

# Design and Evaluation of Proxemics-Aware Environments to Support Navigation in Large Information Spaces

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## **Abstract**

In my research, I explore the use of proxemics in Human-Computer Interaction to design explicit and implicit interaction with knowledge work environments for literature review, reading & writing, or discussion. This paper proposes the employment of proxemics for different tasks in knowledge work such as navigation in large information spaces (e.g. zooming and panning). To evaluate different designs, I created a physical environment with interactive walls and multi-touch tables alongside displays of various sizes to form a multi-display environment that enables measuring proxemic relationships (e.g. for manipulating a digital

viewport according to a user's location and orientation in physical space). The aim of my dissertation is to design and evaluate different navigation concepts for large information spaces that employ Proxemic Interactions.

## **Keywords**

Proxemic Interactions; Ubiquitous Computing; Reality-based Interaction; implicit interaction; explicit interaction; interactive spaces

## **ACM Classification Keywords**

H5.3. Group and Organization Interfaces: Collaborative computing

## **General Terms**

Design, Human Factors

## **Research Situation**

I hold a Bachelor's and Master's degree in Information Engineering from the University of Konstanz. For my master thesis I designed, implemented and evaluated a zoomable design environment that integrates various



**Figure 1:** A 3D model of a smart environment equipped with various input and output capabilities and sensors to track proxemic relationships.

interaction frameworks and toolkits in a common development environment [6]. Since then, I have been fascinated by the exploration of why interaction design succeeds or fails. With the beginning of my PhD, this focus expanded to entire interactive spaces or digital ecologies building on users' pre-existing knowledge of the everyday, non-digital world [3]. I am now in the second of the three year Graduate Program "Explorative Analysis and Visualization of Large Information Spaces" at the Department of Computer Science, University of Konstanz, funded by DFG<sup>1</sup>. In addition, I am affiliated with the Blended Library<sup>2</sup> project, which is funded by the Ministry for Science, Research and Art Baden-Wurtemberg, Germany. The project aims to blend physical and virtual library spaces to offer well-known interaction styles in virtual information spaces and also to enrich reality with digital functionality. My supervisors are Harald Reiterer (University of Konstanz, Germany), Raimund Dachsel (Dresden University of Technology, Germany), and Marc H. Schöll (University of Konstanz, Germany).

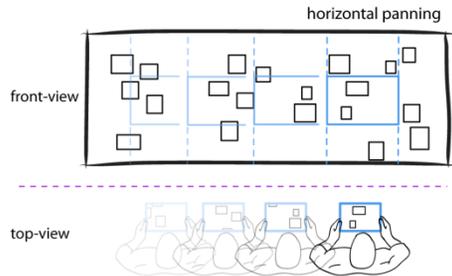
### Context and Motivation

As a starting point with the Blended Library project, I began a study to develop a fundamental understanding of tasks and goals in different fields of knowledge work (e.g. social or political science). I interviewed 20 students and 18 groups consisting of 4 students each about their working methods. Based on the analysis of the interviews, a questionnaire was distributed to students and researchers from the University of Konstanz. The questionnaire was available online and

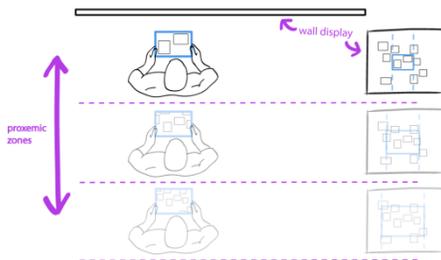
<sup>1</sup> DFG – German Research Foundation – GK-1042

