Reaching for the Ceiling: Exploring Modes of Interaction

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Abstract. The ceiling represents an unexplored domain that will soon be available as information space due to advances in technology. We investigated different interaction techniques for ceiling interaction. For this we developed a peripheral weather display projected onto the ceiling and a wizard of oz prototype. The applied interaction modes were laser pointing, finger pointing, and ball interaction. Overall, laser pointing was clearly favored by all participants, although ball interaction was rated highest concerning playfulness and fun of the interaction tasks. We also present initial design principles and parameters for the design of ceiling applications.

Key words: Ceiling interaction, peripheral displays, pointing.

1 Introduction

Ambient displays are located in the background rather than in the foreground, hence information can be perceived at the periphery of the users' attention. Due to the fact that ceilings literally sit at the periphery of our attention, they are specifically suited as ambient displays. The ceiling is always present, always available, but still unobtrusive. We perceive its surface at the periphery of our attention all the time while we are inside a room. By simply turning the head upwards, we can always "activate" the ceiling, which brings it from ambient to focused attention.

Ceilings have a long and rich traditional history. To understand the potential of ceilings for digital applications it is therefore important to investigate historical meanings of ceilings in art and architecture. Additionally, explorative research is essential to gain a comprehensive view of the domain. This work aims to make a first step towards a more complete view on digital ceiling applications.

2 Related Work

Ishii et al. [2] developed an ambient display that translated the motion of a hamster wheel to the motion of a solenoid in a shallow water tank. This produced water ripples which appeared as shadows on the ceiling. The Hanging

Twines [1] provide a tangible interface for media control. Plexiglas rods hanging from the ceiling are mapped to functions for controlling a media application. The Multimedia Bed [3] supports reading in bed, an alarm mode, and playing a constellation game on the ceiling. Examples for ceiling displays can also be found in the field of interactive architecture. Such displays either aim to create an atmosphere (e.g. the Fremont Street Experience in Las Vegas) or display information (e.g. the multimedia sky above the winter garden of the Bertelsmann residence in Berlin displays weather data from a nearby weather station). A recent example is the use of a ceiling display inside the A350 airplane developed by Airbus, which projects images such as clouds or a night sky onto the ceiling.

3 The Weather Ceiling Application

To gain experiences with the design and implementation of ceiling applications, we developed a simple application that acts as a weather forecast display. Typically information about the current weather trend is most relevant in the morning before leaving the home. This is the moment when we decide whether we should wear a coat or take an umbrella with us. Currently we receive this information through the Internet or the TV. Both require explicit interaction with a device. In our approach weather information is displayed as an ambient visualization on the ceiling in the anteroom. Temperature is represented as color and weather conditions are embodied as symbols. A blue ceiling anticipates a cold day (Figure 1a), while a yellowish color promises a warm day. Animated water ripples (Figure 1b) or snow flakes floating over the ceiling inform the user about rain or snowfall respectively. Users can pick up information on their way to the bathroom, when they pass the anteroom or before leaving the house, when they put on their shoes.

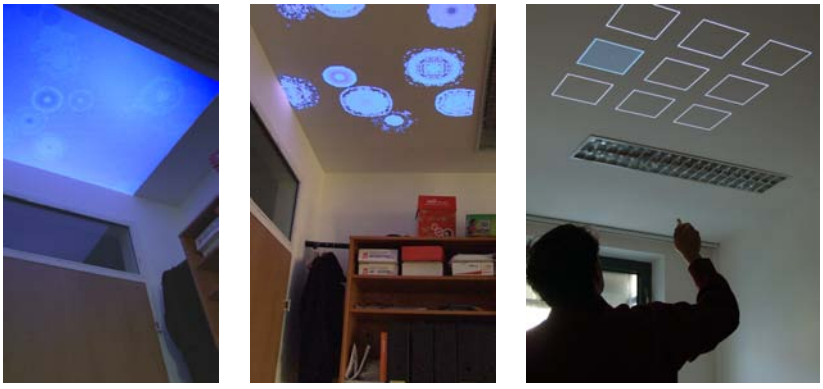

Fig. 1. The peripheral weather application showing cold temperature and rainfall (a), the same application without temperature-encoding showing rainfall (b), and one of the participants interacting with the wizard of oz prototype (c).

