Lucus Feroniae and *Tiber Valley Virtual Museum*: from Documentation and 3d Reconstruction, Up to a Novel Approach in Storytelling, Combining Virtual Reality, Theatrical and Cinematographic Rules, Gesture-based Interaction and Augmented Perception of the Archaeological Context

Eva Pietroni[(1)]
eva.pietroni@itabc.cnr.it

Daniele Ferdani[(1)]
daniele.ferdani itabc.cnr.it

Augusto Palombini[(1)]
augusto.palombini]@itabc.cnr.it

Massimiliano Forlani[(2)]
massimiliano.forlani@evoca.org

Claudio Rufa[(2)]
claudio.rufa@evoca.org

[1] CNR - ITABC, National Research Council - Institute of Technologies Applied to Cultural Heritage
[2] E.V.O.CA.srl

Abstract: The Tiber Valley Virtual Museum aims at providing digital applications for the valorisation of the landscape and cultural heritage of the medium Tiber Valley, north of Rome.

In this context an evocative virtual reality installation has been presented in the National Etruscan Museum in Rome, where we propose a multi-modal approach to the narration of the landscape considered in its several aspects: geological, natural, historical, archaeological, poetic, evocative and symbolic. Through gesture-based interaction the visitor explores the landscape experiencing four different scenarios, two of them related to aerial and underwater landscapes and two others related to specific archaeological sites. This paper will focus on the design of the installation and on the communicative approach followed, in particular, for the scenario of Lucus Feroniae. The methodological approach will be described, from digitization and 3D reconstruction of the site in Tiberian and Trajan ages up to the creation of innovative integration of different media.

Keywords: Virtual museum, Interactive storytelling, Integration of media, Gesture based interaction, 3D reconstruction.

1 'Tiber Valley Virtual Museum': aims and general strategies (E.P.)

The 'Tiber Valley Virtual Museum', lead by CNR ITABC and supported by Arcus S.p.A., has been conceived in order to increment and disseminate the knowledge, the interest and the affection towards the territory north of Rome, crossed by the Tiber river and by two important Roman consular roads, via Salaria and via Flaminia, an area 40 km long x 60 km wide (Fig. 1), (Arnoldus-Huyzendveld *et al*. 2011).

To do this an integrated communicative system has been created, including a website (still in progress at the moment of writing), virtual reality and multimedia installations placed in local museums of the area (*Museum of the River* at Nazzano, *Lucus Feroniae* archaeological museum) and in Roman museums.

These applications have been conceived to encourage people to visit this territory and to support them before, during and after the visit of the real sites, providing cultural contents at different levels.

Starting from the study and documentation of the territory and of its evolution across time (from 3 million years ago until today), 3D representations at different scales have been realized, from the whole landscape to specific sites (Pietroni *et al*. 2013).

One of the most important results of the project is a virtual reality application characterized by gesture-based interaction and by an innovative approach in interactive storytelling, following an artistic and evocative style, based on scientific contents. It is permanently accessible in the National Etruscan Museum of Villa Giulia, in Rome, since December 2014.

It consists of four different scenarios that are visualized on three aligned 65-inch screens, aiming at creating an evocative and narrative experience inside the territory of the Tiber valley.

Fig. 1. The territory interested by the 'Tiber Valley Virtual Museum' project with the sites in evidence and details of the archaeological area of Lucus Feroniae.

It allows the visitor to see the Tiber through the eyes of a fish that swims in the river, a bird that flies over the landscape, the ancient characters living in the Roman city of *Lucus Feroniae*, and a freed slave introduced to the famous Roman *Volusii Villa*, living his intimate drama (Fig. 2).

Swimming underwater in the current of the Tiber, like a fish, the visitor can experience the memory of the river; the swimmer meets fluctuating images, iconographies, sounds, literary fragments taken from ancient and contemporary poets and authors. 3D reconstructions of the geological evolution of the Tiber Middle Valley and of the potential ancient landscape in the orientalising and Roman/Augustan period have been proposed in the aerial scene, whose purpose is also to contextualize the other scenarios dedicated to the archaeological sites of the *Volusii Villa* and *Lucus Feroniae*, respectively reconstructed in the Augustan age and in the Tiberian and Trajan periods.

In this project, efforts have been oriented towards the creation of an emotional, multi-sensorial scenario, inside which visitors can feel embodied and involved, able to acquire cultural contents in a pleasant and not frustrating way. We tried to combine science, art and technology, to meet both museums and research needs (Ryan 2001), (Pietroni and Adami 2014).

The *Lucus Feroniae* scenario gave us the occasion to experiment with an innovative combination of languages: virtual reality paradigms, natural interaction interfaces, cinematographic and theatrical techniques, virtual set practices, augmented reality. Such a mix of media aims at creating an experience, stimulating the users' curiosity and motivations, their perceptive and interpretative faculties.

Several evaluations of the user experience inside virtual museums realized over the past years have shown that storytelling and interaction are the main expectations of the public: they want to enter and interact inside stories, personalizing their experience (Pescarin *et al*. 2012; Pietroni *et al*. 2013). However if we place an uninformed visitor in the midst of several hundred choices which presume some prior knowledge of the subject, we only increase the sense of disorientation. He or she will get lost without understanding fully the contents (Antinucci 2007).

Consequently our purpose was to go beyond the traditional paradigms of virtual reality and guide the user through an 'organized' story, offering progressive objectives and stimulus. In this way he does not become disoriented in such a complex world, even if he plays an active role. The need to create a general 'direction' inside the interactive experience led us towards the definition of a new language combining linear and interactive media.

Moreover the placement of the installation inside a museum requires engaging the public for a reasonable time, not too long, with the best communicative and learning impact. Therefore every media has been employed to give its best potentiality. The experience inside each scenario is 5-15 minutes long, the total duration, including all contents, is 45 minutes.

1.1 The case study of Lucus Feroniae

In the archaic age *Lucus Feroniae* was a very important marker in the territory for a famous sanctuary dedicated to the Italic Goddess Feronia, protecting harvest, fertility, health and freed slaves. At that time different populations coming from a wide area all around, Falisci, Capenati, Etruschi, Sabini, Latini, converged to give honour to this Goddess, in her 'lucus' (originally a sacred wood, then evolving into a sanctuary), and occasionally a site for fairs, as this place was a very important emporium as well (Moretti 1974), (AA.VV. 1986).

Dionysius of Halicarnassus *(Roman Antiquities),* Livy (*History of Rome*), Pliny the Elder (*The Natural History*), Vergilius (*Aeneid, Book*), Strabo (*Geography*) and other ancient authors refer to the life of this well-known and rich sanctuary before the Roman occupation and Hannibal's sack in 211 BC.

