

## **Far away is close at hand: shared mixed reality museum experiences for local and remote museum companions**

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### **Abstract**

This paper discusses the use of a shared mixed reality system that supports co-visiting of museum exhibitions for both on-site and on-line visitors. We briefly present the prototype system that uses wireless communication technologies to combine handheld devices, virtual environments and hypermedia to support a museum visit. We then discuss its use, focusing on the ways that the system shaped the visiting experience with regard to collaboration in the exploration of artefacts, mutual exchange of suggestions and creative conversations among the visitors. We conclude with implications for both the design of mixed reality experiences for museums and the character of the museum.

**Keywords:** Visitor Studies, Mixed Reality Systems, VE, Hypermedia, Collaboration

### **Introduction**

In this paper we present our research in the Equator IRC's *City* project that involves the combination of diverse technologies to support shared collaborative visits to museums, such as ubiquitous computing, virtual environments and hypermedia. Drawing on examples from user trials, we demonstrate important aspects of the co-visiting experience among local and remote visitors, and we argue that mixed reality systems can successfully support museum experiences that are rich in terms of both information access and sociability.

Many museums, in collaboration with universities and industrial researchers, have been exploring the use of novel technologies to enhance the visitor experience. Whether mobile or fixed, wired or wireless, autonomous or networked, such systems tend to focus on the delivery of additional information to augment visitors' understanding of the collections/galleries. In that respect, they function as rich information repositories and resources for a variety of audiences both on- and off-site. Virtual reality techniques have also

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been used on museum websites, to improve visitors' awareness of the gallery space. Relatively few systems, however, treat social interaction as a paramount aspect of the museum experience and attempt to directly support it. Examples of systems and forms of support include *Sotto Voce* and eavesdropping among visitors using audioguides (Aoki et al., 2002), Tourbot and its use of robot guides to bring on-site and on-line visitors together (Roussou et al., 2001), and collaborative museum virtual environments such as *Virtual Leonardo* (Barbieri & Paolini, 2000).

The City project explores how sociality may be supported among both on-site and on-line museum visitors. Our motivation stems from modern museological (Falk & Dierking, 1992) and sociological (vom Lehn et al., 2001) studies that define social interaction among visitors as an important aspect of the overall visiting experience. It also responds to the increasing number of remote visitors to museum websites. Moreover, we are interested in exploring the integration of virtual environments with hypermedia, ubiquitous technologies and the traditional 'physical' features of a space—such as the museum artefacts and building structure—to form one larger system that encourages and supports collaborative experiences. In this respect, the City technologies are intended to present and disseminate a range of cultural information at different levels of detail, through several different environments, and on demand according to the needs of each individual's interaction.

In the course of the system design process, we conducted a series of observational studies of people visiting galleries in non-educational groups, in order to identify key characteristics of co-visiting i.e. collaborative visiting. This was important since existing visitor studies identify the influence of social context in the learning outcomes of the visit but do not focus on how social conduct happens in museums. The initial observational studies were carried out in two cultural institutions in Glasgow, UK: The Lighthouse, Centre for Architecture, Design and the City, and the House for an Art Lover (HAL), which is in effect an historic house. Both places are associated with the life and work of C. R. Mackintosh (1868-1928), Glasgow architect and artist. We used unobtrusive observations—a technique stemming from the ethnographic tradition—to capture people's natural behaviour during their visit. One of this paper's contributions is to present analysis of this data, focusing on what constitutes and characterises a co-visiting experience.

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Co-visiting suggests a voluntary change of behaviour by participants, in order to fit with the needs and wants of the group. However, each individual's personal engagement with the collection is always balanced with his or her engagement in the collaborative experience. In co-visiting, people collaboratively explore displays and specific artefacts by highlighting things for each other, animating features of displays and looking at displays operated by their companions, e.g. touch screens. Co-visitors also inform each other's engagement with the exhibition by making suggestions. The exchange of suggestions may happen in subtle and implicit ways, for example by pointing at or gazing intently at an artefact, or in explicit ways such as direct verbal communication. Moreover, co-visitors converse around and about displays and objects. In their conversations they often refer to their previous experiences with similar—or indeed the same—artefacts, use information from labels and other interpretive material, and express personal opinion. Overall, visitors' interaction with their friends informs their engagement with the collection and the interpretive material, and shapes their visiting experience as well as their interpersonal relationships.

