ISSN 2464–4617 (print) ISSN 2464–4625 (CD-ROM)

CSRN 2602

(Ed.)

- **Vaclav Skala**
  University of West Bohemia, Czech Republic

Computer Science Research Notes

24th International Conference in Central Europe on Computer Graphics, Visualization and Computer Vision
WSCG 2016
Plzen, Czech Republic
May 30 – June 3, 2016

Proceedings

WSCG 2016

Short Papers Proceedings

ISSN 2464–4617 (print) ISSN 2464–4625 (CD-ROM)

CSRN 2602

(Ed.)

- **Vaclav Skala**
  University of West Bohemia, Czech Republic

Computer Science Research Notes

24th International Conference in Central Europe on Computer Graphics, Visualization and Computer Vision
WSCG 2016
Plzen, Czech Republic
May 30 – June 3, 2016

Proceedings

WSCG 2016

Short Papers Proceedings

Vaclav Skala – Union Agency

ISSN 2464–4617 (print) ISSN 2464–4625 (CD-ROM)

Computer Science Research Notes
CSRN 2602

Editor-in-Chief: Vaclav Skala
c/o University of West Bohemia
Univerzitni 8
CZ 306 14 Plzen
Czech Republic
skala@kiv.zcu.cz *http://www.VaclavSkala.eu*

Managing Editor: Vaclav Skala

Publisher & Author Service Department & Distribution:
Vaclav Skala - UNION Agency
Na Mazinach 9
CZ 322 00 Plzen
Czech Republic
Reg.No. (ICO) 416 82 459

ISSN 2464-4617 (Print) **ISSN 2464-4625** (CD/DVD)
ISBN 2464-4625 (CD ROM**)** **ISBN 978-80-86943-57-2** (CD/-ROM)

WSCG 2016

Short Papers Proceedings

Contents

Tiber Valley Virtual Museum: user experience evaluation in the National Etruscan Museum of Villa Giulia

Eva Pietroni, Alfonsina Pagano
CNR ITABC
via Salaria km 29,300
00015 Monterotondo-Rome Italy
"eva.pietroni", "alfonsina.pagano"@itabc.cnr.it

Caterina Poli
Tuscia University
Largo dell'Università s.n.c.
01100 Viterbo, Italy
policat@tiscali.it

ABSTRACT

The paper presents a survey on the user experience related to the *Virtual Museum of the Tiber Valley,* an innovative VR installation requiring gesture-based interaction, designed and developed by CNR ITABC and permanently accessible at the National Etruscan Museum of Villa Giulia in Rome. This research arises from the desire of the authors to verify attractiveness, usability, and communication effectiveness of the system with the end users while having such a multi sensorial experience in the museum. The employed strategy in the survey and the final results will be discussed in comparison with authors' expectations, outlining best practices out of this massive study.

Keywords

Virtual Museums, user experience evaluation, gesture-based interaction, virtual reality, emotional storytelling, qualitative and quantitative analyses.

1. INTRODUCTION

Virtual Museums (VMs) have seen a rapid growth in the past years given the big effort in producing always more user-friendly systems, focused on a fruitful contamination among narratives, new interaction paradigms and sensory immersion in 3D environments. Recently the V-Must project has consolidated the idea that virtual museums have not to be considered as simple digital reproduction of physical museums; whereas they need to be conceived as "aggregators" of different contexts and interpretative layers related to the Cultural Heritage, that are not commonly accessible in the real museums, with particular attention to the enhancement of "museum experience through personalization, interactivity and richness of content" (www.v-must.net). Interaction turns to be of utmost importance when we want to make the user really feel involved within the virtual scene.

Thanks to some recent technologies (i.e. motion-capture sensors, head-mounted displays), the *sense of presence* into such VMs has overcome the limits of traditional desktop-based interfaces, opening great perspectives in human-computer interaction, [Syl08]. The chance indeed of simulating the visitor's physical presence inside the cyberspace, by performing body gestures to interact with not tangible contents, represents a great revolution in the way of making experience. Once the user's senses and mind are "embodied" in the artificial environment, he becomes able to perceive his body as part of the virtual scene and then interact with the 3D elements, reaching the sensory immersion in the 3D environment, with greater emotional participation, conceptual engagement and enhanced learning capabilities, [Wit98], [Sla99].

But how can a VM convey such an experience? Visual aspects, narratives and interaction interfaces are of primary importance. Gestures represent our natural language and therefore the most immediate way to interact with the external environment. However the interface elements still play a crucial role in the user's recognition of gestures and movements to be performed when facing natural interaction inside virtual reality applications. The *VMUXE* work, an approach to the user experience evaluation for VMs by CNR ITABC, Fraunhofer Institute and Lund University [Goc13], revealed that the linearity and simplicity of the interface elements highly influence the user's understanding of what to do with VMs and, consequently, the memorization of the interface useful to accomplish the various tasks.

Moreover, the visual information and the language need to be short and accurate so to be understood by a broad audience. This is strengthened also in the *Etruscanning* project (2012) a VR installation by CNR ITABC allowing the public to explore an Etruscan tomb reconstructed in its original aspect, with funerary goods and dead personages inside. The tutorial proposed at the begin of this natural interaction application (composed by figures and few text lines) is welcomed by the users, but it is claimed to have too much text in the explanation [Pie13]. Instead, during the exploration, storytelling in first person and soundscape have been the most appreciated aspects by the public. The evocative reconstruction granted by the system, together with the location inside the Vatican Museums in a dedicated space without distractions, have been underlined to be strength points.

