Proxemics for Information Visualization on Wall-Sized Displays

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Abstract
Information visualizations are typically designed for working at desktop-sized displays using a mouse. However, visualizations on wall-sized, high-resolution displays may benefit from using users' physical movement as input. We adapt proxemics for information visualization in order to explore how visualizations may change in response to for instance users' distance, movement, and orientation relative to a wall-sized display.

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Proxemics, information visualization, large high-resolution displays.

ACM Classification Keywords
H.5.1. Information interfaces and presentation (e.g., HCI): User Interfaces—Input devices and strategies; interaction styles.

Introduction
Information visualization is a user interface paradigm that uses interactive representations of data to amplify cognition. Large high-resolution displays may benefit information visualization: They provide pixels for visualizing very large data sets [2], give abundant

space for sensemaking [1], and allow multiple people to collaborate [8].

Information visualizations are typically designed for interaction using a mouse on desktop-sized displays. Recent research has begun exploring how visualizations can be designed for non-desktop settings, using tangible input controllers [9], or by adapting interaction techniques for large displays [2],[7].

One promising way of interacting with wall-sized visualizations uses physical body movement as input. Previous research has found that large displays promote physical navigation and that visualizations can be designed to scale perceptually so that they are useful from varying viewing distances. However, whereas most such research has investigated the benefits of physical movement around static visualizations, that is, visualizations that do not change in response to the user's movement [3], visualizations can potentially adapt to the user's body movements.

We explore this potential by using proxemics to generate ideas for adapting visualizations to users' distance, movement, and orientation relative to a large high-resolution display. This paper presents prototypes of such ideas.

Proxemics and Information Visualization

Proxemics as described by Edward Hall [6] concerns spatial relations in the study of social behavior: The sense of distance to and involvement with another person is derived through recorded data on 19 scales comprising over 100 variables (see Hall's handbook for proxemic research [6]). These variables include body orientation, distance, posture, affect, eye behavior, olfaction. Because they are aimed at describing spatial relations in the study of interpersonal encounters, all of these scales may not be equally useful for HCI or information visualization. However, given that data can be derived automatically for many of these variables, by tracking people and objects, they provide a wealth of possibilities to be explored.

In order to make proxemics usable for ubiquitous computing, Greenberg et al. [5] define five dimensions. Whereas other dimensions may be useful, this set provides a good starting point for thinking about opportunities for information visualization:

- *Distance*, the physical distance between entities, either as a continuous measure or as discrete zones. For touch displays, a practical application would be to provide for touch interaction only when the visualization is "*within reach*" of the user: controls may appear and the visual representation may change to accommodate fat fingers.
- *Orientation*, concerning which direction an entity is facing. For instance, a visualization could change its representation to avoid problems of accuracy in perception at extreme viewing angles [3].
- *Movement*, the change in distance or orientation over time. For instance, when one user approaches another user, their personal territories may adapt to the available space [9].
- *Identity* helps distinguish entities from each other. For collaborative visualization, two users might brush-and-link in coordinated views using different colors.
- *Location* is the place where people and objects interact. For instance, people might use different visualizations when up-close to a large display than when seated around a table.

