Laura Carlevaris, Graziano Mario Valenti

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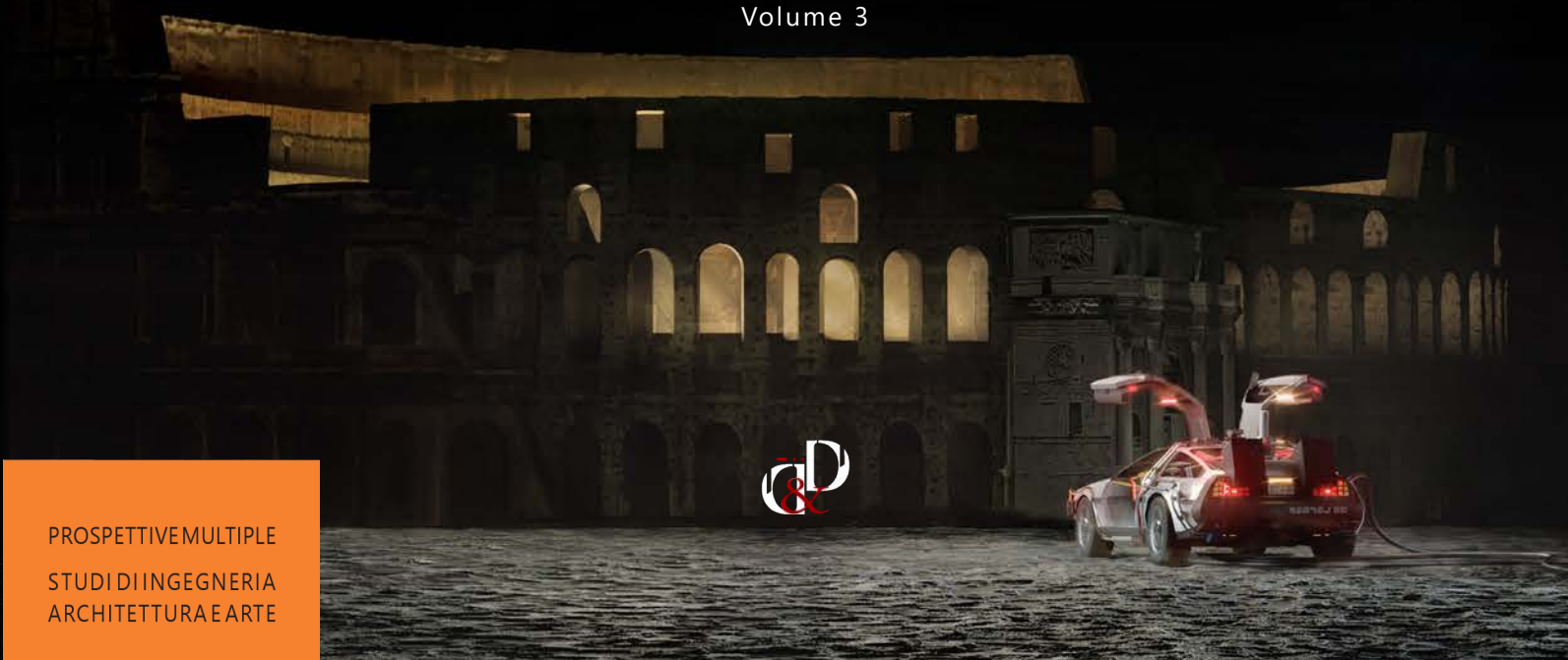
Digital & Documentation

Reading and Communicating Cultural Heritage

Volume 3



PROSPETTIVE MULTIPLE

STUDI DI INGEGNERIA
ARCHITETTURA E ARTE

Laura Carlevaris, Graziano Mario Valenti

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Digital & Documentation

Reading and Communicating Cultural Heritage

Volume 3

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The volume consists of a collection of contributions from the seminar *Digital & Documentation. Reading and Communicating Cultural Heritage*, realised on online platform on December 4th, 2020. The event, organized by Department of History, Representation and Restoration of Architecture, Sapienza University of Rome, promotes the themes of digital modeling and virtual environments applied to the documentation of the tangible, intangible and natural Cultural Heritage. The event has provided the contribution of external experts who are engaged in the management and conservation of the most important Italian cultural assets.
The scientific responsible for the organization of the event is Prof. Graziano Mario Valenti, Sapienza University of Rome.

This publication is made with the contribution of DSDRA, Department of History, Representation and Restoration of Architecture of Sapienza University of Rome.

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Department of History, Representation
and Restoration of Architecture
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The event *Digital & Documentation - 2020* has seen the participation of professors, researchers, scholars and private Institutions

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Architect, Ph.D. in Sciences of Representation and Survey at the DSDRA Department of the Sapienza University of Rome. He deals with the history of representation with particular attention to perspective and the relationship between art and science. He is also interested in architectural survey and, in particular in image-based survey techniques.
Since 2016 he has been teaching as an adjunct professor at the Department of Architecture of the Roma Tre University. At the same department, he was a Research Fellow in 2016 and 2018 dealing with the cultural landscape of the sixteenth-century town of Manziana. Since 2018 he has also been researching on Palazzo Spada in Rome. In 2020 he is a fellow of the Fondazione 1563 della Compagnia di San Paolo.

10 VISUAL RELATIONSHIP ANALYSIS: ALGORITHMIC MODELLING AT THE SPATIAL AND URBAN SCALE

MATTEO FLAVIO MANCINI

Abstract

The potential of algorithmic modelling as an analytical tool was tested in the context of research conducted on the cultural landscape of Manziana (RM), a 16th-century city of foundation. The city of Manziana was established on the Arcispedale del Santo Spirito initiative, which commissioned the architect Ottaviano Mascherino in 1589-1590. The theme investigated in this contribution concerns the evaluation of visual relationships at the territorial and urban scales. The former is used to evaluate the relationships that the foundation site establishes with the surrounding territory and Lake Bracciano. At the same time, the latter allows analysing the perceptual impact of the transformations undergone by the foundation nucleus of the town through the comparison of three configurations: the original project, which was never fully implemented, the conformation of the square attested by the Gregorian Cadastre in the 19th century and the current situation.

