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Territory-Based Interaction Techniques for Tabletop Collaboration

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ABSTRACT

For over hundreds of years people have been gathering around tables for the purposes of eating, conversing, working, and entertaining. Co-located collaboration researchers exploring alternatives to traditional "desktop" computers are beginning to exploit the benefits that this familiar environment appears to have for facilitating social interactions. Studies of tabletop collaboration involving traditional media (e.g., paper and pens) show collaborators often partition the tabletop workspace into various areas (e.g., personal and group). Just as partitioning of our physical spaces helps to maintain social order, such territorial behaviour on a tabletop workspace appears to be an important mechanism for organizing collaborative activities. This research further investigates tabletop territoriality, through new observational studies, as well as development of territory-based interaction techniques for tabletop collaboration. Initial results from these observational studies are presented, along with a proposed test-bed environment for exploring territory-based interaction techniques.

KEYWORDS: Tabletop display, CSCW, territoriality, interaction technique, co-located collaboration.

INTRODUCTION

Few existing computer technologies provide the rich, fluid interactions that occur during face-to-face collaboration involving traditional media such as paper and pens. However, as more and more of our society's work is performed on computers, the information required for collaboration is often in digital form. Translating this digital information onto traditional media often has associated costs, such as the time and effort to print out necessary material, which can inhibit its use. Collaborative technology that better supported interaction with digital material would decrease these costs.

A variety of systems have been created to support computer-supported collaboration in a face-to-face environment. These systems include extensions of the standard desktop computer [e.g., 1], interactive wall displays, [e.g., 7] and digital tabletop systems [e.g., 5, 11]. In tabletop systems, users interact with digital information on a large horizontal display. Systems that provide access to digital media on a tabletop surface can exploit the considerable years of experience people have collaborating at a traditional table. With this experience, though, come certain expectations of the interactions that should be available in this environment. Therefore, to be successful, tabletop systems must support the fundamental mechanisms that people make use of when collaborating on a table.

Previous research has shown that one such mechanism used during tabletop collaboration involving traditional media (i.e., paper, pens, Post-it™ notes etc.) is the partitioning of the table workspace [12]. These partitions are similar to territories that exist in our physical environment, which serve to organize interpersonal and group interactions to facilitate social order [2, 10]. Likewise, these tabletop territories appear to help collaborators organize their interactions with the task objects and with each other [12]. However, few existing digital tabletop systems provide effective support for territoriality.

The goals of this research are to first understand the requirements for supporting workspace partitioning in digital tabletop displays and then to apply this understanding to tabletop interface design. In order to achieve this goal, new observational studies of tabletop collaboration were performed. The next section describes these studies and some initial results. Then, tabletop interaction techniques that build on these results are discussed, followed by a short description of proposed evaluation of these interaction techniques.

OBSERVATIONS OF TRADITIONAL TABLETOP COLLABORATION

Two observational studies of traditional tabletop collaboration were performed in order to gain a deeper understanding of how collaborators interact with objects on a table and how these interactions help to mediate collaborative interactions. The studies investigated co-located collaboration among university students using traditional media in two collaborative environments: one casual and one formal.

The “casual” collaboration study occurred in a drop-in setting, located in a university café/atrium area at Dalhousie University. Eighteen participants played collaborative tabletop games, such as puzzles and board games. The collaborative interactions were recorded in field notes.

The “formal” collaboration study was performed in a usability laboratory at Dalhousie University. In this study three small groups (one group of 2 people, and two groups of 3 people) performed two collaborative tasks: 1) a furniture layout task, and 2) a participatory design (PD) task. Their interactions during these tasks were videotaped for later analysis. Each group began with a 90-minute session that was comprised of the layout task and the beginning of the PD task. Then each group returned for a 60-minute session on a subsequent day to complete the PD task.

