Digital & Documentation V5

From virtual space to information database

edited by
Francesca Picchio

PROSPETTIVE MULTIPLE
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Francesca Picchio

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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.

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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DAda Lab - Drawing and Architecture DocumentAction

PLAY - Photography and 3D Laser for virtual Architecture laboratorY

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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SOFIA MENCONERO

University of Rome "La Sapienza"

Graduated with honours in Architecture at the University of Florence in 2009. In 2013 she attended a post-graduate course (master) in Open Source Technologies for Cultural Heritage at the GeoTechnology Centre of the University of Siena. Since 2021 she has been PhD in History, Representation and Restoration of Architecture at Sapienza University of Rome. She became a research fellow at the Department of Architecture of Roma Tre University at the end of the same year. She mainly works on urban and archaeological surveys, reconstruction of unbuilt architecture, experimentation with spherical visualisation, AR and RTI, and perspective analysis of Piranesian views.

07 SIMULATION OF SPACE IN PIRANESI'S *CARCERI* BETWEEN ARCHITECTURE, PERSPECTIVE AND PERCEPTION

Abstract

Perspective restitution alone is insufficient to achieve a three-dimensional simulation of the represented space in perspective images constructed without projective rigour, such as Giovanni Battista Piranesi's Carceri. Therefore, a method of spatial analysis - that integrates architectural (graphic analysis), perspective (perspective restitution and principles of scenography), and perceptual (eye-tracking technique) interpretations - is proposed and then applied to the frontispiece of the first edition of the series. The result is a three-dimensional simulation of Piranesi's space, whose perspective view can be compared with Piranesi's perspective. Further axonometric views of the 3D model show the architectural elements directly derived from the etching, those varied for architectural-compositional reasons and those assumed to complete the space.

Introduction

Among perspective views, it is possible to distinguish those that present a rigorous projective construction, that therefore derive from and are constructed according to the method of perspective representation, and others that, while simulating perspective vision, introduce inconsistencies and ambiguities. Among the first group, an excellent example can be found in the work of the quadraturist Andrea Pozzo. In his treatise *Perspectiva pictorum et architectorum* (1693) (Fig. 1a), he

Fig. 1 – (a) Theodor Verkruys, engraving in the 2nd volume of Andrea Pozzo's treatise *Perspectiva pictorum et architectorum*, 1700; (b) William Hogarth, engraving for the frontispiece of the treatise *Dr Brook Taylor's method of perspective made easy*, 1754.

described perspective construction procedures for artists and architects, which he also applied in his masterful architectural perspectives inside some Jesuit churches. The purpose of the quadratures is to create an illusory virtual space, and projective rigour is required to make the deception happen. Studying this type of perspective pictures presupposes a good knowledge of the inverse method of perspective, the so-called perspective restitution, which allows us to reconstruct the three dimensions of the illusory space virtually[1]. However, as mentioned at the beginning, not all perspective views are based on a rigorous construction. Some conceal inconsistencies, more or less overtly, which complicate a possible three-dimensional interpretation of the depicted space, and perspective restitution alone cannot provide an unambiguous answer. An extreme and provocative case is represented by the frontispiece (Fig. 1b), illustrated by William Hogarth, of the treatise *Dr Brook Taylor's method of perspective made easy* (1754) in which the caption reads 'Whoever makes a design without the knowledge of perspective will be liable to such absurdities as are shown in this frontispiece'. Giovanni Battista Piranesi's *Carceri* series ranks in a less extreme position than Hogarth's engraving among the perspective pictures constructed without projective rigour.

The research described here aims to devise a method of analysing and interpreting the space represented in perspective views constructed without projective rigour and applies this method to the frontispiece of the first edition of the *Carceri*, entitled *Invenzioni capric[ciose] di Carceri all'acquaforte* (1749-50) (Fig. 2)[2].

The most important graphical-analytical study of the *Carceri* conducted to date is by Ulya Vogt-Göknil and dates back to the 1950s[3]. Concerning the frontispiece, Vogt-Göknil compared the plans of the two versions of the series. These plans do not seem to derive from an attempt at perspective restitution, nor is the method by which she arrived at these representations clearly explained.

