ICT to Increase Knowledge of Cultural Heritage

The advanced Information and Communication Technologies, combined with the development of applications based on Artificial Intelligence, open new possibilities to investigate CH in depth. Through GRID computing it is possible to directly access distributed databases by Web, creating a network of different archives. Instruments for Augmented Reality, modeling, simulation and virtual 3D reconstruction are useful both to predict the process of deterioration and to create innovative means to disseminate knowledge

Silvio Migliori, Dante Abate, Luciana Bordoni, Beatrice Calosso, Vincenzo Fiasconaro, Graziano Furini, Samuele Pierattini, Simona Guiducci, Belén Jiménez Fenández-Palacios, Fabio Remondino, Alessandro Rizzi

Introduction

The set of skills developed during several years, expertise and innovative tools that the Technical Unit for IT and ICT Systems Development (ENEA-UTICT) provides the CH sector with defines a process mostly aimed at promoting the integrated knowledge of CH within its context. Therefore, this process becomes a factor of growth in the cultural, social and economic system, in specific geographical areas. The range of services offered has been developed specifically to meet the needs expressed by stakeholders operating in Restoration, Cultural Tourism and Research.
The process incorporates specific methodologies and technologies for:

- integrated knowledge, aimed at acquiring and sharing information and data, by means of artificial intelligence;
- diagnostic monitoring, carried out through the analysis of the state of disrepair of artworks and monuments, leading to planning the most suitable restoration interventions;
- sustainable use and dissemination of the results obtained by interventions;
- enriching and integrating the visit of sites and monuments by using 3D reconstructions and applications of Augmented Reality.

Three experiences, which represent how this process can be realized, will be described in the following chapters.

Remote Rendering and Visualization of Large Textured 3D Models

The platform implemented and here presented allows an efficient and effective multi-user online sharing of high quality 3D textured models with no need for users to download it locally whilst exploiting the performances of a remote HPC infrastructure.
So far the presence of 3D models on the web is not very frequent, despite the increasing developments

Dante Abate, Luciana Bordoni, Beatrice Calosso, Vincenzo Fiasconaro, Graziano Furini, Silvio Migliori, Samuele Pierattini
ENEA, Unità Tecnica Sviluppo Sistemi per l'Informatica e l'ICT
Simona Guiducci
ENEA Guest
Belén Jiménez Fenández-Palacios, Fabio Remondino, Alessandro Rizzi
Bruno Kessler Foundation – FBK

of libraries, plug-in applications, games, etc.[1]. Nevertheless the scientific community and end-users are expressing an increasing need to exploit 3D models with a client-server architecture. Yet, when it comes to the visualization and interaction of big polygonal datasets online, the reliable commercial solutions are weak. The main problems are due to the bandwidth of the network and the protection of online shared and rendered 3D models. Indeed, sharing online digital archives of 3D CH models presents new challenges for the protection of intellectual property rights (IPR). Different approaches [2, 3, 4, 5] were proposed to protect piracy, copies and misuse – still allowing an interactive sharing – but the topic is still open. Here we present the study regarding the implementation of a hardware-software platform which permits a multi-user access to a repository of 3D models exploiting different applications. Thanks to this, the end user no longer needs specific HW and SW resources during the interaction and visualization of a 3D model whose resolution remains constant during the navigation. At the same time, the system protects the intellectual property of 3D models since they are not downloaded locally, but they remain safely stored on the remote repository. This project, called ARK3D [6], uses the ICT infrastructure of ENEA-GRID and, in particular, the graphic cluster belonging to the project CRESCO. The AFS geographic file system is used to implement the 3D repository.

3D models can be uploaded together with different kinds of metadata by users through a web-based interface following a dedicated registration procedure. The database is queried via web by free search keywords. The result will contain the metadata attached to the models, together with a link to the 3D remote application. The rendering (Fig. 1) is performed using the dedicated remote cluster and guarantees the protection of data, which can be manipulated although they cannot but be downloaded through a secure ftp.

The database is queried via a web page: unregistered users can only visualize an image (screenshot) of a 3D model, whereas users with credentials can choose and run the remote application to visualize and analyse the selected model. To do that, it is not required to know any configuration feature or install any other SW.

