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SCIentificRESearch and Information Technology
Ricerca Scientifica e Tecnologie dell'Informazione
Vol 5, Issue 1 (2015), 69-76
e-ISSN 2239-4303, DOI 10.2423/i22394303v5n1p69

MULTIMEDIA DISCOVERY OF THE LEONARDO'S VITRUVIAN MAN

E.S. Malinverni, E. d'Annibale**, E. Frontoni***, A. Mancini***, C. A. Bozzi*****

*Dipartimento di Ingegneria Civile Edile ed Architettura (DICEA)– Università Politecnica delle Marche, Ancona, Italy.
**Istituto per le Tecnologie Applicate ai Beni Culturali (ITABC), CNR, Roma, Italy
***Dipartimento di Ingegneria dell'Informazione (DII)– Università Politecnica delle Marche, Ancona, Italy.
****EVE S.r.l. Spin-off company of Università Politecnica delle Marche, Ancona, Italy

Abstract

The dissemination and exploitation of cultural heritage milestones by using multimedia and interactive technologies continuously and quickly grows capturing the attention of academia and companies. It is necessary to adopt the state of the art technologies to present and make bi-directional the interaction of users with cultural heritage objects. In this work, we present two different applications of novel technologies applied to the Vitruvian man of Leonardo. The first application is the mirror that exploits a 3D depth sensor to compare the proportions of a user with the perfect ones of the Vitruvian man. The second application is a complex interaction between a complete novel 3D model of the Leonardo's Vitruvian Man, sounds and image effects inside a 360-degrees hologram. These two systems are the results of interaction between academia and the 3D EVE spin-off company.

Keywords

Leonardo's Vitruvian Man, Depth-RGB image, Hologram

1. *Introduction*

The research and development of a collaborative multidisciplinary team are applied to ICT fields to give multimedia innovative solutions with high technological impact for Cultural Heritage (Pescarin, 2014). In particular, it is necessary to provide immersive and multimedia solutions to enhance the experience of the users.

Technologies that support gesture recognition, skeleton detection and augmented reality enable new scenarios in the human-machine interaction applied to the Cultural Heritage.

The actual approach to the design of novel system for museums has become more and more User-Centered where it is necessary to involve actively all the stakeholders modelling user(s) deriving a set of functional and not-functional requirements that is the base for the system design. This approach requires a multi-disciplinary design team (Malmsten and Lindström, 2008).

In every product the team, made of young researchers, designs and offers new communication/representation features, putting the user at the center of the multi-sensorial experience (Liciotti et al., 2014)(Frontoni et al., 2013). The user "interacts" and "reacts". Being aware that the cultural evolution of a population goes with the capability of making culture accessible, touching, communicative and exciting,

EVE – Enjoy Visual Experiences is a Spin-off company of the Engineering Faculty of the Università Politecnica delle Marche (Italy) (EVE, 2014) gives the wonder to excite the knowledge.

We present here the research results applied to an exhibition that has proved the innovation and usability of the multimedia solutions.

The exhibition is related to the Leonardo famous drawing of the Vitruvian man, presented through digital interaction products. The promoter of this event is the Centro Studi Vitruviani which, in collaboration with the Università Politecnica delle Marche and Dr. Annalisa Perissa Torrini of the Gallerie dell'Accademia di Venezia (Venice Academy Gallery), have organized in the beautiful Chiesa di San Michele in Fano (Italy) a digital exhibition. The exhibitions was based on the history and other masterpieces related to the Vitruvian man of Leonardo.

The know-how of the academic research team undertakes a venture and gets onto the market

with the help and support of two companies Touchwindow srl e JEF srl strengthened in the field of multimedia communication and ICT solutions for exhibition, and museums.

We show another way to communicate a famous cultural heritage and playing with it, spreading its knowledge to the younger. The original drawing is not accessible and this is the only way to expose it to a wide range of public. The edutainment aspect is resulted immediately clear by the crown of visitors only after few days of the opening.

The surprise is managed by presenting a 360-degree holographic pyramid that shows, by a tridimensional and virtual representation and in real size, the Vitruvian Man drawing, giving the possibility to admire the work as was intended by Leonardo himself in a new dimension (Chiavoni et al., 2011).

