Designing an Interactive Forest through Sensor-based Installations

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CHI 2008, April 5 – April 10, 2008, Florence, Italy
ACM 978-1-60558-012-8/08/04.

Abstract
We describe the design approach of an interactive exhibition called "The Interactive Laurissilva". The exhibition is about Madeira Island's endemic forest, and is composed of 15 sensor-based interactive installations. We discuss the interaction styles that were adopted, reflecting upon the ethnographic observation of visitors and we summarize the lessons learned.

Keywords
Interactive installations, sensors, interaction design.

ACM Classification Keywords
H5.m. Information interfaces and presentation.

Introduction
Sensor-based interactive installations, in particular installations involving infrared distance sensors, and cameras coupled with real time video processing algorithms, are receiving increasing interest in museums and science centers [6, 3, 8], as a way to provide engaging and learning experiences among visitors.

In this paper, we describe the design approach of a recent exhibition about Madeira Island's endemic

figure 1. Page turning gestures in mid-air are performed to turn the pages of the magical encyclopedia.

figure 2. The magical showcase of the endemic flora species is also controlled through gestures.

forest, called the Laurissilva forest, which is being held at a local Science Center in a 725 sq. meter area. Our approach was tailored to the local visitors' profile and makes a creative use of sensor-based technology, with the explicit goal of reducing the distance between visitors and knowledge towards zero.

Related Work

Several experiences have been conducted to study how visitors experience new kinds of interactions within museums and science centers exhibitions. Explore@Bristol is an interactive science museum which was studied to analyze six of its exhibits according to three dimensions: Drama/Sensation, Challenge/Self expression and Social [6]. 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 [5]. Other interesting studies have been made, regarding new interaction models, schemes applied both to leisure and educational activities. Such examples include the exhibition "The Fire and the Mountain" held in 2006 at the Civic Museum of Como (Italy) and the "Listen Reader" from Xerox PARC, an innovative and engaging reading experience installed in three different museums over a six-month exhibition period [1, 3].

The Design Rationale

Previous exhibitions at our local Science Center were unsuccessful, mainly because they were not adequate to the target visitors. Previous content was related to medicine, another exhibition was about sports and science, and the previous was about human senses. 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 Interactive Installations

The installations were grouped by themes. The design idea was to adopt gestures we are familiar with in real life to adequately control the interactive installations.

The first installation in this exhibition is the Laurissilva Time Machine. This installation allows the visitor to travel from the Tertiary period (when the forest was formed) until the present day. By pointing to the left, a timeline (displayed in the bottom of the projection screen) moves backwards in time. Pointing to the right moves the timeline forwards in time. The second installation is a magic book: using simple hand gestures in mid-air, visitors turn the pages of a virtual book where birds, flowers, Madeira Island's geological story and much more comes to life through videos, animations and pictures, as shown in figure 1. Using this interactive book is easy, and visitors of all ages were surprised and even wanted to take photos when performing the "magical" hand gestures.

The biodiversity of the Laurissilva forest was presented in a second group of interactive installations. The endemic flora species are presented in the form of a futuristic 3D showcase which is inserted on a "real" forest scenery where clouds, light and plants are gently animated. As the visitor approaches, sensors detecting hand gestures in mid-air are triggered and the visitor

figure 3. Visitors interacting with the virtual observatory.

figure 4. The interactive aquarium.

can turn the 3D showcase to watch and learn all about the endemic flora of the Laurissilva (see figure 2).

The virtual observatory of the Laurissilva had to be an installation dedicated to showing the visitor the birds (some of them very rare) that can be observed in the forest. To achieve this, our design was again inspired by the real gestures we perform in real life. When we are at the forest and see a bird, we instantly point to the bird. Therefore, we designed and built a sensor-based installation where visitors can control a virtual observatory featuring a 360º view of the forest. Pointing left or right moves the orientation of the observatory and birds suddenly appear flying, like in the real forest. The difference is, the visitor can watch them closely, hear their sounds, learn their facts and figures, and have fun, as illustrated in figure 3.

