Designing for Collaborative Cross-modal Interaction

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ABSTRACT

We describe the design of a collaborative cross-modal tool that supports visually-impaired and sighted coworkers to access and edit shared diagrams in real time and a case study of its use in a real world workplace environment. Our findings highlight the potential of cross-modal collaboration to improve workplace inclusion and identify initial challenges and opportunities for cross-modal design.

Categories and Subject Descriptors

H.1.2 [**User/Machine Systems**]: Human factors; K.4.2 [**Social Issues**]: Assistive technologies for persons with disabilities; H.5.3 [**Group and Organisation Interfaces**]: Collaborative computing, Computer-supported cooperative work.

General Terms

Design, Human Factors.

Keywords

Collaboration, Cross-modal interaction, Accessibility, Inclusion, Haptics, Auditory interfaces, Diagrams.

1. INTRODUCTION

Collaboration is a fundamental form of human interaction. However, software tools which support collaboration assume that all collaborators have access to the same sets of modalities. For example, shared whiteboards assume equal access to the visual modality [2]. This disadvantages users with differing access to sensory channels due to their context and abilities. The lack of access to shared displays can form a major barrier to workplace collaboration, particularly when visual representations are used which typically form a central part of certain job roles (e.g. System Analysts, Project Managers). These situations contribute to the exclusion and disengagement of visually impaired individuals.

2. CROSS-MODAL INTERACTION

Our brains receive and combine information from different perceptual modalities to make sense of our environment, for instance when watching and hearing someone speak. The process of coordinating information received through multiple perceptual modalities is fundamental and is known as cross-modal interaction [3]. Cross-modality is particularly relevant to individuals with perceptual impairments who rely on sensory substitution to interpret information using alternative modalities. In the design of interactive systems, the phrase cross-modal interaction has also been used to refer to situations where individuals interact with each other while accessing the same shared space through different sets of modalities (e.g. [6, 1]). Current technological developments mean that it is increasingly feasible to support cross-modal input and output in a range of devices and environments, yet there are no practical examples of such systems, e.g. Apple's iPhone provides touch, visual, and speech interaction, but there is no coherent way of collaborating using differing sets of modalities if collaborators cannot see the shared screen. This paper outlines a project that addresses this problem.

3. WORKSHOP

To address the issues identified above we gathered requirements and feedback from project partners and potential users to inform an ongoing development process. We ran a workshop to engage with representatives from end user groups in order to encourage discussion and sharing of experiences with using diagrams in the workplace. Eight participants attended the workshop including participants from BT and the Royal Bank of Scotland and representatives from the British Computer Association of the Blind and the Royal National Institute for the Blind. Activities ranged from round table discussions exploring how participants encountered diagrams in their workplaces, to hands-on demonstrations of early audio and haptic prototype diagramming systems. The discussions highlighted the diversity of diagrams encountered by the participants; from nodes-and-links design diagrams for databases and networks, to business model diagrams, organisation and flow charts and field specific visualisations. Additionally, participants discussed the various means they currently use for accessing diagrams and their limitations. Approaches included the use of a human reader, swell paper, transcriptions and stationary-based diagrams, all of which share two main limitations; the inability to create and edit diagrams autonomously, and inefficiency of use in collaborative interaction.

Figure 1: The collaborative cross-modal tool in use.

4. PROTOTYPE TOOL DEVELOPMENT

Our prototype cross-modal tool supports autonomous non-visual editing of diagrams as well as real-time collaboration. It combines three main views of any given diagram; a visual, auditory and a haptic view. The auditory view uses a hierarchical metaphor to capture and structure diagram elements. Users can browse the tree structure, similar to typical file explorers, and receive auditory feedback in response to their interaction. This approach is thoroughly described in [4] and [5]. We use the PHANTOM Omni Haptic device to support interaction with the haptic view, which captures the content of a diagram and its spatial arrangements and displays them on a virtual vertical plane to match the visual display on a computer screen. We use a number of haptic effects to support the non-visual interaction in this view. Namely, magnetic wells and lines to represent the nodes and edges of the diagrams respectively. Users manipulate the stylus of the device (shown on Figure 1) and are attracted to diagram elements through a simulated magnetic field force, andcan then trace the edges of the diagram through the magnetic lines. Encountered items are also presented in audio using a speech and non-speech sounds.

5. FEEDBACK FROM EXHIBITION

We engaged with potential users over three days at the recent QAC Sight Village event which is the premier technology exhibition for blind and partially-sighted people. The event allowed us to showcase a functional prototype of the cross-modal collaborative tool, to gather feedback about our initial design decisions and to identify avenues for improvements. Among the identified issues were the need for adding contextual features to aid orientation within the haptic view and the variance in users' preference of the vertical orientation of the haptic view and the levels of magnetic attraction forces used.

6. CASE STUDIES OF USE IN THE WILD

We are currently running tests to assess how well the tool supports real-world collaborative scenarios. So far, we have deployed the tool in the head office of a London-based Children and Families Department in local government and observed its use by sighted and visually-impaired coworkers. Our initial observations shows that collaborations typically involve three phases of interaction which could portray different stages on the learning curve of a collaborative cross-modal system; 1) A first phase consisting of the visually-impaired user dominating the interaction. This includes exploring the diagram, editing its content and altering its spatial arrangements. The sighted coworker in this phase typically engages in discussion about the diagram, in addition to providing general guidance about where things are located and how to get to them; 2) In a second phase, the visually-impaired user continues to dominate the interaction, while the sight coworker engages in refining the spatial arrangements produced by their coworker; 3) In a third phase, both coworkers engage in manipulating the diagram, working independently on different parts of its content while continuing to discuss the task and updating each other about their progress. One major issue that affected how coworkers exchanged information, including guidance and feedback, is the lack of representation of partner's actions on their respective views of the system. This meant that the users found it hard to keep track of their partners moment-to-moment progress and could only provide feedback once partner's actions were completed. An interesting point to highlight is that, even when working independently, coworkers would focus on the same task when this is a spatial one, i.e. whenever the visually-impaired user turns to the haptic view. It could be that having a somewhat similar representation (2D visual diagram and haptic diagram) provided the pair with a common perspective of the task, more so than when using the audio tree view.We will be exploring such issues through further workplace studies.

7. CONCLUSIONS

Our work has so far highlighted the difficulty in designing for cross-modal collaboration and has raised interesting questions about issues such as coherence of representations and support for awareness across modalities. Moreover, our initial findings indicate that providing cross-modal mechanisms for all team members to collaborate, share, and edit diagrams has the potential to increase productivity and to significantly improve the working lives and inclusion of perceptually impaired workers.

8. REFERENCES

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