In the late Republican Roman age it lost its previous status, turning into a simple farming town. It was transformed into a colony in Augustan times and a new monumental urban development took place there. One century later it was restored by Trajan and few new structures were built, among which were the Thermal Baths in the *Forum*, in a place previously occupied by a third *insula* of shops.

During the imperial age the Goddess Feronia was discarded and replaced by Salus Frugifera, with similar characteristics. However her ancient sanctuary was not destroyed by the Romans, it was left outside the area of the new colony, beyond the *Forum*, excluded even from sight by the construction of a high wall.

Feronia's memory remains alive to this day in the surrounding area, echoed by the names of a cinema, a shopping centre, a motorway service area, etc.

In the past years the sanctuary was investigated with partial excavations, directed by Anna Maria Moretti Sgubini, and then re-buried: it is no longer visible today. For this reason we were asked to work on 3D reconstruction of the Roman site, as it might have appeared in the Tiberian and Trajan ages, whose pertinent structures are much more evident for visitors to the archaeological site today.

Fig. 2. Lucus Feroniae implemented in the VR installation. Little images below show the other three scenarios.

The 3D reconstructions that have been realized can be enjoyed not only in the Villa Giulia Museum in Rome, but also in the *Lucus Feroniae* archaeological Museum (as soon as it will be re-opened to the public after restoration), to offer a more immediate contextualization of the artefacts coming from the Roman site nearby.

2 Data gathering, 3D modelling and reconstruction guidelines (D.F.)

Along with an archaeological interpretation of the remains, a detailed topographical and architectural survey has been carried out, aiming at checking and integrating the pre-existing plans, the dimensions of the structures and creating a graphic documentation for the study of the construction phases and building technologies.

In addition, all the data related to the history of the archaeological sites have been gathered adopting a homogenous criterion.

On this basis a 3D reconstruction in Tiberian and Trajan periods has been realized, based on archaeological evidences and comparisons with similar contexts.

The adopted procedure is pretty standard and it will be shortly described, starting from survey and data interpretation, up to 3D modelling.

Survey activities involved Dense Image Matching (IBM) techniques, based on processes allowing a 3D model of an object to be obtained from a series of images.

Aerial images of the entire area were acquired by UAV, a SWINGLET CAM with a Canon IXUS 220HS mounted on board. Agisoft Photoscan software was used to orientate images and extract a dense point cloud, a 3d model and also an orthophoto (Agisoft Photoscan software, 2015), correctly oriented and scaled through the integration of GPS and total laser station coordinates. The orthophoto allowed understanding immediately the disposition of the elements in the whole area (Fig. 3).

Following a similar approach, but using terrestrial images, the most complex architectural elements, such as altars in bas-relief and statues (today preserved in the local museum) were modelled and integrated in the successive reconstruction work of the site (Fig. 4).

Fig. 3. Aerial orthophoto of the archaeological site of Lucus Feroniae (ground sample distance: 10 cm).

The dense polygon models were optimized using 'sculpting' software (Sculptrix). This software allowed a selective polygon decimation to be performed, reducing the density of the geometry where unnecessary. Normal map generation and texture baking were carried out in 3DS Max software (Fig. 5).

After this preliminary survey and once all the sources were compiled, the 3D modelling process began.

To achieve a reliable reconstruction of the archaeological site and its buildings, several types of archaeological and architectural data were investigated and interpreted, with the support of experts from the Archaeological museum of *Lucus Feroniae* and from the Soprintendenza.

First of all, the information regarding the archaeological remains, such as drawings, pictures of the excavations and materials documentation were organized. Technical data were integrated with archaeological data, such as previous publications, bibliographic sources, hypothetical scientific-based reconstructions, etc.

In order to identify the original parts of each building and define what they should have looked like in the different phases (Tiberian and Trajan ages), the hypothetical reconstructions were drawn up comparing the historical and archaeological data and considering the constructive and aesthetic Roman building rules.

The hypotheses, when not supported by actual historical or archaeological sources, were supported by formal rules, construction techniques and Roman modules, or founded on comparative data identified in other buildings and nearby Roman towns (Gross 2001).

The criteria used for the scientific reconstruction workflow and gained during previous research experiences, were adopted as follows (Pescarin *et al*. 2012), (Dell'Unto *et al*. 2013), (Forte 2008), (Medri 2003):

1. Reconstruction by 'archaeological evidences': the reconstruction was based on archaeological incontrovertible evidence (dimension and plan of the buildings).

