An Integrated Approach to Archaeology: From the Fieldwork to Virtual Reality Systems

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Abstract. Since 1999 the CNR ITABC (Institute of Technologies Applied to Cultural Heritage) with its Virtual Heritage Lab (VHLab) is involved in the research of an integrated methodology to acquire, elaborate and visualize archaeological landscape, through virtual reality systems. The paper describes the methodological approach followed by the interdisciplinary team of CNR ITABC and Rome Municipal Superintendence in the case study of the Appia Park project (the archaeological park of the Roman Via Appia). Two different types of survey will be described (topographical and architectonic mapping and "micro-topographical" and "micro-architectonic" mapping) which were used to acquire data in real time and directly on the field. Different techniques of data acquisition will be discussed at the same time: Differential Real Time GPS, Total Laser Station, 3D Scanner Laser, 3D Stereo Photogrammetry, Photo Modeling Techniques. All these techniques were used in an integrated way, while the entire set of data acquired was post-processed, overlaid in a GIS project based on their spatial reference, connected with external multimedia databases. Even 3D information was geo-located and processed in order to be used - together with GIS data, Digital Terrain Models and Geoimages - inside a Desktop Virtual Reality environment. The project, through the Appia Antica case study, is demonstrating that the use of integrated technologies and the combination of different typological data is extremely useful in order to manage archaeological information inside GIS and Virtual Reality Systems, in a 3dimensional, interactive and flexible way. At the same time, the approach described can be easily 'scaled' and used even for cultural content dissemination, at different level, without loosing any scientific precision. Thanks to the methodological approach followed, it's possible to create interdisciplinary teams that can work together sharing information and data. Moreover the project's goal, stressed by the paper, is the creation of a VR-System that can be used as a permanent spatial archive of digital monumental patrimony acquired, but also as a virtual museum of the landscape in its different diachronic phases.
Keywords: virtual heritage, mindscape, landscape reconstruction

1. Introduction and Definitions

The last decade revolution on digital technologies has pointed out mainly the technological opportunities more than the informative and communicative ones. In the field of virtual heritage the risk was (and is even now) to consider just the sense of wander and the aesthetical potential, despite the informative and narrative feedback that can be created within the virtual worlds. The ontology of the Virtual is a crucial issue: how can we communicate it? Who can use it? What is the economical impact of a virtual system? How can we process this kind of interactive information?
In our opinion, the real value of virtual reality systems, applied to cultural heritage, is their incredible faculty of changing the way to approach contents and to learn/teach cultural information. We can say that the Virtual communicates, while the user learns and creates new information.
These are the reasons why part of the effort of our team's work in the last years, was dedicated to the creation of a digital protocol for the Reconstruction of Historical and Archaeological Landscapes. This protocol was elaborated and tested, until a satisfactory starting-result was undertaken. With this protocol we can manage Cultural Heritage (in a wide sense) from the fieldwork to the Virtual Reality environment, embracing older and newer data in the same 3D spatial environment of interaction.
The protocol is oriented toward the recording of data, their conservation finalised to avoid the loosing of any information, and the management of all these data. In this process mapping is considered a crucial activity, not only for the classification, but also for the study, the interpretation and the communication of Cultural Heritage.
Today, indeed, in many parts of the world the methodological approach of archaeological research is digital. The amount of information is grown so much, in different phases of processing, that the real risk is to lose this information and, most of all, to lose relations, connections and interpretations between different ontology of data. The risk to lose spatial correlations is high even because multiple digital domains are considered and treated as totally separated: GIS, remote sensing, intra-site data, excavation maps, 3d models, virtual reconstructions. Additionally, the comprehension of the archaeological landscape has to consider even ethno-anthropological factors, mind perceptions, cybernetic maps; we define this direction of research "mindscape" (Forte, 2003). According to this view, the landscape becomes a self-organized system, interpretable in terms of complexity. For this reason we think that we have to consider a wider domain, including Virtual Reality and digital simulation technologies.
Virtual Reality systems, created in transparent ways and within interconnected processes, can really help to solve many of the problems mentioned and to facilitate the transmission of con-

