Multi-Cursor Multi-User Mobile Interaction with a Large Shared Display

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ABSTRACT
When using a mobile device to control a cursor on a large shared display, the interaction must be carefully planned to match the environment and purpose of the systems use. We describe a 'democratic jukebox' system that revealed five recommendations that should be considered when designing this type of interaction relating to providing feedback to the user; how to represent users in a multi-cursor based system; where people tend to look and their expectation of how to move their cursor; the orientation of screens and the social context; and, the use of simulated users to give the real users a sense that they are engaging with a greater audience.

Author Keywords
jukebox, large shared display, interaction design

ACM Classification Keywords
H5.m. Information interfaces and presentation

INTRODUCTION
Large displays are becoming more common in a variety of public and shared environments, serving a wide variety of purposes, from entertainment to collaborative work (Wilson et al. 2006). At the same time, mobile devices have become increasingly pervasive, presenting an opportunity for people to interact with shared displays without any additional equipment. The following scenario demonstrates an instance where casual interaction will be key to allowing the multiple users to interact without interfering with their other activities.

Imagine yourself going out drinking with friends. As you arrive at the bar you hear a song playing in the background - a song about to end. You glance over towards the jukebox and see a collection of songs, picking up your phone you quickly vote for your favourite; looking around you see your friends and everyone else doing the same. As the new song transitions in, you return to your conversation.

This research goes beyond the idea of the democratic jukebox (a system that provides a means for nearby people to 'vote' on what song will be played), using 'Jukola' by O'Hara et al (2004) as a basis, by providing each person a vote, rather than per small group.

This research focuses on using a mobile devices to

directly control one of many cursors on a large shared display and two factors relating to the interaction, discussed in the past by Tuulos et al. (2007) and Muller et al. (2007): the impact of user scalability for multi-user systems; and the rate at which new information is presented to the users of these systems.

RELATED WORK
When investigating the potential for public notice displays to be technological enhanced, Alt et al (2011), after an analysis of current uses of public note displays concluded that any interaction with shared displays needs to keep the barrier to interfacing as low as possible. Jeon et al (2009) created a system allowing users to interact with a large display either via mobile phone, or a fixed touch screen. The system then allowed its users to move and rotate various objects on the display in either 2D or 3D visualised space. This interaction however was designed solely for individual use, with the intention that the large screen could be used to enhance the existing mobile functionality (E.g. by providing a zoom feature).

ShadowPuppets by Cowan and Li (2011) had similar goals as the above system however ShadowPuppets used shadow gestures cast by peoples' hands and pico projectors to control and work with large displays. ShadowPuppets allowed multiple people to interact with the large display at once, resulting in unexpected social interaction including sabotaging others shadows so they could not complete their action.

Kaviani et al (2009) coined the term Dual Display to describe their system of interacting with a large display via a mobile device, where both the mobile device and the large display show relevant information. Despite this dual display information sharing, the example systems developed did not allow for simultaneous interaction by numerous people at once outside of somewhat asynchronous interactions such as SMS.

PebblesDraw by Myers et al. (1998) specifically investigated how people can interact in a multi-cursor environment. Whilst evaluating a drawing program, Myers et al. (1998) found that users need to be able to identify their cursor easily for the system to work.

METHODS
Our approach was to develop a software prototype to test multiple human participants – each with a mobile device – simultaneously interacting with a large shared screen, where the task is to vote on which song they would like to hear next (i.e. a jukebox). The prototype therefore involved two components: the large shared display application, and the mobile application.
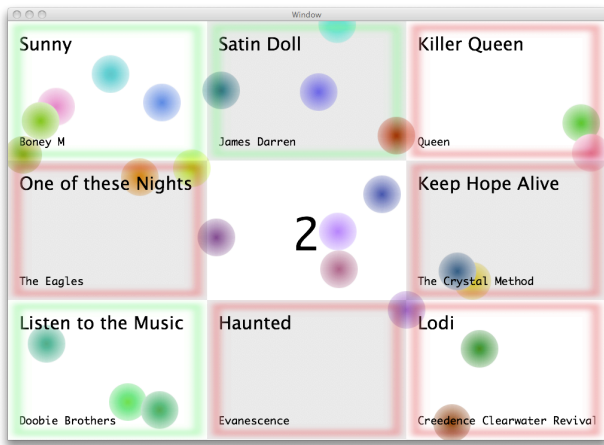
Figure 1 Large shared display application voting screen

This study utilised questionnaires and observation to gather feedback from users regarding their usage of the system (Kjeldskov & Graham 2003, Jones & Marsden 2006). The evaluation was conducted within a conference room with 17 participants (one group of five and two groups of six), a mix of students and visitors at the University of Tasmania, and asked a series of questions regarding: preference with regard to the two varying factors (number of participants, and rate of change of information); and how they used the mobile device with regard to the large display (and why).