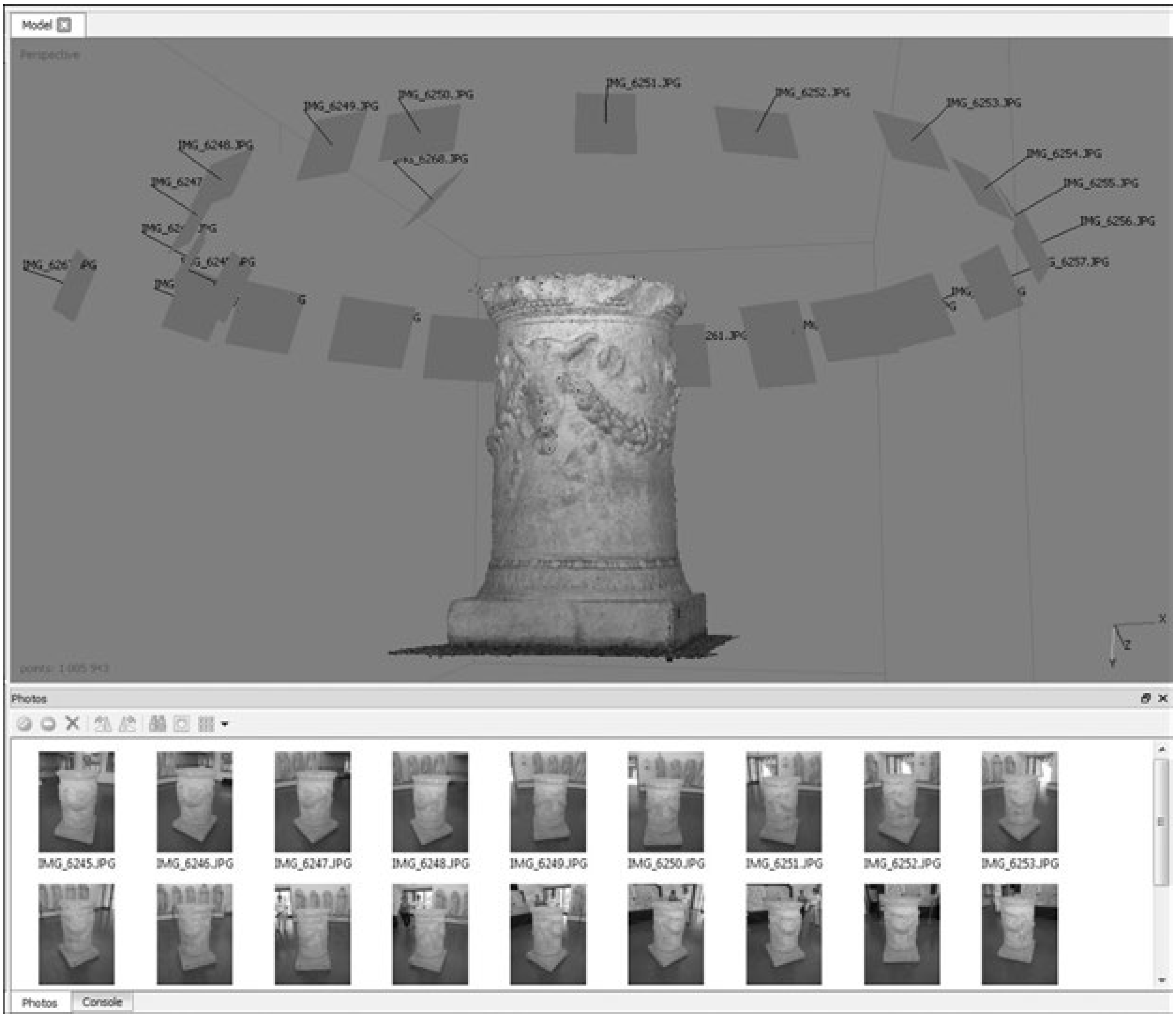

FIG. 4. DENSE POINT CLOUD OF A SURVEYED OBJECT, CREATED USING DIM APPROACH - THE BLUE PANELS REPRESENT THE CAMERA POSITIONS (ABOVE); THE PICTURES USED FOR THE RECONSTRUCTION (BELOW).

2. Reconstruction by 'sources': the reconstruction is based on information found on inscriptions or historical sources (i.e. epigraphs discovered in several altars still present in the *Forum* and the account of foundation made by Plinius in the *Naturalis Historia* (Plinius).

3. Reconstruction by 'analogy': The reconstruction is based on analogy with a well-known and recognizable theoretical model. (i.e. the height of the columns placed in the porch of the *Forum* were calculated based on their diameters according to the canons of Vitruvius).

4. Reconstruction by 'comparisons': The reconstruction is based on direct comparisons with other monuments in the local area in a better state of conservation. For instance for the reconstruction of *tabernae* the most reliable parallels were found in the cities of Minturno, Pompeii and Tivoli. These sites were useful for supplementing historical data, creating a network of comparisons (Ward Perkins, 1974).

5. Reconstruction by 'deduction': although some buildings or architectural elements are incomplete, their complete appearance is deduced by referring to the formal characteristics of the buildings, or to repeated patterns (e.g.: the partial floor of the *Augusteum* was completed by repeating the geometrical pattern of the remaining *opus sectile*; the wooden elements, like doors, were deduced from hinges holes and thresholds).

The computer graphics-based reconstruction was developed using Autodesk 3DStudio Max. 3D modelling work was carried out by using imported 2D plans and profiles derived from archaeological plan and integrated with the ones derived from the aerial orthophoto.

The volumes have been extruded from these construction lines. All the models were unwrapped and mapped with textures designed 'ad hoc', using both an 'in situ' photographic campaign for the existing elements and a 2D digital image processing approach for the missing parts (Fig. 6).

The first 3D drafts were used as a common basis for discussion and analysis of interpretative decisions, and to refine the reconstructive interpretation. This task of the reconstruction

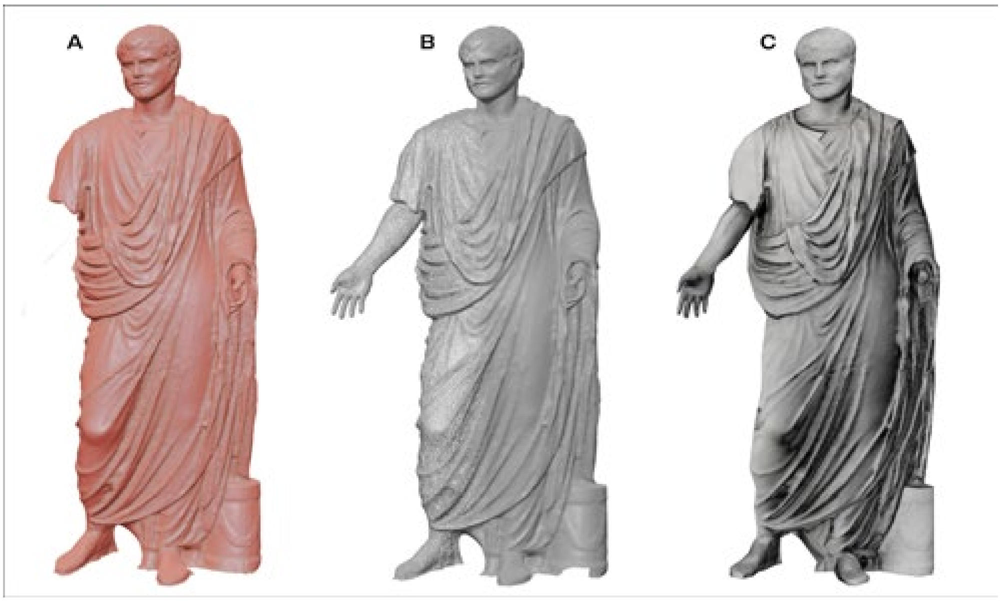

Fig. 5. Optimization workflow - from a scanned model to a RT ready-to-use model: A) scanned model; B) digital restoration of the missing parts; C) polygons decimation and texture baking (diffuse + normal maps).

workflow was crucial in verifying the hypotheses and rejecting those that were proved wrong (Borra 2004).

The 3D models were not only the end result of the work, but also a scientific instrument for interpreting the architectures and understanding better their original shapes. For example, on viewing the first reconstructions of the *Forum*, researchers became aware that the pillars in the south side should have been the basement of the Trajan aqueduct that supplied water to the thermal bath rather than part of a porch. Once the most consistent and reliable hypothesis was established the 3d models were finalised using a low poly modelling approach, particularly useful for the real time output. The small architectural details such as bas reliefs, frieze decoration, roofing, etc., have been described by textures rather than by geometry, allowing better performance in the real time engine, Unity 3D (Fig. 7).

