150004768 HCI-P2-Q1 Aaron Quigley 20/11/2017

Question 1

Complete a one-way ANOVA on the following error rate data which has been generated from three different "between-subjects experiments" on two keyboards A and B, two mouse devices C and D and three multi-touch systems E, F and G.

Results	Table 1	Table 2	Table 3
SSerror	80	72	596
SStotal	142.5	112	11510.5556
SSeffect	62.5	40	10914.5556
n Participants	10	10	21
m Groups	2	2	3
dferror	8	8	18
dfeffect	1	1	2
MSerror	10	9	33.1111
MSeffect	62.5	40	5457.27778
α Confidence Level	0.05	0.05	0.05
F-ratio	6.25	4.44	164.817
Critical value	5.3176	5.3176	3.5546
Significant?	TRUE	FALSE	TRUE
Reporting [α = 0.05]	Keyboard A resulted in fewer average errors than Keyboard B. There is a	Since the statistical significance is false, the null hypothesis cannot	There is a statistically significant difference between the means of error rates of the

	statistically significant difference between the means of error rates taken between A and B.	be rejected (i.e., it was due to chance). It cannot be said that the Mouse C results in statistically fewer errors than Mouse D, or vice versa.	Touch systems E, F and G. This suggests that one or more of E, F or G is statistically significant. To find out which combinations are actually statistically different, a Post-Hoc test should be conducted. [Extension]
α Confidence Level 2	0.01	0.01	0.01
Critical value 2	11.25862414	11.25862414	6.012904835
Significant?	FALSE	FALSE	TRUE
Reporting [α = 0.01]	Keyboard A does not show statistically highly significance in error rate compared to Keyboard B.	Since the statistical significance is false, the null hypothesis cannot be rejected (i.e., it was due to chance). It cannot be said that the Mouse C results in statistically fewer errors than Mouse D, or vice versa	There is a statistically significant difference between the means of error rates of the Touch systems E, F and G. This suggests that one or more of E, F or G is statistically significant. To find out which combinations are actually statistically different, a Post-Hoc test should be conducted. [Extension]
α Confidence Level 3	0.001	0.001	0.001

Critical value 2	25.41476047	25.41476047	10.38991221
Significant?	FALSE	FALSE	TRUE
Reporting [α = 0.001]	Keyboard A does not show statistically highly significance in error rate compared to Keyboard B.	Since the statistical significance is false, the null hypothesis cannot be rejected (i.e., it was due to chance). It cannot be said that the Mouse C results in statistically fewer errors than Mouse D, or vice versa.	There is a statistically significant difference between the means of error rates of the Touch systems E, F and G. This suggests that one or more of E, F or G is statistically significant. To find out which combinations are actually statistically different, a Post-Hoc test should be conducted. [Extension]

As an extension, I did the post hoc test (Turkey HSD) for Table 3.

Multi-touch Systems	Tukey HSD Q statistic	Tukey HSD p-value	Tukey HSD Inference
E vs F	1.8392	0.4144488	insignificant
E vs G	6.8969	0.0010053	** p<0.01
F vs G	5.0577	0.0058005	** p<0.01

We can see that the tests for E and F are insignificant: that is, it may have happened by chance. We can say that E has statistically less errors than G and F also has statistically less errors than G.

Question 2

Gunslinger: Subtle Arms-down Mid-air Interaction

I chose the video Gunslinger: Subtle Arms-down Mid-air Interaction [UIST 2015]

My answers to the questions are based on the video provided and the paper related to it [1]
(http://delivery.acm.org/10.1145/2810000/2807489/p63-liu.pdf?ip=138.251.255.115&id=2807489&acc=ACTIVE%20SERVICE&key=C2D842D97AC95F7A%2E9A2EB7BEEEBA61C5%2E4D4702B0C3E38B35%2E4D4702B0C3E38B35&CFID=820288923&CFTOKEN=24977260&__acm__=1510832572_a89b3ad09fb2aca52d616c8cbccf9d10)

1. **To answer this question, first, describe four issues to consider when creating each of these new interaction techniques. You should describe each issue in no more than 2 sentences.**

I evaluated this interaction technique using "A SLICE" as described in the lecture notes.

Discredits:

- **Setup**

The user would have to set up the apparatus using leap motion sensors strapped to each thigh, with long wires attaching to a large display touch input device. Setting up the device would hence take the user some time and effort, as compared to say, smart watches and head mounted displays for augmented reality.