In the same place is also set up a completely novel game, named "Mirror", whose purpose is to evaluate the correspondence between the proportions of Vitruvian Man and those of a common individual of the nowadays. Both the products are novel and exclusively performed for this exhibition but they could be tailored to host and show different contents.

The paper is structured as follows. Section 2 introduces the mirror game. In Section 3 the hologram solution is described. Section 4 provides details about the overall assessment and maintenance. In Section 5 the conclusion and future works are outlined.

2. *Mirror game*

The mirror game is an application that exploits the technology of depth and Red Green Blue (RGB) sensors. The user/gamer has to compare itself with the ideal proportion of the Vitruvian man of Leonardo. The Microsoft Kinect offers the technology to instantiate an interactive game.

The main motivation is related to the accuracy, precision and robustness of this kind of devices to indoor and poor-illuminated environments.

We decided to split the RGB-depth processing, game logic and human machine interface in order to optimize the resources for the data processing.

2.1 Depth-RGB Processing and Game Logic

The software has been developed to be modular, efficient optimizing the use of resources as the CPU and GPU.

We developed two modules:

- **Module #1**: this module is responsible for the Depth / RGB Sensor processing and game logic.
- **Module #2**: this module is responsible for the Real time 3D visualization of user over the Vitruvian shape.

The Fig. 1 shows the workflow of Depth / RGB Sensor processing and game logic.

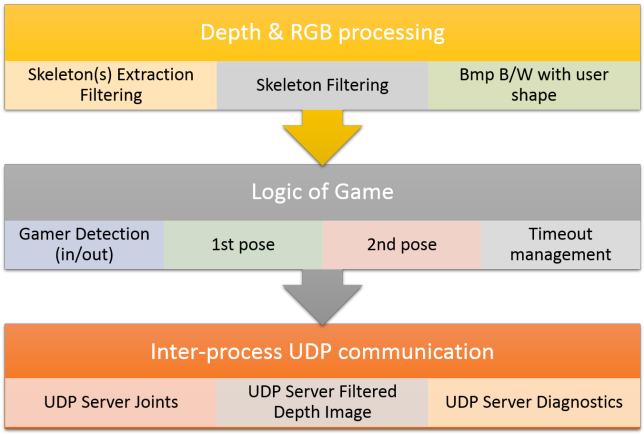

Fig. 1: Workflow of Depth / RGB Sensor processing

The developed software interfaces the Kinect v1 and Kinect v2 Depth / RGB sensors.

We used the Software Development Kits (SDKs) of Kinect v1 and v2 to get the RGB and depth images. The Kinect v2 has the advantage to work fine also in presence of strong and direct light conditions with a higher accuracy in the extraction of skeleton joints.

The application starts looking for a gamer in a given area. We distinguish the following states:

- **WAITING** - the application shows a screen saver to trigger the attention of users close to the game area
- **ENGAGED** – the user entered in the area; the application shows the game rules
- **WAIT4POS1** – the application waits for the reaching of the 1st pose
- **TRACKEDPOS1** – the user reached the 1st pose
- **WAIT4POS2** - the application waits for the reaching of the 2nd pose

- **TRACKEDPOS2**– the user reached the 2nd pose
- **WAITING4EXIT** – the application waits for the exit of user
- **FAILED** – the application is in a failed state due to timeout (e.g., user failed to reach a given pose)

The **Fig. 2** shows the finite state machine of our application.

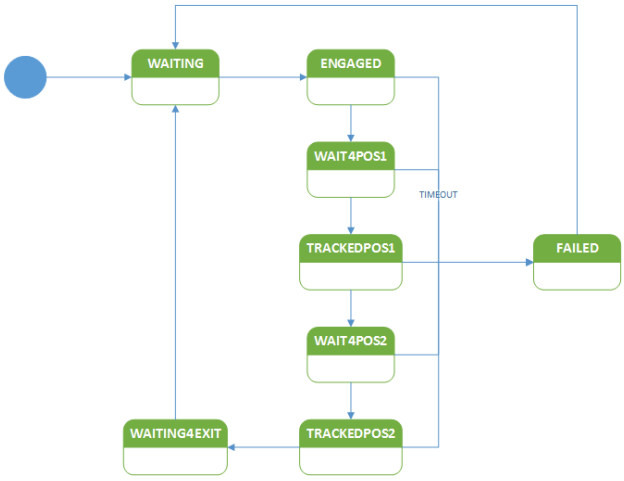

Fig. 2: Finite State Machine of Mirror game.

