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# Remote fruition of material and non material goods

## ICT for IV century BC necropolis

Adriana Rossi

Department of Civil Engineering,  
Design, Building and Environment  
Second University of Naples (SUN)  
Aversa, Italy  
[adriana.rossi@unina2.it](mailto:adriana.rossi@unina2.it)

Emilia Carbone

Department of Civil Engineering,  
Design, Building and Environment  
Second University of Naples (SUN)  
Aversa, Italy  
[c.emily88design@gmail.com](mailto:c.emily88design@gmail.com)

Fausta Fiorillo

Department of Civil Engineering  
University of Salerno  
Salerno, Italy  
[ffiorillo@unisa.it](mailto:ffiorillo@unisa.it)

**Abstract**—The technologies that allow the representation, the organization, the computation and the advanced exchange of information no longer reside within the exclusive domain of engineering. They are embedded in application products which suggest innovative themes and call for novel political, economic and entrepreneurial strategies and therefore more creative paths for research in general and Cultural Heritage in particular. Remote fruition of high interest sites is a central issue for historical, archaeological and environmental research whenever the themes and goods being studied are difficult to access for specialist researchers or no-technical user. One of such instances has been chosen to illustrate the potential of ITC via the description of a pre-organized information elaboration process, which is flexible as to demand.

**Keywords**- ITC, Virtual Heritage, Digital Museum, Virtual tour, Italian Cultural Heritage, Mixed Reality (MR)

### I. INTRODUCTION

The international definition of cultural heritage broadens the scope of its safeguard and upholds its environmentally sustainable fruition to meet the needs of the community [1]. Consequently, there is a need to consolidate the links between institutions and business enterprises in consideration of the potential economic returns [2]. Search engines have proven to be globalized economic systems [3]. Their development has turned the contemporary world into a virtual globe [4] capable of transforming search engines into cultural operators [5] and cultural heritage into a huge and varied category [6].

Collaboration between websites and the main cultural institutions was prompted by a shared interest: search engines update and upgrade their open access repositories and make data accessible to specialized professionals. Therefore, the cultural institutions can improve their final products and trigger revenue generation by offering remote fruition, which is an emerging technology [7].

Emerging technologies and interdisciplinary cooperation allows planning the different levels of knowledge according to users demand.

In the phases of the data archiving process, digital and/or vector models are derived and processed for specific ends. The development of information technology has made it possible to evolve from the electronic drawing of plane geometric figures to the creation of volumes for representation and visualization purposes.

Gradually, attention shifted from a focus on documentation to one aimed at the construction of unified information processes. The models have become more and more metrically precise so that the information discrepancies resulting from analogic to digital generation are negligible. The high definition, true to the original model, is the framework for the design of interactive user spaces. Mobile, or ITC, technologies have enhanced the potential of these animated and flexible environments.

Therefore, the media sectors have been re-organized and new concepts realized and introduced like, for example, the Virtual Heritage [8]. The main aims of the ensuing policies give high priority to the satisfaction of culture consumers, offering the possibility of take advantage of the significance, sometimes forgotten, of artistic and cultural accomplishments. The cultural heritage items, enhanced with a new sensory dimension, can be presented in continuity with tradition but in communication with the present thanks to new form and content [9]. With careful planning, the steps of the archiving process may be followed for research and study purposes. Cloud computing [10] is an increasingly relevant resource for digital restoration projects, reconstruction studies on lost or unexplored traces and reverse engineering processes, integrated with prototyping for form re-construction. The new cultural heritage paradigms may draw from the same source.

In this perspective, the presented case study can be considered emblematic. The survey carried out with a recently passive sensor technique was processed with the aim of furthering web visibility. The Campania Regional Agency for Cultural Heritage and a powerful research engine have embarked on a joint endeavor, which will result, hopefully soon, in a form of net surfing integrated with applications that allow for the interaction between site and users using microphones, cameras, smart sensors and other typical technologies related to mobile devices (web squared). However, the originality of the project lies in its concept. Perfectly in line with the current idea of systemic culture the applications are meant to guide the user toward the discovery of what seems to be an ambitious objective of the artists of the IV century BC and which has been made possible thanks to the man-machine interaction. The new fruition paradigms, which emotionally involve a cultural heritage customer during his web visit, might also bring about advances in historical research and other positive suggestions. Communication technologies may also rekindle interest in archaeological sites of great value that attract little attention because they have been

overshadowed by other more renowned and famous and/or more promoted and publicized.

