Interaction Methods for Large-Group Coordination in Single-Display Groupware

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ABSTRACT
As the number of simultaneous users in system increases, its ability to support coordination can break down due to visual clutter, sub-group differences, and organizational problems. In an iterative design process, we created and observed the effects of five different interaction methods aimed at improving coordination in large groups. The methods are grouped in either imposed or emergent organization. Our design goals were to reduce visual clutter, embed coordinative communication on-screen, and support task subdivision. The effects of these interaction methods and the utility of our design goals are presented.

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General terms: Design, Human Factors

Keywords: large-scale, SDG, coordination, multi-user

INTRODUCTION

Recently, researchers have been experimenting with extending single-display groupware (SDG) systems to support large groups (e.g. a classroom) on one display [5]. However, such systems are not well-understood because user interfaces have not been designed to address the issues that arise in large-group systems. This work attempts to create interaction methods supporting large-group coordination. In this work, “coordination” refers to task-related communication (auditory or visual) which "ensures that work progresses and redundant work is minimized" [3].

UNDERSTANDING LARGE-GROUP COORDINATION

We began to understand the problems associated with large-group coordination through literature review and experience running a large-group SDG system in classrooms. In those experiences, visual clutter arose quickly on-screen, confusing users. Other times, a cacophony of coordinative utterances would either improve efficacy or retard it. Further, users would adopt impromptu roles to help, or sometimes hinder, their group’s progress.

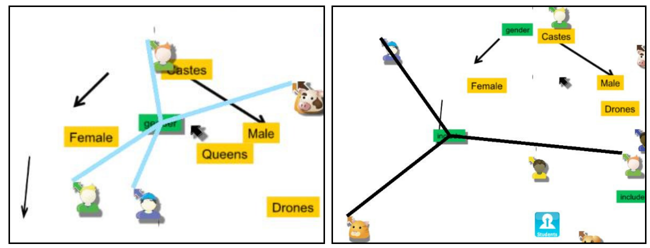

Figure 1a, b: The *rubber band* interaction method allowed individuals to communicate visually, allowing for more high-level verbal coordination.

A group’s ability to coordinate depends in part on the behavioral phenomena that arise within it. These group behaviors are difficult to predict because they depend role diversity, task type, time pressure, etc.

Related work

To help groups coordinate, sub-groups, hierarchy, and individual roles arise naturally and artificially to different results. For example, subdividing a large task can improve effectiveness, creativity, and efficiency but can retard efficacy by making individual differences salient [1].

When considering the use of roles in multi-user systems, they should be flexible rather than pre-determined and permanent [7]. In order to reduce the visual clutter of many moving telepointers [4], Osawa combined cursors into an aggregate pointer, which showed the group’s general intent [6]. Gutwin emphasized an individual's movements by rendering the line of each cursor's movement. This left a trace, like a footprint, that enhanced coordination [4]. Referential identity [2], is the “the mutual belief that addressees have correctly identified a referrant.”

INTERACTION DESIGN

We restricted our domain to classrooms and tasks where users arrange on-screen objects using mice. We asked, “What interaction methods will help the group organize itself to maximize coordination?”

Our design goals were to: 1) reduce visual clutter to improve referential identity, 2) embed coordinative communication into the interface, and 3) support task subdivision.

We used the following organization methods to address our design goals: roles, sub-groups, and neither. We designed and evaluated five interaction methods to support coordination and categorized them into imposed and emergent organization. These methods resulted from an iterative design process of 6 pilot studies of 10-20 participants each solving jigsaw puzzles and concept maps. The methods are presented with the design goals they address.

Imposed Organization

Top-Down and *Bottom-Up*: Uses sub-groups to subdivide tasks and to allow individuals to adopt leadership roles. Users join and leave groups by clicking a group button and right-clicking, respectively. Each group has two roles: one leader, multiple followers. In *bottom-up*, the leader controls the movement of an aggregate cursor whose speed is a function of the followers holding down their left mouse buttons (Figure 2a). In *top-down*, followers independently control their cursors and the leader freezes/un-freezes those cursors *en masse* by pressing her mouse button.

Phasing: Explicitly defines a coordination phase via a cyclical 3-step task process: 1) each person selects an object to move, 2) manipulation of those objects on-screen, and 3) deactivating all cursors (for verbal coordination).

Emergent Organization

Traditional Drag-and-Drop: Used in [5], anybody can drag an object but if an object requires more than one user to drag, its motion is a summed proportion of each selecting cursor's movement.

Rubber Band: Makes user intentions salient on-screen to improve referential identity. Rubber band is traditional drag-and-drop with an object-specific colored bar extending to each cursor dragging it. Object location is the average of the cursor locations. See Figure 1.

Indirect Manipulation: Designed to reduce visual clutter, users click on the object they would like to move and then press one of four cardinal direction buttons at each edge of the screen to move the object in that direction a couple of pixels (Figure 2b). Objects and cursors are color-coded and multiple users can choose the same object to move it faster.

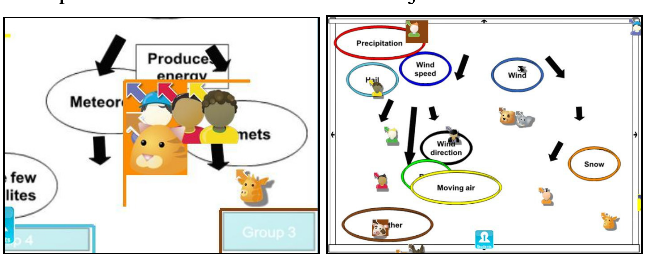

Figure 2a, b: The *bottom-up* and *indirect manipulation*.

RESULTS

This section explicates the utility of our design goals and the differences between the organization methods used.

Visual Clutter: Reducing occlusion of objects also reduced utterances like "Where is my mouse?" However, it should not come at the cost of a less informative interface. Users were surprisingly competent at focusing on desired pieces when it was clear what the desired action was.

Communicative Design: Because the rubber band's color bars added visual complexity, we expected poor results. Surprisingly, users preferred this method and it triggered strategic conversations. Participants often wiggled their bars to indicate desired target position without saying a word. Parsing multiple bars on-screen is easier than tracking concurrent verbal utterances, in spite of the clutter.

Subdividing Large Tasks: With all the designs, large tasks were subdivided into sub-tasks by individuals or sub-group leaders. In the third phase of the *phasing* method, subdividing arose from discussion and opinions rather than the usual just-in-time manner. The extra time devoted to coordination allowed conversations to get deeper into the task.

Observations of the organization methods used:

Roles: High role mobility reduced the risk associated with adopting a role and helped users from getting 'stuck' working alone but also made the roles feel unimportant. In a relatively complex interface, roles lent some structure that participants could work around but the hierarchy implied in bottom-up and top-down may have been too rigid.

Sub-groups: Sub-groups are the seed of many emergent phenomena dictated by the group idiosyncrasies. We observed social loafing and sub-group formation based on physical proximity. Sub-groups alone did not guarantee coordination within the sub-group.

No Explicit Organization: We interpreted the success of the emergent organization methods to the natural tendencies of groups. Therefore, designers should focus on improving referential identity and reducing time pressures of large-group systems rather than on imposing organization.

CONCLUSION

We presented research on factors affecting large group coordination and presented the design of 5 novel methods for doing so. The results of 6 pilot studies evaluating these methods and the design goals they aimed to address were also presented.

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