Perspective Between Representation and AR: the Apse of the Church of St. Ignatius

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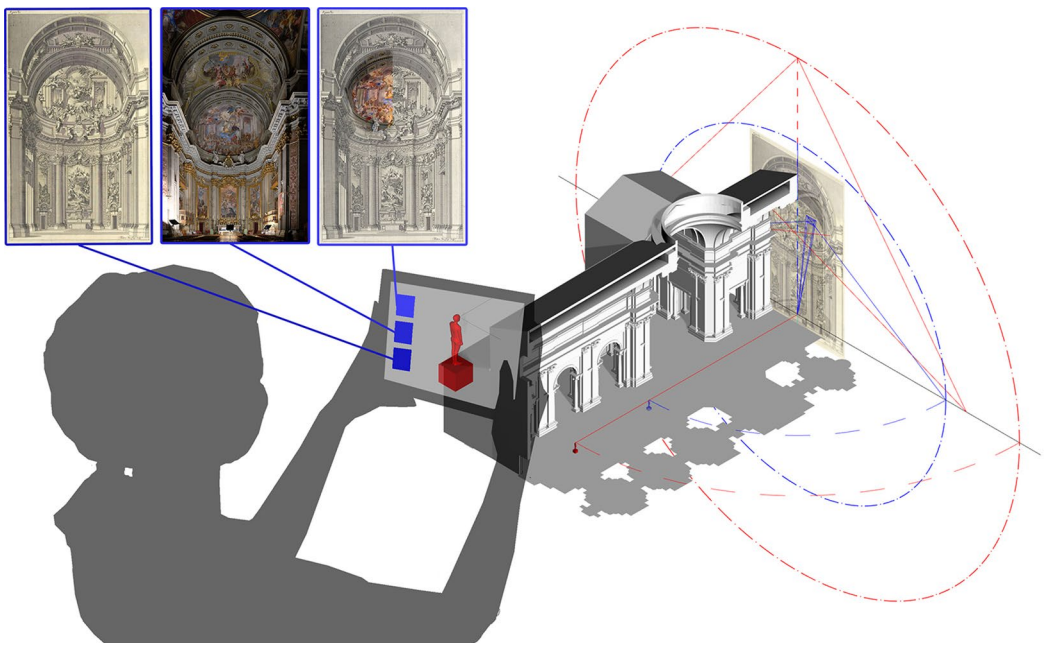
Abstract

This contribution studies the ways in which Augmented Reality (AR) can communicate and disseminate knowledge about our cultural heritage in general and, in particular, Architectural Perspectives (AP). The focus is to increase our knowledge and understanding of perspective technique and how the latter deals with the unique mix between the real architectural environment and an illusory space, in this case the decorations of the presbytery and apse of the Church of St. Ignatius in Rome. The specific objective of the study is the possibility to use the Pozzo's treatise to "augment" its fruition, accompanied by a virtual visit in order to gather more in-depth information about the perspective construction that creates the effect of spatial expansion thanks to this expedient. This decoration is in fact one of the rare cases of a perspective representation of a pictorial project, in turn also a perspective designed by Pozzo; this design is the "activation" element of an AR experience that immediately illustrates the perspective bravura of its creator.

Keywords
perspective, treatise, augmented reality (AR), architectural perspectives (PA), Andrea Pozzo.



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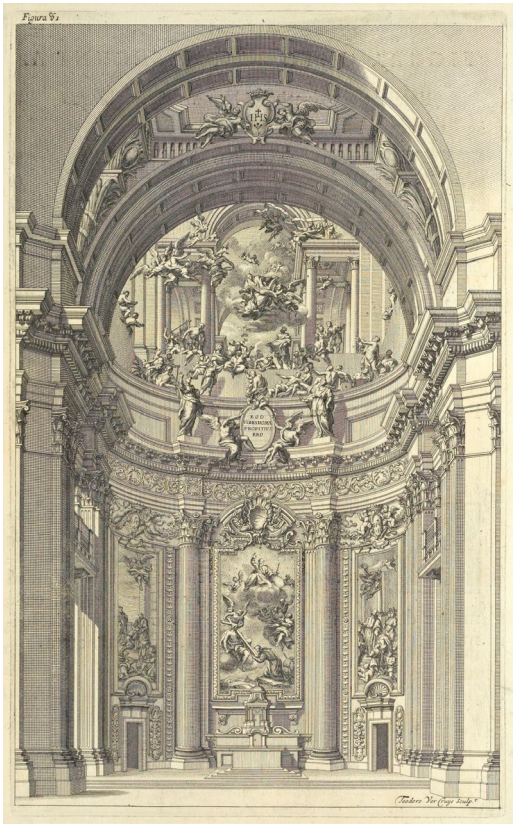
Introduction

