
Range: Exploring Proxemics in Collaborative Whiteboard Interaction

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Abstract

Range is an interactive whiteboard designed to support collocated, ad-hoc meetings. It employs proximity sensing to proactively transition between ambient and authoring modes, clear space for writing, and cluster ink strokes. The inspiration for Range stems from longitudinal studies of student design teams, in which we observed that shifts in collaborative activity correlated with changes in the users' physical proximity to the whiteboard. Through iterative design, we developed techniques for incorporating implicit input like that of the proximity sensors into interaction.

Keywords

Implicit interaction, proxemics, ambient, proactive, whiteboard, CSCW

ACM Classification Keywords

H5.2. Information interfaces and presentation: User Interfaces—*input devices and strategies, interaction styles.*

Introduction

The ephemeral nature of whiteboard ink allows users to share ideas quickly—and just as quickly, to amend those ideas. The utility and ubiquity of whiteboards makes them an appealing platform for computational enhancement. However, since the whiteboard's utility is so dependent on low threshold to entry and minimal attentional overhead, it is desirable that the added features present themselves in ways that do not detract from the generative and

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social activity which is the focus of collaborative whiteboard interactions.

Our longitudinal studies of engineering design teams working on multi-month project-based courses using the WorkspaceNavigator System [4] found that engineering design teams engaged in informal meetings would cycle between phases of drawing and analysis; these changes corresponded with changes in their physical proximity to the whiteboard. Users would stand close to the board when they were writing, further back when discussing written artifacts in detail, or further back still when engaging in meta-discussion.

We designed Range, an electronic whiteboard system that uses user proximity as a form of implicit input, to explore the role proxemics [2] can play in whiteboard interaction design. Using distance sensors mounted to the front of the board, Range alters its behavior to support ambient display of information, active sketching and writing, and discussion and modification. Through iterative design, we developed presentation techniques to enable the whiteboard to transition between modes while enabling correction and override.

Related Work

Prior research and development on electronic whiteboards has created a wide variety of useful features for collaboration. PARC's pen-based electronic whiteboard, Liveboard [1], used a system called Tivoli to introduce interaction techniques for creating and manipulating ink based documents; the system used gestures to distinguish inkstrokes from gestures for selection, grouping and manipulation.⁶ While such *explicit* gesture based systems enabled fluid interaction, they required users to be familiar with the gestural language—a fairly high barrier to entry.

The Flatland whiteboard interface [7], which was based on informal observations of whiteboard use in office settings, provided different sets of functionality adapted to the different types of thinking and pre-production tasks researchers observed people using whiteboards for: generating everyday content (such as task lists, sketches, and reminders), clustering of content (both persistent and short-lived), and a transitioning between semi-public to personal use. In their system, inkstrokes were automatically segmented and clustered—the physical proximity of the strokes is used as an *implicit input* signifying association— but task-specific adaptations required users use *explicit input* to apply “behaviors” to inkstrokes and clear the board.

Current work in ubiquitous computing is exploring the use of sensors to utilize information about the user's physical context as an implicit input. Both Prante, *et al.*'s Hello.Wall [8] and Vogel & Balakrishnan's interactive Ambient Public Displays [9] use the proxemic relationship between the physical distance between multiple users and the display to adapt the mode of display. Range applies this concept of modifying interactive behavior based on the proximity of users and whiteboards to the context of active collaborative whiteboard use.

The Range Whiteboard

Range uses infrared distance sensors to subtly and proactively interact with informal meeting participants.

Implementation

Range was implemented using a combination of pre-existing hardware and software tools and technology.

The Range whiteboard prototype employs a rear-projection SMART Board containing an SXGA+ resolution projector (1400x1050) and a Windows XP PC. Four SHARP GP2Y0A 150cm analog distance sensors were mounted to the bottom bezel of the board, and connected to the PC over USB via the d.tools hardware

Figure 1. Collaborators stand at different distances from the whiteboard when a) sketching, b) having detailed discussion, c) having high level discussion, and d) doing something else.



Figure 2. The Range interactive whiteboard for collaboration.

and libraries [3]. The software component of Range was written in C# using the Microsoft Tablet PC SDK and the SMART Board SDK.

The region in front of the board into four zones, which we called intimate, personal, social, public, after proxemic zones observed by Hall to be used by people in social settings [2]; the physical range of the zones were defined through iterative development. While Range is capable of sensing the presence of multiple people in front of the board if they are not standing in front of another, our observational work suggested that use modes were based on the user closest to the board, and so the zones are defined accordingly. We settled on defining the intimate zone to be the region in which users stand to write at the board, testing with multiple users to increase the robustness of the zone definitions. The personal zone was set further back, at a distance (>15 inches back) where users were not “at” the board, but could easily reach the board for pointing and text manipulation. The social zone (>25 inches back) was out of

touching distance from the board but in easy viewing distance of the board. The public zone comprises the distance beyond the social (>40" back).

Features

We implemented three features in Range that use proximity as an implicit input: an automatic transition from ambient display to drawing space, automatic space clearing, and automatic ink stroke clustering.

