Visualizing cityscapes of Classical antiquity:

from early modern reconstruction drawings to digital 3D models

With a case study from the ancient town of Koroneia, in Boeotia, Greece

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1. Introduction

It was 1519 when Raphael, together with the humanist Baldassarre Castiglione, wrote his famous letter to Pope Leo X in which he explained his method of architectural representation. He was about to endeavour on an ambitious plan, which Leo X had commissioned him to carry out, to draw the first visual reconstruction of Imperial Rome. This project, which was interrupted by Raphael's death in 1520, aimed to preserve and restore the city which had been ruined by the passing of time, the incursion of barbarian tribes, spoliations and neglect under the Popes. As we learn from the letter, Raphael was convinced that he could in all truthfulness ('per vero argomento') and unerringly ('infallibilmente') reconstruct the buildings in ruins by accurately and systematically documenting the still standing examples, using them as comparison to infer the missing elements, and studying the principles of ancient Roman architecture in the works of Latin authors.

Along with the development of a scientific method of archaeological inquiry, Raphael's self-assurance in the possibility of reconstructing accurately ruined buildings has been progressively substituted for by the awareness of the limitations in our ability to understand the past, and of the necessity to rely on conjectures when trying to reconstruct it. In recent years, the introduction of digital techniques has brought about a revolution in the speed and accuracy with which archaeological evidence can be recorded, and has offered new tools to visualize and analyse complex archaeological datasets. In particular, the use of 3D models in archaeology has increased dramatically in the last few years.[1] Two major topics can be identified, one related to the application of 3D recording techniques to obtain digital replicas of extant remains (which represents the majority of the papers), the other regarding the use of 3D modelling techniques in order to create virtual reconstructions of lost artefacts (which makes up only about 20% of the sample of papers in a survey by Münster).[2] These two branches are conceptually and practically very different, even though they are often subsumed under the common label of 3D modelling.

The ever-growing use of computer-based visualizations and the ubiquitous presence of digital 3D reconstructions have created a new set of challenges for archaeologists working in this field and has made more apparent the conflictual relationship that many archaeologists have with visual representations. While the written word allows an in-depth discussion of the available data and the exploration of the possible alternative interpretations, the visual language calls in fact for more simplified and immediate ways of representation, thus making it challenging to account for the fragmentary nature of the archaeological data and the existence of equally plausible alternative hypotheses in a (on paper or digital) reconstruction drawing. For these reasons, images are traditionally not equated to authoritative interpretations and, as Smiles and Moser put it, 'as a result archaeologists have tended to overlook images or, at best, to consider their existence as an adventitious phenomenon, divorced from the work of 'real' archaeology.'[3]

This unsolved tension between scholarly production and popular culture in archaeology has been reinvigorated by the introduction of 3D modelling techniques, especially in regard to the use of digital archaeological reconstructions. The problematic aspects related to the validation of virtual archaeology have been evidenced by scholars soon after its inception,[4] and the term 'reconstruction' itself has

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[1] According to a recent survey conducted by Olson *et al.*, among the works that were published in the *Journal of Archaeological Science* those concerning 3D models have increased by 300% in the last decade (Olson *et al.* 2014, 162).

[2] Münster 2013, 198.

[3] Smiles and Moser 2005, 6; cf. also Favro 2006, 325-6, who cites the 'scholarly discomfort with visual representations of ideas'.

[4] E.g. Miller and Richards 1995; Gillings 2000; Forte 2000; Ryan 2001.

been under debate for its implying a certain degree of certainty in the way archaeologists are able to interpret the past through the surviving artefacts. Some scholars have indeed suggested to avoid to use this term completely, and to opt instead for the use of other definitions such as 're-presentation',[5] 'simulation',[6] 'visualization',[7] or 'construction'[8], which reflects the postmodern view that these models are our construction of the past, mediated by our present culture – contrary to the term reconstruction, which conveys a 'false sense of knowledge'.[9]

The implementation of methods for intellectual transparency in relation to the original data and interpretations to ensure a philologically correct 3D reconstruction have indeed received much attention by scholars working in this field and the debate that has sparked for best practices resulted in the publication of documents such as the London Charter and the Seville principles.[10] Despite this progress made in setting standards for computer-based visualizations in archaeology, a recent survey analysing papers presented at major conferences in 2012 has shown that still only a very small percentage of published papers on 3D models in archaeology (1% of 686 papers) included methods to integrate information on the modelling choices and to validate their results.[11] Moreover, since usually the 3D reconstruction is still seen as an accessory phase for the communication of the results to the public, research has been rarely directed to developing a methodology to embed the creation of the 3D model within the cycle of knowledge generation. Advances in computer graphics and 3D GIS, greater accessibility of computer power and 3D modelling software have resulted in an increased knowledge of dedicated programmes by archaeologists allowing them nowadays to experiment more broadly than what was possible before with the use of 3D modelling as a research tool to formulate new hypotheses and analyse complex datasets. Yet in the last decades, there have been only a few examples of 3D visualizations that are exploited for research purposes before (or instead of) being used for public outreach,[12] this latter field comprising still the vast majority of the applications of 3D reconstructions.

