The TViews Table in the Home

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Abstract

The past several years of computer interaction research have shown an increasing interest in tabletops for shared user interactions through touch or tangible objects. Digital media tables offer the potential to expand our digital interactions into casual social settings that are not appropriate for desktop platforms, such as home living rooms. We have developed a tangible media table called TViews, which provides an extensible architecture to enable multi-user interactions with a range of media applications and content via tagged tangible objects. The TViews object positioning utility functions on the surface of an embedded display and enables real-time tracking of a virtually unlimited set of uniquely identified wireless objects that can be used on the surface of any similar table. These objects can be physically customized in order to suit particular applications, and can provide additional functionality through external input and output elements on the objects themselves. In this paper, we present a first field trial of TViews to gain some initial insight into how such a device could be adopted in a real-world home.

1. Introduction

As digital media content and applications grow and spread, human-computer interaction researchers are designing and refining the interface technologies through which we can experience them. Research fields such as tangible interfaces and ubiquitous computing seek to better integrate the lives we lead in the digital realm with our physical environment and social human interactions. In particular, the past several years have shown an increasing interest in the area of tabletop computing, which explores how tabletops can be used as a shared display space for interaction with media content and applications via touch or tangible objects. By providing multiple points-of-control for multi-user interactions around a shared horizontal display, digital media tables (also called digital tabletop platforms) have the potential to enhance and transform the way we share, interact with and socialize around digital applications and content.

At our research lab, we have developed a digital media table with tangible interaction called TViews, which provides an extensible architecture to enable multi-user interactions with a broad range of media content and applications via tagged tangible objects. Two instances of the TViews platform have been constructed in the form of coffee tables for the home. In this paper, we describe our first small-sized field trial of the TViews Table in the home. Through this test, we hoped to discover how the platform would hold up under prolonged use and to see if and how media tables can be adopted in a real-world home.

2. Related work

This section provides a brief overview of some notable and relevant work in tabletop computing.

Some of the research has focused on the development of tabletop sensing technologies, such as the multi-touch sensing DiamondTouch [2] and the tangible object tracking Sensetable [11]. Other examples of digital tabletops include the Philips Entertaible [5] and Microsoft's recently announced surface computing platform [9], both of which can track multiple touches as well as tangible object interactions on an embedded display surface.

There has also been a variety of work on tabletop application designs. Examples include the Urp urban planning system [16], Personal Digital Historian for building digital group histories on the DiamondTouch [14], the SharePic photo application [1], and role-playing games on the STARS platform [6].

In addition to novel application concepts, a number of researchers have been exploring novel interface metaphors and the display and interaction issues

particular to tabletops. For instance, the DiamondSpin API provides a means of accommodating the different viewing angles that users have when seated around a table display [15], while "interface currents" support shared access to content pieces by flowing them around the edge of the horizontal display surface [4].

There have also been a number of research studies seeking to understand collaboration and group dynamics around digital tabletops in order to inform interface design. Examples include work on territoriality [13] and social protocols [10] in tabletop workspaces, as well as studies of the effects of group and table size on collaboration [12]. To date, most studies done on digital tabletops have been conducted in research labs, and there have been limited attempts to deploy interactive media tables into the real-world. Some exceptions include design case studies done with the Drift Table in real homes to discover how such environments support ludic activities [3] and tabletop storytelling workshops in a clubhouse and art school using the Tangible Viewpoints system [7].

3. The TViews Table

TViews is an interactive tabletop display platform that provides multi-user interaction through an extensible set of tagged tangible objects that can be tracked on its surface in real-time. The following subsections provide a brief overview of the TViews platform and describe some of the media applications that have been developed for the table. For more information on the TViews architecture, please see [8].

3.1. System Overview

The TViews Table is based on custom-built acoustic sensing technology that works through the surface of a glass panel placed above an LCD screen embedded in the surface of the table. The technology allows the table to scale to different sizes, and enables an extensible set of interactive objects called pucks to be tracked on its surface and moved from one table platform to another. TViews also provides a scalable framework so that many different applications can run on the same platform or on many connected platforms at once. The compact sensing and display design of the TViews table allows it to be set up in everyday living environments where there is little or no support for infrastructure that is external to the table itself.