This contribution will reflect on the ways in which Augmented Reality (AR) can communicate and disseminate knowledge about our cultural heritage in general and, in particular, Architectural Perspectives (AP). Following in the footsteps of our proposals illustrated during the REAACH-ID meeting 2020 [Carlevaris, Fasolo, Camagni 2021], the current objective is the dissemination of knowledge regarding perspective technique and how, when large-scale artifacts are involved, it deals with the unique mix between the real architectural environment and the illusory space [Sdegno 2018].
The idea behind our proposal is to shift the activation target of the augmented experience from the architectural reality containing the AP to the images and, in particular, to the pages of many treatises where these perspectives are illustrated, explained, and constructed. Treatises on perspective are therefore the protagonists of this study phase; we intend to assign them a key role in the theory and practice of the construction of illusory architecture and also broaden their fruition so as to involve scholars and users interested in the close relationship between real architecture and illusory *trompe l'oeil* – elements firmly linked to the key idea of "design".
The text and iconography taken into consideration and examined as a case study is Andrea Pozzo's treatise published in two parts in 1693 and 1700 [Pozzo 1693; 1700], while the PA that provides the opportunity for the experiment is his design of the presbytery and apse of the Church of St. Ignatius in Rome [Bosël, Salviucci Insolera 2010]. This decoration is one of the rare cases of a perspective representation of a pictorial project, in turn also a perspective [Pozzo 1700, Fig. 81] (Fig. 1). The image very successfully communicates the perceptive result expected by the designer regarding the *trompe l'oeil* and reveals the skillful pictorial recreation and exchange between the (real) vaulted surfaces and the painted architectures.
Pozzo provides a detailed dimensioned plan and elevation of the apse and presbytery [Pozzo 1700, Fig. 82] (Fig. 2), intentionally inserted for all "scholars who also wish to revel



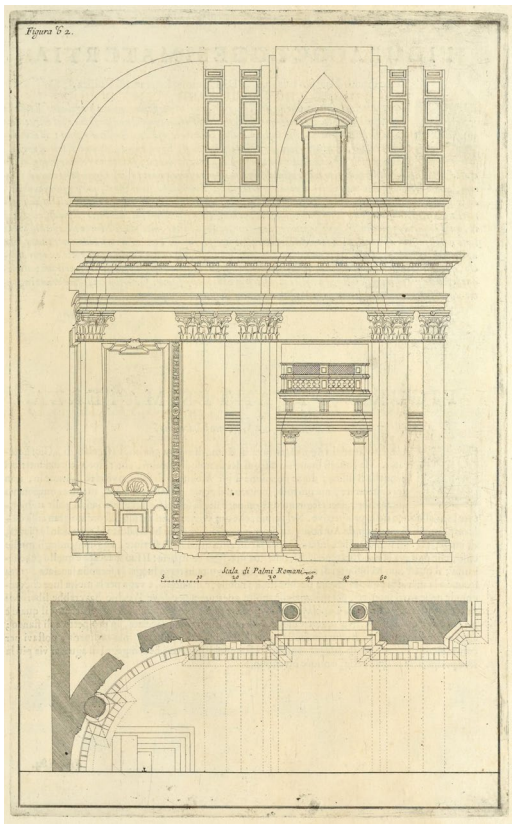


Fig. 1 Pozzo 1700, Part Two, figure 81 [Pozzo 1700].

Fig. 2 Pozzo 1700, Part Two, figure 82 [Pozzo 1700].

