# The better remote control – Multiuser interaction with public displays

**Michael Kruppa**
DFKI GmbH
Stuhlsatzenhausweg
D-66123 Saarbrücken
+49 681 302 2865
kruppa@dfki.de

## ABSTRACT

The issue of multiuser interaction with a single device is addressed in a typical situation of educational entertainment: the visit to a museum. To allow for these multiuser interactions, the museum is equipped with stationary systems, so called Virtual Windows, which are distributed throughout the museum. While each visitor may rent a mobile information system, based on a personal digital assistant, the number of stationary systems is significantly lower than the number of visitors in the museum. Hence, to maximize the benefit of the visitors, it is necessary to allow several users to interact with a Virtual Window at the same time. Since these multiuser interactions are uncommon to most users, a virtual character is used to support the users in their interactions.

### Keywords

Multiuser interaction, mobile devices, stationary devices, virtual characters

## INTRODUCTION

Intelligent computing environments, like for example a museum which is well equipped with all kinds of modern technology, pose new challenges on the design of computer-user interfaces. In such environments, the classical input devices like mouse and keyboard will loose importance. In contrast, more human like communication methods will play the key role. Personal devices will help to provide the users with personalized information based on their special interests. Despite this, large screens, that may have to be shared with other users, will still be used to display huge amounts of text and graphics.

We present some novel developments in the ongoing PEACH [16] project, dedicated to the exploitation of cultural heritage. In this project, some of the salient elements are the emphasis on multimodality in the dynamic presentation and the coherent and seamless transition between presentations running on stationary and mobile devices. This article exploits the possibilities to combine both personal mobile devices and public stationary devices, to allow multiple users to benefit of a single stationary device at the same time. This combined use of mobile and stationary devices allows large groups of users to benefit of a single public device, without physically interacting with it (i.e. interacting at a distance, which is necessary to support large groups). The supported method, used to allow several users to interact with a single stationary device, is based on the idea of a remote voting system.

## PROJECT OVERVIEW

The PEACH project has the objective of studying and experimenting with various advanced technologies that can enhance cultural heritage appreciation. The research activity focuses on two technology mainstreams, natural interactivity (encompassing natural language processing, perception, image understanding, intelligent systems etc.) and microsensory systems. Throughout the project, synergy and integration of different research sectors are emphasized. Two general areas of research are highlighted: (i) the study of techniques for individual-oriented information presentation and (ii) the study of techniques for multisensorial analysis and modeling of physical spaces to unobtrusively collect information about the visitors and the environment.

The project focuses, as a case study, on a museum with beautiful frescoes (figure 2 shows two screenshots of a presentation run on a mobile device in that particular museum, for further detail, please see [9]). To underline the flexibility of our approach, another experimentation is being conducted in a world cultural heritage site dedicated to iron and steel industry.

## RELATED WORK

The main goal within the PEACH project is to go one step further in the development of location-aware adaptive systems similar to the multimodal approaches presented in [14] and [15].

The problem of adapting content for (cultural) information presentations in physical ”hypernavigation” was tackled in Hyperaudio and HIPS [1] [2]. It shares many features with the problem of producing adaptive and dynamic hypermedia for virtual museums (e.g. MPIRO, [4] or dynamic encyclopedias like PEBA-II, [5]). Relevant projects focusing on mobile information presentation for a cultural visit of a town are GUIDE [7] and DeepMap [8]. A fascinating work on wearable augmented reality systems that include localization, vision, graphics and caption overlay for a person moving in a cultural outdoor environment is described in [10]. In [20], a framework allowing users to access multimedia content on a large public display by using a mobile device, is proposed. However, this framework does not support multiuser access to a single public display. In contrast, in [21], a Single Display Groupware is described, supporting collaborative work between people that are physically close to each other.

Several projects have aimed at developing concepts for combined interaction of large and small screen devices. Two examples are the PEBBLE project [12] that focuses on Computer Supported Collaborated Work with handhelds and a framework described in [13] for the distribution of media on different devices. However, none of those systems so far make use of a lifelike-character to transparently combine small and large screen devices.