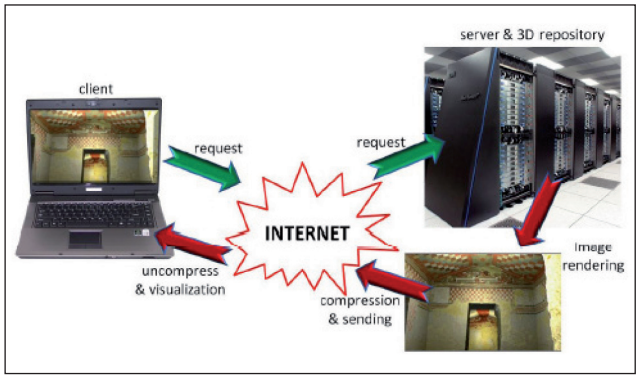

FIGURE 1 Remote 3D rendering based on Cresco graphic section
Source: ENEA

With this technology the final user can work over very large 3D models and visualize them using standard consuming computers, just connecting to the remote cluster via web. Through the dedicated web page, it is possible to upload 3D data onto the repository and eventually upload metadata attached to the 3D object. The metadata are represented by basic information such as the model author, upload/creation date, file name, etc., either in form of strings of characters or of independent files like images or documents (pdf, doc, jpeg, etc.). The remote displaying can be basically occur through any graphic application (proprietary and open-source).

In order to test the possibility of processing and editing 3D data, another solution available in ARK3D for the remote rendering of large 3D models is given using Meshlab [7]: 3D models (compatible with the file formats supported by Meshlab) can be displayed and edited using the functions available in the open-source program (Fig. 2).

Thus the user can: load and work with range maps, unstructured point clouds or polygonal data (millions of triangles), even on a standard laptop with limited computing resources; edit and analyse the model; extract geometrical information, or run batch processes.

This kind of approach is intended to stimulate the sharing and diffusion of 3D models among the communities in order to promote collaborative works

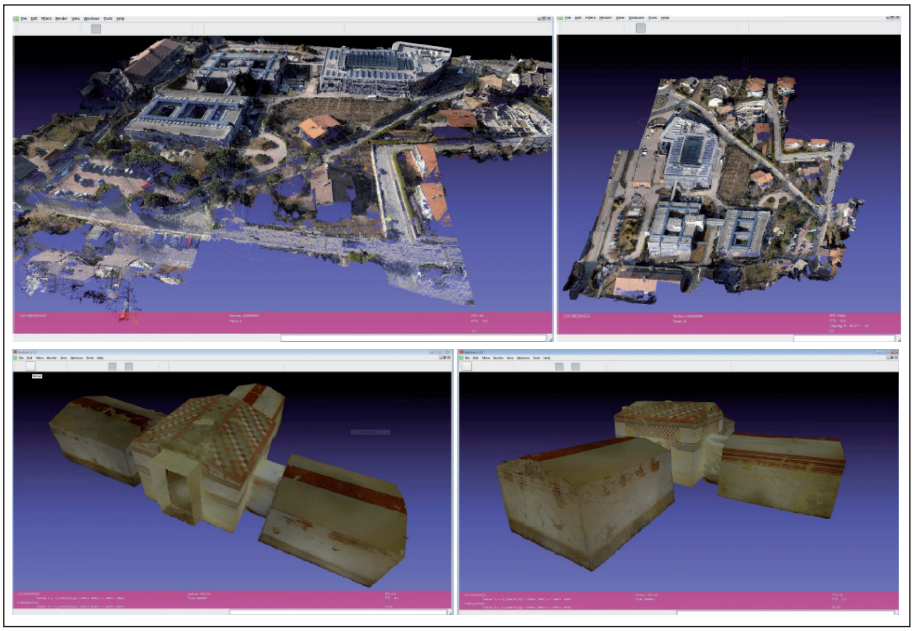

FIGURE 2 Example of a UAV-derived cloud with 108 mil. points with related RGB colour loaded remotely using Meshlab (a). A textured polygonal model with 3 mil. polygons and ca 115 MB texture displayed within Meshlab (b)
Source: ENEA

among technicians and non-experts without the limitations imposed by missing computing resources.

The Aras Project: Augmented Representation of Archaeological Sites

Whilst "Virtual Reality" stretches to totally replace the vision of the real world, "Augmented Reality" aims at enriching its representation, yet maintaining a connection with "reality."

Mixed Reality is the term commonly used for referring to environments that arrange real and virtual objects with visual representations of the real and virtual spaces.

In the ARAS Project the attention is focused on the individual, who becomes the protagonist of the action: we can speak of "augmented walk", a walk in the scene for discreet points.

