Around the Table: Studies in Co-located Collaboration

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Abstract. This video illustrates how pervasive technology can be designed to support more effectively collaborative working. To begin, it shows what happens when small co-located groups try to work together using a single PC or whiteboard: it can be frustrating and encourage one person to dominate. The video then explains our 'multiple entry points' framework, intended to inform the design of shared workspaces, that can facilitate numerous and natural ways of taking control and contributing to the ongoing work by all group members. Two set-ups are presented with increasing number of entry points; (i) a shared touch screen tabletop and (ii) a large physical-digital space comprising a tabletop interlinked with tagged physical objects. The findings from two user studies are outlined; the tabletop was found to facilitate more collaborative decision-making for a simple design task while the extended version, with a larger number of entry points, promoted more fluid and diverse collaborative interactions. Furthermore, it was found that the quiet group members participated considerably more in the physical design activities.

1 Introduction

Much research has been conducted together with the development of novel technologies to enable people to communicate and collaborate while located in different locations. Recent developments in pervasive and display technologies, however, have led to a renewed surge of interest in how collaborative working can be supported, but in co-located settings [e.g. 2, 3, 4, 6, 9]. Our research is concerned with how best to design new workspaces for supporting small groups in meetings and, in particular, while interacting with software during collaborative decision-making.

Currently, many small group meetings involve using laptops, working at a whiteboard or writing on shared paper notepads. However, in such a set-up, one person can often become the impromptu group leader, by being the one either at the whiteboard, holding the PC mouse, or writing on the notepad, while the other group members look on. In so doing, it can be difficult and socially awkward for those who are not in control of the pen/mouse/keyboard to express their ideas effectively. Conversely, it can be difficult for the person in control to record all the ideas of the other members of the group [7].

While having a division of labor – where one person is in control of the recording and accessing of information – may be suited to certain kinds of tasks, it can lead to inequitable participation and be less than optimal for tasks where democratic deci-

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sion-making is considered important. The main problem is that the input devices used in these settings are typically designed with only one user in mind. How can alternative workspaces be designed where the taking of turns, the interactions with resources and the creation and recording of ideas to be more fluid?

The goal of our research is to design and implement novel arrangements of pervasive technologies to provide for more equitable, co-located collaboration by enabling easier control switching between group members. We have designed several novel arrangements, where the selection and sharing of physical and digital information is possible by all. We have used various combinations of technologies including tabletop surfaces and tangibles that are placed around the room and which can be transformed into digital representations at the tabletop.

The primary technology featured in the video is Mitsubishi's DiamondTouch tabletop [1]. The touch surface allows direct hands-on interaction, where users simultaneously point, tap and slide their fingertips across the tabletop surface to select and manipulate information. It also enables simultaneous interactions by interpreting input from multiple users by sending unique signals through them and into receivers located on the floor, which then send information back to the computer about which parts of the table surface each user is touching. The accompanying DiamondSpin software [10] enables a range of novel finger-based interactions, including images being literally spun around the tabletop, and images being automatically expanded and switched orientation towards the person they are moved towards. A very natural way of collaborating is afforded, where the surface invites people to reach out and touch the interactive surface using their fingers.

2 User Studies of Co-located Collaboration

In an initial user study, groups of three participants were asked to work together around the tabletop on a simple design task. The task involved selecting suitable digital images from a number of possibilities to illustrate the front of a calendar for each month of the year. To support simultaneous shared direct manipulation, a variety of novel fingertip based interactions at the tabletop were designed. These included automatic orientation of images to the users around the outside of the tabletop, and automatic zooming of images as they were placed to the center of the tabletop. The findings from the study showed new forms of distributed interactions emerged as groups worked together using their fingers to perform various forms of 'finger acts' that supported or replaced the existing repertoire of speech acts [8].

However, we also found the space on the tabletop to be limited in the number of images that could be manipulated and selected, due to occlusion problems and small surface area. The kinds of interactions they can effectively support are also relatively small (e.g., tapping, stroking). We decided to design an extended tabletop that increased the number of entry points and in so doing, potentially, enable a wider range of collaborative interactions. First, we identified those tasks that are well matched to digital tabletop interactions (e.g., arranging, visualizing, placing) together with those that are less than optimal (e.g., multiple menu selections). Next, we considered how the latter might be more natural and easier to do via interacting with physical objects.

Instead of selecting digital objects from menus they could be selected via tagged physical objects that were placed on the walls and shelves in the room. An important concern was designing the 'glue' between the digital and physical worlds so that groups could switch effortlessly and fluidly between them. We used RFID technology to enable the physical representations to be transformed into digital ones at the tabletop surface.

2.1 Extended tabletop with tagged physical objects

The design task was changed for the second user study to one where a much larger set of items could be selected from and required a more complex design layout. It involved selecting potential objects for a new public garden and laying them out in a suitable arrangement. When the tagged objects were placed next to the tabletop they were transformed into small digital icon versions that could be placed on a bird's eye plan of the garden. Again, groups of three participants took part. The study showed that selecting, showing and comparing of physical objects was relatively easy and all group members took part. The findings also revealed that group members were able to examine, collect, pass, and trade all of the objects easily. The room itself became the browsing space. It was simple for groups to glance around the room and find the various objects they needed to add to their garden design. Transforming them into small digital images was also seamless and became a highly coordinated activity. Moving tens and even hundreds of objects (e.g., trees, plants, benches) in a bird's eye layout and visualizing how they fitted together was conducted in a highly collaborative way.

One of the most interesting findings from our studies was how the extended tabletop facilitated the participation of group members who were less vocal than the others in their group. In particular, they selected objects, transformed them into digital representations at the tabletop while also moving them around the layout. We found that the members who spoke very little during the design task actually performed more of these design activities overall than those who did most of the speaking in the group. Our interpretation of this result is that this novel arrangement provides more *entry points* for people to make contributions, and, therefore, allows various types of users to contribute in ways that they are most comfortable with [5]. A shy participant does not have to acquire the permission of, or even the attention of, the others in order to provide a suggestion but can simply select objects from the wall and move them around on the tabletop. This is quite different from the PC or whiteboard set-up where taking the baton of control is much more awkward, especially for shy members.

3 Conclusion

Our research has shown how designing an extended physical-digital workspace, that has multiple entry points, can enable more equitable decision-making in small groups. One of the main benefits is it opens up more opportunities for collaborative tasks, inviting all to browse, pick up, pass around and compare options. Specifically, shared digital surfaces such as tabletops are effective at supporting arranging and manipulating type tasks while physical objects are good for holding up and handing around to others, encouraging the discussion of options. Physical selection spaces, including walls, shelves and other surfaces, also allow group members to stand beside each other and systematically scan, evaluate, choose, show and compare items that are displayed in or on them. Not having fixed seating encourages group members to change places and move freely between different parts of the space, facilitating fluid switching of activities between group members. Finally, our video shows how a seemingly simple technological solution—interlinking digital representations with physical counterparts—can extend a tabletop surface out into the room, allowing for a range of collaborative tasks to be carried out fluidly and flexibly by groups.

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