Feedforward Interactions for Mid-Air Haptics: An empirical investigation

As part of the King's Undergraduate Research Fellowship

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1   Introduction

The King's Undergraduate Research Fellowship (KURF) scheme I have taken this summer built up upon the existing mid-air interactions domain and been extended to which tactile feedback can be generated to the user's hand, via revolving around the **"feedforward"** terminology that gives users some hints of the result before their intended response. A detailed exploration has been carried out by undergoing a two-part user study across 27 participants, with the data collected that involves the user's verbal response plus their subjective experience as NASA TLX and 5-point Likert scale, leading to the expected results in general except for some minor shortcomings at the beginning of Part 2 impacted by user's training effects.

The fellowship itself was filled with joys and challenges and I did not expect anything less from that, especially the 4 out of many episodes that I would like to highlight where the remaining of this text has been dedicated to.

2 "Going back" to Windows

Properly setting up the device on my laptop before the study is deemed the first challenge of this fellowship. The Ultrahaptics board is something that I have never come across. After the first attempt to register, install the relevant software and connect the hardware to my laptop with the macOS operating system, it failed to find an application on my machine to open the following two files that plays an essential part in this project:
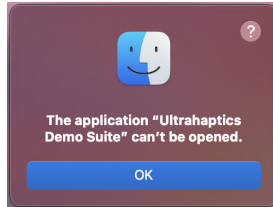

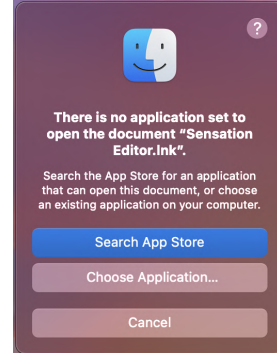Figure 1: Error message when opening "Ultrahaptics Demo Suite" using macOS.

Figure 2: Error message when opening "Sensation Editor" using macOS.

To tackle this situation, me and my supervisor have agreed to take action separately. I continued exploring and trying to set this up in alternative operating systems, such as Linux being installed on my other laptop, and Windows on the college library's machine. In contrast, my supervisor requested someone he knew in the industry for other software versions available. The outcomes on my side were not positive, ending up pretty much the same position as using macOS for Linux, depicted as a screenshot below:

Figure 3: Error message when opening "Ultrahaptics Demo Suite" using Linux.

On the other hand, the permission for installing Leap Motion software on the library's machine has been declined due to its shared student device's property (screenshot below).
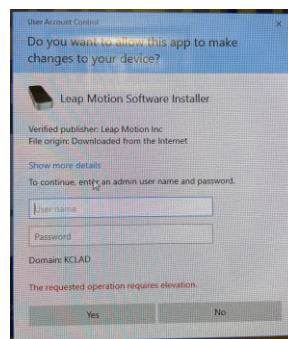

Figure 4: Error message when installing "Leap Motion" using Windows.

I then used Parallel Desktop to install Windows directly on my existing laptop but unfortunately, its performance is not quite as smooth as expected. The final option I picked was to borrow a Windows laptop from my family and the system eventually started running properly.

Windows is the operating system that I have abandoned since high school and never expected that I would have to pick it up at some point in my future. The fact that Ultrahaptics software penalises the macOS and Linux users forces me to refamiliarise most of the Windows set-up in addition to the board itself. The entire process was tedious but I never quit and learned that there are no better ways than exploiting all the resources around me by starting from the one that is most accessible in order to find the optimal solution, which as well minimised the supervisor's workload for assisting my work.

3 Approaching People & "Participants' Maximisation" Algorithm

After getting the board and its software worked on my laptop, I was in a good position of ready to invite 20 people to participate in my study, which brought me to another challenge of this project.