3 Communicative project: design guidelines and implementation (C.R., E.P.)

3.1 Context and condition of implementation: the application in the museum

The consideration of the implementation inside the museum was a fundamental task to help conceive the design of the installation, in order to adapt to visitor experience.

The Virtual reality installation is located in room N31 of the National Etruscan Museum of Villa Giulia, where artefacts related to Faliscans and Capenates are exhibited. These populations lived in the territory north of Rome, along the Tiber River, before the Roman occupation and their stories are told also in the interactive application, thus the integration between museum and virtual contents is quite contextual.

The room has been adapted to host the system; a dedicated, darker, space has been cleared and the installation has been set apart even if, unfortunately, not completely secluded; showcases with artefacts are in the same room.

Visualization extends on three aligned 65-inch screens and contributes to the public's sense of immersion and perceptive involvement; the overall impact is visually very engaging (Fig. 2).

Audio plays a fundamental role in the transmission of storytelling and in the creation, together with visual contents, of a general evocative atmosphere, alternating different registers: emotional, reflective, educational; on occasion the audio style is intimate and contemplative; in other places it is more dynamic because of the multiplication and superimposition of many fragments. Considering the absence of crowding, the compromise to integrate the installation within the surrounding space of the room is perfectly satisfactory.

3.2 Gesture-based interaction design

In the four scenarios of this installation the public has the possibility to explore the 3D space without any traditional input interfaces based on windows, icons, menus and pointing devices (Kurtenbach and Hulteen 1990; Turk 2002). The interaction is possible using simple and natural gestures of the body, standing on a specific 'hotspot' on the floor, in the interactive area in front of the projection.

Mid-air gesture-based interaction constitutes a new paradigm in human-machine interaction; it allows an enhancement of the sense of embodiment and presence inside the virtual world (Featherstone and Burrows, 1995) and this embodiment constitutes a new frontier of the communication and learning processes (Morris *et al*. 2010; Varela *et al*. 1991; Pietroni 2013). In this application gesture-based interaction is implemented through a simple, low cost and standardized sensor, a depth camera, such as Microsoft Kinect (first generation) that that does not require the user to wear any marker and does not

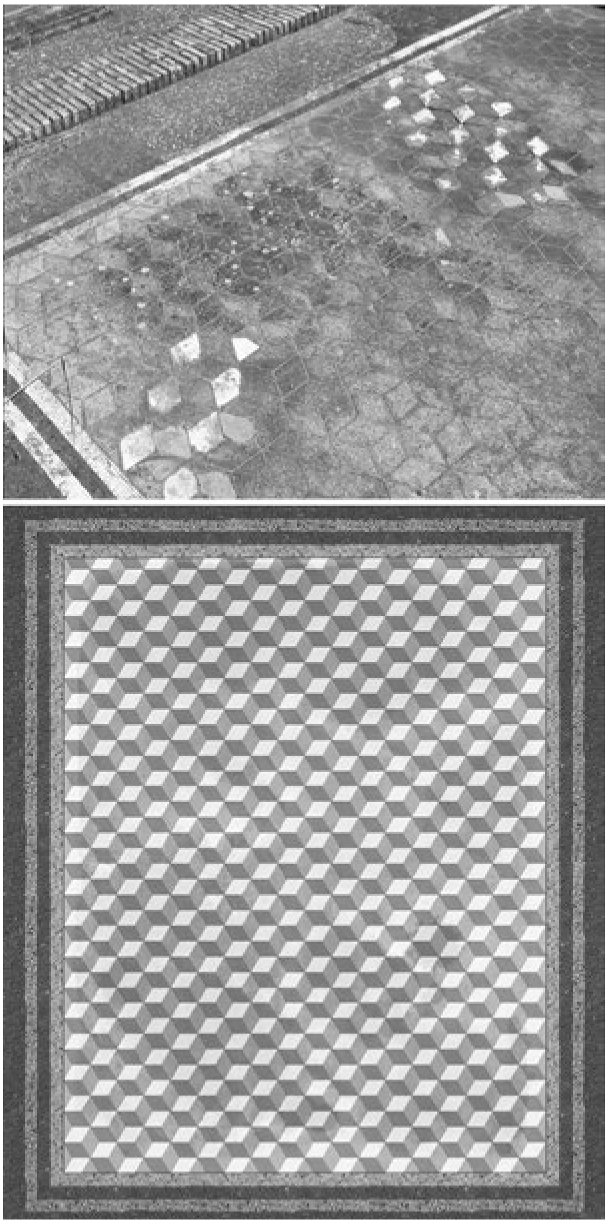

Fig. 6. Remains of the floor of the *Augusteum* characterised by a geometric decoration in *opus sectile* (left) and its digital restoration (right).

Fig. 7. 3D model of the so-called Basilica (solid and textured model).

Fig. 8. VR installation in Villa Giulia Museum, hotspots on the floor and User Graphic Interface, (scene of Volusii's Villa) .

need expensive licenses to operate. Its *frustrum* is about 4.5m (Microsoft Kinect 2015).

The application is single user, this means that one person at a time can enter the interactive area (a space about 3 x 3.5m). Other people can stay in the space all around looking at the virtual contents, the users can alternate continuously in the active role – no calibration is required.

The GUI (graphic user interface) is extremely simple and clear. Four coloured circles on the floor are used to activate the scenarios. The user can change scenario at will, walking and standing on one of these four coloured circles on the floor. Once a scenario is selected, the user is invited to move onto the central yellow circles to perform a range of gestures to explore the 3D environment.

The GUI on the ground is replicated on the screen. Moreover the blue silhouette of a figure is always present bottom right on the central screen, suggesting to the user the gestures available with which to explore the virtual scenario selected (Fig. 8).

The range of gestures is simple (Pescarin *et al*. 2013). In some cases the movements are very natural, like swimming or flying (underwater and aerial scenarios), in some other case, as with *Lucus Feroniae*, we needed to use gestures in a symbolic way, to simulate the action of walking and looking around. In these cases the gesture of the arms simply indicates the direction along which to move. For *Lucus Feroniae*, however, the user is not required to be as interactive. The scenario in fact has a more cinematographic approach and we wanted to keep this delicate balance. Basically the visitor is guided along predefined camera paths and only at specific points are arms used to interact in real time, as with, for example, the scenes of panoramas and crossroads.