## II. CASE STUDY AND REASONS BEHIND THE CHOICE

The possibility of online fruition has prompted a revision of cultural heritage management policies. The data organization, elaboration and exchange techniques are no longer confined to engineering research even if the latter field actually provided the supporting software. The presented case study was chosen as a means to explore the effects induced by emerging technologies.

The chosen site consists of a group of funerary chambers with frescoes dating back to the IV – III century BC and excavated in the Caserta area (Italy). Some of these have been reconstructed to anastylosis in the archaeological area of Ancient Capua (currently Santa Maria Capua Vetere) built around the Campanian amphitheater (Fig. 1). The pictorial graphics [11] clearly show how the architectural elements were isolated to create room for semantic spaces. This marks the beginning of a ‘language’ which would be developed in later years. From the contemporary scientific point of view, the interpretation of this feature can be contextualized in a really topical perspective.

The system of paintings in the funerary chambers seems to have been conceived to allow the visitor to transfer body and consciousness in a metaphysical world in search of an otherwise impossible point of contact with the deceased. An ambition that emerged from analysis and interpretation of the technical drawings elaborated: the existing structural elements matched the ones that were projected on the background of the representation. The same was for the objects, artefacts and visitor shapes that, when superimposed on the section-elevations, blended perfectly with the figures painted among the depicted columns and the real structural elements. Painted elements and physically existing elements overlap in scale, therefore in the painting space are mixed virtual/real columns, persons and objects. The effect calls to mind the sensations obtained by applications of Mixed Reality, a recently coined term to indicate an evolution and interaction between Virtual and Augmented Reality, which permits a coexistence of the physical reality and artificial reality.



Figure 1. Santa Maria Capua Vetere (Italy) archaeological site.

The ultimate voyage, the exegetical theme of the funerary chambers, can be considered the design of a collaborative space where the visitor, with varying degrees of participation, inhabits the constructed atmosphere in a quest for an emerging paradigm in the IV century BC. In other words the artists of the time, with the means at their disposal, had anticipated an accomplishment of our present, i.e. the fruition of an artificial space in search of emotions to be experienced in any place thanks to mobile technologies and communicated in real time thanks to social sharing tools.

## III. THE RECONSTRUCTION OF THE ARCHAEOLOGICAL SITE

In order to create an accurate and realistic digital reconstruction of the current state of the archeological site, useful also to develop a hypothetical reconstruction of the original aspect, a survey campaign was conducted. Due the final purpose of documentation and visualization of the area a photogrammetric approach was chosen.

Furthermore in order to produce a navigable panoramic images, a spherical tripod head (Nodal Ninja 4) and an 18 and 18-55 mm focal lens were used (Fig. 2). The single shots were assembled in a unique spherical image in order to create immersive image for virtual tour applications and allow the exploration of the archaeological area even on-line (using any browser). Using an 8mm fisheye lens is possible with an optimal number of eight shots (six in the horizontal plane with a 60 ° step and two zenithal upwards and downwards) to build



Figure 2. Field operations (student thesis Emila Carbone, dissertation correlator ing. Fausta Fiorillo, relator prof.ssa Adriana Rossi).



Figure 3. Images stitching

a spherical panoramic. The stitching (Fig. 3) is achieved through dedicated software that project the frames upon a sphere whose center is coincident with the used lens nodal point. It is understandable, therefore, the importance of having performed the photographic survey with the camera mounted on a tripod with panoramic head that, rotating around the nodal point, eliminates parallax errors. The parallax is the apparent displacement of an object closer than a distant object when viewed from different perspectives and causes important errors during the assembly process of the photos. This type of error can not be eliminated in post-processing.

