

REGIUM@LEPIDI 2200 PROJECT

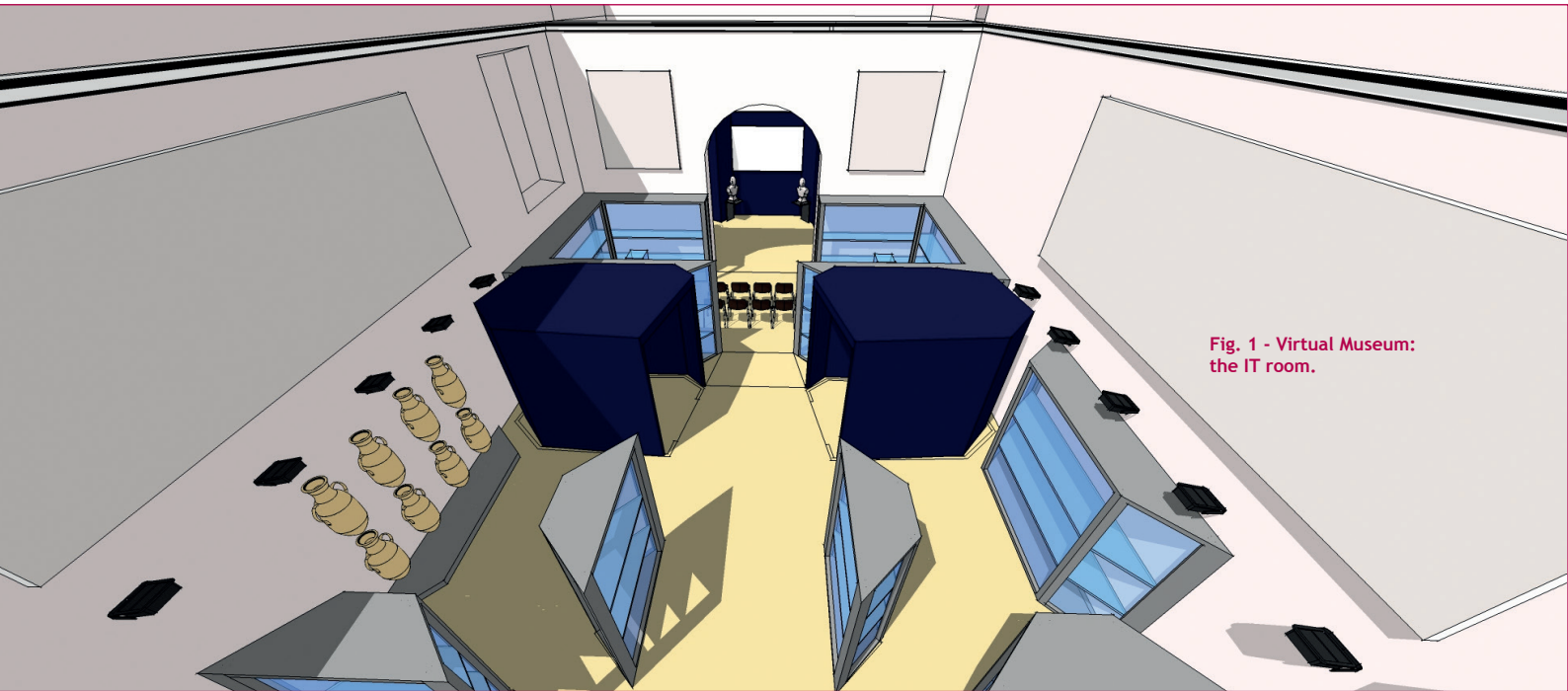


Fig. 1 - Virtual Museum: the IT room.

by Maurizio Forte and Nevio Danelon

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Regium@Lepidi 2200 is an international project designed by Duke University - Dig@Lab in collaboration with the Lions Club Host "Citta' del Tricolore" which is the main co-sponsor. The project was born with the two-fold scope to study and virtually reconstruct the Roman city of Regium Lepidi (now Reggio Emilia) and to support a junior research fellow for the entire period of research and production in USA. The happy end, beside the virtual museum, is that the fellow, Nevio Danelon, achieved a post-doc position at Duke University (Media+Art&Sciences program). More specifically, the final aim is the creation of a new virtual museum and IT room (fig. 1) designed within the archaeological museum of Reggio Emilia (Musei Civici, <http://www.musei.re.it/>).