tents. In fact, from a global point of view, we are dealing not only with acquisition of data, but most of all with questions of "cultural transmission", and only secondly with technological problems. We are facing today a problem of cultural diffusion through digital technologies. Even for this reason we should think of systems able to create and "to manage differences".
According to a cybernetic approach of the Bateson's thought we learn through the difference: the difference represents the continuous interaction between us and the ecosystem, between us and the relations we produce with surrounding environment (Bateson, 1972). Receiving and processing information means to acquire always new differences. The Bateson's theory of knowledge explains the mechanism of information processing: data are neutral objects, the knowledge of a spatial system is by interaction, by the difference between components and inter-connected events. The more the difference is increased in a virtual interaction, the more the learning grows up.
In a virtual reality system, learning activities follow informative geometries of reticular types, namely the user is immersed within networks of information and visual data (Forte et alii, 2001). Inside a VR system we learn through feedbacks received by the digital ecosystem itself and through actions, inter-actions and reactions. To understand contents in a more immediate ways, we need to "be involved", to perceive thanks to the interaction or, better, to an exchange of behaviours between action and reception; in this field one can identifies multiple levels of interaction in real time (Forte, 2000).
For these reasons we think that an ecological approach to virtual reality represents a possible challenge for the future of culture (and content) transmission. Virtual represents a complex of relations, the virtual translation of heritage is explainable according to a connectivity of information creating a system. Epistemological discussion would seem apparently a theoretical speculation but, on the contrary, is fundamental for projecting and communicating the virtual and for understanding the relations between digital ecosystems and cultural heritage. The real challenge will be the increasing of interactions, behaviours and interactivity in new evolved and open systems (VR Systems).
What we are observing even today is a gradual change in the way culture is transmitted. In the next future we can easily imaging how every kind of traditional (linear) transmission of cultural information will be completely integrated by different systems (non linear). Interactivity is already changing the approach, even in our everyday life (see digital TV, for instance). These kinds of systems are extremely complex because they manage complex information and because they are related to our brain, the way we perceive the word, the way we elaborate data and we transform it into new information. That's why these systems need to be studied by interdisciplinary teams and not just by technicians or computer scientists. We don't have only a problem of data rate. We need to change even our approach to the research, learning how to create and to work really inside interdisciplinary and international teams, that could study from different points of view the process of memory transmission, considering even fields that today are felt as completely apart, such as Neurological and Visual Sciences.

1.1 Digital Protocol for the Reconstruction of Historical and Archaeological Landscapes

In this phase of Virtual Heritage and computer application to Cultural Heritage we don't believe that the answer to the problems above mentioned is standardization. We prefer to talk of process and protocol instead, because in this way we can deal with the methodological approach to the issue "landscape reconstruction", leaving the researchers groups free to follow new and different roads. We need to pay attention to common or exchange file formats if we want to let our applications evolving with times and teams.
What we would like to propose here is a protocol that explain which is the process that allow to work from the fieldworks directly to virtual reality applications, through the integration and mutual exchange of methods, techniques, technologies and skills (see fig1a and Fig 1b). In the process all the information is kept, processed, elaborated, interpreted (and not just in one way) and communicated. Different data and sources (commonly used data, such as aerial photos, satellite images, historical maps, excavation plans or stratigraphies, but also digital data acquired with DGPS, Total Station,

