SERIOUS GAMES AT INCREASED IMPACT ON CULTURE AND TOURISM

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ABSTRACT
This paper devoted to present some preliminary activities and results of an ongoing research project, SG-ICT, carried out by the MSC-LES laboratory of the University of Calabria. The SG-ICT main goal is to develop two groundbreaking applications for mobile devices: INSIDE VIRTUAL and OUSIDE VIRTUAL. The former is a mobile app, based on Serious Games and Simulation, designed to allow its users to enjoy digital contents through interactive and virtual experiences. The latter is another mobile app, based on augmented reality and on an intelligent personal assistant, aimed at creating new patterns of interaction with real contents and historical findings during a real tour in a museum or in an archaeological site. After an extensive analysis of the state of the art, the INSIDE VIRTUAL and OUSIDE REAL apps are discussed and the SG-ICT architecture is introduced. Lastly some preliminary results are shown.

Keywords: serious games, simulation, intelligent agents, cultural heritage

1. INTRODUCTION

Some preliminary activities and results of an ongoing research project called SG-ICT (Serious Games at Increased Impact on Culture and Tourism) are introduced. The SG-ICT project aims at providing groundbreaking technological solutions in the field of cultural heritage. In particular, the main project goal is to promote the cultural heritage in two different but complementary ways: allow people to enjoy digital contents through interactive and virtual experiences and set new patterns of interaction with real contents and historical findings during a real tour in a museum or in an archaeological site thanks to augmented reality and to an intelligent personal assistant and knowledge navigator.

In this perspective, the proposed solution integrates emerging technologies and innovative paradigms in order to enhance the cultural heritage enjoyment. As a result, on one hand SG-ICT creates new learning processes by exploiting the informative, educational and training potentials of Serious Games (SG) while on the other hand it creates new interaction patterns that can make the experience in archaeological sites or museums more exciting and fascinating.

Therefore, the SG-ICT project includes two applications that are meant to work synergistically: the former is called INSIDE VIRTUAL and is based on SG while the latter is called OUTSIDE-VIRTUAL and is based on augmented reality and on an intelligent personal assistant. In other words, INSIDE VIRTUAL grounds on users' entertainment and engagement to increase their desire to visit firsthand the hystorical/cultural sites and the artifacts they encounter during the game; OUTSIDE-VIRTUAL supports the user in gathering the information he/she is interested in during an on-site visit.

As a result, the joint use of both applications seeks to enhance cultural content enjoyment using new emerging ICT technologies. Indeed the INSIDE-VIRTUAL and OUTSIDE-REAL apps will be developed for mobile devices in order to allow users to gain the maximum freedom in using (wherever and whenever) thereof.

2. STATE OF THE ART: OVERVIEW

The SG-ICT project represents a "trait d'union" between past, present and future since it seeks to use emerging technologies to preserve and enhance the historical and cultural heritage as well as to create new interaction patterns and learning processes.

From a technological and methodological point of view, the reference paradigms that SG-ICT relies on include Modeling & Simulation (M&S), Serious Games (SG), Intelligent Agents(IA), Computer Generated Actions (CGA), Virtual Environments (VE), and Augmented Reality (AR) in order to create two different Mobile Applications (MA).

M&S has proved to be a powerful methodology to support both decision making and operational processes in various application domains including manufacturing systems, logistics, health and defense. In these areas, several successful applications have been proposed highlighting the potentials of M&S for problem solving in a variety of complex systems (Longo, 2013; Longo et al., 2012). In addition, over the past few years, M&S has been used extensively as a very effective and useful training tool for professionals at different levels,

ranging from managers to operators (Bruzzone and Longo, 2013).

The combination of simulation and gaming technologies for purposes beyond the pure entertainment has brought forth the concept of serious games that are being increasingly popular and increasingly implemented in training and learning activities pertaining to many application domains, from defense to industry (Zyda, 2005).

To date, digital technologies applied to cultural heritage have been mainly used for reconstructing the original appearance of artifacts as well as for information storage. M&S can integrate digital technologies to create "artificial stories" (however faithful to the reality of a given historical period or a particular culture) to ensure greater involvement of users while they enjoy cultural objects.

