Unearthing virtual history: using diverse interfaces to reveal hidden virtual worlds

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Abstract. We describe an application in which museum visitors hunt for virtual history outdoors, capture it, and bring it back indoors for detailed inspection. This application provides visitors with ubiquitous access to a parallel virtual world as they move through an extended physical space. Diverse devices, including mobile wireless interfaces for locating hotspots of virtual activity outdoors, provide radically different experiences of the virtual depending upon location, task, and available equipment. Initial reflections suggest that the physical design of such devices needs careful attention so as to encourage an appropriate style of use. We also consider the extension of our experience to support enacted scenes. Finally, we discuss potential benefits of using diverse devices to make a shared underlying virtual world ubiquitously available throughout physical space.

1. Introduction

Museums, galleries, cultural heritage and tourism are promising application domains for ubiquitous technologies. Personal and handheld devices coupled with embedded and projected displays can enrich experience inside a traditional museum or gallery [1, 4, 11]. Mobile technologies can enhance cultural experiences when exploring a surrounding city [5]. We are interested in how a combination of the two might provide visitors with rich and engaging cultural experiences that connect a conventional museum or gallery to a surrounding city or site of special interest. Our approach involves providing participants with diverse interfaces for detecting, revealing and experiencing events that are taking place in a parallel 3D virtual world; that is a virtual world that is hidden behind, but potentially ubiquitously available from, everyday physical space in both indoors and outdoors locations.

2. A first demonstration – Unearthing virtual artifacts on the Nottingham campus

We have created a museum experience where participants explore an outdoors location, hunting for buried virtual artifacts that they then bring back to a museum for more detailed study. Inspired by the results of previous museum projects, our intention is that the process of actively searching for history will be engaging for visitors and will also lead them to critically reflect on the information that they discover [12]. At the beginning of the experience participants are told the following (fictional) back-story:

During the construction of our campus in 1999 builders unearthed four ancient artifacts: a samurai sword, a maiolica dish, an ivory box of dominoes, and a bell (objects from the collection at the nearby Nottingham Castle museum). Scientists have since discovered that physical artifacts radiate traces of their history. When they are buried for long periods of time these traces can leak into the surrounding earth, and can subsequently be detected and captured using specialized sensing instruments. Unfortunately, our builders failed to note the locations where the objects were unearthed.

Part 1: outdoors – locating the target objects and capturing their history

Groups of participants head outside and search an island on our campus using a "virtual history meter", a device that informs them of their proximity to various virtual objects that actually exist in a 3D virtual model of the campus. This device consists of a laptop and a Compaq iPAQ that communicate with one another and also with computers in the nearby laboratory over a WaveLAN network. The global position of the laptop as given by an attached GPS device is transmitted back to computers in the laboratory, enabling them update the position of an avatar in the virtual world that represents the search party. In turn, the computers running the virtual world update the mobile laptop with measures of this avatars' proximity to different fragments of the virtual objects. For brevity, our initial demonstration is limited to three fragments from one object, the maiolica dish.

It can be difficult to create a satisfactory and reliable visual overlay of a virtual world on an outdoors scene due to a combination of limited tracking accuracy and variable lighting conditions [3]. We have therefore opted for an alternative approach that is primarily based upon audio information. The proximities of the search party to the three fragments are sent to a computer in the laboratory that is running an application that sonifies the party's location in relation to the fragments. Each fragment has a different pulsing synthesised tone associated with it that increases in amplitude and pulse rate as the search party get closer to it. The mix of the three tones is transmitted to the wireless laptop. When our participants are within a (configurable) distance of a fragment, they are deemed to have acquired it. They now hear a different tone and the iPAQ device displays an appropriate image and some accompanying text.

Figure 1 shows two participants searching our campus next to the corresponding image of their avatar in the virtual world as it encounters one of the fragments.