The contextualization of the virtual museum inside the real one is particularly challenging because it creates a strong connection between empirical data, the museum collection (tangible), their ancient invisible context (the city, intangible) and new immersive perception of artifacts (virtual and immersive).

This new scenario should be able to generate a new narrative for museum visitors whereas the virtual can actually generate a special ranking for archaeological objects, a new cityscape and mindscape (the landscape interpreted by an-

cient and modern minds). In other words, the Virtual draws from the taxonomic collections a new meaning which is based on the relations object-environment (what's for? why? how?) and not on a inexplicable technical classification.

The new digital narrative transforms the traditional archaeological taxonomy in affordances, showing potential relationships among objects, context and environment. In this way objects and sites are embodied in and out of the museum and they can tell stories.

The methodological approach used for the digital reconstruction follows the main principles of cyber-archaeology (Forte 2008; 2010): reflexivity, potentiality, multivocality, real time immersive embodiment and interaction. The final goal is to open and choose multiple perspectives in the digital imagination of the city, rather than to choose a peremptory reconstruction.

The case study is quite complex, because of the lack of archaeological empirical evidence in situ and of recent scientific archaeological excavations. The Roman city is almost completely hidden inside the modern city of Reggio Emilia. Citizens and visitors cannot easily get the sense of a Roman urban plan and of their own Roman past, because of the fragmentation of archaeological sites and finds, and the lack of extensive excavations.

This situation is in fact quite different in comparison with other well documented Roman cities along the *Via Emilia*, such as *Mutina* and *Bononia*.

More in detail, the interpretation and reconstruction of the Roman city has used the following methodological criteria:

- ▶ Virtual recontextualization of museum objects and sites within the ancient Roman city.
- ▶ Archaeological and historical markers. Unknown areas of the Roman city can be indirectly reconstructed by other “markers”, such as archaeological finds showing the power of imperial *domus* and/or the high rank of specific areas. Scattered finds, if correctly studied, can create patterns, clusters, otherwise not visible and understandable.
- ▶ Shape and urban plan of the modern city. In two thousands years the development of the city of Reggio is deeply influenced by the original plan of the Roman one. It is a sort of architectural and urban DNA.
- ▶ Archaeological excavations. High resolution and very accurate 3D models made by laser scanners
- ▶ Paleo-environmental and geo-archaeological studies.

The digital and virtual reconstruction, discussed below, show clearly the impressive visual impact of the interpretation of the two cities overlapped (the modern and the Roman one).

DATA COLLECTION AND DIGITAL RECORDING

The Regium@Lepidi 2200 Project aims to thoroughly investigate the archaeological record of Reggio Emilia and envisage what the ancient land- and cityscape would have looked like during the Roman imperial age. We followed an interdisciplinary approach, already outlined for analogous case studies (Pescarin et al. 2002), that entails the integration of different categories of data and methodologies, ranging from, archaeology, geology, topography to remote sensing. The research was based on published bibliographic material and archival records, but it also produced new data and interpretations through different instruments and software. As a result, several Virtual and Augmented Reality applications have been designed to be run with the state-of-the-art devices for stereoscopic visualization and fully immersive experience. In this way, we intend to raise awareness about the invisible Roman legacy of Reggio among the visitors of the local Musei Civici, as well as to promote a debate about possible reconstructive scenarios within the scholarly community. Reggio is renowned among the other Italian historical centers for the Roman mosaics, as Ravenna is for the Byzantine ones. Unfortunately, most of them were unearthed during the post-war reconstruction of the city in the early Fifties, without any proper archaeological record having taken place. Just a few pieces of information about the location and depth of findings were reported, along with some occasional photos relating to the excavation context. Therefore, any attempt to reframe the mosaic floors in their architectural context would be groundless. Nevertheless, this kind of information proved very useful in order to generate a digital model of the city ground level for the Roman period (see further). As a first step, we set up a GIS geodatabase with a cartographic base consisting of raster and vector data. For this purpose, we purchased a Digital Terrain Model (DTM) and a Digital Surface Model (DSM) of Reggio Emilia territory, generated from LiDAR data at a 1 m spatial resolution and provided in raster format. Then, we started collecting and digitizing the available archaeological maps, entering these pieces of information into the geodatabase (fig. 2).