Inside the archaeological site, along a pre-arranged path, some removable supports will be positioned and "camouflaged" with the environment (for instance, small columns), on which AR telescopes (where the real sight is superposed by virtual objects) are mounted.

The visitor can walk in the site being free from backpacks or glasses and, once reaching the observation point for the augmented reality, he can then decide whether to look through this "time window" and be taken several millennia back in time.

This way the visitor chooses the "augmented walk" in the archaeological site, but the necessary technology to make a "trip back in time" is not considerably visible, as in the case of the systems HMD (Head Mounted Display). The systems based on the HMD technology force the visitor to wear a series of instruments that allow to see the reconstruction of the environment surrounding him. In the realization of our project we have made some considerations: the instruments to be put on may not be easy to use for some categories of visitors as, for instance, old and disabled people; not necessarily may the visitor want to immerse himself continuously in the augmented HMD reconstruction; a first approximation of the visitor's position a GPS signal is used, which sometimes could not be received causing the loss of visualization.

Using this technique allows all visitors to benefit from the additional material and they will go deeper into cultural subject thanks to this combination of education and entertainment (*edutainment*).

In many archaeological sites, moreover, there are buildings closed to the public in order to avoid their total destruction. Now it is possible to reopen these places virtually creating their 3D models.
In order to show the application potentialities of the ARAS Project, we have realized a model (Fig. 3) of an archaeological site provided with special supports to arrange the video cameras, that simulate the telescopes AR, on which we have overlapped the virtual models of the 3D reconstructions of the Temple of Jupiter and of a detail of the House of the Faun (Fig. 4).
The idea introduced with the project is to partially get around the phase of recognition of the marker, introducing a preliminary step: the memorization of an initial position of the video camera related to the marker.
Moreover, in this preliminary step the marker will not be a figure alien to the landscape, but an integral part of it: the trusts, that show the historical data placed side by side on monuments, can be used to such purpose, modifying them so as to be recognized as a marker.
This way the only required data are the initial position and the recorded displacements of the video camera through the gyroscopes, so that it is no longer necessary to estimate the position of the video camera frame by frame.
Clearly this approach avoids the lack of visualization depending on occlusion phenomena and changes of brightness. Another important element to be considered is the use of the VRML language: it is possible to generate a real virtual life using animations, so as to create a greater emotional involvement of the customer who visits the archaeological site.
The visitor, in fact, will find himself facing the reconstruction of scenes of life from the places he is observing, with his consequent greater participation.
Our main objective has been to develop an application capable of replacing the *Archeoguide System*, offering the visitors the chance to observe the reconstruction of monuments needless of any visualization device to bring along. The application can be enriched by integrating the monument reconstructions with a vocal description of details and historical information. The software can be implemented with applications for PDA, tablet and smartphones. An application

FIGURE 3 Model that shows the ARAS prototype
Source: ENEA

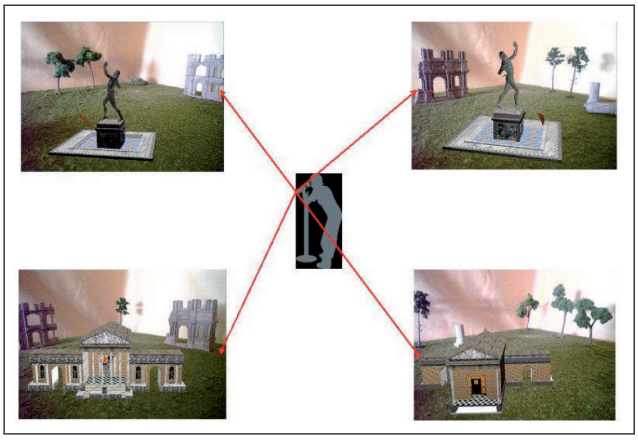

FIGURE 4 3D reconstructions of the Temple of Jupiter and of a detail of the House of the Faun
Source: ENEA

for online Museums can be developed. The objects of the Museums can be shown so that the customer can virtually hold an artistic object in his hands and observe it from several angle-shots.

