International Journal of Information, Control and Computer Sciences
ISSN: 2517-9942
Vol:6, No:1, 2012

6DSpaces: Multisensory Interactive Installations

Pedro Campos, Miguel Campos, Carlos Ferreira

***Abstract*—**Interactive installations for public spaces are a particular kind of interactive systems, the design of which has been the subject of several research studies. Sensor-based applications are becoming increasingly popular, but the human-computer interaction community is still far from reaching sound, effective large-scale interactive installations for public spaces. The 6DSpaces project is described in this paper as a research approach based on studying the role of multisensory interactivity and how it can be effectively used to approach people to digital, scientific contents. The design of an entire scientific exhibition is described and the result was evaluated in the real world context of a Science Centre. Conclusions bring insight into how the human-computer interaction should be designed in order to maximize the overall experience.

***Keywords*—**interaction design, human-computer interaction, multimedia, multisensory installations

I. Introduction

THE use of sensor-based interactive installations, in particular installations involving infrared motion sensors as well as cameras coupled with real time video processing algorithms, have been receiving considerable interest both from industry and academia [1, 2, 3, 5]. During the design and evaluation of interactive exhibitions, much can be learned about interaction design for public settings like these.

We describe the 6DSpaces project, as a research approach based on studying the role of multisensory interactivity and how it can be effectively used to approach people to digital, scientific contents

Several experiences have been conducted to study how visitors experience novel interaction styles within museums and science centers. Explore@Bristol, for instance, was an interactive science museum, which was studied to analyze six of its exhibits according to three dimensions: Drama-Sensation, Challenge-Self Expression and Social [5]. The exhibition titled a "Walk in the Wired Woods" illustrates how to design an engaging experience through context-sensitive media and interaction. The visitors were invited to take a walk in which they were automatically presented with audio content appropriate to their physical location [6]. Other interesting studies have been performed, regarding novel interaction styles and schemes, applied both to leisure and educational activities.

Pedro Campos is with the National Institute of Standards and Technology, Boulder, CO 80305 USA (phone: 303-555-5555; fax: 303-555-5555; e-mail: author@ boulder.nist.gov).

Miguel Campos was with Rice University, Houston, TX 77005 USA. He is now with the Department of Physics, Colorado State University, Fort Collins, CO 80523 USA (e-mail: author@lamar. colostate.edu).

Carlos Ferreira is with the Electrical Engineering Department, University of Colorado, Boulder, CO 80309 USA, on leave from the National Research Institute for Metals, Tsukuba, Japan (e-mail: author@nrim.go.jp).

Such examples include "The Fire and the Mountain" exhibition, held in 2006 at the Civic Museum of Como, Italy [4] and the "Listen Reader" from Xerox PARC, an innovative and engaging reading experience installed in three different museums over a six-month exhibition period [3].

Some researchers have devoted effort into studying interactive installations using mixed-reality [8], in the context of art museums. Expressing the formal aspects of the original artworks, the interactive installations allowed visitors to explore specific conceptual themes through their interactions. Sometimes, researchers also exploit an augmentative approach, adding interactive elements to the displays and artworks of the exhibition [9]. Taking great care to ensure that the installations meld seamlessly into the setting is considered very important, so that visitors don't face the interactive installations as a kind of "computer section" of the museum or exhibition.

Experiments on augmenting art museums with interactive technology have also been documented. For instance, Terrenghi and Zimmermann [11] introduce the notion of 3D sound in headphones for an art museum, providing the user with a contextual and spatial audio guide. This technology is an advanced version of more traditional audio guides. However, the approach still provides only an individual and detached experience, since no conversation is possible while listening to the audio. This communication approach does not disturb the experience of purely visual artworks, however it would be difficult to combine with artworks that contain sound by itself.

The use of abstraction and motion in the design of social interfaces – for which the interactive cultural exhibitions are a special case – has also been explored [10]. Particularly useful for our research was the concept of perceptual causality, which suggests that simple displays in motion can evoke high-level social and emotional content.

With the advent of novel technologies, particularly multimedia projections and sensor-based installations, the public spaces directions and the exhibition's cultural and artistic directions are starting to embrace new digital media as effective ways of approaching people to cultural heritage, as opposed to considering those media as a menace to traditional means of cultural dissemination. Our experience suggests that artists have the potential to provide novel, creative uses to technology, and the opposite as well: interaction designers and technologists have the potential to provide artists with techniques which effectively enhance their portfolio.

The remainder of this paper is organized as follows: the next section describes related work with a particular emphasis on research approaches to add interactivity to cultural heritage

exhibitions and museums. Next, we briefly describe some of the interactive installations designed, as well as the interaction styles and features employed in our exhibition. We move on to describe the evaluation approach and results. Section "Conclusions and Future Work" outlines new avenues of research for this field.

