paper

design goals for networld, an immersive public exhibit about the internet

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Abstract

This paper discusses the design challenges for creating NetWorld, a permanent museum exhibit about how the Internet works. The exhibit space itself is responsive to visitors. It senses them through technologies such as computer vision, wireless ID cards, and physical devices with embedded sensors and responds to them through large touch screens and large-format interactive displays that span across multiple projectors. We present the design goals that lead to the adoption of these techniques and discuss the practical challenges in creating a coherent aesthetic and immersive visitor experience while adopting brand new technologies.

Keywords: Immersive Public Spaces, Physical Interactives, Multimodal Interaction

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Introduction

Over the past several decades the nature of public space has undergone a transformation: public entertainment has become ubiquitous. The growth of urban entertainment centers, theater complexes, theme restaurants, gigantic shopping malls, theme parks, and increased Internet access has fostered fierce competition among entertainment, retail, and educational outlets for an audience that has very high expectations but limited time, money and attention. A direct result of this competition has been an increased demand for a new generation of spaces within which the general public can have a novel entertainment experience [1][2][3][4]. The discussion below focuses on what we have learned from our experiences in designing and building NetWorld, an interactive public educational space. Our past work has been primarily in the domain of location-based entertainment. However, this discussion may prove useful to anyone with an interest in expanding the boundaries of interaction techniques and those looking for ways to design compelling, non-traditional entertainment experiences for the public. In the following sections we first outline some general goals for the design of these types of spaces, after which we discuss our design process and some constraints by which it is guided. Following that, we present the NetWorld project and discuss some of the creative and technical approaches that we used to achieve these goals.

1. General goals

When designing an immersive entertainment or educational space for the general public there are several over-arching goals that we have found to be characteristic of a successful experience.

1.1 Accessibility

We always strive to create an experience that is accessible to and enjoyable by the widest possible audience. One of the many aspects of this goal is the consideration of age. In a science museum, for example, the experience must first and foremost be fun for children, because otherwise they may not participate long enough to absorb the educational content. However, since children rarely attend museums without adults, the space must also be appealing to their parents and other older visitors. Physical ability is another aspect of this goal; public spaces must often meet the stringent access requirements such as those of the Americans with Disabilities Act in the United States.

Another consideration is that around 8% of men and 0.4% of women have some form of colorblindness, so color palettes must be carefully chosen.

1.2 Blending between the real and the virtual

A second major goal for an immersive space is to make the blend between the real and the virtual portions of the space as seamless as possible. The architectural design and the interaction patterns should complement each other. Under ideal circumstances, the physical space is designed to blend with the virtual imagery and support the intended interaction patterns. For example, subtle changes in the physical layout can serve to guide the desired movement of people within the space. More often than not, however, the experience must be designed to accommodate an existing space. In this situation the designers can smooth the virtual-physical boundary by incorporating the real-world objects into the virtual space. It is also possible to enhance the architectural space with projected imagery, thereby adding life to inanimate surfaces.

1.3 Direct interaction

To create a sense of immersion it is not sufficient to merely surround the visitor with imagery. It is also very important that the method of interaction be direct, intuitive, and obvious. Levels of indirection are to be avoided because they distract from the immersion. For example, by requiring a user to move a mouse or press buttons in order to connect with a virtual object the designer has emphasized the seam between the real world and the virtual. A better scheme is to use the visitor's body as the interface whenever possible. If the focus of interaction is on an object, have the user touch it wherever it is--- on the wall, on the floor, on a table, wherever. Use the position and motion of a visitor's body as an interface device. If a physical input device is needed, design it to resemble an item in the virtual world and, if possible, have it physically respond to what is happening around it in the imaginary space. Also it is helpful to take advantage of people's familiarity with the way objects work in the real world. For example wheels turn, and are a familiar interface for steering (in cars). We can take advantage of that familiarity when creating a new interface. These guidelines make the interface more intuitive and engaging.

