Visualizing cityscapes of Classical antiquity : from early modern reconstruction drawings to digital 3D models

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7. Conclusions

This research has focussed on visual reconstructions of historical cities that have been created from the early modern period up to the present day. On a theoretical level, this work aimed at examining how past cityscapes have been visually reconstructed over the centuries, and at reflecting on the current use of digital 3D reconstructions, especially in relation to their applications as means of interpretations and analysis of the archaeological evidence (chapters 2 and 3). On a practical level, these considerations have contributed to the implementation of a workflow for the GIS-based 3D reconstruction of the ancient town of Koroneia, in Boeotia, Central Greece, during the 4th century BC (chapter 6). Moreover, this research has produced a synthesis both of the currently available data for Koroneia and of the urban development of Greek towns from the Archaic period to Late Antiquity (chapters 4 and 5), which can be useful starting points for future research at Koroneia and elsewhere.

The methodology discussed in chapter 6 included the use of tools borrowed from modern urban planning which have been adapted to respond to the requirements of archaeological visualizations, such as intellectual transparency and easy updating. Koroneia's case study is admittedly a difficult one, since the state of preservation of the urban fabric is limited and the use of non-destructive methods for its investigation provides us with a spatially and temporally broad dataset, which lacks however the contextual analysis of stratigraphic sequences. However, as this is a common situation for the majority of urban sites in Greece and elsewhere, Koroneia provided an appropriate dataset to develop and experiment with a workflow that is flexible enough to be applied to other contexts.

The starting point of this research has been the consideration that reconstructions are knowledge representations, thus bound to the specific context of their making.[1286] Their creation and reception depend on the combination of several factors, which include the background of the modeller, the data and technology that are available at the moment of their making, and ultimately also the background of the beholders that will judge the reconstruction according to their own set of previous knowledge and interest.[1287] Following this line of thought, I investigated more closely how the reconstruction of past cityscapes has been approached over the centuries. Chapter 2 therefore analysed a selection of reconstructions of Greek and Roman cities in Europe from the 15th to the 20th century. The works here discussed offered opportunities to reflect on the changing methods, purposes and uses of archaeological reconstruction drawings and three-dimensional physical models over this long period of time. More specifically, some parallel lines of research were examined: When and why did the interest for drawing reconstructions of antiquities arise? Which were the sources and methods used to prepare such reconstructions? When did three-dimensional representations start to be used and which methodological challenges did they pose? To answer these questions, the reconstructions have been contextualized within their historical and cultural framework, as well as the personal background of their creator.

This overview showed how these drawings, far from being neutral representations of a distant past, where instead the expression of specific cultural factors, political and ideological intentions. These reconstructions, however naïve, a-historical and outdated they may appear nowadays to us, provide an insight into the mentality of their time and are valuable sources of information in their own right about the fascinations, interests and political agendas of their creators. This chapter gave moreover a glimpse into the development of a method of scientific inquiry within antiquarian and archaeological studies and aimed to put into historical perspective the work of the present-day researcher, who deals with

[1286] Favro 2006, 326.
[1287] Cf. Favro 2006.

reconstructions of archaeological evidence. In fact, as this chapter has demonstrated, many challenges, questions and pitfalls that affected the earlier attempts of reconstructing archaeological evidence are the same that concern scholars nowadays.

Looking at reconstructions of archaeological evidence from a historical perspective evidenced the time-bound and subjective nature of such representations, which brought into focus another aspect, namely the significance of accurately documenting their creation process. The recognition of the transient nature of reconstructions emphasizes in fact the importance of being explicit about the data, the comparative material, and the line of interpretation underlying their creation. These documents will remain in fact as the starting point for future research, even in case of the obsolescence of digital formats and the replacement of current methods with more advanced techniques. This 'intellectual transparency' allows the replicability of the reconstruction process, which presents a double advantage. On the one hand it allows us to iterate its creation and update it when new data are available, on the other hand it allows its long term preservation.