## TECHNICAL SETUP

In our scenario, each user carries a personal mobile device, while exploring the museum. We make use of infrared technology to locate the users (i.e. mobile devices) throughout the museum. Infrared beacons[1] installed in the museum allow us to detect both position and orientation of each device. Figure 1 illustrates the infrared technology installation.

**Figure 1. Infrared beacon and overview on an exemplary infrared installation in a single room (red semicircles indicate beacon positions and ranges).**

While these mobile devices are basically used to present localized information, based on the actual position/orientation of the users, they are also used to build up user models, based on the movements and interactions the users perform during their visit. Based on the collected data, a central server is capable of choosing appropriate in depth information, to be presented later on, at a Virtual Window. The communication between mobile devices, the Virtual Windows and the server is realized with standard wireless lan technology.

To improve the computer-user interaction, we make use of so called lifelike-characters [17], which may be used on both stationary and mobile devices, and which are also capable of easily moving from one device to another. User evaluations [18] have shown that the introduction of a life-like character makes presentations more enjoyable and attractive (something that we regard as very important to keep younger visitors engaged). As stated in [6], we believe, that the use of these characters may also help to guide the users attention when following presentations spanning several different devices.

While exploring the museum site, the visitors are accompanied by a personal guide, embodied by one of our lifelike-characters. When approaching a Virtual Window, the guide will automatically suggest to make use of it. However, it might happen, that the Virtual Window is already being used by somebody else. Since the system is aware of the interests of the different users, it will automatically decide, whether it would make sense to have a group of users interact with the same Virtual Window.


**Figure 2. Screen shots from a running presentation on a PDA: the life-like character first presents a static graphic and then announces and starts the presentation of a video clip.**

In this paper, we give a solution to deal with this situation of a heterogeneous user group, interacting with a single Virtual Window, by introducing a voting system, allowing to maximize the benefit of all users of the system. In the following section, we give a detailed description on how presentations are rendered on the Virtual Windows, and how the characters move from one device to another. Based on this technology, in the subsequent sections, we present our approach for multiuser-interactions with a single Virtual Window.

[1] Provided by the Eyeled Company, http://www.eyeled.de

## PRESENTATIONS ON THE VIRTUAL WINDOWS AND TRANSITIONS BETWEEN DEVICES

The Virtual Window is the primary medium to provide the visitors with in-depth information on interesting topics. It has enough resolution to allow the full use of graphics, animations and video-clips of all kinds. If visitors approach a Virtual Window, their personal presentation agent will transit to the Virtual Window, where it appears fully sized (see Figure 5). In order to detect the visitor's relative distance to the Virtual Windows, each of them is equipped with two infrared beacons of different ranges.

When visitors approach a Virtual Window for the first time, the presentation agent proactively informs them about the Virtual Window and how to make use of it.