Therefore, not only the graphics but also the interface layout and the stories support the user, by providing an involving and profitable experience. In this sense, the usability evaluation of *Imago Bononiae* project, by CNR ITABC [Fan15b], confirmed that minimal and explicit visual indicators again help users in the recognition of the the urban landscape, allowing them to autonomously "move" inside the 3D scenes. The intense and immersive experience brought the majority of the sample to affirm to be stimulated to know more about the subject of the VM, by visiting the real city of Bologna or deepening the related information on the Web.

The importance of the narrative sphere is proved by Antonaci et al. who presented a pedagogical study on the "Keys2Rome" exhibition (keys2rome.eu), [Ant15], discussing about a natural interaction project, *Admotum*. From direct feedback we can state that users don't want to perceive the complexity of the technology and they desire to fully enjoy the storytelling. Technologies need to be "invisible" [Fan15]. The call for digital stories is finally confirmed by the V-Must Poll on "Quality Labels in Museums" conducted in 2014 [Pes15], where it came out that museum's audience thinks that stories and visual information are more important than getting access to "how" the 3D reconstructions have been done, supported by some visitors that do not think that complex interactive systems are more necessary than stories and 3D visualization.

We can indeed assume that digital narratives, interactive experience and sensory immersion strongly affect the attraction of VMs, allowing the users to better remember the provided cultural information. The case-study we are going to present in the next sections is an attractive on-site virtual reality installation, using gesture-based interaction, dedicated to the Tiber river. Stories are told combining different communication paradigms: cinema, theatre, poetry, augmented reality and game-alike strategies, tied together for the first time in the Cultural Heritage field.

2. THE PROJECT

The *Virtual Museum of the Tiber Valley* has been conceived in order to increment and disseminate the knowledge and the affection towards the territory north of Rome, crossed by the Tiber river, an area 40 km long x 60 km wide. It has been developed by CNR-ITABC in collaboration with E.V.O.CA, supported by Arcus S.p.A. and the Italian Ministry of Cultural Heritage. As the VM aims also at stimulating people to visit the real places, an integrated communicative system and multimedia installations have been realized, diffused in local museums and inside more attended and relevant institutions in Rome.

Starting from a cross-disciplinary 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. The Tiber river is told establishing interconnections among geography, geology, archaeology, architecture, botany, history, literature and mythology, art. One of the results of the project is an attractive VR application characterized by gesture-based interaction and an innovative approach in interactive storytelling. It is accessible as permanent installation in the National Etruscan Museum of Villa Giulia Museum, in Rome, since December 2014 (see Fig.1). This installation is the focus of the current paper. The visualization is distributed on three aligned 65" screens, arranged in a semicircle, in order to arouse a feeling of immersion and perceptive involvement. The user migrates among different "avatars" to explore four virtual scenarios:

1. "*On the spirals of the Tiber: the landscape of the origins*": the user can fly, like a bird (using his arms), over an evocative 3D representation of the middle Tiber valley landscape. The topography is rendered with an evocative and visionary style; 3D graphics resemble a game, the sounds have been composed redeploying traditional folk songs and flock bells. Crossing magic circles, the user can travel back in time, activating movies with stories related to: a) the geological and geomorphological evolution of the territory; b) the potential landscape in the VIII-VII century BC and the birth of cities (3D reconstructions).
2. "*The secrets of the river"*: swimming underwater in the deep of the Tiber like a fish, the visitor can experience the memory of the river; he meets fluctuating images, iconographies, sounds, literary fragments taken from ancient and contemporary poets and authors. Literary quotations come out from a multitude of voices. The visitor uses his arms to follow these images/memories. Movements of other fishes are controlled by artificial intelligence and swarm dynamics.
3. "*Mena's story, Volusii's Villa*": the user acts like a man, walking through a possible 3D reconstruction

of the villa in Augustan time. Here he is involved in the dramatic story of the freed slave Mena, an imaginary character but historically plausible. The archaeological and historical context is used as scientific background of this engaging tale. Through gesture-based interaction, the visitor can navigate the space: he can relax following a predefined camera path, along which he can stop in every moment and look around to analyze details of the architecture and decoration (guided tour with limited interaction).
4. "*Here only you can see me. Lucus Feroniae"*: the user walks through the ancient Roman settlement of Lucus Feroniae reconstructed in 3D during Tiberius' and Trajan's time. He follows predefined camera paths but he finds crossroads where he can choose the "direction" to access different stories and places. Real actors (filmed on a green screen) have been integrated in the virtual scene to represent the ancient characters performing their daily activities. Augmented reality solutions have been implemented as, during the exploration, the current archaeological site and its 3D reconstruction are shown in parallel on the three screens.

Figure 1. VR Installation in the National Etruscan Museum in Villa Giulia (Volusii's Villa scenario)

The user can access scenarios in the order he prefers and he can interrupt each experience in every moment, jumping to another one.
In this installation layered narratives, natural interaction interfaces, embodiment and novel approaches in the integration of different media are considered essential for the cultural experience of end users. They are used to let the visitors feel important and crucial, and to involve them also emotionally. One person at a time can guide the system in the interactive area in front of the screens (4m x 4m). The other users (about 15 persons) can watch from the space all around and they can alternate in every moment in the active role. The interaction interface consists in few coloured circles on the floor (replayed on the screen): when the user walks up to cover a circle, the corresponding scenario is loaded. Moving on the bigger yellow circle in the center, the user can use his arms to explore the selected scenario. A blue silhouette of a figure is always present in the bottom right part on the central screen, suggesting the gestures the user has at his disposal to explore the active scenario (Fig.1). Microsoft Kinect (first generation) has been used for motion capture; it doesn't require any calibration and the user is immediately identified and tracked by the system. The application has been developed in Unity3D. For further information on the systems and the scientific background, please refers to Pietroni et al. [Pie13]. Beside, authors suggest having a look to the demo movie at https://vimeo.com/album/3841439/video/129867454.