The analysis of the state-of-the-art allows pointing out that, most of the time, researchers and research communities are mainly concerned about cultural heritage preservation through modeling techniques, graphics and virtual reality (Addison, 2000). As a matter of facts Anderson et al. (2010) show that the use of M&S and Serious Games for teaching/learning activities and for improving the visits in museums is still poorly considered.

Anyway, when dealing with the cultural and historical heritage, virtual museums and information kiosks (with the aim to make the cultural contents appealing) cannot be neglected.

In this regard, a state-of-the-art proposed by Sylaiou et al. (2009) shows that museums have different at their disposal many tools and methodologies, mostly based on virtual and augmented reality, to make the experience of their visitors more engaging.

As for virtual reality, solutions range from simple interactive screens to full-immersive systems such as projection systems and 3D stereoscopic glasses; whereas as for augmented reality applications, one of the first solutions is dated back to 1995 and was proposed by Bederson. This solution is based on the imposition of audio content based on the user's location. Anyway, since 1995, many solutions have been presented (see for instance Mase et al. (1996) and White et al. (2004)) and even solutions based on the coexistence of real and virtual objects (Mixed Augmented Reality), see Hall et al. (2001) and Hughes et al. (2004).

It is possible to note that Serious Games applied to cultural heritage are gaining increasing attention. According to the taxonomy adopted by Mortara et al. (2013), these SG can have various purposes including cultural awareness, historical reconstruction and awareness of the cultural heritage and can vary according to learning objectives, genre (e.g. adventure, simulation) and application context. To this end some meaningful examples can be found in Froschauer et al. (2010).

The combination of M&S and SG becomes even more innovative when thinking of using Intelligent Agents that allow the simulated scenario to change according to a sequence of events (actions and reactions) generated by the reciprocal and continuous interaction between real users and Intelligent Agents. To this end, a meaningful example in the field of healthcare can be found in Bruzzone et al. (2012)

Indeed, agents are a powerful metaphor for the modeling and analysis through simulation of complex systems in various application domains (Bruzzone , 2013; Michel et al., 2009) and for the implementation of complex software systems (Jennings, 2000). According to this paradigm, a system is modeled as consisting of entities (agents) capable of operating in a given environment with different degrees of autonomy and intelligence cooperating and/or competing to achieve their goals or those of the company/organization they belong to (Woolridge, 2002).

These intelligent agents are the basis for implementing the SOPHOS system (a SIRI-like system) that acts as a personal assistant and knowledge navigator. In the literature, there are some examples of t agent-based environments devoted to enhance the cultural experience in museums. I.e. Costantini et al. (2008) used the agent technology to create a significant experience during a visit. Specifically, the system offers suggestions in line with the profile and interests of visitors by monitoring (via satellite) the movements of visitors within an archaeological park and providing such information to agents.

As far as the use of Augmented Reality is concerned, several articles focused on AR applied to cultural heritage are reported in literature (some of them newer than others) to name a few: Sylaiou et al. (2009), Liarokapis et al. (2008), Brogni et al. (1999). It is evident that the use of AR requires an effort of software modeling, algorithms development and integration driven by the need to perceive and recognize the external environment and attach it to the appropriate source of “augmented” information.

Therefore, the literary background of the Digital Cultural Heritage shows a great variety and heterogeneity in the methodologies and technologies used so far.

At the international level, many projects have been proposed and developed in the field of cultural heritage. Anderson et al. (2010) refers to a set of projects on the visualization and virtual reconstruction of ancient historical sites, including Nova Roma (Frischer, 2008), Ancient Pompeii (Maim et al., 2007) and the Parthenon (Debevec, 2005). Nova Roma is a multi-year project on the 3D reconstruction of Ancient Rome in 320 AD; the model has been integrated with a game engine in order to be interactive and include non-player avatars. Ancient Pompeii is a project based on procedural modeling for the reconstruction of ancient Pompeii; within the reconstruction, entities able to show a realistic behavior of the ancient Romans that are simulated in real-time. In both cases margins of improvement may be highlighted: the system should ensure a greater interactivity, a more consistent web

technology and the possibility of having apps for mobile devices.

There are numerous other projects such as the PEACH project (Stock and Zancanaro, 2010) and the MINERVA project (Amigoni e Schiaffonati, 2009). The PEACH project sees the synergy between different technologies (multi-agent architecture, audio-visual technologies, sensors for 3D visualization, etc..) in order to enhance the experience of enjoyment of cultural heritage whereas MINERVA is a system that, in its latest release, supports the curators in the automatic creation of virtual museums.