Initial analyses of these studies have confirmed Tang’s [12] observations that people partition the workspace. The analyses have further revealed that people tend to partition the workspace into three distinct types of spaces. These spaces will be referred to as personal, group, and storage territories based on the organizational role they appear to play during tabletop collaboration. Collaborators used personal territories for conducting individual work that was often later integrated into the group work. The group territory was used for working on the group product, while storage territories were used to store items that were not currently being used.

The location of these territories was generally defined by the position of the people at the table. Personal territories were maintained on the table directly in front of each person. A group territory was maintained in an area that encompassed the centre of the table within easy reach of each person. Storage territories were maintained near the table edge outside of these other two territories, within reach of the collaborators. Figure 1 shows an example of these three territories during a PD session.

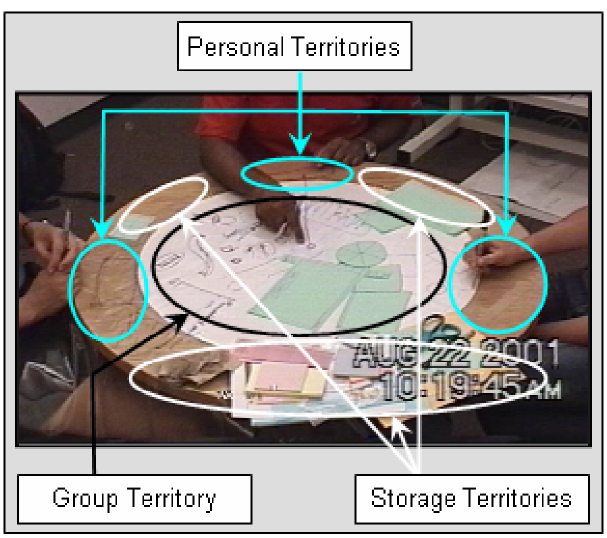

Figure 1. Personal, group and storage territories used in tabletop traditional collaboration.

These initial results have helped generate many ideas about how territories could be used to facilitate interaction with digital information during tabletop collaboration. A more in-depth qualitative video analysis of the data from the formal tabletop collaboration is currently in progress and will be used to inform the particular territory-based interaction techniques that will be developed. A test-bed environment for exploring several territory-based interaction techniques is also under development. The next sections describe this test-bed environment, as well as some proposed territory-based interaction techniques.

THE TEST-BED ENVIRONMENT

The combined observations from Tang [12], Kruger *et al.* [8], and the studies described above suggest three characteristics of territories on a shared tabletop workspace: 1) the workspace contains personal, group, and storage territories; 2) the location of these territories are generally defined by the position of the people at the table; and 3) the boundary of these territories are, in part, defined by the orientation of the objects within them. These characteristics provide the foundation for how the test-bed environment will define and maintain territories on the tabletop workspace.

In general, a personal territory will be maintained on the table directly in front of each user. A group territory that is easily accessible by all users will be maintained in the centre of the table. Storage territories will be maintained near the table edge outside of these other two territories and within reach of nearby users.

The test-bed environment is initially being designed to represent all information items as images (i.e., like sheets of paper) that can be moved, rotated, and resized. Future development could include more functionality, such as the ability to act on files of different formats (e.g., an MS Word document, an image, a webpage, etc.).

Observations from the collaborative tabletop sessions suggest that the following system requirements appear essential in supporting natural human territorial behaviour:

1. Easy adjustment of territory sizes;
2. Easy adjustment of orientation associated with different territories;
3. Easy adjustment of item orientation, regardless of location; and
4. Easy override of system-assisted actions.

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In order to easily override a system-assisted (i.e. automated) action, a user must be aware that an action will occur. One way to notify the user is to provide a "preview" of system-assisted actions before they occur, in the context of the user's current interaction. For example, when an automatic rotation is to occur, a preview could appear anchored to the item being moved to demonstrate the resulting orientation, as in Figure 2(a). Alternatively, "automatic action" could be used, where the system-assisted action (e.g. rotation or resize) could occur automatically when the user initiates an action (e.g., moving an item), as in Figure 2(b). In all cases of system-assistance, users will be able to override the system action. Figure 3 shows a scenario where a user has initiated an assisted orientation by moving an item. The user then invoked a FlowMenu [6] to accept or ignore the default action (i.e. the rotation shown by the preview) or to perform some alternative action.

