Proxemics-Aware Multi-Focus Visualizations to Support Mutual Awareness during Co-located Collaboration

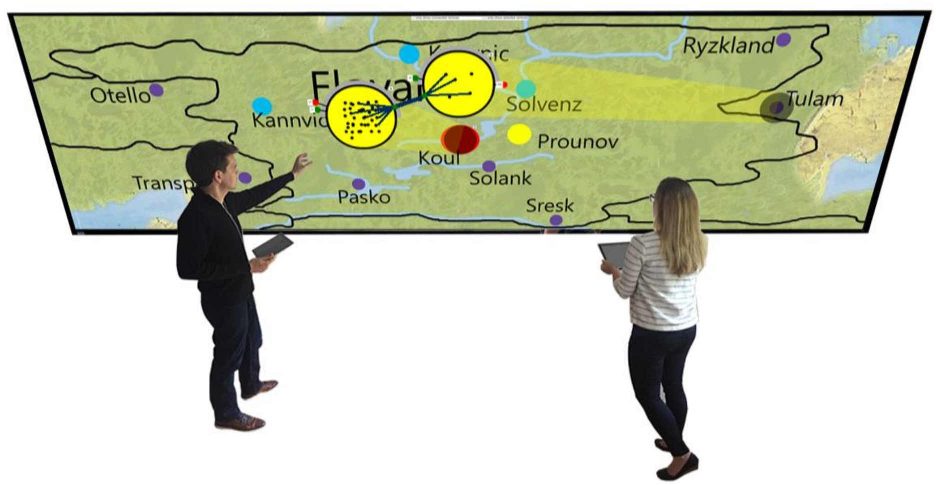


Figure 1. Co-located collaboration in a multi-display environment consisting of a wall display and small personal devices. A proxemic-aware multi-focus visualization facilitates mutual awareness which helps at determining appropriate times to switch to a tightly-coupled collaboration. Proxemics allow for an automatic positioning of lenses on the wall display and the visualization of connections between the lenses.

Simon Butscher
HCI Group,
University of Konstanz
Universitätsstraße 10
Konstanz, 78457, Germany
Simon.Butscher@uni-konstanz.de

Harald Reiterer
HCI Group,
University of Konstanz
Universitätsstraße 10
Konstanz, 78457, Germany
Harald.Reiterer@uni-konstanz.de

Abstract

Co-located collaboration provides several advantages for visual data analysis: complex tasks can be solved faster, experiences can be shared and collaborators have different perspectives on the data. In this paper we introduce proxemics-aware multi-focus visualizations as a means to facilitate collaboration and enhance the situational and mutual awareness during co-located collaboration. Furthermore, we discuss design considerations for proxemics-aware lens interfaces for multi-display environments (MDEs). To illustrate the potential usefulness of these design considerations we describe a hypothetical system supporting a collaborative network analysis task.

Author Keywords

Proxemics-aware visualization; proxemic dimensions; multi-focus visualization; co-located collaboration

Introduction

Co-located collaboration can be a huge benefit for visual analytics. Some reasons are that complex tasks can be solved faster, that experiences can be shared, and that different people have different perspectives on the data [7]. Especially when considering the rapid growth in size and complexity of datasets, it is not remarkable that the expertise to analyze and make informed decisions is often best provided by multiple analysts [13]. In collaborative settings the information is viewed and analyzed by several people with contradictory interest and focuses on the data. Multi-display environments (MDEs) can help to better cope with this problem. Often smaller personal devices, like PCs, laptops or tablets are used in conjunction with large wall displays. Whereas personal devices are used for individual tasks (loosely-coupled work) the large wall displays can support collaborative tasks (tightly-coupled collaboration).

In today's settings, like e.g. in control rooms, the wall displays often show an overview of the information space with the purpose of establishing a shared mental model of the available data. However, especially in collaborative settings, not only the information space is important but also the ongoing group process. To improve the situational and mutual awareness of each individual user wall displays could be used as visualization of: individual tasks of single users, relations between these individual tasks, and ongoing collaborative tasks. Multi-focus visualizations, like lens interfaces, can be used to present this information but at same time preserve the overview of the information space.