2.1 The virtual museum in the real museum

The VR application is located at the first floor of Villa Giulia Museum, in a room dedicated to the Faliscans and Capenates (populations living in the middle Tiber Valley before the Romans' conquest). Entering the room, the visitor can see artifacts in the showcases and, beside, he can interact with the installation. People arrive in this place after having crossed dozens of rooms whose collection are mostly organized according to taxonomical criteria. Thus they are often tired and maybe bored. Authors have not conceived and "designed" the virtual museum for this space: its expected final destination was a secluded and dark room in Villa Poniatowksy, exclusively destined to this installation: a perfect environment to favour the concentration, even if more peripheral. However at the end of the project this precondition failed and the present location in Villa Giulia was considered a possible alternative. Nearby the interactive area, two printed panels and a video tutorial running in loop in a small TV, have been put to introduce and support the visitors' experience. Authors suggest watching the tutorial movie at https://vimeo.com/album/3841439/video/127130786.
After the opening of the installation, authors wanted to investigate the efficacy of the installation in the whole context. The survey has been carried on in Summer and Autumn 2015 on a heterogeneous sample of 117 visitors. In sections 2 and 3 results will be presented and discussed.

3. SURVEY

The core content of User Experience (UX) studies is ensuring that individuals find value in what they are using, playing with, experiencing. In order to be perceived as a meaningful "moment", VM projects must be credible, desirable, useful and usable [Bar94],[Kot09], [Mor06]. When facing digital products, and VR environments in particular, users have the chance to immerse themselves into a context of informal learning, where cognitive and sensory-motor processes (i.e. attention, memorization, pattern recognition, enjoyment, performance, embodiment, emotional involvement etc.) take place [Mat09]. With recent development in ICT and new advanced

applications, the need to understand how people react to digital cultural heritage projects, especially museum visitors, is extremely increased.

3.1 Multi-partitioned analysis

After a long experimentation under the V-Must project [Pes15] [Gra15] to find the best strategy to conduct usability and cognitive studies on Virtual Museums, the evaluation of on site installations has been done using three different techniques:

1. **Active and passive questionnaires.** They reveal basic information about:
- Demographic data (gender, age, occupation…), which are essential to understand users' profiles, as these are significant in providing background knowledge for later analysis;
- Notions concerning the user's knowledge or comfortability with the field of new digital technologies and virtual heritage;
- Detailed experience with specific application's case study.

These are fulfilled by the single user, after their experience with the application.

2. **Driven scenarios.** They allow users to test their abilities and prove their attitudes by means of tasks, while raising up spontaneous impressions. This is possible through the usage of "Thinking Aloud" method, which makes users tell the operator whatever comes into their mind in relation with the experience. The tasks to be accomplished are pre-defined and follow a fixed sequence, articulated by the operator. The user is required to solve these tasks and then to evaluate his performance: if it was easy or not, successful concluded or failed, etc.. The outcomes of this guided virtual exploration, are continuously put in comparison with direct observation made by the operator that highlights relevant aspects of users' feedback on the application's usability, content accessibility and overall engagement.

3. **Observations** (made by external operator). They are essential to have an overview of the context of use and the users' general behaviors and attitudes towards the application. A pre-determined list of features to observe are established and put in sequence, in order to have as accurate and equal framework as possible.

This multi-partitioned analysis turns to be greatly useful when investigating both qualitative and quantitative data (see detail in 2.2.1), because it gives an insight on problematics, viewing the issue from different perspectives. This allows the operator to highlight discrepancies in what was told and what was observed, to verify expectations (of authors and users), and to investigate both usability and comprehension. Moreover it allows us to understand if there is a correspondence (and how deep it is) between difficulty of use and frustration/sense of failure, or on the contrary not necessarily difficult of use generates the desire to abandon the experience. From the **open comments** it is also possible to know the general feeling of the public towards the virtual experience proposed inside the real museum.

3.2 Target and Goals

3.2.1 Target

The survey has been conducted on 117 visitors of different ages and technological attitudes. We have investigated groups' dynamic of participation while interacting with the system, to understand if users naturally change role from active participant to passive observer, alternating and cooperating during the experience. The monitoring of both users typologies has been useful to confirm or reject the authors' preliminary suppositions: passive users generally pay more attention to the content while active ones could probably be more focused on how the system works and how to interact with it.

3.2.2 Goals

The goals of this survey have been (a) to firstly test the attractiveness of the installation, the usability of the system, its main interface features and interaction modes; in parallel, (b) its educational potential. Specifically, for the former, we have analyzed the behaviours of people entering the room, basically if they were immediately attracted by the virtual contents (and by which aspect in particular) and successively by the showcases containing the real artefacts, or the contrary. Regarding the usability, we have examined the interaction between the user and the system to see if the interface elements and the required gestures are able to facilitate the exploration of the installation. We have also analyzed the time of usage and the information accessibility, whether it is easy to go through them or not. We finally have tried to retrace the mental processes that led users to navigate the virtual museum, reaching a satisfying experience. Furthermore, as mentioned in section 1.2, one of the secondary goals is the analysis of pertinence of the exhibition spaces according to the virtual experience modalities.