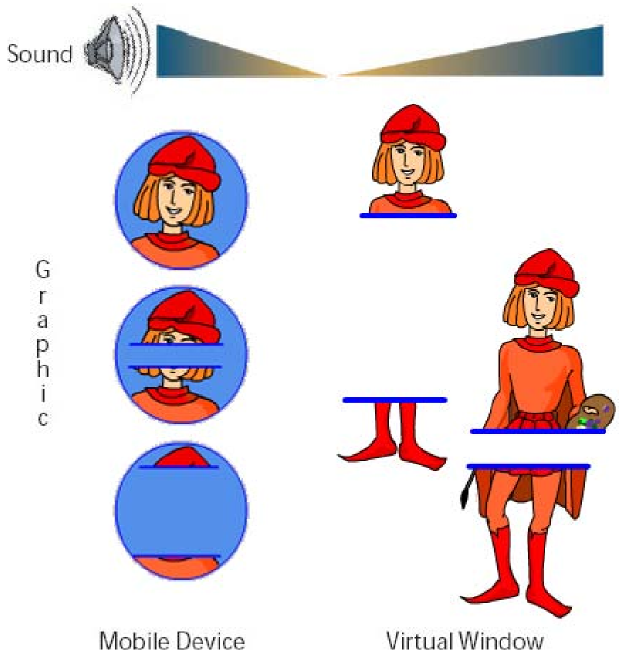


**Figure 3. Key frames of the transition between the mobile device and the Virtual Window (the *beam*-effect).**

If the visitors are close enough, the presentation agent starts to disappear from the mobile device and to reappear on the Virtual Window. The transition from one device to another is underlined by sounds and an animation. The key frames of such an animation are shown in figure 3. This *beam*-effect is used to guide the visitor's attention towards the Virtual Window, where they find the personal presentation agent continuing the presentation. Once the presentation agent is on the Virtual Window, the visitors can continue to coherently interact both with the agent and the presentation. In the current state of the implementation, this is held fairly simple, but future implementations may make more use of the capabilities of the Virtual Window, for example by providing a multimodal interface (see [11]). Generally, the presentation agent is playing a more active role while guiding the visitor through the presentation on a Virtual Window. Sophisticated gestures and animations thus lead to a much more lifelike appearance.


**Figure 4. A screenshot of a presentation rendered for two different users sharing a single virtual window**

Another functionality that we make use of is the possibility for the visitors to choose a different presentation agent before leaving the Virtual Window. Since each character represents a special interest group (e.g. in our scenario a neutral character and an art historian[2], see figure 4), the newly chosen character changes the stereotype that is used to classify the visitors and hence influences the future presentations generated by the server. Finally, when leaving the Virtual Window, the presentation agent follows the visitors and after another transition automatically reappears on the mobile device.

## MULTIUSER PRESENTATIONS ON THE VIRTUAL WINDOW

When using standard devices, like for example a touchscreen, to realize multiuser applications, the first problem is to find out, which user is performing which action. There are specialized devices, like for example the MERL[3] Diamond Touch, which allows multiple users to interact with a single touchscreen. However, interacting with a touchscreen requires the users to stand directly in front of the screen, and hence they obscure part of the display for users standing behind them.

In our scenario, we want to benefit of the fact, that each user has its own mobile device. These devices may not only be used to present localized information throughout the museum, but may also serve as a user-interface when interacting with the Virtual Windows. In [6], several different methods for a combined use of Personal Digital Assistants and large remote displays have been explored.

---

[2] both characters, as well as the layout of the application were designed by Peter Rist, http://www.peterrist.de

[3] The Mitsubishi Electric Research Laboratory, http://merl.com

Each Virtual Window is equipped with two infrared beacons, one with a range of about eight meters, the second one with a range of about twenty meters. When entering the area of the long range beacon, the character will either suggest to make use of the Virtual Window (if the Virtual Window is used by someone with overlapping interests, or if it is not used at all), or it will suggest to come back later.

To support multiuser interactions, we adopt the metaphor of a remote control. Users interact with the Virtual Window by pressing on buttons that are displayed on their mobile device. Using wireless-lan technology, this interaction is communicated via a server to the Virtual Window. This server also selects the content to be presented at the Virtual Window, based on the user interaction history. The user may choose different