Large Shared Display Application
The participants primarily interacted with the voting interface shown in Figure 1. In order to avoid clutter, only minimal information was displayed in the song choice squares, namely 'song name' and 'artist'. This design was loosely based off existing jukebox systems, which tend to use a grid layout for selection. During the experiments the display was projected onto a wall, producing a screen approximately two metres tall, with a resolution of 1024 by 768 pixels in landscape orientation. Participants were seated approximately three to ten metres away from the screen.

Participants voted by moving their cursor to the grid containing the song they wished to hear the jukebox play. Once the countdown in the central square of the grid reached zero a second screen was shown to the participants. The second screen displayed the top two songs up based on the vote count, and the winning song began to play.

Mobile Application
The mobile application consisted of a single screen that was displayed to the user at all times when the application was running as shown in Figure 2. A dot on the mobile device was also displayed on screen, using the same base colour as the cursor on the mobile device. Input was supported in both the landscape (wider) and portrait (taller) orientations. This allowed user's preference of screen orientation to be assessed and compared with the large shared display.

The mobile application, by virtue of running on a mobile phone and using the touch screen, can be comfortably used with one or two hands. This contrasts with previous generation technology such as that discussed by Myers et al. (1998), which used a stylus rather than a finger and was only suited towards two hands.

Interaction Model
Given the prototype was required to support multiple cursors, it is important to consider the design decisions that reflect both how the aesthetics of the cursor were selected, as well as the input mechanism used to move the cursor. The use of a cursor in this evaluation has been simplified such that only movement is important. This presents a very simple interaction model and was derived from the conceptual model of 'Manipulating and Navigation', by Preece et al. (2001).

The cursor was moved to the absolute position of the touch on the screen as opposed to relative positioning, such as how a mouse or trackpad functions. This was intentional such that the participants would have a direct mapping between where their cursor would be located on the large screen display simply by looking at their cursor on the mobile device. The mobile application, demonstrating the absolute cursor positioning in both landscape and portrait orientation is shown in Figure 2.

Trials
The two factors that varied between trials were: the number of perceived participants and the rate at which information (in this case the songs available for voting) changed. The purpose of this variation was to test the scalability of users and how it impacted participant engagement with the application, and compare the impact of an increase in difficulty.

The frequency at which information was updated ranged between the following values: three seconds (fast), six seconds (medium) and twelve seconds (slow). There were eight song choices available at any given point, and at the update frequency throughout each trial the song selection would change. The three songs currently with the most votes would remain, and the other five were replaced.

In the case of the perceived participant variation, the trial configuration were as follows: No additional participants, where the human participants would have complete control over the song choice; Similar numbers of real and simulated participants, adding a level of unpredictability
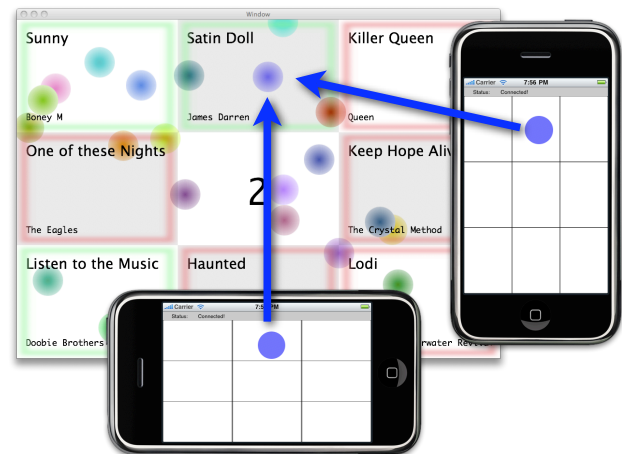

Figure 2 Absolute positioning of the users cursor on both mobile (landscape, portrait) and large shared display

and the ability for real participants to change the vote by following the simulated; and Simulated participants outnumber the human participants, meaning that the real participants would have no choice but to work together if they wanted a chance of their song choice (approximately 4:1 ratio).

These two factors having three states resulted in a total of nine trial configurations. Each trial configuration took approximately a minute to complete, and each trial configuration was repeated up to three times. All three groups of participants participated in the same nine trial configurations, however the order of the trial configurations was different between the groups. The expectation was that this might serve to reduce any effect of learning upon the results, as performed in other evaluations (e.g. Olsen & Nielsen, 2001).

DISCUSSION

The surveys and observation of participants yielded five interesting outcomes with regard to the design of a multi-cursor system, both with regard to the interaction and the presentation of information. For a detailed analysis of the data see Lyle (2009).