After watching and interacting with both fauna and flora, visitors can take a glimpse of what happens under Madeira Island's sea, in the interactive aquarium. A large, 40" LCD displays a realistic video of the underwater creatures. By blowing into the scuba diving tube (see figure 4), visitors can make bubbles which drift apart in the virtual sea. When the bubbles pop, they turn into larger bubbles containing information about an underwater inhabitant. Again, we were following our design rationale: adopting real life gestures to control the virtual exhibits. When we are underwater, we make bubbles.

One of the most popular and attractive installations is an interactive floor (illustrated in figure 5) which projects images and animations of "Levada" walks. Levadas are channels of water built by man in order to carry the water from the forest into the villages by the sea. They are extremely popular among tourists that make long walks through them, because of the amazing sightseeing and contact with deep nature. Our interactive Levada is a projected floor that detects movements of visitors and animates itself as if visitors were walking over water. As they walk, visitors get to know the famous Madeira Levadas and their history, facts and figures. Again, we used real life "interaction styles" to control the exhibit. You interact with the virtual Levada as you would with a real one: walking over it.

For the visitor who wishes to take a souvenir, a virtual photographer is also installed. The usage is very simple: by moving the left or right hand over the sensors, the visitor selects one of five virtual sceneries. Then, she positions herself to take the picture. Pressing a "Take Picture" button, a timer appears on the screen (3... 2... 1!) and the picture is taken and saved. It can then be sent by e-mail, or printed as a normal photo. The difference is that it's a magical photo, because it combines the visitor's real picture at the center with a virtual scenery from the forest. This installation can prove very useful to track people's facial expressions, as well as to maintain a visual record of all the visitors, which can be useful for e.g. gathering demographic information from visitors.

The UNESCO was a central part of the exhibition's concept. The Center wanted to make sure every visitor would get to know well the organization that classified Madeira's forest as World Heritage in 1999. To achieve this, and to make the installations easy to use, we decided to replicate the idea of the Encyclopedia presented before and created a similar book that explains the origin, history and goals of the UNESCO.

figure 5. A visitor walks along the interactive "Levada", as he would do in a real life one.

figure 6. The Science Center guide (dressed in yellow) shows visitors the Lauriquiz game.

The exhibition has other installations, but the last group was designed to promote environmental awareness and test the visitor's knowledge, in the form of games.

The Recycling game is a touch screen based installation aimed at promoting environmental awareness as well as at teaching visitors about recycling. The screen shows several objects floating over the forest. The goal of the game is to select the objects and send them to the correct can.

We wanted to provide new styles of interaction with the exhibit's modules. By using technology composed of real time video processing algorithms, the team conceived a game aimed at providing the visitor with the importance of water as a crucial resource that is captured and stored by the Laurissilva forest. Using a flashlight, visitors control a virtual glass and try to capture as many water drops as they can in the shortest amount of time.

At the end of the visit, people are challenged about what they have learned, and are invited to play "LauriQuiz". This touch screen-based game tests the visitor's level of knowledge about the Laurissilva forest. If a visitor paid attention to the exhibition, she will know the answers and can leave her name as a champion, in the champions list. This is an engaging game, with dice, sounds, and a TV-show style game that proved adequate to both adults and children.

The Experience: Learning and Enjoying

While some of the installations previously mentioned were solely created as experiential activities, providing an increase in the level of learning by adding facts to an already well-formed conceptual model, others were designed to enact a reflective activity, thus supporting a restructuring learning where new conceptual frameworks need to be built [7, 4]. Furthermore, we were also interested in observing the group behavior of the visitors, finding out how collaborative activities can be supported as a feedback mechanism to enhance engagement and learning motivation. To this purpose, and in order to observe the visitors' reactions, we used the testimonials of the exhibition guides. These workers are trained professionals that work fulltime at the Science Center. Over the last 5 months, they were responsible for accompanying every group that visited the exhibition and were only allowed to intervene if asked or if the visitors expressed any sign of repeated frustration on the interaction with one of the installations (see figure 6). Therefore, the guides acted as our ethnographic observers, and provided us with many interesting observations. We complemented this ethnographic study with observations of our own, which lasted 2-3 different days, and with informal interviews performed to some of the visitors.