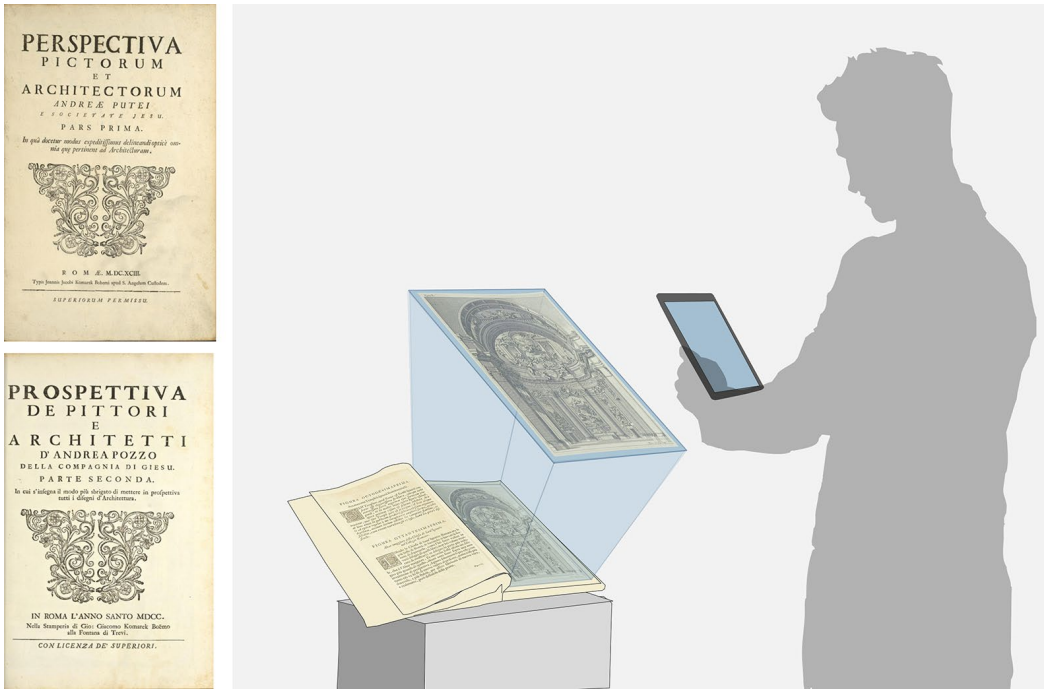


Fig. 3 Right: concept image of the AR application augmenting the treatise. Left: the frontispieces of the two parts of Pozzo's treatise: Part One, 1693, in the Latin version (top) and Part Two, 1700, in the Italian version (bottom).

in putting them into perspective" [Pozzo 1700, text relating to Fig. 82]. Apart from this declaredly didactic intent, the Jesuit father introduces many aspects of Pozzo's versatile genius and creativity into his own theoretical work. This impressive treatise is certainty not just a practical text about graphic geometry: at this point the objective of the study is to reassign the treatise its role as a connector. The two volumes can undoubtedly be interpreted as a wide-ranging repertoire of architectures – real, illusory or ephemeral – as well as a model that can be used to codify representation. The formal and ornamental characteristics of the design are welded to the forms of its representation (*ichnografia, orthographia*, and *scaenographia*, as Vitruvius would say).

Representation as the Activation Target of the AR Experience

The perspective etching that "looks" towards the apse shown in figure 1 is the inspiration behind this study and becomes the activation target of an AR application we can call "multilevel".
From a methodological point of view, several steps lead the user from just observing the treatise to virtually repositioning the page with the perspective table inside the real architectural space it represents. This is achieved by creating a three-dimensional model of the architectural work. The perspective mechanism, closely associated with the observer of the etching, is staged inside this reconstructed space. The perspective table can be virtually scaled and positioned in correspondence with the picture plane; likewise the observer/centre of projection can be repositioned inside the space of the model.
Orienting the perspective makes it possible to critically reconstruct the illusory architecture which, when suitably modelled, will be added to the real architectural space beyond the frescoed surface.
Going back to the plane dimension of the ensuing perspective will allow the AR user to not only reinterpret the projective superimposition between the architectural features in the table in the treatise and the architecture it portrays, but also establish a perceptive comparison between the frescoed surface and the same surface perspectively represented on the plane. All this is mediated by a perspective that is once again theoretical (projective) and practical.

Seen thus, the aim of the AR application – intended for a user interested in the relationships between architecture and perspective [Gutiérrez de Ravé et al, 2016] and not necessarily present in the church, but simply standing in front of the treatise or one of its reproduction – is to reinterpret the crucial mix between design and representation, between the actual work and the treatise, between architecture and perspective. It is an invitation to reflect on Pozzo's fundamental contribution to the definition of an illusory game that continues to be a powerful emblem of the instruments used in the Baroque to create works of art (Fig. 3).