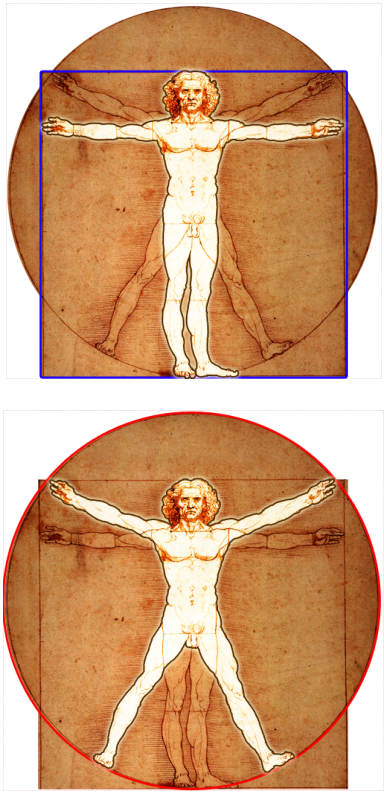

Fig. 3: Top: 1st pose. Bottom: 2nd pose.

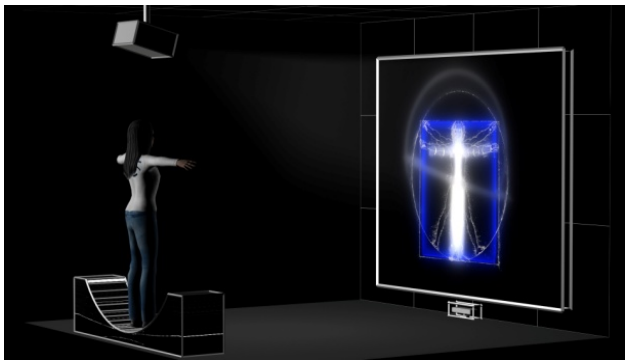

Fig. 4: Simulation of the game.

Fig. 5: Gamers that are trying to measure their self against the perfect proportions of the Vitruvian man.

The **Fig. 3** depicts the two available poses that the user / gamer has to reach compare itself with the Vitruvian man. When a user is detected, we have a change of state that triggers the graphical user interface by a User Datagram Protocol (UDP).

The graphical user interface shows in real time the user shape overlapped over the original Vitruvian man offering an engaging and amazing experience.

The application that processes the depth/RGB data creates three different services used by the graphical user interface application.

We send by UDP with a frequency of 30Hz the following data:

- Monochromatic bitmap of the user shape (320 x 240);
- joints of user tracked skeleton;
- status of game.

The bitmap and joints, as shown in **Fig. 4** (simulated scenario) give the capability to match the user shape to the Vitruvian one.

The joints are also used to calculate indexes of "Vitruvianity" that are proposed to the user when the two poses are correctly reached by the user. The game status is used by the graphical application to drive the user from the start to end of the game.**Error! Reference source not found.** shows a gamer that is trying to measure itself against the proportion of the Vitruvian man.

2.2 Game dynamic pipeline, Graphical User Interface (GUI), Real-time graphic effects

The graphic interface is made of few elements, including an avatar figure depicting the user/gamer, the drawing of Leonardo and its geometries which virtually run around the shape of the user, following the same Artist's rules: the square as element touching the head and the arms/hands when the user is positioned in A, while the circle as element touching arms/hands and legs when he is positioned in B (see **Fig. 6**).

In order to clearly identify the two different phases of the game (square mode and circle mode), an array of elements has been established. Referring to square mode - 1st stage - a *horizontally* turning movement takes place since the user/gamer does not perfectly fit with the Artist's outline. Once he is positioned, the square's outline becomes blue.

Likely, in the circle mode - 2nd phase - a *dynamic* turning movement takes place since the user/gamer does not occupy the exact position, visible on the screen on front of him.