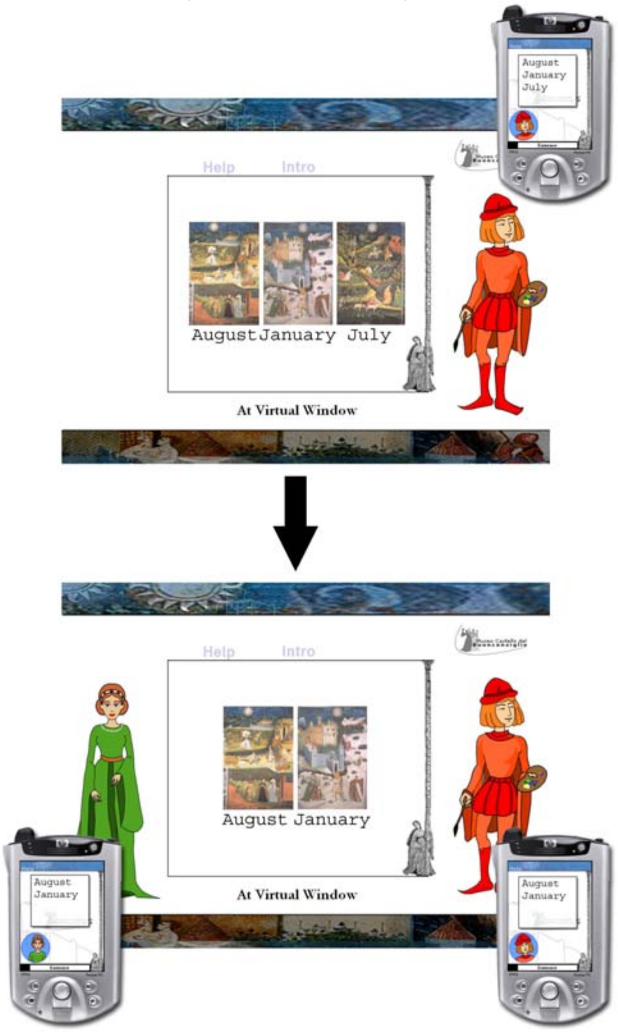


**Figure 5. Content adaptation at the Virtual Window, based on the interests of a single user (upper part), and two simultaneous users (lower part)**

presentations, which are arranged in a list, sorted in order of highest interest. When another user approaches the Virtual Window, the presentation lists of all users in front of the Virtual Window are combined, to form a new list, which holds only items, which are of interest to all users. In case, this list should be empty, very general presentations are included in the list, which should be of interest to most visitors of the museum. As soon as the running presentation is finished, the newly generated list is shown on each mobile device and on the Virtual Window(see figure 5). To encourage communication between users, the characters (now located on the Virtual Window, and thus visible to all users) aurally inform each other about the special interests of their users. The characters also present the topic list and ask the users to agree on a topic.

At this point, each user chooses a presentation on the mobile device. After a first user has chosen a topic, a countdown is started on the Virtual Window. Each user may make a decision until the countdown is finished, or each user has made his/her choice. In case, all users choose the same presentation, it is simply rendered on the Virtual Window. Otherwise, the server will generate a presentation, which makes use of both mobile and stationary systems, to fit the different interests of this heterogeneous user group in front of the Virtual Window. In general, the mixed presentation modes combine a public and a private audio channel (i.e. speakers at the Virtual Window and earphones connected to the mobile device) as well as a public and private video channel. Since humans are capable of focusing on a single audio source in a noisy environment (the so called cocktail-party effect[19]), it is possible to generate presentations, which "override" certain parts of the public presentation with a private one, to be shown on the mobile device. In order not to confuse the users too much, we make use of the lifelike-character to guide the user's attention. Whenever the focus is moved from the public to the private channel and vice versa, the character moves to the appropriate device. The different methods of generating presentations for heterogeneous user groups have been explored in another project and are explained in detail in [3]. When users leave the Virtual Window (during a presentation, or after a presentation has been finished), without moving their character back on their device, the character will reappear on the PDA, as soon as the PDA enters the range of another infrared beacon (which is the moment the system becomes aware of the fact, that the user is no longer located in front of the Virtual Window), not corresponding to the Virtual Window.

## CONCLUSIONS

In this paper, we have discussed a new way to support multiuser interactions with a single public display. By integrating personal mobile devices in our scenario, we were able to distinguish actions performed by different users. To maximize the benefit of all users, sharing a single public display, we took into account the special interests of each user, which were determined by analyzing the interaction history within the museum, to automatically propose appropriate presentations for a particular group of users. In case, the users would not agree on a single topic, a formerly developed presentation planner was used, to generate presentations for heterogeneous user groups, making use of both private mobile devices and a public display. In a next step, we would like to refine our interaction model, so that the system will be able to find out topics, which were of special interest to the user (i.e. topics spanning several different exhibits), instead of simply relating to exhibits the user has visited prior to arriving at the Virtual Window. We also plan to improve the way, the characters encourage the users to communicate with each other, to further improve the overall museum experience.

**ACKNOWLEDGEMENTS**

I would like to thank Martin Hochstraßer for his support on figure 5.