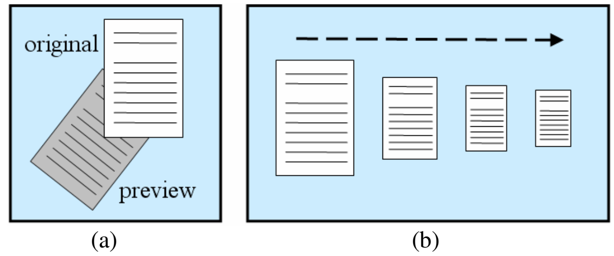

Figure 2. Displaying system-assisted actions: (a) Assisted Orientation using "previews"; (b) Assisted Sizing using "automatic action."

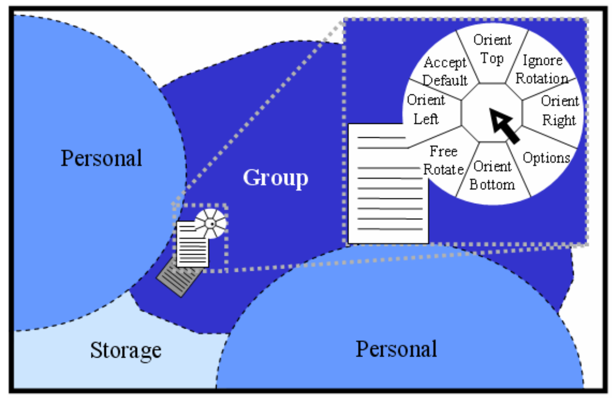

Figure 3. A system-override using a FlowMenu [6].

TERRITORY-BASED INTERACTION TECHNIQUES

The territory-based interaction techniques that will be developed in the test-bed environment will draw on both the analyses from the observational studies, as well as information visualization (InfoVis) techniques that offer potential for helping users organize items on the tabletop workspace.

Within each of these territories, task objects will be oriented appropriately by the system. In each personal territory, items will be oriented towards the respective user. In the group territory, items will be oriented according to some user-established group orientation. In the storage territories, items will be oriented for easy viewing by users with personal workspaces nearby. Figure 4 provides an example of these territories on a tabletop display.

One InfoVis technique that will be explored is based on ZoomScapes [7], as illustrated in Figure 5. In this interaction technique, items placed in a storage space will be reduced in size (e.g., to 25% of their original size) to allow more items to be placed in this area without overlap. To facilitate finding information contained in these items, various methods from the Elastic Presentation Space [3] framework will be explored to magnify these small images when a cursor is passed over them (see Figure 6 for an example of this interaction technique).

Another InfoVis technique that will be explored is "shuffling" [4]. Shuffling allows users to search through a pile of overlapping items by continually selecting the pile of items to make successive items move to the top of the pile at each "click", see Figure 7.

Development of the test-bed environment is currently underway in Microsoft .NET/C#, using Lenses from the Elastic Presentation Space library [3] to implement the three types of territories on the tabletop workspace. The initial environment is being developed for use with the