The prototype system that is presented in the following section was informed by the initial visitor observations. In the rest of the paper we introduce aspects of the co-visiting experience in the system beyond the initial reactions to the novelty of technology. Complex systems that support rich social and personalised interactions by combining heterogeneous media impose technological challenges and often introduce disruption in the interaction; such disruptions with the City system are discussed in (Brown et al., 2003). The question then is whether the disruption causes a breakdown in the interaction or, alternatively, is useful intervention that opens up new opportunities for satisfying and successful encounters.

Drawing on examples from the visitor experience with the system and our knowledge gained during the initial visitor studies, we examine significant elements of shared visits by non-educational group of museum-goers. We then discuss how mixed reality technology may change the overall museum experience and we focus on the use of specific features such as real-time audio. The paper concludes with our plans for further expansion of our analysis and for intervention in the museum experience to before and after the visit.

### **The 'City' system**

The design of the City system was informed by the visitor studies described above, as well as by technical, theoretical and interactional goals. The prototype explored co-visiting among

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people who know each other and share an interest in museum visiting, but who may not always be able to visit together due to difficulties such as geographical separation. The City system was designed for visits to a specific exhibition: the Mackintosh Interpretation Centre (Mack Room) in The Lighthouse. The Mack Room is devoted to the life and work of Mackintosh. The exhibition combines textual and graphical displays with authentic artefacts, and over 20 screens presenting video and interactive material to visitors.



Figure 1



Figure 2



Figure 3

The system combines virtual environments (VE), hypermedia technology, hand-held devices and ultrasound tracking technology, coordinated through Equator's shared tuple space infrastructure, EQUIP (MacColl et al., 2002). The system allows three visitors, one on-site and two remote, to visit the Mack Room simultaneously. An ultrasound positioning system and a wireless communications network is installed in the Mack Room and The Lighthouse respectively. The on-site visitor carries a PDA that is location-aware and displays the ongoing positions of all three visitors on a map of the gallery (Figure 1). The two off-site visitors use two different environments: a web-only environment and a VE. The web visitor uses a standard web browser with an applet that displays the gallery map (Figure 2). The VE visitor uses a first person, 3D display with avatars representing the other visitors (Figure 3). All visitors share an open audio channel, and wear headphones and microphones. The system also supports multimedia information for the off-site visitors in the form of web pages that are dynamically presented upon movement in the map or VE. This automatic presentation schematically follows the spatial organisation of the exhibition, so that all visitors may 'look' at the same display when in the same location. In that respect the system supports interaction

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around corresponding exhibits in the Mack Room and in digital form: 'hybrid exhibits' (Brown et al., 2003).

### **The user trials**

The user trials of the system took place in The Lighthouse. The participants were recruited through poster advertisements as friends and museum-goers. Ten groups of three and two groups of two members participated. Each visiting experience lasted approximately one hour and was comprised of an explorative part and an activity-based part. In the first part, the members of each group were encouraged to familiarise themselves with the technology and explore the gallery according to their own interest. In the second part, they were given a mixture of open-ended and focused questions about Mackintosh's work, and were asked to come up with answers based on evidence from or experience of the exhibition. The group's activity and discussions were recorded, and a semi-structured interview followed each visit. The next section presents aspects of the interaction among the visitors during the trials and relates them to the initial visitor studies and relevant visitor studies literature. The excerpts presented in the next section are taken from the exploratory part of the experience.

### **Shared museum visits**

In both goals and conduct, visiting a museum with friends differs from visiting on one's own or as a member of an educational group. Here we focus on conduct, specifically those observable characteristics that identify a visit to a museum as a co-visiting experience and how these characteristics appear in groups that are comprised of both local and remote visitors. We discuss three of those characteristics: collaborative exploration of displays, implicit and explicit recommendations, and creative discussions about and around artefacts.

