No Need to Stop: Menu Techniques for Passing by Public Displays

Fig. 1. Passing-by interaction at the exit of a subway station.

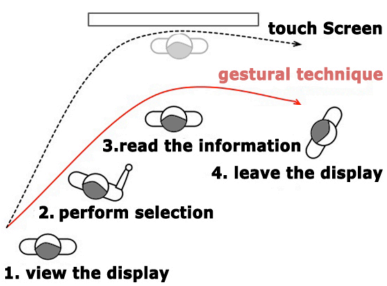

Fig. 2. Passing-by interaction model.

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Abstract
Although public displays are increasingly prevalent in public spaces, they are generally not interactive. Menu techniques can enable users to select what is interesting to them. Current touch screen techniques are unsuitable, because for many public displays, users merely pass by and rarely stop. We investigate command selection in this new context of *passing-by interaction,* in which users only have a few seconds to interact. We present six hands-free gestural techniques and evaluate them in a Wizard-of-Oz experiment. Based on the results of this study, we provide design recommendations for menu selection in passing-by situations.

Introduction
In this paper, we present and evaluate six hands-free gestural menu techniques for a new context of use for public displays: *passing-by interaction* (Fig. 2). Users do not need to stop to interact, but can interact while they keep on walking. This context of use is especially relevant in the case of frequent passers-by, who pass by the same interactive public display every day (e.g., in the subway station) on their way to work.

Our contributions are: (1) to identify a new, important context of use of public displays: passing-by interaction, (2) to propose and evaluate six gestural interac-

Fig. 3. Pointing (left) and Slapping (right) interaction techniques.

Fig. 4. Hand Gesture (left) and Body Gesture (right) techniques.

Fig. 5. Foot Button (left). Touch (right).

tion techniques in this context, and (3) to provide design recommendations for passing-by interaction.

Related Work

In recent years, a number of interactive public displays have been proposed, such as City Wall [1] and Magical Mirrors [2]. Based on observing Magical Mirrors users, the interaction process can be divided into the phases of passing by, looking, subtle interaction (without stopping), direct interaction (stopping), multiple interaction and follow-up actions. Computer vision systems, such as the Microsoft Kinect[1] depth camera, can help to avoid interrupting the user's walking, and resolve the hygiene problems of touching a screen. A large number of menu techniques (MenUA[2]) based on gestural interaction have been proposed for desktop, mobile devices or tabletop. However, no studies have investigated menu selection techniques on public displays, especially in the context of passing-by interaction. With this paper, we take a first step to close this gap.

User Study Design

A typical application scenario of passing-by menu selection is a frequent passerby who wants to see today's weather while she is walking out of a subway station (Fig. 1). She is in a hurry, does not have a smart phone, and she knows this public display very well.

With a menu, a public display can fulfill different individual needs, while still broadcasting advertisements when not in active use.

[1] http://www.xbox.com/en-US/kinect

[2] MenUA: A Design space of Menu Techniques: www.gillesbailly.fr/menua/

Some obvious major requirements for passing-by interaction with public displays are (1) short interaction time, (2) interaction while walking, (3) immediate usability and (4) social acceptance.

To derive possible gestures for menu selection while passing by, we conducted two brainstorming workshops with designers, HCI experts and computer scientists. Based on inspiration from these workshops and Wobbrock's work [3], we propose the following five hands-free menu techniques for passing-by interaction. We also include directly touching the screen as a baseline.

- *Pointing*: The user points towards the item with either hand in the air (Fig. 3, left).
- *Slapping*: The user slaps his hand horizontally to select a target in the direction of hand movement (Fig. 3, right).
- *Hand Gesture*: The user performs a static finger counting gesture (Fig. 4, left). The number of fingers to show is equal to the position of the item on the screen, and also indicated by an icon next to the item (Fig. 8b).
- *Body Gesture*: The user poses his body (Fig. 4, right) to select the target item. Postures are related to the content of items (as derived from brainstorming workshops) and indicated next to the item (Fig. 8c).
- *Foot Button*: The user steps on a physical button placed on the floor 2m from the display to select the corresponding item (Fig. 5, left).
- *Touch*: The user simply touches the corresponding item on the screen (Fig. 5, right).

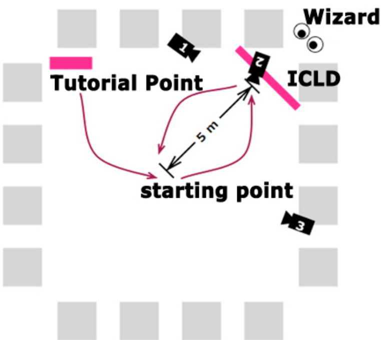

Fig. 6. Experimental setup.

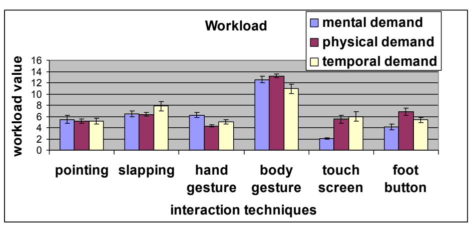

Fig. 7. Workloads of each technique.