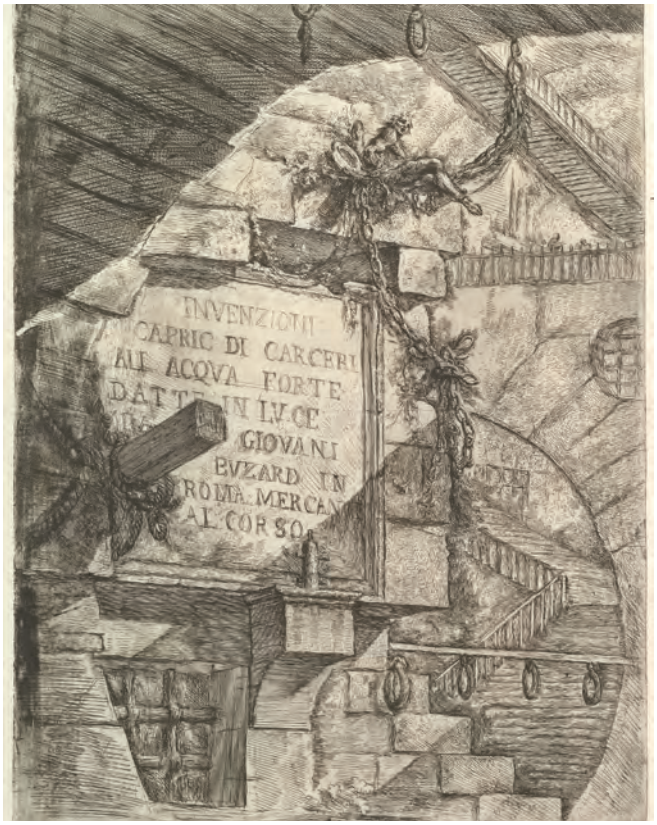


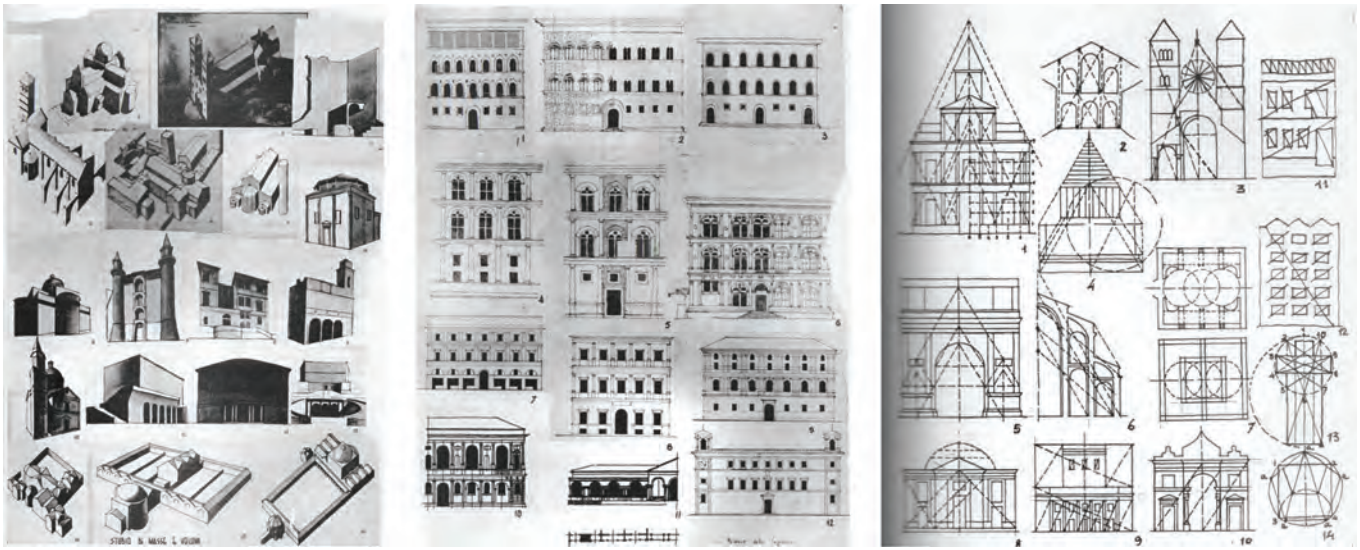
Fig. 2 – Giovanni Battista Piranesi, frontispiece of *Invenzioni capric[ciose] di Carceri all'acquaforte*, 1749-50.

Graphic analysis and simulation of space

The proposed method of study involves the integration of architectural, perspective and perceptual analyses and interpretations, which make it possible to propose a hypothesis for the reconstruction of space thanks to their integration.

Knowledge of the represented architecture is fundamental

since perspective images can only evoke configurations known to the observer[4]. For example, a whole series of assumptions are made upstream of the process in perspective restitution, including identifying triorthogonal elements. The architectural study of the frontispiece was conducted through graphic analysis: a method of studying architecture based on drawing and consolidated in the Roman School since the 1950s[5] (Fig. 3). The complex space was broken down into more easily readable drawings, the functional value of which is determined by the relationship between each level and all others. Eight different types of analysis were conducted on the frontispiece (Fig. 4): the re-drawing of the work; the analysis of symmetries (not present), proportional ratios, masses, the relationship between solids and voids, structures, materials and recurring elements (connections, openings, architectural furniture and decoration, anthropic and prison environment). The analysis of the masses revealed the first ambiguity related to the four steps at the lower edge of the plate (Fig. 5). They can be interpreted as parallel or perpendicular to the plane with the epigraph. This ambiguity is the same type attributed to Necker's famous cube, where depth perception is subject to switching. The architectural analyses are interesting both when considering each plate in the series and when comparing all 14 etchings analysed. The visual programming language (VPL) was the tool through which the percentages of the presence of certain elements of the structural and material analysis were calculated (Fig. 6). These graphs unequivocally show that masonry and arches are the elements most present not only in the frontispiece but also in many other plates. Stone predominates among the materials present in all the etchings in the series. The architectural interpretation of the frontispiece suggested which elements to consider in the following reconstructive hypothesis, excluding those not participating in the spatial configuration. It also suggested the composition's triorthogonality and the architectural elements' recognition. The latter helped