Nell'ambito delle ricerche condotte sul paesaggio culturale della città di fondazione cinquecentesca di Manziana (RM), sono state sperimentate le potenzialità della modellazione algoritmica come strumento di analisi. La città di Manziana deve la sua fondazione all'iniziativa dell'Arcispedale del Santo Spirito che incaricò del progetto l'architetto Ottaviano Mascherino nel 1589-1590. Il tema indagato in questo contributo riguarda la valutazione delle relazioni visuali alle scale territoriale e urbana. La prima viene utilizzata per valutare i rapporti che il sito di fondazione instaura con il territorio circostante e il lago di Bracciano, mentre la seconda permette di analizzare l'impatto percettivo delle trasformazioni subite dal nucleo di fondazione del centro abitato attraverso il confronto di tre configurazioni: il progetto originario, mai completamente attuato, la conformazione della piazza attestata dal Catasto Gregoriano nel XIX secolo e la situazione attuale.

The experimentation presented in this paper is part of the research[1] carried out on the town of Manziana (Rome) and its cultural landscape, the Tuscia Romana, i.e. the area of Lazio that includes the northern part of the province of Rome with the lakes of Bracciano and Martignano. In particular, this essay investigates the role of visual relations at the territorial and urban scale, with two different aims: identifying the relations between the foundation site of Manziana and the surrounding territory and the perceptive analysis of the transformations undergone by the urban node of Piazza Tommaso Tittoni. The analysis of the visual relationships was conducted through algorithmic modelling to experiment with its use as an analysis tool.

Foundation cities in the Patrimony of St. Peter and the case of Manziana

The area of Tuscia Romana corresponds to the southern part of the Papal States known as the Patrimony of S. Peter[2]. The Pope carried out the administration of this territory in two ways: an indirect one, thanks to the entrusting to subjects such as noble families and charitable institutions such as the Arcispedale del Santo Spirito; a direct one, carried out through the activity of the Camera Apostolica.
In the 16th century, this area experienced a moment of economic expansion, which also translated into extensive urbanistic and building activity. The richness of specific natural resources, such as the alumite quarries in the Tolfa mountains, and the abundance of wood from the forests that covered the territory, were among the reasons for the interest of many subjects in this Lazio area. After the Sack of Rome in 1527, the achieved political stability created the socio-cultural conditions for the settlement of summer residences and real extra-urban palaces of the most important Roman families.
In this context, three types of interventions on the region's settlement fabric can be recognised: the modernisation of medieval centres into Renaissance style; *extra moenia* planned extensions; and the foundation of new villages for managing the territory[3]. This last typology finds a significant concentration of cases in the territorial strip that goes from the Tyrrhenian coast, in correspondence with the Civitavecchia port, includes the strip of the Tolfa mountains and reaches the lakes of Bracciano and Martignano. Here, thanks to the action of different subjects, several villages were founded in a few decades: Rota (1550-1592) and Oriolo Romano (1578-1585) on the initiative of the Santacroce di Vejano; Allumiere (1580) by the Camera Apostonica[4]; Manziana (1589-1590) and Castel Giuliano (1664) by the Arcispedale del Santo Spirito (fig. 1). The foundation of Manziana took place between 1589 and 1590 according to the design of Ottaviano Mascherino, architect of the Arcispedale del Santo Spirito, through the construction of its central nucleus: the square overlooked by both the palazzo del Santo Spirito and the church of San Giovanni Battista (today Piazza Tommaso Tittoni)[5]. The foundation's site is located on the eastern slope of the hills immediately adjacent to the western shores of Lake Bracciano and about 15 km from the Tyrrhenian coast. The original project was implemented at the foundation level but only partially realised from an architectural perspective. It is still testified by the project drawings preserved in the Fondo Mascarino of the Historical Archive of the Accademia Nazionale di Santa Cecilia in Rome[6]. The study of these drawings, previously carried out as part of the research (fig. 2), has allowed a three-dimensional reconstruction of the project[7] that is the object of the analyses at urban scale of this contribution together with those at a territorial scale.

Visual relationships and the criterion of intervisibility

The analysis of visual relationships is a powerful tool for knowledge and understanding of the reality around us[8] because it makes it possible to treat in graphic and measurable terms aspects that would otherwise be

exquisitely qualitative, such as those linked to the visual perception of the territory and urban spaces.
The visual experience activates the process of 'symbolisation' and man's identification with the territory[9], while vision is the first tool for measuring and verifying the design. Perspective can be considered the geometric counterpart of the optical-visual process and has been one of the architects' design tools since the Renaissance. The design importance of perspective is confirmed in the late 16th-century experiences of foundation and re-foundation[10] mentioned above.

The analysis of visual relationships is therefore meaningful at different scales because, on the one hand, it relates human settlements to their respective territories and, on the other hand, it allows to analyse the perceptual values of settlements in relation to the people who inhabit them.
These analyses can be carried out by applying the criterion of intervisibility between points, i.e., through geometric operations that check whether two points are mutually visible or whether there is any obstacle between them.

Fig. 1 - The figure represents the territory of Tuscia Romana with the foundation towns built between the 16th and 17th centuries.