II. Interaction Design

The Porto Moniz Science Center acted as the demonstrator for the research project's results. The

Previous exhibitions at our local Science Center were unsuccessful, mainly because they were not adequate to the target visitors.

Since the Center's common visitors are tourists of 50-70 years old (Madeira Islands' typical tourist) as well as children from local schools, we sketched out a user profile map [2] composed of these two. The design goals became clear: the interactive installations had to entertain and instruct visitors, and more importantly, they had to be adequate and appealing to both young and old generations - a difficult challenge to tackle.

The scientific endeavor begins in the underwater of the Madeira Island. Both children and adults can walk along an immersive tunnel where our research hypothesis stood out: a multisensory experience will dramatically improve visitors' levels of satisfaction and bring a more enjoyable, memorable experience. Figure 1 illustrates the 3D rendering of this installation, and was part of our iterative design process, since it enabled a closer, simpler discussion with all project stakeholders (these included the science center staff, biologists, programmers, sound designers and science center managers). Therefore, we targeted at activating all senses: 3D vision, an appropriate audio track, fog and haptic stimulation (using adequate equipment) and obviously the scent projectors. The interaction design basic idea was to put visitors getting to know what happens in those underwater "forests".

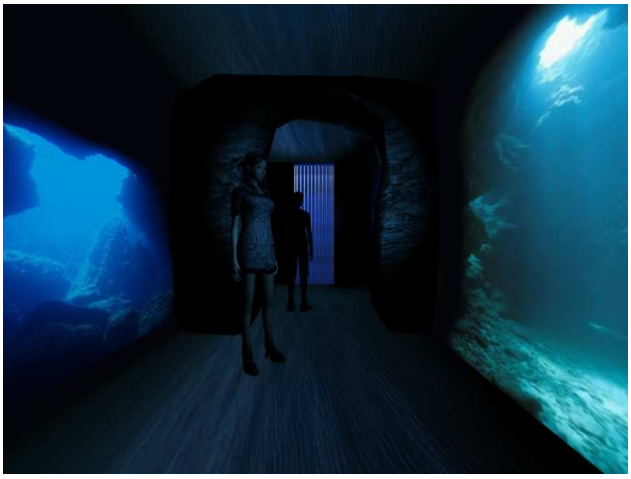

Fig. 1 The 3D Preview for the *Underwater Forest*, used to Iteratively Design with Stakeholders

Fig. 2 The 3D Preview for the *Levada Rangers* installation, used to Iteratively Design with Stakeholders.

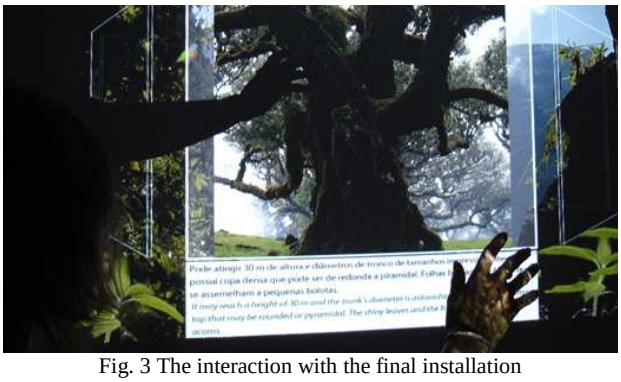

Fig. 3 The interaction with the final installation

The 6 DSpaces' research approach is also evident in the following installation, titled the "Levada" rangers. "Levadas" is the term for water canals built by man hundreds of years ago, which cross the whole forest and currently used for sightseeing and touristic purposes only. Again, the installation's goal was to immerse the visitor in one of those canals and surprises happen in this completely 6D experience: the visitor can watch and interact with 3D forest birds, feel the water falling in the inside of tunnels (throughout the walk) and smell the typical aromas from the forest. This includes fennel, laurel tree, and many other species.

There are many other installations that we didn't describe for brevity reasons and we focus the remaining of the paper on the evaluation of these two, so as to obtain a better insight regarding the impact of the multisensory installations on the visitors' overall impression of the experience.

III. Evaluation

In this section we will briefly present the results from our observations in terms of the quality of the experience provided by the installations. Although there are literally hundreds of different methods to evaluate this type of interaction, we noted that the mere observation and direct inquiry to users were sufficient to gain valuable insight. The goal was to assess the perceived satisfaction level of the experience, qualitatively.

In the 6DSpaces research project, our team built several pilot installations in order to evaluate and compare the users' reactions to several human-computer interaction solutions. In experiment (a), users were confronted with two different installations that had the same essential goal: listen to the birds of the forest, feeling immersed and learning about the species.

