The EcoRaft Project: A Multi-Device Interactive Graphical Exhibit for Learning About Restoration Ecology

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CHI 2006, April 22–27, 2006, Montréal, Québec, Canada.
ACM 1-59593-298-4/06/0004.

Abstract
The EcoRaft Project, an interactive installation designed to help children learn about restoration ecology, allows participants to engage physically with animated agents via a natural and intuitive interface. This physical engagement occurs when the agents transfer seamlessly from stationary computers to mobile devices, on which the agents are realized as quasi-physical manifestations. Utilizing tablet PCs to act simultaneously as objects in the physical world and as mobile virtual spaces, the system incorporates embodied mobile agents that increase levels of engagement. The project has been publicly shown at several venues, where over 2000 participants interacted with the system. This paper presents initial evaluation results based on interviews with participants indicating that the embodied, physical interaction in this installation leads to participant engagement and collaboration, and enhanced educational effectiveness.

Keywords
Multimedia installation, children, collaborative education, physical interfaces, engagement, rainforest and restoration ecology.

ACM Classification Keywords

H.5.1 Information interfaces and presentation (e.g., HCI): Multimedia Information Systems – *Animations; Artificial, augmented, and virtual realities; evaluation/methodology*.

Introduction

Increasingly, mobile computing devices are becoming an integral part of daily life. Devices such as tablet PCs, mobile phones and PDAs are changing both users' business practices and social lives. These devices can provide an avenue through which computational entities break the plane of the computer monitor and engage users in the physical world. Such an approach can be used to create embodied mobile agents [7], increasing an interactive system's ability to engage users. This paper presents a case study of a multi-device interactive educational exhibit called the EcoRaft Project that harnesses this increased engagement to facilitate an enhanced educational experience. This paper describes the implementation and initial evaluation of the installation with a view to further development and evaluation.

The virtual rain forest in the EcoRaft Project.

Figure 1. Several children collaborate while interacting with the exhibit.

The EcoRaft Project is an interactive installation designed to teach children about the process of restoration ecology. The system includes three desktop computers connected to 26" LCD screens that together represent three "virtual islands" inhabited by populations of animated animal and plant species (See Figure 1). One of these islands acts as a "national park," which is a protected area and cannot be deforested. The other two islands, however, have buttons in front of them which, when pushed, remove all of the native animals and plants from that island. To restore the island back to its previous level of biodiversity, children need to use three tablet PCs to move organisms around the installation space, each device serving as a container to transporting a different type of organism – Heliconia flowers (similar to the bird-of-paradise plant), Coral trees (branching trees with red compound flowers) and several species of hummingbirds. The three containers are visually distinct from each other; the two plant containers look like empty wooden boxes with a picture of the correct plant drawn at the bottom, and the hummingbird box has a graphical chicken-wire mesh at the top and newspaper on the bottom. In order for a participant to collect an organism of a specific species from an island, he or she needs to bring the appropriate container up to that monitor. When the tablet PC is brought near the monitor, an animated animal or plant moves from the monitor to the tablet PC. For example, a hummingbird flies onto the tablet PC's screen, or a seed pod from one of the plants appears to roll off the island onto the device. The participant can then physically move the tablet through the installation space, carrying the organism on the tablet from one island to another. When the tablet is brought near another monitor, the hummingbird or seed pod then moves off of the tablet and onto that island. Participants must bring the various species over in the proper order, using one species to lay the foundation for another, enacting the process of restoration ecology. In order to let participants know the current state of an island's ecosystem and understand the underlying ecological principles, the system includes a number of text overlays narrated by a voiceover.

The installation is based on accurate, current research in the study of restoration ecology, e.g., [2]. In addition, it draws on previous research on multi-device systems involving graphical agents [4, 6] and on interactive education systems for children that co-presents collaboration with tangible interfaces [5]. This paper focuses on how various aspects of the system were designed to increase participants' engagement and collaboration, and how that engagement and collaboration is being channeled into accomplishing the educational goals of the installation.

Implementation

This section describes several aspects of the implementation designed to increase engagement and encourage collaboration.

Wireless Transfer with IR for Proximity Detection

The transfer of agents through the system is accomplished by a combination of infrared sensors and wireless Ethernet. The tablet PCs have an infrared port on their sides and IR dongles are attached to the bottoms of the monitors, allowing the desktops to detect when the tablets are in proximity. In addition, since IR requires line-of-sight to communicate, it provides information about the respective orientations of the devices as well. When the two devices are able to establish an infrared connection, they proceed to communicate through the wireless network to determine if any agent should be sent and in what direction, i.e., to or from the tablet. The design team considered using a vision system, Bluetooth triangulation, and a number of other methods for proximity detection, but ultimately chose to use IR because it provided both proximity and orientation information, and because it is standard technology in many mobile devices.

Accelerometer Adds Physicality to Virtual Objects

The tablet PCs used in this system were selected because they feature a built in accelerometer, which can be used to determine the orientation of the tablet about two axes, specifically pitch and roll. By polling this sensor, virtual objects on the tablet PCs can move around as if they were responding to gravity, much like the raft in the Virtual Raft Project [8]. Here, the accelerometer data is tied to the movement of seeds and hummingbirds while on the tablet PC. Specifically, seeds roll around in a wooden box and hummingbirds fly to the highest point in their cage.

The physical orientation of the device was incorporated to increase participants' physical engagement with the system. Subjecting virtual entities on the tablet to the effects of gravity lends them a certain amount of physicality, transforming them into what one participant called "quasi-physical objects." Allowing users to engage with the system in this way gets them to become involved in a physical, visceral way with virtual entities that might otherwise seem ethereal and disconnected from the user's physical world.

