From Clicks to Touches: Enabling Face-to-Face Shared Social Interface on Multi-touch Tabletops

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Abstract. Making the interactions with a digital user interface disappears into and becomes a part of the human to human interaction and conversation is a challenge. Conventional metaphor and underlying interface infrastructure for single-user desktop systems have been traditionally geared towards single mouse and keyboard, click-and-type based, WIMP interface design. On the other hand, people usually meet in social context around a table, facing each other. A table setting provides a large interactive visual and tangible surface. It affords and encourages collaboration, coordination, serendipity, as well as simultaneous and parallel interaction among multiple people. In this paper, we examine and explore the opportunities, challenges, research issues, pitfalls, and plausible approaches for enabling direct touchable, shared social interactions on multi-touch multi-user tabletops.

1 Introduction

Multi-touch has been a buzz word of much media attention and technological discussion. One only needs to type in the keyword "multi-touch" in any search engine today to reveal the fervor. Bill Buxton's recent article [2] offers a historical account into how the form factor of this enabling technology has slowly evolved, in the past twenty five years, from universities and laboratories around the world.

Much of the research so far has mainly focused on innovation of multi-touch multi-user input and display devices including tabletops and walls [4] , and the demonstration of individual interaction techniques [1] [3] [5] [15] [21]. Very little is understood and has been studied with respect to full-blown user interfaces and shared interactions that can be deployed in actual applications and our day-to-day lives. What is largely missing is a holistic approach that examines the social, technological, as well as the cognitive potentials, and shortcomings, of this emerging form factor.

On the other hand, one can't help but notice that there are over a billion mice in use today as inputting devices to interact with computers [8]. This is not just a mere commercial success, it underscores the user acceptance and an entire user culture that have developed around this tiny device, after thirty years from the time when the mouse was invented by Engelbart and English in 1965. Inside the quiet offices and homes, in the midst of banking facilities and stock traders, upon the school classroom desks and lab benches, and amongst the hustle and bustle of airports, cafes and bus

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terminals, we hear billions of clicks each day around the world. So it is almost a daunting task for anyone to think about researching another input modality, and to endeavor to develop a user culture around it. Nevertheless, this is the task some of us took on a few years ago.

There have been many earlier and recent attempts at human-computer interactions using touches, gestures, speech and tactile. 1980's Bolt's Put-That-There [3], and the more recent movie "the Minority Report" are two such examples. These projects/designs have provided inspirations, yet not systematic and scientific studies to offer a path and reason for user acceptance beyond the "*wow*" factor.

In the following sections, I will relate the challenges and research issues, and attempt to describe plausible approaches for enabling direct touchable, shared social interactive applications on tabletops.

2 Why Tables? a Paradigm Shift

In social settings, people often gather around a table, let it be a meeting room table, a coffee table, a dinner table or a game table. It is not hard to envision how computational augmentation on these tabletops can enrich and enhance the group experience. Figure 1 illustrates one of our early visions in this paradigm shift. Given the nature of social interaction where the fluidity and expressiveness of the input device, in supporting interactive casualness and serendipity, are inducible to mutual engagement, one would expect that multi-touch and multi-user affordances might be two of the key desirable capabilities for digital tabletops.

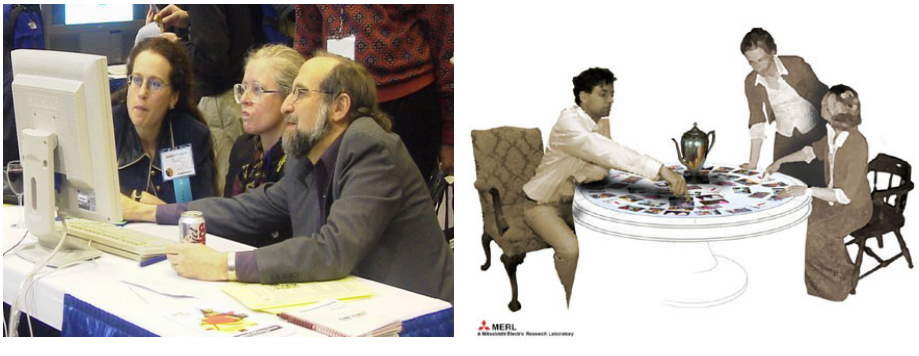

Fig. 1. A paradigm shift: Two images from *ACM CHI 2001*. (Left) PhotoFinder [11] demonstration. (Photo courtesy Bill Kules, University of Maryland). (Right) Design of a tabletop story-sharing system called Personal Digital Historian [16], presented at the Design Expo Session.