3.3 Storytelling (A.P., E.P.)

In this application storytelling does not consist of simple descriptions (as in *Wikipedia* or *Google Earth*), on the contrary it is based on literary quotes, texts from ancient and modern authors, and the use of imaginary but plausible characters whose sequences happen on an historical background, as in the case of the *Lucus Feroniae* scenario.

Here the narrative structure has been carefully designed and implemented according to specific needs.

The user enters the city of *Lucus* as a real wanderer would: the narrative is delivered by common people involved in every-day activities who can be met in the streets, in the *Basilica*, in the shops of the *Forum* or in the baths. Through their personal stories and habits, the historical and cultural background of the site is transmitted, together with the topography of the city and the function of the main buildings.

Such an approach fits well with the specific category of narratives drawn by Umberto Eco in its classification of historical storytelling: '*the past must be recognizable but there is no need of real (famous) personages, as common people make us understand everyday life and their behaviour tells us much more, on their time, than history books can*' (Eco 1983).

For such a purpose a *multi-strand* storytelling structure was created (Truby 2007), in which different independent storylines flow and intersect each other as the traveller gets in contact with them. The characters refer both to common narrative archetypes adapted to the specific context (the countryman, the well-educated person coming from abroad, the shopkeeper, the goddess) or to generic people (men, women, children) who fit a momentary contextual need.

Even if in Tiberian times *Feronia* worship had been discarded, storytelling techniques were adopted to go back in time and evoke Feronia's memory, to whom the deep identity of the place and most of its importance is connected. A more symbolic and evocative stylistic register has been created for this purpose. In our story Feronia reveals herself only to the little child Cesia, who is the only one in the Roman town able to see her. A special relationship is established between the two. Feronia reveals to Cesia her ancient powers and gives her a present: through magic she reveals, just for one day, how the Tiberian city will look in 100 years' time, during the later Trajan age.

Thus, even if the contemporary events happen in the Tiberian age (for which we have more archaeological evidence), the user is brought back and forward in time, experiencing the evolution of the place through a longer timeline.

3.4 Visualization techniques in Unity 3D and general direction (M.F., E.P.)

During the early stages of production in the Unity 3D graphic engine, particular attention has been devoted to the research of graphics solutions capable not only of transmitting historical and scientific information, but also of creating powerful visual moods on several fronts that amplify the degree of usability and involvement for the public. This purpose has been reflected in the management of some major tasks and strategic choices: the creation of a style for camera activity, the distribution of visual digital contents on the three screens, the lighting setup for the 3D environments, the use of effects and filters able to develop the final appearance of the images.

3.4.1 Camera activity and direction

As in the other three scenarios implemented for this installation, the general atmosphere of the virtual reconstruction of the ancient Roman city of *Lucus Feroniae* is very evocative and immersive. The space is quite large, but it is quite patchy in terms of density of information and architectonical detail. For instance we have the *Forum* that is rather empty while information and storytelling are concentrated in specific areas: a shop, the basilica, the *Augusteum*, the thermal baths of the *Forum*.

For this reason we evaluated the opportunity to guide the user along the real time exploration towards those specific targets, and trying not to get the viewer lost or disoriented.

Moreover we needed to limit the duration of the experience inside this scenario to twelve minutes maximum, taking into account the whole context of the application that is composed of four scenarios.

In addition we wanted to strengthen the use of theatrical and cinematographic techniques to experiment their expressive potentiality inside a virtual reality environment. The use of real actors instead of 3D characters follows this approach.

On the contrary, in the other two scenarios, underwater and aerial, the user is completely free to move in every direction without constraints, as in more traditional VR environments. In those cases such freedom is justified by a more de-structured storytelling technique (short poetic fragments randomly flowing, in the case of the underwater scenario) or by the extent of the space and metaphor of interaction (flying, swimming).

Given these premises, for those scenarios characterized by more structured narration (*Lucus Feroniae* is one of the cases), our decision was to make the virtual camera move along predefined paths. The camera simulates the movements of a steadicam, according to a cinematographic style. The user is conducted towards the main contents: he or she only needs to stand on a specific hotspot on the floor to which the function 'move forward' is associated and he is brought along to visit the site. These camera paths head the user along the streets of *Lucus*, the buildings and rooms, up to the narrative areas where he can meet the ancient Roman personages in conversation with each other. A narrative area includes one or two narrative fragments, each one lasting about 20-50 seconds. In the scenario we have four narrative areas (*Forum, Basilica*, shop, thermal baths) and a total of seven narrative fragments.

Users still have two possibilities of free choice:

1. On specific points of the path, they can explore interactive panoramas (see the relevant paragraph below).

2. Along the path they come to some crossroads and can choose a direction: one direction leads to the main characters and the user can listen to their story; in the other direction the user can skip the story and go on, along the exploration path, towards the next narrative point.

3.4.2 Distribution of visual contents on the three screens: an 'augmented' perception

The three aligned screens are used to let the user visualize the archaeological site as it is today and, in parallel, the reconstructed context as seen from the same perspective.

The actual space is presented on the left screen through a sequence of photographs, changing every few seconds. Their flow is synchronized and aligned with the predefined camera paths in the virtual reconstruction of the site that is projected on the central screen. This means that during the movements in real time the images show the site from points of view that have a correspondence also with the animated 3D reconstruction. We could have used animation also in the left screen, making a video in the actual site as well, and using camera tracking techniques to align the two visualizations. However this would have required a large amount of extra work without creating much in the way of added value.

As mentioned above, at specific points along the camera path the user meets interactive panoramas. Here the viewer's eyes can rotate interactively using the arms. In this case the two aligned panoramas, real and virtual, on the two screens, will rotate simultaneously according to this input by the viewer.

In this way the visitor can live an 'augmented' experience of perception and comprehension of the site, continuously comparing the real and virtual on the two screens (Fig. 9).

On the third screen, on the right, the 3D reconstruction of the site is shown through a direction of cameras looking at the site from a greater distance, in perspective view, in order to contextualize the position reached by the user along his exploration: while the two visualizations on the left and on the middle screens are in the first person, this last one, on the right, is in the third person.

When the user is led to the narrative area, the story and performance of the characters of *Lucus* start, and in this case the visualization on the three screens shows no longer three different scenes (as it does during the exploration) but a unique viewport that extends over three screens ('cinema-like' visualization). This solution favours a more powerful sense of presence and immersion for the user within the story.