1.4 Seamless/ Invisible technology

Another goal is to make the technological behind the experience invisible in the interaction. One of the main reasons why Disney World is so successful is that people leave their experiences wondering "how did they do that?!". This sense of wonder makes the experience magical and unique, driving the visitors to return again and again.

2. The Design Process

While these general goals give us directions in which to push a project and help us to evaluate a project, most of the work in creating the exhibit lies in making tradeoffs between various approaches and coming up with solutions that work within the constraints of the project. This section outlines the design process that we go through to create an exhibit.

2.1 Project-specific goals

Design goals are meaningless without first articulating the primary goals of the installation itself. When we work with a client, the first month or two is often spent trying to articulate the high-level goals of the project. Sometimes this is easy to define and we quickly move on to interaction design, while other times the process is iterative because the client does not want to close off any options by making an early design decision. Clients often worry that the specification of goals will constrain the possibilities for design. While this is true, fear of goal specification is counterproductive, because once the goals are clarified, potential paths to achieving those goals can be identified earlier and more quickly. In addition, it becomes possible to evaluate whether or not a given design will help create a successful installation.

An example of a how a primary goal might be determined is by answering the question "what is the one thing people should remember about this experience?" or "what is the story that needs to be told?" The answers should be one or two sentences long, such as "kids should feel like they were inside the Internet", or "people should leave with the experience with the knowledge that Internet packets travel through many computers before they arrive at their final destination."

2.2 Project constraints

Once the project-specific goals are defined we can begin thinking about the kinds of experiences that will best meet those goals. Should the experience be guided, like a linear narrative, or should people be able to jump in at any time? If the installation has multiple components, will there be a preferred order of viewing, or should each unit be self-contained? Sometimes these decisions are constrained by the client's throughput requirements (i.e., people per hour). If high throughput is required we have to estimate the amount of time it will take to complete each task; if an interaction is too slow, it must be changed or simplified to allow the desired throughput. In high-volume locations such as museums or theme parks, crowds will form if visitors spend more than thirty seconds at certain units.

There are many ways of working around constraints without losing the essence of the design. For example, NetWorld had a high throughput constraint that needed to be reconciled with highly personalized interaction. Instead of having visitors step up to a kiosk and type in personal information like a username, which would have created a backlog during peak museum hours, we instead created a collectable visitor pass containing a tiny wireless ID tag (using Bistatix RF technology from Motorola[6]). This reduced the interaction required to simply waving the pass in the air next to each unit. The unit can then present something unique for each visitor based on what they did in the exhibit. The card was designed to be a keepsake by placing an attractive lenticular animation displaying an avatar character on the card's front face.

The designer needs a great deal of experience and creativity in order to effectively balance geometric, calibration, economic, and human-factor issues. When design choices are constrained by the characteristics of the physical space, such as ceiling heights and physical layout, we attempt to use these architectural elements to our advantage whenever possible. For example, projection displays require large throw distances to achieve large display geometries so large walls or high ceilings present opportunities to build giant displays that entertain many visitors simultaneously and create a visual experience that the visitor is unlikely to encounter at home or elsewhere. Furthermore, projection displays have expensive bulbs that need to be replaced periodically, as well as brightness and contrast limitations. Often the cost of projectors is constrained by budget, so a designer must carefully choose equipment that balances all the needs. The following sections outline how these some of tradeoffs were implemented in the NetWorld exhibit.

3. NetWorld

NetWorld is an exhibit about how the Internet works. It was created for the Museum of Science and Industry in Chicago and opened in March 2001. Nearlife worked on the project for about a year and a half, including about 6 months of design time. After having done some prior conceptual work in 1998, the museum approached Nearlife with the idea of making a major exhibit about the Internet and solicited our design approach. Considering the possibilities, we realized that we did not want to create an exhibit that simply shows what can be done on the Internet (e.g., surfing the web, shopping, participating in chat rooms) but rather gives visitors a unique look "under the hood" of the Internet [7]. The exhibit was intended to be "permanent," which meant a life span of 5 to 10 years. Because of this we did not want to focus on issues that might be timely at the opening, such as Napster, but could potentially be outdated a year later.