Many other projects, funded by the European Community under the Seventh Framework Programme, are also reported below.

The V.MUST.NET project aims at defining a knowledge base, a common language and an ontology dedicated to the creation of virtual museums as well as to identify innovative visualization and interaction tools for the virtual museums of the future. The 3D-COFORM project deals with all the aspects of the 3D digitalization, the semantics of shapes and material properties of cultural heritage objects, with the aim of moving forward the 3D digitizing frontiers. A similar project (but smaller in size and partnership) is DASI that aims at digitalizing the inscriptions found in the Arabian Peninsula before the Islamic period. Finally, the DECIPHER project promotes the development of new solutions that combine rules, engines, virtual environments and interfaces in order to support curators in the preparation of cultural goods which are as much as possible in line with the interests of the visitors.

3. THE SG-ICT APPS

The SG-ICT project (*Serious Games at increased Impact on Culture and Tourism*) combines in an innovative way Modeling & Simulation (M&S), Intelligent Agents (IA), Computer Generated Actions (CGA), Virtual Environments (VE) and Augmented Reality (AR) for:

- creating an interactive and immersive way to produce, use and distribute cultural contents in museums and archaeological sites (to this end, M&S, IA, CGA, VE and MA are used to develop the INSIDE-VIRTUAL app);
- creating an easy-to-use and effective way to receive cultural contents while visiting real museums and archaeological sites (to this end, AR and MA will be used to develop the OUTSIDE-REAL app that is integrated with a “SOPHOS” intelligent personal assistant and knowledge navigator).

INSIDE-VIRTUAL and OUTSIDE-REAL are two sides of the same coin and, once they will be ready as a product or service, they can be easily sold on the market in two different ways:

- a low-cost mobile application for INSIDE-VIRTUAL (that may run on tablets, smart-phones, AR glasses, head-mounted display, etc.) that can be bought by all those people interested in enriching their cultural knowledge about museums and archeological sites through an immersive, interactive and intelligent experience in 3D virtual environments;
- a low-cost mobile application for OUTSIDE-REAL (that runs on tablets, smart-phones, AR glasses, head-mounted display) that can be sold by museums and archeological sites to their visitors that are interested in trying a unique augmented reality experience and an intelligent personal assistant and knowledge navigator during their visit.

SG-ICT combines multiple methodologies and cutting-edge technologies to guarantee:

- an interactive and immersive cultural experience (the immersion is provided by the 3D VE while the interaction is provided by the IA and CGA);
- the production and intelligent automation of cultural contents (by using both IA and the SOPHOS assistant);
- the digital distribution, mobility and interoperability of cultural contents (by developing multi-players and web based Mobile Applications).

3.1. The SG-ICT Inside-Virtual App

INSIDE-VIRTUAL is a multi-player, avatar-based, web-based mobile app in which the player follows a learning process as a virtual visitor in a museum or in an archaeological site. Within this app, the joint use of Intelligent Agents and M&S increases the levels of interactivity and immersion offering a unique learning and entertainment experience.

By using INSIDE-VIRTUAL, the user can easily understand cultural contents; specific avatars (driven by Intelligent Agents) provide the user with the most important information related to cultural heritage through questions and answers, videos and so on. For example, consider the case of an encounter with a virtual avatar that explains the history and significance of an archaeological find such as the Riace Bronzes. The avatar will illustrate the history of the discovery, the assumptions on dating, the provenance, who are the sculptors and the mythology. The avatar could also present the user with more options in terms of information to display or may suggest getting in touch with other avatars (e.g. the Head of the Magna Grecia area).

3.2. The SG-ICT Outside-Real App

OUTSIDE-REAL is a mobile app that could be provided by museums or archaeological sites to visitors throughout their tour. The visitor can use the application installed on his/her mobile device and receive, through the use of AR, "augmented information". The application is also be equipped with a software

(SOPHOS) that recreates the features of a personal assistant and knowledge navigator. The SOPHOS software provides the user with appropriate information and, at the same time, collects information about the users' preferences that may be used by the museum or the archaeological site to improve the arrangement of its cultural contents.