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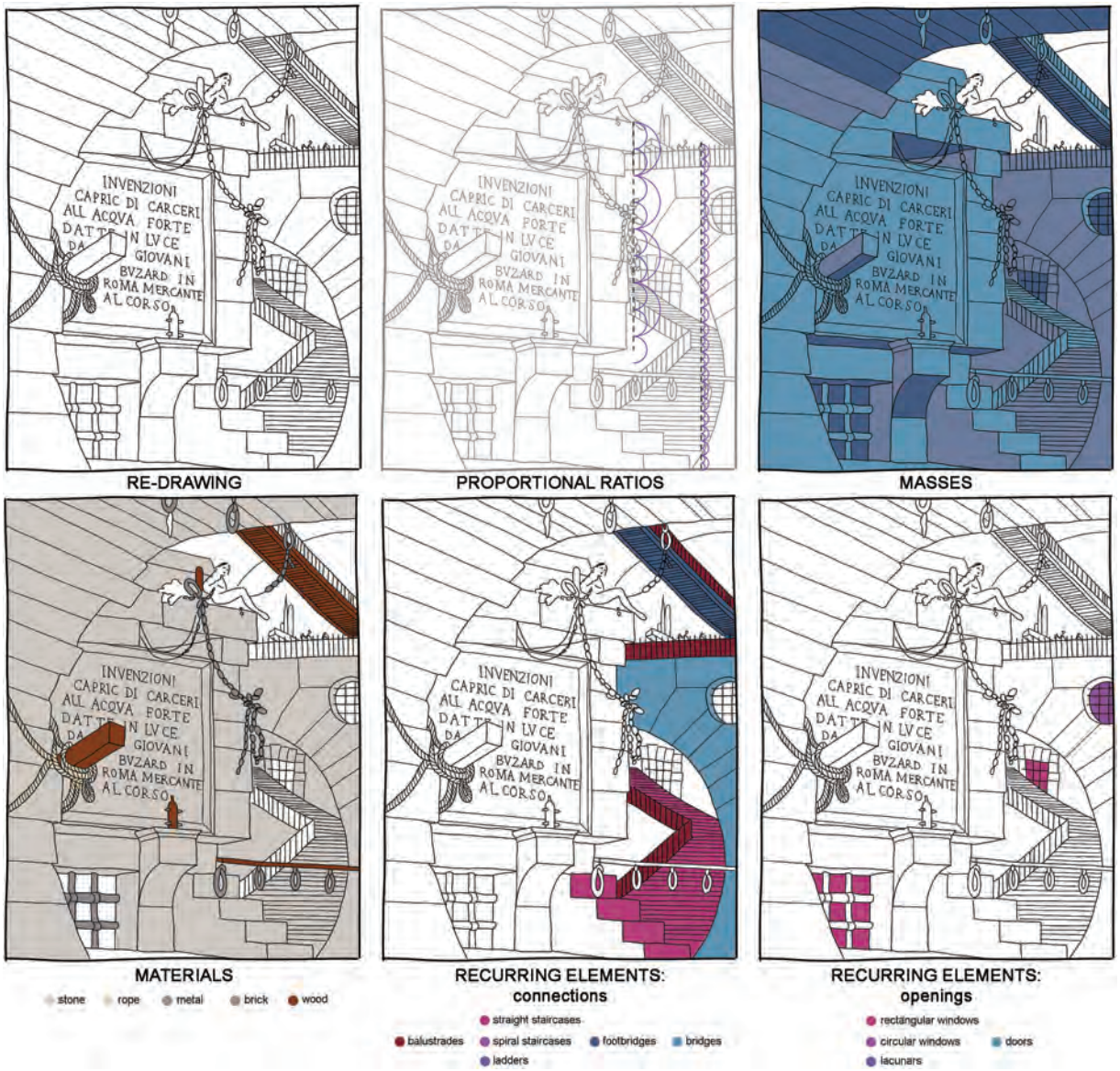
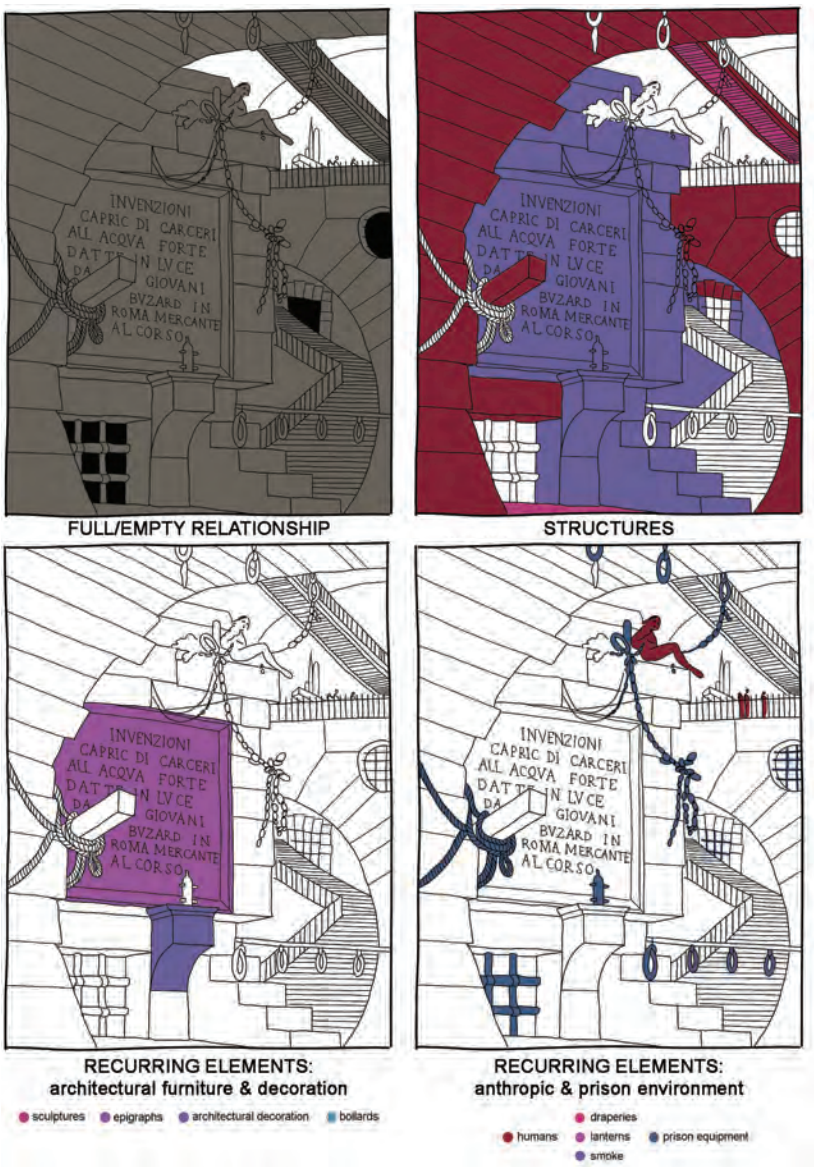


Fig. 4 – Architectural analyses conducted on the frontispiece of the Carceri (graphic elaborations by the author).