With these goals and constraints in mind we decided to focus on the fundamental concepts behind how the Internet works, since these concepts were not likely to change as quickly as the technological advancements based upon them. We put our focus on explaining concepts such as packet switching, bandwidth, and how web pages are built up from 0's and 1's traveling between nodes on the Internet. The fundamental story that we wanted to tell was that "digital information of any sort is broken down into its constituent bits; those bits are used to fill up many fixed-size packets that are then sent out onto the Internet, traveling across many computers before being reconstituted at their final destination".

This story is told in one way or another using the same visual language throughout the many units in the exhibit. The visual story is of media (email, audio, image, or video) being broken into parts (e.g., email text breaks into letters; images break into chunks of pixels) that further break up into streams of flowing 0's and 1's. We call this process "bitification". The 0's and 1's fill up pill-shaped packets that are then sent out into the Internet. These transitions were implemented in our 3D interactive system with various combinations of particle system effects. In addition to helping us share the core software development across many of the units, we found that a consistent visual language helped to repeat the story in all of the various contexts.

3.1 Immersion in the Internet

Inspired by imagery from films such as The Matrix, we found the idea of a dense, frenzied, overwhelming network of data to be a compelling aesthetic, and wanted the visitors within the exhibit to feel like they were immersed in such an environment. To that end, we made heavy use of floor projection and computer vision sensing to make the space itself responsive to visitors. In particular, we created two units that are large multi-projector floor projection interactives. In one, luminous discs with Internet trivia questions written on them wander around on the floor and then flip over when someone stands on them to reveal the answer. In the other, a huge simulated river of 0's and 1's flows across the floor; as people move through the virtual river the particles adjust to flow around them as they are tracked using ceiling-mounted cameras and people-tracking software. The centerpiece of the exhibit is a custom-built 9.75 by 1.82-meter rear-projected display called the "Portal Wall". This display tells the story of how web pages are built up from packets; It shows how 0's and 1's flowing out of packets are converted to ASCII characters that form HTML code that makes up web pages. Because the display is so large, it becomes a major attraction point and adds to the feeling of being immersed in the environment.

3.2 Aesthetics

Though we wanted to use imagery that was familiar to people from other popular representations of "cyberspace", we did not want to simply repeat what had been done before[11]. Also, our vision of the network was of an organic space filled with flowing information in it, not one that was cold and linear. To emphasize this we designed the architectural structures to be smooth and organic-looking, incorporating curved walls and a curved cable tray that functions as a both the figurative and literal backbone of the exhibit as well as a decorative element. In the design of the virtual space, we focused on creating curved flowing streams of 0's and 1's in various incarnations and colors.

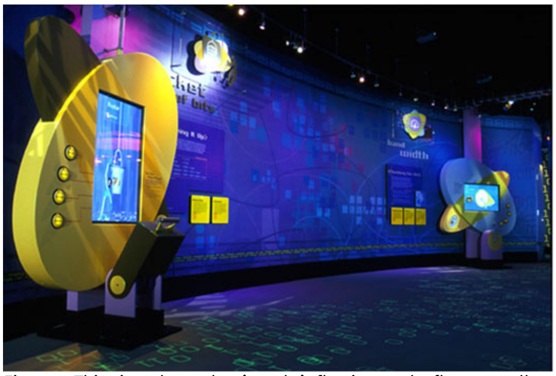

Figure 1. This view shows the 1's and 0's flowing on the floor as well as two mixed physical and virtual interactives that tell visitors about bits and bandwidth on the Internet.

3.3 Bits and bandwidth

To give people a feeling for how information is represented on the Internet, it is important to show how all types of information are represented as 0's and 1's. To convey that, and to give a sense of how much information is in different media types, we let people compare how much an email "weighs" versus how much an image "weighs" with a force-feedback lever. People can select a media type, whose bits fill up a virtual bucket, and then attempt to lift the bucket with a real lever whose resistance changes in response to what is inside the bucket.