### **Collaborative exploration of artefacts**

Visiting a museum in a group is, by definition, a collaborative activity. As McManus (1987) and vom Lehn (2002) discussed in their studies, members of a group collaborate in the exploration of both galleries and displays by conversing with each other, animating the displays for each other and so forth. In our studies we also observed that, during collaborative exploration of displays, members of a group contribute to the shared exploration of a display by volunteering information about the display and highlighting interesting points, often by pointing at them. In this respect, different members of the group were able to satisfy their own interests and, at the same time, share those interests with the group. This often led on to

greater engagement with the exhibition and discovery of details that would probably have been unnoticed otherwise. Collaborative exploration does not only happen with displays but with whole exhibitions too—this being more obvious in the exploration of historic houses, where the display coincides with the exhibition space. Collaborative exploration is facilitated by the shared content that is available to all visitors in the gallery, even when it is accessed through personal devices such as audio guides.

The ‘hybrid exhibits’ supported by the system offered a great deal of shared information to all three visitors. The information, however, on the touch screens was available only to local visitors. Additionally, the graphical arrangement of the information on the gallery displays was not replicated on the web, where a standard ‘low tech’ hypermedia arrangement, common in web pages, was used. These differences in the presentation of the information shaped the way people explored the displays and in many cases enhanced their engagement, as in the following example:

In the excerpts, G (green arrow on the map) is the local visitor, B (blue) is the virtual environment visitor, and R (red) is the hypermedia visitor. Square [brackets] show overlapping talk, underline shows speaker’s emphasis, *italic* indicates text taken from museum labels, and numbers \*1\* show where in the talk images have been captured. For clarity, the arrow that represents the local visitor on the map view has been circled.



Figure 4

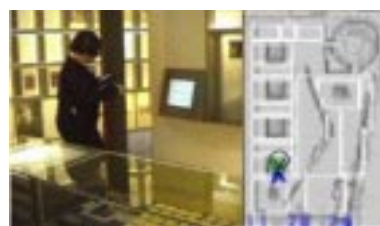


Figure 5

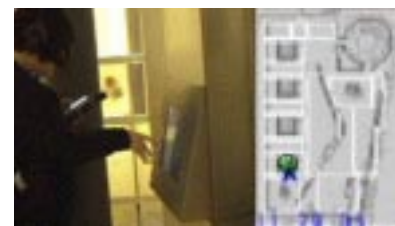


Figure 6

B: Is it something about Derngate? 78 Derngate.  
G: Yeah, yeah, I think that’s it.  
B: [Is it something, yeah]  
G: [yeah], I am not so sure where that was though, the house... \*4\*, \*5\*  
B: Right, *it’s a late Georgian terrace house in the middle of Northampton, which Mackintosh altered, decorated and furnished for*  
G: Ahhh!  
B: *for Wenman J. Bassett-Lowke, Look, Lowk...*  
G: [Ohh, I got a little screen on it]  
B: [who engineered models] and made model railway engines.  
G: Ok  
B: Can you see the dark lounge hall?  
G: No... Let’s see if I can find that. It’s in interiors presumably..

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B: Yeah, it's quite, it's quite something!

G: (Not audible) Would you like to click at the *guest bedroom*? \*6\*

B: Hmmm, I am not sure, I am not sure if I can. Oh wait, maybe I can. Is it two beds in it? Two single beds very close together?

In this situation, the two visitors found themselves within the area of the display that talks about the house on 78 Derngate Street, Northampton, the interior of which was designed by Mackintosh. The visitors were unfamiliar with the specific work and they exchanged a series of questions during the exploration of the information. The questions targeted both information and the other person's opinion on the topic. During the dialogue both visitors repeated or reused phrases from the text in the labels, for example 'dark lounge hall' – behaviour commonly observed among group museum visitors (McManus, 1989). Furthermore, the interaction with each other motivated them to search for information that was not readily available or visible at first glance, which resulted in longer and deeper engagement with the display. Despite of being geographically separated, the local visitor used a pointing gesture to emphasize her question but this did not affect the conversation since it was not recorded by the system. Shared reference was achieved through verbal communication instead.