The implementation of intellectually transparent visualizations has received much attention in recent years. In its dawn, the field of 3D digital archaeology had been mainly practice-driven and lacked a more conceptual reflection on methods, purposes, opportunities and pitfalls of this range of techniques. Over the years, not only the technical equipment that archaeologists found at their disposal have expanded, but also the theoretical discussion has converged to provide more conceptual tools to approach this discipline in a critical and mature way. I have dealt with these aspects in chapter 3, which discussed the development of 3D visualisations applied to the archaeological domain, with a particular focus on the built environment. Specifically, the first part of the chapter was dedicated to the presentation of the main methods that are available to create reconstruction hypotheses for buildings and sites that are now (partially) lost. An historical perspective on the applications of Virtual Reality in archaeology was also presented. The second part focused on the solutions that have been adopted so far to make 3D reconstructions more intellectually transparent, by including data, hypotheses, modelling methods and choices that guided the process of their creation. The attention to the philological process behind the creation of 3D reconstructions has represented a great step forward towards their acceptance as valid instruments to communicate scientific knowledge. A tangible risk of deception related to 3D reconstructions in archaeology was in fact recognised since their early applications by practitioners in this field. Providing access to this kind of information has become a crucial prerequisite for the admission of 3D visualizations among the instruments of scholarly communication, as stated in the documents issued in recent years such as the London Charter and the Seville principles. These considerations form the basis onto which I have developed the methodology for the creation of Koroneia's 3D GIS.

In the same chapter, I have moreover elaborated on the assertion that the contribution of 3D visualizations for interpretation and analysis has not been fully exploited yet. While 3D recording techniques have been increasingly adopted as tools for a fast and accurate documentation, 3D reconstructions are in fact usually limited to describe and present knowledge that is already acquired. Through the presentation of published case studies, I have showed how 3D reconstructions can offer instead interpretative and analytical capabilities that allow the formulation of hypotheses on the past use of space and on its social implications. In this regard, I have argued that in order to unlock the analytical potential of 3D visualizations, archaeologists need to have a key role in the creation process, as understanding the technique is a prerequisite to formulate the relevant questions that can be appropriately addressed by using it. To this end, a broader digital literacy among archaeologists is needed to be able to understand the capabilities of these methods in order to assess whether and how the creation of such applications would be beneficial for their research.

The convergence between 3D modelling and GIS and the analytical possibilities that a 3D GIS currently offers is particularly interesting, and the teaching of these techniques should be taken into consideration as part of the academic curriculum. Such applications offer a viable solution for bridging the still existing gap between data collection, analysis and public fruition: the most plausible 3D reconstruction hypothesis, congruent with the dataset and resulting from an iterative modelling process, can in fact be used to communicate the results of the research in a visually appealing way. In this case, an increased digital literacy in this field will constitute a valuable asset to better communicate with technicians in case of the likely scenario that extra technical expertise (e.g. in scripting, game development, animation etc.) needs to be outsourced for the completion of a project.

The introductory chapters 2 and 3, sketching the history of archaeological reconstructions of Greek and Roman architecture before and during the digital age, were followed by three chapters in which the case study and the methodology of this research were presented more in depth. Chapter 4 focused on the ancient town of Koroneia, by presenting its geographical context, historical background and a discussion of the currently available data coming from both the Boeotia survey project and previous investigations at the site. The latter include the accounts of 19th century travellers, the reports of the excavations carried out in the course of the 20th century, and surveys by scholars such as the German topographer Siegfried Lauffer. The combination of old and new data and the interdisciplinary approach that we have taken have allowed the formulation of hypotheses on the function of some of the surveyed structures and areas of the ancient town. The ongoing survey and the consequently continuous flow of incoming data from Koroneia made this site a suitable case study to experiment with the creation of a 3D visualization that is introduced early on in the archaeological investigation and acts as a virtual laboratory where data are merged and compared, and reconstruction hypotheses are generated, tested and refined in the light of incoming new data.

The necessity to study Koroneia's urban life from its beginning during the Archaic period to its abandonment in the late Middle Ages urged us to collect a body of comparisons with other sites that could help in contextualizing Koroneia's urban development in its broader framework. To this end, chapter 5 has outlined general trends and discussed specific case studies that illustrate the development of Greek urban centres, especially from a topographical and architectural point of view, from the Archaic period to Late Antiquity. Specifically, chapter 5 focussed on the elements of continuity and discontinuity in the urban topography of Graeco-Roman towns over the centuries, drawing particular attention to the 'three-dimensionality' of the sites and their relationship with terrain morphology. The first part of the chapter was dedicated to present a brief overview of the range of possible urban layouts that have been documented for Greek urban centres. A selection was made of the sites that share similar characteristics with Koroneia, such as the fact that they are laid out on hilly or irregular terrains, and that have been excavated to such an extent to make it possible to draw conclusions about the relationship between town plan and landscape. The second part of the chapter was dedicated to the buildings that are typically found in a Graeco-Roman town and the transformation they underwent in their architectural development and in the use of space during the centuries taken into consideration. Specific elements and areas of the urban space were discussed, such as sanctuaries, *agorai*, theatres, houses, training spaces, industrial areas and urban fortifications.

