ec(h)o: Ecologies For Designing Playful Interaction

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Abstract: This paper discusses the design issues of playful interaction within a museum through the study of a museum guide prototype that integrates a tangible interface, audio display, and adaptive modeling. We provide an overview of our case study, summary of our user evaluation, and discuss our use of ecological approaches from the domains of acoustics, ethnography and information technology in order to investigate the liminal and engagement qualities of a museum visit.

Keywords: interaction design, tangible user interface, ecology, museum, audio display, adaptive museum guide

Introduction

Do we play in museums? Anthropologist Genevieve Bell identifies the notion of play together with learning in museums. She describes museums as different cultural ecologies in which the museum visit has the qualities of liminality (a space and time set apart from everyday life) and engagement (where visitors interact to both learn and play) (Bell). Guided by the notion of play in a museum experience we have considered playfulness equally with functionality and learning in the design of an adaptive museum guide. Our approach includes a tangible user interface (TUI), spatial audio, and an integrated user modeling technique combined with semantic technologies that support exploration and discovery. We understood our interface as playful action along the lines of aesthetic interaction. By this we do not mean the type of structured play that is found in a software game on a mobile device, rather we refer to the less structured and open play that is always possible and often can be subtle and implicit like toying with a ball.

In this paper we describe our case study of an augmented reality museum guide, known as ec(h)o, which we installed and tested at Canadian Museum of Nature in Ottawa. We discuss our use of a set of ecological approaches from the domains of acoustics, ethnography and information technology. Acoustically, we based much of our work on the ideas of sound ecologies. We also adopted the idea of museums as ecology informed by Bell’s cultural ecologies and Nardi’s and O’Day’s information ecology. This approach led to us being inspired by simple physical displays and puzzles we observed in our ethnographic sessions. These observations encouraged the playful tangible object and use of puzzles in our audio content. We were also motivated by the storytelling of the museum staff and researchers that was often humorous as well as informative. In this project, we found that learning effectiveness and functionality can be balanced productively with playful interaction through an adaptive audio and tangible user interface approach and that diverse ecology models help define the imaginative space and contextual aspects of play.

Previous Work

ec(h)o shares many characteristics with the adaptive systems of HyperAudio, HIPS and Hippie (Petrelli et al., 2001, Benelli et al., 1999, Oppermann and Specht). Similar to ec(h)o, the systems respond to user’s location and explicit user actions. All systems adapt content to the user model, location and interaction history. Among the key differences with ec(h)o is that these systems depend on a personal digital assistant (PDA) and graphical user interface (GUI); ec(h)o uses audio display as the only delivery
channel and a tangible object as an input device. In addition, ec(h)o uses inference at the level of semantic descriptions of independent audio objects and exhibit, and ec(h)o treats user interests as dynamic.

Prior to the evolution of adaptive and user modeling approaches in museum guide systems, there has been a strong trajectory of use of the PDA graphical user interface. Typically, hypertext is combined with images, video and audio (Semper and Spasojevic, 2002, Proctor and Tellis, 2003). Yet, a PDA is essentially a productivity tool for business, not a device that lends itself easily to playful interaction. Given the fact that PDAs utilize miniaturized desktop-based GUIs, we wonder if we should metaphorically carry around our desks in order to experience such things as museums – in what might be described as a world-behind-a-desk approach to mobile computing. Museum systems have mostly maintained the PDA graphical user interface approach despite the shifts in other domains to other approaches that better address the experience design issues most prominent in social, cultural and leisure activities. The play constraints of these devices are too great for the level of interaction that goes beyond playing a software game on a mobile device. For example, in the area of games and ubiquitous computing, Björk and his colleagues have identified the need to develop past end-user devices such as mobile phones, personal digital assistants and game consoles (Björk et al., 2002). They argue that we need to better understand how “computational services” augment games situated in real environments. The same can be said for museum visits.

Audio is seen as an immersive display that can enrich the physical world and human activity while being more integrated with the surrounding environment (Brewster et al., Pirhonen et al.). In addition, audio tends to create interpretive space or room for imagination as many have claimed radio affords over television. In the HIPS project, different voices and delivery styles were used to create an “empathetic effect” between the user and the artifacts they engaged (Marti). We’ve adopted a similar approach to our use of audio content.

