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KAINUA PROJECT: PRINCIPLES, THEORETICAL FRAMEWORK AND ARCHAEOLOGICAL ANALYSIS

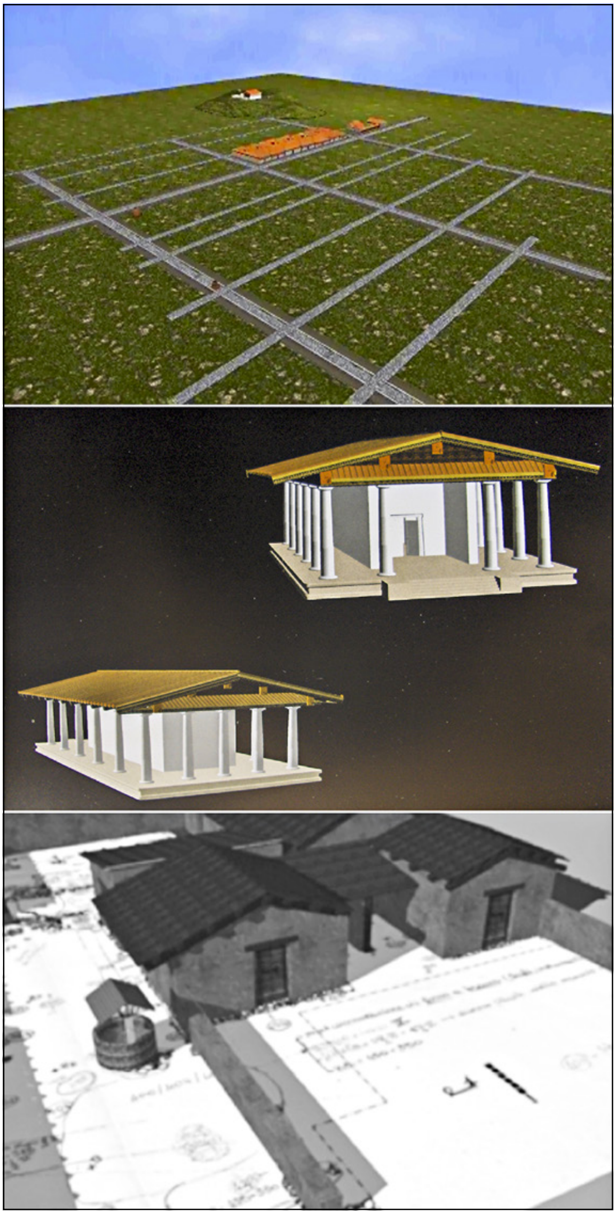
1. Principles

Since the 1990s, virtual reconstructions have been considered an essential demand in long-term archaeological projects (Hermon 2008). After years of debate about this cutting-edge issue (Barceló, Forte, Sanders 2000; Beacham, Denard, Niccolucci 2006), the objectives of these interpretative processes based on Virtual Reality techniques have been mainly defined by the *London Charter* (2009), which established the principles for the use of computer-based visualisation methods and outcomes in the research and communication of cultural heritage. The London Charter is the theoretical framework for the International Charter of Virtual Archaeology (*Seville Charter* 2011). The principles of this document are the interdisciplinarity, clarity of the purposes, and the complementarity of the virtual approach to more traditional tools, the authenticity of reconstruction, historical rigour, efficiency, scientific transparency, and training and evaluation. While the London Charter rules ethical principles (Vergnieux 2011, 41), the Seville Charter marks the fundamental guidelines for the methodological issues of the discipline (Yu Hook 2016), responding to well-known needs emphasized by scholars (Barceló 2001; Ryan 2001).

2. The project: its theoretical framework and the main challenges

The Kainua Project is explicitly based on the principles of the *Seville Charter* (2011) and chiefly aims at the virtual recreation of a whole Etruscan city. As E. Govi (in this volume) has emphasized, this aim implies dealing with the architectural, historical and social issues which guided the construction of the project and clearly defined its workflow and objectives.