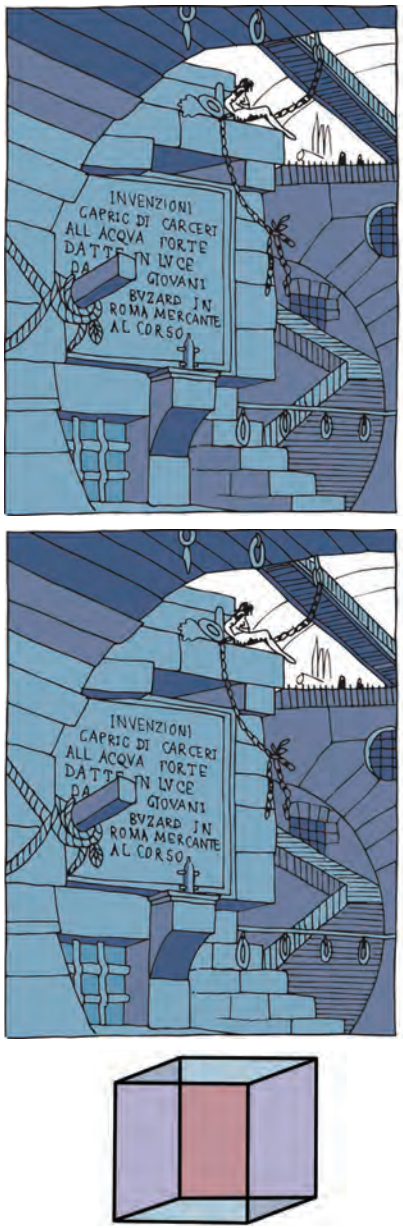


Fig. 5 – On the right, analysis of the masses Analysis of the masses of the frontispiece with the two perceptible versions of the four steps below the epigraph and the famous Necker's cube (graphic elaborations by the author).

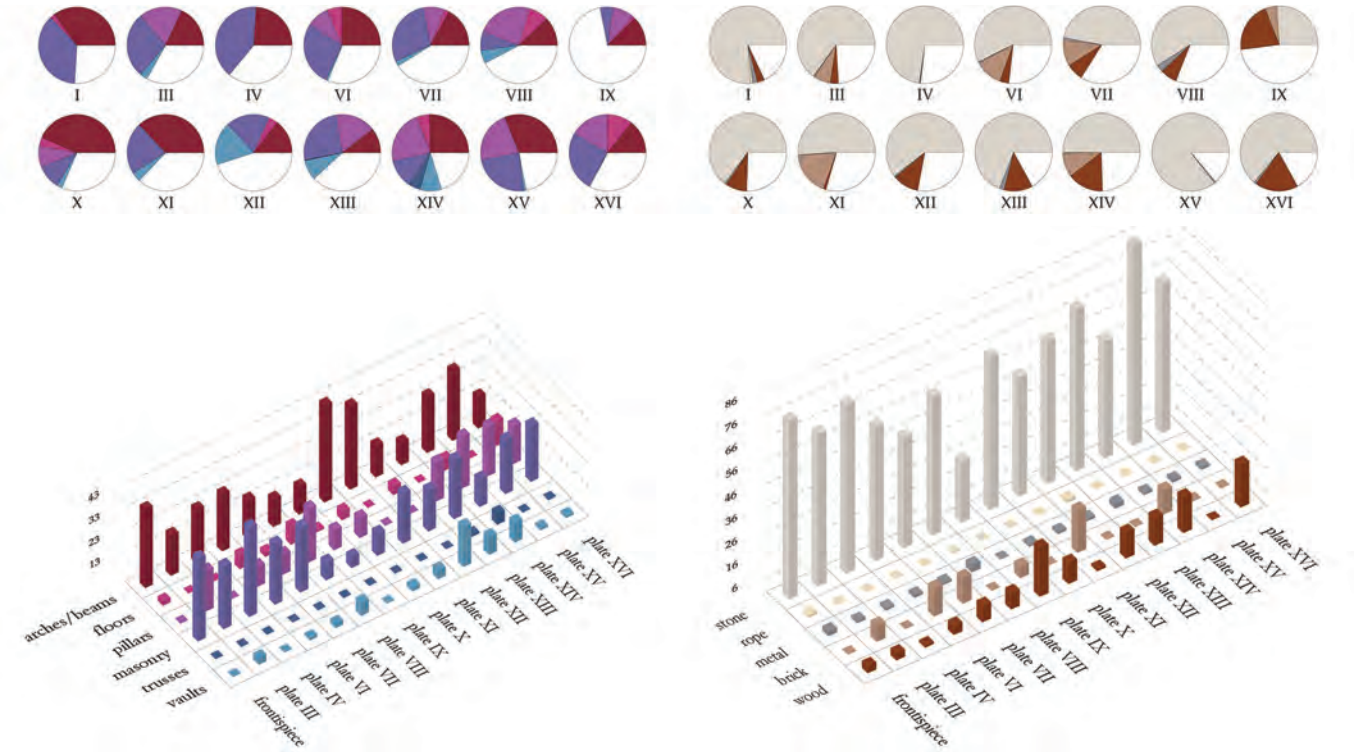


Fig. 6 – Graphs obtained by VPL showing the summary data of the analysis of structures (left) and materials (right) for the 14 plates in the series (graphic elaborations by the author).

Fig. 7 – Decomposition of the frontispiece into depth planes (graphic elaborations by the author).