3.3 Strategy

3.3.1 Qualitative vs. quantitative analysis

The collection of meaningful data sees the combination of two investigative strategies:

1. Quantitative data retrieval. This method is effective to obtain a large number of information units. A statistical analysis should be made possible. We can retrieve quantitative information thanks to:
- multiple-choice questions
- yes-or-no questions
- scales (i.e. give value between 1 and 5….)

2. As quantitative data are often not adequate as a stand-alone evaluation method for the achievement of interpretable results, **qualitative data retrieval** is planned. By using this method, the reasons "behind" the quantitative data should be identified with the purpose of obtaining a better understanding of the

users' reactions and deduce some suggestions for future improvements of VMs. We can retrieve qualitative information thanks to:

- open questions
- free comments
- "other" blank space

Often these strategies investigate similar aspects and they are deliberately repetitive, with some variations and in-depth analyses, so that the user's responses can be properly verified. This is important to understand responses' level of reliability, the easiness of reply, and the users' feelings towards specific themes.

3.3.2 Working plan

The survey has been done over the course of 16 days during the summer. End users have been interviewed alternating between normal working days and festivities, in different hours of the day. In this way we have obtained a representative and heterogeneous sample. Promotional days have been organised too, inviting people to come to the museum and become a "tester" of the application.

Survey information have been mainly collected using traditional paper questionnaires - as this has allowed us to reach several users at the same time. In some cases, we have also adopted questionnaires running on iPad - for its practicality and technological flexibility.

3.4 Analysis and interpretation of data

3.4.1 Demographic data

Of 117 observed users, 44 visitors have been involved in the driven-scenario, 46 answered the active questionnaire and 40 the passive questionnaire. Out of 117 global individuals, 107 interviewed left their personal data, even if in anonymous form: the majority has been women (60%), mostly coming from Europe, 68% from Italy. The users' age is homogeneously spread with a pick of 22% between 40 and 50 years old, followed by 18% between 20 and 30. A very low percentage of younger has been registered, although the innovativeness of the VM. This datum can be easily explained by noticing that the average age is in line with the usual museum visitors' demographics.

3.4.2 Installation's attractiveness

When visitors stop in the Falisci and Capenati's room the attractiveness of the system compared to the traditional showcases is confirmed. According to the **observation,** out of 117 active and passive users, 75% have been attracted exclusively by the installation and did not stop to look at the other objects on display. Users recognise the space as being an interactive area, indeed 63% actively participate by controlling the system, while 34% observe another visitor (only 3% do not stop in the area at all).

From 86 global **questionnaires**, 28% of people says to have been attracted by the graphics in the scenes, the color and the atmosphere. 26% have stopped because they consider the installation to be an unusual thing in a museum and 21% because of a personal interest for the subject (see Fig.2).

From 116 **observations** made, it emerges that 76% do not see the poster explaining the project and 81% neither the small TV displaying the video tutorial.

Questionnaire results confirm that 74% do not notice the video tutorial, while there is a moderate difference regarding the poster - which is not noticed by 51%. This divergence can be explained referring to different factors such as a margin of error in conducting observations, unreliable or uncertain answers from users (6% of the cases). In the end, there is the possibility that the user is not answering honestly or refers to another poster.

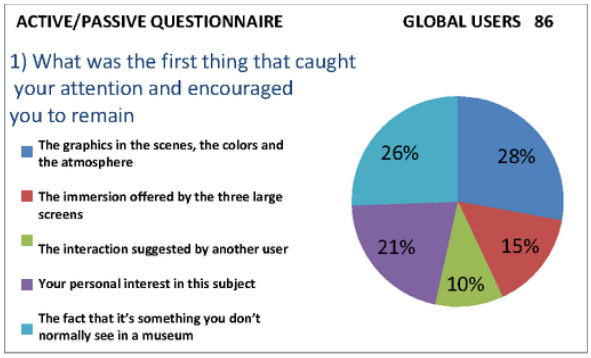

Figure 2. Attractiveness of the system

3.4.3 Usability

From 73 **observations** of active people, it emerges that 93% understand how to use gestures to interact with the system once they enter the interactive area, even if 27% have problems with the gestures and they try to ask suggestion to the operator. The operator provides minimum prompts to the user in the following cases: if the user does the appropriate gestures but is not on the yellow circle; if he moves but does not manage to understand how to interact and he seems near to leave the installation. The first attempt is to suggest the user to examine panels and video-tutorial and then try again.

During the **observation** it has been discovered that **at the very beginning** of the interaction, gestures are performed in different ways: 92% understand the blue silhouette of figure, 45% of them perform the gestures correctly; 47% reproduce the suggested movements but not in a efficient manner; only 8% have difficulty in interacting with the system at all. From the comments collected during the survey, it has been possible to single out the reasons why users could not perform the gestures correctly: 35% do not concentrate or they think it is a game, while 50% do not follow exactly the suggestions of the blue figure.

For the other users that follow the gestures correctly (45%), it emerges that 8% manage to synchronize exactly and replicate every gesture, instead of performing freely the gesture grammar suggested by the blue figure (as it should be done) (see Fig.3).

From a conceptual point of view, this result can be explained by saying that gestures are simulated by a virtual avatar in a continuous sequence but without giving information about the chance to freely use them. Moreover, each of the four scenarios implies different gestures to interact with the system, in fact the user migrates from an avatar to another one and this can be perceived as an amusing factor but sometimes, maybe, misleading.