TViews interactive objects can be associated to a particular application or used as generic controls for multiple applications. The functionality of the pucks can be extended via externally attached input/output devices, such as buttons, lights or small displays. The current generic puck design includes a top-mounted button and snap-in acrylic pieces that enable color-customization. In contrast to touch-based tabletop displays, interaction through tangible objects allows application designers to create customized physical objects for different applications, such as the building models in Urp [16]. Using the extensible I/O feature, TViews tags could eventually be embedded into existing devices, such as cameras or cell phones.

3.2. Applications

Over ten different applications have been developed for the TViews platform over the course of our development and testing. We describe here the four applications for media content management and tabletop gameplay that were used during our first field trial of the TViews table.

3.2.1. Picture Sorter. This picture management application allows users to organize their digital photos in a manner similar to sorting physical photos on a tabletop. New images appear in a pile at the center of the table, and the pucks are used to sort them into smaller clusters. The application currently provides only basic sorting functionality, however we plan to incorporate tagging and intelligent sorting features similar to those found in desktop photo applications.

3.2.2. Map Browser. The Map Browser uses GPS metadata to automatically organize images on a geographical map based on the time and location at which each picture was taken. A timeline view provides a temporal means for browsing larger collections on the map. Users attach the pucks to different days on the timeline and drag them around the map to reveal the images, which appear clustered around the puck.

3.2.3. Pente. Pente can be played with two or three players on a single table or in networked mode across two tables. Each player uses their own color-coded puck to drop yellow, red or blue stones onto the playing grid. The goal is to place five stones in a row or capture five pairs of an opponent's stones.

3.2.4. Springlets. Virtual spring objects (masses connected by springs) are controlled by the pucks, leaving colorful trails behind them as they bounce around the display area. Users latch onto the masses with a button press, and drag them around the table causing the attached masses to follow behind. A

second button press drops the masses, propelling them forward on their own. Once the spring objects are in motion, users can engage in improvisational play as they try to trap the masses to control the movement and display of colorful trails on the tabletop.

4. TViews in the Home

In this section, we describe our first field trial of the TViews Table in a real-world apartment. Our motivations for conducting a trial of the TViews Table in an actual real home setting were three-fold:

- To evaluate how the technology and system design would hold up when put under prolonged real-world use.
- To examine the use of the interactive objects for controlling media applications and to assess the ease-of-use of the TViews design across our two types of leisure-oriented applications: media sharing and gameplay.
- To see if and how interactive media tables adapt to existing social practices within a real-world home in the context of casual media sharing and gameplay.

The informal and situated nature of this preliminary trial allowed us to observe how one particular home environment assimilated the physicality and playful intent of the table. In this section, we provide and overview of the demographics and methods of the trial, and discuss observations and user feedback.

4.1. Demographics and Methods

We situated the TViews Table in the home of a volunteer user, a technology-related project manager in his early 30s, for a one month period. During this time, he hosted a series of six small social gatherings for his friends and family, during which guests were invited to interact with the table.

In addition to the host, sixteen other users came to try the table, in groups of one to four at time. Larger groups were difficult to accommodate given the small size of the apartment. Nine of the sixteen participants were young professionals in the 25-35 year age-range, whose professions ranged across consulting, software engineering, law, landscape architecture, industrial design, library services, publishing and marketing. Five of the participants were graduate students aged 25-35, in computer science, design and media studies fields. One participant was a filmmaker and academic, and one was an older family member who had worked in nursing (both were over 50). Nine of the participants considered themselves to be digitally savvy. Finally, four of the sixteen participants were family members, four were very close friends, seven were casual friends and one was a work colleague.

We tried to provide a casual atmosphere for the interaction sessions that fit into the ordinary lifestyle of our volunteer host and other users. Since many participants were young professionals with full-time jobs, the interaction sessions were typically held in the evening or on weekends, with two sessions each week for the duration of the month. Participants were invited to the apartment of the host as guests, for a social evening that could include gameplay and hearing about the host's recent travels. They were also made aware in advance that they would have the opportunity to engage in these activities using the host's newly (and temporarily) acquired digital media coffee table, and that a researcher would quietly observe and videotape the social event from the sidelines.