Since a direct touch interactive table serves both as a visual display and as the user's immediate direct input device, natural hand gestures and intuitive manipulations may be employed to improve the fluidity and reduce the cognitive load of interaction between the user and the digital content. By leveraging the tendency to

gather around a table for face-to-face interaction, a horizontal tabletop surface offers affordances and opportunities for building and enhancing co-located collaborative social environments. Moreover, large surfaces such as tabletops offer a spacious work area that may influence meeting styles and group dynamics. The larger area also provides a larger visual field, which may be utilized as external physical memory in order to extend the working memory capacity of people, and as an external cognitive medium.

Although the cynical may see a digital tabletop as simply a vertical touch sensitive display laid down horizontally, this mere re-orientation of the display surface breaks down much of the usual usage patterns and conventions. People treat vertical desktop displays as personal information spaces. Tabletops bear no such connotation. Now, instead of a personal display, it leaps out at the users' visual field and invites them to touch and interact, *together*.

3 Tabletop Opportunities and Challenges for Social Interaction

Physical, non-computationally augmented, tables existed long before computers were invented. Yet, we do not have much experience in the design and implementation of digital tables that provide direct multi-touch affordances. Here we discuss experiences and challenges that tabletop designers may face. Digital tabletop is still in its infancy, design challenges fall into at least three categories: (1) social and psychological effects, (2) UI and interaction techniques, and (3) human tactile and perceptual implications. Some of these challenges stem from the aforementioned "click" centric human-computer interaction culture that has been ingrained for the past few decades. Given that much research has been focusing on the UI and interaction techniques in the recent years [1] [3] [4] [15] [21], the following sections will discuss the social and human tactile/perceptual aspects.

3.1 Social Challenges: Group Interaction, Walk-Up Usage and Shared Multi-device Ecology

When group activities are mediated by a digital tabletop, the group dynamics can be different from when the mediation is through other form factors, such as vertical displays. One set of our controlled studies has shown these effects [7]. In [7], we compared groups' working on either a single vertical display, an array of four vertical displays, or sitting around a horizontal display. An interesting outcome of the study indicated that groups sitting around a tabletop display may not work as fast as sitting in front of a row of multiple displays when given a specific visual search task, but the groups do carry out more inter-personal discussions and communicate more around the tabletop. The egalitarian seating arrangement around a tabletop seems to encourage comfortable interaction amongst participants.

In a broad sense, digital touch tabletops, differing desktop displays and electronic wall displays or whiteboards, have at least two unique personas – (a) offering equal access (almost), and (b) inviting social interaction.

Equal access can imply both shared usage and a lack of permanent ownership. Anyone and everyone can claim the temporary possession of a table for the intended

usage session or meeting, then can also just as easily to walk away. Moreover, most of the people today carry one or more personal digital devices with contents that they might want to show and share during these social meetings and encounters. They can leverage the large display space of a digital table.

A multi-touch surface invites all participants to reach out and touch in an egalitarian manner. This entirely deviates from the conventional one-mouse, one-keyboard, single-control interaction, or the one-scribe, one-moderator meeting dynamics. With a non-computationally augmented tabletop, everyone around the table has a socially well-understood personal space [12] [19], and physical documents and objects have a well-defined protocol for handling and sharing. With a multi-touch digital table, there are no established protocols and conventions yet.

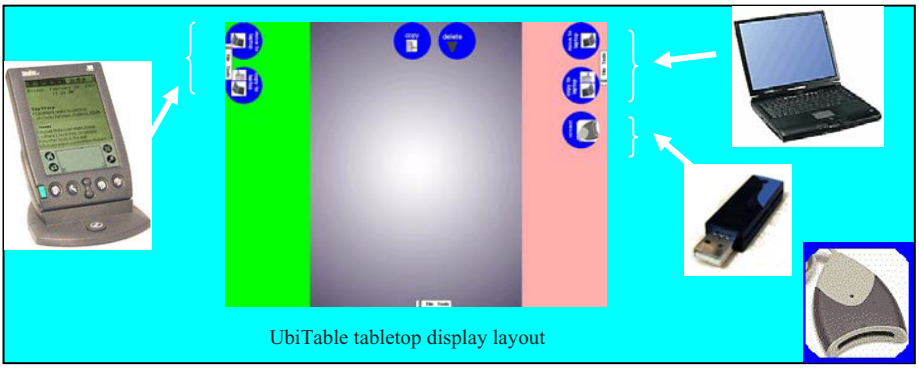

Fig. 2. UbiTable: Tabletop view and the devices that can share data with the tabletop

One of the social interactive tabletop environment that we have developed is called UbiTable [18]. The UbiTable was intended to provide "walk-up" usage for people to fluidly share the viewing and manipulation of contents from their personal devices, such as PDAs or laptops. In our observational study [5], some interesting user experience and problems arose from group interaction on document sharing.