3.4.3 Lighting the virtual environment

The techniques used to illuminate *Lucus Feroniae* reconstructed in Tiberian and Trajan times have been borrowed from the traditional methods usually employed for 3D rendering. Thanks to the expedient of *LightMapping*, real-time scenarios are pre-processed with the means of lighting typical of conventional global illumination (with marked preference for photorealism), but then drawn to the screen with the same agility of a scenario exempt from the calculation bounces of light. Thanks to this technique we are able to focus on the aspects related to the behaviour of direct light (sunlight) as well as the behaviour of diffused light (mainly by scattering the blue component of sunlight).

The lighting setup and *LightMapping* were aimed at creating a realistic setting, visually rich and deep, because of gradient data from the decays of indirect light but chromatically neutral;

Fig. 9. Augmented experience in *Lucus Feroniae* scenario.

they constitute a base layer for optimal coupling of the third stage of work: the setting of the image effects of the camera.

3.4.4 Image effects

Post production and colour manipulation strategy are largely consolidated in the cinematographic and theatrical domains. *Colour correction* effects, provided in real-time by the graphic engine (Unity 3D), are used to give rich colour tones to the virtual construction, creating an enchanting and evocative atmosphere. Our goal is a powerful visual storytelling. In fact we wanted to evoke rather than merely describe.

Through colour we are able to establish a particular atmosphere for our virtual environment. Colour is meant to tell a story to users even before they hear a single word from the spoken narration.

Another relevant image effect used on the *Lucus Feroniae* scenario is real-time *Tonemapping*. Using *Tonemappin*g we can control the camera exposure and the behaviour of mid-tonal light. In this way we can decide whether to generate generous mid tones for clean air atmosphere, or strong contrast and dense shadows for darker and more mysterious atmospheres. *Vignetting* effect is used to give additional depth to the image; *Bloom* effect is used to produce evocative light halos extending from the borders of bright areas of the objects. *Sun Shaft* filter uses the '*God rays*' effect from sunlight (Fig. 10).

3.5 Virtual set and theatrical paradigms in the Lucus **storytelling (C.R., E.P.)**

Characters in the *Lucus Feroniae* scenario are not in 3D, but they are real actors shot in a virtual set while performing in front of a green screen. The video shoots have been realized in Raw format with a Blackmagic Cinema Camera and have been filtered and balanced in terms of light and colour to be matched within the 3d environment. Then through *chroma key* techniques the green background has been made transparent and the actors have been integrated within virtual space in real time (Fig. 11).

In effect, even if a virtual set is commonly used for cinematographic productions, the final result obtained in the *Lucus* scenario is something closer to theatrical than cinematographic paradigms.

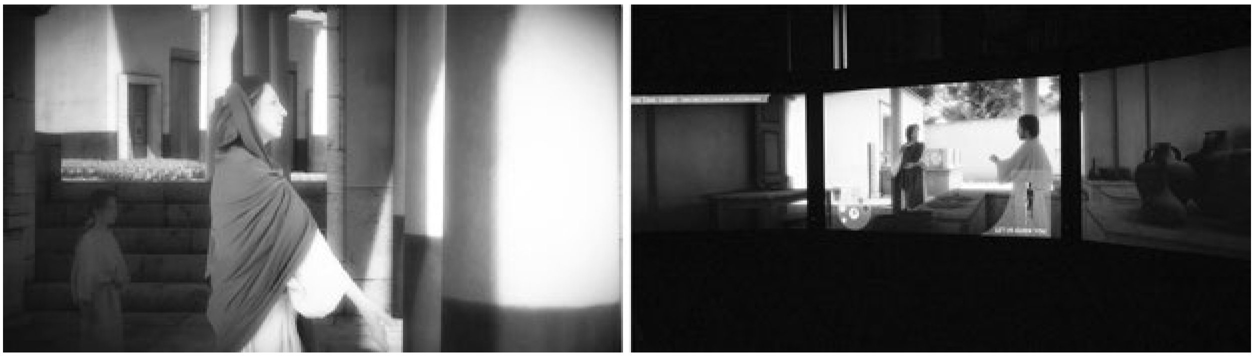

Fig. 10. Virtual reconstruction of *Lucus Feroniae*, final result of the render in Unity 3D.

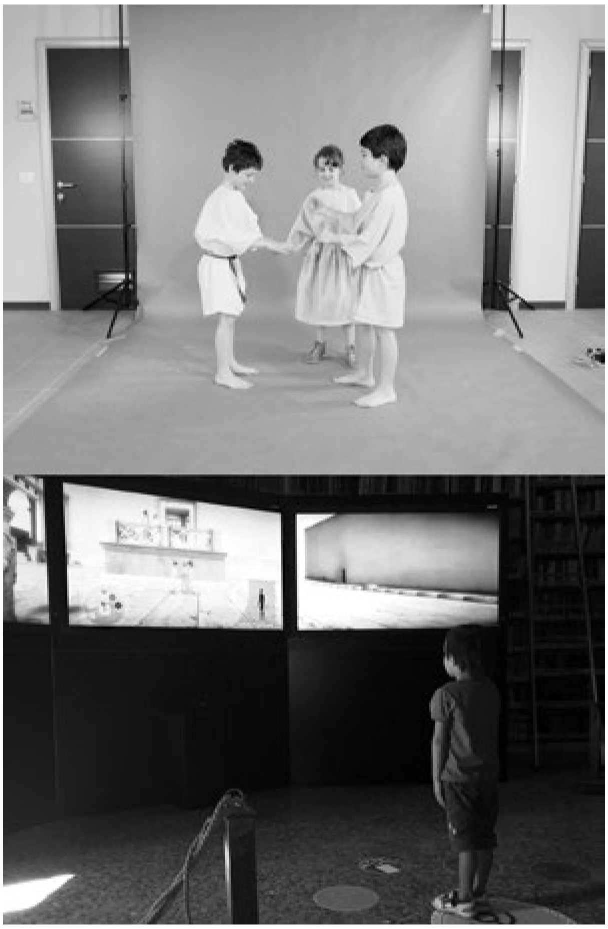

Fig. 11. Virtual set with real actors performing the ancient characters living in *Lucus Feroniae*.

Proximity to theatrical language in this scenario comes from:

1. *Unity of time:* actions develop in a unique moment. The same Goddess Feronia (that was venerated before the Romans, in the archaic period) reveals herself in the Roman age, and when she evokes past time she can only describe it with words, no journey back in time is shown with images. The only time travel that has been represented is the passage from the Tiberian to the Trajan phase (100 years later), and it is made possible by the magic performed of Feronia: in this case part of the 3D model of the city disappears under the floor and new buildings appear, coming up from the same point of the floor. This is a typical theatrical technique.