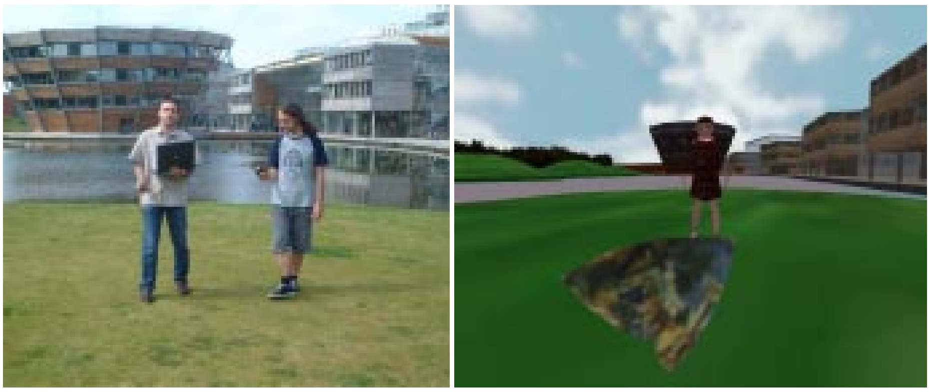

Fig. 1. Hunting for fragments of virtual objects outdoors

Part 2: inside the museum – viewing the captured history

The search party brings the captured virtual history back to the museum in order to view it in detail. Each captured fragment is loaded onto a periscope, a rotating ceiling-mounted screen that allows a user to view and hear a virtual world by turning about a fixed virtual location. Grasping and rotating the periscope rotates one's viewpoint in the virtual world and controls the mix and spatialisation of associated audio (both ambient sounds and commentary) that is heard through wireless headphones. A small projector mounted on the base of the periscope projects an additional view onto surrounding screens that is supplemented with four external audio speakers. This public display is intended to allow the experience to be shared by groups of visitors (e.g., families) and to attract other visitors to the exhibit.

The periscope user finds that they have been transported back to the island, but this time as a 3D model, and that a historical scene from the object's past has now appeared at the location where they found the fragment. By rotating the periscope, they can explore the scene, trigger spoken information and mix related sounds. Inspired by the presentation of the actual dish at the Castle Museum, one scene depicts the event that is painted onto the dish, a second tells of how and where the dish was made, and a third tells so of how it came to be in Nottingham. Figure 2 shows the periscope and an example scene.

2.1. Implementation

Our demonstration has been implemented through the coordinated use of the MASSIVE-3 and EQUIP software platforms and applications authored in the MAX/msp audio programming environment [15]. MASSIVE-3 is a platform for distributed virtual worlds. It can support between ten and twenty mutually aware avatars in a shared virtual world communicating using real-time audio and has previously been used to create a variety of on-line storytelling events [6]. EQUIP is a dynamically extensible framework for integrating C++/Java based applications with a variety of interfaces and devices, ranging from wireless portable devices through to fully immersive systems. EQUIP provides applications and devices with one or more shared tuple-like data spaces through which they can publish and subscribe to each others' data. For example, our virtual history meter publishes its GPS updates to an EQUIP data space so that they can then be read into a MASSIVE-3 virtual world. In return, MASSIVE-3 publishes the positions of fragments in the world that can then be read by the meter. An EQUIP module was also developed which (in part 1) published the GPS data as MIDI continuous controllers to communicate with the sonification and (in part 2) sent periscope angle to a panoramic mixing application which triggered commentary sound files, generated ambient textures algorithmically, and controlled the overall mix and spatialisation. The operation of EQUIP, its integration with MASSIVE-3 and its role in supporting this demonstration are not covered here (but see [8]).

Fig. 2. Viewing the captured fragments indoors

2.2. Immediate reflections

Our initial demonstration was given to a small audience of invited participants, including a curator from Nottingham's Castle Museum and sociologists who have been studying visitor behaviour in museums. A round-table discussion suggested a number of possible refinements. For this paper we focus on those comments that relate to the design of the virtual history meter.

- It was possible, but quite slow and sometimes difficult to locate the target fragments outdoors. The island presents a featureless landscape and the virtual fragments were not sited at obvious locations. Users probably needed to be more systematic and painstaking about searching than they were.
- Several participants commented that they expected the handheld devices – the iPAQ and GPS – to be sensitive to orientation. In other words, that the sonification would change according to the direction in which these devices were being pointed.