The impression one gets is indeed that 3D reconstructions still mainly follow the path that was set since their first popularization in archaeology, when few archaeologists were practically involved in their creation. Especially in early projects related with 3D reconstructions, the quest for realism and for spectacular renderings or interactive experiences could not be fulfilled by archaeologists themselves, who were lacking the computer skills and infrastructure necessary to obtain such results. For this reason, the creation of virtual past environments was often passed over to computer graphics designers or to people that were not directly involved in the data collection and interpretation. Being the focus on delivering the end product, the process of creating the reconstruction and its use as an integral part of research was therefore most of the time overlooked. Except for a few cases (some of which I will discuss in chapter 3), these 3D models are still mostly used as digital counterparts of traditional 2D drawings and as presentation aids for knowledge that is already acquired, namely when the process of data gathering, comparison and interpretation is completed. In doing so, these tools are excluded from the process of hypothesis generation.

This research aims to contribute to current debate on the implementation and use of 3D digital reconstructions in archaeology by developing an intellectually transparent, replicable 3D visualization

5 Kolb 1997.
6 Forte 1997, 12-3.
7 Pletinckx 2007, 4.
8 Clark 2010, 66.
9 Clark 2010, 66.
10 http://www.londoncharter.org/; http://smartheritage.com/seville-principles/seville-principles (last accessed Sept. 2016).
11 Cerato and Pescarin 2013, 290.
12 A selection of these projects using 3D reconstructions as research tools is discussed in chapter 3 (§ 3.4.2). It must be noted that in other branches of 3D modelling in archaeology such as DEM based regional research, analytical or research uses are much more common (e.g. for visibility studies or optimal path analysis).

that uses advanced methods for the quantitative analysis of the built environment. The approach that I follow in this work is inspired by the use and definition of models in science, namely as dynamic representations of complex systems and phenomena, which are employed as tools for reasoning and continuously evaluated, adapted and updated.[13]

The starting point of this study has been the archaeological survey of the multi-period site of Koroneia, which is located on a hill on the spurs of Mount Helikon in Boeotia, Central Greece. This site has been investigated since 2006 by an international and multidisciplinary team (under the directorship of John Bintliff), which I joined in 2009. The survey research methodology includes a combination of methods such as pottery collection, recording of architectural remains, geophysical prospections and geomorphological analysis, with the aim of shedding light on Koroneia's urban development. The application of such non-destructive methods allows the study of large areas and the collection of a vast quantity of data in a reasonable amount of time. Such investigations add key elements to the comprehension of regional historical development, creating also new narratives for local communities as testimony of their own neighbouring heritage.[14] The sites that are investigated exclusively with such methods continue however to be invisible, which poses challenges for their protection, preservation and valorisation. The use of 3D reconstructions, therefore, is helpful in visualizing the archaeologists' interpretations of the site, both as a way to look at the data from another point of view and as a way to present it to a larger public.[15] The creation of 3D visualizations of past cityscapes, however, presents challenges in itself and therefore the methodology should be chosen carefully to be able both to handle the complex dataset and to enable further engagement with the data and the re-elaboration of the 3D reconstruction.

Koroneia shares the common destiny of 'invisible' town with many other ancient Graeco-Roman settlements, and therefore offers a case study to test methodologies that can be applied also to other contexts. Specifically, the methodology we propose uses in an innovative way tools that are targeted to geo-design and modern urban planning to create a 3D visualization of Koroneia in a GIS environment. With a strong focus on the automation and iteration of the reconstruction process, our visualization allows an intuitive insight into hidden relationships and associations among data and can be used not only as a visualization aid, but also as a platform for generating hypothesis and performing analysis of the townscape.

Chapter overview

The structure of this book is as follows. In **chapter 2**, I will discuss a selection of archaeological reconstructions (both drawings and 3D plaster models) of Roman and Greek cities from the 15th to the 20th century, focussing especially on the motivations, the aims and the methods that guided such endeavours. The attempt to 'reconstruct' ancient urban sites, in fact, is not a novelty of the digital age and, although little research has been done so far in this direction, much can be learned on the role, potential and pitfalls of 3D visualizations in archaeology by taking an historical perspective on reconstructions of archaeological evidence before the introduction of digital techniques. This chapter will shed light on how much the process of reconstruction resulted in a 'construction' of a past that was in fact the re-elaboration of present needs, thoughts and beliefs. The progressive development of a method based on first-hand experience and critical assessment of previous sources led to an increased awareness for the problematic aspects related to 'reconstructing' the past, which can offer food for thoughts to the present day 3D modeller.