Finally, in chapter 6, the methodology for the creation of Koroneia's 3D GIS and the results of this study were presented in more detail. As some areas of Koroneia's hill are not accessible for surveying, or could be only partially investigated due to the presence of overgrown vegetation or a steep slope, a number of questions about the urban structure and its relationship with the hilly terrain arose during the survey, which we aimed to investigate by creating this 3D environment. More specifically, one of the objectives of this research was to formulate a series of hypotheses about the town layout, which preliminary data showed as following two different orientations (a roughly north-south and east-west orientation in

the northern part of the town with a shift of about N25°E in the southern part). This in turn led to a series of considerations about the number of houses and hence population estimation, which could be suggested on the basis of explicit assumptions. Interestingly, these estimations independently agree in scale with the results from the calculations based on historical sources. This thesis aimed moreover at exploring the current analytical possibilities of a 3D GIS for the urban environment, which allows the overlay of data and interpretation within the same georeferenced environment, and the evaluation of the buildings' visibility.

In choosing the appropriate methodology to achieve these goals, three requirements needed to be met, which ruled out most of the currently available computer graphics software packages based on manual modelling: the suitability for creating a 3D GIS environment that could store efficiently the survey data and display them on the hilly terrain, the possibility to design a 3D reconstruction that could be easily updated when new data are available, and the ability to model the entire urban fabric in an efficient way, including individual houses. Cities pose in fact methodological challenges in handling data at different resolutions and in integrating the unavoidable missing pieces of such a large environment with comparisons to other sites. In this respect, additional requirements for the resulting 3D reconstruction were moreover the transparency and the replicability of its creation process, which have been considered necessary elements to ensure its assessment and validation by the academic community.

The data from the survey have been visualized and integrated using a novel approach that combines GIS and procedural modelling, which entails the creation of 3D geometries by writing text-based rule files that contain their formal description. The software I used was Esri CityEngine, which is currently targeted to modern urban planners to present different development scenarios to local communities, aiming to foster a form of participatory and interactive urban design. The procedural and parametric modelling that CityEngine affords allows in fact the user to change in real time elements in the 3D scenes, by simply modifying values or lines of script in the rule file. While being developed for satisfying the needs of modern urban planners, this methodology is suitable also for historical towns. Instead of presenting a fixed image of Koroneia, this approach contributes in fact to establish a visual dialogue between the original data and the 3D reconstruction, which can be changed to reflect different hypotheses based on the most updated state of the data. The focus of this project is therefore more on the *process* of creation, and what kind of observations can we gain from it, than on the end result.

The adopted workflow consisted of two phases: 1) mapping of the finds onto the DEM of the hill to visualize their distribution and characteristics as recorded during fieldwork; 2) reconstruction of the ancient terrain and the possible layout of the *polis* in the 4th century BC. As I have discussed in the course of chapter 6, the methodology based on a combination of GIS and procedural modelling met the requirements of the ongoing survey and can be applied to other archaeological contexts with similar characteristics. For Koroneia, I have written a set of rule files, which generate the 3D models of domestic and public architecture, and enables an analytical approach to the built environment. While procedural modelling has already been used for other archaeological sites, this is the first implementation of a set of procedural rules for (late) Classical Greek architecture.

An additional rule was written to be used as a procedural symbology layer in ArcGIS, which exposes the properties of the architectural dataset (i.e. dimensions and stone type) in an automatic and more customizable way in comparison with standard 3D symbology. This provides an immediate overview of concentrations of larger or smaller blocks, and clusters of stone types, which can point to the presence of different types of buildings. Working in a 3D GIS environment has moreover the advantage that it is possible to observe – better than in a 2D GIS – the relationship between the hilly morphology of the terrain and the distribution of finds, such as the locations of the architectural blocks in relation to the

terraces' edges. The proposed workflow can be extended to other classes of finds (e.g. pottery sherds), and can be applied to other contexts where stratigraphic information is available to create a 3D GIS of excavated trenches.