2. *Use of non photorealistic colours*: the 3D environment, even if very sophisticated in terms of rendering quality, is deliberately false and no realism is attempted. The general grading of the light is red and does not change during the whole experience within the scenario. This condition recalls those theatrical directions where similar lighting effects are very common.

3. *Camera direction during dialogues*: the camera is fixed, looking at the actors, with few and small movements and different from what happens in films. For this reason a small green screen was sufficient to obtain good results. A larger virtual set would have been needed to multiply and vary the perspective during the dialogues.

4. *Recitation style of the physical actors*: their movements, facial expressions, gestures and rhetoric are derived from the theatrical repertoire.

Cinematographic techniques are achieved by camera movements during the exploration of the space, as a virtual steadicam has been created to move from one narrative area to another. The combination of different languages, together with image effects and soundscape, creates something new, never seen before by the public; the results are strange and attractive.

4 Conclusions (E.P.)

The *Tiber Valley Virtual Museum* is an interdisciplinary project aimed at the creation of an effective and involving communication so as to encourage visitors to the region north of Rome and enhance the awareness of its cultural identity (Antinucci 2007). It has been conceived as a digital ecosystem integrating different scenarios and levels of visualization, multi-layered models, storytelling, tools of visualization and interaction, in order to create a performative space where all the information is connected (Varela *et al*. 1991; Cameron and Kenderdine 2007). Every scenario has its own characteristics and atmosphere but together they compose an harmonic ‘whole’.

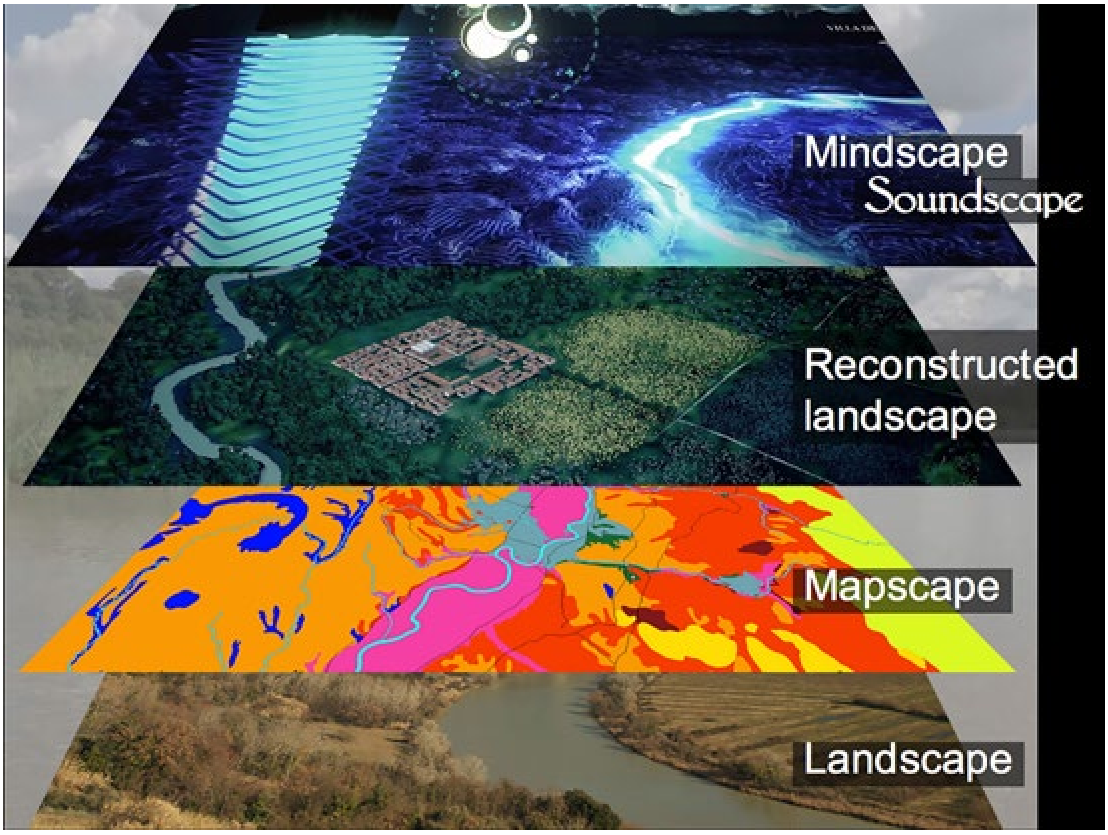

FIG. 12. 'TIBER VALLEY VIRTUAL MUSEUM', DIFFERENT LEVELS OF REPRESENTATION OF THE CULTURAL LANDSCAPE.

The integration of b*ottom-up* and *top-down* approaches (Forte, 2008) supported the representation of the territorial context in its diachronic evolution and at different scales of resolution: from the holistic vision of the landscape up to the monographic representation, focusing on specific sites. Among them is included the ancient Roman town of *Lucus Feroniae*, which has been the specific topic of this paper.

The observable archaeological landscape, that was the starting point of documentation and interpretative processes (*map-scape*), continuously alternates with the potential reconstructions of its past phases of life (*reconstructed landscape*) and imaginary dimensions (*mind-scape*) (Fig. 12).

In this way the learning process is greatly fostered by redundancy and variation (Bateson 1979).

A suggestive installation with gesture-based interaction has been developed and presented in the Villa Giulia Museum in Rome, where the user can experience four different scenarios, migrating through different avatars. The design of the *Lucus* scenario has been described in detail to give a clear idea of how the communication has been conceived and developed, depending on the progress made inside the museum.

The *Lucus Feroniae* scenario is a dynamic space that includes not only real objects (3D models of buildings, streets, fountains, trees, etc.) but also stories and relations, where the user can perform activities and create a 'visual drama' beyond what he can see, and thus experience an empathic evaluation of the context.

Both in the general design and in the detailed implementation of the application, great importance has been given to the emotional involvement and aesthetic impact as essential parts of the experience, since they partly determine the sense of presence within the virtual environment. The beauty of the graphics, the music and sounds, the evocative style of the script, the interaction design based on body gestures offer the users the opportunity to feel alive, partakers in the magical dimension taking place. This all immediately translates into an improved educational experience.

The need to create an involving storyline led us towards a new communicative approach, going beyond the traditional paradigms of virtual reality. Narration, in fact, requires a 'direction' that implies script, image effect, atmosphere, camera animations, soundscape (Ryan 2001; Pietroni and Adami 2014). Predefined camera paths have been created to prevent the user from disorientation and to preserve the 'metaphysical' dimensions of the experience; however a certain degree of freedom for the user has been kept in the exploration of the 3D space, as in the 'augmented' panoramas and the choices at the 'crossroads'. This strange convergence of media, the magical atmosphere generated by the image effects and the story itself are immediately perceived by the public (particularly by children) as innovative and highly attractive.

