Finger Talk: Collaborative Decision-Making Using Talk and *Fingertip* Interaction Around a Tabletop Display

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ABSTRACT
We describe a study that investigated how a shared interactive tabletop (DiamondTouch) can be designed to provide new opportunities for supporting collaborative decision-making. Small groups of users were required to work together using the table by selecting and placing digital images into a calendar template and justifying their choices to one-to-another. A variety of novel *fingertip* interactions were developed to support simultaneous, shared direct manipulation at the tabletop. Our findings showed that new forms of distributed interactions emerged while the groups worked together. Alongside conventional methods of communication, group members *talked* to each other with their fingers. The role of this *finger talk* served a number of functions, including the support of turn-taking, the emphasis on and substitution for speech acts and the encouragement of balanced contributions from all participants. We discuss how *finger talk* is integral to the collaborative use of the interactive tabletop surface.

ACM Classification Keywords
H5 [Information interfaces and presentation]; User Interfaces.1.3.6 [Methodology and Techniques]: Interaction Techniques

General Terms
Design

Keywords
Shared interactive tabletop; computer supported collaborative work; user studies

INTRODUCTION
Recently, there has been a growing interest in designing shared interactive displays to support collaboration among groups of people who are collocated. A number of large commercial surfaces have been developed, enabling a variety of digital information to be shared, viewed and interacted with using conventional input devices (e.g., keyboards, mice and pens). These include large flat monitors, plasma displays, Mimio and Smartboards. In addition, a few novel interactive tabletop surfaces have been developed that use hand and finger gestures for input. These include MERL's DiamondTouch [6] and SONY's Smartskin [2]. A key concern is how to design the various shared surfaces so that they facilitate collaborative interactions in ways not possible with a single PC set-up. Compared with mouse and keyboard input, fingertip input using a tabletop surface, has the potential to allow multiple users to interact with the information displayed on it at the same time.

A number of studies have begun to investigate the efficacy and usability of this form of fingertip interaction as an input technique for pushing, selecting and manipulating data objects, when using shared interactive tabletops [e.g., 6]. Our focus, here, is to examine the kinds of collaborative interactions that take place when groups use this technique to share and discuss digital information.

The problem space we are interested in is face-to-face meetings where asymmetries in access to and the creation of information can arise [4]. While it is possible for all to view the external representations being displayed (e.g., through using whiteboards and flipcharts) it is more difficult for all group members to take part in creating or manipulating them. In particular, our previous research has shown how often one person can dominate the interactions by monopolizing the keyboard/mouse or pen when creating and editing a document on a shared interactive whiteboard [3]. A main finding was that once a person is established in a particular role (e.g. note-taker, mouse controller) she or he tends to remain in it. Moreover, those not in control of the input device, can find it more difficult to get their suggestions and ideas across.

Our idea is that interactive tabletops can help reduce such asymmetries in collaborative working by providing more equal and direct access to the digital information that is being created and discussed. Our goal was to investigate how groups sitting around the interactive table collaborate when all are provided with the opportunity to open, share,

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move, annotate and manipulate digital information using simultaneous, fingertip direct manipulation. Our research question is: *to what extent does having equal access to a surface where digital representations can be laid out and manipulated by all result in more equitable decision-making?* In particular, do all participants take part in the planning and how do they use the interactive surface to introduce their suggestions and further their ideas? To address these issues we carried out an initial study investigating how groups of collocated people make a set of choices, given a number of possible options, using the table. A simple group decision-making application was developed, requiring the creation of a calendar. In this paper we present the findings from our study, showing how groups worked collaboratively to solve this problem by talking with their fingers.

BACKGROUND

The DiamondTouch table and the DiamondSpin software toolkit are the two core components of MERL's state-of-the-art prototype fingertip interactive surface system [6]. The former is an interactive, multi-user, touch-sensitive surface. The latter offers several novel interface features enabling users to use their fingers to do the interacting, including dragging images from different parts of the surface resulting in the automatic shrinking and enlarging of the images, selecting options by tapping menus and annotating by drawing. The table is unique in that it has the ability to distinguish between several users touching the surface concurrently, and the ability to determine exactly where each user is touching. Unlike other interactive technologies, such as Smartboard and Mimio, the DiamondTouch table is intended to be used horizontally on a table, rather than vertically on a wall.