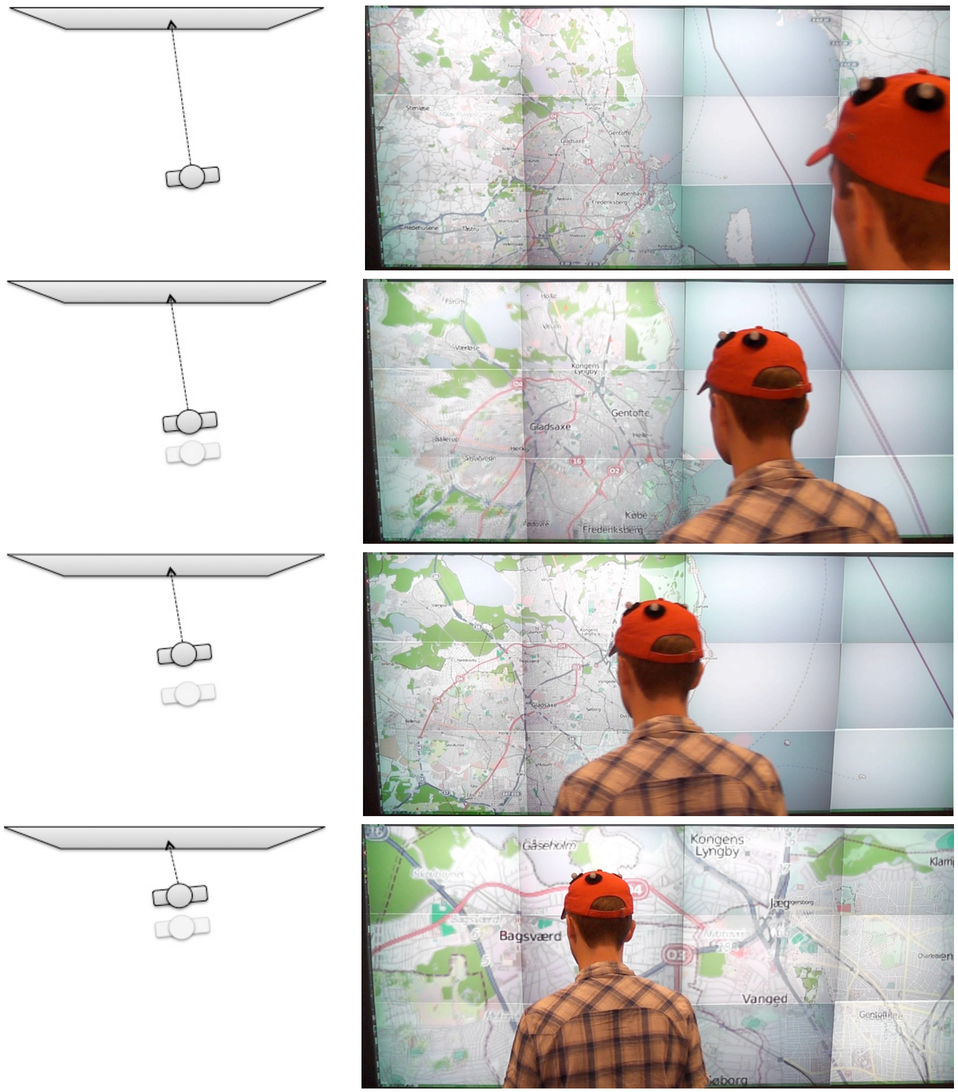


Figure 1: Interface for navigating maps using physical movement for zooming and panning.

Prototypes and sketches

To illustrate the potential of proxemics for information visualization, we describe two examples of using the position and orientation for interaction. These examples have been implemented as prototypes using a 24 megapixel wall-sized display measuring 3m×1.3m (resulting in a resolution of about 65ppi). The display consists of twelve HD projectors that are manually aligned to minimize seams between the display tiles. We use a motion capture system for tracking reflective markers attached to baseball caps that are worn by the users. The tracking system provides us with data describing the user's position and orientation, which is used as input for interacting with the visualizations.

Movement for navigating information spaces

One of the simplest cases of linking proxemics and visualization is to use your body's movement to zoom and pan. **Figure 1** shows interaction with an interface that extends the user's physical navigation in maps on a large high-resolution display. This interface uses a direct mapping between the users' movement and movement of the map. Users can move toward the display to zoom in (i.e., to see parts of the map in more detail) and away from the display to zoom out. Movement is combined with head orientation for zooming. A crosshair indicates the location that the user's head is oriented towards, and zooming is centered on that point. Lateral movement controls panning: Moving left causes the map to move right, moving right causes the map to move left.

Adapting representations to distance

A visualization may dynamically adapt its visual representation to the user's distance (e.g., to show aggregations of the data instead of the individual data

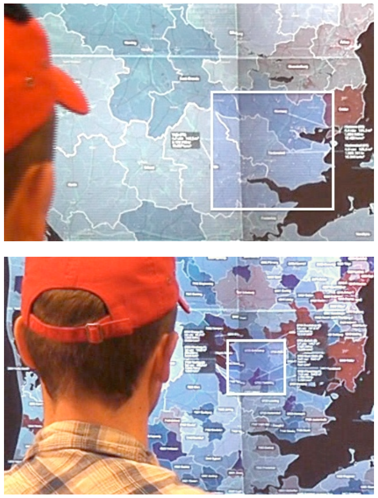


Figure 2: Multi-scale selection of data for showing details at distances corresponding to (b) and (c) in **Figure 3**.