- **Intrusiveness**

The user would have to strap the aforementioned leap motion sensors (3D camera with hand tracking software) to each thigh in a position such that his hand would be parallel to it while his/her arms are down. This attachment of apparatus (with wires) at an inconvenient area (depends on clothing, material, etc.) makes it infeasible and difficult to use.

- **Learning Curve**

Any modern-day user is used to the straight-forwardness of the touch screen. For a user to learn the finger movements that manipulate the software has a learning curve- it may take quite long for a user to remember the various commands and he/she might eventually use touch instead of going the extra mile.

- **Context of Use**

This is used for large screen displays with wires attached to the LMs and can hence only be used indoors. A great application would be to use it in large halls where the touch screen is far away (such as lecture halls), but this is inconvenient as the length of the wires might have to be very long. The proposed solution of using Gunslinger-specific hardware can be quite costly.

2. **Experiment you might design to evaluate this interaction technique. Ensure you describe the setup, independent and dependent variables, your participants, apparatus, material, procedure. Note any possible skill transfer effects, asymmetrical skill transfer, balancing and counterbalancing. An excellent or exceptional answer will describe an experiment different than any described in a paper related to the video.**

In order to test the *usability* of Gunslinger based on time taken by a user, I would set an experiment for the user to navigate a map by finding 3 places of his choice, planning a travel route, and saving it.
To compare this usability of Gunslinger with a touch interface, and the usability of the two combined, I would use three input conditions: Gunslinger-only, Touch-only, and Mixed.

Apparatus and material: Gunslinger device and large display input for touch. The gunslinger apparatus is strapped onto the thigh parallel to the non-dominant hand of the user, and cables connecting it to the touch display.

Participants: 16 participants chosen, 8 women and 8 men. 4 were left handed (2 men and 2 women), 4 were over the age of 40, 4 had experience with mid-air game controllers.
This randomization is necessary as the strength of physical action may vary for the mid-air interaction technique to work (for example, would only strong motions be detected by the apparatus or would it detect a weak non-intended one?)

In this case the **dependent variables** are:
- **Time taken to complete the task**
- **Errors made**
- **User experience** measures (Acer Scenario Questionnaire)

[https://studres.cs.st-andrews.ac.uk/CS3106/Lectures/Week_3/CS3106%20Slide%203%20-%202017.pdf]

- **Overall preference** (ranking)

The **independent variables** here are:

- The Google **Maps** Interface
- **Gunslinger** as strapped to thigh parallel to the non-dominant hand

This experiment is conducted under 3 input conditions:
E1 - pure touch
E2 – pure gunslinger
E3 – touch and gunslinger

The Gunslinger Paper Method:

Upon reading the paper on Gunslinger, I observed that there was no mention of the setup used (between subjects, within subjects (repeated measures), or mixed). It seems that all participants were asked to perform the task (similar to the one I chose – creating at itinerary and saving it), in the same sequence (E1, E2, E3) with no randomization/counter balancing/skill transfer effects noted.
"….Sequence of three Controlled Tasks: T1 required locating and pinning two cities, each city must roughly fill the whole screen when pinning; T2 required undoing, then redoing the last pin-drop; and T3 required changing to satellite view, generating an itinerary using the contextual menu, then saving the itinerary with the global menu.
Each task sequence was completed under three input conditions: Gunslinger-only, Touch-only, and Mixed in which the dominant hand uses touch and the non-dominant hand uses Gunslinger."

Hence, it came across as a *between subjects* design.

My method:
The way I would do it is very different to the one described in the paper – using a *mixed subject*s design.

In this experiment, there is a high possibility of skill transfer between E1 and E3, E2 and E3:
If E3 is performed before E1, a person may be much better at pure touch/might find it more familiar to use and would then give it a higher ranking.
If E3 is performed before E2, a person may have learnt the technique better and hence may take lesser time performing E2.

If E1/E2 are performed before E3, the time taken to perform E3, preference or ranking of E3 may change based on familiarity and learning.

Hence, I would choose the mixed design approach to tackle this experiment.

There is no possible skill transfer effect between E1 and E2. In this case, a within subjects design would be useful. Each participant could perform E1 and E2.

