Navigation Concepts for ZUIs Using Proxemic Interactions

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Abstract
Proxemics in Human-Computer Interaction (HCI) offer new prospects for the design of explicit and implicit interaction techniques to support multiple users and a concurrent navigation for zoomable user interfaces (ZUI). In this paper we describe a navigation concept for zooming and panning based on a multi-display environment using proxemic relations as input (e.g. a user’s location and orientation in physical space to manipulate a viewport). We hope to foster awareness of the topic and to inspire further discussion and research on proxemics in HCI.

Author Keywords
Proxemics; Proxemic Interactions; Ubiquitous Computing; interactive spaces; implicit interaction; tablet; magic lens; ZUI

ACM Classification Keywords
H.5.3. Group and Organization Interfaces: Collaborative computing

General Terms
Design, Human Factors

Introduction
In light of Mark Weiser's vision of Ubiquitous Computing (UbiComp) [16] most of today’s interactive spaces are

Figure 1: An interactive space for knowledge work such as literature search, discussion, sense- and decision-making.

equipped with multiple computing and sensing devices and displays. These devices can vary in input modality and form factor (e.g. smartphones, vertical and horizontal interactive surfaces, digital pen & paper) [3]. In addition, a compound of connected displays extend the output space (Multi-Display Environment, MDE [11]), which conceivably offer traditional input devices such as keyboard and mouse, touch input, or emerging technology such as Microsoft Kinect or alike for user interaction. The latter enables skeleton tracking and object recognition and is increasingly available at affordable prices. Such input devices have the potential to turn ordinary rooms into interactive spaces as Izadi et al. show in the KinectFusion [5] project. These interactive spaces can support multi-user activities, but require new post-WIMP user interface paradigms to support collaborative tasks (e.g. creative design, decision making, or knowledge work). The ZOIL Framework[1] introduced by Jetter et al. [7] tackles this UI paradigm issue by allowing the development of consistent post-WIMP user interfaces applicable for MDEs with different display sizes, and supporting synchronization of information among connected displays. However, this presents the need to tackle further issues such as concurrent panning and zooming on a shared landscape in a multi-user setting.

To address this, we propose multi-user navigation techniques for a ZOIL landscape and ZUIs in general based on implicit and explicit interaction utilizing proxemic measures.

[1] ZOIL as acronym for **Z**oomable **O**bject-oriented **I**nformation **L**andscape

Implicit and Proxemic Interactions

Previous research in Human-Computer Interaction has focused consistently on the development of implicit interaction [8, 10], which is used to implement smart interactive spaces. Such a holistic ecology integrates implicit interaction concepts and is aware of current users and their context-of-use to assist implicit user interaction. Showing tailored information to the user on a public ambient display to inform her about next meeting dates or incoming and unread emails [15] is one example of this. The Proxemic Interactions introduced by Greenberg et al. [4] take these concepts even further. They propose proximity measures (proxemics) consisting of five dimensions: distance, orientation, movement, identity, and location. These dimensions help to explain the proxemic relationships of people and objects and the distinctions between devices, fixed, and semi-fixed features. Based on this, they implemented the Proximity Toolkit [2], which helps firstly to visually test and define these proxemic relationships between people and objects and secondly to provide a high-level API that supports the development of applications employing Proxemic Interactions. In addition, they show the feasibility of Proxemic Interactions in a series of prototypes (e.g. The Proxemic Media Player or The ViconFace [9]). These prototypes lead us to believe that Proxemic Interactions may also apply to other domains such as knowledge work and sense-making. However, the usability of such interactions in these domains needs to be explored in user studies.

In this paper we introduce interaction techniques that employ proxemics:

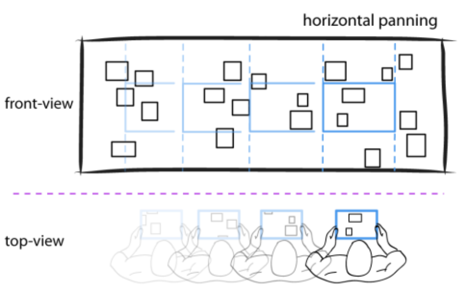

Figure 2: The viewport of the mobile device is displayed on the overview display as blue rectangle. The view pans horizontally when the user moves left or right.

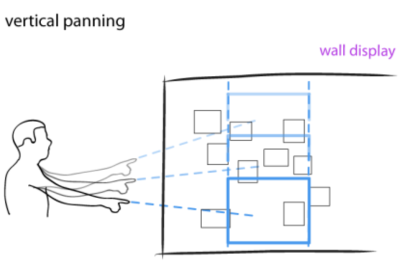

Figure 3: Pointing with the arm up- or downwards moves the view accordingly.

1.) to support zooming and panning in a multi-display environment based on a wall-sized vertical display and single or multiple mobile display(s)
2.) to support different collaboration styles and facilitate concurrent multi-user navigation in ZUIs

The following sections describe *Proxemic Navigation Techniques* in detail. We hope to foster awareness of the topic and to inspire further discussion and research.

Proxemic Navigation Techniques

Related work shows the practicability of navigation techniques based on spatially aware displays, mostly handheld devices, for navigation in 2-dimensional information spaces [14, 17]. For instance, tracking a handheld device's position to navigate in a larger virtual 2-dimensional canvas to write or draw on using pen input [17]. This technique allows navigation on the canvas by physically moving the device and simultaneous pen input. Other concepts extend the navigation to 3-dimensional virtual spaces [14], allowing pen and audio input for making annotations and a freezing function ("taking a snapshot") for putting the device in a comfortable writing position without unintended zooming and panning. The navigation of virtual space is very promising and will therefore be adapted for proxemic navigation. Furthermore, we expect that an additional 2-dimensional overview display that indicates the current user viewport will guide the user and function as an additional visual reference point within an information space.