In installation number one, users had a multimedia projection where simply pointing left or right controlled a 360º forest view towards one side or another, making the birds appear. In installation number two, the same users were invited to a closed dark room, without any visual references and started to listen to the sounds of the birds and forest through a synthesized 3d sound surround system. Note that we employed a between subjects experiment design, but took care of randomizing the order of presentation ($N = 34$).

Although users enjoyed the interaction style in installation number one, several of them commented that it was difficult to use at first glance and to gain the initiative to try and interact with the whole installation.

The vast majority (82%) responded that they preferred the second installation, stating that they felt like "teletransported" to the forest and that without seeing anything, they could actually imagine easily the birds and the forest by themselves. They were surprised by the simplicity of the system and stated in general that everyone, regardless their age, sensibility or literacy, would enjoy it (except the ones who feared the dark).

In another experience, users where faced with two similar installations. Number one consisted on a large videoprojection that was controlled by the users movements, i.e., if they walked right or left, a sea creature would follow them. The second installation was again perceived as being much more immersive. Users would enter a tunnel with videoprojections on both sides, as well as top and bottom, thus recreating an underwater subworld. To enhance the experience, once again surround sound was used, coupled with two scents projectors which were placed to recreate a sea breeze smell. Interaction on this installation was minimal. The animations of creatures swimming were played once a user was detected.

Once again, most users (73%) preferred the second experience, commenting that the immersive ambient was much more interesting and real and it that really marked their memory. Although direct interaction was nonexistent, they stated that simply being in a 360º simulated ambient was enough per itself to enjoy themselves. The scents projectors enhancement largely contributed for the popularity of this experience.

Regarding the first experience, users found it funny and easy to use and understand the interaction itself but weren't overall impressed.

Taking into account this feedback, our team then combined these two installations in one unique interactive 360º tunnel, featuring surround sound, multimedia projections, scents projectors and interactivity based on user's movement (left or right, the creature would follow the user using a Kinect camera for this job). To make the experience valid, a brand new group of 50 testers was defined. At the end, 95% was very impressed with the installation itself and the positive remarks were distributed the following way:

95% highlighted the 365º videoprojections - "it really puts you underwater!";

92% thought that the scent projectors really enhanced the overall experience;

62% highlighted the kinect-based interaction (40% considered "interesting" and 8% didn't detected at all).

From the previous tests, we concluded that human-computer interaction techniques in public spaces' exhibits needs to be carefully devised in order to make it work easily, without much effort from users and embedded in true sensorial immersive spaces, that will surely make visitors come back. In the next section we will sum up the details of our conclusions.

IV. Conclusion

The recent years of human-computer interaction research have been shaped by exciting advances in multi-touch technology, and gesture-based control of digital contents, either by direct manipulation or using infrared cameras or sensor systems – as proven by, e.g. the recent popularity of the Kinect box. Although these advances are regarded as being useful and conveying a high-tech "cool" component, the truth is that they are not completely easy to understand, grasp and manipulate by all users. This depends greatly on the target audience, including factors such as age, mood, technology literacy level, and others. Sometimes this causes the entire experience to become frustrating, as technology is used per se and not as an effective means of bringing a memorable interactive experience that public spaces should provide.

If these technological advances are ideas for enhancing electronic devices – such as the iPhone – where they solve actual usage and task problems for their users, the scenario regarding large-scale interactive multimedia installations shows too often the opposite result.

During the development and the analysis of this exhibition, we have learned a lot about interaction design for museums and science centers. Important conclusions about engaging and learning and how they should be coupled are being reached. Motivation is an issue that is hard to measure in non-controlled environments, and almost impossible to quantify accurately. However, it is easily observable. We are currently gathering statistical data in order to better support our observational conclusions and to find even more information about the learning and enjoying experience of the visitors (by age, gender and other significant parameters).

Our experience with the 6DSpaces project demonstrates that what clearly matters is delivering a memorable experience when visiting public spaces such as science centers and museums. That cannot be accomplished by using intrusive technology or anything requiring inputs from the user. On the contrary, our observation and evaluation suggests that the

simpler and straightforward the interaction is, the better is the experience. However, this conclusion is only valid if the entire experience is sufficiently immersive and stimulating to all senses. That was the main rationale for this project, where we installed a new interactive experience at the local Porto Moniz Science Center, which has acted as the case study for our research project.

