Benefits and Challenges of Tabletop Peripheral Displays

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ABSTRACT
People tend to gather around tables both for work and for recreation, making them a tempting space to present awareness information. We motivate the use of tables as ambient displays in ubiquitous computing spaces, and reflect on lessons learned from our experiences with the AmbienTable, a prototype tabletop peripheral display deployed in the iRoom.

Keywords
Ambient displays, peripheral displays, tabletop displays.

INTRODUCTION
Ambient displays, peripheral displays presenting non-critical material, are a growing area of interest within the ubicomp research community. Such displays are often embodied in physical objects [2, 10], although some projects have shown peripheral information on secondary monitors or projected onto the walls of a room [4, 8]. Although physical and vertically-projected ambient displays have been explored, there has been little investigation in the space of horizontally projected peripheral displays. de Bruijn and Spence [1] proposed using ambient technology embedded in a coffee table to support opportunistic browsing; however, they did not explore the ramifications of choosing to use a table for this purpose. Simply repurposing an ambient display designed for vertical projection by displaying it horizontally would not address the unique affordances and obstacles inherent in designing tabletop interfaces.

TABLES AS AMBIENT DISPLAYS: MOTIVATIONS
Social conventions surrounding the use of tables make them appealing as vehicles for ambient technology. Tables are widely and cheaply available, and are incorporated into the design of nearly all workplaces and meeting areas, as well as in homes and educational settings. Furthermore, any "normal" table can be transformed into a display simply by adding a projector – this is appealing, since it is difficult and time-consuming to construct custom physical displays. Augmenting tables in this manner is also in keeping with Weiser's vision of ubiquitous computing [9], by subtly blending technology into everyday objects. The idea of using tables to display ambient information should not be too surprising to people, as standard tables already, in a sense, provide us with ambient data – a glance at the contents of a table can cue us in as to whether we are in a dentist's waiting room, an office, or the playroom of young children. Using digital tables to display these sorts of social cues and awareness information is a logical step.

Furthermore, in a situation where several people share a space, such as a lab or meeting room, tables are often considered public areas, while vertical displays are temporarily "owned" by the current discussion leader [6]. Thus, the more public table area might be favored as a place to display ambient information relevant to the entire group.

Another motivation for using tables in this manner stems from considering the weaknesses of tables. Because people tend to place objects (plates, mugs, papers) on horizontal surfaces, a table is often not well-suited for use as a main display since critical information could be occluded. However, the multi-purpose nature of tables does not preclude them from showing information of peripheral importance. In a ubiquitous computing environment, using a table as an ambient display allows users to get more mileage out of the existing components of their space.

Naturally, the specific goals of a project should be taken into account when selecting the appropriate type of display to create. For instance, tables are not practical in situations where an ambient display is meant to be viewed simultaneously by a large crowd of people, since the number of viewers is limited by the available seating space around the table. However, the aforementioned motivations should encourage designers of ambient technology to consider using tables, particularly if they are constructing a software, rather than a physical, peripheral display.

CHALLENGES AND DESIGN GUIDELINES
To aid our exploration of issues involving the use of tables as ambient displays, we constructed the AmbienTable, which displays peripheral visualizations on a horizontal display in the iRoom [3], a ubiquitous computing testbed. The display is bottom-projected onto a four-foot-by-three-foot screen embedded in a conference table. The AmbienTable software is written entirely in Java, using the DiamondSpin toolkit [7]. The display shows several visualizations relevant to users of the iRoom, including abstractions of the status of the computing infrastructure [5], and a visualization indicating recent levels of activity in the room. Our experiences creating and deploying the AmbienTable have allowed us to identify several challenges inherent in using tables as peripheral displays, and to formulate design suggestions to address these challenges.

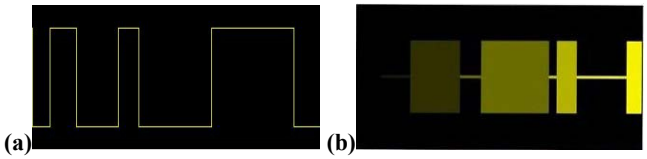

Figure 1. (a) The original activity visualization conveyed misinformation when viewed upside-down. (b) The revised activity visualization is orientation-independent.

Orientation. Unlike vertical displays, tables do not have a single privileged viewing angle. Because there is no single privileged angle of view for tables, it is important to consider designing ambient displays that are rotation-invariant, or, at minimum, do not convey misinformation if viewed at a non-standard angle. For example, the AmbienTable's visual depiction of activity levels in the iRoom originally displayed a line graph (Figure 1a), which had different interpretations when viewed upside-down. The revised visualization (Figure 1b) uses line thickness instead of line height to convey activity levels, and uses changes in brightness to indicate the direction of time flow. Since text is difficult to read at non-standard angles, minimizing the use of text makes an ambient display more table-friendly.

Size. Because a table may be large enough to seat several people, a user at one end of the table may not be able to see a part of the display that is farther from them. Unlike vertical displays, users are not equidistant from the entire display. Ensuring that everyone at the table gets to see all of the information is another challenge associated with this form factor. Possible solutions to this problem include choosing a smaller table size, having the display rotate so that everyone eventually sees all parts of it, or having a design that involves periodic repetition of the display at different points around the table.

Shape. Furthermore, unlike traditional vertical displays, which are typically rectangles with the same (4:3) aspect ratio, tables vary widely in shape – rectangles, squares, circles, ovals, even octagons are all relatively common. If a single software application is written, it may not look correct on each of these different table types. One possible solution is to develop using the DiamondSpin tabletop interface toolkit [7], which facilitates constructing various polygonal tabletop interface geometries.

Occlusion. The potential for occlusion by other objects could be an obstacle depending on the specific contents of a display – someone using a stock ticker monitor could become frustrated if it were occluded at just the moment when it happened to display a price change that was of interest to them. If time-sensitive information is displayed, it may be desirable to periodically rearrange different parts of the display so that there is an increased probability that key items will eventually be uncovered. Top-projection can also help with occlusion issues, as the projected information will be shown on top of objects placed on the table – although projection onto most objects is less legible than projection onto the table, there is still more information conveyed than if the objects completely occluded bottom-projected information.

CONCLUSION

The ubiquity of tables makes them an intriguing vehicle for conveying ambient information, and their familiarity and unobtrusiveness make them appropriate for content intended as peripheral. Based on our experience developing the AmbienTable prototype, we have discussed several challenges and corresponding design suggestions that are applicable to designers of tabletop ambient displays.

ACKNOWLEDGMENTS

We would like to thank Mitsubishi Electric Research Labs for providing the DiamondSpin toolkit, and Pedram Keyani for contributing code to the AmbienTable project.

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