Coordination and Interaction of Mixed-Focus Collaboration Groups using Shared Interactive Surfaces

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Abstract— Shared interactive surfaces for group collaborations are an innovative way of enhancing traditional tables and whiteboards. Ideally, they provide software to promote collaboration and to facilitate problem solving. To design such surfaces effectively, it is crucial to know how groups interact. Since groups generally operate by applying mixed-focus collaboration, software must support frequent shifts between tight and loose coupling. Dynamic territories should also be provided. To equalize roles in a group and to enable simultaneous surface interaction for all members, input devices should be provided for each person, requiring Single Display Groupware. Surface orientation also influences group behavior, making horizontal surfaces better suited for small groups working on creative design and vertical surfaces more appropriate for presentation settings featuring larger groups. At the moment, shared interactive surfaces are not very common, but this is likely to change as research delves deeper into the realm of group-oriented devices.

Index Terms—mixed-focus collaboration, Single Display Groupware, group coordination and interaction, shared interactive surfaces

1 Introduction

In the last few decades, more and more everyday objects have been digitalized (e.g. ebooks for books, tablets for notepads). Generally, these objects are designed for individual use. However, group work and collaboration are at least as important as individual work. To date, there has been little marketable development of shared interactive surfaces despite the fact that there are many useful applications for such group-oriented devices. Many settings could benefit, including: work spaces for brainstorming or design collaborations, teaching environments where students and teachers can simultaneously interact with materials, or space for everyday collaboration, such as students working on assignments together or parents helping their children with homework.

Shared interactive surfaces could enrich traditional work spaces such as tables or whiteboards, ideally providing software to promote collaboration and to facilitate problem solving. To design such surfaces effectively, it is essential to understand how group members work together.

In the following, coordination of actions in mixed-focus collaboration groups will be examined and the effects of surface orientation on group behavior will be discussed.

2 Key words

2.1 Mixed-focus collaboration

When groups of people work together, the interaction between group members changes constantly. There is a spectrum of actions, from closely shared work to completely independent work [2]. Mixed-focus collaboration takes place when activity within the group shifts between these two end points.

In groups, individuals are dependent on each other to a greater or lesser degree. If work can only be done by interacting closely, "tight coupling" takes place. "Loose coupling" occurs when members can manage without having to interact as much [7].

2.2 Single Display Groupware

Currently, personal computers are designed for individual use. Providing larger screens is the first step in improving usability for groups, but does not solve the problem of interaction devices (e.g. mouse, touch screen), which are designed for one user at a time. In order to accommodate multiple users simultaneously, Single Display Groupware is required. This software enables participants to collaborate using multiple input devices, as well as a shared computer and display. [1]

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2.3 Shared Interactive Surface

Shared interactive surfaces ideally use Single Display Groupware combined with large surfaces, such as electronic tables or whiteboards to support group collaboration. To be able to design user-friendly shared interactive surfaces, researchers have begun studying how groups coordinate their actions.

3 Coordination of actions in mixed-focus collaboration groups

A study by Tang et al. [7] researched pairs working on independent and shared assignments to explore group collaboration around shared interactive surfaces. The groups used a shared interactive horizontal surface for which each member was given a pen to interact. The study identified six different stages of mixed-focus collaboration *(as seen in table 1)*. The table shows that these six stages of collaboration range from closely sharing both interaction and workspace to working separately in separate areas.

Tight coupling, which occurred in "Same problem, same area" and "View Engaged" often required group members to stand fairly close together and use an overlapping workspace. However, this arrangement caused interference, both on the interactive surface and in physical space. Group members reacted by reserving certain areas for personal use. This phenomenon of territoriality has also been observed by Scott et al. [6], who discovered that group members define their own personal territory for individual use and that group territories are used by the group for tight coupling activities. Tang et al. [7] found that interference in physical space was rarely a problem, as it was observed that when collaborators were tightly coupled, they became very aware of each other and seemed to coordinate their movements subconsciously.

These observations reveal several important aspects to be considered for the design of shared interactive surfaces: it is essential to enable different coupling styles and smooth transitions between styles, since groups frequently switch between various coupling styles. Dynamic territories (personal, group and storage) are also crucial in order to give collaborators defined working spaces that can be moved around when needed [7].