The Perspective Etching

In the table shown in figure 1 Pozzo presents the barrel vault with lunettes of the presbytery and the apse in a central perspective view. The true complexity of the drawing is revealed when one notes that the vaulted surfaces of the real architecture here perspectively represented are decorated with images that are in turn perspectives, transporting the observer in a sort of half-space where the perspective multiplies in a crescendo of perspective bravura. The real architecture of this part of the church is put in perspective, as mentioned earlier, based on the way it is described in the text and portrayed in the drawing in figure 82 of *Part Two* of the treatise (Fig. 2) showing the plan cut along the axis of symmetry and the vertical section; elements that suffice to create its perspective projection.
Instead, as concerns the illusory architecture that appears in the perspective (figure 81, *Part Two*), Pozzo provides no indications regarding its true form: in actual fact this is the only occasion when, amongst all the designs Pozzo realised in St. Ignatius and described in the treatise, the illusory architecture is not provided as an addition and complement to the real architecture, as if it were an architecture that was indeed present beyond the surfaces on which it was to be frescoed. In the other tables with indications about how to create these perspective frescoes, the architecture to be "added" is coupled with that of the architectural environment and which, once built, will act as an enlargement. Instead in the etching of the apse, the metric-dimensional indications refer only to the real architecture, while the perspective image describes the environment "augmented" by the presence of the illusory component.
So, once again, the etching appears to represent a Baroque hyperbole, in line with the customs of its inventor, in which a space, whose design he shares with the reader, is placed in perspective and then used to support additional perspective projections on these represented surfaces. This game of references suggests that Pozzo comprehensively studied the construction methods and the unitary (or non-unitary) nature of the perspective construction between the two symbiotically juxtaposed components: the perspective of the real architecture and the perspective of the illusory perspective.
The perspective deconstruction tends to not only ascertain the internal orientation of the image in relation to the real architecture, but also to establish whether it coincides with that of the illusory construction. If, in fact, Pozzo conveys the best position from which to observe both the vault of the nave and the fake dome (indicating a spot on the ground corresponding to the centre of projection), he does not suggest the same spot for the apse.

Perspective Decoding

The act of perspective decoding takes place on two levels, separately tackling the perspective (real architecture) and the perspective of the perspective (illusory architecture). Figure 4 shows the convergence of all the straight lines perpendicular to the picture plane; the ones belonging to the real architecture (red) and those belonging to the virtual architecture (blue). It is easy to verify the convergence of all the lines orthogonal to the picture plane towards the same main point O_0 through which the vanishing line of the horizontal

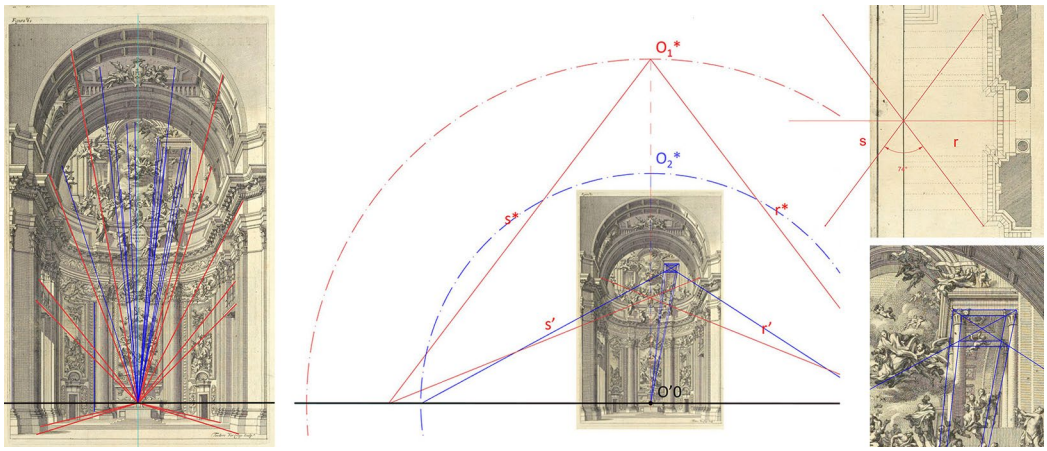
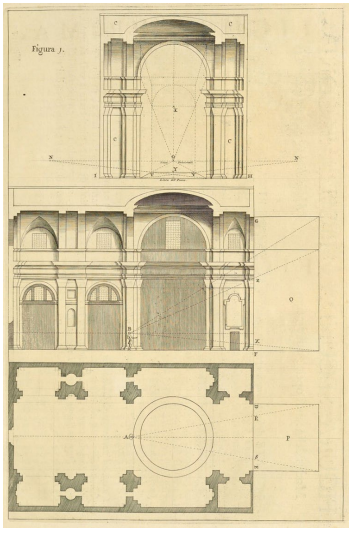