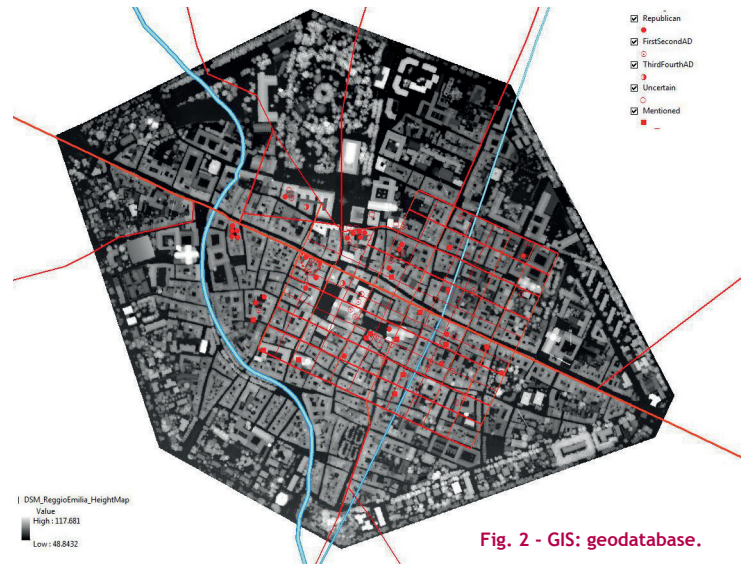


Fig. 2 - GIS: geodatabase.

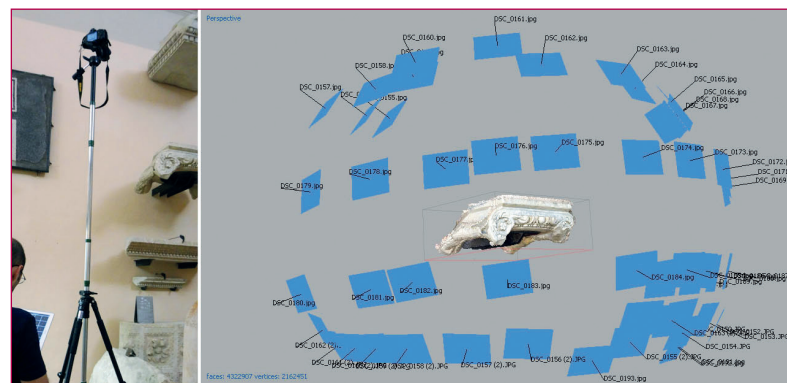


Fig. 3 - SfM: photo acquisition and processing in PhotoScan.

In particular, a map of Reggio Emilia (Scagliarini & Venturi 1999) representing the location of each floor findspot, was georeferenced. For each point, a numeral value relating to the floor depth in respect to the present ground level was entered in the corresponding attribute table, together with other information such as the age of the artifact. The archaeological maps representing the main reconstructive hypotheses about the original Roman centuriation grid were also georeferenced, while the street axes were redrawn in a vector layer as linear features.

We carried out a number of high-detailed 3D digital acquisition of several Roman artifacts, preserved in the local archaeological museum. The technique chosen was Structure from Motion (SfM), via PhotoScan software, that generates 3D models by processing a number of digital photos, taken all around the object (figs. 3, 4). In this way, it is possible to reuse some of the original architectural elements in 3D simulations, after virtually restoring the missing part of the fragments (fig. 5).