Each interaction session consisted of an informal dinner or snacks, following by casual chatting and social interaction in the living room. Participants sat on a couch and chairs around the TViews Table and were invited to try out the different applications. Over the course of the session, the host casually introduced participants to the range of applications and activities that were available on the table: viewing and organizing personal photos (using the Picture Sorter), browsing a collection of recent travel photos (using the Map Browser), playing a game of Pente, or playful interaction with the Springlets application. Each session lasted around three hours. The guests would try out the different applications on the table, often choosing to interact more or less with certain ones depending on their interests. Details about the actual usage of the table and different applications are provided in the following section. As the evening wound down, we engaged the users in informal brainstorming to gather their feedback about the table and potential applications.

We observed user interactions with the table, and used video and audio recording for data collection purposes during the interaction and brainstorming sessions and to keep track of the applications used by each group. Participants were also asked to complete a questionnaire before leaving. This was used to gather background information about each participant's level of media and technology use, and to get some specific comments and feedback about the interaction sessions. The following section presents our observations of the table and application usage and user feedback.

4.2. Usage Observations and Feedback

The informal and situated nature of the trial allowed us to observe how one particular home environment adopted the physicality and playful intent of the table. The natural setting and relatively long duration of each interaction session (~3 hours per session, a typical duration for an evening social gathering at the host's apartment) drew the focus of participants away from the novelty of the platform. Parallel to our goals described above, we present our observations from three perspectives: the table's technical performance, the interactions with different applications, and the assimilation of the table into the home environment.

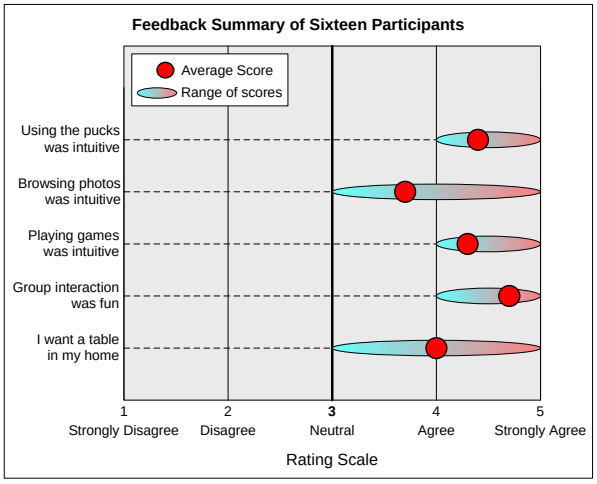

Figure 1. Results of user feedback questionnaires.

4.2.1. Technical Performance. In addition to sharing media and playing games, our TViews users put the table through the usual everyday coffee-table usage, such as placing a wide assortment of objects on its surface and eating food on the display while playing games. Additionally, we observed that the host would slightly rearrange the furniture in his living room at times, for example to make space for a larger group of guests. On two occasions, this took place during the interaction session itself, in order to accommodate more people sitting around the TViews table. In these cases, the table did not require any kind of recalibration of the sensing technology.

Overall the system performed well, and participants were able to use the table and pucks without difficulty. The only significant technical issues that came up were position errors resulting from poor contact of the acoustic sensor to the surface of the glass and a lag in positioning if a puck was moved too quickly. Unlike our past experiences with the table in lab-based tests, users at home (even the non-technically-oriented ones) were not particularly cautious with the interaction objects, often pressing them hard or repeatedly banging them on the display surface to force the tracking to correct itself. We are continuing to further develop the TViews sensing technology to address the current sensing issues.

Figure 2. Map Browser user interaction.

4.2.2. Application and Object Interactions. In general, people found the pucks intuitive to use and liked the idea of a shared tabletop interface for the home. Figure 1 shows the results of the feedback questionnaires. On average, people found the picture sorting and browsing activities (with the Picture Sorter and Map Browser applications) less intuitive than the games (Pente and Springlets). This was somewhat surprising: we had imagined that since the Picture Sorter application is based on a real-world metaphor, it would be very easy to understand. One reason for this result might be the position errors, which sometimes made it difficult to grab and hold the photos. Another reason might be that the pucks were acting only as generic controls (similar to a stylus). Since users tend to focus on the photos themselves rather than on the interaction objects or technology, direct touch on the tabletop might serve as a better means for dragging/manipulating images.