Fig. 4 Perspective decoding of figure 81, Part Two, in Pozzo's treatise [Pozzo 1700], examined using two reference systems: in red, analysis of the real architecture; in blue, analysis of the illusory architecture.

planes will pass. The horizon, at roughly 2.21 m from the floor, is rather high when compared to the height of an observer standing in the church; the fact Pozzo usually uses a viewpoint that is higher than a standing obsever is also confirmed by the position of the centre of projection imagined for the great vault of the nave [Mancini 2021].
To complete the orientation of the two perspectives (of the real architecture and illusory architecture) we have to establish the distance of the observer (or two hypothetical observers, if they do not coincide) from the picture plane, so as to position them inside the space of the church.
For the real architecture we can use the plan (Fig. 2) in which it is possible to identify two straight lines *r* and *s* that form equal angles, but in an opposite direction, with the lines orthogonal to the picture plane *x*, and measure the angle between the two (Fig. 4, top right). Having also established in perspective the straight lines *r'* and *s'* (obviously more visible at the top, at the level of the moulding), it is possible to determine the vanishing points on the horizon. The rabatment in true form around the horizon of the horizontal projecting plane allows us to draw the directions *r** and *s** that form an angle equal to the one measured in the plan (74°). Due to the symmetry of the construction, these two rabatted straight lines meet in point *O** that belongs to the vertical straight line drawn through O_o which is the rabatment of *O* on the picture plane. The main distance is identified by segment O_oO^*.
This operation is quite simple for the real architecture, but less so for the illusory architecture since, as mentioned earlier, we have neither its true form nor true measurements. We can, however, identify an element whose geometry can undoubtedly be interpreted as that of a square in the architectural span painted on the right side. At this point we can draw the diagonals of the square and thus establish the two points of distance of the "blue" perspective, the one relating to the fresco (Fig. 4, bottom right). Although they are symmetrically positioned compared to O_o, they do not establish a main distance coinciding with that of the perspective of the real architecture.
In this case it would seem possible to identify a duplication of the centre of projection: the observer of the "red" perspective (real architecture) is further away from the picture plane that the observer of the "blue" architecture.
At this point we have to ask ourselves where this picture plane should be placed in the space of the church, portrayed by the digital model, given that Pozzo provides no indications.
The tables Pozzo inserts in the treatise – e.g., figures 1 and 15 in *Part One* (Fig. 5) – come to our aid; they explain how to create the perspective based on the "enlarged" plan and section, i.e., where the illusory architecture is also included. These tables reveal a sort of "routine" that Pozzo uses to construct the perspective on a plane corresponding to the centre of curvature of the apse, on the line separating the apse and the presbytery.
After verifying the position of the picture plane for St. Ignatius, we established the position of the two centres of projection O_1 and O_2, which are distant from one another but are both positioned along the axis of the church, in the space of the nave (Fig. 6).