However, there is a chance of asymmetrical skill transfer for E3.
Performing E1 before E3 will give the user an advantage over the touch interface part of E3, increasing the usability preference of touch.
Similarly, performing E2 before E3 will enable the user to be more familiar with the gunslinger approach of E3, reducing the time taken.
Performing E3 before either E1 or E2 may affect the usability (for example, on using E3 the user might find touch to be easier and more familiar and hence might hardly use Gunslinger, hence not performing well on E2).

To limit this asymmetric skill transfer, I opt to use a between subjects deign between E1, E2 and E3.

Hence, the ultimate experiment setup would be a *mixed subjects design*.

The participants would be divided randomly into 2 groups- 8 of them would start with E3 and then move on to E1 and E2.
The other 8 would start off with E1 and E2 and then move on the E3.
This would aim at eliminating the skill transfer effect.

(Another approach would be using the Latin Square method to counterbalance the conditions, but I would choose the splitting method to increase variance. This is because E1 and E2 don't have much of a risk of skill transfer, and using the same participants for the task is useful to control variance is controlled within the participant, and reduce the number of participants required.)

- **Third, describe two possible threats to the experimental validity of what you propose in no more than 2 sentences each.**

Internal Validity:

- Experimenter bias:

Most people are familiar with touch, and hence while ranking usability would prefer touch to Gunslinger, which has a learning curve to it.

External validity:

- Can I apply this experiment to the outside world?

Posture plays a very big role in the use of this device. As it can be seen from the paper, an incorrect posture can trigger a false positive/not trigger anything at all. This is a serious situation when it comes to *universal usability*- not everyone can have posture perfect with respect to the device, and the usability of Gunslinger in this scenario can be a threat to its external validity.

Extension Elements

- *Extension, I also commented on the credits of the Gunslinger interaction technique.*

Credits:

- **Social Acceptability**

Social acceptance is a consequence of arms-down subtle interaction. To make bare hand gestures smaller, more comfortable, and more socially acceptable, they should be made more subtle, meaning "fine or delicate in meaning or intent." [1]. Mid-air interactions can be tiring [1] and the Gunslinger technique aims to reduce physical input space and social awkwardness using finger movements.

- **Error handling**

The Gunslinger Interaction technique prototype aims to elicit "normal" conversational gestures in order to investigate whether these create false positive gestures. There are finger movements to undo the previous action on the interface tested on.

- *Extension- Threats to external validity as inspired from different research papers.*

Pressure

Upon reading papers on "strapped" devices, I read one on Watch Movement Input:

[http://delivery.acm.org/10.1145/2940000/2935375/p394-yeo.pdf?ip=138.251.245.155&id=2935375&acc=ACTIVE%20SERVICE&key=C2D842D97AC95F7A%2E9A2EB7BEEEBA61C5%2E4D4702B0C3E38B35%2E4D4702B0C3E38B35&CFID=820288923&CFTOKEN=24977260&__acm__=1510851156_a3c2c84eab101d84610c57510680a986]

Strapping the watch too tightly to the wrist created a serious issue wherein no hand movements could be detected. I saw a correlation to the Gunslinger device in this case – if there is a certain pressure threshold above which the device cannot record any data, not all users may be familiar with it and this could create a major flaw in its external validity.

Distance

Another threat to external validity based on this paper on text input mechanisms for large input displays by the University of British Columbia.

[http://www.cs.ubc.ca/~jqdawson/publications/InputTechForLargeDisplay_GI09.pdf]

In the application of such devices when *distance* becomes an issue. For example, to be widely usable, it is sensible for one to be able to use Gunslinger while moving around in a large room (such as a seminar/lecture hall). *Situation* also plays an important part – the test was done in a closed room with the participants standing in one position: only moving towards the touch screen if necessary. Would this work in the case when a participant does not have visual feedback, i.e., is not looking towards the screen while moving around a room?

Question 3

WatchMI: Pressure Touch, Twist and Pan Gesture Input on Unmodified Smartwatches

To answer this question, write a 1000 word summary (maximum) of the research paper.

More and more people are using smartwatches to access information as compared to smartphones, as it is “less socially intrusive” [3]. However, due to limited screen size of smartwatches, multi-touch input can be difficult. In order to facilitate multi-touch input wrist-worn devices, many companies are engineering their own devices (such as the Samsung Gear or Apple Watch). However, many problems present themselves in this case, such as the external hardware required to use them which can increase cost and weight of the devices, limiting the people who can use them.
In order to enhance touch interaction on a smartwatch using existing hardware and expand the input expressiveness, the Watch Movement Input technique was devised.