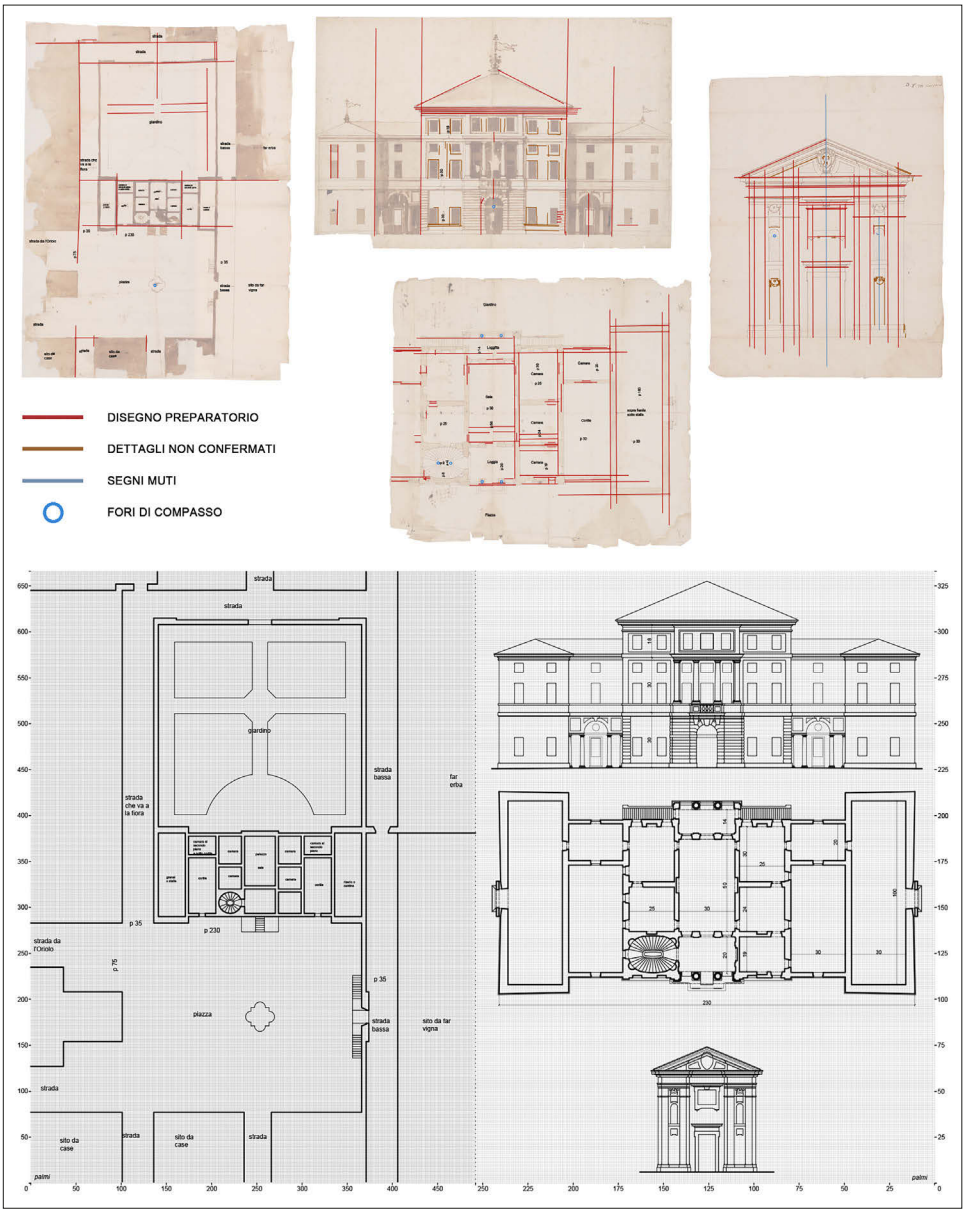


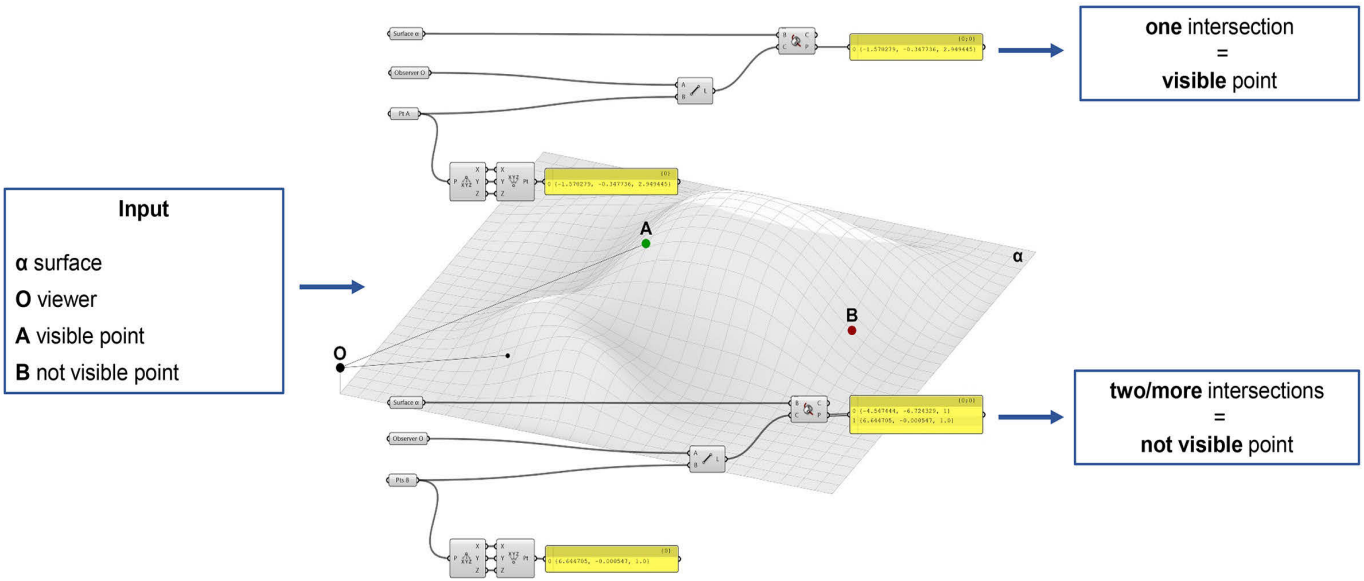
Fig. 2 - The analysis on drawings by Mascherino for Manziana: the construction signs in the original drawings (above); the critical transposition of the drawings (below).