### **Implicit and explicit suggestions**

In the previous example the two visitors made suggestions to each other as to what to see in the display. The exchange of suggestions is very common in the gallery. This often happens explicitly, for example by asking one's friends to see something. It also happens implicitly through one's own engagement with a display. In our observation we found out that people in a group were aware of where their friends were and what they were looking at, and they took advantage of their friends' engagement to inform their own actions. In the visitor studies literature this has been described as 'modelling' the other members of the group (Falk & Dierking, 1992). The location of the visitor, the time s/he spends in the display and usually his/her gestural behaviour—for example the stance with regard to the display—are resources people take into account in understanding their co-visitors' engagement with the displays. Other people's activity informs one's own action rather than being merely copied. In many cases, the way one presents one's engagement operates as a recommendation for co-visitors to follow.

In the user trials, co-visitors extensively used each other's location to check what they were looking at. In many cases, a co-visitor openly followed others around. Traditional gestural

behaviour, however, was not supported by our system. In cases, the participants achieved the same effect through verbal activity:



Figure 7

Figure 8

B: I am looking at the reconstruction of the guest bedroom in the Hunterian Art Gallery  
G: Is what you are looking at? \*7\*  
B: I am. Quite stripy!  
R: Oh, me too now.  
B: I am not so sure about all these stripes; I think I would feel a bit disturbed at night! \*8\*  
R: Yeah

In this example, the VE visitor used the audio channel to announce what she was looking at. She also expressed her personal opinion about the look of the specific room. At the same time, the local visitor was looking at another display in another part of the gallery. He became, however, peripherally aware of what his friends were looking at and he used it to inform his own exploration soon after:



Figure 9

Figure 10

Figure 11

G: Did you see me passing? Do you see me go by? \*9\*  
B: I do, where are you going? I am going to follow you then.  
G: Oh, are you? I was going to go to the bit you were looking at which was...  
B: Oh, I was walking... oh where did you go again?  
G: [I was looking at]  
B: [Where...]  
G: [Where did you]  
B: [Not audible]  
G: Ha, what was the exhibition you were looking at before? \*10\*  
B: It was the Hunterian Art Gallery, the guest bedroom. \*11\*

This case indicates that interaction among companions is not strictly based on proximity but more generally on awareness of each other's activity. Location awareness and real-time audio were used to support this. Furthermore, the participants appeared willing to follow their friends regardless of the media they were using, passing the 'leading role' among them.



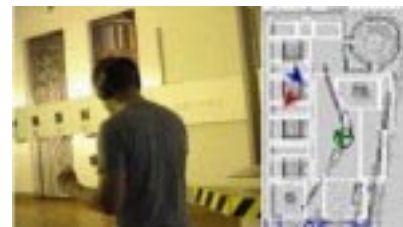
Although one might expect the on-site exhibition to have primary impact on people's choices, we believe that participants regularly treated all environments as equal resources for interaction as long as they supported the activity at hand.

### **Creative discussions**

Creative discussions among museum visitors are perceived as an indicator of successful interaction, and the lack of them is often associated with information technology in museums (Walter, 1996). By creative discussions we mean conversations about and around displays and exhibitions, which give speakers the opportunity to share their knowledge and understanding, and to develop their own ideas. In their discussions about the exhibitions, museum visitors refer to their previous experience, whether this was gained long before the visit or just a few minutes earlier. In HAL, for example, visitors were heard to associate aspects of the display in the rooms with elements of a video narrative they had watched at the beginning of their visit. In other cases, they were heard to compare the style and atmosphere of HAL with the atmosphere of the wider geographical area. The shared content, available to everyone in the gallery, and the shared context, in the form of past common experiences and related aspects of visitors' relationships, support discussion and exchange of opinions among co-visitors.