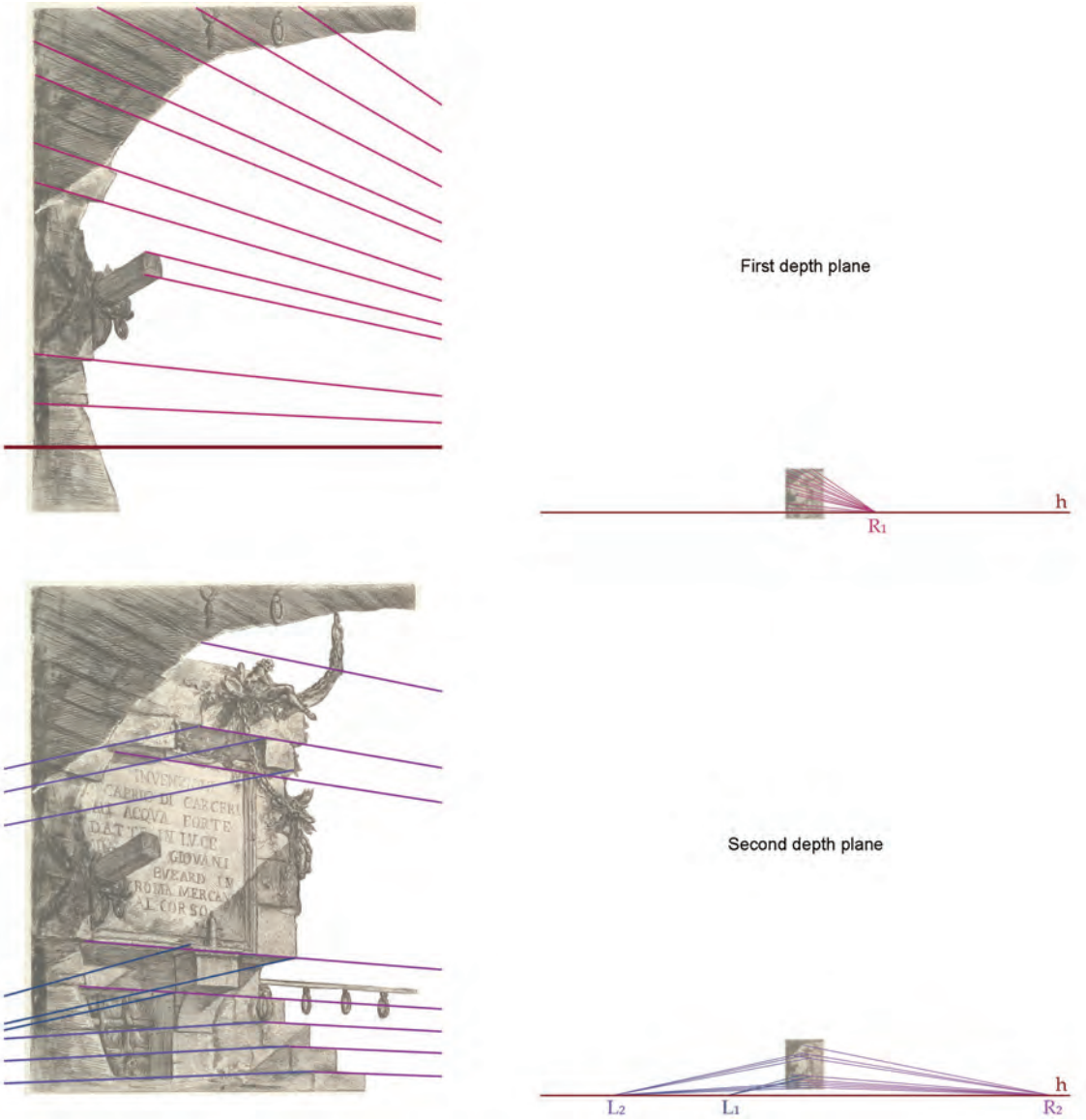
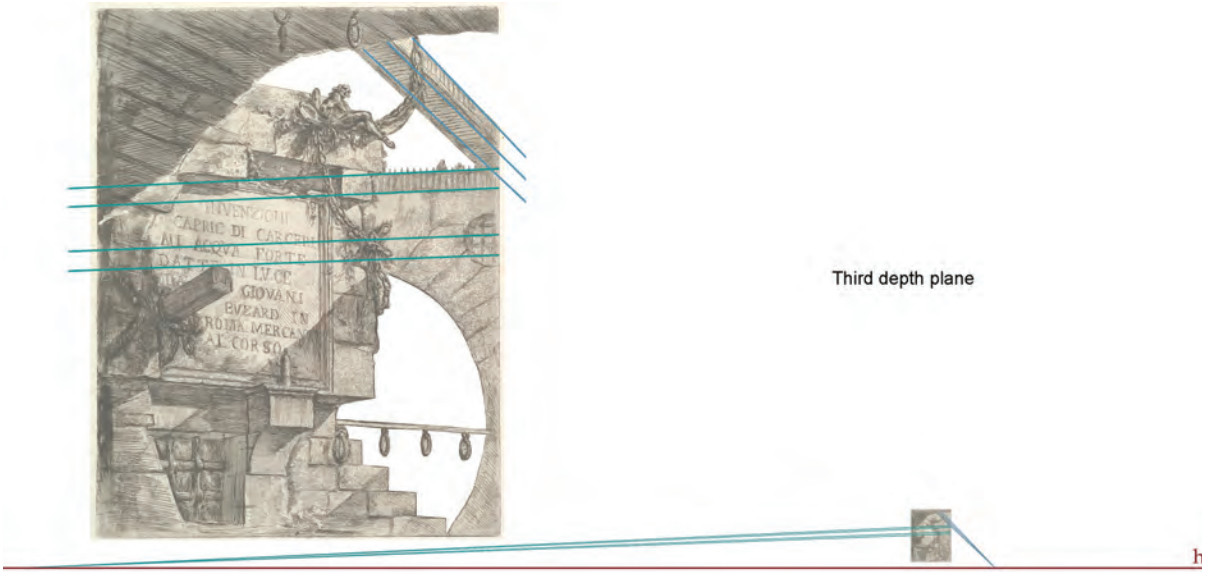
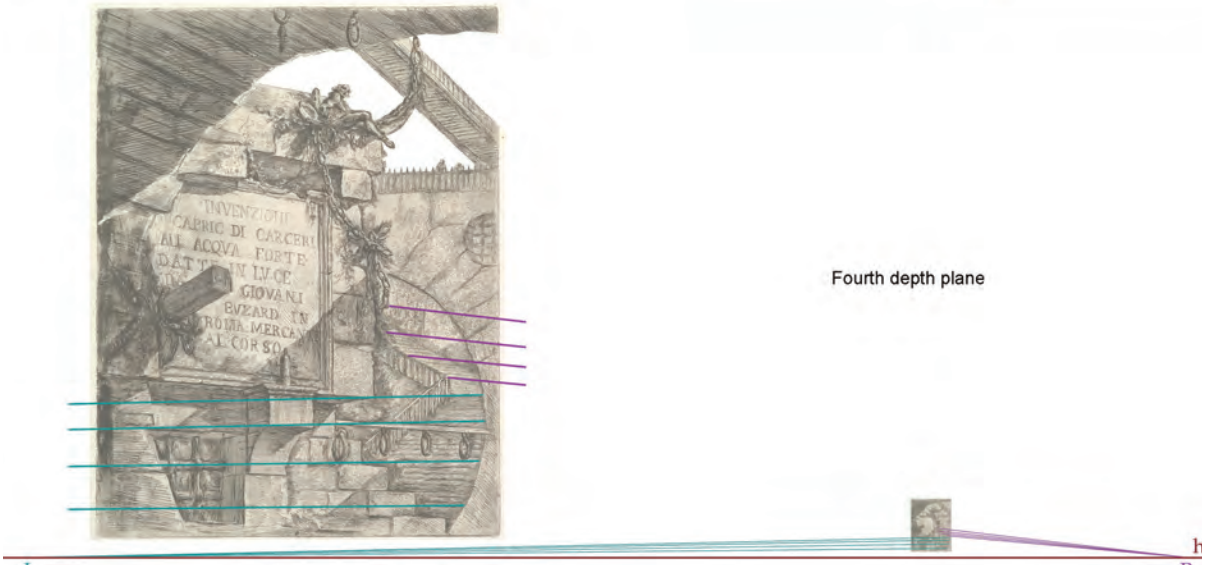