4. The SG-ICT Apps Architecture

Basic components of the SG-ICT Inside-Virtual App are hereunder described:

- *SG-ICT INSIDE-VIRTUAL Game GUI* represents the graphics interface that allows the user to interact with the application. This interface includes suitable menus, a control panel and is also be able to operate both in stand-alone mode or remotely (connected on the web);
- *SG-ICT M&S Game Engine* is based on simulation and drives the evolution of the game according to the player's actions and decisions;
- *Virtual Agents* are avatars driven by Intelligent Agents and interacting with players through the *Game Engine*. Rules and logic behind the IA are implemented in a dedicated module called *IA-Inside*;
- *Virtual Environment* recreates a virtual museum or an archaeological park and gives the player the feeling of being inside them. The *Virtual Environment* is populated by *3D Geometric Models* representing both the environment and the cultural heritage (e.g. both the building housing the museum and all the findings contained within the museum itself);
- *SG-ICT Common Database* is a database where the information and data required for running the apps as well as the data that are generated while using the app are stored;
- *Museum Informative System* is a possible connection between the INSIDE-VIRTUAL application and the information system of the museum. This connection is carried out to ensure the app development and its maintenance;
- *SG-ICT OUTSIDE-REAL Connection* represents a connection gateway with the OUTSIDE-REAL app. In this sense, some of the functionalities implemented within INSIDE-VIRTUAL could be used to provide additional functionalities to the users of the OUTSIDE REAL app. While using OUTSIDE REAL during a visit to a museum the user can obtain, by means of the augmented reality and of the personal navigator, more information about a specific finding. The user may want to display a 3D model of the specimen (in order to be able to rotate or zoom in and then have a better view). The 3D models are part of the app INSIDE-VIRTUAL; so the user will have access to the sought information (3D models) through the connection gateway.

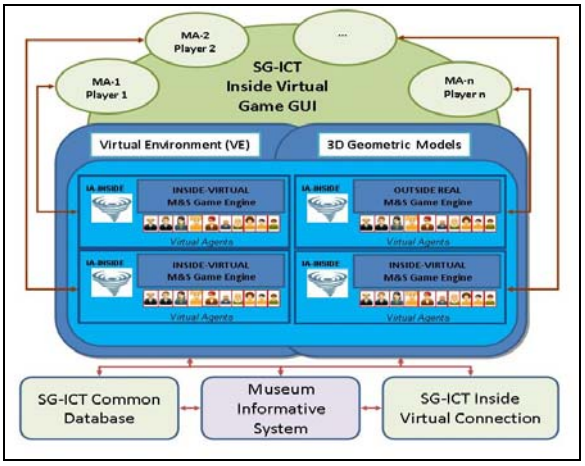

Figure 1 - INSIDE-VIRTUAL General Architecture

In order to provide a more detailed description of the INSIDE-VIRTUAL app architecture, consider the point of view of a player using the app. The user will see a three-dimensional virtual environment of a museum or an archaeological site on the screen of his/her tablet or smartphone.

The user can interact with the app through the *Game GUI*, request information and perform specific actions (e.g. establish a relationship with one of the Intelligent Agents and inquire about a specific exhibit inside the museum). Depending on the actions taken by the user, various "Course of Actions" are generated and, consequently, the user is led towards the knowledge and the enjoyment of the cultural heritage of the museum.

Intelligent Agents (which are the domain experts the user interacts with) may provide multiple options/answers to enrich the cultural experience of the user. By this approach, the game evolves dynamically according to the decisions/actions taken by the user (each user will then live an individual experience of enjoyment of the cultural heritage).

In order to make the cultural experience even more interactive and engaging, different levels of difficulty and scenarios are implemented to allow a vehicled access to a richer information content.