The Watch MI technology uses existing hardware to sense continuous rate-based based “touch pressure”, “twist angle”, “pan movement” and the combination of these on unmodified smartwatches. The goal was to enable users to interact with small devices despite screen size.
The techniques leverage the built-in IMU already available in almost every smartwatch and smart wristband in the consumer market, and does not require additional sensor or hardware modification of the watch.
Prior watch-based interactions have extensively relied on custom hardware extensions or modifications, such as custom pressure, photo-reflective, infrared sensors, etc. to achieve the input expressiveness that is usually not possible on off-the-shelf devices.
WatchMI allows highly expressive input by supporting continuous and different levels of touch pressure, pan movement and twist angle using only the data collected from the built-in sensor. Applying these techniques, one could use the smartwatch to navigate a map, set alarms, etc.

The experiment assesses the usability of the three bespoke input interfaces - *pressure*, *twist* and *pan input*.

“12 volunteers were recruited (3 female, 3 left-handed) from a local university, including undergraduate and graduate students, with 5 familiar with wearable devices, and of these, four said they own a smart wristband or fitness tracker.” The study followed a ***repeated-measures design***, and the three interface conditions were balanced in a Latin-squared design order for counterbalancing. The experiment studied the average time and error rate in performing the sequence of tasks, after which the usability of the interface was measured through a post-experiment questionnaire and interview.
Participants received a demonstration of one of the interfaces and had a chance to practice with it for about 2 minutes. They then were seated on a chair with their arm with the smartwatch rested on the table. They were required to select the correct region to complete a targeting task - each of the 24 regions were highlighted in randomized order..
Thereafter, participants rated the perceived usefulness and usability of each interface using a 7-points Likert scale.

Overall, participants were able to complete all input tasks in less than 2.4 seconds (including the 1 second dwell time) and with an average error rate of 0.7%.
The system was described to be “responsive” and “easy to learn”, with the Pressure interface described to be the most challenging, as it was difficult to apply the correct force in the correct direction. It is suspected the way the watch is *strapped* on the wrist might impact on the overall recognition performance of the system - it was observed that if the watch is strapped tightly on the wrist, it can’t register any motion when the screen was pressed due to the Ulnar Styloid process.
There were errors that occurred due to *occlusion*, as the right hand clicking on the left portion of the watch screen (strapped on the left wrist), and the usage of three fingers to twist, blocked the user’s line of sight. However, there are workarounds.

The context of enhancing smartwatch capabilities is getting quite popular due to the social convenience of smartwatches. As mentioned in the paper, a lot of research has already been done on enhancing smartwatch capabilities. However, what makes WatchMI stand out is that there no external hardware is required, which means it can potentially work on most smartwatches through a software update.
On research, I thought of some applications that the WatchMI interface can be used for. An important property for interaction techniques that I noticed through research papers was relying on user familiarity [1].
For example, it can rely on a user’s familiarity with iPods (the “Wheel”), and extend it to use in similar way except without a physical wheel. It can be used in

smartphones to turn off an alarm/phone call by applying pressure rather than using small buttons. (Beats [2], which uses taps to operate interfaces such as alarm clocks, toggle menus, navigate music, etc.).
Inspired by Zoomboard [1], text entry is also an area for enhancing usability. Rather than applying pressure per character in a wheel, one could use pressure /pan to zoom into a tuple of characters and then type.

However, I noticed some flaws with respect to its External validity.

- “During the targeting tasks, users remain seated on a chair and the arm with the smartwatch rested on the table. The Pressure interface was described to be the most challenging, as it was difficult to apply the correct force in the correct direction.”

A user will not, in real life, be seated while using the interface. Most would be moving, with pressure, concentration, etc. changing. The interface may not be able to handle the changes.

In summary, the *capability* and *feasibility* of the software makes it a valuable commodity in the context of smartwatch interaction, and its flexibility makes it useful in many applications, such as navigating a map, twisting a clock hand, adjusting volume, controlling game characters, etc., to name a few.