In this paper we argue why proxemics-aware multi-focus visualizations could facilitate collaboration and enhance the situational and mutual awareness during co-located collaboration. Furthermore, we present design considerations for proxemics-aware lens interfaces for MDEs. In order to explain the usefulness of these design considerations we describe an imaginary system supporting a collaborative network analysis task.

Related Work

Research showed that users often switch between two coupling styles [12]: loosely-coupled work, where each collaborator is working on his own, and tightly coupled collaboration, where the collaborators work together. Isenberg et al. [9] presented a framework for visual information analysis. The framework outlines individual and collaborative activities performed during data analysis. Whereas the tasks "select", "operate", "parse", and "browse" are tasks which are most often done individually, the tasks "clarify", "strategize", "validate", and "discuss" are collaborative tasks and are most often performed in a tightly-coupled manner. Private devices are suitable to perform individual tasks, whereas public devices, like wall displays can support collaborative tasks. However, also during loosely-coupled work collaboration is important. When working in a loosely coupled manner the collaborators should be able to keep track of the others' activities (improved situational and mutual awareness) which helps determining appropriate times to switch to a tight coupling [5]. In order to support this switch of coupling styles we need to identify the user's intention to change from individual work to collaborative tasks.

Proxemics in Co-located Collaboration

During co-located collaboration the interpretation of the spatial and social context can give valuable insights to the ongoing group processes. Hall [6] gave evidence that especially spatial relations between people can give insights about intentions to communicate and interact with each other. Based on this findings Marquardt et al. [3] investigated not only spatial relations between persons but also between persons and devices. They proposed five dimensions of proximity which can be used to give an abstract description of the context in terms of spatial relations. These dimensions are: distance, orientation, movement, identity, and location. Mendes et. al [11] visualized the presence, distance, and orientation of users to facilitate the mutual awareness during remote collaboration. Jakobsen and Hornbæk [10] presented a first analysis of spatial and social relations between collaborators during an analysis task and showed how this information is related to the ongoing group process and the coupling style. However, research still lacks a deeper understanding on how to use this information to design adaptive visualizations which facilitate mutual awareness and smooth switches between coupling styles. Therefore we pose two open research questions:

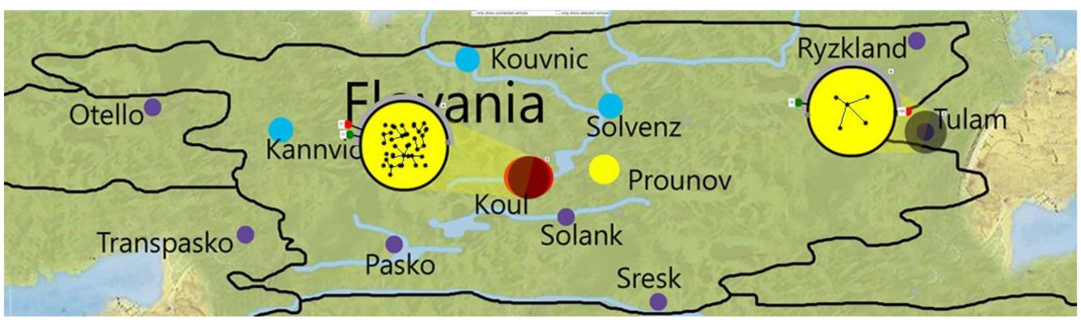


Figure 2. Social network and geospatial task of the VAST challenge 2009: the members of a criminal organization are spread over the fictive country Flovania. The lenses show an aggregation of the individuall work of the users. Each lens shows the sub graph currently examined by a user.

