Virtual Archaeology Review

Natural interaction in Virtual Environments for Cultural Heritage: Giotto in 3D and Etruscanning study cases

Eva Pietroni[1] Claudio Rufa[2]

[1] CNR Institute of Technologies Applied to Cultural Heritage, Italy
[2] E.V.O.CA srl, Italy

Abstract

A basic limit of most of VR applications created by the scientific community and reproducing cultural sites or artefacts is that they do not fire up the attention of public, in comparison with the great potentialities of VR system for cultural transmission: they are often lacking in emotional storytelling and difficult to manage. An important factor is the need of more natural and simple interfaces, especially for applications hosted inside museums. Starting from our experience in this domain, we propose new metaphors of narration and paradigm of interaction based on natural interfaces (body movements), presenting three study cases: "The Rule confirmation: virtual experience among Giotto's characters", "Etruscanning3D", "Virtual Exploration of the ancient Pharmacy of S. Maria della Scaletta Hospital at Imola".

Keywords: VIRTUAL REALITY, CULTURAL CONTEXT, COMMUNICATION, PERCEPTION, NATURAL INTERACTION, LEARNING, COGNITION.

Resumen

Un límite básico de la mayoría de las aplicaciones de realidad virtual creadas por la comunidad científica que reproducen sitios culturales o artefactos es que no logran activar la atención del público, en contraposición y contraste con las grandes potencialidades que ofrecen los sistemas de RV para la transmisión cultural. A menudo estas aplicaciones carecen de una narración emocional y son difíciles de manejar. Un factor importante a tener en cuenta es la necesidad de generar interfaces más naturales y sencillos, especialmente para las aplicaciones alojadas en el interior de los museos. A partir de nuestra experiencia en este campo, se proponen nuevas metáforas de narración y paradigmas de interacción basados en interfaces naturales (movimientos corporales). Para ello se presentan tres casos de estudio: "La confirmación de la regla: experiencia virtual entre los personajes de Giotto", "Etruscanning3D", y "Exploración Virtual de la antigua Farmacia del hospital de S. Maria della Scaletta en Imola"

Palabras clave: REALIDAD VIRTUAL, CONTEXTO CULTURAL, COMUNICACIÓN, PERCEPCIÓN, INTERACCIÓN NATURAL, APRENDIZAJE, COGNICIÓN.

1. State of the art of VR environments for Cultural Heritage

Digital cultural heritage deployment in the communication domain has changed in the last few decades. Unlike early approaches based on showing collections of items aimed to the expert and culturally prepared audience, there is an emergent need of institutions that promote diffusion of culture and education in a broader sense, and to a larger public (ANTINUCCI, 2007). The focus has thus shifted from collecting items to define a communication strategy and style, able to capture the interest and attention of people from different ages and different education or cultural backgrounds.

Three-dimensional perception and action are necessary in the cognitive process based on experience (embodiment), because the possibility to explore and perceive the space and the information from different points of view enhances our sense of presence and learning. The third dimension creates a difference between who is interacting and the environment; we learn, in fact, through the perception and interpretation of the differences

(BATESON, 1972): we try, we act in the surrounding environment while observing the results of our behaviors, we try again till we understand and obtain what we are looking for. To receive, elaborate information means to acquire new differences, to establish and modify relations in the space-time. Given that visualization and exploration of the 3D space are necessary first steps towards knowledge, they are not sufficient to understand, learn, and experience cultural contents.

In many cases, VR applications developed by the scientific community show an accurate graphic elaboration, that is often obtained through advanced techniques of digital acquisition (laser scanner, photogrammetry etc.), but they are not satisfying in terms of cultural communication, artistic impact and interaction with the information. They do not suit the wider needs of the public. Cinema and video-games have made the public accustomed to very involving, immersive and sophisticated scenarios, advanced languages and media, complex interaction metaphors. The research in this field for CH is still pioneering. A storytelling oriented approach needs to be undertaken to make the application more compelling for the

public, and to make it possible to convey the contents to a larger audience.

Moreover many people have still problems to manage common input devices for interacting inside the 3D space and with cultural objects: mouse, joystick, keyboard, console are not natural interfaces, they request time to become familiar. This condition can produce uneasiness and effort in establishing a contact between us, the digital environment and the technologies. The improvement of this aspect is fundamental.