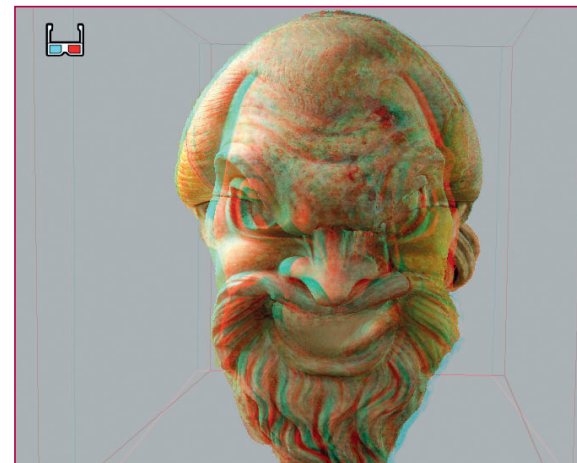


Fig. 4 - Anaglyph of a fountain mask (PhotoScan).



Fig. 5 - Virtual anastylosis integrating the original fragments (red lined).

In some respects, the sense of proportion in classical architecture is quite codified in Vitruvius' rules, so that the possible structure of a building can be predicted on the basis of the foundation layout and the surviving architectural items.

We experimentally applied SfM to some of the Roman mosaics on exhibit at the museum, trying to generate very dense 3D polygonal meshes in order to capture the minute geometric details of the *tesserae* (fig. 6).

This approach led to interesting results, providing a first comprehensive 3D documentation for the corpus of the Roman mosaics in Reggio.

The extensive excavations carried out between 1980 and 1983 in the basement of the Credito Emiliano headquarters (Credem) has proved to be one of the rare chances to investigate a large area - almost an entire block - of the Roman city center (Malnati 1988). Here, the massive foundations of two buildings, now lost, were unearthed in a complex stratigraphy. These remains have been identified with a Roman basilica and an undefined structure - possibly late defensive walls or a temple podium - whose archaeological interpretation, however, is still controversial (Lippolis 2000). Far from suggesting a *de facto* reconstruction, we ideally chose to simulate the hypothesis of a temple in order to verify its compatibility with the underlying archaeological layout. We found it reliable in terms of spatial constraints, it being understood that no archaeological evidence has been so far found, to support this hypothesis.

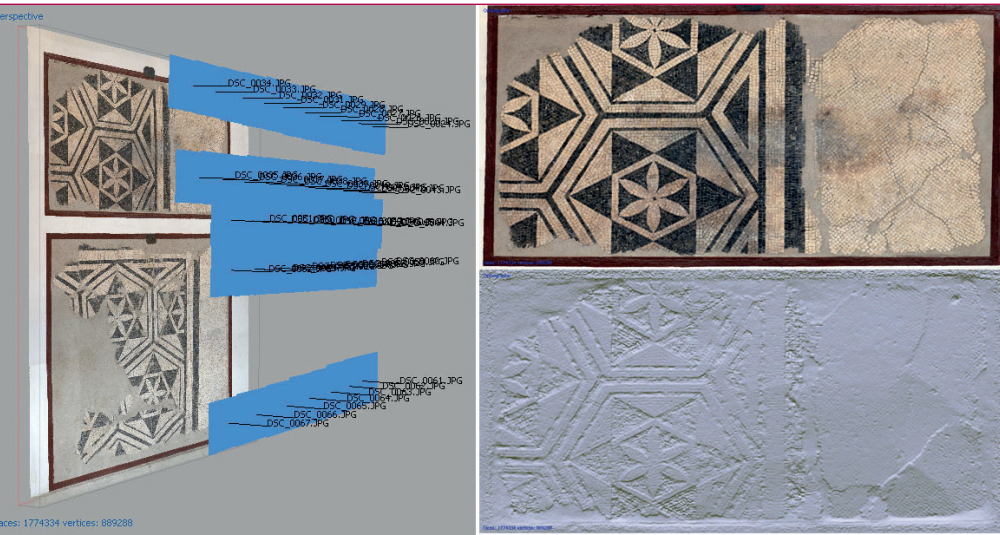


Fig. 6 - SfM: mosaics (PhotoScan).