Fig. 3 - The basic algorithm that determines the intervisibility condition between points.

The essential condition of intervisibility from an algorithmic point of view can be effectively represented through the number of intersections of the visual ray:
- if the visual ray, which connects the analysed points to the observer O, returns only one intersection, this intersection will correspond to the observed point itself, and then it will be a visible point;
- if the visual ray returns any number of intersections greater than one, the analysed point will not be visible[11] (fig. 3).

The structure of the algorithm

The algorithms used for analyses at different scales share a basic structure consisting of three functional blocks that perform specific tasks (fig. 4):
- Block A generates the three-dimensional model to be analysed using different inputs while identifying the point(s) of view is done by indicating them directly on the model. In territorial scale analysis, the inputs are GeoTIFF satellite images and OSM (Open Street Map) data: the former are used for modelling the topography while the latter provide data for tracing artificial structures. For urban scale analysis, the input is instead a three-dimensional model treated to consist of a single polysurface. This block is also responsible for creating the grid of analysed points on the model's surface through its intersection with two arrays of orthogonal and equidistant vertical planes;
- Block B performs the intervisibility analysis by performing three operations: it traces the visual rays; it locates the intersections between the visual rays and the polysurface; it counts the number of intersections for each ray;
The outputs of this block are the intersection points and the numbers of occurrences for each analysed point, the latter represented by data lists;
- Block C generates the analytical and graphic



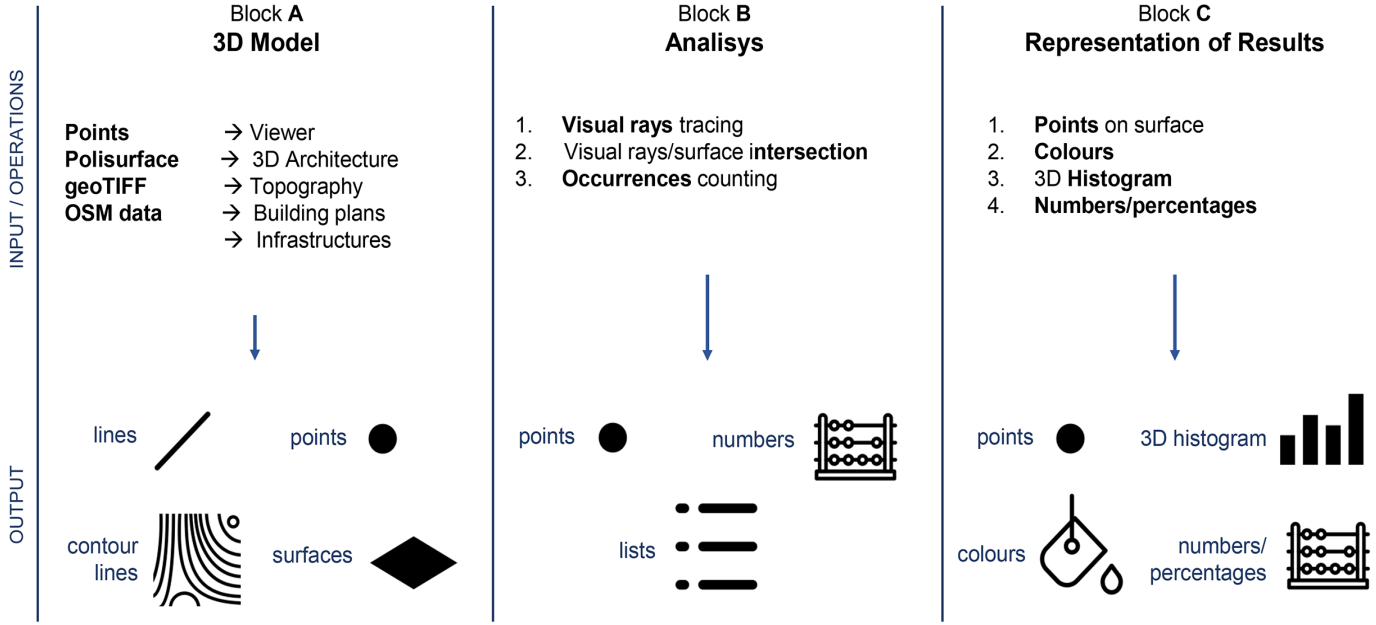


Fig. 4 - The logical outline of the structure of the algorithms adopted in the experimentation.

Fig. 5 - The part of the territory covered by the intervisibility analysis and the seven considered settlements.