We think that it is really necessary to develop, beside the technological improvements, an appropriate epistemological approach aimed to identify the conditions of cultural transmission, the dynamics of learning, the quality and the "geometry" of information, new approaches in the interaction, languages and metaphors of the "virtual". All the data need be integrated in the virtual space, linear storytelling and free interaction need to find a new positive combination; one that is alternating, yet mutually empowering.

Starting from this premise and from our past experience, we are focusing part of our research on the development and experimentation of new low cost and markless interaction interfaces inside of 3D environments - interfaces that can be used inside a museum - based only on the use of body movements (natural interaction). This kind of approach influences also the general design of the application: the perceptive impact of the real time exploration, the sense of immersion an emotional involvement, the access to storytelling, the selection mode, and the possibilities of objects manipulation, the duration of the virtual experience. The experience for public is completely new.

In the next paragraphs we are going to present three study cases based on this approach.

2. "The Approval of the Franciscan Rule". Virtual Experience among the Characters of Giotto's Work

On the 10th of April 2010 an important exhibition has been opened in Assisi, dedicated to the restoration of Giotto's fresco paintings in the Basilica of St. Francis, after the earthquake of 1997, and to the virtual restitution of the artist's original colors. The exhibition, promoted by the Municipality of Assisi and the Franciscan Fathers, has been coordinated by the Italian Central Institute for Restoration (BASILE, 2010). In this occasion the National Research Council realized an innovative project creating a virtual environment from the scene "The Rule Confirmation", painted by Giotto in the Upper Basilica of St. Francis at the end of the XIII century.

Starting from a very accurate analysis of the perspective, the proportion and the position of the elements painted in the scene, a complete three-dimensional model has been realized, matching as nearly as possible the original (figg.1a -1b).

Giotto's image was acquired at very high resolution and subdivided in order to be used for the texturing of the 3D models.

A wondering effect has been obtained, as it is possible to recognize the artist's strokes and style on the volumes.
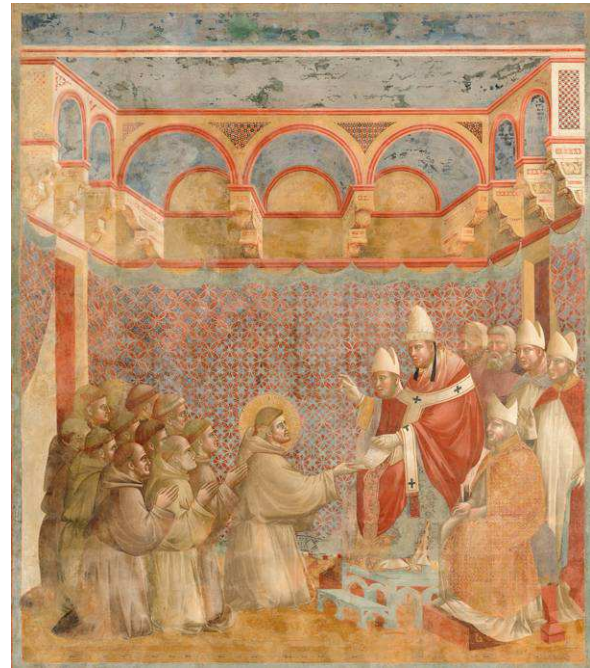

Figure 1a. The Rule Confirmation painted by Giotto (actual condition   of conservation)

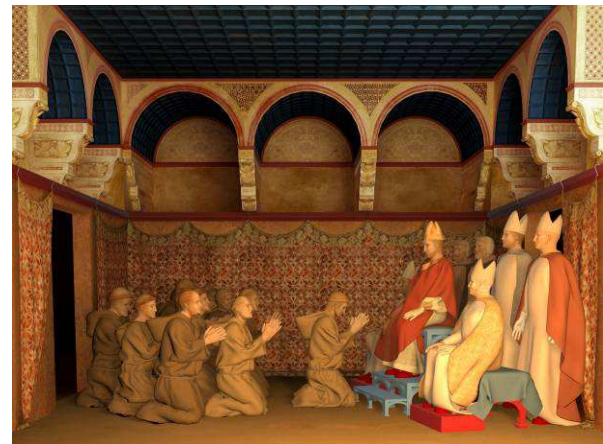Figure 1b. The Rule Confirmation represented in 3D (elaboration by Massimiliano Forlani

The installation has been located in a dark space and the visualization is projected on a surface of 4x5 meters. The visitor can move in real time within this virtual environment, changing the view points, entering among the characters and live an experience of sensorial, emotional immersion into the scene.