The evaluation demonstrated that the mere placing of scent projectors in the spaces that are also visually and audio recreated can improve a positive visitors' reaction. In fact, if the visitor is "transported" to a 360-degree recreation of a certain space or environment (the Madeira Island sea scape and the Laurissilva forest, in our case study), applying the technology but putting no effort on the visitor side, then the global experience is improved and human-computer interaction achieves its ideal "fusion point" between the different senses. The "computer part" is not perceived as something industrial or mechanic but instead as something that appears completely natural from the visitor's perspective, since there is no direct contact with it – contrarily to what happens using large multi-touch displays or gesture-based interactive installations.

REFERENCES

[1] Danks, M., Goodchild, M., Echavarria, K., Arnold, D. and Griffiths, R. Interactive Storytelling and Gaming Environments for Museums (2007). *Technologies for E-Learning and Digital Entertainment*, LNCS, ISBN 978-3-540-73010-1, 2007.

[2] Hornecker, E. and Stifter, M. (2006). Learning from interactive museum installations about interaction design for public settings. In *Proceedings of the 18th Australia Conference on Computer-Human Interaction*. J. Kjeldskov and J. Paay, Eds. OZCHI'06, vol. 206. ACM.B.

[3] Back, M., Cohen, J., Gold, R., Harrison, S. and Minneman, S. (2001). Listen reader: an electronically augmented paper-based book. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, ACM Press, 2001, pp. 23-29.

[4] Kidd, A. Technology experiences: What makes them compelling? *Hewlett Packard Laboratories*, Bristol, UK, 2001.

[5] Hull, R., Reid, J. and Geelhoed, E. (2002). Social impacts of computing: Codes of professional ethics. *Pervasive Computing*, 1(4), 2002, pp. 56-61.

[6] Hull, R., Reid, J. and Geelhoed, E. (2002). Social impacts of computing: Codes of professional ethics. *Pervasive Computing*, 1(4), 2002, pp. 56-61.

[7] Self-Reference

[8] Birchfield, D., Mechtley, B., Hatton, S., and Thornburg, H. (2008). Mixed-reality learning in the art museum context. In *Proceedings of the 16th ACM international Conference on Multimedia*, MM'08. ACM, New York, NY, pp. 965-968.

[9] Ferris, K., Bannon, L., Ciolfi, L., Gallagher, P., Hall, T., and Lennon, M. (2004). Shaping experiences in the hunt museum: a design case study. In *Proceedings of the 5th Conference on Designing interactive Systems: Processes, Practices, Methods, and Techniques*, DIS'04. ACM, New York, NY, 205-214.

[10] Mutlu, B., Forlizzi, J., Nourbakhsh, I., and Hodgins, J. (2006). The use of abstraction and motion in the design of social interfaces. In *Proceedings of the 6th Conference on Designing interactive Systems* (University Park, PA, USA, June 26 - 28, 2006), DIS'06. ACM, New York, NY, 251-260.

[11] Terrenghi, L. and Zimmermann, A. 2004. Tailored audio augmented environments for museums. In *Proceedings of the 9th international Conference on intelligent User interfaces* (Funchal, Madeira, Portugal, January 13-16, 2004). IUI'04. ACM, New York, NY, 334-336.

[12] Prensky, M. (2001). Digital natives, digital immigrants. *On the Horizon* (MCB University Press, Vol. 9 No. 5, October 2001).

[13] Hall, T. and Bannon, L. (2005). Designing ubiquitous computing to enhance children's interaction in museums. In *Proceedings of the 2005 Conference on interaction Design and Children* (Boulder, Colorado, June 08 - 10, 2005), IDC'05. ACM, New York, NY, 62-69.

[14] Norman, D. *Things that make us smart*. Perseus Books, USA, 1993.

Pedro Campos (M'76–SM'81–F'87) and the other authors may include biographies at the end of regular papers. Biographies are often not included in conference-related papers. This author became a Member (M) of IEEE in 1976, a Senior Member (SM) in 1981, and a Fellow (F) in 1987. The first paragraph may contain a place and/or date of birth (list place, then date). Next, the author's educational background is listed. The degrees should be listed with type of degree in what field, which institution, city, state or country, and year degree was earned. The author's major field of study should be lower-cased.The second paragraph uses the pronoun of the person (he or she) and not the author's last name. It lists military and work experience, including summer and fellowship jobs. Job titles are capitalized. The current job must have a location; previous positions may be listed without one. Information concerning previous publications may be included. Try not to list more than three books or published articles. The format for listing publishers of a book within the biography is: title of book (city, state: publisher name, year) similar to a reference. Current and previous research interests ends the paragraph.The third paragraph begins with the author's title and last name (e.g., Dr. Smith, Prof. Jones, Mr. Kajor, Ms. Hunter). List any memberships in professional societies other than the IEEE. Finally, list any awards and work for IEEE committees and publications. If a photograph is provided, the biography will be indented around it. The photograph is placed at the top left of the biography. Personal hobbies will be deleted from the biography.