Information Wall: Evaluation of a Gesture-Controlled Public Display

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ABSTRACT
Public displays that allow users to interact with them through mid-air gestures are still relatively rare, as many applications rely on touch-based interaction. This paper introduces Information Wall, a gesture-controlled public information display that provides multi-user access to contextually relevant local information using remote pointing and mid-air gestures. The application has been studied in two settings: a lab-based user study and several short-term deployments. Based on our results, we present practical guidelines for gesture-controlled public display design.

Categories and Subject Descriptors
H.5.2 **[Information Interfaces and Presentations]**: User interfaces – *evaluation/methodology, interaction styles, graphical user interfaces*.

General Terms
Design, Experimentation, Human Factors.

Keywords
Public displays, gestures, mid-air pointing, pervasive displays, user study.

1. INTRODUCTION
Interactive public information displays have been deployed in malls, train stations and similar spaces over the recent years, and regularly rely on touch input. While touch works well for certain environments, it may create a situation that counters the display's purpose. Users interacting with these displays in very close proximity can block the view from passers-by, which leads to a situation where public displays are not all that public anymore.

Gestures within public information displays (PIDs) remain rare. Instead, displays with motion detection capabilities are often produced in the form of a playful application, such as a simple physics-based game [6]. In this paper we present Information Wall, a gesture-controlled public information display that provides multi-user access to contextually relevant local information. Interaction happens via mid-air pointing and an on-screen cursor, through which targets on the screen are triggered. In our studies of Information Wall we focused on: a) measuring the subjective experience of users and defining the level of quality of the system, and b) producing design guidelines for gesture-controlled public displays.

Next, will first present related work, and our Information Wall prototype. Then, we present the setup and results of the user study and public sessions. Finally, we discuss the results and present design guidelines and suggestions for future work.

2. RELATED WORK
In a public setting most users are likely to be first time users, and people tend to interact with the display only briefly [11]. Thus, it has been argued that immediate usability is more important for a public display than performance [12]. In addition, people trying out public displays tend to be impatient: interaction usually ends if users do not succeed with what they are trying to achieve [3].

Müller *et al*. [5] present three issues that public displays specifically need to address. First, the audience is not necessarily even aware of the public display in the first place, or they might not be aware that the display can be interacted with. Second, users need to be motivated to start interacting with the display. Third, the fact that interaction with the display happens in public should be accounted for. For instance, people may avoid interaction completely or partially because of their role (e.g. police officer) or physical limitations (e.g. an elderly person). Parra *et al*. [7] add a fourth issue that public displays should address: users should reach a goal or "final stage" of interaction with the system.

Very few serious public displays use gestures for direct interaction. The cardiac arrest awareness campaign [7] introduced a system where passersby could touch their heart in front of the display, after which a short video was played. The WaveWindow [8] enabled users to scroll through a list of items by waving in front of the display. Other deployments include a survey tool [12], and the Media Ribbon [9]. All these systems share an aspect in that they introduce only a limited set of simple gestures – most likely a desirable trait when utilizing new ways of interaction such as mid-air gestures in public displays. Further, most systems display instructions for interaction, usually in plain-text form.

3. INFORMATION WALL PROTOTYPE
Information Wall is a public information display that offers its users access to simple information like the lunch menus of nearby restaurants and events taking place around the campus. The Microsoft Kinect sensor is used to detect user movements.

When no users are present, the wall displays a dialog in which users are encouraged to try interacting with the wall by stepping closer and moving their hands in mid-air (Figure 1A). The Information Wall also attracts passersby by displaying rectangular