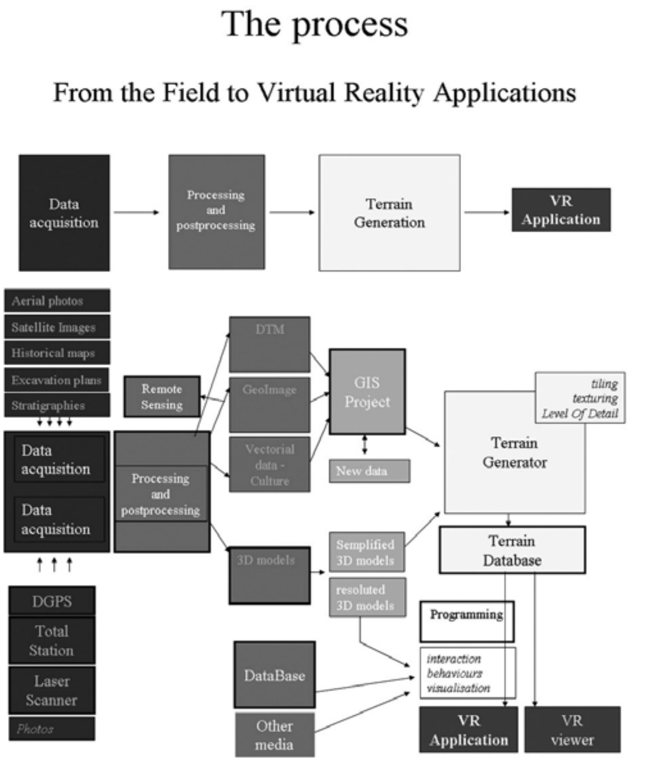


Fig. 1a–1b. The process of creation of a virtual reality system through the integration of data and methodologies.

Scanner Laser and so on) are processed and integrated in a GIS project and in Relational Databases. Existing structures are modeled at different scales and other media (audio, video, html, etc) as well are integrated in the databases.
A Terrain Generator is used to processed GIS data. Raster and vectorial information become thematic layers of the landscape. A terrain generator is fundamental to maintain geographical and spatial information of the data, on one side, while, on the other side, it is used to tile, texture and create

levels of detail of the models of the landscape we intend to generate in 3D and to navigate in real time[1]. 3D models, vegetations, 3d menu are added as instances inside the terrain generator or they can be added later, editing the tiles of the terrain with a 3d modeler. The landscape can be now explored in real time with a VR viewer (there are even free viewer available, such as CG2 Audition).
What we think the real value of such applications is the possibility to interact with the models in a transparent way, querying and analyzing data. Just a VR application, whose realization implies in most of the cases some programming activities, allows this kind of interactions. There are also new kind of tools that allow, without programming, to introduce even complex behaviours in the VR application, such as Virtools[2].

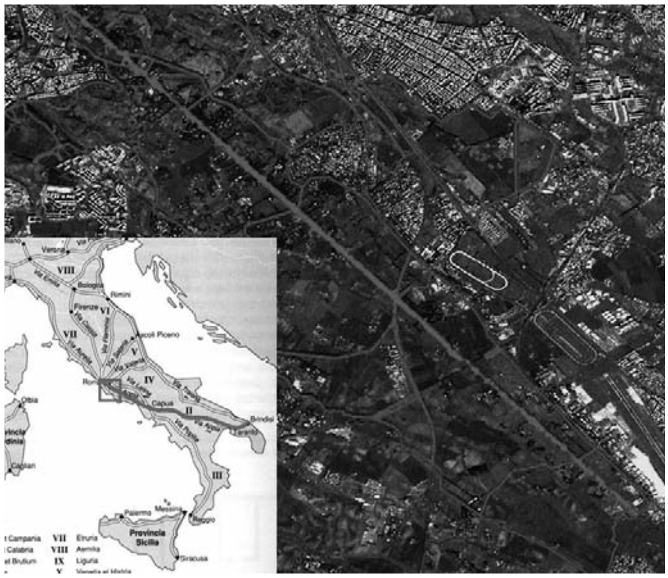


Fig. 2. The area of the Appia Antica archaeological Park.