Participants in the user trials in Mack Room conversed constantly. Their conversations may fall in two broad categories: creative conversation, as described above, and 'functional' conversation. Functional conversations among visitors were comprised of descriptions of the environment, their representations in the system, the look and feel of the hybrid displays and directions as to where people or objects were. This type of conversations initially facilitated the construction of a shared understanding of the environment:

G: There is a big thing along, it looks like a boomerang shape, that's a big wall with glass with pictures on it.  
R: Where is the big wall?  
G: I am walking along that, is on my left hand side as I move up \*12\*  
R: Yes on your left side. It's got a boomerang [shape?]  
G: [Boomerang] shape, aha



**Figure 12**

In this example, the hypermedia visitor (R) asked the on-site visitor to clarify the shape and the size of the partition in the room. The local visitor, by describing the physical aspects of

the gallery, did not only offer an account of the environment as he saw it but also established terminology to use in talking about the space, i.e. the term 'big wall'. The establishment of shared terminology to discuss and refer to the space was crucial in the shared experience and collaboration. As reflected in the conversations of the participants during the visit, the landmarks, dominant features and other elements that made up the shared environment of the gallery were socially constructed during the experience. These elements were initially used by one person in one environment or medium, but became collaboratively used by all participants in their interactions. Similar discussions (and 'constructions') of participants' avatars also occurred. Although these discussions did not directly relate to the exhibition they offered a basis for shared experience and they revealed, we believe, the way visitors went about interpreting the museum space. They also enhanced people's feeling of being co-present with their friends, hence experiencing the same environment with them. Creative discussion, where visitors exchanged personal opinions, preferences and comments, followed the initial establishment of shared understanding.

## **Discussion**

So far in this paper, we have presented excerpts from and characteristic elements of the visitor experience involving the City mixed reality system. The participants used the resources available in each setting to explore the gallery, and to communicate and collaborate with each other. The technology used was novel and unfamiliar, which undoubtedly led to minor breakdowns and limitations, but this did not jeopardise the overall experience.

As soon as visitors had adjusted their headphones and microphones, they were able to start talking to each other. The navigation of the information and the virtual model imposed a greater challenge for them. The spatial arrangement of the information on the web pages was unexpected for the participants, who initially had difficulties in locating information. Visitors who had previous experience of virtual environments, such as in games, appeared more effective in the use of the virtual model, in terms of navigating the environment, orientating themselves, giving instructions to their friends and recalling where things were in the gallery. Visitors in the gallery, during their exploration, also used other media available in the gallery such as touch screens, leaflets and so forth. On-line participants, however, used the search facilities of their browser in very limited cases. In this respect, the system did not compete with the existing gallery arrangement but enriched the set of resources people had for exploration and understanding. We may argue then, that in many cases the use of the system

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went through an interpretive circle much like that discussed in hermeneutics (Grondin, 1994): the system changed from being the focus of attention, unfamiliar, 'present-at-hand' and explicitly dealt with, to being a familiar, 'ready-to-hand' and implicitly-used element of the visit experience.

The richness and topical coherence of visitors' interaction with each other and with the exhibition is the basis of our claim that local and remote museum visitors had a shared visit. In this co-visiting experience, the museum's remote presence was treated not strictly as an information space, used in isolation, but also as a social place to visit, enjoy and relate to others. The latter afforded a set of behaviours that, as we have shown, constitutes a social experience that shares several significant attributes of traditional museum co-visiting. The experience offered rich information and afforded rich interaction within a heterogeneous mix of media. This approach moves away from the traditional design focus on a single user's experience, toward multi-user interaction that treats the traditional and new media aspects of a museum as equally important elements of the museum experience (Galani, 2003). Furthermore, it broadens design to address both personal and social aspects of the visit, and does not restrict the visitor to either one of these modes. It supports the individual's interpretation of artefacts and displays, which can be used as a resource for social interaction, and which in turn informs and influences later individual interpretation.

Our work does not attempt to substitute or reproduce a visit to a traditional museum. It supports, however, a mixed reality museum visit that may cover needs and expectations that are not easily addressed by the traditional museum. Remote visitors, disenfranchised by geographical or other barriers, may interact with the layout and content of the exhibition and become immersed in exploration of and discussions about artefacts. Local visitors may also access additional information on-line, with the difference that they can use the contributions, experience and understanding of their remote friends. Specific aspects of our system, such as shared information space, location and real time audio supported the shared experience.