The modelling process has been founded on a rigorous archaeological analysis, starting from the collection of all available data for each context (Gaucci, Garagnani, Manferdini 2015; Gaucci 2016) and the elaboration of up-to-date interpretations (Govi 2016, 2017). The use of virtual reconstructions is an approach already applied within past projects directed by G. Sassatelli in the Etruscan city of Marzabotto. As a matter of fact, the first attempt to apply computational technology to reconstruct the city (Fig. 1, a) was published in 2000 (Sassatelli, Taglioni 2000). After that, the results of the excavations of the Temple of *Tinia* (Sassatelli, Govi 2005, 29, pl. 3) and House 1 of *Regio* IV, *insula* 2 (Beltrami 2010) led to virtual reconstructions of these buildings (Fig. 1, b-c). These last works traced the



a

b

c

Fig. 1 – a) A first attempt of the virtual reconstruction of the Etruscan city of Marzabotto (Sassatelli, Taglioni 2000); b) Virtual reconstruction of the temple of *Tinia* (Sassatelli, Govi 2005, 29, pl. 3); c) Virtual reconstruction of House 1, *Regio* IV, 2 (Beltrami 2010).

path towards a complex application of Virtual Reality, no longer just a tool for dissemination but also dedicated to a more in-depth understanding of the context. Following this line, the task of the Kainua Project is therefore the foundation of a more articulated process of analysis. The virtual Kainua, analysed as a network of buildings and open spaces in a complex urban plan, represents a social model (mainly the middle level highlighted by Govi in this volume) to investigate social issues (Barceló 2001, 2012).

The problem of validation of virtual models is of prime importance in the discipline of Virtual Archaeology (Ryan 2001; Vergnieux 2011; Forte 2015, 296-298) and even the Seville Charter addresses this important issue (*Seville Charter* 2011, Principle 8: training and assessment). Regarding the reconstruction of the Tuscanic Temple of *Uni*, we defined a methodological process of reconstruction of what is missing, named "ArchaeoBIM": the final model presupposes the validation of the reconstruction itself (Garagnani in this volume). The highly innovative aspect of this method, which complements a more traditional and historical approach, is the application of reconstructive technology to formulate reflections on the architectural credibility of the virtual model, facilitating control of all the steps of analysis, from the starting data until the final simulation (Garagnani, Gaucci, Govi 2016; Garagnani, Gaucci, Gruška 2016). However, the BIM model can address another important topic of Virtual Archaeology, namely the simulation (Vergnieux 2011, 41-42; a critical view to simulations in Premo 2008, 45-50). As a matter of fact, we can simulate static and resistance of the sacred building in the presence of different weather, thermal or lighting conditions, with respect to the context and the diachronical perspective. It is therefore a big step not only within the internal debate on the purposes of virtual applications, but towards the entire archaeological process of analysis.

Nevertheless, the investigated buildings are few compared to the entire urban area. The elaboration of virtual models starting from scarcely-known inhabited areas is an established approach in scientific literature and it is considered as a need in research which involves wide spaces. Examples of this approach are the Radio-Past Project (Klein, Vermeulen, Corsi 2012), the case of the Gladiatoral School at Carnuntum (Neubauer *et al.* 2013) and the Iberian village of Ullastret (Codina *et al.* in this volume), where the archaeological investigation was chiefly non-invasive. The river terrace, where the Etruscan city was planned and built, has been involved in an articulated campaign of geophysical surveys, where different methodologies were applied (Govi 2014, 90-94; Boschi 2016, 91-93, fig. 5). The results of the surveys, put together with the archaeological data known from the excavations, led E. Govi to formulate an interpretative scheme of the modules of the buildings and their allocation within the blocks (Govi 2016, 230-231, figs. 9-12). We used that scheme to recreate wide areas of the city with a good approximation.

This approach allows us to reach a more complete view of the city and to propose more comprehensive actions.