Users responded slightly better to the Map Browser than to the Picture Sorter. In the Map Browser (see Figure 2), users attached collections of photos (sorted by date) to different pucks. This metaphor of physical puck as containers for media content was well understood, and suggests that placing cameras or other personal media devices placed on the table would be a useful means for accessing collections of media content. The following two short dialogues show typical interactions with the Map Browser application. Jack is the host, and Fred and Amy are family

members (names of the participants have been changed). In both examples, Amy and Fred are each browsing a different collection of photos on different parts of the map, and repeatedly switch focus between the two collections.

Map Browser Example 1

Amy: [*Dragging an image collection to a location*] Two pictures from Jill's home town… or college…

Fred: [*Switching focus from his own puck*] Oh, the college... I took these!

Amy: That's the college? [*Moving to next picture in the collection*] Oh... and there she is in her big coat… it's cold there.

Jack: Cold, rainy and wet…

Amy: Rainy and wet in Ireland…

Map Browser Example 2

Fred: [*Looking over at Amy's puck*] Ah yes, driving on the sand bar, haha…

Amy: [*Focusing back to Fred's pictures for a moment and referring to a previously mentioned paint job*] I'm sure you're proud of your work.

Jack: [*Pointing at picture from the puck Amy is holding*] Do you see this one right here?

Amy: [*Looking back to her puck to see what Jack is showing*] Yes.

Jack: This was an island off the coast and we were driving by over here [*indicating location on map*] and we saw some cars driving over and we were wondering what was going on over there. And mom said "oh, they do auto commercials on the beach." [*Amy takes another puck and drags aside the image Jack is talking about for a closer look*] So we drove closer and it turned out that when the tide is out you can actually drive… you can't really see it in this picture because it's zoomed out… [*Pointing at picture again*] but there are road signs that go all the way through.

Amy: [*Leaning over to look*] Oh weird!

Jack: And it's basically what the locals do… they drive out onto the beach but you can only do it at certain times of day. [*Stepping through pictures on puck*] The other picture might actually show it better here… [*Stopping at picture*] That one, see… there's a road sign.

Amy: Oh yeah, neat!

From these short sequences, we see how people are able to fluidly switch focus between their own puck interactions and those of the others around them. It is important to notice that the user interactions are not turn-based, but simultaneous. The nature of their interactions transitions easily from the way they used to browse physical photographs on a table, and allows casual conversation and informal storytelling to emerge around digital media content. This example shows how a traditional activity like photo-browsing can transition easily onto a novel platform like a digital tabletop, and integrate the benefits of automatic (temporal and geographic) organization of the photos. It also demonstrates that such a platform can transition easily into existing spaces like the home living room by making use of and adapting to existing social practices and conventions within the shared environment.

After the first few interaction sessions, it became evident that different groups of users were interested in different applications based not only on personal preference, but also on their relationship to the host. For instance, of the six groups invited for interaction sessions, the three groups that included family members were far more interested in browsing photos than in playing games. Since the Map Browser application was used to navigate a collection of photos from the host's recent trip to Ireland, family members all wanted to hear him tell stories about his trip. Since the photos were from a single vacation, it was possible to browse the entire collection within 10-15 minutes. However these users typically spent 1-2 hours with the Map Browser application, and most of the time thus went to storytelling triggered by the photos and locations they were looking at. The Picture Sorter was the least frequently used application. User feedback suggested that this was because they weren't interested in sorting another person's (in this case the host's) photo collection. This suggests that a Picture Sorting application on tabletop should allow users to contribute their own collections, and might do best to focus on sharing and swapping rather than on organization.

The groups that included more casual friends or acquaintances on the other hand were least interested in the photos, and chose to play games instead. This included the Springlets application and the Pente game. Like the photo-related applications, Springlets encouraged simultaneous user interactions, while Pente followed a turn-based approach like traditional board games.

All six groups tried Springlets, which proved to be a nice background/ambient application that users could interact with off and on in a casual manner (e.g. while eating or having conversations). Three groups (one with two family members, and two groups of friends) got very engaged in the Springlets interaction for around 30 minutes. This was quite surprising since we

had initially thought that the application might be too simplistic for real use, but we found that many participants became very engaged with the improvisational form of interaction, calling it "addictive" and "mesmerizing". Participants often turned the interaction into a form of game play, where they would try to capture the bouncing masses with their pucks, sometimes even using two pucks at a time (one in each hand) or trying to coordinate their movements with those of other players. During the brainstorming sessions, participants said they wanted to see more games on the table that would engage them in collaborative or competitive play where they have to coordinate their movements with one another. Along those lines, a number of participants suggested that simulation games would be particularly appropriate, such as the line of popular games produced by Maxis (SimCity, The Sims, etc.).