The alignment of the images takes place thanks to the recognition of homologous points common to two adjacent frames. This process is operated automatically, although there is always the possibility of a manual intervention for an addition or increase of corresponding points or a cancellation of the wrong ones.

The images are deformed into curved patches, scaled and mapped on a sphere of constant radius on the basis of common control points. The final elaboration of blender will change the brightness of the common parts for there to be a gradual color transition between the various frames.

The virtual tour (Fig. 4) allows the exploration of immersive panoramas, moving from one image through the hotspots. The final project of the virtual tour can be exported in .html file format and is adaptable to mobile devices such as smartphones and tablets. Navigate through a virtual tour can be further facilitated if it is implemented with a key plan in which the steps of the path are identified.

The 360° images can have links with data of different types, i. g. graphic elaborations, text information illustrative videos, and digital 3D models of artefacts. Thus, a virtual tour application allows not only to explore the place, but also to

access to additional media content and information that promote the knowledge, the promotion and the divulgation of the site.

Due to the small size of the interior of the tombs (about 1 x 2 m), a spherical photogrammetry applications (using 2/3 interior panoramas, Fig. 5) were conducted in order to extract a reference model [12 - 14].

The images processing followed the standard photogrammetric pipeline: automated tie points extraction and a photogrammetric bundle adjustment (for internal and external orientation parameters calculation), generation of dense point cloud and surface model, texture mapping of the mesh model. The software used are focused on computer vision technology by image-matching algorithms that combine the automation of computer vision techniques with the photogrammetric principles.

The polygonal models studied are generated by primitive graphics using the photogrammetric model as a reference (Fig. 6). These in turn allow to efficiently construct free forms on which the photographic texture can be applied. thanks to the studies and surveys performed it was possible to generate both the textured digital model of the tomb in its current state that its



Figure 4. Virtual tour of the Santa Maria Capua Vetere (Italy) archaeological site



Figure 5. 360° spherical projection of tomb (c 37) interior.

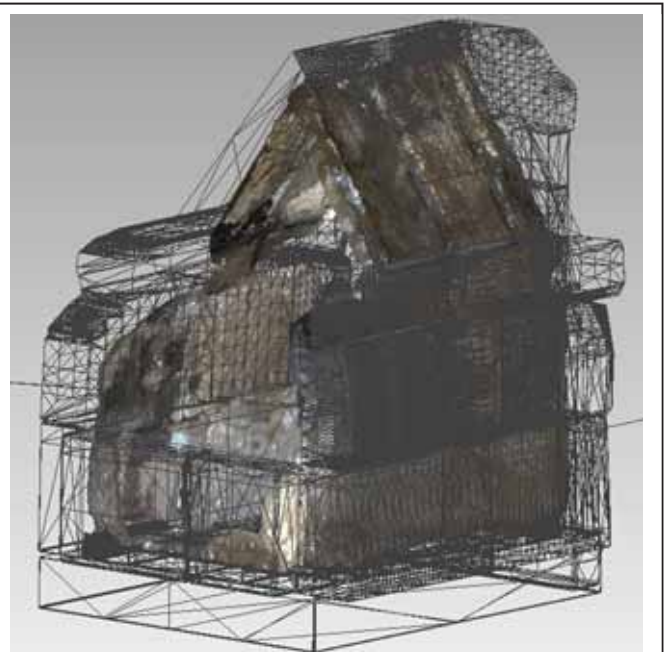


Figure 6. Overlay of the photogrammetric textured mesh and the geometric three-dimensional model.



Figure 7. 360° spherical panoramic rendering of tomb (c 37) interior.



hypothetical virtual reconstruction. From the digital reconstruction of the tomb was also extracted a panoramic render (Fig. 7). The latter was added to the virtual tour to enrich the virtual experience by making it more interesting and exciting. Further, in the virtual reconstruction it was also reproduced the context of the burial chamber (Fig. 8). The digital reconstruction of the tomb highlights that the space represented in the paintings seem to continue and complete the real space.

Even if polygonal models only represent the surface explicitly (volume, in fact, is implicit) they can be used for other purposes if 3D computer graphics and solid modeling are also employed. In this study, the digital restorations of the paintings inside the tombs were developed (Fig. 9).