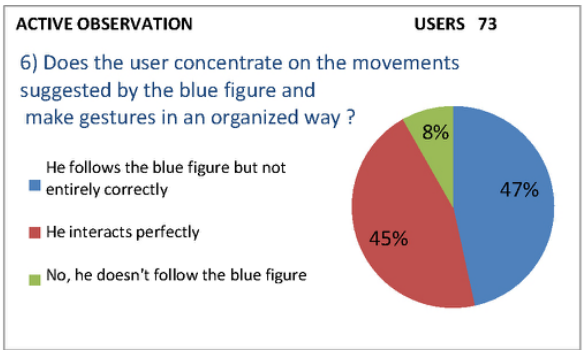

Figure 3. Usability related to gestures

Nevertheless, from **questionnaires,** it emerges that the function of the blue figure is understood in 91% of the cases, and 81% of global users answer correctly about its function, replying that "it is a guide that suggests movements". 5% of users say erroneously that it is "a mirror of yourself" (exclusively passive users) and 7% claim to not understanding its function whatsoever. 2% do not answer.

Of the 46 active **questionnaires**, 50% register an initial difficulty but after a while, throughout the interaction with the system, they are able to comprehend how it works.

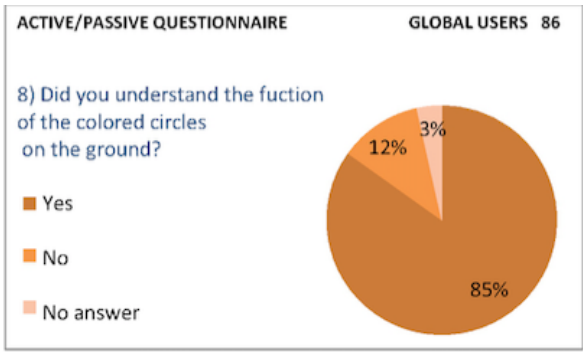

Figure 4. Usability related to the floor interface

For 35% the tasks to accomplish to access information or change scenarios are simple, while for 15% they are difficult from beginning.

From **questionnaires**, it is confirmed that the graphic interface of the floor and the screen is quite well understood. Out of 86 global visitors, 85% understand the function of the colored circles on the floor and 51% specify, correctly, that they are used to change scenes. 12% do not understand their functions and how to perform them (see Fig.4).

3.4.4 Dynamics of participation

From the **notes** taken during **observation and questionnaires** the dynamics of participation can be identified: of 117 observed users, 30% are couples that change between active and passive roles, 31% are groups of 3 up to 7 people and 36% are single persons; only 3% are cases in which entire family or a couple interact with the system playing just one person. In all other cases there is an exchange of role between active and passive experience. There are two questions in the active and passive questionnaires which help understanding the motivations that encourage user to be either an active participant or an observer. In the former, 61% of active users have seen someone else interacting with the system and in 82% of the cases they prefer to be the protagonist, as opposed to 18% that prefer to be the observer. 85% of passive users says they would have liked to interact but they did not. 50% have different reasons i.e. factors external to the application like a lack of time, or the area was occupied by other visitors. Only 7% says that they are not interested and not attracted by the system.

Slight differences appear when comparing the two types of the questionnaires: 5 active visitors prefer the archaeological and historical scenes with 30% of preferences with Villa of Volusii and 28% with Lucus Feroniae; the passive users prefer the symbolic and evocative scenes, where 32% of users vote for the flying scene and 27% for the underwater scene.

3.4.5 Satisfaction

From data collected by **active observation** we see an homogeneous percentages about the duration of user experience. Out of 73 visitors, 28% stay in the interactive area between 15 and 20 minutes, showing a great interest for the VM, independently from the real usability and the final appreciation. It follows a 25% of people who interact between 5 and 10 minutes and 23% between 10 and 15 minutes, with an equal percentage that even overcomes 20 minutes. Only 1% stay for less than 4 minutes. 73% of the active users explore more than one scenario for more than five minutes. This datum is extremely positive given the articulation of the application in multiple scenarios and different levels of learning. This can mean that users are not "afraid" of the interactive

installation, even in cases their performance is not always satisfying.

The virtual worlds explored for a longer time are those of Lucus Feroniae with 49% and the flight scenario with 48%. These are followed by the Villa of Volusii with 36% and the underwater scenario with 30%. It is important to notice that this latter is the scenario with the most de-structured storytelling: here, indeed, the stories do not follow a precise storyline but are poetic fragments floating in the deep of the water. On the contrary, Lucus Feroniae is the most linear scenario, with pre-determined narrative episodes connected by a predefined path. During the visit the user finds some crossroads and he can choose which story to enter. That is why users remain for a longer time: they do not need to perform gestures all the time, the story proceeds anyway, showing the 3D reconstructions and the Feronia's tales deployment. The same goes for the flight scene, which can be interesting and relaxing for users given the particular setting (i.e. blue color predominance; natural gestures…) and the didactic videos that encourage them to stay for a longer time.

In the direct questions in the **questionnaire,** a certain homogeneousness emerges from the quantitative and qualitative data about the appreciation of the different scenes. Out of 86 global users, 26% prefer the flight scenario, 26% the Volusii's Villa, 24% like the underwater scene, 23% the Lucus Feroniae scene and 1% of the users don't answer. From comments left by users we know the reasons why these scenarios are liked. The archaeological historical scenes are liked for the 3D reconstruction of the environment, the site and stories from the characters. The flight scene and underwater scene were liked because of the sensation it created by connecting the way of interacting with the graphics.