**Description of ec(h)o**

Our approach includes a tangible user interface (TUI) for its inherent playfulness, spatial audio display for its imaginative qualities, and an integrated user modeling technique combined with semantic technologies that supported exploration. Our aim is to improve the visitor engagement by considering playfulness equally with functionality and learning.

The implementation went as follows: visitors are given a pair of headphones connected to a small, light pouch to be slung over their shoulder. The pouch contains a wireless receiver for audio and a digital tag for position tracking. When in front of an exhibition display, ec(h)o offers the visitor three short audio pieces as *prefaces* that are acoustically to the visitor’s left, center and right respectively. This spatial structure allowed the three *prefaces* to be distinguishable. The spatialization was mapped to the TUI, a wooden cube (see figure 1), for selection. The visitor *responds* by rotating the wooden cube in his hand and thus selecting a *preface*. The system delivers the audio object related to the *preface*. After the delivery of the object, the system again offers three *prefaces*. The visitor’s response is expressed through the gesture selection with the wooden cube. Additionally, the system may be met by no response, because the visitor does not wish to engage the system. The system will then enter into a silent mode. The visitor may also have moved away and the system will then initiate a soundscape that continuously plays while the visitor is in the spaces between exhibition displays.

The audio objects are semantically tagged to a range of topics for possible integration with networks of information across the Internet. At the beginning of each interaction cycle, three audio objects are selected based on ranking using several criteria such as current levels of user interest, location, and interaction history reasoned through our user model (Hatala and Wakkary). The topics of objects are not explicit to the visitor; rather the content logic is kept in the background.

In regard to the design process, many of the design choices were made through a series of participatory design workshops and scenarios (Wakkary, 2005). For example, the tangible user interface and its implementation as an asymmetrically shaped wooden cube resulted from these workshops, as did the use of the conversation metaphor, navigation and audio interface. In addition, we prototyped the exhibition environment and system in our labs in order to design the interactive zones, audio display and interaction with the exhibit displays.
Tangible object

The tangible user interface is an asymmetrically shaped wooden cube with three adjacent colored sides (see figure 1). The cube was carefully designed to ensure proper orientation and ease of use. The “bottom” of the cube has a convex curve to fit comfortably in the palm of the visitor’s hand and a wrist leash is attached to an adjacent side to the curved bottom suggesting the default position of being upright in the palm and at a specified orientation to the visitor’s body. The leash allows visitors to dangle the cube when not in use and frees the use of their hand. The opposite side of the bottom of the cube is colored and shows an icon denoting a pair of headphones with both channels active. The sides to the left and right are each uniquely colored and display icons showing active left and right channels of the headphones, respectively. The cube is made of balsa wood in order to mitigate tiredness from carrying the object and is therefore very light (approximately 100 grams or 3.5 ounces).

Audio display

The audio display has two components, a soundscape and paired prefices and audio objects. In the latter component, we used a simple spatial audio structure in order to cognitively differentiate between objects. Switching between the stereo channels created localization: we used the left channel audio for the left, right channel audio for the right, and both channels for the center. In addition, we provided simple chimes to confirm that a selection had been made.

The prefices were written to create a sense of surprise, discovery and above all play, especially in contrast to the informational audio objects. In order to create this sense we utilized diverse forms of puns, riddles and word play, such as ambiguous word play used in the preface “Sea urchins for sand dollars”; turn of phrase like the preface “An inch or two give or take a foot”; and riddles like “What is always naked and thinks on its feet?” In addition, the audio recordings of the prefices and audio objects used a diverse set of voices that were informal in tonality and style. This added to the conversational feel and created an
imaginary scene of a virtual cocktail party of natural historians and scientists that followed you through the museum.

Visitors’ movements through the exhibition space in between artifact displays generated the soundscape. Visitor movement was tracked using a combined Radio Frequency Identification (RFID) and optical position tracking system developed by Precision Systems (http://www.precision-sys.com). We divided the exhibition space into interactive zones and mapped concepts of interest to each zone and display. The concepts are translated into environmental sounds such as the sound of an animal habitat, and sound of animals such as the flapping of crane’s wings. The visitor navigates the exhibit exploring it on a thematic level through the ambient sounds that are dynamically created. If a set of concepts strongly matches the visitor’s interest the related audio is acoustically more prominent (see figure 2).

Fig. 2. Still frames depicting the dynamic soundscape based on visitor movement.