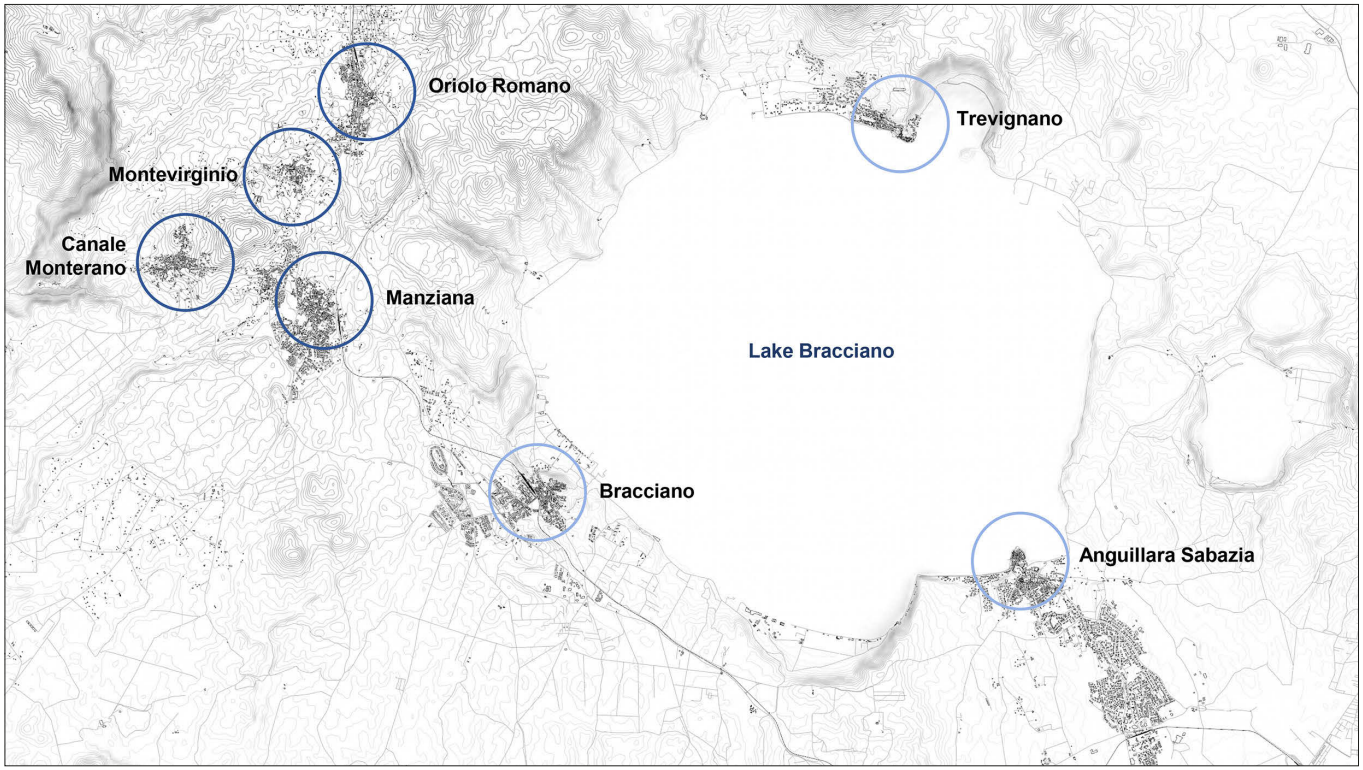
representations of the analysis results. The former are lists composed of the absolute number of visible points and the respective percentages to the total number of analysed points, while the latter can be of two different types. A first representation is composed of points, which coincide with the analysed points, coloured according to their condition of intervisibility.

A second representation, which is more abstract than the previous one because it maintains the planimetric position but not the altimetric location of the analysed points, is composed of a coloured three-dimensional histogram in which the height and the colour of the columns represent the number of viewpoints from which the analysed point is visible.

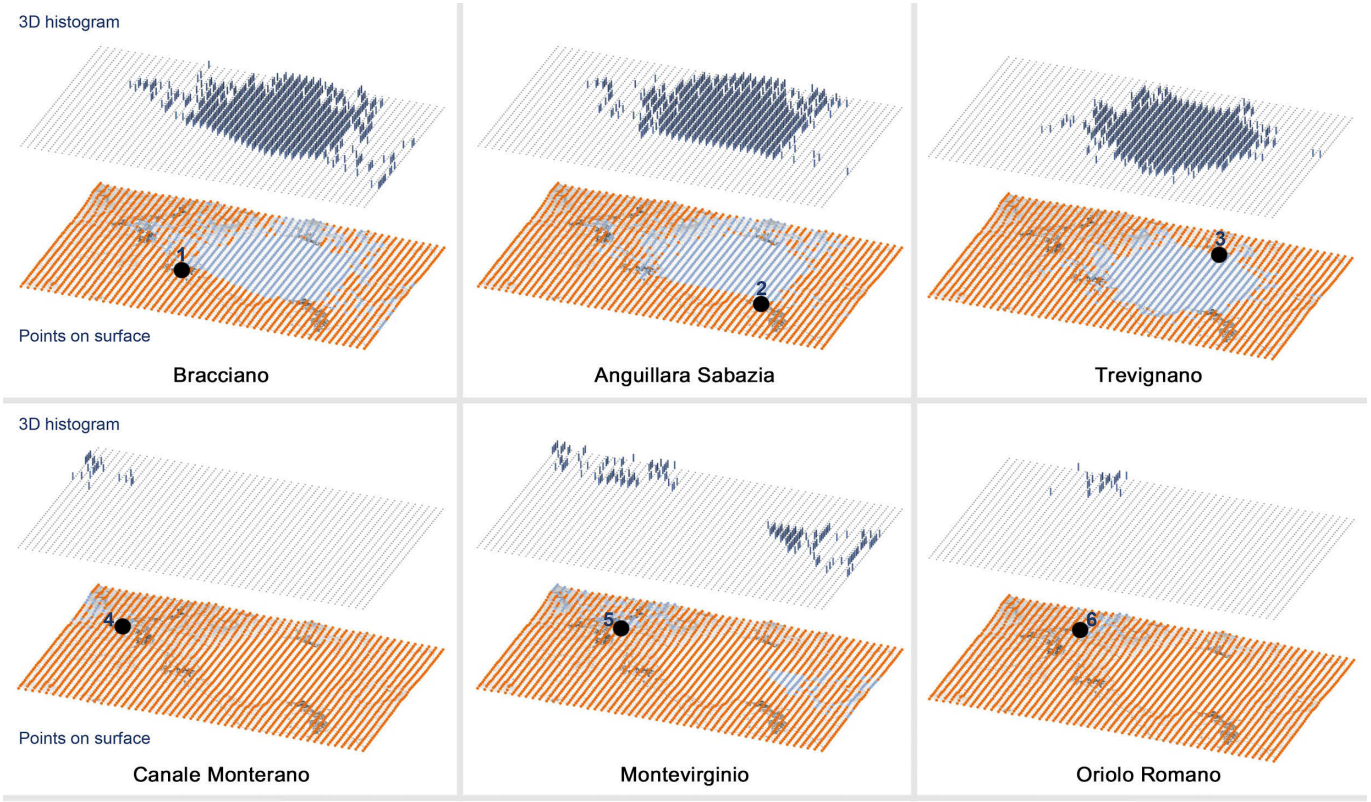
This second representation is handy in the case of analyses conducted from several simultaneous observation points.