RQ1: How *can proxemics be used to interpret the group process during co-located collaborative visual analytics in MDEs?*

RQ2: *How can adaptive visualizations be designed using proxemics and do this kind of visualizations facilitate collaboration during visual analytics?*

Proxemics Aware Multi-Focus Visualizations

To describe the role of proxemics for collaborative visual data analysis we present an imaginary system which is designed to analyze network structures. As the basis for the task we take the VAST challenge 2009 [4]. In the social network and geospatial task the members of a criminal organization have to be identified. The members of the social network are spread over cities of a fictive county (see Figure 2). To unveil the criminal organization, a known social structures has to be found in the network.

Figure 1 shows an imaginary multi-display environment suitable for a collaborative visual analytics. Mobile devices in form of tablets are used as private devices on which individual tasks like browsing the network, selecting areas or single items of the information space or examining detailed information can be performed. Mobile devices allow the users to freely move in the room which in a study of Inkpen et al. [8] users liked more than fixed positions. A wall display is used as a shared device which gives an overview of the information space and can be used to clarify, strategize, validate, or discuss the collaboration style.

On the wall display a multi-focus visualization in the form of a lens interface is used to visualize detailed information of the ongoing individual work of the users but at the same time preserve the overview of the information space. Lens interfaces, are easier to understand than visualizations based on distortions and provide a high flexibility. The lens interface builds on a physics model which provides an automatic arrangement of the lenses within the viewport. Individual forces can be assigned to the lenses to define their approximate position on the screen. At the same time the physics model guaranties that the lenses don not overlap each other. With PhysicLenses[1] we showed that this is a promising approach for the arrangement of lenses. Although we designed this technique for the use on private multi-touch devices it can easily be adapted to wall displays [2]. The comprehensible behavior of an interface build on a physics model seem to naturally support adaptive visualizations based on spatial relations. In the following section we describe how proxemics can be used to automatically adapt this lens interface to the group situation.

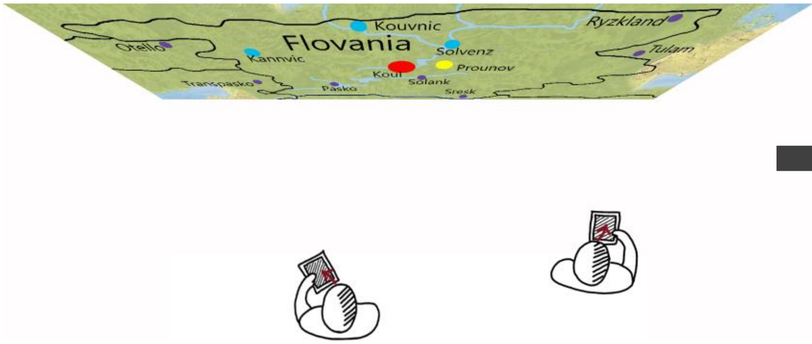
Person-to-Device Proxemics

In collaborative settings different users have different foci on the data and during loosely-coupled work perform individual tasks. Still it is important to provide the other users clues about the ongoing individual tasks to facilitate mutual awareness. To do so an aggregation of the information shown on the private devices can be visualized on the wall display in terms of a lens. In our example the currently explored cities and persons of the social network can be presented as an aggregation (see Figure 2). Additionally, proxemics can be used to assign the lens to the single users. Here the proxemic dimensions identity, location, and movement are of special importance. The location of the user in front of the display can be mapped to the position were the lens is shown. When walking in front of the display, the lens moves along with the user. The lenses therefore serve as a proxy for the users showing the current individual work.