Again, once he is positioned the circle's outline becomes red. In both cases, a message informs user/gamer that he has reached the correct position and he can proceed with the interaction.

Aside the avatar figure, matching with the human being interacting in that moment and the

Fig. 6: Graphic interface overlooking five different game status: WAIT4POS1, TRACKEDPOS1, WAIT4POS2, TRACKEDPOS2 and WAITING4EXIT.

drawings outline appearing on the screen, the application also grants the vision of proportional parameters occurring when the user/gamer tries to fit with the Vitruvian figure.

A supplementary image is presented as a help to indicate in which point he has to position the body.

2.3 Exhibition setup and final environmental layout

The final setup of the application is a semi-circular platform where users/games is invited to get into and start interacting.

It has been designed so to advantage the correct positioning of user/game, especially in circle mode - 2nd stage - with open legs.

The overall layout is flexible and modular, in order to be adapted to space and audience flow necessity.

The hardware needed is a PC, a video projector with wide optic and an infrared sensor,

and a Microsoft Kinect v1 (the v2 version is also compatible with the developed software).

The minimum space configuration is 3(W) x 3(D) x 2.5(H) m.

2.4 Usability and User experience studies

While implementing the application, user tests have been carried out (an amount of 15 people in laboratory) so to understand potentialities and weaknesses in the GUI, in the interaction and in the final involving experience.

The ease to use, the linear game engine and the dynamic of interaction allowed users/gamers to provide positive feedbacks toward this application.

Once it has been setup, the usability has been studied and validated by means of observation sessions and direct interviews to people.

The results of these activities made clear that the designed system has great potential in terms of reliability and overall engagement.

Hence, positive feedback have been released to the staff and no help requests has been asked during the interaction.

3. Hologram

The Hologram allows a visualization of a certain figure inside a pre-defined structure (i.e. modular pyramid system), having the illusion of looking at it as it was suspending in the air (Sidharta et al., 2007).This concept comes from the theatre technique of Pepper's Ghost (see **Fig. 7**).

The latter uses a projected surface and a semi-reflective and semi-transparent glass where the image depiction takes place (see **Fig. 8**).

The original technique foresees the public disposition in front of the scene (i.e. theatre stage) - so in a direct line perspective and hence a unique point of view. In our case, instead, visitors have the chance to turn around the structure and visualize the object all around.

Fig. 7: Virtual simulation of the installation.

To grant an optimal view, 3D virtual simulations have been carried out so to assure visitors a perfect hologram experience, not only from a structural point of view but also from a typological necessity of target users.

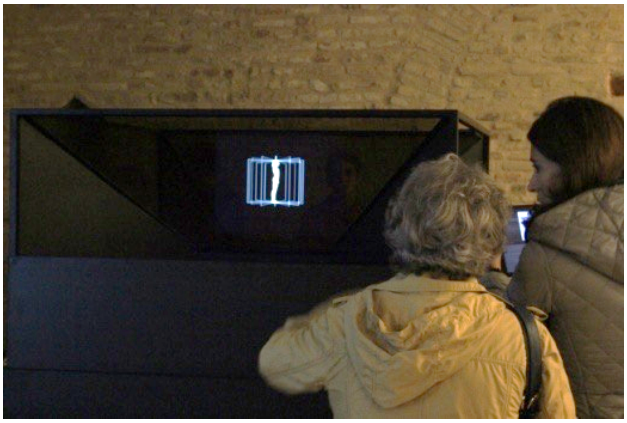

Fig. 8: The developed hologram structure during the exhibition (3D model: copyright Fabio Severini).

3.1 The structure

The dimensions of the structure (as detailed in **Error! Reference source not found.**) are scalable and strongly connected to monitor's dimensions.

The relationship between the 3D virtual simulation of the entire structure and the object's dimensions to be then projected are 3:1.