The primary objective of the first installation is to involve the observer in the scene painted by Giotto in such a way as to enable the visitor to feel and understand the message that Giotto was communicating, at least on an emotional level.

In fact the space illustrated by Giotto becomes a place of experience, open to multi-sensorial narration and participation.

The scene itself is brought to life: the characters are animated, and they are represented while performing the action described by Giotto (fig. 2).

Pope Innocence III and his following of bishops and prelates are in the room, waiting to be joined by Francis and his eleven disciples. Few seconds later the franciscan enter in the room and stop exactly in the places in which Giotto has portrayed them. Then a brief conversation between Francis and the Pope follows.

At the end of this dramatized prologue, the user can interaction in the scene in real time.

One of the project's most innovative elements is the paradigm of interaction which has been developed using natural interfaces.
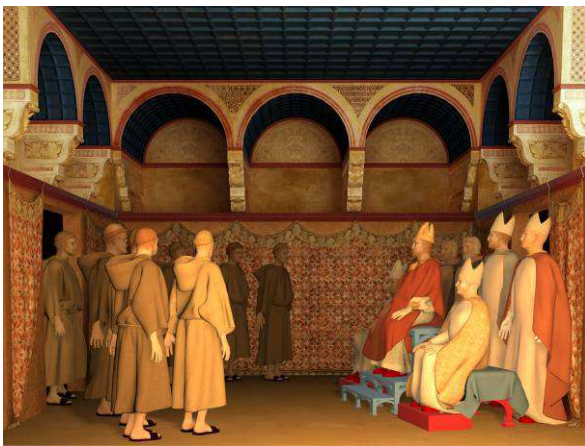

Figure 2. Characters performing the action represented by Giotto in the virtual environment

To encourage the perception of immersion, the scene is projected on a scale of 1:1 in respect of the space represented by Giotto, thus on a screen of 5 x 4m. Visitors can interact inside the virtual space simply by changing their position and moving their bodies in the real space, without the aid of any traditional interfaces (mouse, joystick, etc.), so in the most natural way (fig. 3).

Figure 3. Children playing with virtual characters in the interaction area, VR application with natural interaction (CNR ITABC in collaboration with BCAA s.r.l.), 2010.

When the visitor moves in the area in front of the projection (a space of about 5 x 4m) his position is identified and tracked – in coordinates xy on a horizontal plane – instant by instant by a motion capture system which is able to recognise and follow the visitor. This position is transmitted to the graphic engine which calculates and returns, in real time, the correspondent view point of the scene. In this way, the visitor, thanks to his own movements takes on the function of a tracer and has the sensation of entering and walking in the scene.

Therefore icons, push-buttons, dialogue windows, keyboards, all disappear. What remains is the sensitive space of which the user is an integral part and, above all, an active element. The technology is modelled on the needs and the natural capabilities of a person, no particular knowledge or training is necessary to communicate with the system except that which comes from one's natural experience.

Music and sounds have another key role; environmental noises, murmurings, music are contextualized in the three dimensions. Medieval gregorian chant, polyphony fragments, contemporary electronic sounds are combined in order to create a very impressive suggestion. The interaction can be managed by only one person at a time but the public (up to about 15 people) can watch and take turns at interaction.

The system of motion capture is agile and low cost. There is no need for the user to wear markers or sensors because the whole system is based on the use of an infrared videocamera placed on the ceiling, which frames the interactive space, identifies the first user to enter and traces him while he remains inside the sensitive area. The interaction continues until the user leaves the area or changes places with another user. The person traced by the system is illuminated and "marked out" by a bull's eye light installed on the ceiling which follows him. This makes clear for the public who is the active user recognized by the software.

Motion capture is managed by VVVV 3d engine, based on Microsofts DirectX technology; the graphic engine used for real time visualization is Unity 3D, a multi-platform game development tool. The software has been developed by BCAA s.r.l.

The three-dimensional reconstruction of the scene "The Rule Confirmation" offers a unique occasion to penetrate in the history of painting and to appreciate one of its fundamental step: the transition from the medieval, ancient, approach in representation to the modern approach, born during the Renaissance. Giotto's image, in which the perspective simulation of space appears still very empirical, is compared with its three-dimensional translation. A second installation, more descriptive and interpretative, has been created in order to analyse and investigate Giotto's space and perspective.

In conclusion this project constitutes one of the first example of real time, natural and immersive interaction inside a painted scene and it allows to test a new way of experiencing and learning the art, useful for students, children, common public and even for experts.