Transition from ambient to drawing space: When users are not engaged with Range, the whiteboard switches to ambient display mode, overlaying the existing whiteboard contents with a transparent blue backdrop and a stream of digital images of interest to the collaborative team. We used snapshots of previous whiteboard states and other photos of interest from an online photosharing site to improve shared project awareness.

As a user approaches a Range whiteboard in ambient mode, the backdrop fades and the displayed ambient content floats off to one side, allowing the user to re-engage the whiteboard contents beneath. If the user touches the departing content, it stops and becomes selected so that the user may move it to some place on the whiteboard of his or her choosing. We found this “floating” to be important because it helped users to form a model of where the ambient images “went to.” This metaphor also facilitated override; users found it “natural” to keep images by grabbing departing images.

Making space: In our longitudinal studies, we found that people often leave drawings or notes on the board; groups, in particular, would leave notes in order to provide shared persistent reference for groups. However, a whiteboard full of writing discourages active whiteboard use, as users are hesitant to erase work. Copying content to another surface takes time, time that may kill a serendipitous, free-flowing conversation.



Figure 3. In ambient mode, Range displays photos of interest overlaid on top of any content on the board. These photos glide off the board when a user approaches, but can be “caught” for active use.

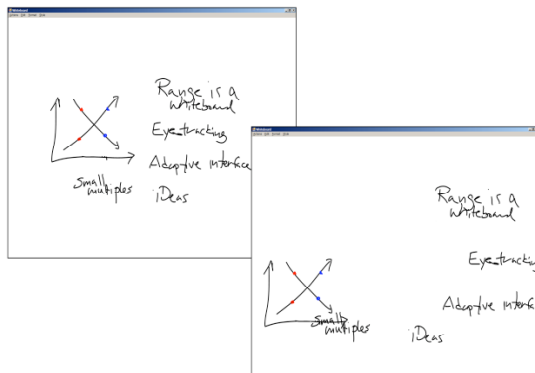


Figure 4. Making space. *Left:* Whiteboard before user approaches board. *Right:* Whiteboard starts to clear the board as user walks up.

To address this problem, Range moves whiteboard contents out to the left and right of the board center when it senses a user approaching, clearing a space so that the user immediately has a blank space in which to write. Data on the edges of the board are not affected during the board-clearing maneuvers; this “place-based exemption” was based on our observations that information that is meant to be persistent—e.g. phone numbers of colleagues, lists of upcoming—tend to be placed on the outside edges of the board. Like the ambient display transition, we found that animating cluster relocation better supported user comprehension and override capability.

Clustering inkstrokes: In order to move text and graphics around while maintaining coherency of the sketches, the underlying system needs to have some conception of the semantic units of whiteboard contents. To achieve this, we have implemented a simple form of stroke clustering, using the stroke’s timestamp (time of creation) and location on the board (estimated by its bounding box).

One of the design tradeoffs faced by electronic whiteboard designers is whether and how to explicitly show users how their inkstrokes are being clustered and recognized; instant feedback allows users to correct mistakes, but interrupts fluidity of idea generation, whereas lack of feedback can wreak havoc when semantically related inkstrokes are relocated or transformed incorrectly after the fact.

Range uses the user’s proximity as an indication of “when to interrupt” with information about how it has automatically clustered inkstrokes. The clustering occurs automatically as users write, but users are not shown the bounding box around their clusters are clustered until they step back into the personal zone. Following this metaphor, marker strokes read by the SMART Board are interpreted as inkstrokes when users are in the intimate zone, and as manipulation gestures when the users are in the personal zone.

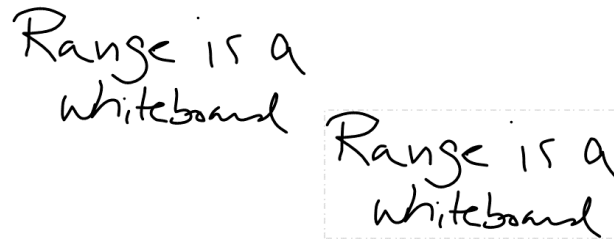


Figure 5. Clustering. While strokes are invisibly clustered in writing mode (left), feedback about clusters is displayed when users are standing in the personal zone (right).

Users can use manipulation gestures to move clusters or to correct the system's automatic clustering.

Users who tested our system informally during iterative development found that this zone-based implicit interaction was both more fluid and more intuitive than the explicit command-based or artifact-based models built into the current SMART Board system. Although they did not always “naturally” stand in the correct zone to write or manipulate drawings, the simple feedback of the cluster outlines let users know to stand closer or further; eventually, experienced users tended to stand in the appropriate locations without much forethought.

Conclusion

In this paper, we have explored implicit interaction by applying proxemics to the design of an electronic whiteboard application, Range. In its current form, Range indicates that proximity can be an important aspect of context for interaction designers. Its design also illustrates some of the important techniques for incorporating implicit input; lightweight and non-interrupting ways of providing explanation and feedback for automatic actions can vastly improve user comprehension of proactive system activity without interrupting workflow. In future work, we hope to provide a more comprehensive evaluation of Range and its features.

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