We focused the observations on four issues: (i) Usability, how easy and intuitive was the interaction with the installations, (ii) Interaction model, how did the interaction model was learned and reapplied, (iii) Social interaction, which type of interactions triggered more collaborative activity, and how did this activity affect the performance of the interaction, and finally (iv) Learning effectiveness, did visitors learned anything, can we support reflective learning?

Concerning usability, all the installations were found to be easy to interact with, both by young and old visitors. The interaction styles proved to be intuitive and well

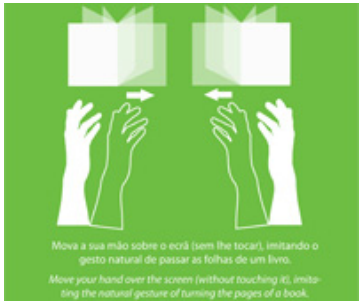

figure 7. A visual cue for using the magic encyclopedia was placed next to the sensors.

correlated with the conceptual model behind the information being displayed.

Regarding the interaction models used, it was observed that these were "transported" from one installation to the next, i.e., visitors that had interacted with the first three exhibits showed little or no trouble interacting with all the following others. This was accomplished by selecting three different interaction models to "open" the exhibition. Although this decision could harden the "work" of the visitor in the first installations, this was solved by placing visual cues in the form of little cards near the interaction space – as shown in figure 7 – which have proven to be quite valuable in sustaining a smooth flow throughout the exhibition, given that these models were reused.

We were also curious to notice how visitors interacted with each other. In particular in installations like the recycling game and Lauriquiz (which are game-driven installations), the social interaction reached much higher levels than in other installations. That collaboration clearly enhanced the level of engagement and focus of the users and at the same time, we believe that the social interaction was increased by that same engagement, working as a feedback mechanism, feeding the interaction and also being fed by it, reaching levels of focus that can support the formation of new conceptual models, thus enacting a reflective learning [7].

One of the biggest challenges we had, was to create an engaging and fun exhibition that could be appealing to both children and adults, that would be entertaining but at the same time educational. The crucial question we asked ourselves was "will people actually learn anything?"

Locating the Lauriquiz game at the end of the exhibition's circuit allowed us to informally measure whether or not visitors actually learned something with the exhibition. The questions asked during this game are not general but instead specific, regarding content that is presented in the previous installations. From what was noticeable, we could observe that visitors actually learned some of the content, and sometimes if they didn't know a specific answer, they would go back to the related installation and tried to look for the information.

Conclusions and Future Work

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 which 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 approach, centered on the visitor's profile description and based on using the real life gestures to control the virtual environments, has proven successful and was efficiently coupled with an agile design and production process that allowed the production of the whole 15 interactive installations in just 3 months, with

a reduced team. The number of visitors is constantly increasing and more than 90% of the visitors reported a happy, educational experience. We should reinforce that the installations were successfully explored by visitors of all ages. This suggests that the designs we presented here could also be re-applied to the design of inter-generation games, which could be an important way of making parents and grandparents play together and also learn with their children.

Jean Piaget once stated that to know the objects one must act over them and therefore transform them, move them, bound them, combine them and separate them. Knowledge in its origin, is not born from the objects neither the individual, it's born from the interaction of the individual with those objects [5].

The main problem we face nowadays, when trying to provide an educational experience and making it enjoyable, is to find out what should be experiential and what should be reflective. And how to efficiently support those two types of learning, and converting them to engaging interaction styles, should be addressed by the HCI community through concrete design case studies coupled with observational analysis drawn from those case studies.

One final conclusion was based on the fact that according to the center's guides, the majority of visitors referred the pleasing aesthetics of the installations as well as the smooth integration of the interaction with the animations and content. Tourists, in particular, referred the usefulness of learning about the forest they visited in this engaging way. We believe this exhibition achieves a nice balance between art and science by using artistic interactions to expose scientific content.

Acknowledgements

We thank the Porto Moniz Science Center staff for providing us with the resources needed to carry out the extensive observational study.

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