The elaboration of the virtual model of the city as part of the archaeological process of analysis is not the only challenge we dealt with. As a matter of fact, the evidence in the archaeological area has little visual impact, since only the level of the buildings foundations remains. Therefore, there is a gap between the scientific relevance of the evidence and its perception by visitors, who need an adequate tool to decode and understand both visible and invisible structures. We can use different media to communicate the virtual model of the city, which becomes an interactive tool of transmission of information mainly based on simulation (Pujol Tost 2010, 501-502), but it should be above all a decoding key that visitors can use during a visit. Solutions based on Augmented or Mixed Reality could probably be the most appropriate. In this way, the visitor can overlay the virtual models on the real environment, while moving freely within the site. AR has already been achieved in in-door systems, and there are some applications on open areas. Significant examples are the case of ArcheoGuide in Olimpia (Vlahakis *et al.* 2004) or Carnuntum (Bohuslav *et al.* 2002), but we have also stationary and panel-bound systems such as Ename in East Flanders (Callebaut 2002; Pletinckx 2013). However, a system based on an AR experience in an open area without visually striking structures needs recognisable markers (Frassine *et al.* 2014).

In the study case of the Neolithic site in Bylany in the Czech Republic (Květina, Unger, Vavrečka 2015), there are no visible structures in the site, only the negative evidence of huts. Thus the creation of an AR experience brought considerable difficulties. Moreover, the effectiveness of these systems is strictly bound to the opportunity of tracking the position and orientation of the visitor and to the access to computational resources to reach the overlay between reality and virtuality (Ryan 2002). The lack of appropriate markers and effective computational resources to use in long visits led us to look for a much easier system based on stationary immersive views of the virtual model, such as Panoramic Virtual Reality or Immersive Imaging (Krasniewicz 2000). Visitors have to be provided with adequate communication systems according to the possibilities that technology and the environment permit. We could show the city as it was in the middle of the 5th century BCE, or we can narrate aspects of the social life and episodes of the city's history, such as the foundation rite. In any case, our main task, according to the principles on which the project is based, is not to betray the philological rigor which guided the reconstruction of the lost reality (Sideris 2008).

The ambition to obtain realistic models is indeed mainly seen as in contrast to the concreteness of information at our disposal (Kantner 2000). The pursuit of visually-striking environments and details, not really attested by the data, could push us beyond credible limits, which are always the parameter

a

b

Fig. 2 – Frames of the Panoramic image of the Eastern necropolis of Kainua: a) The Eastern Gate and the funerary road; b) Part of the necropolis with people around a grave. Characters and costumes are provided by Pro Ponte Etrusca Onlus, Perugia.

of our interpretations, towards the imaginary (Pujol 2004). This risk does not, in our opinion, imply refusing some issues in terms of technical implementation, among which photorealism and the possibility of filling the model with objects and people (Fig. 2). These implementations not only attract the interest of the public, recalling a living environment with which everybody can identify (Roussou 2002, 99), but they are also a yardstick for the visitors inside the virtual model.

3. The archaeological analysis

Collecting all the information at our disposal, the reconstruction of the urban texture started from the Digital Terrain Model and the infrastructures (Muzzarelli, Franzoia in this volume), namely streets and sewers. Thanks to the survey of the acropolis (using a terrestrial laser scanner) and of the open area of the lower town (using photogrammetry through UAV technologies),