We describe proxemic interaction techniques for zooming and panning in large information spaces in a multi-display environment for collaborative sense-making (see Figure 1). Moreover, and in contrast to related work, we propose a pad-sized device with simultaneous pen and touch input to allow object annotations (e.g. notes or text highlighting) and object manipulations (e.g. resizing or rotation). The environment tracks user positions (identity, location, and distance measures) as well as devices' orientation to support navigation tasks (e.g. a user movement in physical space pans a viewport horizontally). This complies with the reality-based interaction theme *Environmental Awareness and Skills (EAS)* as put by Jacob et al. [6], which describes that people have knowledge about their location in the physical space and awareness about spatial relationships of objects and other people, as well as the necessary skills to move precisely within the physical world. Beyond this, we demonstrate concepts for searching for specific objects on a landscape by providing visual hints on the user device to guide direction, by using halos as offered by Baudisch et al. [1].

Horizontal and Vertical Panning

In contrast to Spindler et al. [11, 12], we propose an egocentric manipulation of the tangible magic lens' viewport and thus set the user as a reference point to navigate within an information space. This viewport is visible on the mobile device and panned horizontally according to the user's lateral movements, in relation to the fixed feature of a wall-sized display showing the overview. Figure 2 illustrates a user moving from left to right in order to subsequently pan the content of the viewport to the right. The current view on the mobile display is visualized as a blue rectangle on the wall-

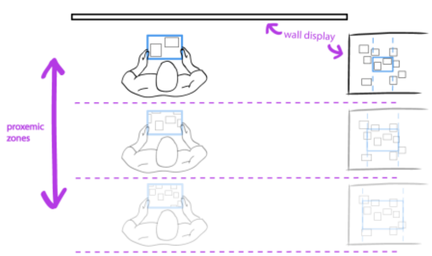

Figure 4: Moving backwards from the overview display zooms out and moving towards the overview display zooms in to get a detailed view.

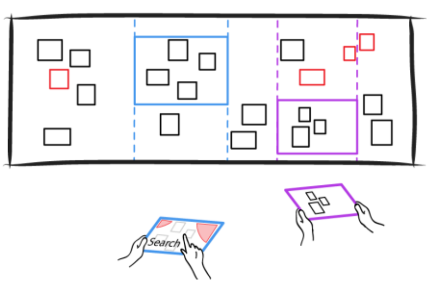

Figure 5: The proxemic navigation technique allows multi-user interaction on a ZUI without impairment by competitive panning and zooming. Users are able to perform different tasks simultaneously (e.g. searching and navigation).

sized display, and the two vertical dashed lines indicate the area currently reachable through vertical panning. Movements of the arm up or down are translated into vertical viewport movements, so that for instance when a user moves their arm upwards, the virtual content also pans upwards (see Figure 3). Something that needs to be considered here is the distinction between wanted and unwanted vertical panning - moving the hand back to the device, for example, competes with a vertical panning of the viewport. This is solved by offering a grab gesture, which is derived from human behavior in the physical world. The viewport can be panned vertically, if the user postures a grab gesture. While this gesture is active the viewport moves up- and downwards according to a user's hand movement. The viewport can be released by exposing the palm.

Zooming

In comparison to the discrete usage of proxemic zones by Ju et al. [8], we implement a continuous interaction space in front of the wall-sized display for zooming. In Figure 4 a user approaches the wall display to focus on something in more detail and implicitly zooms into the information space.

Search and Multi-User Collaboration

The proxemic navigation technique allows multi-user interaction on a ZUI without impairment as a result of competitive panning and zooming - users are able to perform their tasks simultaneously (e.g. searching and navigation). Figure 5 shows two users interacting on the same information space. The user with the purple device can navigate in the information space while the user with the blue device starts a search. Search hits are highlighted on the wall-display and in addition halos on the mobile device indicate the direction of search hits. However, if users want to collaborate together they move close in physical space and the virtual viewport adapts implicitly. Users move away from each other to change the interaction style again without the need for additional touch gestures on the mobile device to pan or zoom the viewport. This enables seamless transitions between loosely-coupled parallel work and closely-coupled collaboration.

System Implementation and Technology

Our prototype is based on the Proximity Toolkit, which provides sophisticated instruments to model various fixed and semi-fixed features in interaction spaces (e.g. presences and displays) and a high-level C# API to implement interaction concepts based on the proxemic relationships between those features. As a first step, we implemented an OptiTrackInputModule that integrates NaturalPoint OptiTrack[2] cameras into the Proximity Toolkit. The input module receives data via NatNet 2.2 protocol from NaturalPoint Tracking Tools and translates rigid body data and marker data as Proximity Toolkit subjects.

Conclusions and Future Work

We proposed a navigation concept for panning and zooming in a ZUI based on proxemic relationships. This concept allows for concurrent multi-user interaction and mixed-focus collaboration, which means a seamless transition between loosely-coupled parallel work and tightly-coupled collaboration [13]. As a next step, we will implement a prototype based on the Proximity Toolkit and the OptiTrackInputModule to evaluate the interaction techniques proposed here.

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[2] http://www.naturalpoint.com/optitrack/

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