2. The Appia Antica Project: Goals and Technology

The protocol explained above has being tested by the team in a very complex project. The Appia Antica Project started in 2002 with the founding of "Rome Capital" and with the support of the Archaeological Municipal Superintendence. The project will last four years and will see the partnership of public institutions such as the Municipal Superintendence itself, under the guidelines of Dr. Sassodelia and Dr. Mucci, the Institute of Technologies Applied to Cultural Heritage of the National Council of Researches (CNR ITABC), under the direction of Dr. Forte and Dr. Salonia, the National Archaeological Superintendence and with the partnership of hardware and software house such as Leica Geosystem. The project is aimed to obtain a complex and digital database of all the monuments of the entire park of the ancient Via Appia: topographical and architectonic surveys, GIS and complete documentation of monuments and sites.
The area is quite large: more than 3000 hectare. More of a thousand archaeological structures are inside the park (1/5th of all the monuments of the entire Province of Rome) (Fig. 2). In the territory there are very relevant complexes such as San Sebastian Gate (Porta San Sebastiano); the Caffarella Park, were there was during Roman times the huge villa of Erode Atticus, with its beautiful Ninphaeum of Egeria, still visible; and also many catacombs; the circus and Villa of Massentius; the Quintili Villa and many funeral monuments of different kinds and dimensions, all disposed along the ancient Via Appia, regina viarum as it was called, since it was one of the most known and used road of ancient Roman world, connecting Rome with Brindisium. There are also Medieval towers and remains dating to different period up to nowadays. After a long period of savage "urban aggression", building abuses, landscape alteration, scarce protection of the environment, a regional park is now protecting all these monuments, many of them are no more visible, because covered, destroyed, included inside private residences (Fig. 3).
For all this reasons is very important to carry on a complete a continuous survey of the entire territory, recording digitally, as accurately as possible, all the monuments and connecting them spatially in a GIS and with relational databases. Part of the effort of CNR ITABC team, conducted by Maurizio Forte, is directed in particular to the creation of a 3D spatial system. The work involves different professionals and different tasks and includes some researches activities on new methodologies applied to fieldwork (Fig.4) and to virtual reality applications, as well as some didactical activities with students.
The activities listed below are the tasks that are going on during the entire year. These are some of the principal activities:

- Digital acquisition of the monuments of the area and photo-interpretation through
- Topographic and architectonic Survey with laser Total Station;
- Topographic survey with RealTime RTK, Double Frequency, DGPS;
- Topographic survey and RealTime DEM construction: with PDA connected to the GPS;
- Processing of the photos through control points: 2D monoscopic Photogrammetry;
- 3D Photogrammetry with photographic stereo pairs;
- 3D photo-modelling with monoscopic photos;

Fig. 3. The via Appia actual landscape.

Fig. 4. A moment of the activity on the field with GPS and Digital Photos acquisition for photo-modelling.

- Survey and acquisition with 3D Laser Scanner;
- Postprocessing of laser scanner data to obtain mesh models.
- Topographic integration with satellite data.
- Desktop Virtual Reality System – Virtual Heritage System

These activities allow a continuous implementation of the GIS and of the Virtual Reality System, that are continuously updated. What our team is expecting from the project, after all the digital acquisition phases that will last at the end of 2006, is to work with the Archaeological Superintendence and with the Park institution, in order to create a sort of visitor centre or virtual reality centre of the Park. In the center the real time system could be used by visitors to obtain information and to understand the history of this landscape, while the GIS and the DataBases could be queried by researchers, scholars, administrative professionals.

2.1 Laser Scanner

The most indicated technology for a monographic representation of a structure or a monument is laser scanning that allows the digital acquisition of three-dimensional objects as point clouds. The main advantage of this approach is the possibility to obtain very detailed 3D acquisitions and models characterized by high geometric resolution that is fundamental for an accurate representation and interpretation of the monument.

The Ninpheum of Egeria, in the Caffarella area, is our first case of study in which we have employed the laser scanner technology for the acquisition on site of 3D data (Fig. 5-6).

The Ninpheum was built by Tiberio Claudio Erode Attico in the 2nd Century A.D., inside his suburban villa.