Fig. 7 - Regium Lepidi: nadiral view.





Fig. 8 -Regium Lepidi: bird's eye view.

For the digital recording of the Credem archaeological site, we used a terrestrial laser scanner (Faro Focus 3D) together with a large number of checkerboard and spherical targets in order to overcome the visual obstacles preventing the correct alignment of the scans. What currently remains visible in the Credem basement is the result of a final display that has concealed or removed most of the structures unearthed in the course of the excavation, leaving visible only some masonry samples of the foundation walls. Therefore, a total station survey proved necessary for the reunification of the different sections, as well as to provide a topographic base for the subsequent three-dimensional reconstructions.

DATA PROCESSING AND APPLICATIONS

Two Unity3D-developed applications were created for each typology of device: Regium@Lepidi is a macro-scale representation of the Regium landscape to be visualized through the main stereo projector, while Forum@Lepidi is a fully immersive scenario focusing on the forum area and developed for Oculus Rift. Below a short description of the main installations.

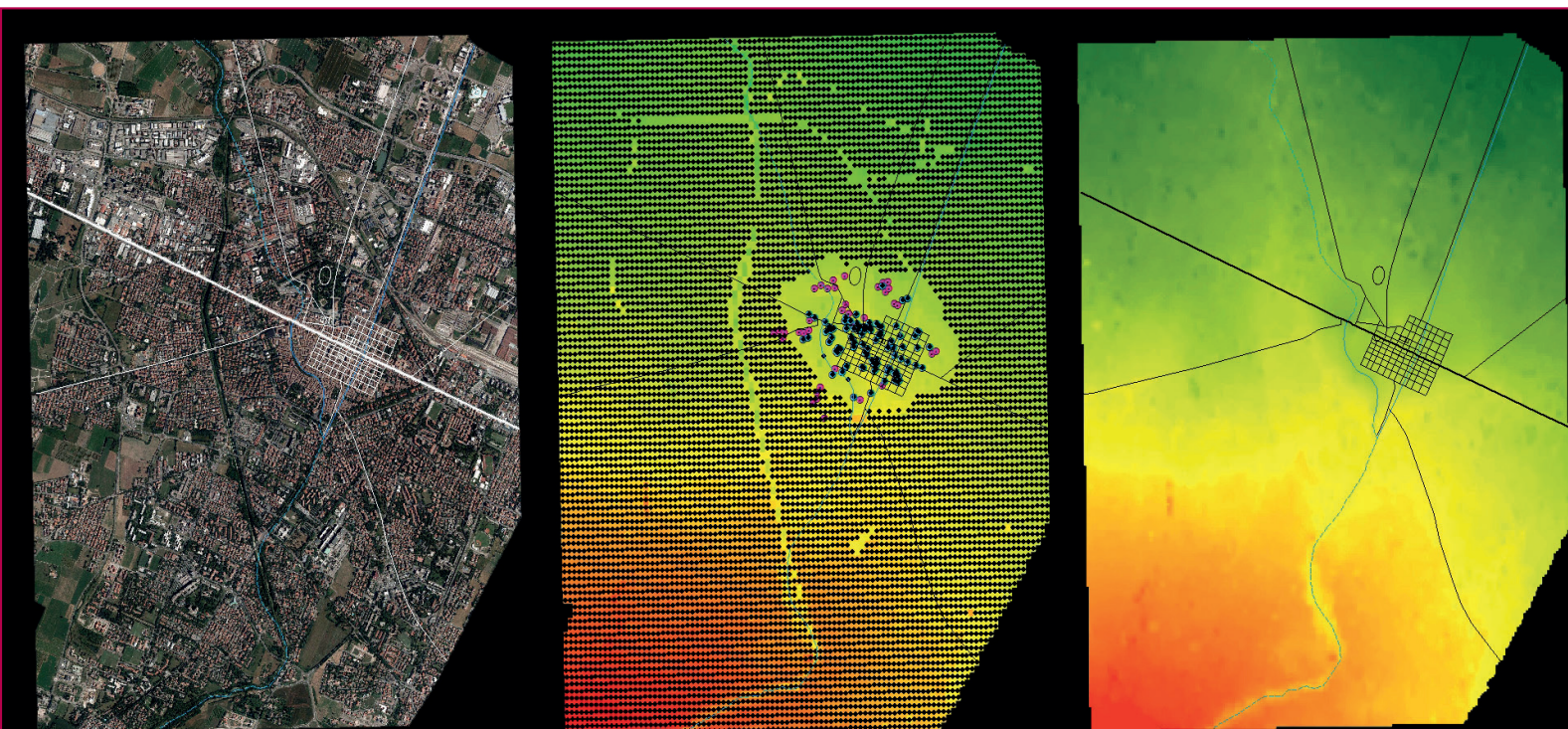
REGIUM@LEPIDI

gives the visitor a global glimpse inside the Regium country, back to the Roman times.

This application contains a realistic macro-scale terrain model and a camera flying over the ground in a bird's-eye view (figs. 7, 8).

The observer can scroll the landscape, characterized by an almost uniform land subdivision (centuriation) that originates in the city center from the intersection of the main roads (Via Aemilia and the main cardo). One can swap to the present day in an attempt to notice the landscape