Enhancing Multi-Touch Table Accessibility for Wheelchair Users

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ABSTRACT
Wheelchair users can find accessing digital content on large multi-touch tables particularly difficult and frustrating due to their limited reach. We present work in progress that is exploring the potential of enhancing touch table accessibility through the use of mid-air gesturing technology. An overview of an experimental prototype is provided along with the key findings from an evaluation conducted with fifteen wheelchair users at a public library and heritage centre.

Categories and Subject Descriptors
H.1.2 [**User/Machine Systems**]: Human factors. H.5.2 [**Information Interfaces and Presentation**]: User Interfaces - Ergonomics, Evaluation/Methodology, Input devices and strategies, Prototyping, User-centred design

General Terms
Design, Human Factors

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1. INTRODUCTION
Multi-touch tables are increasingly being used in public spaces such as museums, libraries, and art galleries to provide engaging interactive experiences [1]. However, whilst touch tables are generally intuitive and easy to access for the majority of the general public, they can be particularly frustrating to use for those who have physical impairments. In particular, people in wheelchairs can have significant accessibility issues when attempting to interact with content on touch tables due to their limited reach.

One potential solution is the use of mid-air gestures to access and manipulate content that is out of reach. The recent release of affordable sensors such as the Leap Motion [2] have made it more feasible to build interactive systems that can be controlled by body movements. Mid-air gesturing can provide several benefits in terms of enhancing touch table accessibility - for instance, the Leap Motion sensor can easily be incorporated into the border around a touch table allowing people to simply approach the table and start interacting with content (without the need of an external device). The design of a touch table application would also not need to be significantly altered to accommodate physically disabled users as a mid-air interface could enable them to easily access all features.

Related work has started to examine how users can perform mid-air gestures to interact with digital content [3]. There has also been research that has investigated the use of mid-air gesturing above a multi-touch table [4-5]. However, despite this work, there have been no research studies to date that have explored the potential for mid-air gesturing to enhance touch table accessibility for people with physical impairments. This paper therefore presents the first body of work in this area - we initially provide an overview of an experimental prototype that has been developed and then highlight the key results from an initial user evaluation with fifteen wheelchair users. We conclude with an overview of the next steps we plan to take in this project.

2. PROTOTYPE
We have developed a prototype that enables people to interact with touch table content using mid-air gestures performed over a Leap Motion sensor. In this application people can select and drag images around the table via both multi-touch and mid-air gestures. We created two different mid-air selection techniques - Thumb Trigger and Screen Tap (Figure 1). The Thumb Trigger gesture allows a user to control a cursor on the screen using a single index finger. Once the cursor is positioned over an image the user can pick it up by extending their thumb. The image can then be dragged around and dropped in a desired location by placing the thumb back in. The Screen Tap version also allows people to control the cursor with a single finger, but requires a rapid downward tap gesture to pick an object up. The user can then drag the image around and perform another downward tap to drop the image.

3. EXPERIMENT
We ran an initial user evaluation to explore the potential of the prototype to enhance accessibility for people in wheelchairs and to investigate performance and perceptions around the different selection techniques (Figure 2). This evaluation was conducted on a 55" multi-touch table installed at a public library and heritage centre. We recruited fifteen participants (three female) who are all wheelchair users. The sample had a mean age of 33.4 years

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ranging from 16-72. There were three conditions - Touch Only, Thumb Trigger, and Screen Tap. The experimental task involved participants having to move eight images into designated boxes along one border of the table. The first condition always involved them completing the task using touch gestures only. The researcher initially gave a demonstration of the appropriate gestures and the participants then had five minutes to complete the task. This process was then repeated for the other two mid-air conditions. When a participant had completed all three versions a semi-structured interview was conducted to explore further their perceptions of the technology. We videoed all interactions and interviews for later analysis.

Figure 1. The mid-air gestures (from left-right: single finger cursor control, screen tap, thumb trigger)

Figure 2. A participant in a manual wheelchair interacting with the table via the Leap Motion sensor

4. RESULTS

Analysis of the video footage demonstrated that users were able to manipulate content via mid-air gestures that would have normally been out of their reach (this was measured through the number of images placed in appropriate boxes and task completion times). However, there were also several interaction issues that will need to be addressed in our ongoing work:

Cursor Control: Only small finger movements were required above the Leap Motion sensor to control the cursor, but people naturally tended to make larger movements at first which moved the cursor off the screen. People also tended to move their hand out of the range of the sensor which could result in jittery cursor movements (although this became less of an issue with practice).

Thumb Trigger: Several participants had issues in manipulating the images using this gesture. This was often due to the position of the thumb which could occasionally occlude the index finger making it difficult for the sensor to see the gesture. This occlusion could sometimes result in participants unintentionally dropping images or not being able to efficiently pick up the images as expected.

Screen Tap: Participants typically had to make numerous attempts to perform this gesture before they could pick an image up (sometimes on up to twenty occasions). This was usually due to not performing the downward tap gesture quickly enough.

Spreading of Fingers: Some participants had a tendency to spread their fingers over the sensor when only a single finger was required. The application was programmed to track the nearest finger to the sensor, so when fingers were spread this could result in a jittery cursor or issues with selection gestures.

Not intuitive for first time users: During interviews several participants commented that the device would not be intuitive to use without some instruction as they would be unsure about which gestures they could perform. This raises important questions around how to subtly inform people how to use the sensor without impacting significantly on the overall design of the application.

Tiredness: A couple of participants commented on how their arm started to feel tired during the study. They had difficulty holding their arm in an "artificial" position. One participant wanted more flexibility in where the sensor could be placed (e.g. the arm of their chair might have been more comfortable).

Practice: Participants highlighted a desire to spend more time playing with the device to get used to performing the gestures. It took the majority of participants between 1-5 minutes to try and complete both the Screen Tap and Thumb Trigger tasks. However, one of the authors who has had more time to practice with the application was able to consistently complete both the Screen Tap and Thumb Trigger tasks in around 12 seconds.

5. CONCLUSION

The work completed to date has highlighted both the potential of mid-air gesturing for enhancing accessibility and some of the interaction issues that need to be resolved. We are now looking to refine the prototype in terms of adjusting cursor sensitivity, making the selection gestures easier to perform, and exploring how to subtly inform people about the gestures available with minimal instruction. We also plan to examine and compare other approaches such as simply being able to point at an object of interest to select it and then manipulate that object through a range of different mid-air gestures.

6. REFERENCES

[1] Geller, T. 2006. Interactive tabletop exhibits in museums and galleries. *Computer Graphics and Applications*. IEEE, 26, 5, 6-11.

[2] The Leap Motion Controller. https://www.leapmotion.com/

[3] Song, P. et al. 2012. A handle bar metaphor for virtual object manipulation with mid-air interaction. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, 1297-1306

[4] Pyryeskin, D., Hancock, M., and Hoey, J. 2012. Comparing elicited gestures to designer-created gestures for selection above a multitouch surface. In *Proceedings of the 2012 ACM international conference on Interactive tabletops and surfaces*. ACM, 1-10.

[5] Banerjee, A. et al. 2011. Pointable: an in-air pointing technique to manipulate out-of-reach targets on tabletops. In *Proceedings of the ACM International Conference on Interactive Tabletops and Surfaces*. ACM, 11-20