Out of 86 global visitors, 44% indicated that the aspects of the system they preferred mostly are the graphics, the colours and the atmosphere and for 39% the exploration based on body movements. Scripts, music and visualization on the three screens seem to be considered of secondary importance.

Comparing these answers with the comments left by the users it emerges that 90% found the experience to be enjoyable for a series of reasons, because of the given information and because it was a new experience, involving and interactive.

The visitors did not exhaust their interest in the Tiber Valley Museum in one visit, out of 86 global users 88% declared that they would return to Villa Giulia Museum. 98% of the cases they are curious to visit the actual places with 64% preferring to visit the archaeological sites and 31% the villages and natural areas along Tiber Valley.

In the free comments about appreciation, two passive users said:" I liked because it's not passive" and "it makes you participate". Other people say "it's surely a beginning of another way to experience the museum", perfectly matching the intent of developers and the new communication strategy that the museum is undertaking.

Eight people expressed a comparison between the real and the virtual museum. They wrote: "it's something different from ceramic", "it gives more information", "the system permits easy understanding of that on display in the showcase", "it permits the ability to connect the objects in the showcase to the context and it inspires new visits and curiosity about the archeological site" and "it helps to introduce the public to art in an enjoyable way".

Other people said "It's rare to find an application like this in a museum", "Normally the interactive applications are dull, instead this is involving". Two active users declared: "too noisy and complicated", "too interactive, it seems like a videogame"

3.4.6 Educational potential

Attention and recognition

Both the active and the passive **questionnaires** ask the user the recognition of scenes out of a collection of 6 images, 4 effectively corresponding to the installation and 2 false. The 2 false images occur in 9% of the cases.

Another question asks to connect various images of scenarios with the corresponding name. The flight and the underwater scenes are matched correctly with a percentage of 71% and 66%, respectively. The Lucus Feroniae and the Villa of Volusii scenes are correctly matched 51% and 43%, respectively. It has been noted that a lot of users declined to answer this question, about 28%. The highest number of incorrect answers however are for the Villa of Volusii with 27% and 23% for the Lucus Feroniae, while the percentage of incorrect answers in the flight scene is 2% and 5% for the underwater scene. It is important to notice that both Lucus Feroniae and Volusii's Villa are both roman sites with some common elements in the story, so this result can be explained. Moreover, while in the flight and the underwater scenes the users need simply to evocatively move in the 3D space with fragmented information provided, Lucus Feroniae and Villa of Volusii scenes are more focused on a topic and need to be followed carefully to understand the storyline.

Memory

Using a series of multiple-choice questions in the **questionnaire** we examine the memorability of the content: the user is asked to remember information provided by characters they have met or to recognize portions of landscapes or specific architectures. Almost all the answers are good: of 86 global users, 62% answer correctly to the questions about the goddess Feronia, 59% to questions about Lucus Feroniae and 68% about the flight scene, 48% to the Villa of Volusii questions; 30% of users decline to answer any question. Despite the considerable level of evasion, this datum is promising, given the innumerable visual inputs and information provided;

this means that users pay actually attention to each of the four scenarios, memorizing the main graphic elements.

Reasoning
Users manage to orientate themselves within the archaeological scenes, with 75% of active users saying that they have understood the function of the "small dot" on the right screen (see Fig.5 and Fig.1).
Of the same group, 71% specify, correctly, that it is used to "indicate your position within the scene". 20% claim not to understand its function, 5% do not answer. From open questions in **driven-scenarios**, the operator understands that users easily recognize the GUI elements and understand their function. In the flight scene, out of 25 users, 68% understand that they are flying over the Tiber Valley; in the Lucus Feroniae scenario, out of 12 users, 83% understand that they are looking at a real archaeological site which has been reconstructed from the same point of view (see Fig.5). Of these, 16% require prompting - so to say they recognise it only when asked.

Figure 5. Lucus scenario: on the left the real site, in the center the reconstructed site from the same point of view, on the right a perspectival view with the user's position evidenced by a white dot.

4. DISCUSSION

4.1 Strength points of the installation

4.1.1 Emotional experience

The design of the *Virtual Museum of the Tiber Valley* aims at making technologies "warm", supporting the capacity of the cultural (and virtual) heritage to generate a feeling of intimate enjoyment, that could translate in spontaneous actions of participation and visit, founded on an enhanced knowledge.
But how can *emotion, involvement, and participation* strengthen the educational potential of a Virtual Museum? This survey has found some answers: historical and archaeological scenarios have been appreciated mostly for the 3D reconstruction of architectures and gardens and the story of major characters allowing to get in touch with the past historical events; evocative scenarios whereas, like flight and swim, have been appreciated for the accurate "sensation" of being there, the calming and relaxing mood created by the interaction, finally for the equilibrated atmosphere and restful colors of the graphics. All these aspects have pushed museum visitors to pay more attention to the installation, gaining benefits out of the contents, as they affirmed.
In general, the graphics is not only an attractive factor, but a stimulus, a fundamental ingredient to make users being involved in the experience. Contrary to the authors' expectations, passive users show a preference for the aerial and underwater scenarios; instead active users prefer archaeological ones where they are involved with less spontaneous gestures. Maybe this can be explained in the light of the theory of mirror neurons [DiD15]: the observers experience a sensation of pleasure in perceiving others swimming or flying.