changes occurred over the centuries. This is an important chance to understand the spatial relationships over time since many features are no longer recognizable. While Via Aemilia is still unmistakably identifiable by its straight path, the original regularly spaced street grid is difficult to find from the modern road layout. The ancient course of the Crostolo River is still identifiable along Corso Garibaldi that follows its original riverbed. The Roman terrain was reshaped on the basis of the present DTM. Assuming that the natural landscape underwent very little change, the major modifications are mainly anthropogenic. Thus, elevation data in correspondence with largest artifacts, such as embankments, highways and canals, were removed from the DTM grid, while the original ground level of the ancient city - up to 4 m lower than at present - was generated by interpolating both geological and archaeological elevation data relating to the Roman phases (fig. 9) (Pescarin 2001).

Fig. 9 - Generation of the Roman DTM.



The ancient city layout was recreated after importing the archaeological maps to the GIS. The original street grid was hypothesized by scholars on the basis of the road fragments found during post-war rebuilding activity. GIS features (points, lines and polygons) as well as the modified DTM, were imported into procedural modeling software (CityEngine) in order to generate the city blocks (*insulae*) and the residential lots (*domus*) in an almost automated way (Pescarin et al. 2010).



Fig. 10 - Stereo-view inside the Oculus Rift headset.



Fig. 11 - Forum Lepidi: view inside the Roman forum.

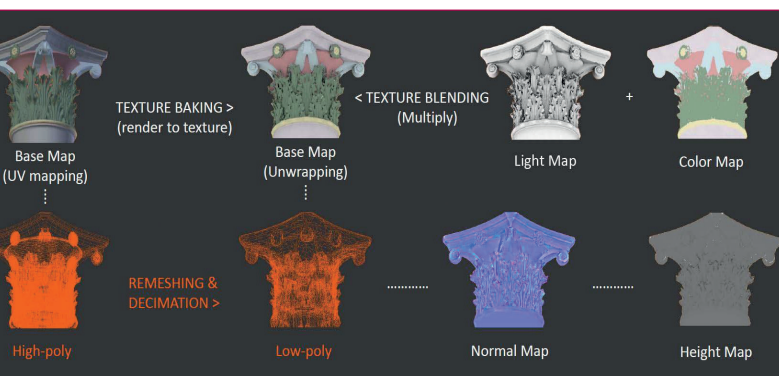


Fig. 12 - Model simplification and texture baking workflow in Blender.