Since UbiTable used DiamondTouch [cite Dietz] as the physical tabletop platform, we were able to provide two special computational support to the users. First, since the DiamondTouch can tell which seated user is touching which location of the table, this capability was used to designate ownership of documents on the table. If a document is put on the table from a particular user's laptop, that user has full control of the sharing semantics of that document. During our user studies, we used documents with similar contents from different users' laptops and used color borders around the digital display of the documents to indicate the ownership when they are placed on the tabletop. This mechanism seemed to work fine until the users needed to bring (copy) the documents from the tabletop back to their respective laptop. Since the user task required them to take copies of documents that were originated from both each of their own laptop and their meeting partner's laptop, the ownership of documents become blurred.

Second, DiamondTouch allows users to simultaneously touch any location on the tabletop. Therefore, using the UbiTable, the users are able to write and annotate on

the exactly the same document at exactly the same time. This brought out unexpected "conflict" resolution issues. Some people took turns to modify a document by verbally negotiating whose turn it is, while others had near-physical 'collisions' (i.e., hands collided inside the same document).

Many opportunities and challenges still remain to be investigated with respect to the value of digital tabletops for social interaction.

3.2 Human Perception and Tactile Input

When people interact over a direct touch surface, some of the problems that one may incur include imprecision with fingers as input devices, occlusion by the operating hand, meaningful usage of multi-hand gestures, multi-user widgets, multiple input tools and multi-modal input. Much of previously published research has addressed these issues and proposed technical solutions [15] [22]. On the other hand, there has not been a body of systematic examination on the effects of direct touch interaction compared with conventional mouse on a tabletop, and the visual effects of viewing information horizontally.

Visual distortion is a phenomenon that people encounter and are accustomed to daily. Given sufficient contextual information, people are good at correctly perceive what appear to be distorted. However, in social settings, the presentation of information to be perceived on a horizontal tabletop surface may need to be carefully thought out so that the orientation, rotation, and position of information to be shared can be most conducive for the collaboration and flow of conversation. Figure 3 illustrates this difference between information perceivable on a vertical display (right) and that on a tabletop (left). From our first set of user evaluations, our findings indicate that data values encoded in position (as in x, y axis on a tabletop) are less accurately perceived on a tabletop than those encoded in length (as in bar charts).

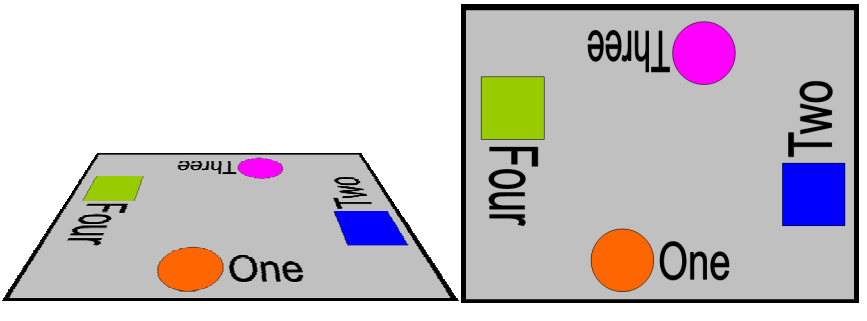

Fig. 3. Perceptual distortion due to planar rotational distortion [wigdor 07]

One of the compelling usage scenarios of a direct touch tabletop is when people can use bimanual (two-handed) interactive metaphors to manipulate digital objects, such as those described in [1] [22]. However, when it comes to performance in terms of speed, error and user preference, do bare hands outperform the well-accepted,

well-understood mice? Our most recent study [6] suggests that people benefit from bimanual direct bare hand input techniques on a tabletop, while for single point interaction, a mouse would be a better choice for performance.

4 Let There Be Touches

In this paper, we have offered a brief look at some of the challenges, opportunities and issues regarding the support for interactions around multi-touch digital tabletops. We focused on how simultaneous touches, horizontality, group interaction and visual information encoding can be challenging in the design of tabletop user interfaces and interaction techniques. We have only made initial strides in examining the effects of various aspects of multi-touch tabletop designs on human perception and tactile operations. Much still remains to be studied in order to derive full benefits for social interaction using this exciting new form factor.

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