The technology set-up is particularly well suited to developing applications that support the joint browsing and manipulating of a set of images. For example, one of the earliest projects using DiamondSpin developed an interactive coffee table that enabled opportunistic browsing of news stories [1]. Other applications that have been developed include the Personal Digital Historian [7] that supports the sharing of stories via interacting with visual images and the Collage and WebPage Builder, that allows a document to be compiled using several elements, e.g., images, text, banners [6]. Underlying much of this research is the quest to design applications so that the interactions with the digital user interface on the table disappear into and become part of the human-human interaction and conversation.

DESIGNING A CALENDAR

The calendar application we developed was based heavily on the DiamondSpin SDK. A small set of features were adapted to enable users to move images across the surface, enlarge and shrink them, annotate them, provide a way to orientate all images to one perspective, and a way to rotate an entire center section of the surface. This combination of features allows several ways for users to do a small number of desired tasks. For example, to orientate an image to view it, a user can drag the image with a finger, rotate the center section, or select a menu option that orientates the entire collection of images.

The group decision-making task we designed involved creating a 12 month calendar by choosing an image that would represent each month. Each participant is provided with a different set of 7 iconified images, initially located in in front of them on the table. Three categories were used: faces, abstract images and campus images. The rationale for giving each person a different category of images (rather than all the same or random) was to provide a talking point.

The template for the calendar was designed as a circle that could be spun around the tabletop like a lazy Susan contraption (see Figure 1). It was carved into 12 segments labeled with the 12 months of the year where the images were to be placed. In the middle was a large, round white workspace intended for viewing and inspecting of the images.

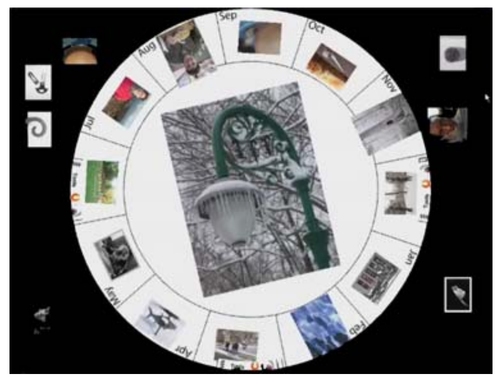

Figure 1. The calendar interface.

THE USER STUDY

Four groups of three participants took part in the study*. The gender make-up for each group was varied: (i) 2 females and 1 male, (ii) 3 females, (iii) 2 males and 1 female, and (iv) 3 males. The members of each group knew each other as friends and/or as work colleagues. This was a deliberate choice to prevent unfamiliarity affecting the form of collaboration.

The participants were introduced to the table and given a chance to try out the novel interaction techniques before starting the task. They were then told to design a calendar for college students.

All sessions were recorded using (i) video and (ii) screen capture software. To analyze the data we viewed the two sources of data together, enabling us to analyze the conversations that took place, the interactions at the table

* We decided to carry out an in-depth study of a small number of groups because we were interested in investigating how different individuals collaborated around the DiamondTouch table.

and the way the data was manipulated at the table. To answer our research question – the extent to which having equal access to the resources needed to solve the task resulted in equitable decision-making – we classified our data in two ways and then compared the classifications. First, we classified the talk as decision-making components, in terms of various speech acts (e.g., suggesting an option, asserting, rejecting, suggesting an alternative and justifying) and, second, we classified the actions and interactions that took place at the table in terms of finger movements (e.g., spinning the calendar, moving an image to the workspace). In so doing, we were able to analyze the coordination of talk and interactions.

Findings

One of the most striking findings from the study was how easy it was for all members of the group to talk with each other while moving and manipulating the images on the surface. All the groups got very engrossed with the task at hand and had many animated discussions about their designs and rationale behind them (see figure 2). They rarely, if ever, talked about the technology they were using despite it being so novel – it simply became invisible.

Figure 2. Group discussion around the table.

Fingertip manipulation of images and calendar: The participants had no problem sliding images around the surface of the table and did not ever stop to query why they shrank or increased in size depending where they were placed. They also used the spinning feature of the calendar to orient and show images to each other that they had placed in the segments. In contrast, the option to change the orientation of all the images on the table to one's own view was used less frequently by the groups. One of the reasons for this is that the action of doing so might be considered to be rude insofar as it instantly shifts all images towards that person's viewpoint, thereby momentarily excluding the others. Furthermore, changing an image's orientation with a finger or spinning the calendar allows the user to change the perspective of the image or calendar to either face themselves or the other's perspective. Interestingly, our observations showed that all the participants used the spinning function to orient the image or segment of calendar most of the time towards the others rather than towards themselves.

Simultaneous versus sequential interaction: Although the groups knew they could all interact with the table at the same time, our observations showed that they rarely did. The times when they did were at the very beginning of the task when trying out the various functions and occasionally when viewing images by themselves. Instead, the group members were very aware of each other and rapidly adopted a turn-taking method of interaction, coordinated with their ongoing decision-making.

