3D-GIS as a platform for visual analysis: Investigating a Pompeian house

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ABSTRACT

The aim of the present work is to introduce an innovative framework for employing 3D-GIS as an exploratory platform to perform visual analysis. Such a methodology is aimed at detecting patterns of visibility to simulate the past human perception of specific categories of artifacts placed inside a virtually reconstructed three-dimensional space. As a case study, the house of Caecilius Iucundus in Pompeii (regio V, insula 1, entrances 23 and 26) was chosen and two media of visual communication, a painting and a graffito were tested to make an assessment of their visual impact on hypothetical observers. The approach consists of a vector-based line-of-sight (LOS) analysis, now available as an integral component of the 3D-analyst toolkit of the ESRI ArcGIS 10.x software package. This toolkit allowed us to perform the entire process inside a GIS environment, without splitting the tasks among different software platforms.

It was thus possible to detect a significant difference in terms of visibility among the observed objects.
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1. Aims: *Insula* V 1 goes digital, from collection to simulation

The case study presented provided us with a great opportunity to test an innovative approach in the field of 3D visibility analysis. Among the research objectives it is worth mentioning:

1) The use of a GIS platform for managing and analyzing geometrically-complex 3D models 2) Adopting the same georeferenced digital environment both to collect research datasets and to perform cognitive simulation. 3) Defining a work pipeline to investigate multiple datasets of objects so as to detect complex patterns of human presence/absence inside the ancient built space.

Two different artifacts have been tested as a case study to develop this methodological framework. Both of the objects, a small alphabet graffito and an erotic fresco represent a class of artifacts which was made with the intention of visually communicating to one or more observers. Despite no significant patterns emerged, due to the small amount of data included in the process, such an experiment was important to show an innovative method for overcoming some of the current limitations in viewshed analysis and to provide new instruments for supporting the investigation of the Roman buildings and shedding new lights on the concept of public and private dimension in the domestic space.

In the autumn of 2000 the Swedish Pompeii Project, affiliated to the Swedish Institute in Rome, initiated fieldwork in *Insula* V, 1, Pompeii, with the aim of recording and analyzing a full city-block. From the very beginning, several different types of documentation techniques were performed; this multiple methodological approach was used in order to find more effective workflows. During the field campaigns 2011 and 2012 a 3D acquisition was performed by means of laser scanning and image-based 3D modeling by a team composed of researchers from Lund University (Institute of Archaeology and Ancient History together with the Humanities Laboratory) and the National Research Council of Italy (Institute of Information Technology and Science "A. Faedo") (Dell'Unto et al., 2013a). This work allowed the generation of 3D models of the complete insula at different levels of details. Once post processed the 3D models generated by the team were used to develop a virtual interpretation of different parts of the *insula* (Dell'Unto et al., 2013b) and to build a 3D-GIS system capable of visualizing 3D texturized boundary models generated by the scanner in spatial relation with the rest of the data collected so far by the Swedish Pompeii Project (Dell'Unto et al., 2015).

The reconstructive workflow (from fieldwork to the 3D interpretation) was carried out taking into account the results of the theoretical and methodological discussion built so far around the definition of Virtual Archaeology. In the last years a lot of efforts have been spent in defining guidelines for the implementation and formalization of workflows to construct virtual interpretations and visualization methods in specific documents such as the London Charter (LC) and the Principle of Seville (PS) (LC, 2009; PS, 2011) with the purpose of supporting and promoting interpretation and simulation based on a theoretical and multidisciplinary scientific approach (Barcelò et al., 2000).

More recently new theoretical approaches such as Cyber Archaeology have defined an important shift promoting the use of 3D models/systems as instruments of interpretation. The discussion developed was focused on interaction between models or between models and users (Forte, 2010).

The possibility to have direct access to a large number of different sources (such as digital drawings, ortho-images, textual reports) and the opportunity to acquire the archaeological structures employing a number of different techniques, make *insula* V 1 a perfect case study for experimenting new workflows for the development of virtual interpretation. The southern part of the double atrium house that belonged to the "banker" Lucius Caecilius Iucundus (floruit in the 40s and 50s CE) has been chosen for the full virtual reconstruction described below.

1.1. Spatial analysis in Roman archaeology: previous studies

In the last twenty years, an increasing interest has been devoted to the study of the spatial configuration in Roman contexts (Wallace Hadrill, 1994; Laurence, 1995; Allison, 1997; Foss, 1997; Grahame, 1997; George, 1999; Stöger, 2011; Van Nes, 2014) with several studies dealing with the application of digital tools for assessing space (Earl, 2005, 2007; Anderson, 2005; Stöger, 2014).