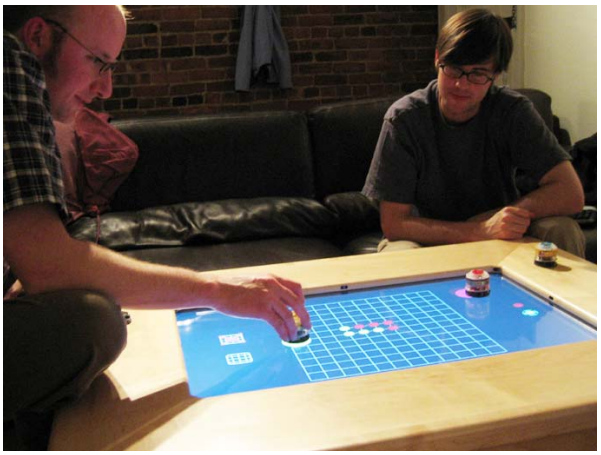

Figure 3. Users playing a game of Pente.

The Pente game (see Figure 3) proved to be very popular, particularly with participants who were already familiar with the board game. The puck interaction was very natural, and people did not focus on the technology at all during gameplay (aside from the times when a sensing error caused a mistake in a person's move). Three of the groups played the Pente game for 1-2 hours, becoming very competitive at times. The following short dialogue is an excerpt from a typical three player Pente session at the TViews table. Jack is the host, and Bob and Tom are close friends (names of the participants have been changed).

Pente Example

Bob: [*Pointing*] But you've gotta put it there…
Tom: [*Pointing*] Right, because he'll have… [*Indicates region of pieces on board*]
Bob: No, I guess it doesn't really matter.
Jack: [*Laughs*]
Tom: Ah, we'll put it here… [*Places piece*]
Jack: I love my friends.
Tom: [*To Bob as he prepares to place piece*] So you gotta knock that out, and then he'll have [*indicates area on board*]… and you'll get to put another piece somewhere. [*Bob places piece*]

This short sequence shows players being playfully competitive, and interacting in a similar manner to traditional board games. Even though Pente is a turn-based game, all participants said they preferred to each have their own puck rather than to share a single puck between multiple people. Since traditional board games typically provide separate pieces for each player, this is a well-known interaction style and it provides players with a physical object that they can identify with during game-play. We observed that several people actually held the puck in their hands even when they were not using it, rather than leaving it sitting on the table. This behavior brings up an interesting design issue, which is how to map the pucks to the virtual objects within the game space. Different board games use different approaches to map the playing pieces to the space of the game board. For instance in a game of chess or Monopoly, the pieces must remain on the board at all times and they move around mostly within the space of the board (unless they are captured for instance). In contrast, in a game such as Pente the stones are picked up from a central bin at each turn and deposited onto the game board, which suggests a mapping where pucks are used to drop stones rather than act as stones themselves.

4.2.3. Assimilation into the Home. The TViews Table was quite easily assimilated into the living room, and users found the shared media interactions to be a lot of fun. It was clearly important that, in addition to being a shared media platform, the table could also act as a regular coffee table with its display turned off. When asked whether they would like to have a media table in their home, user responses ranged from neutral to a very positive "yes". Some were hesitant to add another technological device to their lives and worried that it might demand too much of their time. Several people said they would like many surfaces around their home to be media-enabled, so they could turn them on/off as desired and use them in place of their regular desktop PCs for everyday tasks such as checking calendars or managing other media devices. A few people said they wanted a table like this simply to play games.

Another important observation in terms of adoption relates to shared vs. single person use. Given that our applications were designed for multi-user interaction,

the host rarely played with them by himself. Instead, he would use the table, together with an ordinary wireless mouse and keyboard, to check the weather or read the news in a web browser over his morning coffee, or to search for information, such as directions to a store. Since the computer inside the table was always running (the table would go into standby mode after 20 minutes of non-use), this was quicker and easier than starting up his laptop as he would otherwise have done (he did not have a desktop PC).