Augmented Reality

Now the question is: how can we insert the data acquired during the previous study phases in an AR application and thus successfully communicate the unitary value of Pozzo's design and, at the same time, optimally exploit the potential provided by the selected digital system?
There are several important contents that have to be "added" to the page of the treatise; however we decided that in this experiment we would involve the three-dimensional model, the data of the perspective decoding, the model of the illusory architecture, and a comparison between the architecture represented in the table of the treatise and the real architecture built in St. Ignatius.
The target, i.e., the image activating the technology, plays a key role in AR applications. To study particularly successful perspective images the latter can be used as targets so that the user consciously perceives the perspective mechanism.
Scanning the page of the treatise with a device (smartphone or tablet) makes it possible to place the perspective inside the model of the architecture, corresponding to the position previously established for the picture plane.
Apart from the three-dimensional model, shown in section (Fig. 6) so as to facilitate exploration, one can also insert the perspective system: for example, it is possible to simultaneously place and visualise, in the same space, the "blue" observer of the frescoed perspective standing on a pedestal in order to emphasise his unusual height. It is also possible to materialise in space the "blue" perspective, characterised by its fundamental elements such as the horizon and the circle of distance, and highlight the square element that allowed us to decode the perspective. By doing so the AR user draws closer to all the features of the perspective, i.e., its spatial and two-dimensional features. The user can also verify the objectives of Pozzo's illusory design in relation to real space and review the choices made by the creators of the application.
A lot of different data has to be inserted into the system, which is why we chose to work inside the application, selecting different kinds of interactions. Our choice was not dictated only by our interest in testing the limits and potential of this technology, but also by the need to involve the user as much as possible in the exploratory experience.
Apart from the different interactions and contents, other aspects had to be taken into consideration in order to try and optimise the way the application worked.
First and foremost, as mentioned earlier, the position of the target/picture plane has to be established; it was placed between the apse and the presbytery. This hypothetical position has enormous consequences during the set up: in fact, due to the way in which virtual reality is configured, the model is always visualised "in front of" the target. In this case,



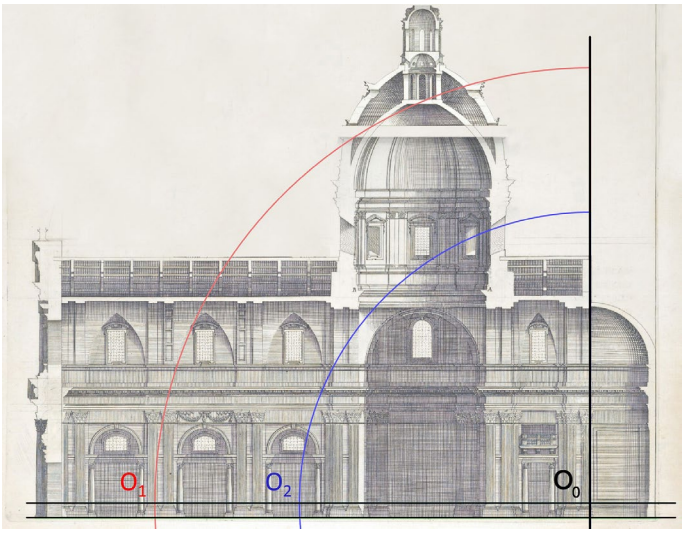


Fig. 5 Pozzo 1693, Part One, figure 1 [Pozzo 1693].

Fig. 6 Positioning of the centres of projection and the picture plane in the longitudinal section of the Church, obtained by developing figure 94, Part One [Pozzo 1693].

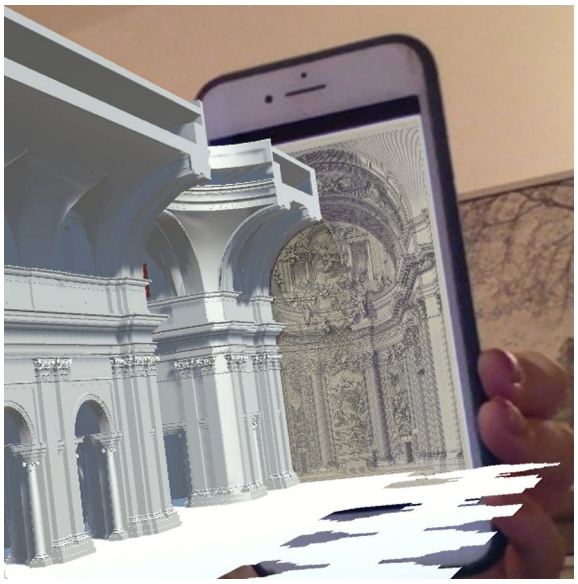


Fig. 7 Model and treatise page projected in the AR application.