Fig. 8 – Perspective analysis of the depth planes of the frontispiece. All the lines running to the same vanishing point have the same colour (graphic elaborations by the author).


Third depth plane
L3
R3


Fourth depth plane

present a hypothesis of the development of the space that is not directly visible on the plate.
The perspective interpretation investigates the spatial relationship between the objects represented, using scenography principles and perspective restitution tools wherever possible. From the former, we derive the idea of decomposing the plates into various planes at different depths, as if they were backdrops and stage flats. The decomposition is done by looking for those elements that define limits in the representation and identifying space sectors at different distances from the observer. A perspective analysis of these planes is then performed to trace the main elements of perspective (horizon, vanishing points) as these settings inform about Piranesi's communicative intentions. The frontispiece can be broken down into five depth planes (Fig. 7): the element framing the left margin in the foreground; the architecture with the epigraph; the bridge and the footbridge above; the stairs; the background. The perspective analysis of the individual depth planes (Fig. 8) shows that the horizon's position is not shared: it

Fig. 9 – Alfred Yarbus, eye movement experiments (reworked from Yarbus 1967). The work observed was the painting *An Unexpected Visitor* by Ilya Repin (1884), and each of the seven recordings had a duration of 3 minutes and specific instructions: (1) observe the painting freely; (2) assess the economic condition of the family; (3) propose the age of the people depicted; (4) hypothesise about the activities the family was engaged in before the visitor's arrival; (5) recall the people's clothes; (6) recall the position of the people and objects in the room; (7) assess how long the unexpected visitor had been away from the family.

is contained within the board in the foreground and then passes beyond the lower margin in the subsequent planes. The vanishing points of the horizontal lines also vary. The second depth plane shows a further oddity: the monument with the epigraph, assumed to be triorthogonal, has one right vanishing point, R_2, and two left vanishing points, L_1 and L_2. The left vanishing point splits but not due to a rotation of the triorthogonal element because the right vanishing point remains the same. What has just been described is likely a mechanism Piranesi used to provide greater depth to the block with the epigraph at its lower edge above the shelf.

The perceptual interpretation contributes to finding the spatial configuration closest to that the observer perceives. In particular, an experimental method was used based on the image decoding process, which is implemented by the human visual system continuously and unconsciously. This method involved the recording of eye movements using the eye-tracking technique. The greatest acuity in the human visual system is in the *fovea centralis*, the central part of the retina, so the observation of the eye movement allows us to understand what is attracting an observer's attention moment by moment, and its recording is helpful for perceptual purposes. Alfred Yarbus was the pioneer of this type of study[6]. The Soviet psychologist conducted a series of experiments, which enabled him to understand that, during an observation, the elements on which the gaze lingers most are those the observer considers most helpful in perceiving and understanding the phenomenon. The results of one of his eye-tracking experiments applied to a painting show that the tracking pattern varies depending on the instructions given to the observers, confirming that eye movement varies depending on what the observer unconsciously considers most useful for perceptual purposes (Fig. 9). Yarbus in his experiment performed seven three-minute recordings. He gave specific instructions for each one: e.g. to estimate the economic condition of the family, the age of the persons portrayed, to remember the clothes, and so on. Another factor

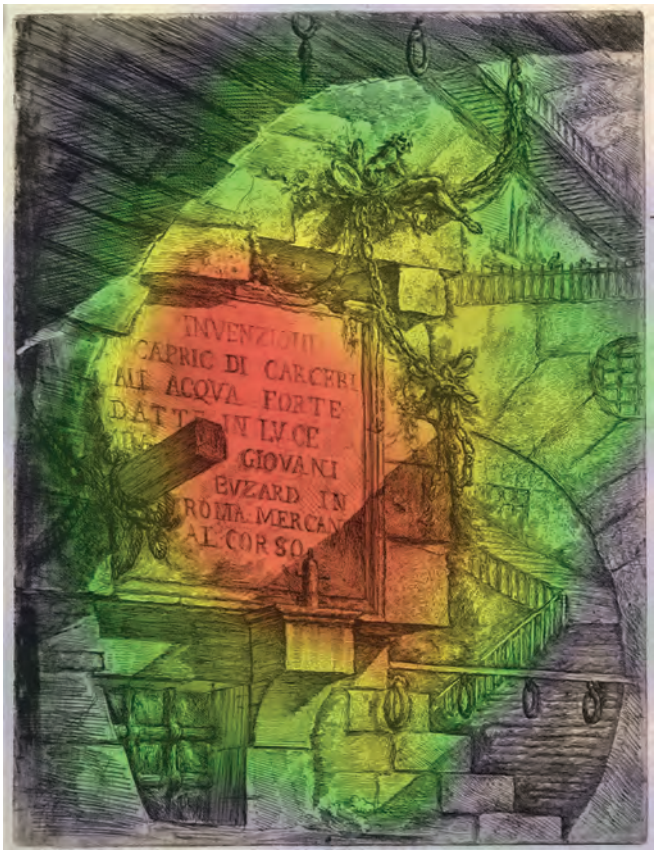


Fig. 10 – Eye-tracking map of the frontispiece (graphic elaboration by the author).