4.1.2 Gesture-based interaction

Similarly to other VR installations previously developed for museums, and in line with other evaluations conducted [Pie13], [Pes15], the *Virtual Museum of the Tiber Valley* has demonstrated that gesture-based interaction attracts and involves persons of every age and even not familiar with technological devices, as it just requires to perform simple actions in front of the screen. Looking at the average age we can notice that, although the audience is not digital-native, it is still pushed to try the VM installation, spending between 15 and 20 minutes playing with it, inside a museum. Thus not the single good performance but the overall experience and the kind of contents seem to mostly affect the success of the Tiber River project. Another interesting verification is that among active users we have a major percentage of people over 50 years old. This confirms that the technological barriers seem to not divide young from older audience (as observed also in previous projects using natural interaction). Surprisingly, regarding the appreciation, out of 10 people over 60 years old, 6 affirm that the aspect they preferred mostly is the exploration and the interaction, even if the incorrectness in performing gestures seems to be a bit more frequent in this age range.
No meaningful differences emerge between males and females.
Moreover, even if the interaction has been designed for one user at a time, it encourages cooperation, participation, emulation, thus multiplying the impact. This aspect is revealed by users willing to play with the system another time or in other occasions. The curiosity to see the "unexpected" inside a museum like Villa Giulia, brings people to stop and see what is going on with the virtual reality installation.The survey has shown that in most cases difficulty of use does not correspond with frustration and desire to abandon the experience. There is a sense of embodiment [Var91], [Pie13], playful and aesthetic pleasantness that goes beyond gesture-based interaction, making the experience not frustrating but fun, similar to a game, attractive even if not always simple. In our case, users have indeed affirmed to have a pleasant experience while using the installation, new and involving. Definitively, we can confirm that gesture-based interaction let us expand the potential public of virtual installations inside museums.

4.1.3 Storytelling

Authors of the *Virtual Museum of the Tiber Valley* tried to create an involving storytelling going beyond the traditional paradigms of virtual reality through the inclusion of techniques coming from games, theatre, cinema, augmented reality.

This survey let us understand that the undertaken direction in the virtual museum conception (especially regarding "on site" installations) is well accepted and very promising; results in fact reveal that Lucus Feroniae and Villa of Volusii (where storytelling is more structured and adopts some historically plausible "fictions") have reached great appreciation, especially among active users, stimulating curiosity and interest - observable in the positive level of content memorability. Also "visual moods", image effects, camera behaviours and soundscape help creating "the story" to be brought and re-thought at home, after the museum visit.

Authors have received many requests from schools that are interested to continue this educational program in the real context, to have a direct contact with the remains. Further results are expected in the next future, because the new archaeological museum of Lucus Feroniae has been re-opened on the 23rd of April 2016, together with the site of Volusii's Villa, after a long period of unavailability. The virtual museum is actually working as a vehicle of interest, multiplying the public's expectation for the new opening. A great interest towards both the virtual and the real visits is demonstrated also on Facebook at www.facebook.com/muvivate/?fref=ts.

The future research needs to continue following this approach, bringing screenplay and storytelling more and more powerful and professional, finding a link between the way to tell stories and interaction interfaces - possibly clearer.

4.2 Weaknesses of the installation

4.2.1 Gestures interpretation

Despite the graphic interfaces being rather well understood, an element seems to be a bit problematic: the blue silhouette, bottom right on the central screen, showing the gestures the user has at his disposal to explore the environment. Gestures are shown in a loop sequence and each one lasts few seconds. This choice was done to keep the instruction as simple as possible: a unique silhouette occupying a limited portion of the screen and catching the user's attention. The authors' assumption was that, once understood the gestures, the user would have automatically performed them freely, to follow the desired directions during the exploration. On the contrary the survey has shown that many users synchronize themselves with the silhouette's gestures, rather then feel free. It is interesting to notice that this misunderstanding is much less evident when the user is required to swim and flight: in this cases, being the embodiment more immersive, the users are induced to be free and spontaneous in performing actions. The problem does not exist in case of crossroads, when the poses of the blue silhouette are multiplied on the screen to suggests how to go left, right, forward, (see Fig.6).

Figure 6. Poses of the silhouette on crossroads

4.2.2 Support and tutorials

This survey has shown the importance for the public to be supported by the museum's staff to have a full comprehension of the potentialities of interactive installations, in fact in some cases (generally 10% with peaks of 30-40%) users have reached the goal after a suggestion coming from a physical guide (in this case the operator). In few cases panels or video-tutorial have been noticed and effectively used by visitors to learn how to interact with the system. Users generally prefer the immediate experience to learn, facilitated, in this case, by the easiness of body gestures. In case of failure in the interaction, they prefer to be assisted by a living person. This condition recurs several times in virtual installations proposed in real museums, even if the interface design is simple and minimal. In general, while living an embodied and sensory-motor experience, the public tends to evade the reading of texts on panels (even when such texts are very short) or the GUI on the screens explaining how to use the installation.

4.3 Dynamics of participation

4.3.1 Active and passive users

An interesting result concerns the comparison between active and passive users. Authors supposed that individuals directly using the installation would have been more focused on the interface and gestural aspects, while observers would have payed more attention on stories and contents. Actually, results of the survey tell us the contrary: the former, more concentrated in the interactive area, are perceptively absorbed by storytelling and scenarios; the latter, instead, are a bit more distracted by other museum visitors. 23% responses of questionnaires reveal that the museum setting do not contribute positively in making the users concentrate and vigile on what is going on the three screens.