Table 1. Six stages of mixed-focus collaboration as identified by Tang et al. [7]

Stage name	Description	Interaction	Workspace
Same Problem, same area	actively working together, both gesturing and interacting with the surface	tightly coupled	closely shared
View Engaged	one person using surface and other watching closely, giving feedback and offering opinions	tightly coupled	not shared
Same Problem, different area	collaborators using divide-and-conquer method on seperate parts of the surface but are aware of what the other is doing	loosely coupled	loosely shared
View	one person working, other watching, but not closely enough to give feedback	loosely coupled	not shared
Disengaged	one person working, other is not involved and not paying attention to the task or the partner	not coupled	not shared
Different problems	collaborators working on completely seperate problems	not coupled	not shared

4 Behavior of group members on horizontal versus vertical interactive surfaces

A further aspect to be taken into consideration when designing shared interactive surfaces is the orientation of the surface. While there may be advantages for vertical as opposed to horizontal surfaces such as space and expense [4], studies of group interaction on either vertical or horizontal surfaces indicate that horizontal interactive surfaces might promote collaboration within the group [5].

In a study by Rogers et al. [5], groups of three had to make an itinerary for tourists in London. Each group had one special pen to interact with the surface (not shared, only one interactive device per group) and each member had paper and a pen to write their own notes. There were chairs around both surfaces. It was found that in the horizontal constellation, "group members switched more between roles, explored more ideas and had a greater awareness of what other members were doing". The role of interactor (group member with pen that is interacting with the screen) was switched considerably more often in the horizontal condition.

In contrast, participants rarely changed roles in the vertical set-up. This was attributed to the fact that the interactor stood in front of the surface while the rest of the group sat. To switch would have required "a much greater and concious effort to stand up and move towards the display or back". In general, collaboration around the vertical screen was found by group members to be "awkward and difficult".

These findings suggest that groups using horizontal surfaces have a less rigid group structure and better group coordination than those using vertical surfaces. It must be noted, however, that this might have had to do with having only one pen per group and as a result only one interactor at a time. Also the uneven arrangement around the vertical display (one person standing while the others sat) as opposed to the horizontal (everyone sitting) might have influenced the participants' perception of equality and leadership.

A related study by Potvin et al. [4] focused on pairs of people using non-interactive surfaces (whiteboards). This enabled each participant to be an "interactor" simultaneously. The result was that there was no significant difference in either physical or verbal participation. An interesting discovery was that there was more face-to-face contact in the vertical orientation than in the horizontal orientation which opposes the thesis of Rogers et al. [5]. This contradiction in findings may also be due to the fact that participants in the first study were seated around the table, whereas in the second study they were standing around the table, making face-to-face contact more of an effort to achieve. In addition, the different set-ups of the two studies make them difficult to compare, e.g. in the second study, both participants had the opportunity to write, talk, and interact with the surface at the same time [4], whereas in the first, only one person at a time could interact with the device.

Circumstances, such as group size and task objective are also important when choosing the optimal screen orientation. For large groups, vertical screens would be advantageous because every group member can see the same image. Horizontal screens are limited by the number of people who can be around them and still have the same viewpoint [5]. Vertical screens would be more fitting for presentation-like scenarios with larger groups of people and horizontal screens for creative and design work in small groups [5, 4].

Clearly, while different surface orientation seems to influence group behavior, there has not been enough research with comparable conditions to be able to draw empirical conclusions. In order to improve group interaction, what appear to be optimal conditions could be researched further, such as giving each group member an interactive role (shared interactive surface), having group members at eye level, and using horizontal surfaces for certain types of interactions and vertical for others.

5 Using a curved surface for shared interaction surfaces

A possible approach to resolving the display orientation issue in group interactions could be to use a curved surface that supports Single Display Groupware.

"Curve", developed by Hennecke [3] is a feasible starting point. This device combines a horizontal and a vertical display, connecting them with a curved display surface, enabling users to seamlessly move objects from one orientation to the other.

For small groups, this could be an optimal way of providing similar conditions for members. They all would have a similar view and physical arrangement, either seated or standing. Territories might be divided so that the horizontal space is reserved mostly for personal use, where collaborators could make complex sketches and then present the result on the vertical group territory.

6 Conclusion

By analysing relevant research, several aspects of group collaboration on interactive surfaces have become clear. People working in groups generally use mixed-focus collaboration. This should be supported by giving members the freedom to be able to easily shift between tight and loose coupling. To minimize on-screen interference, dynamic territories should be made available.

The input device is a key factor in making group collaboration effective. Having only one input device per group inhibits equal roles within the group, as only one person can interact with the surface at a time. Single Display Groupware offers a solution to this problem, enabling all members to interact simultaneously.

Since surface orientation influences group behavior to some degree, benefits of horizontal and vertical surfaces should be considered. Vertical surfaces are more convenient for larger groups and presentation settings, whereas horizontal surfaces support creative design work in small groups. One way of combining advantages of both orientations is to use a curved surface, which provides similar conditions for group members.

Although group-oriented devices are currently not very common, research on adequate software and hardware is in progress. It is likely that shared interactive surfaces will soon become a significant part of working, and teaching, and home environments.

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