A Panorama-Based Interface for Interacting with the Physical Environment Using Orientation-Aware Handhelds

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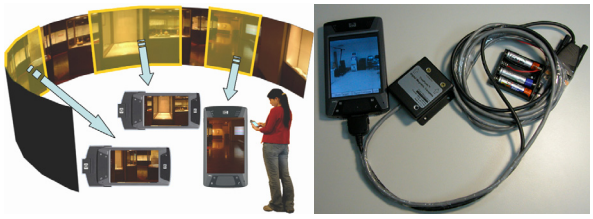
ABSTRACT
This paper presents an intuitive user interface (UI) for interacting with the physical environment. A panoramic view of the environment is displayed on the handheld device equipped with an orientation sensor to align the panorama with the real world. A user can interact with an object within the environment by selecting the corresponding item on the display. Perceiving the same scene on both the handheld and the real world, a user can quickly and accurately select items. Furthermore, the panorama is augmented with additional information to provide a better understanding of the environment. The simple yet intuitive selection scheme allows, in the physical environment, users to exchange information or to control devices such as home appliances. A prototype system is implemented to demonstrate the system in e-home and museum guide applications. A user study has been conducted to examine its usability and performance.

Keywords
User interface, orientation sensor, interactive environment, human-computer interaction, museum guide, e-home.

INTRODUCTION
People are constantly on the move. We transit from one environment to another many times in our daily life. The way we interact with the physical environment has a profound impact on the quality of our life. It is important to design tools that facilitate and enhance this interaction in applications like e-home, digital office and museum guide. Information comes from all directions when a user is situated in a physical environment. At any moment, deciding on which information to concentrate is challenging. For example, concentrating on sound coming from the rear, a user may miss someone passing on the left.

A panorama-based UI is achieved using a handheld device integrated with an orientation sensor. The orientation-aware handheld determines which direction the user is facing, and automatically aligns the panorama view with the real world (see Figure 1). The correspondence between the panorama on the handhelds and the physical environment provides an explicit and natural scheme. It also provides the facility to augment the panoramic view with extra information.



(a) **(b)**

Figure 1. (a)Users See the Same View in Handhelds and in the Real World. (b) Client Prototype.

RELATED WORK
Using handhelds as viewports for virtual and augmented reality, [1,2] utilizes a spatially aware display as an information lens onto a larger virtual space. Though, we all use the spatial information of handhelds. Their focuses are on improving usage of general applications by extending handheld's physical screen. We are focusing on providing a simple yet intuitive selection scheme. As a selection scheme, Woodruff et al. developed Sotto Voce [3], an electronic guidebook, which improves social interaction by enabling visitors to share audio information. Their UI for selecting objects in the environment is similar to ours. However, they use a single photo image for each wall in a room, switching images by pressing a button. In contrast, a panorama is used to present a room and a user perceives the current view by simply turning their body. Wilson and Pham propose the WorldCursorl [4], an evolution of their previous work on XWand, allowing users to select and interact with physical devices by pointing the cursor on the device.

SCENARIOS AND FUNCTIONS
Our system can be used in applications such as a museum guide system or e-home. Here is a sample scenario: Susan enters a crowded exhibition room in the museum. Her PDA automatically downloads the panorama of this room. She looks around and is immediately attracted by a sculpture in the distance. However, she has trouble reaching the sculpture due to the crowds. Susan holds her PDA, and the panorama displayed on the PDA is automatically aligned with her orientation. She easily identifies the sculpture in

the panorama and taps it with a stylus. A detailed description of the sculpture appears on the screen. Upon returning home, Susan's PDA downloads the living room's panorama, with which she can control appliances. By tapping the TV in the panorama, the PDA displays the TV control penal. She then turns on the TV through the control panel.

We can summarize three functions provided by our system. First, in our system, a user sees the same scenes in the handhelds as in the physical environment; it is easy to recognize and control the object even if the object is obscured by others. Second, additional information can be superimposed on the panorama. In the case of a museum guide, the exhibits in the panorama are labeled for easy reading. The panorama may be annotated with private information, which is unsuitable in the physical environments. Third, we create control panels associated with items in the panorama. In the e-home, by tapping a specific appliance in the panorama, a user can trigger its control panel. It serves as a unified UI for all kinds of appliances that users can control easily.

In our implementation, we use an iPAQ hx4700 connected to TruePoint orientation sensor released from PointReserch. TruePoint is a true 3-axis digital compass module, which can achieve 0.1 degree in resolution and 1 degree in accuracy. Figure 1 (b) shows our client prototype.

DISCUSSION

In order to display a user's view of the physical environment on the handheld, we use panorama technique to reconstruct a physical environment. The panorama is the most popular image-based approach for its photo-realistic view effect and for its ease of acquisition. It is widely applied to applications which require the exploration of real or imaginary scenes. However, if a user stands at a location not exactly where the panorama was shot, the user will perceive a slightly inconsistent view with the real world. We conducted a user study with 35 volunteers, ranging from 15 to 60, to examine two hypotheses: (1) the panorama-based UI decreases seek time and (2) the inconsistency between the image and the user's view can be compensated for by the human visual system. There are 19 males and 16 females. 4 participants are familiar with using the PDA, 12 participants used a PDA occasionally and 19 participants never used it before. The experiment includes: four sessions, a questionnaire and an interview. In each session, participants are instructed to finish ten randomly assigned selection tasks. Time and correctness are logged. In session Ⅰ, Ⅲ, Ⅳ, participants use panorama UI in distance 0, 1 and 2 meters away from the shooting point respectively. Each task, we assign target items by notifying its direction (N, NE, E, SE, S, SW, W, NW) followed with emitting a laser point on the item. Participants recognize the target and pick it out in the panorama. In session Ⅱ, participants use a list-based GUI. We assign a random target device by specifying its name in each task. The result shows that, in table 1, the panorama-based UI performs 25% better than list-based GUI in average seek time and with a lower error rate. Table 2 shows that the seek time does not increase while the location deviation occurs within 2 meters away from shot point. Accordingly we concluded that such inconsistency does not affect the selection process due to human's excellent vision system. Most participants operate our interface well within merely 5 minutes training time, including explanation of the UI and practicing. All but two express they can visually utilize relative position among items to orient their body and find the target quickly. Participants also felt that the familiarity with the environment could help speed up the selection process.

Table 1. Target Seek Time (sec) and Error Rate (%) in Session Ⅰ, Ⅱ.

	Session Ⅰ	**Session Ⅱ (List GUI)**
Average seek time	65.5	88.0
Error rate	5.7%	9.4%

Table 2. Target Seek Time (sec) in Session Ⅲ, Ⅳ.

	Session Ⅲ	**Session Ⅳ**
Average seek time	66.5	69.4

CONCLUSION

We proposed a simple yet intuitive UI for interacting with an intelligent environment. The novel UI utilizes augmented panorama to display the surroundings. With the help of an orientation sensor, the panorama can be aligned automatically with the real world. Perceiving the same scene both on the handheld and in the real world, users can select target items quickly and accurately. We have presented our system design in detail and tested the system in sample environments, including our research laboratory, e-Home and a science museum. A user study has been conducted to examine its performance and usability.

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