Awareness in Synchronous Collaboration between Tabletop and Handheld Displays

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Abstract

We have implemented a synchronous remote collaboration system for distributed teams, where one team member is in a command centre using a large tabletop display, while others are out in the field using small handheld displays. This asymmetric form of collaboration motivates our choice of asymmetric viewing and control of a shared model, in which the tabletop can see and control everything but the handheld is restricted. Key principles are that visibility awareness is important on the tabletop, whereas control awareness is important on the handheld.

1. Introduction: Distributed Teams

Many examples of teamwork involve some personnel being situated in a fixed location, like a command centre, while others go out into the field. Typically team members communicate via two-way radios, but digital wireless networks offer the possibility of complementing this voice channel with a shared visual workspace for synchronous collaboration.

A team co-ordinator in a command centre can exploit the benefits of a large tabletop display to view and manipulate information, but personnel in the field are constrained to using small handheld displays. Teams of many types could use this combination of devices. In particular, we are considering urban search and rescue operations, in which several search and rescue units are controlled from a central location.

The different devices complement the roles of the users because the co-ordinator must monitor and fuse much information, while the field personnel are more concerned with their physical tasks.

In our scenario, users share a map of the urban area showing positions of items such as team members and buildings to search, and a timeline showing the assignment of tasks to team members.

We expect information to be passed in both directions as the field personnel pass up information on the current situation and the co-ordinator passes down command decisions. The need for conversation about the facts, and negotiation about the plan, is why closely-coupled collaboration over the shared data is useful.

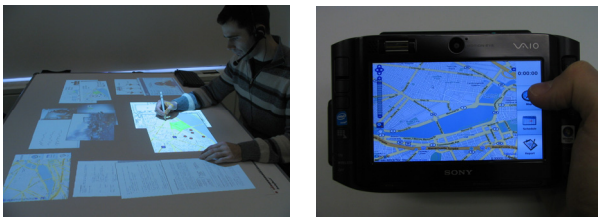

Figure 1. A single tabletop (left) is linked to several handheld displays (right).

2. Shared Workspaces

Each type of information, such as the map and timeline, is placed in a two-dimensional shared workspace to allow several collaborators to simultaneously view and control it. The model-view-controller paradigm, originating from the Smalltalk programming language, is very applicable here. The shared information resides in a single model, while a view and a controller are provided on each device.

A key aim is to augment the audio channel with a visual channel for communication, so it is desirable to keep the views as similar as possible to support conversational grounding. However, the extreme asymmetry in display sizes means that the views on the tabletop and handheld cannot be identical, so we have used relaxed WYSIWIS [4]. Visualizations of the shared data are identical, but the handheld user sees a much smaller region of the space.

The tabletop is defined as being able to view and control everything. Its large size means it is able to show the whole of each 2D workspace, while the handheld shows only a subset of one workspace. Thus,

hardware asymmetry causes view asymmetry. The co-ordinator at the tabletop is the common point for team decisions, so all functions are available on the tabletop while some are disabled on the handheld. Thus, role asymmetry causes control asymmetry.

3. Awareness for Views and Control

We use the principles below to cater for the different awareness requirements of the two device types.

Visibility awareness on tabletop

Visibility awareness [1] is provided for the tabletop user to indicate what the handheld displays are viewing, as shown in Figure 2. The tabletop user knows that if she makes a spoken reference or a deictic gesture to something inside the indicated region, the handheld user will be able to see it. No such awareness is provided on the handheld because the tabletop user is assumed to have space to view everything. Also, the tabletop user can drag a visibility region (labelled rectangles on left of Figure 2) to direct a handheld user's attention to a new location.

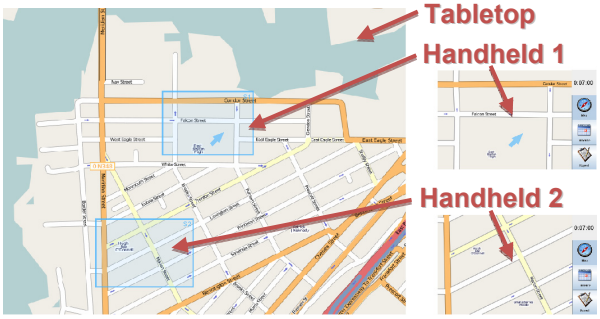

Figure 2. Visibility awareness on the tabletop (left) reveals what the handhelds are showing. The regions can be moved by the tabletop user.

Control awareness on handheld

We have strived to provide an expressive interface [3] which allows remote collaborators to be aware of each other's past, present, and future actions. Consequently, direct manipulation is used, rather than symbolic commands like keyboard shortcuts.

Present actions are visualized via feedthrough [1]. For example, in Figure 3 left, a task in a timeline is being dragged. The existing task is highlighted and the drag location is indicated for all collaborators to see.

Telepointers and traces (Figure 3 left) are included for deictic gesturing, and to aid prediction of future actions via consequential communication. Because of the display-size asymmetry, a telepointer may be outside the viewport of a handheld display. In this case, an indicator is displayed (Figure 3 right) to give some indication of the action occurring off-screen.

Awareness of past actions is supported by slowly fading highlights on modified items, to mitigate change blindness.

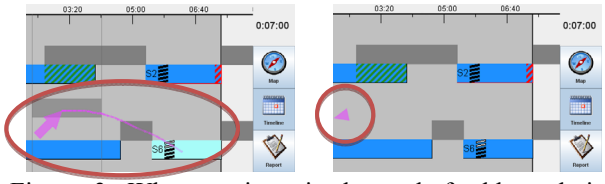

Figure 3. When an item is dragged, feedthrough is displayed (left). If the telepointer is off screen, an indicator shows the direction in which it lies (right).

Because control is mostly conducted on the tabletop, the control awareness features are mostly for the handheld. Our devices support only single-touch or single-pen input, so basic telepointers are sufficient. Richer input, such as multi-touch, would call for more expressive embodiments, such as hand shadows, although how these should be implemented on a small handheld device is unclear.

4. Future Work

The use of relaxed WYSIWIS and direct manipulation reflects the intention that the system will be as much a communication medium as a facility for users to work independently. There is a tradeoff between design for individual and group work [1], and in this case we have opted for the latter.

The next step is to test the system with groups of users performing a simulated mission. In addition to indicating whether the shared information supports the specific urban search and rescue co-ordination task, this will indicate how well the awareness mechanisms work, and suggest further enhancements to support asymmetric synchronous collaboration.

5. References

[1] C. Gutwin, S. Greenberg, "Design for Individuals, Design for Groups: Tradeoffs Between Power and Workspace Awareness", Proc. CSCW 1998, pages 207–216.

[2] C. Gutwin, S. Greenberg, "The Importance of Awareness for Team Cognition in Distributed Collaboration" in E. Salas et al. (Eds) *Team Cognition: Process and Performance at the Inter- and Intra-individual*, APA Press, 2004.

[3] S. Reeves, S. Benford, C. O'Malley, M. Fraser, "Designing the Spectator Experience", *Proc. CHI 2005*, pages 741–750.

[4] M. Stefik, et al., "WYSIWIS Revised: Early Experiences with Multiuser Interfaces", *ACM Trans. Office Information Systems* 5:2, pages 147–167, 1987.