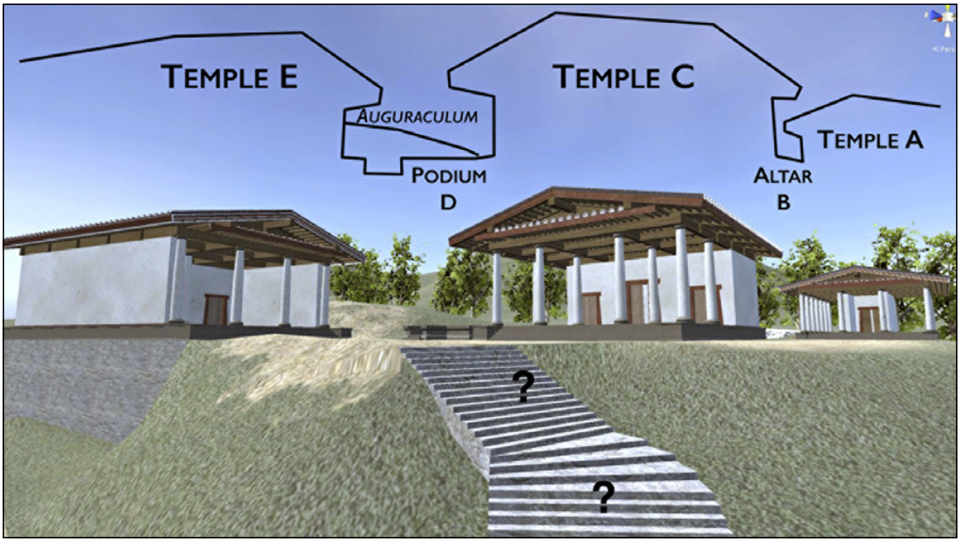


Fig. 3 – View of the acropolis from the *plateia* B in the Realtime Virtual Environment. The reconstruction of the staircase is based on a doubtful hypothesis.

we derived a multi-scalar DTM of the current archaeological area (Gaucci, Garagnani, Manferdini 2015), which has been the basis for producing the model of the ancient terrain from archaeological data. Some data about the borders and the southern part of the city, where river erosion caused ruin phenomena, are irreparably lost (Mansuelli 1972, 127). Otherwise, working on the morphology of the ancient terrain, we had to deal with a very important problem, namely the connection between the lower city and the acropolis. Although scholars have already pointed out the huge difference in height (around 11 m) between the street, currently 4.5 m under the ground level, and the higher terrace where the sacred buildings arose (Lippolis 2001, 263), this fact has never been inserted in a spatial model which brings to light the way to cross the (once) steep slope of the acropolis (see the consideration formulated by Lippolis 2005, 142). Even if we suppose that a monumental staircase (see the hypotheses about the infrastructures of and towards the acropolis in Lippolis 2001, 263, 267; 2005, 140-143) in front of the sacred buildings could be an adequate hypothesis, the problem of its position, orientation and structure will be solved only through a dedicated campaign of excavations and research (Fig. 3).

Currently we know a limited number of structures of the urban area (Sassatelli 1994; Govi 2016, 188, note 3). Regarding each single context, the elaboration of the digital model was based on the archaeological data at disposition. The excavations carried out in various areas of the city, directed by G. Sassatelli between 1988 and 2014 and currently by E. Govi, namely the House 1, *Regio* IV, 2 (Govi, Sassateli 2010), the Temples of *Tinia* and *Uni* (Sassatelli, Govi 2005; Sassatelli 2009; Govi 2017) and a complex of structures behind the sanctuary of *Tinia* (Govi 2014, 105-106; 2016, 235-239), have provided a remarkable experience which we applied to other poorly-known contexts, excavated with outdated investigation techniques. An illustrative case of our method is the study and reconstruction of the buildings of *Regio* IV, 1, whose excavations were directed by P.E. Arias and then G.A. Mansuelli between the 1950s and 1960s (Gaucci 2016, 245-248), and more recently in limited areas of Houses 2 and 6 of that block by the University of Bonn and Regensburg and at the time Soprintendenza per i Beni Archeologici dell'Emilia Romagna. These houses have been the subject of a study based on archival data, which led to a new interpretation of the structures (Gaucci 2016). In this regard, the context of House 1 in *insula* 2 (Govi, Sassatelli 2010) and the latest studies on Etruscan household architecture provided effective decoding keys. Likewise, E. Govi applied this method to formulate a new interpretation of Building E in the acropolis (Govi 2017, 153-156). As a matter of fact, the recent finding of the Temple of *Uni* shed new light on the structure of Building E, very similar in its plan to the Temple recently discovered. In this way, Govi confirmed the sacred nature of the building, already presumed by G. Colonna to be a temple (Colonna 1986, 473), and we are now able to give a virtual model of its elevation based on a more concrete interpretation (Fig. 3).