A Case Study for Cultural Tourism: the Latin Latium

Cultural Heritage Tourism has become a major source of revenue for many communities and states across

the globe. Not only does it create jobs, but it has the potential to stimulate the local economy, beyond the capacity of its residents. As the Web has changed people's daily life, it has significantly influenced the way that information is gathered and exchanged in the tourism sector. Information technology starts playing a challenging role in the domain of tourism, such as Semantic Web and Web2.0. In the tourism domain different in-house taxonomies and catalogues already exist which are designed and used internally by tourism agents to help them manage heterogeneous tourism data. Efforts are made to generate global standards to facilitate inter- and intra-tourism data exchange (e.g., by the World Tourism Organization). Mediation, ontologies and semantic web can create an image of a future harmonised electronic tourism environment. Ontologies play an important role to facilitate the semantic integration of heterogeneous data [13]. They can assist organisation, browsing, searching, and more intelligent access to information and services available online [14]; for this reason several formal tourism ontologies publicly available have been created [15].

Since the beginning of the 2000s, Semantic Web technologies and their potentials for the integration and exploitation of digital CH information have drawn increasing attention, and today they represent an exciting and dynamic field of interdisciplinary research [16]. Many little-known areas have interesting "heritage" to be capitalized on, promoted, and rendered useable by and attractive to the broader public.

The territory of Latium, in particular, offers considerable development opportunities with the creation, for example, of appropriate infrastructures that do not simply connect the centre with the outskirts, but are vehicles for the region's deeper economic and cultural integration.

The object examined in this case study is the area in the Latium Region, south of the Tiber, where the Latin civilization was born and developed. Still little known and visited, as confirmed by statistics, and only partially included in parks and natural reserves, this area possesses a vast archaeological, artistic, ethnographic, natural, historic, and scientific heritage. It has been studied, analysed, protected by different stakeholders throughout the history (people and institutions), each of them documenting their actions and knowledge in all kinds of records, monographs, articles, legal texts, collections, etc. This knowledge comes from different sources (encyclopaedias, reference books, finding aids, government publications, databases, web sites, etc.) that can be accessed only in a fragmented way, without any or with weak interconnection. Moreover, they are at different stages of formalisation, standardisation or,

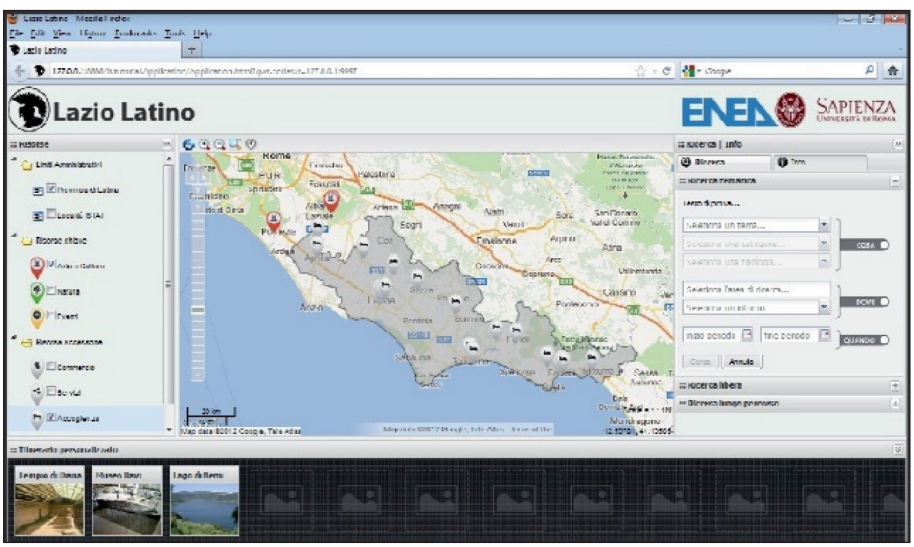

FIGURE 5 A screenshot of the portal
Source: ENEA

even, digitisation. All that has been described above makes it very difficult to access the information. This case-study intends to make it possible to: 1) capitalizing this area of Latium, emphasizing its singular nature and great worth; 2) facilitating the visits by providing the user with all the necessary and useful services; 3) permitting cultural enrichment through easy learning and full understanding of the place's historical, artistic, and cultural issues.

For this purpose, semantic web technologies are proposed for application to diversify the information sources that may be referred to two major areas of cultural tourism interest: services (transport, hospitality, etc.) and culture (history, art, traditions, etc.) [17].

The portal (Fig. 5) is the main step of this application and is conceived to offer easy access to all the contents gathered. For this case-study two application scenarios have been elaborated. A "static" scenario permits cultural enrichment through easy learning and full understanding of the place's historical, artistic, and cultural issues. A "dynamic" scenario allows virtual tourists to exchange opinions and experiences on itineraries in the Latin origins of ancient Rome through the use of WebGis technologies and social media.

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