The virtual reconstruction of the metaphysical environment depicted in the paintings was also modeled. Figure 10 illustrates the geometric constructions that were needed to develop virtual models of shown imaginary space in paintings.

The geometric and spatial digital reconstruction of the architecture painted on the walls of the tombs (Fig. 11) was the result of a careful and accurate perspective study.

The possibility of generating an integrated system with panoramic images and additional media content is offered by the creation of the virtual tour and this can be employed to highlight the qualities of the archaeological site, the equipment and the entertainment offers. So, if a Virtual tour is integrated with online services (for example Google Business Google Maps Indoor [<http://exampletours.com/category/art->



Figure 8. Textured model render of the interior reconstruction of the tomb c 37.

culture/museumart/] it allows for the virtual visit of spaces.

The remote fruition enables the users to move within the spaces, to focus attention on specific areas aided by audio and video. The experience is surprisingly realistic and particularly useful in the cultural sector in that it offers opportunities for experiences that are qualitatively comparable to real life ones.

The project is particularly competitive if one considers the possibility of digitally reconstructing lost prototypes or destroyed parts so as to re-create original atmospheres including additional information to the real scene (augmented reality) or even devising an entirely computer generated one (virtual reality).

The most interesting and attractive aspect is the possibility of enhancing the virtual visit with interactive applications. For this reason, efforts have been made to produce models that can parametrically adapt during movement to give the user the impression of inhabiting the funerary chamber.

It is in fact a forerunner of sorts of the hyper-technological space capsule imagined by the film *Avatar* (2010) director of James Cameron [[www.avatarfilm.it](http://www.avatarfilm.it)]. The metaphysical world in which the living could come into contact with their deceased



Figure 9. Digital restoration of the interior paintings.

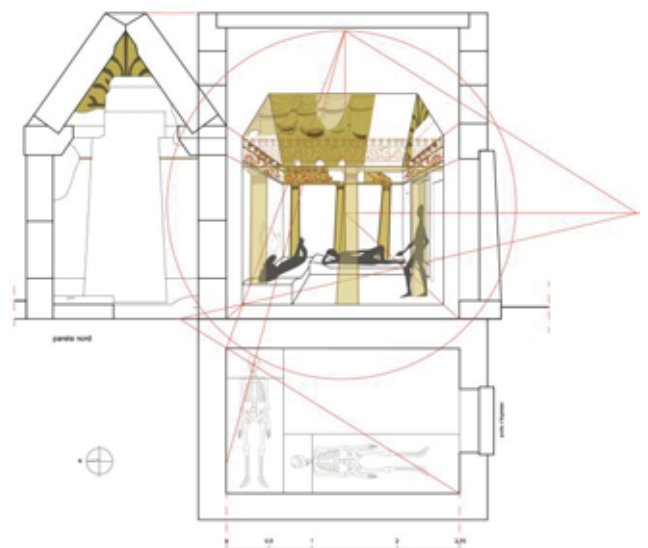


Figure 10. Geometric reconstructions of the virtual models of shown imaginary space in paintings.



Figure 11. Reconstruction of the metaphysical space and architectures represented on the painted walls (render by Daniele Caccavale and Antonio Basilicata Students of the course (prof. A.Rossi)).

loved ones in Hades was conceived to cater to responsive type behavioral logic.

#### IV. CONCLUSION

The possibility of digitally representing reality in 3D using static models or dynamic, which can be explored in virtual space, has allowed to document, for future reference, an important museum reality.

The Virtual Tour is an interactive tool that gives the user the opportunity to explore the archaeological site and remote use and focus the interest in programmed points. The addition of multimedia elements such as audio, video and text, can enrich the experience and make it more attractive. The most

relevant is the possibility of integrating the real and virtual tour with applications and devices that allow direct interaction-site user. Particularly for Capuan tombs, the new technological applications may rediscover the artist's intent represented in the painted architectures. Overcoming the temporal distance, the contents of a distant culture can be revived and even understood by the contemporary viewer. The remote fruition of the funerary chambers is a promise for the preserving and furthering of knowledge and also for economic growth in the tourism sector.

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