On the occasion of the expo in Laval *Virtual/ReVolution*, where the application was presented in April 2015, the user experience was seen for the first time, although in a very crowded context and far from ideal conditions. A new and closer evaluation was carried out in the Villa Giulia Museum, the final destination of the application, both on active users and observers (120 viewers in total) to verify the attractiveness, usability and educational impact of the system. In both cases the results were very promising and extremely useful in terms of understanding whether the outcome matches the creators' expectations, and what are the strengths and weaknesses of the application. The amounts of data collected are huge and multi-layered and the final reports are near completion and publication.

Acknowledgments

Special thanks to our colleagues from CNR ITABC and to the Institutions who supported the project: Arcus S.p.A., Direzione Regionale per i Beni Culturali e Paesaggistici del Lazio, Soprintendenza per i Beni Archeologici dell'Etruria Meridionale, Società Geografica Italiana.

Design, contents and software development are by CNR ITABC, E.V.O.CA. srl. The general design was conceived in collaboration with Franz Fischnaller (F.A.B.R.I.CATORS).

Bibliography

AA.VV. 1986. Tevere: un'antica via per il Mediterraneo, Roma.

Antinucci, F. 2011. P*arola e immaginie, storia di due tecnologie.* Roma, Laterza.

Antinucci, F. 2007. *Musei Virtuali.* Roma, Laterza.

Arnoldus-Huyzendveld, A., Di Ioia, M., Ferdani, D., Palombini, A., Sanna, V., Zanni, S., Pietroni, E. 2012. The Virtual Museum of the Tiber Valley Project. In *Virtual Archaeology Review* 3, 7: 97-101.

Bateson, G. 1979. *Mind and Nature: A Necessary Unit*, New York, Dutton.

Borra, D. 2004. Sulla verità del modello 3D. Un metodo per comunicare la validità dell'anastilosi virtuale. In *Proceeding of eArcom 04, Tecnologie per comunicare l'architettura, Ancona 20-22 maggio 2004*: 132-7. CLUA edizioni.

Dell'Unto, N., Leander, A. M., Dellepiane, M., Ferdani, D., Callieri, M., Lindgren, S. 2013. Digital reconstruction and visualization in archaeology. Case-study drawn from the work of the Swedish Pompeii Project, in A. C. Edison, G. Guidi, S. Pescarin, L. De Luca (eds.), *Proceeding of the 2013 Digital Heritage International Congress*, Marsiglia 28 ottobre-2 novembre 2013, 1: 621-8. IEEE Computer Society.

Eco, U. 1983. Postille al Nome della Rosa. In *Alfabeta,* 49. Milano, Cooperativa Alfabeta.

Featherstone, M., Burrows, R. 1995. Cultures of technological embodiment: an introduction. In M. Featherstone, R. Burrows (eds.), *Cyberspace, Cyberbodies, Cyberpunk: Cultures of Technological Embodiment*: 1-19. Thousand Oaks (CA), Sage Publications.

Forte, M. (ed.) 2008. *La Villa di Livia. Un percorso di ricerca di archeologia Virtuale*, Rome, L'erma di Bretschneider.

Kurtenbach, G., Hulteen, E. 1990. Gestures in Human-Computer Communications. In B. Laurel (ed.), *The Art of Human Computer Interface Design*: 309-17. Reading (MA), Addison-Wesley.

Medri, M. 2003. *Manuale di rilievo archeologico*. Roma, Laterza.

Moretti Sgubini, A. 1974. *Lucus Feroniae: centro di incontro sul Tevere, in Civiltà arcaica dei Sabini nella valle del Tevere*, Roma.

Morris, M. R., Wobbrock, J. O., Wilson, A. D. 2010. Understanding Users' Preferences for Surface Gestures. In Proceedings of Graphics Interface 2010, Ottawa, Ontario, 31 may – 2 june, 2010: 261-8. Toronto (Ontario), Canadian Information Processing Society.

Pescarin, S., Fanini, B., Ferdani, D., Lucci Baldassari, G. 2012. Archeologia Virtuale a Montegrotto. In M. Bassani, M. Bressan, F. Ghedini (eds.), *Aquae Pataviane. Montegrotto Terme ed il termalismo in Italia. Aggiornamenti e nuove prospettive di valorizzazione*: 309-326. Padova.

Pescarin,, S., Pietroni E., Wallergard, M., Omar, K., Rufa, C., Rescic, L. 2013. NICH: a preliminary theoretical study on Natural Interaction applied to Cultural Heritage contexts. In *Proceedings of Digital Heritage International Congress,* IEEE Advanced Technology of Humanity 1: 355- 62.

Pietroni, E. 2013. Natural Interaction in VR environments for Cultural Heritage: the virtual reconstruction of the Regolini Galassi Tomb in Cerveteri. In *Archeologia e Calcolatori* 24: 231-48. Sesto Fiorentino (FI), All'Insegna del Giglio.

Pietroni, E., Adami, A. 2014. Interacting with virtual reconstructions in museums: the Etruscanning project. In *Journal on Computing and Cultural Heritage* '*Interacting with the past'* 7, 9.1-29. New York, ACM

Pietroni, E., Palombini, A, Di Ioia, M., Sanna, V., Arnoldus-Huyzendveld, A. 2013. Tiber Valley Virtual Museum: 3D landscape reconstruction in the orientalising period, North of Rome: A methodological approach proposal. In *Proceedings of Digital Heritage International Congress, 28 October - 1 November 2013*, 2: 223-30. Doi: 10.1109/ DigitalHeritage.2013.6744758

Gross, P. 2001. *L'architettura romana. Dagli inizi del III secolo a. C. alla fine dell'alto impero. I monumenti pubblici*, Milano, Longanesi.

Ryan, M. L. 2001. Narrative as Virtual Reality: Immersion and Interactivity. In *Literature and Electronic Media*. Baltimore and London, Johns Hopkins University press.

Truby, J. 2007. *Anatomy of a story*. London, Faber and Faber.

Turk, M. 2002. Gesture Recognition. In K. M. Stanney (ed.), *Handbook of Virtual Environments*: 223–37. London, Lawrence Erlbaum Associates.

Varela, F., Thompson, E., Rosh, E. 1991. *The embodied Mind. Cognitive Science and Human Experience.* Cambridge, MIT Press.

Ward Perkins, J. B. 1974. *Architettura romana*, Milano, Mondadori Electa.