The recent acquisition of CityEngine by Esri, moreover, has initiated the assimilation of the software capabilities within the ArcGIS components, resulting in a CityEngine toolbox added to the version 10.2 of ArcGIS among the 3D Analyst tools. This partnership has furthered the creation of a 'true' 3D GIS of cityscapes, and included the possibility of procedurally sampling a grid of points on the 3D geometry's surface that can be used to perform visibility analysis. This workflow, which we included in our rule files, allows the quantitative analysis of which portions of a building are visible from a given location. The application of this workflow in past urban contexts can have a great impact on the understanding of relationships between buildings, and enables the evaluation of different scenarios that are created using the parametric modelling approach that we have adopted.

This methodology addressed also the issue of providing an intellectually transparent 3D visualization. It is in fact impossible to eliminate subjective bias from 3D reconstructions, as these are culturally and historically bound and result from a personal interpretation of the available data. The approach that has been here presented deals with the issue of transparency in several complementary ways. On the one hand, I have created different reconstruction hypotheses that are plausible given our dataset, which is made possible in a time efficient way by the parametric modelling approach that we have adopted. On the other hand, the procedural rules hierarchically record the steps I have taken in modelling the 3D environment and include annotations which clarify the comparative material that I used, thus making the creation process more explicit. In addition, the 3D reconstruction is created on top of the GIS data within the same coordinate system, thus maintaining a spatial and visual relationship between the hypothesis and the original data. Finally, chapters 4 and 5 offer an in-depth textual discussion of the original data and the sources for comparisons that were used for the 3D visualizations, thus providing the starting point for future research. When the study of the survey material will be concluded, additional ways to make available the original data can be explored, such as by adding layers in the CityEngine webviewer, thus allowing users to see for themselves the relationship between data and interpretation.

The multidisciplinary approach that is enabled by using this workflow promotes a holistic approach to the study of past built environments. This process allows a better overview of the available data, helps to trigger new questions that can drive the fieldwork practice, and to generate and evaluate hypotheses. Besides finding the most appropriate workflow for Koroneia, the purpose of this work was also to propose a methodology that could be effectively applied to other urban sites that were investigated with non-destructive methods. The possibility of using 3D reconstructions as an integral part of research is enabled only if these 3D models can be easily modified to visualize and test different hypotheses that emerge from the interpretation of the data, and quickly updated to include new available data. To this end, our rule files can be customized and reused on different configurations of street networks, thus making this approach time-efficient in the long term.

The rule-based approach in combination with GIS mapping has proven to be a viable solution for Koroneia, but it can be applied both to the reconstruction of other historical cities, and to automate (part of) the process of creating or distributing 3D models. Visualizing past cityscapes is a challenging task,[1288] but the application of rule-based modelling helps to tackle some of the issues involved. For early modern cities, or for historical cities in which part of the city layout is preserved, available (cadastral) maps could be digitized and related to a database containing the surviving information about the buildings and their inhabitants. An *ad hoc* rule that interrogates the attributes in the database could

[1288] At this regard, see Favro 2006.

then be written to automate the creation of 3D buildings complying with the target characteristics (e.g. roof shape, number of floors and windows etc.), but also to create different visualizations that display additional information on the buildings when available (e.g. census data).

In conclusion, 3D visualizations in archaeology have much more to offer than an artificial image of the past, and the exploration of their potential for the reconstruction of the built environment provides new opportunities to research and to present to the public the complexity of the archaeological record. At the intersection between 3D modelling, GIS and Virtual Reality lies an exciting new field of research that investigates the multisensory experience of the city, which indeed does not only rely on sight but introduces the other senses as co-participants in the exploration.[1289] This approach would encourage the experience of the city from the street level, not only from the bird's eye view that we are accustomed to by the use of 2D plans. Parametric modelling, with its possibility of generating different visualizations based on the encoded numerical values, would allow us to quickly change the characteristics of the reconstructed buildings (e.g. heights) and thus evaluate the impact of these changes on the urban fabric.

The modelling strategy that has been adopted here is instrumental for conveying the 'in progress' nature of our knowledge of a site, and allows the 3D visualization to become a replicable process, which is based on explicit assumptions that can be easily inspected and whose reliability can be assessed. The contribution that this work hopes to have made is indeed in the direction of considering 3D reconstructions not as fixed images of the past, but as laboratories where multiple reconstructions and hypotheses can be visualized, evaluated and discussed.

[1289] Among the advocates of this approach: Favro 2006 and Betts 2011.