4.3.2 The role of the museum's personnel

Most of the public has expressed the wishes that future evolution of museums can follow such an approach, to overtake the static nature of actual exhibitions. However results have confirmed that not only the research in the field of virtual museums need

to evolve, but the museum's management as well, and the ability/availability of the museum's personnel to support the public dealing with interactive experience and digital technologies. Technologies represent a great opportunity to transmit culture contents to the public but they cannot be abandoned to themselves. Definitively strong collaboration between researchers, creative talents and museum's curators and personnel is required, aiming at strengthening the central role of the public, as main addressee of the cultural experience.
In the case of Villa Giulia Museum, it could happen that some museum's keepers turned down the volume of the application in order to be not disturbed during their work. This has negatively affected the installation's use.

5. CONCLUSIONS

Recently, psychologists, neuroscientists and philosophers have put in evidence the role of emotions in creative processes and intuitive human knowledge: the knowledge and experience of something always requires the activation of an emotion [Cia01]. Emotions can motivate understanding, self-identification, contributing to higher cognitive process of learning [DiD15]. Therefore they represent a method to easily access the culture for everybody, promoting a greater social inclusion. This is confirmed by several evaluations of the user experience inside virtual museums realized in the past years [Pie13] [Pes15] and by the one presented here: users' main expectation is to *enter and interact inside stories*, personalizing their experience, as if they would have been really there, with an active role. Storytelling, embodiment, evocations are key issues. It is of crucial importance to evaluate how people react to digital contents and interaction approaches proposed by researchers and creatives; it is really difficult to match the expectations of such an heterogeneous audience in museums, but some fundamental criteria making an interactive installation successful are today more and more consolidated.

6. REFERENCES

[Bar94] Barrett, E., Sociomedia, Multimedia, Hypermedia, and the Social Construction of Knowledge. Digital Communication series, The MIT Press, 1994.

[Cia01] Ciarrochi, J., Forgas, J.P.. Mayer, J.D., Emotional intelligence in everyday life, in Psychology Press, Taylor & Francis Group, 2001.

[DiD15] Di Dio, C., Ardizzi, M., Massaro, D., Di Cesare, G., Gilli, G., Marchetti, A., Gallese, V., Human, Nature, Dynamism: The effects of content and movement perception on brain activations during the aesthetic judgment of representational paintings, in Frontiers in Human Neuroscience, 2015.

[Gra15] Graf, H., Keil J., Engelke T., Pagano A., Pescarin S., A Contextualized Educational Museum Experience - Connecting Objects, Places and Themes Through Mobile Virtual Museums. In Proceedings of Digital Heritage 2015, Granada, Ed. IEEE, 2015.

[Kot09] Kotsakis, K., Liarokapis, F., Sylaiou, S., Petros P., Virtual museums, a survey and some issues for consideration. Journal of Cultural Heritage, Vol. 10, 2009, pp. 520-528.

[Mor06] Morganti, F., Riva, G., Conoscenza, comunicazione e tecnologia. Aspetti cognitivi della realtà virtuale. LED ed., 2006.

[Mat09] Matlin, M., Cognition, Holboken, NJ, John Wiley & Sons, Inc., 2009.

[Pie13] Pietroni, E., Palombini, A., Arnoldus H., A., Di Ioia, M., Sanna, V., Tiber Valley Virtual Museum: 3D landscape reconstruction in the Orientalising period, North of Rome. A methodological approach proposal, in Proc. Digital Heritage 2013, Vol. II, IEEE, pp. 223-331.

[Pes15] Pescarin et al., Del. 7.1 Virtual Museum Quality Labels. V-Must.net deliverables' collection, Ed. 2015.

[Pie13] Pietroni, E., Pagano, A., Rufa C., The Etruscanning project: Gesture based interaction and user experience in the virtual reconstruction of the Regolini-Galassi tomb, in Digital Heritage Proceedings 2013, Marseille France, IEE, ISBN: 978-1-4799-3169-9, Vol II pp. 653-660

[Var91] Varela, F., Thompson, E., Rosch, E., The Embodied Mind. Cognitive Science and Human Experience, MIT Press, Cambridge, 1991.

[Ant15] Antonaci, A., Pagano, A., Technology enhanced visit to museums. A case study: Keys to Rome. In proceedings of INTED2015, Madrid, Spain, 2-4 March 2015.

[Goc13] Gockel, B., Eriksson, J., Graf, H., Pagano, A., Pescarin, S., VMUXE, An Approach to User Experience Evaluation for Virtual Museums. In Proceedings "The HCI International 2013", Ed. Springer, Heidelberg.

[Wit98] Witmer, B. G., Singer, M. J., Measuring presence in virtual environments: A presence questionnaire. In "Presence", Vol. 7, No. 3, June 1998, 225-240.

[Sla99] Slater, M. 1999, Measuring presence: A response to the Witmer and Singer Presence Questionnaire. In "Presence", 1999, 8(5), 560-565.

[Syl08] Sylaiou, S., Karoulis, A., Stavropoulos, Y. and Patias, P., Presence-Centered Assessment of Virtual Museums' Technologies. In "Journal of Library and Information Technology", Vol. 28, No. 4, July 2008, pp. 55-62 , DESIDOC.

[Fan15] Fanini, B., et al., Engaging and shared gesture-based interaction for museums the case study of K2R international expo in Rome. In Proceeding of Digital Heritage, 2015, Granada. Vol. 1. IEEE, 2015.

[Fan15b] Fanini, B., and Pagano, A., Interface design for serious game visual strategies the case study of "Imago Bononiae". In Proceeding of Digital Heritage, 2015, Granada. Vol. 2. IEEE, 2015.