4 Interacting with the Ceiling

Ambient information systems typically do not require user interaction. However, concerning our weather application, users might be more interested in seeing the current weather conditions or the forecast for the next day rather than the forecast for the current day. To provide this functionality we included three circular interactive areas in the application. Mode-switching is currently only possible via the mouse connected to the base computer. However, on the long term we want to allow users to directly interact with the ceiling application. Pointing seems to be a promising interaction technique for such applications. Different kinds of pointing interaction that have been explored for distant interaction with walls or large-scale displays are laser pointer-style devices, hand tracking, direct hand pointing, selection with the hand, and eye tracking (cf. [4]). In this work, we explored laser pointer interaction and direct hand pointing. We also included a more playful mode of interaction in our experiment. In this mode users can select an item by throwing a ball at the ceiling.

5 Experimental Setup and Results

The goal of the experiment was to reveal user preferences and to gather qualitative feedback. We set up a wizard of oz prototype with a grid of nine panels projected onto the ceiling (Figure 1c). The task was to activate one specific panel out of nine using a laser pointer device, finger pointing, and ball interaction. Finger pointing was prototyped by attaching a small laser pointer to the participants' index finger using tape. Subjects had to repeat the task five times for each condition. We deliberately kept the number of tasks low, since looking at the ceiling is rather fatiguing. In post-test interviews participants had to rate the interaction techniques according to five dimensions (Table 1). We recruited five subjects (2 female) aged between 20 and 30 years. They all had computer experience and interacted with computers on a daily basis. The experiments lasted approximately 20 minutes each.

All participants generally liked the interaction modes and showed great interest in ceiling applications. Detailed results from the post-experiment questionnaires can be found in Table 1. Overall, laser pointing was the clear winner. The participants favored this mode of interaction, since it was "fast and efficient." They also felt that they could control their actions best with the laser pointer. In contrast to finger pointing, they could turn the pointing device on or off. They further stated that this interaction was less tiring, since they could hold the laser pointer at a lower height. Both laser and finger pointing were rated as being fast, but four of the participants thought that finger pointing was less precise. Ball interaction was last in all categories, except fun. Participants liked the playful interaction, but also said that it was far more exhausting than the other two interaction modes. Only two of the participants complained that the tasks were tiring for their neck since they stood close to the projection.

The error rate was zero in the first two conditions. When interacting with the ball, participants experienced about two to three void hits (i.e. they did not

Table 1. Means (and standard deviations) of the questionnaires.

Questions	Laser	Finger	Ball
Selection speed was ... fast (1) - slow (5)	1.4 (0.89)	1.6 (0.89)	3.4 (1.14)
I felt that the selection method was ... precise (1) - imprecise (5)	1.4 (0.55)	2.6 (1.14)	4.2 (0.45)
The interaction was ... fun (1) - boring (5)	2.2 (1.30)	1.8 (0.84)	1.4 (0.55)
The interaction was ... facile (1) - exhausting (5)	1.4 (0.55)	1.8 (0.45)	4.2 (0.84)
I liked this interaction method ... very much (1) - not at all (5)	1.2 (0.45)	2.6 (0.55)	3.4 (0.89)

activate any panel) and one false hit (i.e. they activated a wrong panel). We did not measure performance, since this would require actual working prototypes. Further, performance measuring was not of importance for this study.

6 Conclusions and Future Work

The present experiment showed that laser pointing represents the most promising method for ceiling interaction. However, ball interaction has potential for applications that engage users in a playful way. Based on the results from the experiment and on our broad experience with the domain we can derive the following design principles: (1) the ceiling is only apt for peripheral applications; (2) the application should only require sporadic interaction (i.e. the interaction should not require more than five selection tasks in a row); (3) the interactive area should have an appropriate size depending on the interaction mode and ceiling height; and (4) icons that support ceiling interaction should feature a circular design, since users might approach the application from different directions.

Next steps of our research work are: building prototypes that support ceiling interaction, exploring impacts of different parameters (e.g. ceiling height), and implementing further applications in both private and public contexts.

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