It is possible to find material and movies about the project in the dedicated website *www.icoloridigiotto.it*.

We are now working on an update of the application to be presented as permanent installation in Assisi.

3. The Etruscanning project

Etruscanning is an European project in the Culture 2007 framework, that involves a consortium of museums and research organizations from 3 European countries for the purpose of exploring the possibilities of new digitization and visualization techniques, in order to re-create and restore the original context of the Etruscan graves. Although the project is still in progress, some important results have been already obtained. The main objectives of the project are:

- International cooperation in digital acquisition, digital restoration, 3D representation.

- Communication of Etruscan tombs and collections during exhibitions in the Netherlands, Belgium and Germany, and, at the end of the project, for permanent use in Italian museums.

- Enable and support cultural heritage institutions to create, run and exchange digital 3D reconstructions.

We focus on two important Etruscan tombs: Regolini Galassi, the grave of a princess in the Sorbo necropolis of Cerveteri, and Tomb n.5 in Monte Michele, the grave of a warrior, in Veio. The finds from these tombs are mostly in museum collections and the existing (empty) tombs are not always open to public. By making 3D reconstructions of the tombs and of the objects which originally were found inside, we can re-create the archaeological context of these Etruscan tombs. The Regolini Galassi tomb is the tomb which we have already reconstructed in 3D and implemented in a Virtual Reality environment using natural interaction interfaces.

It is one of the most appealing Etruscan graves we know, famous for its rich contents but also for the many objects that show the Orientalising influence. The discovery of the tomb in 1836 was done by the priest Alessandro Regolini and the general Vincenzo Galassi who made some reports on the discovery but they did not document methodically. Our virtual reconstruction tries to visualize this tomb at the moment it was closed, halfway through the VII century B.C. (fig.4). Therefore, by developing a 3D reconstruction, we have been forced to re-evaluate and verify all of the available sources, asking ourselves very practical questions relating to the placement of the objects and their original position.

The project has been developing through a complex methodological approach; from the collection of existing data, to new topographical digital acquisition (laser scanner, photogrammetry dense stereo matching, computer graphics).

This VR application has been presented during two exhibitions in the Netherlands, *Riches and Religion of the Etruscans - Princes and Priests* (in Amsterdam) and *Princesses and Goddesses* (in Leiden), open from the 13th of October 2011 until the 18th of March 2012, and during the exhibition *Archeovirtual* in Paestum at the Mediterranean Archaeological Tourism Exchange, in November 2011.

Also in this case the VR application uses paradigm of interaction based on natural interfaces.

The user moves inside the 3D space through his body movements. The public explore the virtual tomb, get near the artifacts and listen to the narrative contents directly from the voices of the prestigious Etruscan personages buried inside; the princess and the warrior. All this is possible moving in the space in front of the projection, in the simplest and natural way and without any device. The user walks on a real map of the grave placed on the floor, onto which some "hotspots" are attached. Changing his position from one hotspot to another, he also moves in the virtual space, going closer to the objects and prompting the storytelling to emerge. The order in the choice of the hotspot activation is free, so every sequence can be activated (fig.5).

Figure 4: 3D model of the Regolini Galassi tomb and re-contextualization of the grave goods. In this image, captured from the VR application, we can see the final chamber with the buried princess.
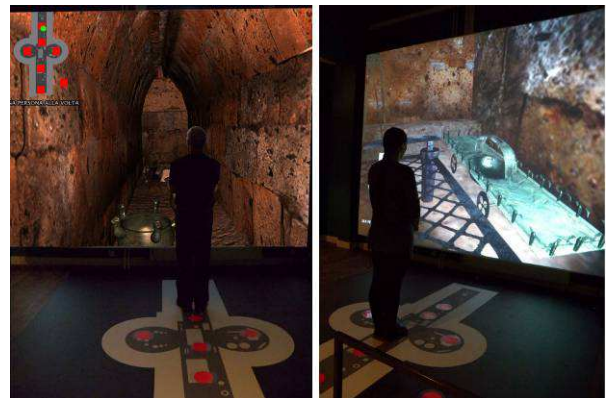

Figure 5: VR installation in Allard Pierson Museum, Amsterdam and at Archeovirtual in Paestum (2011, photo by Bartolomeo Trabassi).

The projection of 12 m², the evocative storytelling done in first-person, the use lighting to gradually reveal the objects as the space is explored, and the physical involvement of the user produce a strong sensation of immersion. While the active user is guiding the system, other visitors can sit down in the viewing area, visualizing and listening to the cultural contents in a passive way; always with the opportunity to engage in active exploration.