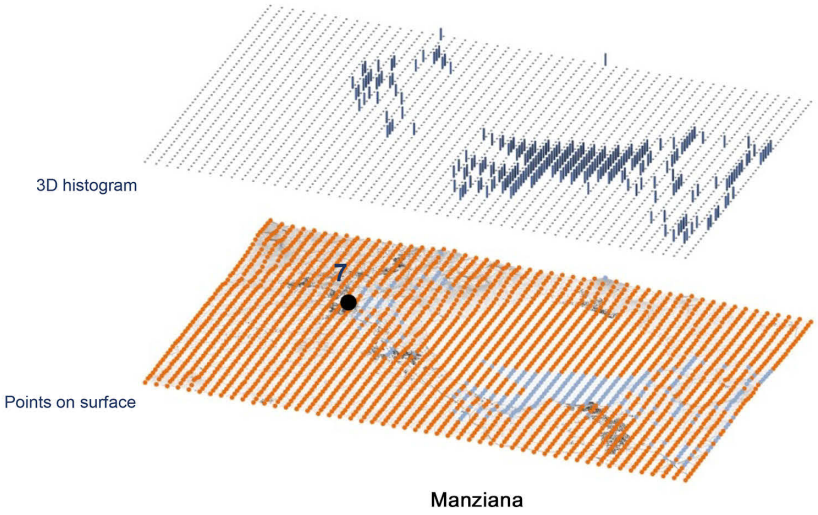
Visual relations at territorial scale

The analysis of intervisibility at a territorial scale was carried out on a portion of territory that includes Lake Bracciano and the hills immediately adjacent to its western shores. Seven settlements fall within this territory. Significant points of these settlements, such as the main squares, were chosen as observation points (fig. 5).



The analyses performed from the individual settlements revealed two types of visual relationships between the villages and the territory.
A group of settlements – consisting of Anguillara Sabazia, Bracciano and Trevignano – showed solid visual relationships with the lake basin, as we could expect given their coastal position, and showed a total absence of relationships with the surrounding area due to the rapid altimetric growth of the lake shores. Another group of settlements – to which Canale Monterano, the Hermitage of Montevirginio and Oriolo Romano belong – shows a total absence of visual relations with the basin and a tendency to relate to the northwest territories even though they are located immediately behind the lake. Among the settlements on the hills, which share the same foundation or important renovations histories, Manziana is the only one that establishes a significant visual relationship with the lake. In fact, the analysis has shown a clear visual relationship with the south-eastern shores of the lake and other, less significant, relationships with the northern shores. This characteristic makes unique the foundation site of Manziana among the centres gravitating around the shores of Lake Bracciano (fig. 6).
Two analyses were also carried out from multiple viewpoints. The first concerned the Olmata avenue, which connects the Altieri Palace in Oriolo Romano with the village of Montevirginio, located at the foot of Mount Sassano. In


3D histogram
1
Points on surface
Bracciano
2
Anguillara Sabazia
3
Trevignano
3D histogram
4
Points on surface
Canale Monterano
5
Montevirginio
6
Oriolo Romano


3D histogram
7
Points on surface
Manziana

this case, eight viewpoints equally distributed along the 4Km straight road were taken into consideration. The analysis showed that, due to the orographic conformation of the straight road, the walker has visual relationships exclusively with Altieri Palace and the Hermitage situated on the slopes of Mount Sassano. In contrast, he has none with the rest of the surrounding territory.
These results prove the design intentions of the commissioners, the Altieri family, who were lords of both Oriolo Romano and Montevirginio in the 17th century and who wanted to symbolically underline the link between the family, the two villages, the territory, and the sacred place of the Hermitage.
The second test involved the simultaneous analysis of the area from the seven settlements to assess which part of the territory is most strongly linked to the human settlements gravitating around Lake Bracciano. The result showed that the part of the territory with the most significant visual relations with the settlements is that of the south-eastern shores of the lake. This result could support the hypothesis regarding the existence of alignments oriented towards Rome at a territorial scale[12] (fig. 7).