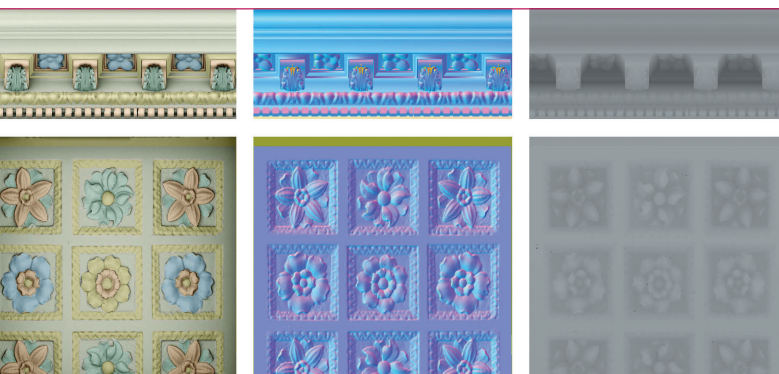


Fig. 13 - Parallax normal mapping: a) base map; b) normal map; c) height map.

These 3D models were created accordingly to some predefined rule set (shape grammars) and small objects (assets), so that repetitions are avoided yet the number of assets is limited.

Procedural modeling also generates an almost neutral and homogeneous cityscape, preventing the observer from focusing on particular buildings.

FORUM@LEPIDI

Provides an insight into the Roman forum daily life, allowing the user to walk through some of the most monumental public buildings, originally located in the central area of Regium. Oculus Rift allows a real-scale perception so that the observer can appreciate the architectural details from a closer range than in the previous application (figs. 10, 11).

Preserving graphic details in a real-time visualization is a major challenge that computer artists are facing, since polygonal models need to be very simple in order to minimize the workload on the Graphic Processing Unit. To overcome this issue, different techniques borrowed from computer game design were used to increase the efficiency of real-time rendering. Complex objects can be dynamically replaced by instances at different polygonal resolution - called Levels of Detail (LODs) - depending on camera range. Occlusion culling can further reduce the number of objects that lie outside of the view. Parallax normal mapping is by far the most effective way to preserve minute geometric details in very simple objects. The latter technique was extensively adopted for the architectural decorations featured in Forum@Lepidi. Complex models, made of dense polygonal meshes, have been retopologized and decimated, while the lost geometric details were resumed from the original object to be mapped onto the surface of the simplified model, through render-to-texture procedures (figs 12 and 13).

Virtual simulations of ancient sites are possible even in case of scarce archaeological clues, as long as the objective record of the archaeological evidence can be clearly distinguished from its interpretation (Forte et al. 2006; Bentkowska et al. 2012). The imposing buildings, whose foundations were unearthed in the basement of the Credem building, were stripped of their marbles since the Middle Ages and none of the architectural elements belonging to the original superstructure has been found in situ. On the other hand, some architectural fragments of outstanding elegance survived as reused material in later structures; eventually they were recovered and are now in exhibit at the local museum. We felt it significant to ideally reuse these decontextualized blocks for simulating the buildings in the forum area, not with the intention to give the visitors a precise idea of what the Regium forum was, but in order that they may understand their original architectural function as a part of a building.

Z-SPACE IMMERSIVITY

Z-space is an holographic virtual reality collaborative platform managed by a 3D stylus. Here the users will explore the potential of proprioception and eye-tracking in the virtual exploration of archaeological artifacts. This interaction is collaborative, since the interaction of the user with tracking glasses will be displayed in an external monitor by a video camera. This monitor will show in augmented reality real people and virtual objects in the same frame.

DREAMOC

This case is a 3D holographic display with a remote access for uploading the virtual content. The system shows 3D models of museum artifacts and virtual reconstructions visualized in a three-dimensional case.

Since it is able to host endless models and AR applications and it is remotely upgradable (for example from our lab in USA), it is the ideal platform for displaying objects not included in the public collections (for example archaeological finds in the museum storage) or not correctly contextualized.