References:

[1]: http://www.chrisharrison.net/index.php/Research/Zoomboard
[2]: https://dl.acm.org/citation.cfm?doid=2702123.2702226
There is also potential in the 3D orientation of finger (depth sensors, 3D posture recognition).
[3]: https://hcii.cmu.edu/news/2014/hcii-researchers-develop-new-approaches-smartwatches

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Extension Summary Paper
Gunslinger: Subtle Arms-down Mid-air Interaction

Aside: Inspiration

Wearable computing extends from smartwatches, headsets, eyeglasses, etc., which ae used more and more nowadays to facilitate day-to-day tasks.
Upon reading the WatchMI Paper [1], I subsequently read a lot of papers on devices conveniently strapped to the human body to facilitate Human Computer Interaction techniques. One of the papers was that of Gunslinger [2], a wearable mid-air interaction technique, which is also the basis of the video I reviewed for Question 2.
The technologies of WatchMI and Gunslinger are both similar in the fact that they are wearable, but the devices themselves and the paper summaries were quite different. This difference interested me as I read more and more about wearable technologies, and so I decided to write a summary of the Gunslinger paper as an extension, comparing the styles of the WatchMI and Gunslinger papers as well.

Summary

Most mid-air bare-hand techniques use large hand and arm gestures performed in front of the body, which can be tiring, and require physical space to perform. To make bare-hand gestures smaller, more comfortable, and more socially acceptable, Gunslinger was invented to use hand postures, and small finger and hand movements for events and parameter control, most easily achieved by mounting sensors on the thighs, such that free-body postures (arms-down) can be used for dual-handed input, or even combined with touch.
The Gunslinger design aims to make mid-air interaction more socially acceptable, by making it subtle, relaxed, precise and expressive.

An arms-down posture satisfies relaxed input in terms of arm fatigue, and reduces the physical space needed to perform gestures. Mounting 3D cameras on both thighs enables tracking precise and expressive finger movements and hand postures performed with both hands.

The Gunslinger can be used to navigate a map (panning, zooming, selecting map styles, defining landmarks, etc.) using hand gestures. It can combine hand gestures and touch input, which places it in a vocabulary which showcases its usefulness across modularities, based on one important keyword in HCI – user preference.

In previous work done in terms of making mid-air interaction techniques, “Each modality should have a separate use.” [5]. However, usability is an issue here. Most people would, if given the choice, use touch and Gunslinger where they would find it easier or more convenient to use. This helps in location independence.
“Our system treats mid-air gestures and touch more equally, so the most suitable input method can be used regardless of location. “
The technique features a new kind of hand-cursor feedback, to show recognized hand posture, command mode, and tracking quality. This is quite different to other hand-cursor inputs, such as is PocketTouch [6], or Gloves with sensors [4].
Another aspect is how to combine mid-air interactions with large touch-enabled large displays. Previous work has applied the principles of Proxemics, where the input possibilities change based on spatial factors like distance. For example, use mid-air gestures for mode selection from a distance, but change completely to touch input when near the display.
The usefulness of the interaction technique also lies in the social acceptability of it. Even though there is a learning curve to it, it is easier and less obvious for a user to operate a machine in hands-down position (such as to reject a phone call during a meeting – this could be a future application of the machine).
It is also quite error resistant and does not consider background noise/Midas Touch.
Relaxed, natural postures are reserved for the neutral system state and are therefore not considered.

Experiments were conducted to validate technical and usability aspects of Gunslinger.
The study is a sequence of experiments to test the following:
(1) Midas Touch
(2) Posture recognition and hand cursor feedback
(3) Arms-down pointing performance
(4) General usability with and without touch.

By completing these parts in sequence, participants incrementally learned and practiced the system leading to the final usability part. 10 participants were chosen (3 female, mean age 24.2): 4 had experience with mid-air game controllers and all were right-handed.
The main study in this case was usability, and as described in my video analysis of the Gunslinger interaction technique, the setup is not described anywhere. It seems that all participants who took part in the study performed all tasks, and the order was what was stated in the paper - Gunslinger-only, Touch-only, and Mixed.
The setup should be mentioned in the paper for clarity, and for reproducibility-

The validity of the Interaction technique can be questioned, as there is no mention of the setup/technique used in the experiment. Hence, the results found could be flawed and not usable when applied to the outside world. This threatens the reproducibility of the paper and makes it a difficult reference.

The goal of the final part is to evaluate Gunslinger with realistic tasks in two phases. Participants performed a sequence of three Controlled Tasks: locating and pinning two cities, undoing and redoing the last pin-drop; and required changing to satellite view, generating an itinerary using the contextual menu, then saving the itinerary with the global menu.
Each task sequence was completed under three input conditions: Gunslinger-only, Touch-only, and Mixed in which the dominant hand uses touch and the non-dominant hand uses Gunslinger.
In the second phase, participants were given an Open-Ended task: to plan a trip, generate an itinerary, and save it: the task elicited map navigation and exploration.