Visual relations at the urban scale

The intervisibility analysis was then applied at the urban scale to evaluate the perceptual impact of the transformations undergone by the foundation nucleus, today's Piazza Tommaso Tittoni. The three-dimensional models to be analysed were carried out based on different sources: Mascherino's drawings were used to reconstruct the three-dimensional model of the foundation project; the building consistency attested by the Gregorian Cadastre

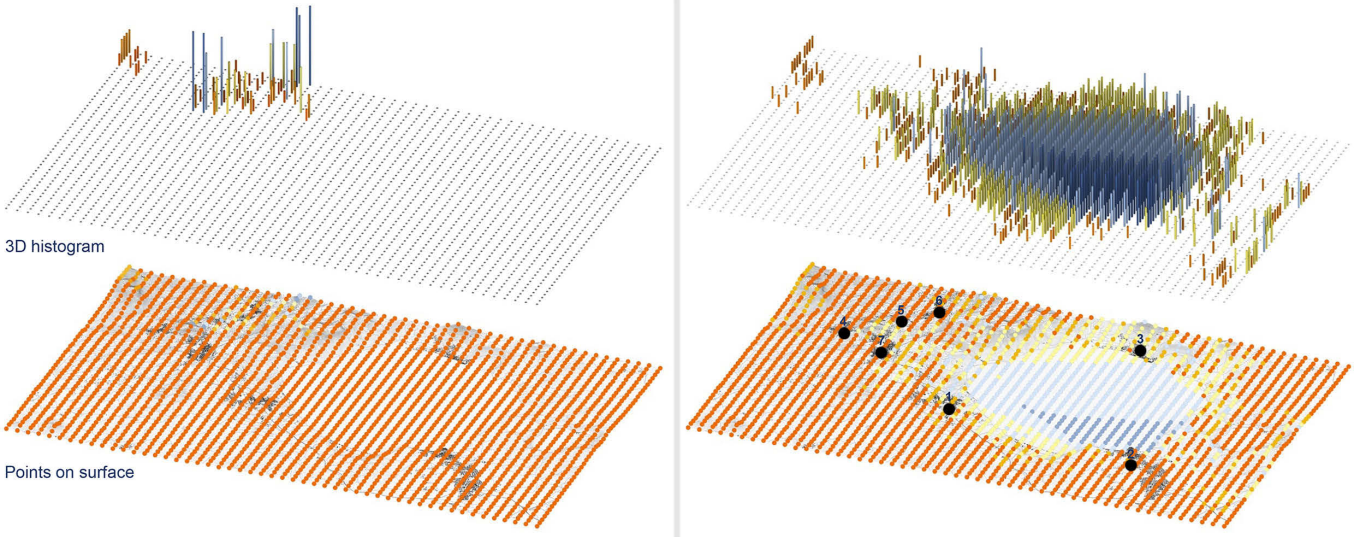
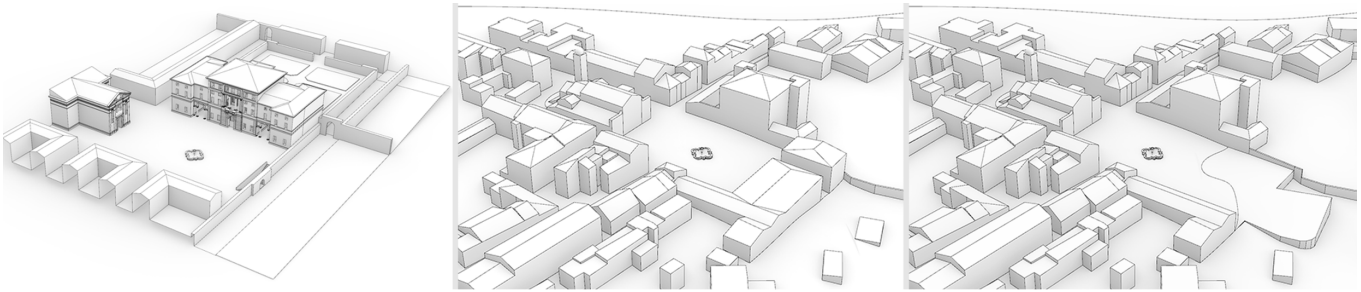


Fig. 6 - The results of the intervisibility analysis at territorial scale from an individual point of view.

Fig. 7 - The results of the intervisibility analysis at territorial scale from several simultaneous points of view.

was reconstructed from the map of the nineteenth-century cadastre and the integrated survey of the actual state; the model of the current situation is based on the integrated survey of what is now present in Manziana.
The comparison between the three phases highlights the continuity existing between the foundation project and the current configuration, especially regarding the overall layout and the palace on the north side of the square, the church on the west side and the residences on the south side. The western side of the square has undergone the most transformations: in Mascherino's project, it was envisaged as a side closed off by a wall and a staircase; in the Gregorian cadastre, however, it appears cluttered by a thick building block; today it is completely open, like a panoramic view towards the lake (fig. 7).
The analysis at urban scale was carried out for the three phases taking into consideration the three main accesses to the square: the one from the south, from the current Via Roma, the one from the west, through the current Corso Vittorio Emanuele, and the one from the east, coming up from the train station. Comparing the quantitative results is helpful to determine which entrance offers the broadest view of the complex and, therefore, to evaluate how much the transformations that have occurred to the original project have interfered with Mascherino's initial intentions. The evaluation of the results assumes that the preferred access of each configuration is the one that ensures the widest view of the architectural-urban complex.
The first emerging result is that the design conceived by Mascherino was perceptually more balanced than what was actually built. In fact, the number of visible points from the respective entrances varies considerably less, with variations within 100 points, compared to the other two analysed phases, which instead show considerably more significant variations. In particular, the phase attested by the Gregorian cadastre shows a substantial equivalence of the south and east entrances, while the one that returns the highest result is the one from the west (932 points). The latter can be considered as the perceptually privileged entrance. On the contrary, the current state appears the most unbalanced, with a substantial prevalence of the east entrance (1926 points) due to its complete opening towards the territory to the east and south.
We can also observe that the preferred entrances of Mascherino's project were those from the south, oriented towards the palazzo del Santo Spirito, and those from the east, aligned with the façade of the San Giovanni Battista Church. This characteristic was wholly altered in the 18th century, while today, the prevalence of the east entrance appears to partially recover the importance assigned by Mascherino to this direction of access (fig. 9).