AUGMENTED REALITY

A new app was developed in Metaio (software for augmented reality applications) for the museum visitors. QR codes will be labeled close to a selection of key objects of the Roman collection. Every user with a smartphone, after downloading the app, will be able to visualize 3D models and metadata in front of the museum objects.

CONCLUSIONS

Regium@Lepidi 2200 Project is a challenging case of 3D simulation. The major issue concerning a correct understanding of Regium Lepidi topography is that the Roman city lies beneath the modern settlement. Therefore, the city layout has emerged only unevenly, mostly during rescue archaeological investigations carried out within the boundaries of the modern construction sites. The topography of Regium during the imperial age is better known than the previous phases and more intelligible. The extent and the boundaries of the city could be inferred from the centuriation imprint that still characterizes the present urban street layout, as well as from other clues such as the discontinuity between paved and graveled road surface along the Via Aemilia (Pellegriani 1996).

Between the end of the first century BC and the beginning of the second AD, Regium underwent a considerable urban development, coinciding with a period of economic prosperity. A substantial urban renewal occurred in the central area where private residential blocks on the north side of the forum were torn down to make room for a large basilica and possibly other public buildings. The earthenware (*cocciopesto*) paving technique that characterized the private houses during the Republican age was mostly replaced by fine mosaic floors. At this time, some of the wealthiest residences were provided with thermal baths facilities whose presence demonstrates the high standard of living of their owners. In order to make this visible in the virtual simulation, steam flows rising from the roofs were placed in correspondence with the archaeological finds of thermal infrastructures. Burial grounds were arranged along the main access roads to the city, as in the case of the Eastern necropolis (fig. 14) from where several items stored in the museum (sepulchral



Fig. 14 - Via Aemilia: the Eastern necropolis.



Fig. 15 - Industrial area: furnaces.

altars, tombstones and sarcophagi) come. Industrial areas were located in the immediate vicinity of the city, such as the furnaces for firing pottery found in the northern suburbs of Regium (fig. 15). No entertainment buildings have been found yet, even if they undoubtedly had to be present in Regium. Thus, we have envisioned a theater and an amphitheater relying on a recent study of topographic maps (Storchi 2009). The presence of city walls in Reggio is much more uncertain and controversial (Gelichi & Curina 2007) so we decided not to include them in the virtual simulation. Three-dimensional models and the major reconstructive scenarios underwent a careful validation process by a multi-disciplinary research team of Italian and American scholars involved in the project and by an international scientific committee.



Fig. 16 - Data transparency: archaeological layout and hypothetical reconstructions.

Nevertheless, in order to provide transparency into the process of interpretation and simulation, the raw evidences (the ruins at the present state) have been incorporated in the Forum Lepidi scenario so that it is possible to overlay archaeological data and virtual hypothetical reconstructions (fig. 16).

Ultimately, the Regium@Lepidi Project has produced a large amount of new spatial data (GIS, remote sensing, laser scanning, 3D modeling), which can be shared with a large community of scholars, archaeologists and historians, beside the public virtual installations. The virtual museum is designed mainly according to a bodily-kinesthetic approach: the users are stimulated to learn by interaction and in that way they should be able to produce new knowledge. We imagine the virtual museum like an experimental lab of digital-cognitive embodiment where mind and body are involved. The more users/visitors exchange information with the environment, the more they learn, share and transmit knowledge.

At the same time the project tries to reconnect the Roman and modern towns and their environment in the cityscape, hopefully stimulating the local communities to rethink the space they inhabit and to imagine two thousands year of history and urban transformations.

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ABSTRACT

Regium@Lepidi 2200 is an international project designed with the scope to study and virtually reconstruct the Roman city of Regium Lepidi (Reggio Emilia). The final aim is the creation of a new virtual museum and IT room designed within the archaeological museum of Reggio Emilia.

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KEYWORDS

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NEW sources for the UV Fluorescence/UV Reflected Imaging



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Uniform Illumination



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