Basic components of the SG-ICT Outside-Real app are described in the sequel:

- *SG-ICT OUTSIDE-REAL GUI* represents the graphics interface that allows the user to interact with the application during a visit to a museum or an archaeological site. This interface include suitable menus, a control panel and is also able to operate both in stand-alone mode or remotely (connected on the web);
- *OUTSIDE-REAL Engine* is the application engine that enables the integration of the Augmented Reality (AR) module with the Intelligent Agents (IA) which in turn should manage the SOPHOS personal assistant and knowledge navigator;

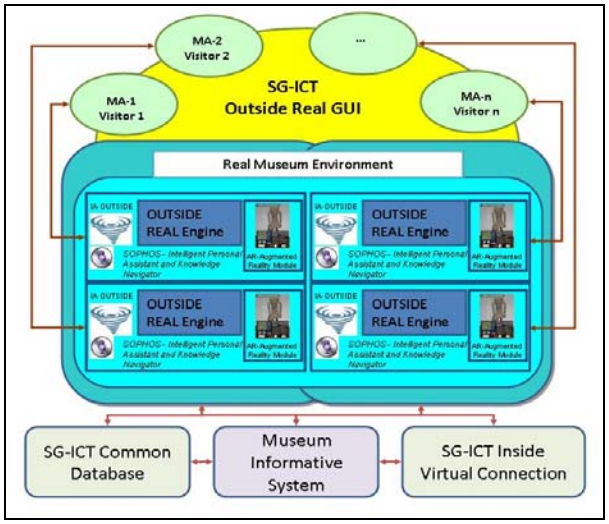

Figure 2 - OUTSIDE-REAL General Architecture

- *SOPHOS* is an *Intelligent Personal Assistant and Knowledge Navigator* that the visitor can use during the visit to the museum in order to get quickly, easily and efficiently further information about the cultural object of interest through questions orally made. Intelligent Rules and logic that characterize the navigation system of knowledge are be implemented in a dedicated module called *IA-Outside*;
- *Augmented Reality Module* allows the user to get "augmented" information about the cultural object of interest through the mobile device (smartphone or tablet), pointing the camera to the find of interest;
- *SG-ICT Common Database* is a database in which are stored all the information and data required for the functioning of the app combined with all the data that are generated during the functioning of the app itself;
- the *Museum Informative System* is the possible connection between the OUTSIDE-VIRTUAL application and the information system of the museum. The rationale behind such a connection is the same of those reported for the INSIDE-VIRTUAL application. In fact, this connection is devoted to ensure the development of the app and its maintenance.
- the *SG-ICT INSIDE-VIRTUAL Connection* represents a connection gateway with the INSIDE-VIRTUAL app. As previously highlighted, some of the information, used in the INSIDE-VIRTUAL app, could be used in the OUTSIDE-REAL application. Besides 3D models (the information flow goes from INSIDE-VIRTUAL to OUTSIDE-REAL), reviews, statistics, users' preferences are collected through the use of the OUTSIDE-REAL app (in particular through the SOPHOS system). In this sense, such information could be viewed comfortably by other users who use the INSIDE-VIRTUAL app. (the information flow goes from OUTSIDE-REAL to INSIDE-VIRTUAL).

In order to provide a more detailed description of the OUTSIDE-REAL app architecture, consider the point of view of a user who is using the app during a visit to a museum or archaeological park. The visitor can download the OUTSIDE-REAL app for free, or paying a fee, and install it on his/her mobile device before starting the visit to the museum. During the visit, just pointing the smartphone or the tablet towards the object of interest, the user receives additional information in augmented reality about the exhibit. There are different kinds of "augmented" information and they are proposed to the user through different modes (e.g. text, images, videos, audio files).

In addition, the user can request specific information through the SOPHOS software, driving consequently his learning process according to their needs.

Another important aspect is the scalability and replicability of the SG-ICT apps. In fact, museums and archaeological sites are constantly trying to define a knowledge base and a common language (especially for the Virtual Museum concept and for the identification of new tools for visualization and interaction).

The scalability of the SG-ICT apps is guaranteed by the capacity to operate correctly both in the case of larger system and in case of smaller ones. While Intelligent Agents, Augmented Reality algorithms and the SOPHOS software continue to work regardless of the size of the system, virtual environments and databases can easily be expanded/reduced. So the transition from a little to a larger museum will only need the upgrade of virtual environments and databases.

The repeatability is ensured by the definition of specific ontologies for the Intelligent Agents, for Augmented Reality algorithms and for the SOPHOS system. Such ontologies ensure the capacity of the various components to be replicated and operate in different contexts than those for which it was originally designed.