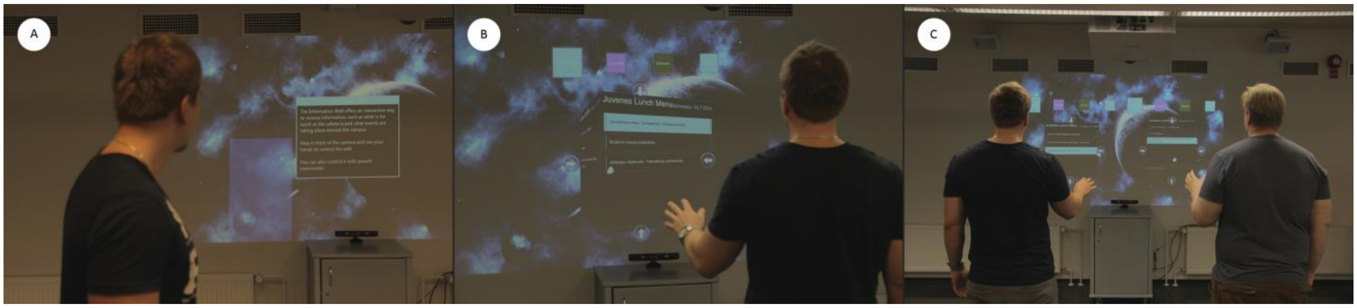

Figure 1. A) A user is tracked with a rectangular shape on the screen. An instruction dialog is displayed. B) A user interacts with an information cube. C) Two users simultaneously interacting with the wall.

elements on the display that follow the movements of the passersby (Figure 1A). Whenever a user steps into the interaction zone of the display (2.8 meters or less away from the Kinect sensor), a three-dimensional information cube is opened on the screen (Figure 1B). The system supports two simultaneous users, in the case of which the interface adjusts to the users' location and opens two information cubes, one for each user (Figure 1C). A cube is closed whenever the corresponding user leaves the scene, and remaining cubes adjust to make use of the whole screen.

Interaction happens via an on-screen cursor which moves according to where the user is pointing. Pointing uses the physical interaction zone algorithm provided by the Kinect SDK. Different functions are launched through buttons, which are triggered with the *dwelling* technique [12], in which hovering over a button with the cursor for a short period of time triggers the corresponding button. During dwelling a circular animation is displayed on the target to indicate that it is being triggered. Target selection is made easier by utilizing the magnetic cursor technique [4].

Figure 2. Selectable elements of the information cube. A) Shortcuts for switching to another section. B) Arrows to trigger the rotation of the cube. C) Entries providing information, which can be triggered to open a detailed information dialog.

The content of the display is navigated by rotating the information cube in desired directions. Rotation happens by triggering a button at the edge of the cube (Figure 2B) and then moving the cursor over to the other side, as if a physical object was being rotated. When a rotation button is triggered, an arrow animation is played to point to the direction of the rotation. Rotating to the right and left will change to the next and previous view inside the current section, e.g., one can switch from today's lunch menu to tomorrow's lunch menu. Rotating up and down will change the section, e.g., from the lunch menu to the latest news. Sections can also be changed via shortcuts (Figure 2A). More detailed information, e.g., the ingredients of a dish or the full story of a news headline, is provided after triggering the corresponding entry from the cube (Figure 2C), which will open a separate dialog in front of the cube. The dialog can be dismissed by triggering a button in the bottom right corner.

4. USER STUDY

We conducted a lab-based user study to evaluate how users perceive and interact with the system in a controlled setting, and to identify the strong and weak points of the system. We recruited 19 participants (16 male, 3 female) for the user study, who were between 19 and 56 years of age (median = 21). The participants were first-year interactive technology students, most with little experience of gesture-controlled systems. The participants received credit towards the completion of an undergraduate course as compensation for their participation.

The Information Wall interface was displayed on a 1920 x 1080 full HD projection screen with physical dimensions of roughly 1.8 (width) by 1.1 (height) meters, and the Kinect sensor was positioned at the horizontal midpoint under the screen. Participants were instructed to stand roughly 2.4 meters away from the screen center.

4.1 Procedure

The participants started the experiment by filling out a short background questionnaire. Afterwards, an introduction to the information wall was presented, however no instructions on how to interact with the system were given. Before the task session, participants were asked to fill out a questionnaire measuring their expectations of the system. The content of the questionnaire (Figure 3) was based on the SUXES user experience evaluation method [10] and consisted of 9 claims to which participants responded on a 7-point scale, where 1 = "strongly disagree", 4 = "neither agree nor disagree" and 7 = "strongly agree".

During the experiment, the moderator gave out tasks for the user, most of which were about finding information or learning a certain interaction. An example of such task would be "There's a seminar this Friday that's open to the public. Which classroom will it be in?" Afterwards, the moderator joined the participant in order to demonstrate how the information wall works with two simultaneous users. During this period the moderator and the participant engaged in a conversation about user experiences and opinions of the system. Lastly, participants filled out the second part of the SUXES method (experiences) as well as the AttrakDiff questionnaire [2]. In addition, we also asked participants what kind of content they would like to see in the system in the future.