**REFERENCES**

1. E. Not, D. Petrelli, O. Stock, C. Strapparava, and M. Zancanaro. The environment as a medium: Location-aware generation for cultural visitors. In *Proceedings of the workshop on Coherence in Generated Multimedia, held in conjunction with INLG'2000*, Mitze Ramon, Israel, 2000.
2. A. Krüger, M. Kruppa, C. Müller and R. Wasinger. Readapting Multimodal Presentations to Heterogenous User Groups, *Notes of the AAAI-Workshop on Intelligent and Situation-Aware Media and Presentations, Technical Report WS-02-08*, AAAI Press, 2002.
3. Androutsopoulos, J. Calder, E. Not, F. Pianesi, and M. Roussou. Multilingual personalised information objects. In *Proceedings of the International Workshop on Information Presentation and Natural Multimodal Dialogue*, Verona, Italy, 2001.
4. M. Milosavljevic, A. Tulloch, and R. Dale. Text generation in a dynamic hypertext environment. In *Proceedings of the Nineteenth Australasian Computer Science Conference*, Melbourne, 1996.
5. M. Kruppa and A. Krüger. Concepts for a combined use of Personal Digital Assistants and large remote displays, *Proceedings of SimVis 2003, Pages 349-361*, Magdeburg, March 2003.
6. K. Cheverst, N. Davies, K. Mitchell, A. Friday, and C. Efstratiou. Developing a context-aware electronic tourist guide: Some issues and experiences. In *Proceedings of CHI 2000*, Amsterdam, 2000.
7. R. Malaka and A. Zipf. Deep map – challenging it research in the framework of a tourist information system. In D. Buhalis (eds) D. R. Fesenmaier, S. Klein, editor, *Information and communication technologies in tourism*. Springer-Verlag, Wien, New York, 2000.
8. M. Kruppa , A. Krüger, C. Rocchi, O. Stock, M. Zancanaro. Seamless Personalized TV-like Presentations on Mobile and Stationary Devices in a Museum, *Proceedings of ICHIM 2003,* Paris, September 2003.
9. S. Feiner, B. MacIntyre, T. Hollerer, and A.Webster. Touring machine: Prototyping 3d mobile augmented reality systems for exploring the urban environment. In *Proceedings of ISWC 97 (Int. Symp. on Wearable Computing)*, Cambridge, MA, 1997.
10. Christian Mueller. Multimodal dialog in a mobile pedestrian navigation system. In *Proceedings of the ISCA Tutorial and Research Workshop (ITRW) on Multi-Modal Dialogue in Mobile Environments.* University of Southern Denmark, 2002.
11. B. Myers. Using hand-held devices and pcs together. In *Communications of the ACM*, volume 44(11). ACM Press, 2001.
12. T.L. Pham, G. Schneider, and S. Goose. A situated computing framework for mobile and ubiquitous multimedia access using small screen and composite devices. In *Proc. Of the ACM International Conference on Multimedia*. ACM Press, 2000.
13. O. Stock. Language-based interfaces and their application for cultural tourism. *AI Magazine*, 22(1):85–97, 2001.
14. J. Baus, A. Krüger, and W. Wahlster. A Resource-Adaptive Mobile Navigation System. In *IUI2002: International Conference on Intelligent User Interfaces*, pages 15– 22, New York, 2002. ACM Press.
15. PEACH - Personal experiences with active cultural heritage, website, URL: http://peach.itc.it/home.html , 2003
16. E. Andrè and T. Rist. Presenting Through Performing. On the Use of Multiple Lifelike Characters in Knowledge-Based Presentation. In *Proceedings of the Second International Conference on Intelligent User Interfaces (IUI 2000)*, pages 1–8, 2000.
17. S. van Mulken, E. Andre, and J. Mueller. The persona effect: How substantial is it. In *In Proc. Human Computer Interaction Conference*, pages 53–58. Springer, 1998.
18. B. Arons. A review of the cocktail party effect. Journal of the American Voice I/O Society, 1992.
19. E. Not, D. Petrelli, M. Sarini, and O. Stock. Hypernavigation in the physical space: Adapting presentations to the user and the situational context. *New Review of Hypermedia and Multimedia*, 4, 1998.
20. T. Lam, G. Schneider and S. Goose. A Situated Computing Framework for Mobile and Ubiquitous Multimedia Access using Small Screen and Composite Devices. In *Proceedings of the 8th International ACM Conference on Multimedia (Multimedia-00)*, pages 323-332, ACM Press, 2000
21. J. Stewart, B. Bederson and A. Druin. Single Display Groupware: A Model for Co-Present Collaboration. In *Proceedings of CHI Conference*, pages 286-293, 1993.