<sup>2</sup> <http://hci.uni-konstanz.de/blendedlibrary/>

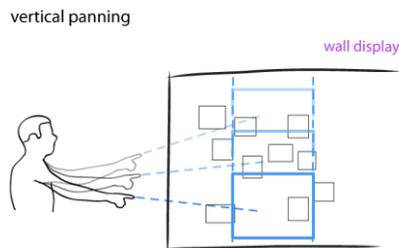
also offline as a paper questionnaire for 8 weeks (57 days), and asked about common tasks when undertaking knowledge work (e.g. *What tools do you use for literature search?*). To increase the likelihood of reaching technology-averse users, I also employed a paper questionnaire. Participants could also comment on existing systems and propose ideas to fulfill their current needs and requirements beyond the scope of tools they currently use. A total of 682 people replied to the online questionnaire (599 students, 83 academic researchers), with our control sample reaching 5.48% compared to the number of enrolled students at the University. The results of the study showed that users are often facing problems when navigating in unknown or even personal information spaces, for instance when acquiring information from digital libraries or managing information on a local storage space (e.g. hard disk). After conducting the user survey, user requirements were extracted. Based on these requirements and on the metaphor of cold, warm, and hot documents by Sellen and Harper [9], I sketched a physical environment that aims for seamless transition between the different document-use categories (see Figure 1). This model conforms to the prior vision of Ubiquitous Computing (UbiComp) by Marc Weiser [12]. This vision presents the notion of ubiquitous devices available everywhere and in different sizes and form factors (pad, tab, and wall). Computing devices disappear and input and output (beyond keyboard and mouse) are integrated seamlessly into their surrounding environment. The various input and output capabilities (e.g. touch enabled walls and tables) offer a smart environment, and thus user interaction is available almost everywhere it could be needed. Although hardware to implement UbiComp is available and it can provide new possibilities for HCI [2, 7], it is still



**Figure 2:** The viewport of the mobile device is displayed on the overview display as blue rectangle. The view pans horizontally when the user moves left or right.



**Figure 3:** Moving backwards from the overview display zooms out and moving towards the overview display zooms in to get a detailed view.



**Figure 4:** Pointing with the arm up- or downwards moves the view accordingly.

cumbersome to navigate within large information spaces, especially if it requires continuous zoom and pan interaction. My dissertation will focus on smart environments that support (personal) information management, particularly in the domain of academic knowledge work. I aim to offer support for the different activities of researchers, such as exploration of large information spaces for literature review, brainstorming, and discussion. For instance a user wants to visualize a large collection of related documents to find further relevant literature or needs to identify patterns in a social network (e.g. co-authorship). Consequently, my research focuses on different concepts for navigation in large information spaces that exploit human navigation behavior in physical spaces based on proxemics (see Figure 2–4).

### Background and Related Work

Research in HCI has focused on spatially-aware information systems that can leverage body movement and location to facilitate interaction with digital information spaces [10,13]. For instance systems that interpret the spatial context [10,11] can provide a mixture of explicit and implicit interaction and thus show tailored information to the user on public and ambient displays [11]. Proxemic Interactions (PI), introduced by Greenberg et al. [1], take this concept further. They propose dimensions of proximity such as distance, orientation, movement, identity, and location. These dimensions help to explain proxemic relationships between people and objects (devices, fixed, and semi-fixed features). Based on this, they implemented a series of prototypes to show the feasibility of PI [7]. Other studies show that body movements can improve users' spatial memory and navigation in zooming and panning UIs [4], which can

be carried from a planar surface to interactive volumes as users move freely within such spatially-aware environments.

### Statement of Thesis and Goals and Methods

In my dissertation I address the research question of how to inform the design of navigation techniques for large information spaces that exploit human navigation behavior in physical space. My contributions are fourfold. I aim to:

- 1.) Explore how PI can be incorporated into the Reality-Based Interaction framework (RBI) and what tradeoffs of power vs. reality need to be made in order to provide a usable navigation concept.
- 2.) Design and implement prototypes that employ PI based on 1. Figures 2–4 illustrate a navigation concept for zoomable user interface (ZUI) sensing a user's lateral body and arm movement for panning and zooming.
- 3.) Evaluate the developed concepts and prototypes. The feasibility of the design will be tested in controlled experiments. Different user populations, ranging from social and political science to law, will be considered as participants for experiments.
- 4.) Make prototypes accessible to students and researchers of the university. Since the lab is located in the library of the University of Konstanz, additional feedback from real users will be gained by allowing it to serve as a "living lab" where users can undertake real tasks, such as preparing for a presentation.



**Figure 5:** The "living lab" as a reference implementation of the 3D model in Figure 1.

### Dissertation Status

After having planned the smart environment I have started to implement a "living lab" (approx. 16 square meters) within the library facilities at the University of Konstanz (see Figure 5). As previously described, this "living lab" will serve as platform to evaluate and study design prototypes that employ PI. My current work is focused on the implementation of a prototype to investigate different navigation techniques for ZUIs based on Proxemic Interactions. For this reason, I am also one of the organizers of the workshop on *Proxemics in Human-Computer Interaction*<sup>3</sup> at the NordiCHI 2012 conference in Copenhagen, Denmark to connect and network with other researchers working in the field of proxemics.

### Expected Contributions

Through my research, I aim to design and evaluate different concepts to navigate in large information spaces employing PI and with regard to RBI tradeoffs. Specifically, I am interested in improving the quality and memorability of information management tasks.

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