This solution not only makes the interaction amazing for the public, but allows people of every age and every "technical" skill to enjoy the virtual contents. The total duration of storytelling in 7 hotspot (about 30 objects) is 28 minutes. We have verified that the medium time of interaction for each user is about 12 minutes; a very good result according to our expectations.

The application is built in Unity 3D and uses the Kinect sensor for motion capture. The system has been derived from the new generation of games, but for the first time it has been applied to VR environments dedicated to the CH . The framework to interface between the Kinect and the computer is OpenNI; an open source application programming interface (API) developed by Prime Sense and Willow Garage industries for writing applications using natural interaction. The application doesn't need calibration, as the skeleton does not require measurements. If another user enters the interactive area without stopping on an hotspot, his presence has no influence on the system (even if he is detected); if he enters the interactive area and goes on an hotspot, he will be identified and the system will be guided by him. We tested the system with seven people present in the same time in the interactive area and we had no crashes, demonstrating the stability of the software.

A very important evaluation on public behaviours has been done during the exhibitions and this observation has been fundamental to improve the system, enforcing some aspects and changing some other functions, in successive versions of the application. The general feedback is now very good.

4. Virtual Exploration of the ancient Pharmacy of S. Maria della Scaletta Hospital at Imola.

This third study case has been developed in occasion of the exhibition "*Ceramic Masterpieces from Castelli between '500 and third fire*", opened on the 2nd of April 2012 at the Pinacoteca Civica in Teramo and presenting more than two hundred ceramic artifacts of the Matricardi collection. This wonderful objects were produced from the Renaissance to the end of the XVIII century A.D. by artists of Castelli, a small village in Abruzzo (Italy), close to Gran Sasso montain. In this context we have realized a VR stereoscopic application using natural interaction in order to explore some precious vases, re-contextualizing them inside the ancient pharmacy of S. Maria della Scaletta Hospital at Imola.

Starting from photos taken all around each artifact, 3D models of a bottle and two vases ("albarelli") have been reconstructed and textured with high resolute images. Manual computer graphic techniques have been used for this process in order to obtain the best result.

The VR installation, requiring stereo glasses, has been located in a proper space integrated within the main visit path of the exhibition.

The user interacts from a fixed position and his movements are captured by a Kinect sensor, without need of calibration He needs to use just the right hand to dialogue with the digital space. Moving the right hand in front of the sensor, left and right, he can select an object; pushing the same hand forward the selection can be confirmed. After selection it is possible to use the same hand to manipulate the object in real time, turning it left and right, up and down, along z and x axes, while the object tells its story (fig.6).

A virtual character on the screen suggests the user the proper gesture to perform in every moment (only two gestures are required) in order to make the interaction as immediate and simple as possible.

Also in this case the application has been developed using OpenNi and Unity3D, the Kinect sensor has been put just below the projection, 1 mt from the floor.

Figure 6: VR stereoscopic application dedicated to the ancient pharmacy, 2012

The application is very easy but it has a great impact on public. Visitors are really involved in this experience and they remain playing with the objects for several minutes, repeating the actions until they have full control on the system, listening many time the audio explanations and narratives.

In conclusion the use of the natural interaction in virtual applications can be much simpler than the traditional interfaces and it seems a wonderful chance for museums. We are developing an interesting research in order to define a proper grammar of gestures that can be tested on public and continuously improved, also with the support of experts in cognitive science.

In fact gestures needs to be really intuitive, responsive and well designed by the authors as no all people have the same perception, coordination and awareness of their own movements. Many people reveal a creative/emphatic approach in performing the required movements, as they have the feeling to be in a game, exaggerating their role. For this reason the use of natural interaction can produce less precise input, in comparison with traditional interfaces (mouse click, keyboard, joystick....) but this limit does not generate frustration in the visitors, on the contrary it translates in a challenge encouraging people to try, explore and learn until they obtain good results.

We believe these three study case can be considered pioneering, as at the moment there are no projects in the world dedicated to the communication of cultural heritage in museums using natural interaction interfaces in 3D real time environments. Instead, this kind of approach seems to be a bit more diffused in 2D visualization, in order to browse through images and multimedia. In the next projects we are going to develop the motion capture system further on, in order to multiply the possible behaviours and exchanges between real and virtual worlds.

Acknowledgements

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