As per user feedback, it was described as "subtle", but touch was preferred in tasks as it was "more natural". The mixed touch and Gunslinger combination "required more practice."
Gunslinger was considered advantageous at a distance with larger displays and up close with high targets, but might be "too sensitive" (partly due to occasional erroneous input).

Gunslinger's usefulness lies in the fact that direct touch is not viable at a distance.
As mentioned, most mid-air input interaction technique require the user to be in close proximity to the screen, with large gestures[3], such that background noise is minimized and it is easier for sensors to track movement. However, a big application of Gunslinger is the location independence it provides, with the social acceptance (less fatigue) the movements have. Due to sensors being strapped to the thigh of the user, he could move around a room (provided the technology becomes wireless, as suggested in the paper). This makes it useful for many scenarios like lecture halls, public theatres, etc.

There are flaws to the validity of the experiments performed, such as-

- *Reproducibility* – as mentioned.
- *Internal validity*, as users may have a bias towards touch interfaces.
- Visual feedback was provided, but it may be harder to use without looking at the screen, as one might not in real life (*external validity*)

To highlight the main differences in the papers of WatchMI and Gunslinger, I have tabulated the credits and discredits.

Interaction Technique	Discredits	Credits
Gunslinger	As summarized, there is no mention of the setup/experimental technique/order of randomization, etc. mentioned. This leads the reader to assume a certain technique, which threatens its reproducibility.	The experiments, however, are crisply divided into 4 different parts, which cover the real-life use of the interactive device (such as rejection of background noise, posture recognition, arms down pointing and usability). Each part is tested and results calculated, which makes the feedback clearer.
WatchMI	Unlike the Gunslinger paper, all aspects of the usability (such as applications) aren't tested. Only the touch/pan/zoom pressures are tested. However, this leads to its limitations: for example, while setting an alarm, if the user touches the rim, it does not take in any input. Based on the error rate for this particular experiment, the overall error rate might increase.	There is proper mention of the techniques used to experiment and detailed information provided to reduce redundancy. For example, it is clear that internal validity while experimenting was taken care of. "Participants received a demonstration of one of the interfaces and had a chance to practice with it for about 2 minutes. They then were required to complete a targeting task..." This is a threat to internal validity as not all participants might use that time with the same focus to play with the device: social anxiety, time taken to attain familiarity and register the

		device, etc. also plays a part. However, it is clearly mentioned that “the first 48 trials were considered practice and discarded in the analysis.” This also credits its reproducibility.

As future work, using Gunslinger while seated, or using it with head-mounted displays for virtual and augmented reality, or for controlling a smartphone when in a pocket or bag, can be quite useful and sought after. Overall, its location independence, subtlety and social acceptance makes it useful for many applications in the future of HCI.

References:

[1] https://studres.cs.st-andrews.ac.uk/CS3106/Practicals/Prac_2/CS3106_paper_3_WatchMI.pdf

[2]
http://delivery.acm.org/10.1145/2810000/2807489/p63-liu.pdf?ip=138.251.254.158&id=2807489&acc=ACTIVE%20SERVICE&key=C2D842D97AC95F7A%2E9A2EB7BEEEBA61C5%2E4D4702B0C3E38B35%2E4D4702B0C3E38B35&CFID=820288923&CFTOKEN=24977260&__acm__=1511288357_4d0ed5b3e3bee7e7f5cf6accc49b0c1c

[3]
Bragdon, A., DeLine, R., Hinckley, K., and Morris, M. R. Code space: Touch + air gesture hybrid interactions for supporting developer meetings. In Proc. ITS ’11, ACM (2011), 212–221.

[4] Lu, G., Shark, L.-K., Hall, G., and Zeshan, U. Immersive manipulation of virtual objects through glove-based hand gesture interaction. Virtual Real. 16, 3 (Sept. 2012), 243–252.

[5] Oviatt, S. Ten myths of multimodal interaction. Commun. ACM 42, 11 (Nov. 1999), 74–81.

[6] Saponas, T. S., Harrison, C., and Benko, H. PocketTouch: Through-fabric Capacitive Touch Input. In Proc. UIST ’11, ACM (2011), 303–308.