In the Bandwidth unit, visitors choose different media types that are digitized and sent down "pipes" of varying bandwidth so that the visitor can get a sense of the difference in capacity of various transmission mediums (e.g., 28.8 kbps modem, T1, OC3, etc).

3.4 NetPass wireless ID cards

We also wanted to give visitors a feeling of being "inside the network" by putting some part of them into the network. To that end, we encourage visitors to purchase a collectable card called a NetPass that contains a wireless ID tag. At every unit, the visitor can swipe their NetPass on a sensor, causing a personalized avatar to pop in and join the visitor in the particular unit's activity. At "Digitize Yourself" unit a visitor can have his or her face digitized; if they have a NetPass their face will be placed on their avatar's face. The avatar will then appear with their face on it in every other unit. The idea is that, by having the visitor's own bits traveling through the exhibit's network, visitors will begin to feel like they themselves are inside the network. In fact, the people's images are not purged from the exhibit database until disk space is low, so repeat visitors will still be "in the network" when they return for a second visit.

The NetPass is supported by a central database that stores every card swipe and associated data (e.g., visitor's face). Each time a card is swiped, the database is queried for data associated with the card so that a current avatar representation can be shown. The avatar character and all the 3D animation presented to visitors is supported by a networked version of Nearlife's character animation system based loosely on [8] and [9].

Figure 2. This shows the Portal Wall display with an avatar in the foreground.

3.5 Messaging

One important use of the Internet is personal communication. We wanted to reinforce the idea that anything that people create and communicate over the Internet uses the same underlying representation of packets, bytes, and bits. To that end we created two units: Shipping and Receiving. In the Shipping unit, people can create messages using an interface similar to the familiar refrigerator magnets and see how they are made of bits that are chopped up into fixed-size packets. In the receiving unit, people can reassemble those packets to read their messages as well as others' messages. The Shipping unit is a large (approximately 120 by 160 cm) rear-projected touch-screen display that shows words floating in space. When people touch the words, they float down onto a message tray. When they are happy with the message, it can be sent out into the network and retrieved on the Receiving unit. Because the display is so large, the whole interface is on a virtual pivot that allows visitors to move it up and down so that children can reach the words as well as adults. We used rear infrared (near-IR) illumination and computer vision to sense screen touches in the Shipping interactive [10].

3.6 Packet Switching

Another key message that we wanted visitors to learn is that information is sent on the Internet from node to node and then reassembled on the destination computer.

Figure 3. A boy blocks the flow of packets on the Packet Switschung Table

We showed this through an interactive Packet Switching table where people could turn off a node by touching it and see how the packets are rerouted to reach their destination. Visitors learn intuitively how this is a fault-tolerant system until all routes are blocked (at which point an alarm goes off). The interface for this is a table with a simulated network projected onto it. Media objects fly in on one side and are bitified before they fly into the network as packets and are reassembled on the opposite side. Nodes in the network are represented by metal touch-sensitive disks that stick out of the table surface. People find this interface inviting and often come up to it and start experimenting naturally without any particular purpose. When their curiosity is piqued, they can quickly determine how the table is functioning algorithmically because they can see the packets flowing through the nodes or being blocked as a result of their actions.

4 Practical Issues

4.1 Managing complexity

The NetWorld exhibit presented us with many challenges during the design and implementation process. One of the main issues was scale. The exhibit contains 10 distinct units (4 of which are repeated), and uses 35 computers, 19 projectors, and several other display types (such as LCD and large-format plasma displays). For sensing touch on the rear-projection screens we are using 2 IR-sensitive cameras; and for people tracking we use 6 special depth-sensing Triclops cameras from Point Grey Research[12]. We found that a significant portion of our time was spent researching and ordering equipment and maintaining accurate inventory. For example, computer projector bulbs can cost a few hundred dollars each, so with that many projectors, bulb-life became a significant issue. By finding a projector that met our other specifications (high brightness and short throw distance) and had a 2000 hour bulb life instead of a 1000 hour life, we potentially saved the museum twenty thousand dollars per year in light bulbs!