The SG-ICT project opens the way for the application of similar OUTSIDE-REAL approaches in Marine Protected Areas, with the adoption of new waterproof technologies to be used and installed on devices with the purpose of a sustainable diving tourism. Even the INSIDE-VIRTUAL app could be used to create interactive virtual underwater environments. In addition, both OUTSIDE-REAL and INSIDE-VIRTUAL are very interesting tools to produce, distribute and enjoy scientific, ecological, cultural and educational contents (which are the most expensive activities in Marine Protected Areas). To this end, the Protected Marine Area of Portofino has expressed its interest in the SG-ICT project, indicating clearly the potential of the project.

In particular, the SG-ICT project involves several museums as end users:

- the Museum of "Brettii" and Sea of Cetraro;
- the Operation Avalanche Museum of Eboli;
- the Silk Museum of Mendicino.

4.1. Intelligent Agents and SOPHOS System

As already pointed out, the SOPHOS software is a personal assistant performing the role of an intelligent navigator and, therefore, able to answer to a specific question.

Initially, the SOPHOS ability to comprehend and provide coherent answers to the questions posed by the user is limited not only by the available technologies but also by the willingness to develop a system capable of responding coherently to a list of keywords or simple questions made up of keywords that can be used by the user in an intuitive, fast and effective way. The SOPHOS system is able to collect information and then to transfer such information from the Common Database to the Museum Information System (via remote connection). Such information can be useful for the museum management to improve the service and the usability of the cultural heritage (e.g. modify the information available for each exhibit, change the layout of the museum or of a particular exhibition area).

5. THE SG-ICT PRELIMINARY DEMO

Currently an SG-ICT preliminary demo has been developed as shown in Fig. 3,4,5,6. In particular Fig 3 and Fig.4 refer to the INSIDE VIRTUAL mobile app while Fig 5 and Fig. 6 pertain to the OUTSIDE REAL app. As previously discussed INSIDE VIRTUAL is a Serious game based on simulation and is devoted to provide the user with and engaging and interactive experience while he/she is gaining information about the cultural heritage of a particular site or museum. In addition, in the INSIDE VIRTUAL app the scenario evolution evolves thanks to Intelligent Agents that are implemented in the form of avatars. Therefore, Fig 3 shows the user and its interaction with a virtual avatar that is providing information on a particular finding and is trying to get insights about the user's interests in order to provide him/her with the information he/she is interest in and drive suitably its visit within the museum based on his/her feedbacks. In Fig.4, the point of view is changed and the user can give a look into a museum room to have just a quick overview of the historical artefacts it contains before deciding whether to get into the room or not so that he/she can assess if there is something that could be of interest form him/her.

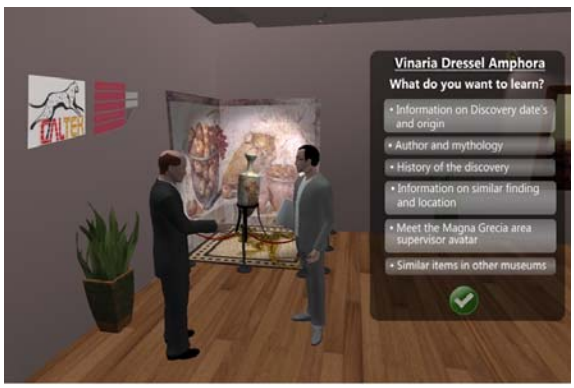

Figure 3, Example of digital Mock-up for INSIDE-VIRTUAL: the users interacts with an avatar virtually

Figure 4, Example of Digital Mock-up for INSIDE-VIRTUAL: view from a museum room

Fig. 5 and 6 show some digital Mock-up of the OUTSIDE-REAL app. As discussed in section 3.2 this app is based on Augmented Reality and includes an intelligent software navigator SOPHOS. This way, the app is able to provide the user with the information he/she wants about a particular finding during a visit in a real museum or archeological site. As a matter of fact, Fig.5 and Fig. 6. show a user while he/she is getting information on a particular amphora simply pointing his/her mobile device toward it. At this stage the knowledge navigator SOPHOS that is a siri-like system can be directly asked for further information (through a dedicated button placed in the lower left corner) on the particular object being considered, or even the user can ask for the location and the correct position of other artefacts.

