[12] Rossi, 2018.

[13] De Rosa, 2020, p. 225.

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The evolution of theories and methods for creating informative or educational digital images of cultural heritage is an ongoing process, anticipating and following technological and instrumental advances. The fifth edition of the conference 'Digital and Documentation' and the present volume, which collects the results of a study day, is part of this debate by showing the use of digital tools for understanding and preserving cultural heritage. Young researchers presented case studies focusing on two current topics: the perception of heritage through virtual design and its renewed management through three-dimensional information systems. Despite their separation, the two parts of the volume intersect through the interaction between virtual and informational systems, prompting new reflections on potential evolutions of representation and opening new avenues for simplified and efficient management of cultural heritage through untapped digital strategies.

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