Definitively, we outlined a method of validation of the interpretative hypothesis based on more or less recent data, primarily within the same urban context. In this regard, it is worth drawing attention to the interdisciplinary nature of the interpretative process aimed at the virtual reconstruction of the models (see *Seville Charter* 2011, Principle 1 and Principle 5 on historical accuracy). Such interdisciplinary research is not limited to interaction with disciplines more closely related to Virtual Archaeology (i.e. engineering, architecture, informatics), but involves the entire complex of studies which contribute to the understanding of the context (i.e. palaeobotany, archaeometry, geophysics, archaeozoology). For example, in the case of Kainua, this has allowed us to reconstruct the productive processes within the workshops (Morpurgo, Pizzirani, Mattioli in this volume), and has also made it possible to evaluate the building material of the elevations based on mud bricks, as confirmed by archaeometrical analysis, and moreover from oak beams, as confirmed by palaeobotanical samples found during excavations (Garagnani, Gaucci, Govi 2016, 52).

Based on all this information, the virtual models of buildings and the urban environment have by now been virtually elaborated for the period of the city's peak, dated to the 5th century BCE. Working on contexts known only through foundations, elevations were then created on the basis of building

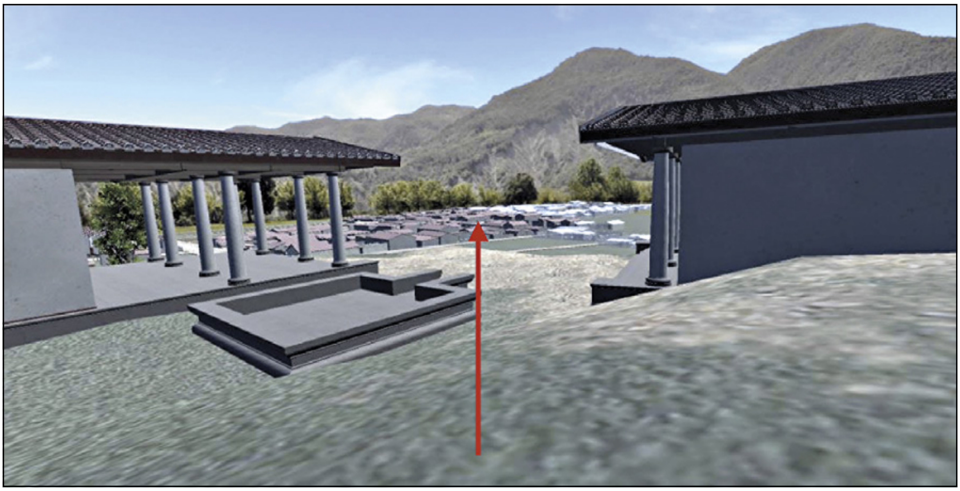


Fig. 4 – View of the lower city from the *auguraculum* in the Realtime Virtual Environment: the arrow points at the crossroad between *plateiai* A and C, where the *decussis* was found.

materials used and found onsite and the parameters derived from ancient sources (Vico, Vassallo 2013).

The next step was the insertion of the models in the urban plan, which thus defines the critical issues related to the use of spaces and the relationship between the buildings, according to an already identified objective (Barceló 2000, 26-28). On this point, the contribution of E. Govi (in this volume) is the theoretical framework within which the model of the city proves to be an effective evaluation tool: some examples to consider result from the virtual environment of the acropolis. The archaeological study led to the delineation of a sequence of occupation of the sacred space starting from Altar B (Sassatelli 1989-1990, 605-606). After this first moment, and probably after the foundation rite of the city around 500 BCE, the terrace was occupied by other sacred buildings, among which the Tuscanic Temple C (Vitali 2001, 42-44; Colonna 2006, 160) and Temple E (Lippolis 2001, 241; different perspective in Colonna 2006, 160), which was a considerable constructive effort since it was raised on a partially artificial platform (Lippolis 2001, 238; 2005, 142). Inside the virtual acropolis' environment, the volume of these temples (Vitali 2001, 35-44, about the many problems of reconstruction of the Temple C), parametrically rebuilt from the BIM model of the Tuscanic Temple of *Uni* (Garagnani in this volume), occlude the view of the lower part of the city from the *auguraculum* on the top of the hill (Sassatelli 1989-1990, 607; Lippolis 2001, 267), with the exception of a narrow window oriented towards SE, which was the visual line between the *auguraculum* and the *decussis* (Govi in this volume). The