Figure 5, Digital Mock-up for OUTSIDE-REAL: a visitor is using the app installed on a tablet in a real museum

Figure 6, Digital Mock-up for OUTSIDE-REAL: view of a visitor that uses Augmented Reality glasses.

6. CONCLUSIONS

The SG-ICT project (*Serious Games at increased Impact on Culture and Tourism*) is devoted to create an interactive and immersive way to produce, use and distribute cultural contents in museums and archaeological sites and to create an easy-to-use and effective way to receive cultural contents while visiting real museums and archaeological sites. To this end SG-ICT combines Modeling & Simulation, Intelligent Agents, Computer Generated Actions, Virtual Environments and Augmented Reality. The project goals will be achieved thanks to two different but complementary applications for mobile devices INSIDE VIRTUAL and OUSIDE REAL.

INSIDE-VIRTUAL is a multi-player, avatar-based, web-based mobile app in which the player follows a learning process as a virtual visitor in a museum or an archaeological site.

OUTSIDE-REAL is a mobile app that will be provided to visitors throughout their tour in a real museum or site. The visitor can use the application installed on his/her mobile device and receive, through the use of AR, "augmented information". The application will also be equipped with a software (SOPHOS) that recreates the features of a personal assistant and knowledge navigator.

A preliminary demo of both the apps has been developed and some digital mock-ups are given to demonstrate the potentials of the SG-ICT framework.

REFERENCES

Addison A., 2000. Emerging trends in virtual heritage. *IEEE Multimedia, Special Issue on Virtual Heritage*, 7 (2): pp. 22–25.

Amigoni, F., Schiaffonati, V., 2009. The Minerva System: A Step Toward Automatically Created Virtual Museums. *Applied Artificial Intelligence* 23(3): pp. 204-232.

Anderson, E.F., McLoughlin, L., Liarokapis, F., Peters, C., Petridis, P., and de Freitas, S., 2010. *Developing Serious Games for Cultural Heritage: A State-of-the-Art Review*. Virtual Reality 14 (4): pp. 255-275.

Bederson B.B., 1995. Audio Augmented Reality: A Prototype Automated Tour Guide. *Proceedings of ACM Human Computer in Computing Systems conference (CHI'95)*, pp. 210-211.

Brogni A., Avizzano C., Evangelista C., Bergamasco M., 1999. *Technological Approach for Cultural Heritage: Augmented Reality*. The IEEE 8th International Workshop, pp. 206-212.

Bruzzone, A.G. (2013) Intelligent agent-based simulation for supporting operational planning in country reconstruction. *International Journal of Simulation and Process Modelling*, 8 (2-3), pp. 145-159.

Bruzzone A.G., Longo F., 2013. 3D simulation as training tool in container terminals: The TRAINPORTS simulator. *Journal of Manufacturing Systems*, 32: pp. 85-98.

Bruzzone, A.G. , Frascio, M. , Longo, F., Massei, M. , Siri, A., Tremori, A.,(2012). MARIA: An agent driven simulation for a web based serious game devoted to renew education processes in health care, *1st International Workshop on Innovative Simulation for Health Care, IWISH 2012*, Held at the International Multidisciplinary Modeling and Simulation Multiconference, I3M 2012, pp. 188-194

Costantini S., Mostarda L., Tocchio A., Tsintza P., 2008. DALICA: Agent-Based Ambient Intelligence for Cultural-Heritage Scenarios. *IEEE Intelligent Systems*, 23 (2): pp. 34-41.

Debevec P. 2005. Making ‘‘The Parthenon’’. *6th international symposium on virtual reality, archaeology, and cultural heritage*.

Frischer, B., 2008. *The Rome Reborn Project. How Technology is helping us to study history*, OpEd, November 10, 2008. University of Virginia.

Froschauer, J., Seidel, I., Gartner, M., Berger, H., Merkl D., 2010. Design and evaluation of a serious game for immersive cultural training. In: *Proceedings of the 16th International Conference on Virtual Systems and Multimedia*, 2010, pp. 253–260.

Hall T., Ciolfi L., Bannon L., Fraser M., Benford S., Bowers J., Greenhalgh C., Hellstrom S., Izadi S. and Schnadelbach H., 2001. The Visitor as Virtual Archaeologist: Using Mixed Reality Technology to Enhance Education and Social Interaction in the Museum. In: *Proceedings of VAST 2001: Virtual*

Reality, Archaeology and Cultural Heritage, ACM SIGGRAPH, Glyfada, Greece, pp. 91-96.