Experimental design. We ran a Wizard-of-Oz study in which our Wizard observed participants via three cameras and controlled the public display accordingly. A commercial display showed four items (Fig. 8a). For the Hand Gesture and Body Gesture techniques, we labeled the gestures on the menu for immediate usability (Fig. 8b, c). For the Foot Button technique, we attached four cardboard buttons to the ground. Users had to select the item as instructed by the experimenter, then say aloud the content appearing on the display. Users also had to complete a marked walking route (Fig. 6) to simulate passing by. Each of the 17 participants performed 24 selections with each menu technique. After the experiment, participants filled out a questionnaire for evaluating each technique. They were then shown a video of a real passing-by scenario in a Berlin subway station to introduce a social effect, and afterwards filled out another questionnaires repeating these questions.

Results

Mental, Physical and Temporal Workload. Fig. 7 shows these workloads for each technique. 15 participants did not realize that the display was controlled by a human. Since the inherent complexity of the task for the user is similar across all techniques, the NASA TLX questionnaire is a useful tool to compare workloads. There is a significant main effect on mental workload for techniques (ANOVA, $F_{5,75}$=17.97, p<.0001). A post-hoc Tukey's range test shows that Body Gesture causes significantly more mental workload (mean=12.6) than the others. It also shows that Touch requires significantly less mental workload (2.1) than Hand Gestures (6.2), Slapping (6.5), or Body Gestures (12.6). There is also a significant main effect on physical workload for the techniques (ANOVA, $F_{5,75}$=15.17, p<.0001). A post-hoc Tukey's range test shows that Body Gestures (13.2) require more physical workload than the others. Similarly, there is a significant main effect on temporal workload (ANOVA, $F_{5,75}$=4.6, p<.001). A post-hoc Tukey's range test shows that Body Gestures (10.9) require more temporal workload than the others except Slapping (7.8).

Walking vs. Stopping Interaction. ANOVA reveals a significant main effect on user behavior for the techniques (ANOVA, $F_{5,75}$=39.47, p<.01). A post-hoc Tukey's range test shows that users walk significantly more with Hand Gesture (81.0%) and Pointing (76.4%) than Body Gesture (47.5%). Finally, users perform 66.7% of selections with Slapping while walking. For Foot Button and Touch, participants always stopped to complete the menu selection.

Preferences. Before watching the video (no social effect), Pointing and Foot Button were preferred by participants, followed by Touch, Hand Gesture, slapping and finally body gesture. After the video (social effect), Touch was preferred, but Foot Button dropped to the fourth preferred position (Table 1).

Interaction distance. Touch (0m) and Foot Button techniques (2m) obviously force the user into a specific distance. The other techniques were used at about 3.7m from the display, with apparent differences between the techniques. However, participants started with selection relatively close to the display (about 3.4m), and after 12 trials selected from a distance of about 3.9m.

Discussion

The *Touch* technique sets the baseline. 10 out of 17 participants expressed in the interviews that it causes extra work as it forces users to make a detour. More-

	Social Effect	
	Without	With
Pointing	1st	2nd
Slapping	5th	5th
Hand Gesture	4th	3rd
Body gesture	6th	6th
Foot button	1st	4th
Touch	3rd	1st

Table 1. Ranking of interaction techniques before and after introducing social effect

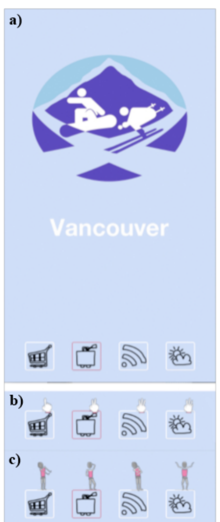

Fig. 8. (a) Graphical user interface with default icons. (b) Hand Gesture icons. (c) Body Gesture icons

over, users have to "press the button and move backward, lift their head to read the screen." Since participants always stopped before touching, this technique is clearly not suitable for passing-by interaction.

Pointing. Users preferred this technique, and in 76.4% of all cases pointed without stopping. In real scenarios, however, it may be hard to recognize the desired item from the pointing direction, especially when walking.

Hand Gesture. This technique seems to be promising for passing-by interaction: users performed these gestures without stopping 81.0% of the time. Moreover, it seemed that during the first trials, Hand Gestures were conducted at the longest distance. Expert users can use this technique eyes-free, as they do not need to look at the screen to select a known command. For instance, they can maintain their attention on their smart phone during the interaction.

Slapping. From our observations, this technique is too slow for passing-by interaction and forces some users to stop to finish the interaction. This is due to the fact that it does not provide direct access to items (multiple slaps can be necessary). Moreover, our video recordings reveal that participants use both hands.

Foot Button. While participants found this technique simple ("it is clear which button to press / step on)", they also mention that they need to stop at the buttons, look down the ground, step on one button, then look up at the display.

Body Gesture. This technique did not perform well in our experiment, probably because it requires significantly higher mental, physical and temporal workload than the other techniques. This is interesting because many commercially applied gestures (for example some gestures on Microsoft's Kinect) are currently body gestures. Our users performed these gestures less often while walking than other techniques (only 47.5% of the times). Furthermore, this technique is scored worst of all in user preference due to its social (in)acceptance in public situations.

Conclusion and Future work

We presented and evaluated six menu techniques for *passing-by interaction,* a new and important context for interaction with public displays. We found that our Body Gestures were not well suited to passing-by interaction, while our Hand Gestures seem to be promising—they can be performed while walking, and have acceptable mental, physical and temporal workload. In the future, we plan to investigate this technique further, and to implement and evaluate it in a public setting.

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