**Ecological Approaches**

We endeavored to consider how our design both intervenes and integrates within a complex museum experience. The ecological models of cultural ecologies and information ecologies provided us with frameworks for contextual analysis (Bell, Nardi and O’Day). This approach allowed us to look further into the design process past the interface for guidance into how our design decisions were integral to the ecology or ecology inhabitants, thus supporting us in developing more appropriate design responses. Bell’s cultural ecologies formally linked different actions and attributes of the museum visitor into a coherent description. As a descriptive tool it validated our assumptions and provided a clearer link between what we observed and the design implications. It was therefore generative much like Nardi and O’Day’s information ecologies framework. Both guided us in specific design decisions, namely the high degree of physical interaction that suggested a tangible user interface; the wide use of puzzles, riddles and games as modes of learning which led to our use of a riddle-like approach to our audio content; and the localized and informal storytelling on behalf of the museum staff and researchers that inspired us to structure our audio experience like a virtual cocktail party. For further discussion of the role of ecologies in museums we refer readers to (Wakkary and Evernden, 2005).

The auditory interface is another form of ecology. It provides the basic mechanisms of navigation and orientation within the information space. This entails investigations of mechanisms for mediating space-time modulations within the narrative information space. These mechanisms form the key components of a modeled acoustic ecology that takes into account the variety, complexity and balance of the informational soundscape. The research takes into account both psychoacoustic and cognitive characteristics of the ecology as well as compositional problems in the construction of a meaningful and engaging interactive audible display. Psychoacoustic characteristics of the ecological balance include spectral balancing of audible layers. Cognitive aspects of listening contribute to the design and effective use of streaming mechanisms allowing segmentation, selection, switching among audible semantic objects within the soundscape. Compositional problems were addressed in the form of the orchestration of an ambient informational soundscape of immersion and flow that allowed for the interactive involvement of the visitor. Techniques were drawn from sound design for cinema in developing relationships among soundscape, speech, and musical elements of the audible scene. The interface display takes into account
transitions, beginnings, ending, and, perhaps most importantly, interruptions in the narrative audio-informational flow situating the awareness of the visitor.

**Summary of User Evaluation**

User experience was evaluated through observation, a questionnaire, and a semi-structured interview. The evaluation group included two men and four women, from 25 to 53 years old. We also performed expert reviews by a senior researcher and senior interaction designer from the museum. Participants found the system enjoyable and stimulating, perhaps in part due to its novelty. The results were quite clear that play was a critical experiential factor in using the system. It was often remarked how the experience was similar to a game:

"The whole system to me felt a lot like a game. I mean I got lost in it, I found myself spending a lot more time in a particular area than I normally would. And just the challenge of waiting to hear what was next, what the little choice of three was going to be. Yeah... So I found it over all engaging, it was fun, and it was very game like." (Participant 5)

The playfulness did in most instances suggest a quality of engagement that led to learning even through diverse types of museum visits including the visitor who browsed through quickly but is still looking to be engaged, to the repeat visitor who experiences the audio information differently each time.

The evaluation did point out challenges and areas for further research. Some things we expected such as the headphones were uncomfortable, yet to such a degree that we are currently rethinking the use of personalized spatial audio and headphones. Other results point to a threshold in the balance between levels of abstraction and local information, since visitors had difficulties at time connecting what they were listening to and what was in front of them (in part this was an inherent challenge in the exhibition since the display cases had dozens to over a hundred artifacts). In many respects this points to the finding that the semantic technologies approach did not always provide a clear enough contextual link between the artifacts and the audio information. In addition, we see both a threshold point in play versus focused attention on the exhibit. For example, one user’s enthusiasm for the game-like quality led her to at times pay more attention to the interaction with the system than the exhibition. This raises the issue of balance in play and the possibility to shift attention away from the environment rather than play as a means of further exploring the environment.

**Conclusion**

ec(h)o is an augmented audio reality system for museum visitors that utilizes a tangible interface. We developed and tested the prototype for Canadian Museum of Nature in Ottawa. In this paper we have presented relevant work in adaptive museum guides and described the components of our prototype. We discussed our use of ecological approaches in acoustics, ethnography and information technology systems. The findings of this project are positive while also calling for more research in several areas. We conclude that learning effectiveness and functionality can be balanced productively with playful interaction through an adaptive audio and tangible user interface approach and that diverse ecology models help define the imaginative space and contextual aspects of play.

**References**