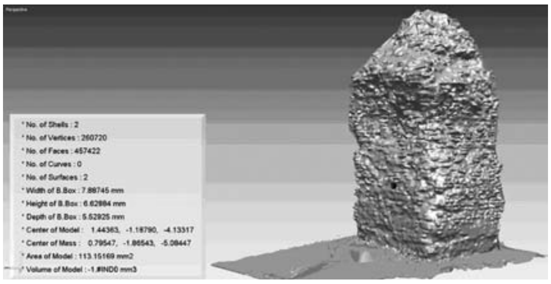
The residential area was included between the Appia road (Via Appia) and the river Almone and it was not a unique structure, but it included some different buildings, decentralized according to their different destinations and topographic characteristics. From an urban point of view, the entire complex was developed through an organic inter-relation between nature and architecture. In its residential context the Ninpheum, separated from the main building of the villa, was probably used for short stays to repair from summer heat.

Archaeological researches, recently conducted on the monument, have identified that the Ninpheum of the II century A.D. replaced a previous structure of uncertain destination. It has been possible also to identify a successive restructure of the building, built under the emperor Massenzio (306–312 A.D.). During the Renaissance, the monument was very appreciated by the antiquarians and was among the most represented in drawings and engravings. The perimeter of the building is rectangular, with niches on the bottom wall and on the side-ones, and differently from the traditional structure of the Ninpheum, a grotto excavated in the natural rock, this building is wholly artificially constructed. It was adorned with statues (the most important of them was the statue of the divinity of the river Almone, placed at the bottom, in the centre of the

Fig. 5. Satellite images of an area of the park (Caffarella Park inside the Regional Appia Antica Park) with the location of the Ninpheu.

Fig. 6. Scanner Laser working at the acquisition of Nympaheum.

Fig. 7. 3D model, from laser scanner data, of the arrangement by Canina.



Figs. 8–9. 3D models of two structures on Appia Antica axis, elaboration from laser scanner data.

frontal wall, on the shelf, from which the three spouts of water were flowing out), precious marbles and, probably, mosaics and paintings.

During the last months of 2004 other monuments have been acquired along the axis of Appia Antica, using scanner laser technology, the next figures show the result of postprocessing of data and the 3D models obtained (Figs 7–9). We are going to implement them in our virtual reality application.

Laser scanning technology allows the digital acquisition of three-dimensional objects as point clouds. The resolution, set for the acquisition, defines the density of the point cloud and so the detail of the representation. Every point is described by a spatial position in x, y, z coordinates referred to the origin, that is represented by the position of the scanner. To acquire the whole monument it is necessary to change the point of view and the position of the scanner many times, otherwise a lot of areas remain occluded to the laser ray (Fig. 10).

For the digital acquisition of monuments in the park of Appia Antica we have used a Cyrax 2500 that is a portable scanner based on the technology of time of flight, produced by Cyra

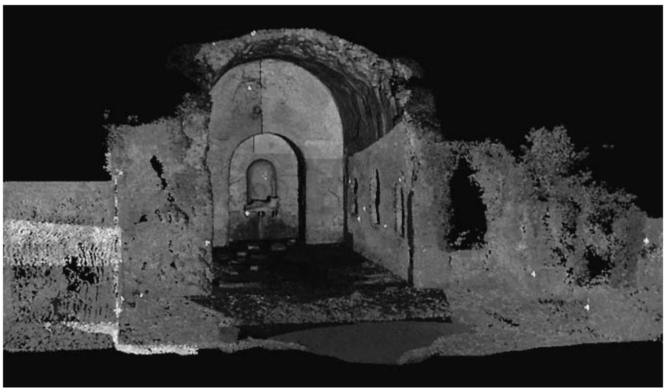


Fig. 10. Global point cloud of Nymphaeum of Egeria.

Fig. 11. Integrated acquisition by laser scanner, total laser station and camera for stereo photography.