4.2 Results

The participants' responses to expectations and experiences as measured with the SUXES statements are presented in Figure 3 as boxplots showing the median and interquartile range. In five out of nine claims the experiences meet the users' expectations, in three claims exceed them and in one claim did not meet the expectations. A Wilcoxon signed-rank test shows that in two claims the experience significantly exceeded the expectation: "The system performs correctly" ($Z = -2.705$, $p < 0.01$) received a median of 5 while the expectation was only rated as 3, and "Using the system is easy to learn" ($Z = -2.070$, $p < 0.05$) received a median of 6 with the expectation receiving a median of 5. No other significant differences were found.

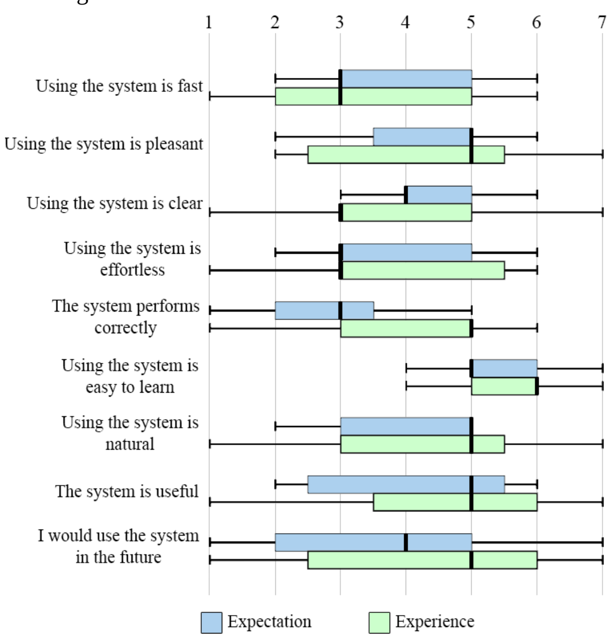

Figure 3. Distribution of users' expectations and experiences.

The clarity, speed and level of effort of use were considered to be slightly negative (median = 3), which suggests that the interaction and interface design had minor usability issues. The system was found fairly pleasant and natural to use (median = 5 for both) and was considered useful (median = 5), which is also supported by indication that the participants would consider using the system in the future (median = 5).

The main results of AttrakDiff are divided into two categories: Pragmatic Quality (PQ), which describes the usability of the system and how successful users are in achieving their goals with it, and Hedonic Quality (HQ), which is concerned with properties such as novelty, how interesting the system appears and what kind of experiences it offers. Both PQ and HQ received slightly higher than average scores.

The mean values for all word pairs are presented in Figure 4. Highest values are found in the hedonic quality – stimulation category (HQ-S), whereas the lowest values are in PQ. This suggests that although the participants found the Information Wall to be neutral in its usability and practical utility, the key elements of experience lie in more hedonic dimensions such as inventiveness, creativeness, presentability and novelty.

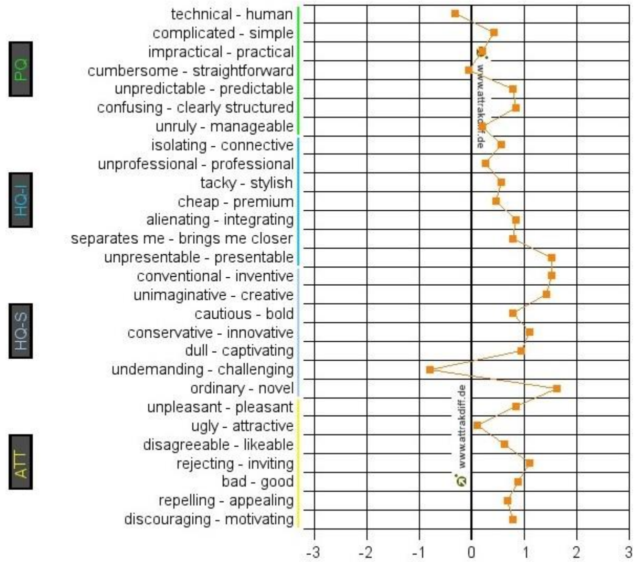

Figure 4. Mean values for AttrakDiff word pairs.