Decision-making and table interactions: When analyzing the data using our two classification systems, we began to see an emergent phenomenon of *finger talk*: many of the finger interactions with the table were used in combination with the decision-making components that we classified as speech acts. The role of this finger talk served a number of functions, including the support of turn-taking, the emphasis on and substitution for speech acts and the encouragement of balanced contributions from all participants. We describe these below.

Speech acts and turn-taking: As is well known in the literature we use speech acts during our conversations to get things done, letting people know what we want to do or what we are about to do (e.g. asking permission, issuing commands, giving thanks). In our study, the use of speech acts was frequently evident; for example, participants often made suggestions, disagreed with other's proposals, or proposed alternatives. At the same time as making them, the participants often manipulated and moved the images around on the tabletop in a way that supported them or was used in place of them. Such 'finger acts' emerged without any explicit discussion and were readily used across all groups. As well as emphasizing the intention behind a speech act they provide a visual way of letting others in the group know implicitly or explicitly that they wanted them to take over or respond to their speech act (e.g. approve of their request, follow their command). Most commonly used were:

- *Asking a question:* pointing to an image and asking one of the others what they think
- *Instructing another:* pointing to an image and asking one of the others to move it (e.g., place an image in a given segment).
- *Making a suggestion and inviting:* moving an image with a single finger to the central workspace, causing it to enlarge, swiveling it around the right way up for the others to see it and then removing the finger to indicate the other's turn to do and/or say something
- *Requesting confirmation and inviting:* spinning the calendar around while talking about one aspect of it, stopping and lifting the finger up and in so doing inviting another to comment on it
- *Offering and inviting:* moving an image from a calendar slot back to one's own space allowing another to move a different image into to it

Encouragement of contributions: Finger talk was also used to manage asymmetries in contribution that became apparent. The way the table was set up makes it visible to all what each has contributed to the task at hand. A set of images that has remained static in front of a participant suggests inactivity, indicating to the others that something needs to be done to bring that person into the task. For example, in Group 2 (all female), two of the members (R and Z) took it in turns to place a couple of their images in the shared workspace, then spun the calendar around, enabling the other to move the image into a calendar slot. The third participant (S) watched on while this happened, often moving her finger to the table but not moving anything. On noticing her hesitation to touch the table and the fact all her images were still in tact, Z stopped what she was doing and began to invite her to take control of the floor. R then began pointing at her images and saying things like "take it away, Susie!" Z removed one of the images she had placed in the calendar and then spun the calendar so that the empty slot was facing towards S, inviting her to place an image in its place. For this group the number of encouragements by R and Z was 8 and 3, respectively. Similar patterns were found for the other groups.

CONCLUSION

Our study has shown that collaborative decision-making can be promoted by providing group members with equal access and direct interaction with digital information, displayed on an interactive table surface, required to solve the task. In particular, much discussion, sharing of ideas and invitations to others to take a turn, to respond, confirm or to participate took place. Furthermore, the lightweight fingertip mode of interaction provided by the tabletop surface encouraged the participants to talk with their fingers while conducting a verbal conversation. Rather than working in parallel, the table configured for the calendar task, encourages more distributed interactions, where one person does something and then hands over the 'floor and table' control to the next. In particular, there was much evidence of turn-taking, orchestrated use of speech acts (that were followed up) and the encouragement of contributions from each other.

Compared with the asymmetrical forms of collaboration that can take place during group meetings, where only one person controls the technology, the interactive table shows much promise for supporting flexible and fluid ways of creating and discussing digital documents.

In our study, we had groups of three working side-by-side (due to the constraints of the technology). It is interesting to speculate as to whether such equitable levels of collaboration and consideration of each other would persist for larger size groups or whether divisions of labor would necessarily ensue. To accommodate more people the technology will have to increase in size. In turn, new interaction techniques will need to be developed to allow users sitting furthest away from each other to access, pass, orient and select information from different parts of the table. To what extent will introducing new methods of interaction, which will invariably not be as direct as those used here, result in different forms of collaboration?

A set of guidelines has just been published for the design of collocated collaborative work on tabletop displays [5]. Suggestions include the need for natural interpersonal interaction and fluid transitions between interactions and activities. In addition, the preliminary findings from our study suggest that providing a limited set of direct manipulation fingertip interactions, that are accessible and usable by all, can facilitate social cohesion, engagement, encouragement and other important aspects of collaboration to take place.

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