influencing the tracking pattern is the cultural variability of the observers. For this reason, 29 individuals of different ages and cultural backgrounds were involved in the *Carceri* experimentation. Each was asked to look at the frontispiece freely for 20 seconds while eye movements were recorded by a webcam placed above the monitor and processed by a software-based system (GazeRecorder). The resulting output includes an eye-tracking map, whether dynamic or

collecting fixations over 20 seconds. The warm tones of the map are associated with the most observed areas of the plate. The free view allowed us to understand which areas were the most attention-capturing so that more attention could be paid to modelling those parts. In addition, the absence of instructions helped us understand whether the points of most significant fixation were the elements selected as ambiguous, for example, the four steps toward the lower edge of the plate. The perceptual interpretation of the frontispiece shows a pattern concentrated on the epigraph (Fig. 10), as was logical to expect. Since the eye-tracking map shows few fixations at the four steps, it seems reasonable to assume that most observers overlooked the ambiguity introduced by Piranesi. In the last part of the test, the group of individuals was asked to look freely at the four steps and indicate which of the two proposed variants came closest to the one they perceived (Fig. 11). The results show that the most selected variant is the one where the steps are perpendicular to the wall with the inscription. Furthermore, it seems that cultural background was not decisive in the choice. Similar results were obtained in percentage terms between individuals with a background in the scientific disciplinary field of Representation (ICAR/17), thus with a specific background on knowledge of architecture and its representation, and all the others. By combining the results of the three levels (architectural, perspective and perceptual) of analysis and interpretation conducted, it was possible to propose a three-dimensional reconstructive hypothesis of the space represented by Piranesi in the frontispiece. The 3D model shows the same perspective view as the etching when observed from the same projection centre (Fig. 12). The horizon height was assumed by choosing the height

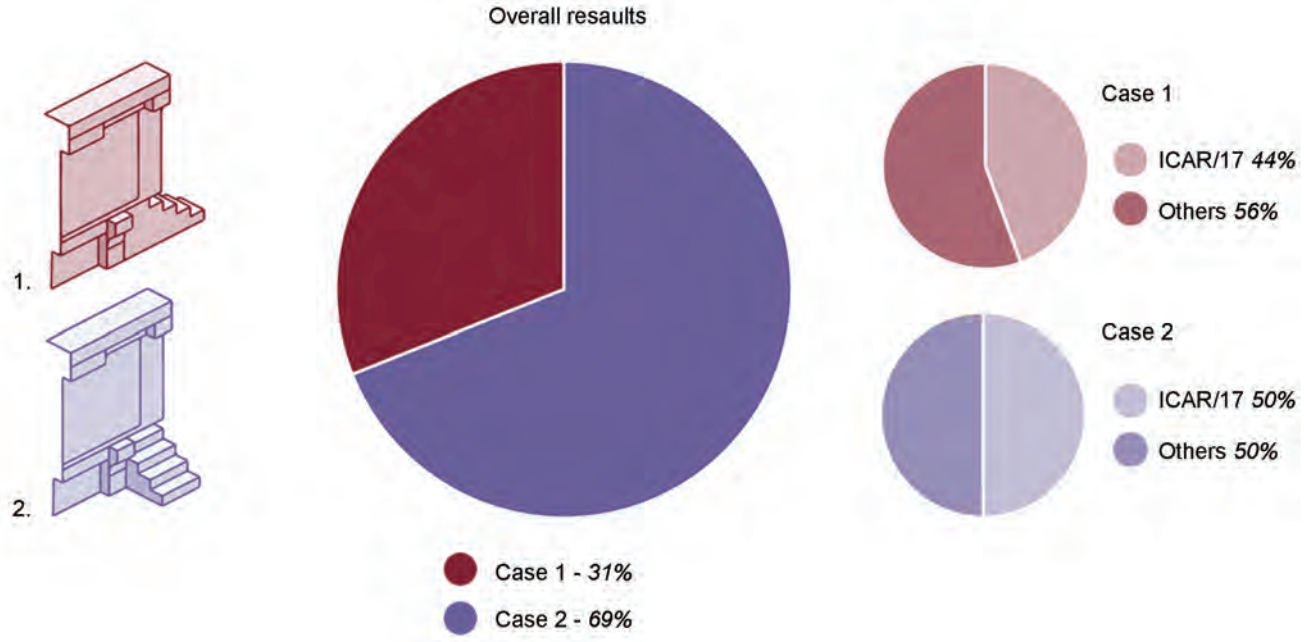


Fig. 11 – Percentages of perception of the two variants of the frontispiece steps (graphic elaborations by the author).