Thecnology and Leica Geosystem. The resolution setted is about 6–8 mm.

To join together all the partial point clouds and to obtain a global representation of each monument we have used the most precise method of alignment, based on the topographic survey, by total laser station, of target positioned on the monument (Fig. 11).

The successive phases of processing of the point clouds have been realized with the software RapidForm by Inus Technology[3]. The main steps of work are:

- cleaning of point cloud and filtering of the noise;
- triangulation;
- correction of reversed normals;
- correction of abnormal faces;
- filling of holes;
- decimation;
- texturing.

For texturing we've used the ortophoto resized in power of two, for real time implementation. The final result is a very precise overlapping and correspondence between geometric and photographic documentation of the surfaces of the monument (Figs. 12–13).

However it can be very useful to analyse the geometry without textures, with a monochromatic material, because the volumes and the topology of the object can be better appreciated and interpreted.

Laser scanner technology allows high accuracy in the measure process, but often produces very complex models that are too difficult to manage with the most diffused pc platforms. The gigantic amounts of data representing the archeological structure can produce problems of visualizing and interaction for the most part of the users belonging both to the scientific community and to a wider public.

The mesh obtained is very detailed (millimetric precision) and it represents a very precious archive of information about the monument, its topology and its conservative conditions. For this reason it is necessary to keep an archive of the progressive simplifications of the mesh, so that no are lost.

The level of simplification depends from the final destination of the model. In our case we needed 3D models for a real time graphic engine, in a desktop virtual reality system. So the most decimated version of the Nynphaeum has been reduced from 7 millions to 250 thousands faces.

We can also distinguish portions that are of special interest for us from other ones that are less significant, and so we can represent, also in the same model, the two tipologies with different levels of detail, decimating more or less the geometry.
Furthermore in a hierarchical informative system, each element of the monument can be analyzed with more and more detail, to increase, in terms of architectural and archaeometric representation, the level of knowledge and the possibilities of critical interpretation of the topology of the structure.

2.2 Photo-Modelling

Photomodeling is a technique which permits to calculate measurements and constructs 3D models through digital pictures using the same outset of the photogrammetry. The control points took directly on the images, are projected in a virtual space by the calculation of the optical lines coming from every pictures.
The models created by these techniques are spatially correct, they are scaled and texturized and it is possible to export it in every format.
The advantages of this technique are many, first of all the speed of acquirement and processing of the object represented into the pictures, but it is necessary to have enough pictures to completely document the object otherwise the software can't calculate a 3D metric model. The level of detail depends from the number of control points taken on the images, but in any case models obtained by this kind of processing are optimized, in terms of number of polygons, to be implemented in real time applications (Fig. 14).

Fig. 14. 3D models of Torre Valca and Colombario, in Caffarella Park, realized by photomodelling techniques.

Fig. 12–13. 3D model of Nympaheum before and after texturing. The model has been already decimated.

2.3 Exporting and Implementation in Virtual Reality Application

The finished model is exported from RapidForm in .wrl 97 and then imported in 3D StudioMax. Even if the digital model of the terrain is created and elaborated inside GIS oriented environment (ArcView, Terravista, ecc.), it is important to refine and improve the design of the landscape in a software for 3D graphic authoring (Fig. 16). Here all the elements of

Fig. 15. 3D model of Caffarella Park, refined in 3D Studio Max.

Fig. 16. 3D model of Nymphaeum of Egeria, refined in 3D Studio Max.

the landscape, toghether with other 3D obiects (monuments, interfaces of interaction and so on) are added and the entire scene is composed. Finally each object is exported from 3D Studio Max and implemented in a real time graphic engine (Fig. 17).

In the real time visualization and exploration of the whole landscape a semplified version of the object and monuments, obtained by photomodelling techniques, are used, while the high resolution version obtained by laser scanner are employed for a monographic analysis of the monument.