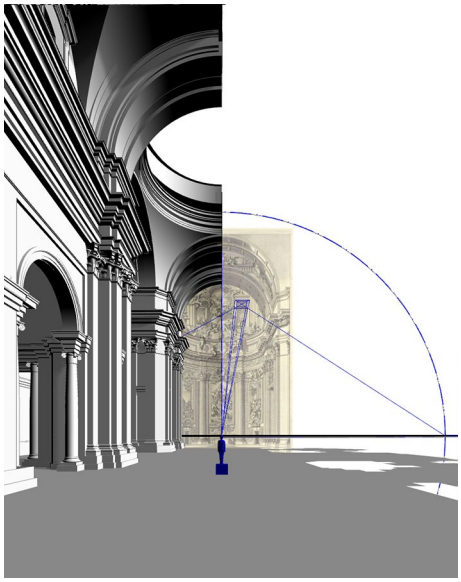


Fig. 8 Observation of the additional content system as seen from the actual architecture projection hundred.

Pozzo's table (the activation element of the AR) would be hidden by the model. To solve this problem, all that needs to be done is to insert, inside the system of added contents, a second copy of the page of the treatise, placed in the same position as the target, so that the perspective image, representing the target but also the element activated by the target, remains visible when the application is launched (Fig. 7).
The three-dimensional model of the architecture was built, together with Matteo Flavio Mancini, by extracting data from figures 93 and 94 in *Part One*, showing the whole church, and also from figure 83 of *Part Two* (Fig. 2) which instead provides a detailed description of the apse and presbytery and is much closer to what is represented in the perspective table (Fig. 1). The model of the illusory architecture, obtained through the perspective restitution operated by O_2, is then "added" to the 3D model.
The architectural order and decorations have to be simplified when creating the model so that the application can be used dynamically and interactively [Russo 2021]. The syntax of this schematisation is provided by Pozzo himself; in line with the didactic intent of his treatise he often used simplified drawings before providing a detailed description of his architectural models. This critical step is necessary because the objective is not to imitate reality but facilitate the interpretation of the illusory and perspective design of the ensemble.
Another element we intend to implement is the role of the virtual camera as the centre of projection. The idea is to create perspective constructions that are activated close to the multiple centres of projections established by Pozzo. This makes it possible to reconcile the role of the kinetic camera, a characteristic of AR, with the static viewpoint of the perspective.
Operationally speaking this means exploiting the algorithms that have already been studied: using a collider the virtual camera must become an activation element so as to "switch on" (close to the centres of projection) the relative perspective decodifiers, continuing to associate, in a continuous comparison, the model, the treatise, the perspective simulation, and the projective construction that generates it. To obtain this result suitable solutions have to be identified; the latter are present in advanced studies regarding Real Time visualisation, but have not yet been verified when coupled with AR.
Yet another issue exists regarding activation buttons. The latter can be associated with a range of comparison options. It is interesting to immediately relate the treatise, where the perspective etching is present, and real space, with its architecture and decorations, both described in the perspective table. Finally, it is also interesting to compare the two elements so as to verify if the system is coherent from its ideation to its construction, and from its development to its successful illusory power (Fig. 8).

Conclusions

Ours was a privileged study because we were able to examine several drawings by the artist who painted the frescoes that reproduce the information contained in the etchings. It was a deliberate choice because it exemplified a methodology intended to link the drawings, paintings, approaches, and decisions regarding the perspective design invented by Andrea Pozzo. By emphasising the perceptive and educational value of the pages of the treatise and physical reality, the AR is not only an instrument destined to communicate the artwork, but also acts as a genuine support for the scientific study.
Any further study could use the same method to analyse other parts of the treatise, for example the ones dedicated to the fresco of the vault of the nave and the canvas of the fake dome.
In addition, our cultural heritage includes other old treatises on perspective; the procedure described here could also be applied to those treatises, thus triggering greater understanding of projective principles and the construction of perspective images placed on walled surfaces. The ultimate goal of this type of approach to research is an awareness that the drawings and pictorial works, based on said drawings, are inspired by just one idea: that of a meaningful architectural project.

Attributions

While sharing what is expressed in the contribution as the result of common reflections, the drafting of the paragraphs *Introduction* and *Representation as the activation target of the AR experience* are to be attributed to Marco Fasolo, the paragraphs *The perspective etching* and *Perspective decoding* to Laura Carlevaris, and the paragraph *Augmented Reality* to Flavia Camagni. The *Conclusions* were obviously jointly written by the three authors after joint discussions.

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