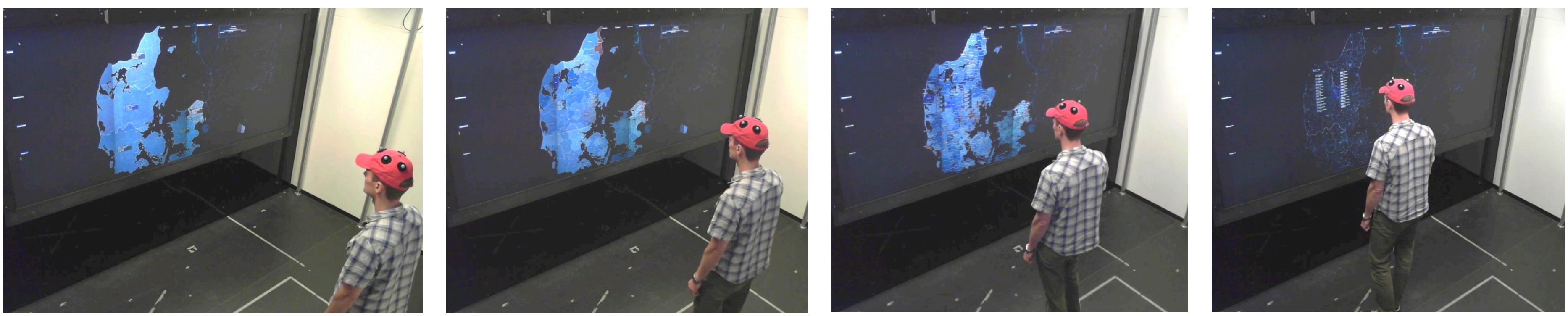
items). Similar to the previous example, this example relates to the experience of physically "zooming out" by stepping back to get an overview, or to move closer to see details. We demonstrate the idea of adapting the visual representation to distance for a visualization of real-estate data, describing homes for sale. This is shown in **Figure 2** and **Figure 3**.

At a far distance (more than 1.75m), data on homes for sale are shown aggregated on larger regions of the country (**Figure 3**a). As the user moves closer, the representation changes to show data aggregated for smaller geographic areas (for municipalities at 1.25m, **Figure 3**b, for postal districts at .75m, **Figure 3**c). At less than .75m, homes are shown as individual points (**Figure 3**d). Font size is adapted for reading at different distances.

The interface also provides details about homes within a selection box that follows the user's position horizontally and moves vertically with the pitch of the user's head. Multi-scale interaction [11]—the user's scale of interaction depends on their distance from the display—is used for the selection. The selection box is enlarged with increasing distance and details are shown for data at higher scales: homes, districts, or municipalities. This is shown in **Figure 2**.

Challenges for future research

We have described proxemics-based interactions based on user's distance, movement, and orientation relative to information visualizations on large displays. Much richer forms of interaction with visualizations than what we have described here may be designed. First, different types of data from tracking of users can be combined in numerous ways for meaningful interactions. For example, the orientation of a user's head and its position relative to the user's body can be used to determine if the user is leaning closer toward an area of the display in front of him, or leaning back to



(a) Aggregate, regions

(b) Aggregate, municipalities

(c) Aggregate, postal districts

(d) Individual homes

Figure 3: Adapting the visual representation of real-estate data to the user's distance: Data are aggregated for larger geographical areas when the user is far from the display (a and b), aggregated for smaller areas when the user has moved closer to the display (c), and are shown as individual data points when the user is close to the display (d).

look at information in another area of the display. Second, proxemics data can be used in combination with other types of input (e.g., from mice or mobile touch devices or from tracked gestures). Third, the examples that we have presented here relate to single-user interaction with visualizations, but there is also potential for using proxemics to support collaborative visualization. For instance, we imagine visualizations that automatically merge or juxtapose to show relations when two users move close to each other. A challenge for future research is to systematically explore this design space. Much work must follow to build proxemics-based techniques for information visualization, but also to build an empirically founded basis for understanding how proxemics can be used for information visualization.

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