Many studies have been focused: (a) on finding new ways for interpreting the built environment of Pompeii, and to demonstrate the Roman house as an indicator of patron's wealth and power; (b) on the role of space in defining and modeling identity. In this interpretation, the potential of digital models to reconstruct the ancient space of Roman society has been underscored by authors (Earl, 2007). In this respect, Anderson (2005) carried out a GIS-based visibility analysis to make an assessment of the most visually-connected areas within a series of Pompeian houses. The main limitation of this study was the bi-dimensional nature of the analysis. To overcome this limitation, Earl (2007) made one of the first attempts to investigate the spatial configuration of a Roman house through an integrated approach of 3D modeling software and GIS. The introduction of 'agents' in Roman models contributes to their transformation into engaging and living places (Earl, 2007). Compared to more traditional approaches to the study of spatial configuration of architectural contexts, which often rely on the use of space syntax and access analysis techniques, the latest developments include the use of visual analysis.

1.2. The research context: description of graffiti in the house of Caecilius Iucundus

A total of 19 graffiti (inscriptions made by scratching the wall plaster with a sharp object), three painted "graffiti", two *programmata* (painted electoral notices) and three drawings are known from the house of Caecilius Iucundus. None of them is visible today due to the deterioration and disappearance of wall plaster. They were published in the supplement to *Corpus Inscriptionum Latinarum* (CIL) IV printed in 1909.

In the southern part of the house of Caecilius Iucundus, V 1,26,

most of the graffiti is found in and around the peristyle. Several are found on the columns. There is one starting with the word *vestali* (Vestal virgin) and then continuing with the whole alphabet from e onwards and there are also the letters a and b written on their own. These kinds of texts are likely to have been written by children as a sort of practice (Huntley 2010).

The almost complete alphabet (CIL IV 4084) is likely to have been written by a child in the house. It is quite small, made in a less visible technique (scratching the plaster with a sharp object) and was not meant to be seen or read by many. The records in CIL tell at which wall and at which column the inscriptions were found, and at which side of the column. They do not give any more exact location of the inscriptions, like height above ground or distance from a corner. The placement shown in this article is therefore hypothetical and based on what we know about location from still preserved inscriptions of the kind.

1.3. The research context: erotic fresco in the peristyle

The erotic fresco, now in the Archaeological Museum of Naples, was situated in the north Portico of the peristyle between the most elaborate banquet hall of the house, exedra O and the neighboring double cubiculum P. Its original position on the wall can still be spotted easily. The size, position and costly material (among which gold sheet) clearly indicated that this fresco was a piece of pride, made for visibility. The fact that it depicts a bedroom scene has been put forth as abnormal in such a public location, as "unambiguously misplaced", thus betraying the it had been commissioned by a person "who did not know better", i.e. Caecilius Iucundus, a freedman lacking in elite decorum (Clarke, 1998, 153–161). It merits observing that the image in itself is rather innocent, showing the couple nude, but by back, and not involved in actual love-making. The position of this painting remains however, an oddity, needing comments, when approached in light of "normal" Pompeian practice (Hackworth Petersen, 2006, 164–6; Karivieri, 2014, 105–6).

2. Methodological description of the visual analysis

In the last few years, 3D vector-based visibility analysis was adopted in urban planning and geography studies, with several examples presenting the use of line-of-sight (LOS) analysis for assessing the perception of urban space (Yang et al., 2007; Rød and van der Meer, 2009; Moser et al., 2010; Suleiman et al., 2011). In the frame of this project, the recent technical advances occurred in 3D visualization system, made ESRI ArcGIS the most suited solution. The possibility of importing geometrically-complex texturized 3D surface models and 3D models on the ArcScene extension has been already explored by Optiz and Nowlin (2012) and further developed in the context of the Swedish Pompeii Project (Dell'Unto et al., 2015; Landeschi et al., 2015). As a result, both the model of the southern house of Caecilius Iucundus as it was acquired during the fieldwork campaign (Dell'Unto et al., 2013a) and the reconstruction of the entire house as it was in ancient times (Dell'Unto et al., 2013b) were imported in GIS as multipatch geometrical features (ESRI, 2012). The latter one in particular provided the basis to perform a LOS analysis on a set of defined targets.

2.1. Targeting the alphabet and the fresco

As one of the purposes of this experiment was to test the visual impact of different categories of objects, an alphabet inscription and a wall painting were compared against each other (Fig. 1). Accordingly, both of them were set as the objects to be targeted by means of sightlines generating from a set of observing points. The