Distinct Containers
As mentioned above, each of the three transferable types of organisms in the EcoRaft installation has must be carried using a specific type of container. Each of these containers was implemented on a separate tablet PC, so that one tablet carries Coral tree seeds, one carries seeds of the Heliconia flower, and one carries hummingbirds. The feature of having three different containers was chosen in order to prevent a single participant from completing the entire restoration process by only making a single trip from the thriving island to the deforested one. Furthermore, since no one container can be used to restore an island fully, participants need to work together and use all of the tablets in order to achieve full ecological restoration. This design choice is also preferable because it bears resemblance to a real life scenario, since a single person who specializes in one aspect of restoration would seek the help of other colleagues when engaging in the restoration process. In addition, it enhances the educational aspect of the system by helping children to experience the collaborative component of the complex process of restoration ecology.

Evaluation

The EcoRaft project has been exhibited in several venues allowing for some initial evaluations to be performed. These evaluations consisted of semi-structured interviews with participants after, and in some instances also before, interacting with the system. The participants interviewed interacted with the installation either through the SIGGRAPH Emerging Technologies venue, the Discovery Science Center (DSC) in Santa Ana, CA, or in a research lab on the campus of UCI.

During these evaluations, several goals were considered. First, the evaluation should establish the installation's efficacy as an educational tool. Second, the evaluation should help determine to what extent the engaging and collaborative aspects of the installation aided in the educational process. Third, the methods used should allow the evaluators to determine what the weaknesses of the system are and how they can be improved. To these and other ends, certain aspects of Druin's cooperative inquiry [3] were incorporated.

Education and Collaboration
The EcoRaft Project was designed to foster collaborative behaviors as a means to enhance education. However, another, unanticipated collaborative behavior also occurred, one that has even more bearing on the learning process. In all of the deployments, participants not only worked together to restore the virtual ecosystems, but would actually instruct each other in the use and principles of the system. While this behavior was common at SIGGRAPH, it was far more prevalent among the deployments with the target audience of 8- to 12-year-old children. Bruckman found a similar phenomenon of experts acting as mentors for novices in her system [1]. In the EcoRaft installation, such collaborative teaching occurred in a number of forms. For example, experienced onlookers would sometimes instruct users, telling them the proper orientation to hold the tablet, why the seed they planted would not grow, or what they should do next.

Both these forms of collaborative teaching also occurred with the groups of children, and to a much greater extent than at SIGGRAPH. One of the participants interviewed at DSC started using the system when his older sister brought him over and explained the use of it to him. Another, when asked how he knew what to do, commented that he "figured it out by [himself]… kind of looked at someone else." Something else that occurred at DSC was spontaneous collaboration between strangers. When approaching one child about an interview, one of the researchers asked if the child's brother would be interested as well, to which the child replied with a very curious look. When the researcher clarified that he meant the boy with whom the child had been working, the child replied that it was not his brother but just some other kid he was playing with. However, children engaging with the system did more than instructing each other; they actually worked together to solve the challenges presented by the system, as necessitated by the fact that each tablet can only carry one species. These initial evaluations indicate that the processes of communal learning and collaborative reconstruction facilitated by the design of the system function to make the EcoRaft an engaging and effective educational tool.

Improvements

As mentioned above, the evaluations were performed with a view not only to determining EcoRaft's successes but also its shortcomings. As such, the interviews indicate a number of ways that the installation could be improved. One of the main ones was that the system lacked the complexity and challenge necessary to achieve the highest possible levels of engagement.

During the process of designing the installation, one of the goals was to make the system simple enough that children could comprehend the problem presented to them and complete the process of restoration within the space of a five-minute interaction while still maintaining and conveying the core ecological concepts behind the installation. However, two problems with this approach emerged. First, most people who used the system ended up spending anywhere from 5 to 10 minutes interacting with it, some as long as 20 minutes, which was more time than anticipated. Second, many of the participants interviewed, both adults and children, said that the system needed more complexity, either that it was too simple and thus too easy, or that it lacked the complexity of a natural system. A majority of participants suggested that the added complexity come in the form of more species.

However, designers were hesitant to introduce a plethora of new species into the system. In general, when asked how to make a system better, users often tend to reply, "More." More features, more buttons, more physical objects, more species, more things to transfer. One child, when asked how to make the system better, replied that she wanted to see "lions and tigers! And jaguars! And big snakes! Big snakes! Poisonous snakes! Alligators and crocodiles." This "lions, tigers, and bears" mentality easily gives rise to a feature creep that can very quickly over complicate a system, and an excess of complexity was explicitly avoided in this system. Part of the point with this installation is that it be simple enough for a novice to approach and, in a matter of moments, grasp the concepts behind it start interacting. Any system above a certain level of complexity is, by the nature of that complexity, prohibited from being immediately intuitive to the novice user. That level of complexity was intentionally avoided. However, it is possible that additional complexity could be built into the system through the implementation of different levels, which allow more advanced participants to experience a more complex system.

Future Work

The next directions for EcoRaft will pursue two main avenues. First, work is currently being done on improving the system based on feedback gained from the initial evaluations described here. Second, the team is attempting to determine the best methods for evaluation of the project, both in terms of evaluating the interaction and educational experience as well as determining long-term retention and transferal of knowledge gained from the installation. Initial evaluations have been conducted, but there is still a great deal of work to be done to assess effectively the educational impact of the experience.

Acknowledgements

The authors thank the other researchers on the EcoRaft team, the Donald Bren School of Information and Computer Sciences, the Claire Trevor School of the Arts, the California Institute for Telecommunications and Information Technology, the Nicholas Foundation, the Emulex Corporation and several anonymous reviewers for their support and contributions.

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