Indicators of Changing Information

Observed in both the feedback received from participants in the questionnaire as well as through comments during the experiment, it was not clear when the information on the shared display was about to change, what information was about to change, and when the information itself had finished its transition. This was due to the shared display implementation instantly updating its information at the designated time interval. For future systems, particularly in busy environments such as a pub, feedback would be vital to ensuring its users are able to use the system.

Cursor Individualisation

Participants indicated that when there were many cursors on the screen it became difficult to differentiate their own cursor based on colour alone. With regard to design implications the use of shapes or symbols would be useful variations when the number of participants increases. A setting where the identity of the 'owner' of each cursor can be known to all (such as a collaborative work environment), would create transparency in decision making. As such, it would be interesting to investigate the effect of cursor personalisation options, such as including the participant's initials as part of the cursor.

This limitation with colour as a differentiating factor was also identified by the collaborative drawing program 'PebblesDraw,' because of this, combined with the application allowing participants to draw in numerous colours, the researchers chose to use symbols instead of colours to identify cursors (Myers et al. 1998). While the use of shapes was a suggestion by a number of participants in the feedback questions, it was also raised by another participant, who was short-sighted, that the colours was beneficial to them as they had trouble differentiating anything else at any significant distance.

Input and Focus

While the absolute mapping of input was an intentional design decision, a number of participants indicated they expected the input to act in a relative fashion, similar to a laptop trackpad.

Minimal information was displayed on the mobile device. The intention of this was to ensure the mobile device was not simply duplicating the large shared display, and further ensure the participants shared the same experience on the large shared display. The feedback from all participants over all trials indicated a bias toward solely using the large shared display both to locate and move their cursor. There was also no difference between where participants indicated they would look when either moving or locating their cursor between individual trial configurations.

As the participant's focus was mostly on the large shared display, it is perhaps not surprising that users tended to only look at the large display for interaction. Relative movement would be an interesting design alternative.

Mobile Device Screen Orientation

While most participants indicated their preference was for the landscape mode, the cited reason for this was because it provided a closer match to the aspect ratio of the large shared display application (which was also wider than it was taller). The smaller group of participants who preferred the portrait mode indicated it was because it allowed the device to be used in one hand.

This presents an interesting consideration with regard to the aspect ratio of both the input device (the touch-screen of the mobile device) and that of the large shared display. If designing a system for casual interaction in a situation where a user may only be capable of participating by using a single hand (E.g. at a pub, with an expectation that a drink would be in their other hand), then the screen of the mobile device would benefit from a portrait orientation. This would suggest the design of the large shared display application should be in a similar orientation.

Simulated Participants

Due to the random behavioural nature of the simulated participants and lack of co-ordination or team work, the likelihood of a single participant being able to have their preferred song chosen as the winner was remote. This forced the participants to 'gang up' against the simulated participants in order to have a significant influence over the chosen song, resulting in active discussion amongst participants calling out suggestions to try and sway the vote. This cooperative nature and the creation of groups is what we would expect to see if more real participants were used in place of the simulated.

CONCLUSION

The research presented investigated a potential means of interaction with a large shared display via multiple mobile devices, in the context of a democratic jukebox scenario. The evaluation of participant trials highlighted the five findings that will be considered for future design of cursor-based interaction between mobile devices and shared displays. First, the social context of the scenario will dictate how a user is expected to hold their mobile device to participate. Second, the individualisation of the cursor to represent a user on the shared display should

either have elements of customization, or take advantage of different shapes and colours to reduce issues of similar-colours and short-sightedness. Third, prior participant experience with a relative means of moving a cursor using laptops created an expectation as to how they provide input to the system. Fourth, if the context dictates single-handed use, the typical portrait orientation of mobile devices should be replicated on the large display if the content on both devices is expected to be similar. Finally, by providing a 'common enemy' to the users choice there appeared to be more cooperative behaviour and strategy as the group must work together to influence the outcome of their interaction, which may be less important as the user base naturally increases.

FUTURE WORK

As the study was conducted with three small groups the findings could be reinforced and expanded with further trials, both in the number of people involved, and in the recruitment of individuals that are less tech savvy.

It would be worthwhile to perform further evaluation whereby the large shared display application was presented in different aspect ratios (e.g. portrait, square) and see how participants' use of the mobile device changed, both in casual and serious environments.

A novel approach suggested by participants regarding user input and feedback was the use of the vibration motor to signal that a change was about to occur (E.g. Sahami et al, 2008). This could be used in conjunction with update messages appearing on the mobile device to provide a useful way to provide feedback that can target specific users, in a manner similar to notifications on modern mobile devices.

The simulated participants represent a limitation to the study because of their simplistic behaviour and complex behaviour may result in a more engaging experience. In a setting with a larger number of users the resulting scenario may produce smaller groups working together.

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