Fig. 5 – a) Zenital view of the virtual Kainua; b) View of the Realtime Virtual Environment from SE; c) View of the lower city from the acropolis. The buildings in trasparence represent the lost part ruined due to erosion phenomena.

considerations expressed by G. Sassatelli about the monumentalisation of the foundation rite in the acropolis (Sassatelli 2009, 334-335), lead us to confirm that the entire space of the terrace was planned to save the space of that visual line (Fig. 4). Study of the spaces within the virtual environment allows an initial analysis of a social event for which it was possible to reconstruct the actions and we can therefore evaluate its effects in the monumentalisation of the area in a virtual space. Moreover, we could recreate astronomical arrangements and simulate the rite itself. We are not therefore at the level of simulation of historical processes, as indicated by J.A. Barceló (2012), but we can surely evaluate social events for which we know the actions within the environment.

However, the city is mostly made up of areas which have not yet been investigated. Excluding the southern part, inevitably ruined, and a large part of the borders, we have already mentioned data and analyses which may guide us on the interpretation of unexcavated areas. During the first phase of the project, we decided to represent these areas with procedural modelling. This did not involve the simple structure of the buildings, created procedurally using defined parameters taken from the excavation data, according to a process whose most important example is the Rome Reborn Project (Dylla *et al.* 2010). Based on the interpretative model developed by E. Govi for the study of the distribution of housing units in the city, we realized that every block had its own specific features. So the large-scale potential that allows procedural modelling is not applicable to very limited areas and there are strong constraints related to the types of buildings that were present, on the basis of the interpretation scheme. Therefore, in our specific case, we thought it would be better to switch to hand-modelling of the buildings. Not unexpectedly, the city is represented only where we are certain of the philological correctness of archaeological data, present or based on interpretative models (Fig. 5). As a matter of fact, we suspend judgment on *Regio* II, because it was probably destined to host sacred buildings and their facility services as with *Regio* I and *Regio* III, mostly empty following the results of past excavations (Govi in this volume).

4. Conclusions

This project has definitely led to the creation of a virtual model of the Etruscan city through a multidisciplinary and integrated approach, based on all the available archaeological data. The primary objective of the project was to create a useful tool for archaeological analysis. The "ArchaeoBIM" method, formed within the project, has been used to confirm the credibility of the architectural models and is therefore an important step towards a more detailed architectural analysis of non-preserved structures. Through forms of interactivity and simulations of physical, environmental and astronomical conditions, the virtual model of the city allows us to formulate important considerations about historical and social issues, thus putting us at the forefront in the debate about Virtual Archaeology. The model, however, is also the base for an updated system for the fruition of the archaeological area by a wider audience, chiefly onsite. If the implementation of adequate positioning technology and the development of computational technology lead to the improvement of AR systems, current systems within the reach of the general public and based on an immersive experience can still be a suitable tool for the reading of poorly visible or buried structures in the Etruscan city.

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ABSTRACT

The use of virtual reconstructions is an approach which has already been applied for past projects in the Etruscan city of Marzabotto. The Kainua Project, which aims at the virtual recreation of the whole Etruscan city, is based on the principles of the London and the Seville Charter. The modelling process of the virtual Kainua is based on a rigorous archaeological analysis. The ArchaeoBIM method, formed within the project, has been used to confirm the validation of the models and is therefore an important step towards a more detailed architectural analysis of non-preserved structures. The unexcavated areas of the Etruscan city were involved in a campaign of geophysical surveys, which were the basis for the recreation of wide areas of the city with a good approximation thanks to an interpretative scheme of the modules of the buildings and their allocation within the blocks. The virtual Kainua is first of all an analysis tool. As a matter of fact, through forms of interactivity and simulations the virtual model allows us to formulate important considerations about historical and social issues. The model, however, is also the base for an updated system for the fruition of the archaeological area by a wider audience, chiefly onsite and it becomes a decoding key that visitors can use during their visit.