Because of the technological limits of graphic cards it is not possible to visualize the whole monument at the highest resolution. For this reason the monument can be divided in many elements and structures and it becomes possible to visualise each component with greater and greater resolution, so to exploit the accuracy of data obtained by laser scanner acquisition.

Libraries actually diffused are of two types:

- graphic libraries for the representation of generical virtual reality;
- library best oriented and specialized in the field of videogames.

Both of them have advantages and disadvantages.

Engines oriented to generic representations (such as OpenGL Performer, Vega and so on) have the benefit to implement the scene quickly and easily and associate metadata.

Engines for videogames allows more powerful and refined visualizations, it is possible to create very complex animations, to associate with more flexibility every kind of behaviours to the objects, to create and animate characters, agents of artificial intelligence, to implement complex editor tools, and, lastly, to support multiuser interaction. These benefits seem correspond better to the purposes we want to develop in the close future.

Some of the engines we have tested are Vtree (CG2), Gizmo 3D, Director 3D, Auran Jet, Performer, and others. We have also written our own Open GL graphic engine in C++ (Desktop Virtual reality applications, such as Casa dei Vettii in Pompei and Giotto's Scrovegni Chapel).

One of our directions of research in the last period is oriented towards Virtools-Dev, that is a very powerful tool for virtual reality authoring that allows a very sophisticated level of visual programming, many possibilities of interaction, the possibility to implement forms of artificial inteligence, multiplayer interaction and many other behaviours.

3. Conclusions

Our methodological approach is especially oriented towards real time desktop OpenGL applications, where the incremented cognitive value of scientific 3D reconstructions can be fully integrated with complex informative system integrated by all the metadata linked. This method allows a multidisciplinary critical interpretation of the monument and of the landscape.

If we collect all the data in a 3D interactive environment we'll find that one unique vision is not sufficient to allow an integrated and strucutred compehension of the contents. In fact data have been acquired and represented at different scales and levels of detail, and they have to be organized according a multidisciplinary approach and specific metaphors of communication. Only in this condition we become able to identify complex relations, to relate us with the virtual context, to create and understund differences between us and the ecosystem, to become part of the ecosystem. In other words we can interpretate the virtual and create our mental maps.

So a VR system has to be aimed to integrate many different levels of real time visualization and interaction.

Interacting directly with the cognitive model, the user will find different kinds of information and critical contents, through a dynamic, virtual process of de-construction and re-construction of information.

Each level of representation is functional to the kind of information we want to communicate.

In detail, graphic layers, analyses of materials and of the conservative conditions, historic documentation, iconography, digital archives, databases, movies, audio files, etc., occupy the same three-dimensional space of information, permitting the users to query the system during real time walk-throughs or fly-throughs.

In order to draw progressive levels of complexity and detailed representations in a virtual archaeological landscape, we distinguish two types of vision: holistic and monographic.

Fig. 17. Navigation in real time on the territory of Roma, mapped with a landsat image (resolution 30 m.), holistic vision.

Fig. 18. Navigation in real time in the park of Caffarella, holistic vision.

Figs. 19–20. navigation in real time in the Nympaheum of Egeria realized with scanner laser technology, monographic vision, (Virtools-DEV and Auran Jet).

Figs. 21–22. 3D models of Nympaheum as it is today (observed reality) and an hypothesis of reconstruction of the ancient structure (reconstructed reality, the model has been made by the Arch. Lola Vico e Lucia Gomez).

This methodological choice helps us to organize information according a hierarchical management, exploring and entering the landscape through a progressive vision, both in geographic and in conceptual sense.

From a technical point of view this choice is also suggested by the need to separate data in some 3D graphic layers, to optimize graphic real time performances in terms of calculation of geometries. So the holistic vision includes satellite and aerial images and a 3D flythrough of the landscape (Figs. 18–19).

The monographic vision embraces all the photogrammetric models of the monuments of the park and it can be even considered a meta-reality because each model is represented on the basis of a very detailed relief, (realized, for example, using laser scanner technology or 3D photogrammetry, figs.20–21).