As we have shown in the examples from the user trials, the shared information space effectively supported collaborative exploration of displays among participants; it also offered discussion material. We additionally observed that participants were intrigued by slight differences in the available information and they inquired about additional detail. For example, in the debriefing interviews, participants expressed the opinion that the experience

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would be richer if the on-line visitors had access to more textual information than that available in the gallery. In their opinion, this would even out the ‘balance of power’ between the local visitors—who have the opportunity to interact with the traditional collection—and the remote visitors, who do not. This suggests a challenge for designers: to offer on-line information that is as rich as possible in supporting individual exploration but which does not inhibit the shared experience. Additionally, since on-line information should have a spatial arrangement that basically corresponds to the layout on-site, spatial changes on-site should be also reflected on the organisation of the digital environment—and vice versa. Sustaining this correspondence should be considered part of ongoing exhibition maintenance. Therefore, mixed reality visits may effectively be best suited to permanent exhibitions that change little, temporary exhibitions, and sections of exhibitions that are primarily associated with educational activities.

In addition to shared content, the participants in the user trials used shared location to collaborate with their friends and inform their engagement with the exhibition. Tracking technology, such as ultrasound and infrared, has been used before in museum systems that focus on the delivery of information to visitors walking around the gallery. In these applications, a major concern has been to improve the accuracy of the tracking system used to trigger visual and audio displays, or to improve the relevance of information by the use of visitor profiles (Marti, 2001). However, our experience from observation of visitors indicates that sociality among museum visitors may be effectively supported by use of approximate location, rather than precise position. Additionally, visitors often interact with sets of artefacts within a general area, and their decisions on what to look at are based not only on their personal interest and position, but also on their social interaction with their companions. We believe, therefore, that social museum visits would benefit from location information that supports awareness and leaves space for social construction of shared references, possibly at the expense of the ‘pop-ups’ of location-specific information unremittingly pushed towards the visitor.

Real-time audio has been used to a great extent among visitors, to communicate both their location as well as their ideas about the displays. In the debriefing interviews, visitors said that the human voice was valuable in creating the sense of being together at the same place. As one of the visitors pointed out:

*And then the voice worked so well, cause, you know, you well respond to the human voice... I felt like you [to her friend] were there and I adjusted very quickly to that.*

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Audio-based media spaces have been used before in workplace environments, and have been successfully used to establish communication and shared awareness among participants (Ackerman et al., 1997). In our trials, the real-time audio improved the experience of the remote users who felt unrestricted enough to cheer, laugh and talk loudly during the visit. Similarly, local visitors extensively used the audio channel and, in cases, talked loudly and cheered when meeting with their on-line friends. On asking local visitors whether they felt intimidated about apparently talking to themselves, they replied that they were not particularly concerned but that they would be more concerned in a crowded gallery. Moreover, in one case, the local visitor admitted that she was relieved to use the closed headphones and speak to her friend, instead of having to hear what other people were saying in the gallery! An alternative to talking would be send text messages to fellow visitors, and instant messaging has been used successfully among children visiting a museum (Exploratorium, 2001).

In the user trials, a great deal of talking involved giving directions and establishing common reference. This kind of behaviour among collocated visitors is effectively served by familiar gestures. Although some trial participants used map or VR location as a pointer, better support for pointing through the system would enhance the accuracy of deixis and aid creative discussions, while decreasing the length of 'functional' discussions. Reference in museums, especially in rich exhibition spaces, is not a straightforward procedure, since it is related not only to artefact arrangement and the visitor's related position (Aoki & Woodruff, 2000) but also to the rhetorical or conversational purpose of the reference and the visitor's awareness of his or her self-presentation to others. Nevertheless, exploring and supporting pointing in shared visit experiences is among our future plans.

## **Conclusion**

Mixed reality systems can support rich social interactions among local and remote participants. Our investigation in a museum setting indicated that visitors can go beyond the novelty and unfamiliarity of such technology to enjoy a satisfying exploration of the exhibition. We suggest, however, that the designers of such technological interventions should take into consideration organisational characteristics and goals of the museum institution, such as the cost of creating and maintaining exhibition layout and content. Design and maintenance need to balance consistency between on-site and on-line visits, which supports the construction of shared references, and possibly giving more detailed information

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to on-line visitors, so that they can contribute something unique to their conversations with on-site visitors who have the richness of the original collection at hand.