During the brainstorming sessions, participants suggested a broad range of applications for media interaction tables. These were by no means limited to interaction within the home environment, but included applications for other physical contexts, such as workplaces, classrooms and public places. Suggested applications for the home environment fit into two broad categories: personal home management and leisure or entertainment activities. Personal home management includes information retrieval (calendars, recipes, directions, etc.), management of home devices (appliances, lighting, media center, etc.), management of portable devices (cell phones, MP3 players, etc.) and messaging and remote communication. Suggested leisure activities included gaming (board games, networked games, educational games, simulations, role-playing, etc.), storytelling, virtual terrariums, audio control (mixing, playlists), and media browsing and editing. While more investigation needs to be done to assess who will use media tables in the home, how often, and for what purposes, we feel that in addition to leisure activities, the practical (and often single-user) uses will be important for adoption.

5. Summary of Findings

In this section, we provide a brief summary of our findings based on the observations and feedback discussed above. These include lessons learned about the practicality and logistics of conducting digital tabletop trials in real homes (5.1 & 5.2), and lessons learned about the design and development of digital media tables and applications for the home (5.3 & 5.4).

5.1. Novelty Factor

There is a high level of novelty associated with digital tabletops in the home, and users are likely to be impressed by this. Interaction sessions thus need to be long enough for users to get engaged in the applications and media content, and not simply be impressed by the table alone. Relevant and personal media content is important in this respect, since it focuses user attention on their own interests and lives, and engages them in natural interactions in which the novel technology can become transparent to them.

5.2. Natural Setting

To keep the interaction sessions natural (as close as possible to the home's normal social gatherings), subjects can be drawn only from people who normally socialize with and visit the host. However different people have personal preferences for different forms of entertainment. These can be influenced by many complex factors, both permanent (e.g. some don't like board games) or temporary (e.g. are they in the mood to play a game, have they already seen those photos). Trials with a much larger subject base and in many different homes should be done to get a clearer sense of which applications have the broadest appeal.

5.3. Form and Robustness

An appliance and furniture item such as a digitally enhanced coffee table most likely replaces the existing non-digital equivalent in the home. As such, in addition to providing new functionality, it needs to support the ordinary uses of the table. The form of the table thus needs to be of an appropriate size to fit in the space, and of the correct height to be usable with the couch and chairs. Moreover, the table and technology need to be robust enough to support ordinary use. People at home are less careful with new technology than in a laboratory setting; they drop food and spill their drinks on their coffee tables all the time.

5.4. Applications and Use

The potential applications for digital media tables in the home are broad, and further exploration is needed to understand the full scope. For example, our findings suggest that single-user practical applications could be as critical as multi-user leisure-oriented applications. While some users (particularly the non-technically-oriented ones) were hesitant to add more technology into their lives, there is potential that in certain cases a digital tabletop could replace regular PCs for specific tasks, e.g. searching for information like travel directions. Also important is the ability for the table to communicate with other devices, such as cell phones and PDAs, particularly for technically-oriented users who already have many devices and for whom compatibility is a major issue. Lastly, as mentioned above, users have different preferences for leisure activities at home. Depending on the application,

different means of interaction are more or less suitable (e.g. tangible objects or touch), and one must think carefully about their design in each case.

6. Conclusion

As digital applications such as media sharing and gaming increasingly permeate our everyday lives, we need think about how these activities can be integrated into our everyday physical and social settings in a way that minimizes the gap between our physical and digital world interactions. Digital tabletop platforms provide a solution to the physical/digital separation within certain contexts, such as shared spaces in the home. However the physical settings and possible uses for tabletop platforms are very different from desktop PCs, and there is much work to be done to move this emerging field forward.

Tabletop research ranges from sensing and hardware development, to the study of collaborative interactions with co-located users, and to the design and development of tabletop interfaces and applications. Important questions are whether and how real-world settings can assimilate these new platforms in practice: how does ordinary table usage successfully extend into the digital realm, and what are the applications and methods that can enrich user experiences and social interactions around digital tabletops. Our first field trial of the TViews media table has provided some initial insight into how such a device might be adopted in a real-world home. Based on our findings, we plan to further develop the TViews platform and applications in order to provide engaging experiences for users.

7. Acknowledgements

We would like to thank our collaborators at Samsung and the Media Fabrics group at the MIT Media Laboratory.

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