Hughes Ch., Smith E., Stapleton Ch. and D. Hughes, 2004. Augmenting Museum Experiences with Mixed Reality. In: *Proceedings of Knowledge Sharing and Collaborative Engineering*, 2004, St. Thomas, US Virgin Islands.

Ikeuchi K., Nakazawa A., Hasegawa K., Ohishi T. 2003, The Great Buddha Project: Modeling Cultural Heritage for VR Systems through Observation. In: *Proceedings of the 2nd IEEE/ACM International Symposium on Mixed and Augmented Reality*, IEEE Computer Society Washington, DC, USA.

Jennings N.R., 2000. On agent-based software engineering. *Artificial Intelligence* 117(2): pp. 277-296, Elsevier.

Liarokapis F., Sylaiou S., Basu A., Mourkoussis N., White M. and P.F. Lister, 2004. An Interactive Visualisation Interface for Virtual Museums. In: *Proceedings of the 5th International Symposium on Virtual Reality, Archaeology and Cultural Heritage*, Brussels, pp. 47-56.

Longo F., Massei M., Nicoletti L., 2012. An application of modeling and simulation to support industrial plants design. *International Journal of Modeling, Simulation, and Scientific Computing*, 3, pp. 1240001-1-1240001-26.

Longo, F. (2013) On the short period production planning in industrial plants: A real case study. *International Journal of Simulation and Process Modelling*, 8 (1), pp. 17-28.

Luck M., McBurney P., Preist C., 2004. A Manifesto for Agent Technology: Towards Next Generation Computing. *AAMAS*, 9(3): pp. 203–252, Springer.

Maim J., Haegler S., Yersin B., Mueller P., Thalmann D., Van Gool L., 2007. Populating ancient pompeii with crowds of virtual romans. In: *Proceedings of VAST07: the 8th international symposium on virtual reality, archaeology and intelligent cultural heritage*, pp 109–116

Mase K., Kadobayashi R., Nakatsu R., 1996. Meta-Museum: A Supportive Augmented-Reality Environment for Knowledge Sharing. In: *Proceedings of the International Conference on Virtual Systems and Multimedia '96* in Gifu, pp. 107-110.

Michel F., Ferber J., Drogoul A., 2009. Multi-Agent Systems and Simulation: A Survey from the Agent Community's Perspective. In: *Multi-Agent Systems: Simulation and Applications*, Cap.1, CRC Press, 2009.

Mortara M., Catalano C.E., Bellotti F., Fiucci G., Houry-Panchetti M., Petridis P., 2013. Learning Cultural Heritage by Serious Games. *Journal of Cultural Heritage*.

Stock O,, Zancanaro M., 2010. Personalized Active Cultural Heritage: The PEACH Experience. In: *Handbook of Research on Culturally-Aware Information Technology: Perspectives and Models*.

Sylaiou S., Liarokapis F., Kotsakis K., Patias P. 2009. Virtual museums, a survey on methods and tools. *Journal of Cultural Heritage*, 10(4): pp. 520–528

Vilbrandt C., Pasko G., Pasko A., Fayolle P.-A., Vilbrandt T., Goodwin J. R., Goodwin J. M., Kunii T. L., 2004. Cultural Heritage Preservation Using Constructive Shape Modeling. *Computer Graphics Forum*, 23(1), pp. 25–41.

White M., Mourkoussis N., Darcy J., Petridis P., Liarokapis F., Lister P.F., Walczak K., Wojciechowski R., Cellary W., Chmielewski J., Stawniak M., Wiza W., Patel M., Stevenson J., Manley, J., Giorgini F., Sayd P. and F. Gaspard, 2004. ARCO: An Architecture for Digitization, Management and Presentation of Virtual Exhibitions. In: *IEEE Proceedings 22nd International Conference on Computer Graphics*, Hersonissos, Crete, June 16-19, pp. 622-625.

Woolridge M., (2002). *Introduction to Multiagent Systems*. John Wiley & Sons, Inc., NY, USA.

Zyda M. (2005) From visual simulation to virtual reality to games. *IEEE Computer*, 38(9): pp. 25–32.

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