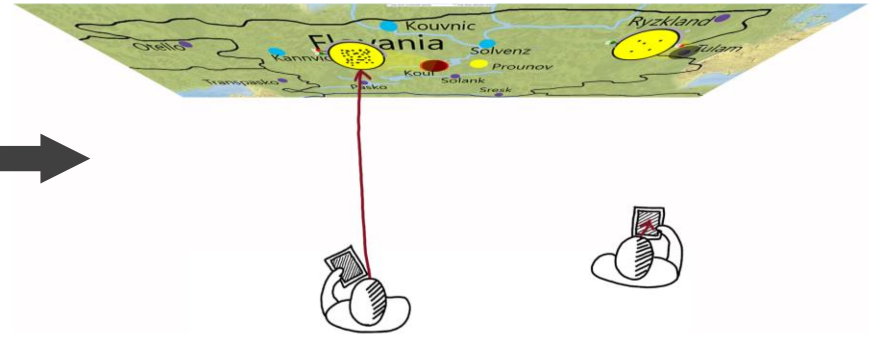
Person-to-Person Proxemics

The main purpose of the analysis of the spatial and social context in terms of person-to-person relations is the identification of trigger situations for switching to a tightly-coupled collaboration. The definition of person-to-person relations in this example can be extended to the relations of single persons to the proxy lenses represented on the wall display. During co-located collaboration in front of a wall display proxemics can be used to anticipate user's intentions. In this particular case the orientation of a user to other users or to the wall display can give valuable insights. Figure 3 (left) gives an overview of interpretations which are mainly based on findings of Jakobsen and Hornbæk [10]. In the lower tow constellations of Figure 3 a potential transition from loosely-coupled work to a tightly-coupled collaboration can take place. An adaptive visualization can support such transitions. Some design considerations for a proxemics-aware multi-focus visualization are shown in Figure 3 (right).

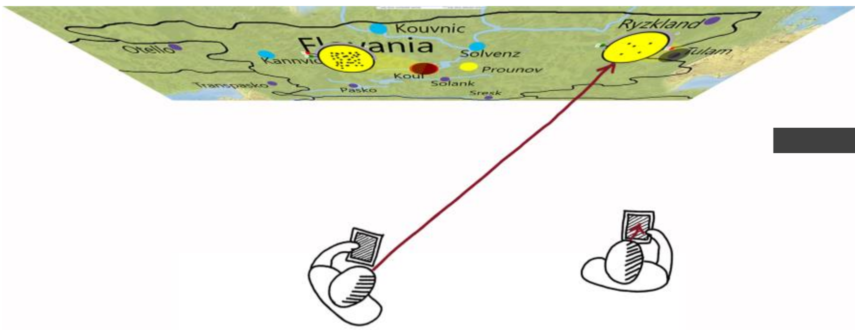
Co-located collaboration can benefit from proxemics-aware multi-focus visualizations. Such visualizations have the potential to provide an overview of the information space and facilitate mutual awareness in terms of visualizations of ongoing individual tasks and the underlying data. A situation-related adaption of these visualizations, based on spatial relations, can facilitate switching between loosely coupled and tightly coupled work. Especially the orientation of the users give valuable insight to the users intentions. Additionally the distance of the users can be considered to get a clearer picture.



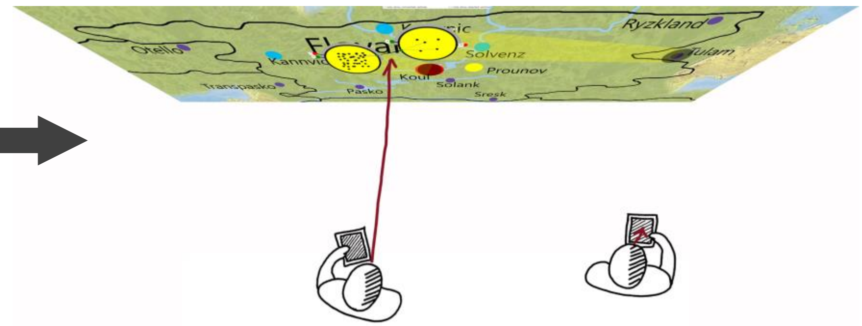
Users look at different areas or at the private devices, each focusing on different parts of the information. Therefore users are focused on individual work and do not indent to collaborate.