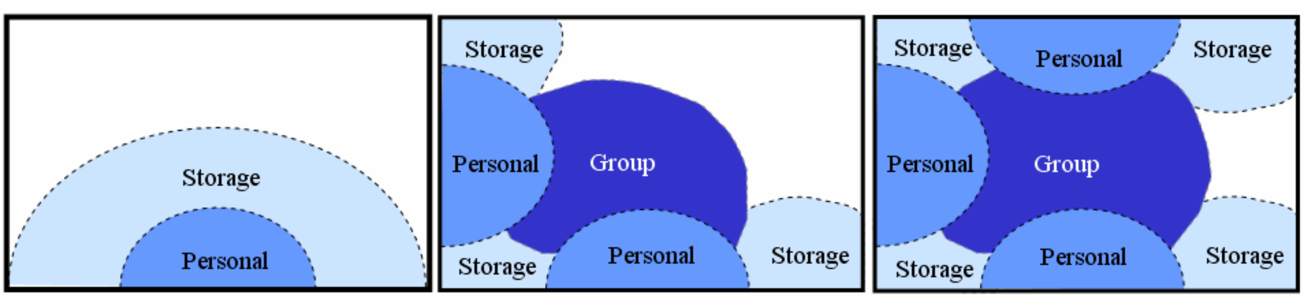

Figure 4. Territories on a tabletop display. The left picture illustrates an arrangement of territories with only one user located at the table, thus no group territory is necessary. The centre and right pictures illustrate 2 and 3 users at the tabletop, respectively.

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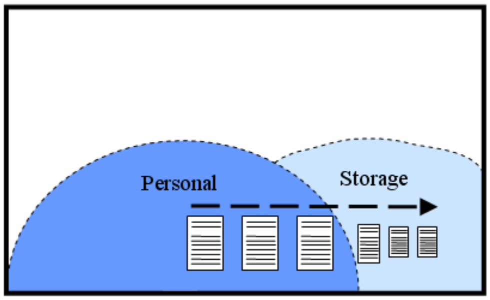

Figure 5. An example of resizing items as they are placed in a storage territory to create more storage space, using the ZoomScapes [7] InfoVis interaction technique.

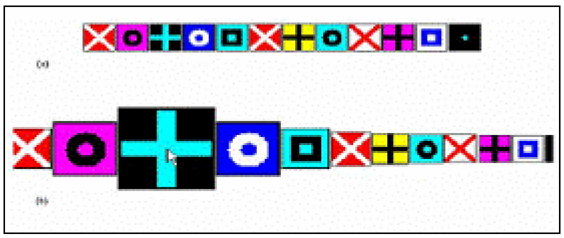

Figure 6. An example of widget distortion interaction available from the Elastic Presentation Space [3] framework (image from [9]).

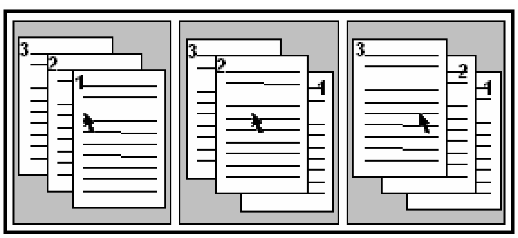

Figure 7. Using a "shuffling" technique [4], users can iterate through a pile of items by continually selecting the pile, as seen in the sequence from left to right.

DiamondTouch [5] tabletop input device, which provides concurrent, multi-user interaction[1]. The exact territory-based interaction techniques to be implemented will be decided during the system design and implementation phases of the project.

EVALUATION OF INTERACTION TECHNIQUES

A series of user-studies testing the ability of these interaction techniques to support territoriality during collaborative tabletop activities will be performed once the implementation of the test-bed and interaction techniques are complete. The studies will investigate the effectiveness, efficiency, and the suitability of these techniques for facilitating interaction with digital media.

SUMMARY

Observational studies of traditional, small-group collaboration have been performed to provide further understanding of interaction on a table. These studies show the emergence of personal, group, and storage territories during tabletop collaboration. In order to facilitate this territorial behaviour, various territory-based interaction techniques are being developed. Interaction techniques that leverage existing work practices, such as tabletop territoriality, can hopefully improve collaboration involving digital information. Furthermore, leveraging information visualization techniques offers the potential to provide more effective use of limited tabletop workspace.

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[1] The DiamondTouch provides an excellent multi-user input technology but it is only available in 88cm and 107cm diagonal surfaces, which are still too small to support groups of 3-4 people. Other table input devices are being investigated for such groups.