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While displays have the connotation of affording visual output, surfaces invite the users to interact. What happens when the surfaces are also displays, when a direct input interface space and output visual space are superimposed onto the same touch interactive surfaces? In the past three years at MERL, we have systematically examined, studied and evaluated, holistically, user interface and interaction techniques on one particular type of direct-touch computational surfaces - multi-touch multi-user tabletops. We have created and prototyped a set of novel interface systems ranging from a photo story-sharing table called PDH (Personal Digital Historian) to the DiamondSpin tabletop tool kit, and UbiTable, to interaction concepts including CoRDs, Modal Spaces, Glimpse multi-level input model. ExpressiveTouch bimanual gestures and bifocal tabletop display interactions. We have also obtained preliminary findings on non-speech audio feedback on multi-user interactive tabletops, and some of the effects of the size of tables and size of groups on different aspects of multi-user collaboration. Our future research will investigate interaction and visualization across table-centric interactive spaces with multiple surfaces of tabletops and walls in a new project called DiamondSpace.

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Multi-User Interface and Interactions on Direct-Touch Horizontal Surfaces: Collaborative Tabletop Research at MERL

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Abstract

While "displays" have the connotation of affording visual output, "surfaces" invite the users to interact. What happens then when the surfaces are also displays, when a direct input interface space and output visual space are superimposed onto the same touch interactive surfaces? In the past three years at MERL, we have systematically examined, studied and evaluated, holistically, user interface and interaction techniques on one particular type of direct-touch computational surfaces – multi-touch multi-user tabletops. We have created and prototyped a set of novel interface systems ranging from a photo story-sharing table called PDH (Personal Digital Historian) to the DiamondSpin tabletop tool kit, and UbiTable, to interaction concepts including CoRDs, Modal Spaces, Glimpse multi-level input model, ExpressiveTouch bimanual gestures and bifocal tabletop display interactions. We have also obtained preliminary findings on non-speech audio feedback on multi-user interactive tabletops, and some of the effects of the size of tables and size of groups on different aspects of multi-user collaboration. Our future research will investigate interaction and visualization across table-centric interactive spaces with multiple surfaces of tabletops and walls in a new project called DiamondSpace.

1. Introduction

Tables are a familiar piece of furniture commonly found in homes, offices, command-and-control centers, cafés, design centers, show rooms, waiting areas, and entertainment centers. Tables provide a familiar and convenient physical setting for people to meet, look over documents, layout maps, and carry out tasks that require face-to-face collaboration. Digital documents, on the other hand, are commonly used only on desktop/laptop computers, vertical plasma displays, and handheld devices. Digital documents are not easy to share and manipulation face-to-face, due to a lack of a physical media that contain the necessary computational support for face-to-face around the table applications. For the past three years, our group at MERL has researched and studied new user interfaces and HCI mechanisms that will enable tabletop applications.

2 Tables Are Not Desks

Making computational artifacts disappear into the architecture space is only one of the challenges in the design of a digitally augmented tabletop environment. Making the interactions with a digital user interface on the table disappear into and become a part of the human to human interaction and conversation is a bigger challenge. Research on digitally augmented desks supports user activities that are focused tasks, such as writing, editing, calculation, design and drawing. On the other hand, people usually meet around a table, facing each other, rather than facing the display. A table setting encourages collaboration, coordination, as well as simultaneous and parallel problem solving among multiple people. A horizontal interactive surface brings about new challenges in human computer interaction and interface designs.

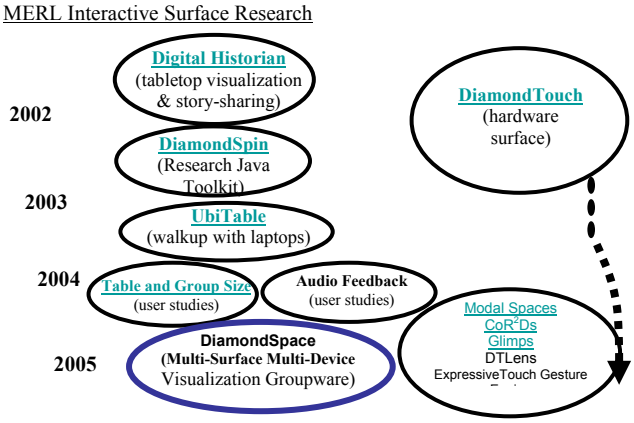

Figure 1. Tabletop research at MERL.

Figure 1 shows a timeline of the research steps and projects at MERL that together have defined a new research area of interactive direct-touch multi-user tabletops since 2002.

3 DiamondSpin, PDH, UbiTable & DiamondSpace

DiamondSpin is a tabletop Java tool kit providing a rich set of UI functions for interactive and collaborative document browsing, visualization, manipulation and navigation by small groups of people (www.merl.com/projects/diamondspin/). DiamondSpin focuses on the study of what affordances an augmented digital table should offer, that can preserve the simplicity and informality of around-the-table interaction. Currently, DiamondSpin runs on both conventional mouse-&-keyboard based systems, as well as on the multi-user multi-touch input surface of DiamondTouch(www.merl.com/projects/DiamondTouch/). DiamondTouch is a novel multi-touch input technology enabling significantly more interactions than conventional input devices. Most noticeably, up to four users can **simultaneously** operate on the table. Additionally, each user is not limited to a single point of contact. This is drastically different from the sequential turn taking that arises when people use traditional input devices.

In *PDH*, we created a new type of interface addressing many issues. One of PDH's primary focuses is on developing content organization and retrieval methods that are simple and understandable for the users, and can be used without distracting them from their conversation. Rather than a folder&file mechanism, PDH organizes the contents along the four W's of storytelling (Who, When, Where, and What), and allows users to design new contexts for organizing their structures. A second issue we have focused on is affording casual and exploratory interaction with data by combining a multiplicity of user interaction mechanisms including tabletop pop-up menus, direct manipulation, natural visual query formulation with minimal menu-driven interaction and freeform digital ink strokes. Finally, in order to support the multi-threaded and non-linear progression of group conversation, PDH provides tools to help people navigate a conversation as well as their content. (See www.merl.com/projects/PDH/)

UbiTable (www.merl.com/projects/UbiTable/) is a study on interface design for walk-up usage of interactive tabletops. In particular, UbiTable allows users to dynamically connect their personal laptops, cameras and USB devices to an interactive tabletop, so that people can fluidly share, manipulate, exchange and mark up data on a shared large tabletop surface. At the same time, each user can still maintain explicit control over the accessibility of his own documents displayed on the tabletop. The affordances are very much like when they bring personal paper documents to a meeting.

DiamondSpace (www.merl.com/projects/dspace) is our ongoing effort in researching how multiple interactive display surfaces, including multi-touch multi-user tabletops, electronic walls, and laptop/desktop displays, can be used in concert to create flexible visualization and problem solving spaces in which people can explore, understand, utilize and manipulate information from many data sources and types. Fluid interaction and meaningful visualization are the key for multi-surface, multi-device, interactive spaces to become the users' true cognitive prosthesis. Such interactive environments are suitable for a variety of application domains, including collaborative business and work spaces, emergency response and mission control centers, urban planning rooms, as well as geospatial visualization and analysis.

Research on collaboration with interactive tables is still in its infancy. We are concurrently working on many new exciting research challenges that still lie ahead, including gestural and multimodal interaction techniques, understanding the visual and cognitive benefits of large horizontal interactive surfaces, as well as a basic taxonomy of how the different interactive surfaces should relate with each other under varied application scenrions.

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