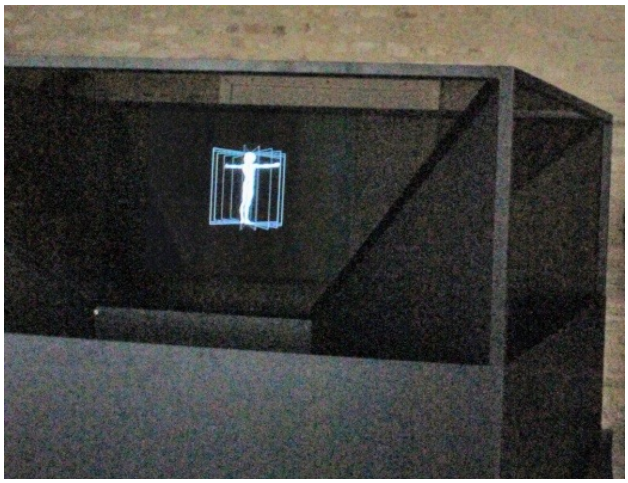

Fig. 9: Real Hologram Structure (3D model: copyright Fabio Severini).

3.2 Content and video animation

Geometrical optimization done, the 3D model (shown in **Fig. 10**) of the Vitruvian human being has been included in a pipeline where other elements were present as the Artist's drawing and geometries.

Fig. 10: The 3D model (copyright Fabio Severini).

The challenge was to make the 3D model shifting outside the drawing and the geometries of reference (square and circle), while using well-studied illusionistic optics in laboratory.

The storytelling behind the projected object has been the result of a real-time registration of a 3D video animation, generated with a mix of automatic animations and manual user manipulations (using MIDI controller) on some specific parameters. **Error! Reference source not found.** shows two frame of the developed multimedia content.

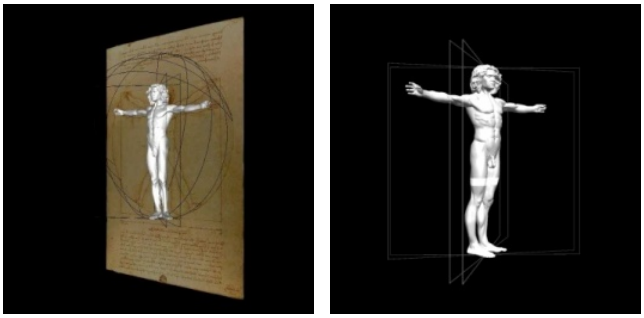

Fig. 11: Video animation: examples of frame (3D model: copyright Fabio Severini).

Video resolution is 1920x1080 px, the maximal one available for the adopted monitors, although the registration could be pushed forward to more high values.

4. *Overall Assessment and Maintenance*

One of the most crucial point to consider when designing such types of installation in museums is the simplicity of the system and easiness of maintenance of the multimedia product, as for museum staff and interns whose expertise is often not confident with complex multimedia systems.

Fig. 12 Staff working during the setup of exhibition.

The power on/off, and reset procedures have been automatized to simplify the operations of the exhibition staff. About the system start-up, electrical connection is the only needed, while the power-off occurs when a timer elapses (after the closing of museum).

Maintenance is thus limited and not always necessary due to professional hardware parts and the activity of experts in the field, together with clear and reliable pipeline of work.

The content update or changing in certain parameters are possible using remote control (only if museum is equipped with internet connection).

5. *Conclusion and Future Works*

In this work, we presented a novel interactive dissemination and exploitation of the Leonardo's Vitruvian Man.

We adopted state of the art technologies to present and make bi-directional the interaction of users with cultural heritage objects.

The novel mirror application exploits 3D depth sensor to compare the proportions of a user with the perfect ones of the Vitruvian man.

The second application is a complex interaction between a complete novel 3D model of the Leonardo's Vitruvian Man, sounds and image effects inside a 360-degree hologram.

These two systems are the results of interaction between academia and the 3D eve spin-off company.

As future works, we plan to augment the user interaction with adaptive lights to increase the attractiveness of the system. The augmented reality will also deployed to give an additional point of view of the Leonardo's Vitruvian Man.

Acknowledgments

The authors would like to thank Fabio Severini for the 3D model of the Leonardo's Vitruvian Man and Marco Gaiani (UNIBO), Fabrizio Apollonio (UNIBO), Annalisa Perissa Torrini (director of the Gabinetto dei disegni Gallerie dell'Accademia, Venice) and Paolo Clini (UNIVPM) for their scientific support.

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