Fig. 12 – Rendering of the 3D model with the reconstructive hypothesis of the frontispiece seen from a projection centre similar to the etching (graphic elaboration by the author).

most commonly found in the perspective analyses of the depth planes. The position of the projection centre was assumed to be at the intersection of the horizon line and the vertical axis of the plate (Fig. 13). The rendering and the etching do not coincide perfectly due to the series of optimisations required to make the Piranesian drawing consistent. For this reason, some axonometric views of the 3D model show different colours based on adherence

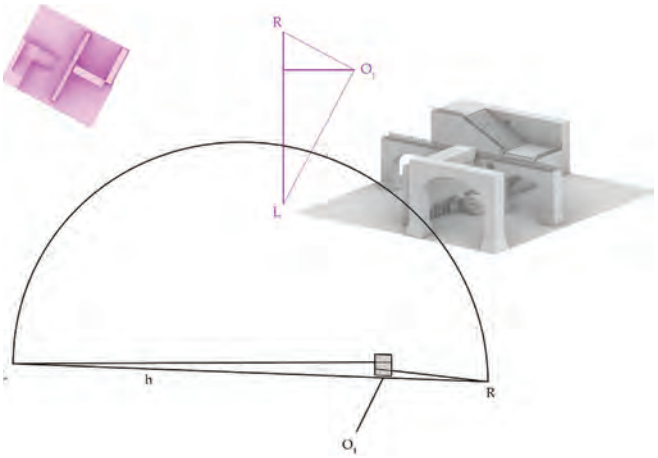


Fig. 13 – Floor plan (in purple) and axonometric view of the 3D model with the perspective setting and position of the projection centre related to the architecture (graphic elaborations by the author).

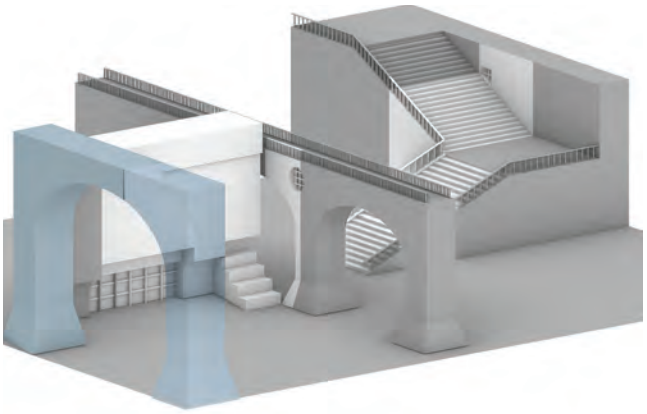


Fig. 14 – Axonometric view of the 3D model with the reconstructive hypothesis in which the colours indicate the level of reliability: the elements deduced from the etching in light grey, the altered elements in blue, the hypothesised elements in dark grey, the omitted elements in transparent blue (graphic elaboration by the author).

to the etching. Elements directly deduced from the plate are in light grey. In blue are those elements modified for architectural and structural coherence. Hypothesised elements not visible within the plate are in dark grey. They have been deduced based on symmetry principles and recurrence from the architectural interpretation (Fig. 14). Given these considerations, the model is one of the infinite possible reconstructive hypotheses since perspective views constructed without rigour do not provide biunivocity between the representation and the represented space.

Conclusions

In order to move from a non-rigorous perspective representation to a three-dimensional reconstruction of the represented space, a path was traced involving the integration of analyses and interpretations in three areas: architecture, perspective and perception. None of these disciplines, individually, would have provided sufficient information for reconstruction, but together they allowed the process of interpretation to be based on the most objective data possible. The main problem in approaching a perspective analysis of the *Carceri* concerns what the literature defined as the multiplication of viewpoints[7]. The solution to this problem was found in breaking down the plates, the frontispiece in this case, into a series of depth planes and analysing the perspective setting of each plane to highlight differences and invariances. This operation, on the one hand, confirmed the general contradiction of the perspective system; on the other hand, it made it possible to 'break down the problem' into small and more coherent portions. The reconstructive hypotheses were based on the recurrences in the analysis of the perspective settings. The analytic study guided the choice of the main elements to base the restitution of space and, first and foremost, the height of the horizon line. In the absence of a pair of vanishing points of at least two mutually rotated triorthogonal elements, the position of the projection centre was hypothesised on an experimental basis at the intersection of the horizon and the vertical axis of the plate. The model was scaled by assuming the size of a human figure: the prisoner above the epigraph. The perspective layout of the reconstruction was chosen so that the perspective image would be faithful to that of the etching: thus cancelling out perspective inconsistencies but not completely distorting Piranesi's 'vision'.

The advancement of knowledge on the subject of the *Carceri* would not have been possible without the attempt to rationalise a space that has very little that is reasonable, a space that fascinates precisely because of its contradictions. There is no risk of belittling an architecture that amazes and disquiets, a space where the gaze is lost and difficult to find again. The result is not intended to replace the artist's imagination or the pleasure of viewing the artwork. The reconstructive hypothesis is not meant to have an emotional response: other interesting outcomes have already been proposed in this sense[8]. The aim was the simulation of the imaginary space. It was achieved by revealing some deception but with the certainty of not undermining the fascination of direct observation of the etching.

Notes

[1] Studies on the subject of virtual reconstruction of perspective views are numerous. Of particular note are the three volumes with the outcomes of the PRIN 2010 research coordinated by Riccardo Migliari on architectural perspectives (Valenti 2014; Valenti 2016 tome I and tome II) and the book *Roma anamorfica* (De Rosa 2018).

[2] This contribution draws its methodological basis from the research conducted by the author during her doctorate (Menconero 2021). This study was further advanced by the publication of a monograph on the subject (Menconero 2022).

[3] Vogt-Göknil 1958.

[4] Baglioni *et al*. 2016, p. 1029.

[5] Fasolo n.d.

[6] Yarbus 1967.

[7] Vogt-Göknil 1958, p. 28.

[8] Grégoire Dupond's videos from 2010 for the exhibition *Le arti di Piranesi: architetto, incisore, vedutista, designer* organised by the Cini Foundation in Venice https://gregoiredupond.com/piranesi-carceri-d-invenzione-2010/; another video by the same author produced in 2020 for the Galleria Nazionale dell'Umbria https://gregoiredupond.com/piranesi-carceri-d-invenzione-300/; the video by the ACE group of the Scuola Superiore Sant'Anna as part of the exhibition *Piranesi. La fabbrica dell'utopia* organised by the MetaMorfosi Cultural Association and curated by Luigi Ficacci and Simonetta Tozzi (here an excerpt https://youtu.be/TYcKiJadgZw); the virtual reality produced by Alessandro Basso (Basso 2018).

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