[13] See the concept of Model-Based reasoning as explored in Magnani *et al.* 2002 and Magnani and Nersessian 2002.
[14] Bintliff 2013b.
[15] Examples of townscapes surveyed with an integrated approach and visualized in 3D are discussed in Corsi and Vermeulen 2012 and Vermeulen forthcoming.

Chapter 3 continues the discussion taking in consideration the use of 3D modelling in the digital age. The various methodologies available to obtain 3D models in archaeology will be presented, and their use, including applications such as Virtual and Augmented Reality, will be discussed from an historical point of view. Attention will be given to the progress made so far towards the creation of more intellectually transparent 3D visualizations, a key element to assess their reliability and their scientific value. I will moreover investigate in more detail what has been done so far to use 3D visualizations as research tools in archaeology and discuss some of the projects that have successfully proven that the potential of 3D goes beyond accurate documentation and public outreach.

After these two introductory chapters, **chapter 4** focusses on the site of Koroneia itself, by presenting its geographical and historical context and discussing both previous research and the currently available preliminary results of the survey on the hill. The combination of old data coming from 19th century travellers' accounts and 20th century excavation reports with the new insights of the survey, will allow us to formulate new hypotheses on the function of some of the surveyed architectural elements and on the urban organization of the hill, which will be further explored and elaborated on in chapter 6.

To offer comparisons to interpret the survey data from Koroneia, in **chapter 5** I shall consider the topographical development of Graeco-Roman towns over the centuries by relying on published material from Boeotia and elsewhere in Greece. In this chapter I will discuss general trends in urban planning in Greece from the Archaic to the Late Roman period, and select specific case studies showing changes or continuities in the architecture and use of public and private spaces (e.g. *agorai*, sanctuaries, theatres and houses). The study of the ancient city has a long tradition, starting from the pioneering work of the French historian Numa Denis Foustel de Coulanges (*La Cité Ancienne*, 1864). The body of literature dealing with aspects of the ancient Greek city (religious, economic, political) and with the development of individual buildings within the city (e.g. *stoas*) has grown immensely over the years. These approaches, however, have often interpreted the ancient city under the light of a dominant socio-economic framework, and presented it as a disjointed ensemble of discrete entities instead of a unified, layered, and ever-changing system. Similarly to the modern city, for which models describing urban growth have been developed since the 20th century (such as the concentric zone model by the Chicago school, or the sector model devised by the economist Homer Hoyt at the end of the 1930s),[16] models have been proposed to explain the origin and development of ancient urban sites. The study of cities has been approached from very different angles and the analytical instruments of various disciplines, such as geography, history, social science, anthropology and economy, have been deployed to investigate urban environments. These models, although complementing each other in partially explaining some aspects of urban developments, focus however on only one element of ancient urban life, such as economic aspects which predominate in the Weber-Finley 'consumer' city and in the 'service' city model proposed by Engels.[17] By simplifying the dynamics of urban life and overemphasizing some aspects over the others, these models evidence the complexity of the city as an entity whose development is difficult to grasp, analyse and predict. The aim of chapter 5 is therefore specifically to reconnect the various phases of the life of Greek urban sites that are often dissected in smaller units, either physical or chronological, due to constraints in the extent of excavation or the deliberate choice of focussing on the best attested phase of occupation, thus offering the background information needed to integrate Koroneia's data and suggest a 3D reconstruction of this site in one of its historical phases.

Finally, in **chapter 6**, the methodology that I have adopted to create a 3D GIS of Koroneia is presented. The workflow is mainly based on the exploitation of procedural modelling techniques and GIS with the

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[16] For a discussion on the most influential models that have been developed to explain the growth of cities, see Marcus and Sabloff 2008, 3-12.

[17] Engels 1990.

additional assistance of manual modelling software packages. The chapter will focus on the practical implementation of a 3D visualization both of Koroneia's surveyed architectural elements, and of alternative reconstructions of the 4th century BC urban layout. The aim of this work is to provide an intuitive insight into types and concentrations of the recorded architectural pieces, and to create different models that explore a range of possible solutions for building on slope and their impact on urban population size. Our methodology is centred on the exploitation of a rule-based modelling approach, which enables the automation of the 3D modelling process in order to allow for an easy update of the survey data, the iterative display of different reconstruction hypotheses in a time efficient manner, and the creation of a 3D GIS in order to exploit this platform for a quantitative analysis of the built environment. This book concludes with **chapter 7**, in which I summarize the main points that I have explored in this research, discuss the results of the proposed approach, and provide a future outlook for the use of scientific 3D visualizations in archaeology. The rules that I have created for this project are distributed via github for research and educational purposes.[18]

[18] https://github.com/cpiccoli/rules.