Additionally, participants were asked what kind of content they would hope to see in public information displays such as the Information Wall. 15 out of 19 participants were happy with the current content, most of which explicitly mentioned that they appreciated the lunch menus and the public events. Eight participants hoped to see public events extended to also cover recreational activities such as student parties and festivals. Other mentions were public transportation timetables, latest news and a map of the university campus. We have implemented some of these new content types in the next iteration of Information Wall.

4.3 DEMO SESSIONS

We conducted several short-term deployments at various events at the university campus, involving visitors from information technology companies, other universities and student course groups. The number of participants has varied between 10 and 100 per event. The system setup for these sessions was similar to the user study. However, due to a large open-ended space, the physical size of the screen was larger at around 3 meters in width.

Visitors were encouraged, but not required, to interact with the installation. In all cases, a clear majority of participants interacted with the system once the first few users had the courage to try out the installation in front of an audience. This observation follows the "honeypot" effect [1]. Furthermore, almost all users interacted with the system simultaneously with another user, for example two students who knew each other would interact with the system at the same time. Our observation here is that having another person interact with the system increased the users' confidence and lowered the threshold for interaction in public. Due to mid-air pointing and cursor-based control, it is easy to interact with the system while at the same time observing the other user.

5. DISCUSSION

Our research was focused on measuring the user experience of the Information Wall and producing design guidelines for gesture-controlled public displays. While users' expectations were mostly met in the lab-based study test, it should be noted that the expectations were somewhat low to begin with. Users not only perceived – but also expected – the usability of the system to be rather low. This might suggest that people do not have high hopes for novel ways of interaction. It is worth noting that among the highest values for AttrakDiff word pairs were properties such as novelty, creativeness, and inventiveness. We see this as intuitive and encouraging considering the experimental and playful nature of the system, with which we aimed to offer new and exciting ways of interaction. However, low scores in pragmatic quality along with SUXES results suggest that more attention should be paid to practical usability. Users seem to appreciate quick and effortless interaction over a playful and exciting first-time experience. Based on the user study as well as public session observations, we identified guidelines to consider when designing gesture-controlled public displays:

Support simultaneous interaction: Observations show that even after the initial honeypot effect users prefer interacting in pairs. We encourage systems to support at least two simultaneous users.

Don't hold content back: Most study participants were satisfied with the system's content, however several participants mentioned issues with the way the content was presented. Indeed, the information cubes only display a very limited set of information at a time, while most of the screen space has no informational value whatsoever. We recommend designers to make use of the screen space and display content in a clearly structured manner. Do not hold content back to force interaction – if something can be shown right away, show it.

Aim for relevant content: Subjective feedback seems to indicate that users like to see local and timely content in information displays, e.g., content that is related to nearby areas and relevant right away or in the near future. Among the most popular content were lunch menus, university events and leisure activities.

Display one cursor per user: Information Wall displayed cursors for both hands if they were high enough to appear on the screen. This resulted in two issues. First, while the cursor icons were different for each hand, users had trouble recognizing which cursor was mapped to which hand. Second, due to the use of dwell time for target selection, users often unintentionally selected targets with their inactive hand. This was especially evident when users had items on one hand, such as a coffee cup. The inactive hand was thus high enough for the cursor to accidentally trigger a target. We recommend supporting the use of both hands but displaying a cursor only for the active hand. Furthermore, users had trouble recognizing their own cursors during simultaneous interaction. Designers should consider ways to map a user's cursor to his space on the screen with e.g. similar colors or icons.

Use target selection aids: Freehand pointing quickly results in physical fatigue and minor hand movement often makes trivial tasks such as selecting targets a nuisance. The effects of this issue can be minimized with selection aids such as the magnetic cursor [4], which lowers both the required level of motor accuracy and mental load to select targets and also makes interaction faster.

6. CONCLUSIONS

In this paper we presented the Information Wall, a gesture-controlled public information display that provides simple and relevant local information to users. The application has been studied in a lab-based user study as well as observed in several demo sessions and semi-public events where first-time users explored the system. Based on our findings, we produced several guidelines to consider when designing gesture-controlled public information displays, and also recognized issues with the current version of the Information Wall that will help us improve similar systems. We have also conducted a long-term deployment of our system, during which extensive log data has been gathered. Our future work includes analyzing this data as well as carrying out in-depth observations of Information Wall in situ.

7. ACKNOWLEDGMENTS

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