Of course, we might directly address these comments by changing the locations, spacing and target sizes of the fragments and adding a directional compass to the wireless device. However, it is also interesting to speculate whether a different physical design for the wireless device would have encouraged a more appropriate style of use to suit the original set-up. What if the GPS sensor had been embedded into something resembling a metal meter? Would this have encouraged more systematic searching over the ground? Would participants expect a larger ground-hugging device such as a metal meter to be as sensitive to orientation as a hand held pointing device? In future experiences we should pay greater attention to the physical design of devices in order to ensure that they communicate their intended style of use rather than just relying on off-the-shelf devices.

3. Extending with enacted scenes

In order to be able to create richer historical experiences we have extended our system to support enacted scenes. Users, represented as avatars enter the virtual world, move around, manipulate objects and talk to one another. MASSIVE-3 allows such scenes to be enacted live or to be saved as 3D recordings that can subsequently be replayed in a live virtual world [7]. In this way, actors can stage scenes from the past and tour guides, curators and teachers can quickly create customized virtual tours that to be played out into physical space.

Two further technical innovations support these ideas. First, we have created a version of the virtual history meter that tracks avatars as they move around the virtual world (showing their positions on a radar style display on the iPAQ) and that allows users to listen in to their dialogues (via the laptop). Second, we have experimented with a technique for projecting “shadow avatars” into physical environments so as to give fleeting impressions of ghostlike figures from a parallel world. When an avatar passes by a specific location in the virtual world, its shadowy image (with associated sound) is projected onto the wall or floor of the equivalent physical location. This shadow technique demonstrates a further class of device for revealing the virtual world, one in which users do not have to carry any specialised equipment at all or even have any intention to experience the world. Such techniques could be used to attract the attention of bystanders so as to draw them into virtual events.

4. Diverse interfaces onto a ubiquitous virtual world

We finish with some general reflections on the approach of using diverse devices to access a shared virtual world. Conventional augmented reality employs physical or video see-through displays to overlay a virtual world on the physical [2]. Recent projects have begun to move augmented reality outdoors, for example exploiting handheld displays and wearable computers with see-through head-mounted displays [3,9]. Other researchers have also explored the use of hand-held devices to interact with immersive virtual environments [10, 14].

Our approach focuses on how very diverse devices can provide radically different experiences of a virtual world at different times and in different places. Some devices will offer high fidelity and accurately registered views of the virtual along the lines described above. However, others will offer more impressionistic views of the virtual, for example audio sonifications as demonstrated by our virtual history meter or projected shadow avatars. We propose that our approach offers a number of benefits.

Variable engagement – heterogenous interfaces can allow participants to vary their engagement with the virtual world. An unfolding story may gradually introduce participants to a virtual world. Bystanders have only a fleeting awareness of virtual events, whereas committed players may be fully involved. Participants in a long-term event may vary their level of engagement over time.

Variable tracking – the display of the virtual can be configured to match the accuracy of tracking in different locations. Where accurate tracking is available the user may be offered a fully 3D view of the virtual. Where it is not, they may be offered more impressionistic views.

Variable physical environments – sound-based representations of the virtual may be able to accommodate bright and variable lighting conditions where it might be problematic to project detailed graphical views.

Orchestration – staff in the virtual world can monitor and dynamically shape participants' experiences from behind-the-scenes, for example moving virtual objects to make them easier or harder to find. In fact, our demonstration supported an additional interface, a table-top projection of the virtual world as an interactive map, for this purpose.

Finally, connecting multiple wireless physical devices to a common underlying virtual world brings advantages from a systems perspective. VR research has developed a repertoire of techniques that use virtual space to manage information flows among large numbers of communicating users [13]. These techniques can be directly applied to mobile devices that are tracked and represented in a virtual world. For example, a group of PDAs that are proximate in the virtual world (i.e., whose virtual "auras" have collided or who are in a common virtual "locale") would automatically join the same server or multicast group and so communicate with one another.

Acknowledgements

This work has been carried out within the SHAPE project under the European V Framework Disappearing Computer Initiative and the EQUATOR Interdisciplinary Research Collaboration funded by EPSRC in the UK. Please note that the authors are listed purely in alphabetic order.

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