Both visions, holistic and monographic, can be also faced according to three main perspectives: the observed landscape, the classified landscape, the reconstructed landscape.

- The observed reality: how the landscape or the monument appears today, according to two 3D levels: macro maps constituted by satellite imagery and micro maps related to the archaeological landscapes including all the monuments in the actual state of conservation.
- The classified reality: it includes satellite and aerial classified imagery, (spectral analysis, image processing, etc.), raster cartography and any kind of processing oriented to the comprehension of the landscape.
- The reconstructed reality: it concerns the virtual display of the ancient landscape with detailed representations of all the monuments and ancient places, swithcing from full landscape visualization until to a monographic view of each single structure.

This sequence represents the methodology of research needed for understanding relations and spatial connection between observable data, digital classifications and possible reconstructions; we could say: data capture, data interpretation, data communication (Figs. 22–23).

The basic idea is to allow the user the possibility to compare different ontologies of the landscape, starting from the actual observation how it is (aerial and from the ground) and up to the reconstruction of the ancient landscape (how it was). Only so many ontologies offer the possibility to understand the spatial relations of the landscape.

The basic concept is "the map is not the territory" (Bateson's thought), so we need to understand the landscape creating

Fig. 23. 3D menu in the monographic exploration of Nymphaeum.

cybernetic maps with different amount of information: micro and macro "maps" draw the alphabet of the system.

The model represents an articulated, multilayer and multidisciplinary set of information, integrated each other as in a mosaic, in which the whole informative "model" is more significant than the sum of the single components. The connection among all the levels of detail and of content determines the cognitive space and it makes the virtual reality "increased" reality.

Actually the construction of the VR system for the Appia antica project is still in progress. In our real time application we can fly-through the 3D model of the territory of Rome, an overview employing satellite maps and able to contextualize the landscape before of analysing and observing in detail the environment (Fig. 18).

The Caffarella area is put in evidence and, selecting it, it is possible to access to a second level of detail of information, the holistic reconstruction of the archaeological landscape of the Caffarella valley. In this level we find general information about the valley, we can query the monuments and have access to the corrispondent scientific and historical contents. Data that don't need a spatial contextualization are accessible in html format, whether off line or on line (Fig. 19).

It is possible also to select one monument to access to the third level of detail, its monographic reconstruction (models processed from laser scanner), where the information can be organized in many hierarchical or narrative levels (topological data, historical and artistic documentation, state of conservation, restauration data, diagnostic analyses, hypothetic reconstructions of the original state, and so on, figs. 20–23).

In the case of the monographic views we have planned two virtual cameras, subjective and target camera (following an avatar): in the subjective navigation we move directly inside the virtual environment choosing views, head movements and any visual perspective; in the second type of navigation we follow the movements of an avatar that personalizes the user's choices. The different movement of the avatar will involve several virtual behaviors in order to familiarize the user with the digital ecosystem: each action is a spatial experience because it involves a detailed perception of the dimensions of the virtual space. Moreover the avatar's actions can be narrative, in the sense that they can explain the activities that, in the ancient time, were made in that place. We could talk with the avatar so to estabilish also a relation between us and the artificial creatures of the world. In this way one has a multiple perception of the VR system and of all the interconnected relations (Fig. 24). This experience of virtual storytelling should accelerate the potentialities of self-learning of the users, opening the system to multiple interactions and narrative feedbacks.

Notes

1 See in this volume: Diamanti, Felicori, Guidazzoli, Liguori, Pescarin "3D Temporal Landscape: a New Medium to Access and Communicate Archaeological and Historical Contents".

2 www.virtools.com

3 You can find a detailed description of each phase, from a methodological point of view, in Eva Pietroni: 3D data acquisition and 3D modelling applied to cultural heritage: from laser scanner to virtual reality aplications, bilateral Workshop Italy-USA: Roma, November 2003 - Berkley, May 2004

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