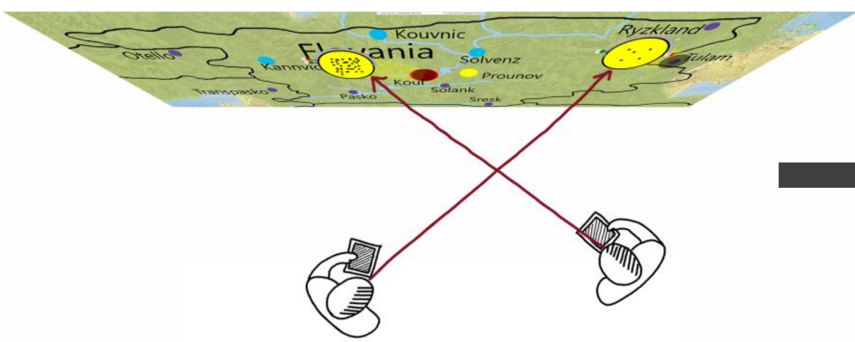
Lenses, showing the currently explored sub graph of the corresponding users, are positioned directly in front of the users. The lenses therefore serves as a proxies for the users and the explored data is visible to the other users.



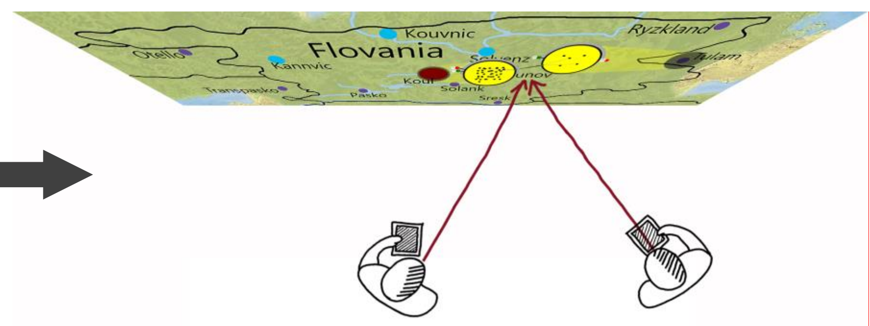
One User is looking at another user or at the information another user is currently exploring. It seems that the user is interested in the individual work of the other user and elaborates if switching to a tightly-coupled collaboration is appropriate.



If the lens is focused by a user it can automatically move towards the users. This allows for a better readability. Furthermore relations to the currently explored data of the user can be visualized in terms of relations between lenses.



The users are looking at each other or at the information the other user is currently exploring. Both users are interested in the individual work of the other user. Both will elaborate if switching to a tightly-coupled collaboration is appropriate.



If the lenses are focused by the other user both lenses can be moved towards each other and can be placed directly between the users. Relations between the sub graphs can be visualized in terms of relations between the lenses.

Whereas in the described concept the main purpose of the wall display is to facilitate mutual awareness, a shared display also provides advantages for a tightly-coupled collaboration. Some reasons are that users see the exact same information and that deictic gestures can be used. Furthermore also during tightly-coupled collaboration proxemics can be used to adapt the visualization: the level of details can be determined based on the distance to the display, contextual information can be visualized based on the location in front of the display, and lenses of users can be merged when moving towards each other.

Whereas we described the design considerations in the context of a scenario with only two users, they also apply to scenarios with more than two users. The concepts behind PhysicLenses can be used to apply a physics model to the interface. Based on proxemics, forces can be assigned to the individual lenses which are therefore automatically arranged on the display.

Conclusion and future work

We are in an early stage of our research on proxemics-aware multi-focus visualizations. In this paper we presented possible interpretations of spatial relations during co-located collaboration. We additionally outlined first design considerations and a concept to support the concrete use case of analyzing a network structure. As a next step we plan to implement the described concept of a proxemics-aware multi-focus visualization based on the PhysicLenses technique and evaluate the influences on collaboration.

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