We also had to create systems that manage the day to day running of the whole exhibit by starting up and shutting down the exhibit from one central location, as well as monitoring the functioning of all the units. These systems are often overlooked when designing public interactive spaces. It is as important for the exhibit technicians to effectively monitor the exhibit as it is for the public to have a rewarding experience.

4.2 Multi-projector Displays

Another technical issue we had to tackle was using multiple projectors to create large seamless displays. Wherever possible we used multi-board graphics card solutions to avoid writing and debugging complex networking software; this also saved money requiring fewer computers. The multi-board solutions had their own problems, however. Because graphics cards that support multi-board configurations represent a small niche market for many manufacturers, the performance is usually lower than that of single-board solutions, and sometimes certain features are not supported. For example, we are using a four-board solution in some of our units. Their graphics driver only supports a 4 by 1 display matrix because that is how the manufacturer the board being used: running a driving simulator with four monitors on a desktop. We required a 2 by 2 arrangement, however, so we had to come up with a creative solution, mirroring the scene geometry with an offset so that the geometry appears on each screen in the proper place. Readers interested in approaches to building scalable displays may enjoy reading [13].

4.3 Testing

During our development process we always perform several rounds of visitor testing. Sometimes this takes the form of inviting people to the company for testing of our interfaces, and sometimes we do on-site testing with random museum visitors. The latter is preferable whenever possible, because it provides a more accurate sample of our target audience.

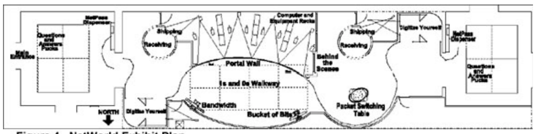

Figure 4. NetWorld Exhibit Plan

When asked carefully, visitors can give very valuable feedback about what makes sense to them and what does not. Sometimes we are aware of what needs improvement and this feedback helps to validate our intuitions speed up the improvement process.

On other occasions user feedback helps to reveal unforeseen problems. When testing a one NetWorld unit, for example, we discovered a surprising and important issue. The unit in question (Receiving) involved a touch-screen interface where visitors had to properly arrange color-coded packets arriving from the network in order to decode a message that had been sent by another visitor. One of the visitors testing the unit was colorblind and could not see the difference between the packets! After finding a site on the Internet that shows what an image will look like to various types of colorblind individuals [14], we adjusted the colors and brightness levels until the difference between packets was clearly discernable.

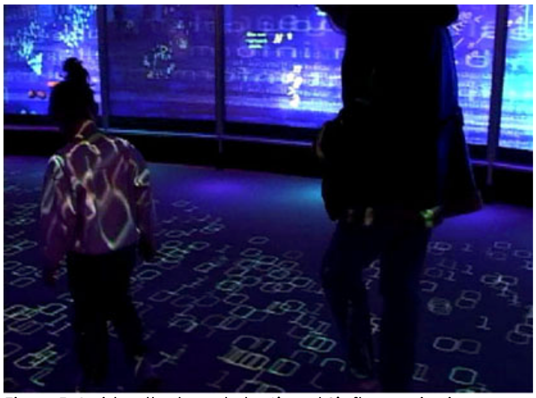

Figure 5: A girl walks through the 1's and 0's floor projection

In the previous sections we discussed Nearlife's approach to designing successful, immersive public entertainment spaces. While we believe that the approach outlined above is a useful and successful one, we consider it neither perfect nor cast in stone. Having evolved over time from experiences with NetWorld and other projects, our approach continues to expand and improve. It is our sincere hope that future designers will apply their talents to this exciting domain, and create spaces that we can both learn from and enjoy.

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