In our current research, in the second phase of the City project, we are combining synchronous encounters among participants with asynchronous interaction, allowing one to show one's friends where one has been and what one has done, and more generally to use the past as a resource for the present visit. We also support visiting and tourist activity in the city streets and other urban spaces. This work is informed by the way that museum experiences extend beyond the time, the people, the media and the place of the 'official' visit, to the visitor's everyday life and to the city as a whole. We believe that this is in accord with contemporary cultural institutions' work to become more effectively integrated with the tourist activities that visitors engage in, and also reflects our view that museums are best seen not as isolated or insular, but as connected and contributing to city life.

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### **References**

Ackerman, M. S., Hindus, D., Mainwaring, S. D., and Starr, B. (1997). Hanging on the 'Wire: A Field Study of an Audio-Only Media Space. *ACM Transactions on Computer-Human Interaction* 4(1), 39-66.

Aoki, P. M., Grinter, R. E., Hurst, A., Szymanski, M. H., Thornton, J. D., and Woodruff, A., (2002). Sotto Voce: Exploring the Interplay of Conversation and Mobile Audio Spaces. *Proceedings of CHI 2002.* ACM Press, 431-438.

Aoki, P. M., and Woodruff, A. (2000). Improving Electronic Guidebook Interfaces using a Task-Oriented Design Approach. *Proceedings of Designing Interactive Systems*, ACM Press, 319-325.

Barbieri, T., and Paolini, P. (2000). Cooperative Visits for Museum WWW Sites a Year Later: Evaluating the Effect. *Museums and the Web 2000* (D. Bearman, and J. Trant, eds.). Pittsburgh: Archives & Museum Informatics.

To be presented in ICHIM 2003, Paris, France, 8-12 September.

Brown, B., MacColl, I., Chalmers, M., Galani, A., Randell, C., and Steed, A. (2003). Lessons from The Lighthouse: Collaboration in a shared mixed reality system. *Proceedings of CHI 2003*. ACM Press, 577-584.

Exploratorium (2001). *Electronic Guidebook Forum*. San Francisco: Exploratorium.

Falk, J. H., and Dierking, L. D. (1992). *The Museum Experience*. Washington: Whalesback Books.

Galani, A. (2003). Mixed Reality Museum Visits: Using new technologies to support co-visiting for local and remote visitors. To appear in *Museological Review* 10. Leicester.

Grondin, J. (1994). *Introduction to Philosophical Hermeneutics*. Yale University Press.

MacColl, I., Millard, D., Randell, C., and Steed, A. (2002). Shared visiting in EQUATOR City. *Proceedings of CVE 2002* (C. Greenhalgh, E. Churchill, and W. Broll, eds.). ACM Press, 88-94.

Marti, P. (2001). Design for Art and Leisure. *Proceedings of ICHIM 2001* (D. Bearman, and F. Garzotto, eds.). Pittsburgh: Archives & Museum Informatics, 387-397.

McManus, P. M. (1987). *Communication with and between visitors to a science museum*. London: Kings College London. Unpublished PhD Thesis.

McManus, P. M. (1989). Oh yes, they do: how museum visitors read labels and interact with exhibit texts. *Curator* 32(3), 174-189.

Roussou, M., Trahanias, P., Giannoulis, G., Kamarinos, G., Argyros, A., Tsakiris, D., Georgiadis, P., Burgard, W., Haehnel, D., Cremers, A. B., Schulz, D., Moors, M., Spirtounias, E., Marianthi, M., Savvaides, V., Reitelman, A., Konstantios, D., and Katselaki, A. (2001). Experiences from the Use of a Robotic Avatar in a Museum Setting. *Proceedings of VAST01*. ACM Press, 153-160.

vom Lehn, D. (2002). *Exhibiting Interaction: Conduct and Participation in Museums and Galleries*. London: King's College, University of London. Unpublished PhD Thesis.

vom Lehn, D., Heath, C., and Hindmarsh, J. (2001). Exhibiting Interaction: Conduct of Collaboration in Museums and Galleries. *Symbolic Interaction* 24(2), 189-216.

Walter, T. (1996). From museum to morgue? Electronic guides in Roman Bath. *Tourism Management* 17(4), 241-245.