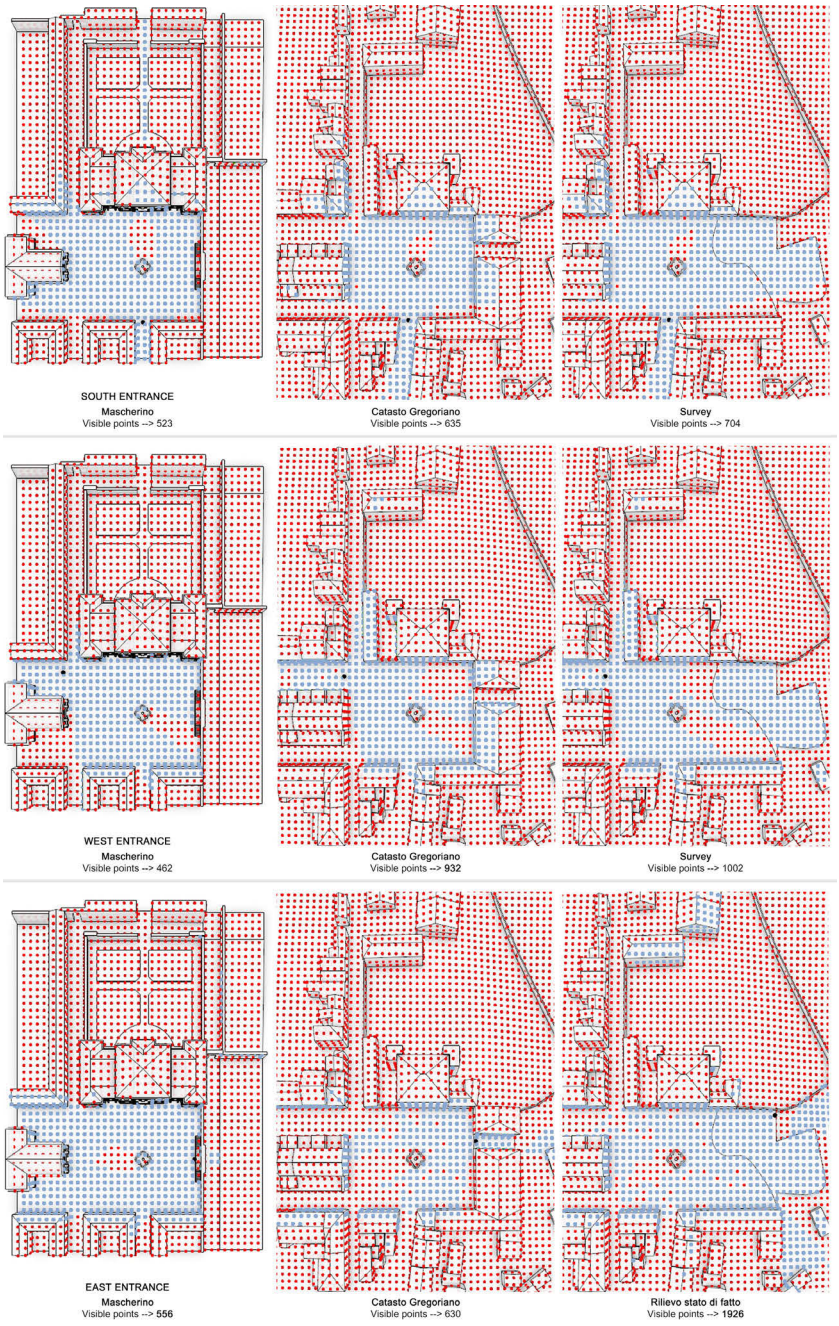


Fig. 8 - The three-dimensional models of the three analysed spatial configurations.

Fig. 9 - The results of the urban scale intervisibility analysis from an individual point of view.

Conclusions

The results of the intervisibility analyses provided useful data for interpreting the urban transformations that occurred on the foundation nucleus of Manziana. It shows that the original project was significantly balanced concerning the different accesses, with a slight preference for the east entrance, while the subsequent configurations present more evident preferences, the west access in the 18th century and the east one nowadays.
The discussion of the results provided by the algorithms for the analysis of intervisibility shows the effectiveness of algorithmic modelling tools for analysis due to the possibility of simultaneously providing both purely quantitative data and their three-dimensional spatialisation. The latter property is essential as it is of great help in the critical interpretation of purely numerical data.
The user's possibility to build customised algorithms, capable of equally effectively working at different scales, ensures a high degree of control over the entire analysis process, from the simulation of the environment to the extraction of the data to be analysed, up to the production of the results and their representation.
The proposed algorithms can be further implemented in different directions: the introduction of components that allow for the processing of other types of data, such as LiDAR data, at both territorial and urban scales; the application of filters that model human vision more accurately, for example by introducing a maximum radius of analysis from the chosen viewpoint; segmentation tools that allow for more specific analyses.

Notes

1. The Department of Architecture of the Roma Tre University has been researching cultural landscapes for many years; the research on Manziana was developed between 2016 and 2020 within a framework agreement with the Municipality of Manziana coordinated by Prof. Giovanna Spadafora (Drawing) and Prof. Saverio Sturm (History of Architecture). Thanks to this convention, two research grants were activated in 2016 and 2018, the second one being co-financed by the Municipality of Manziana.

2. Conti 1980.

3. Bruschi 2000.

4. Rinaldi 1978.

5. Sturm 2014; Colonna 2016.

6. Wasserman 1966; Marconi 1974.

7. Mancini 2017; Mancini 2019.

8. Rizzo 1990.

9. Norberg-Schulz 2016.

10. Norberg-Schulz 2012.

11. Mancini 2020.

12. Norberg-Schulz 2016.

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