I began by utilising my most-followed social media account Instagram (around 4000 followers) and posted them as 4 consecutive stories, including the hashtag, sticker, tag to the company, link to the participants' handout as well as 2 demos that maximise the views of my stories displayed below:

Figure 5: Instagram story 1.
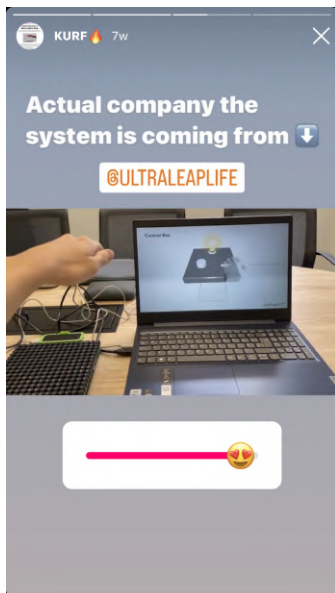

Figure 6: Instagram story 2.
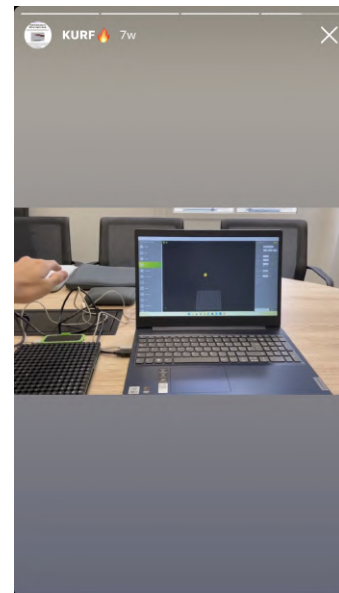

Figure 7: Instagram story 3.

Figure 8: Instagram story 4.

Although more than half of my followers have viewed the stories, very few of them have responded regarding participation, which can be verified by the almost no increase in the number of views of those 4 files inside the participants' handout. I then wrote them as messages and sent them to several WhatsApp group chats I have joined that consist of more than 100 members, causing a similar outcome of a high number of message views but low engagement.

From then on, I learned that recruiting people by just getting their attention is far from enough, as the number of views of the content reflects poorly on the number of people interested in attending the study. Hence the essence of undergoing one-to-one interaction that potentially boosts their interest cannot be neglected, either.

The situation has improved slightly after unicasting the message to as many people as I have contact with across various platforms, and it had dramatically improved when I started reaching out to people in person followed by sending them messages for more details and arranging a schedule on Microsoft Teams if they have agreed to take part. In this way, everyone has a complete view of my expression when being introduced to my experiment, which in turn utilises the interaction that constitutes the core of their decision makings for participation, leading to having 35% more than expected participants for the actual study.

4 Board's Instability

Although the board has now been given the device with the right operating system, its peak performance is still not always maintained. This can be reflected by the board getting overheated if its operation time goes beyond a certain limit, which causes the board automatically disconnect from the laptop with neither sensations being generated nor the user's hand position being recorded (screenshot below):
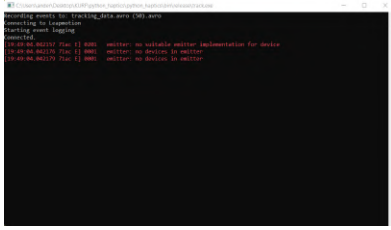

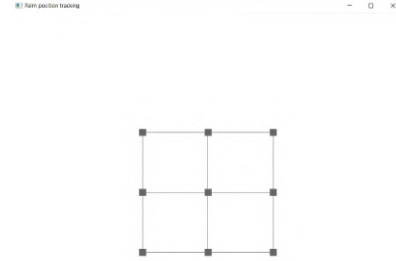Figure 9: Error message when the board gets overheated.

Figure 10: User's hand position not getting recorded when the board becomes overheated.

This, unfortunately, happened in the first study and caused Part 2 of the study to be unfinished. I reported this to my supervisor immediately afterwards and agreed that the number of trials in Part 1 must be cut shorter to lessen the duration of the entire study. In other words, each study ideally should not take more than 45 minutes to complete as the threshold for the board starts overheating is approximately 50 minutes, as learned from the first study.

Besides reducing the number of trials, I also realised that the board does not have to be strict "ON" throughout the entire study session. As a result, I only connected the board to my laptop right at the start of Part 1 of the study and disconnected once Part 2 has completed, which potentially minimises the board operation time per study and is particularly efficient for the case of running several back-to-back studies as the participants do not have to spend too much time waiting for the board to cool down before their study begins.

5   Fellow-Supervisor Interaction

Before this fellowship, I had already got a chance to work with my supervisor on my 3rd year individual project and ended with a first-class grade (71%). However, the communication with my supervisor was not the best during that time and hence I decided to adjust the interaction slightly for this fellowship.

When I was working on my individual project in my previous year, I regularly attended his weekly office hours to update the progress I had made and ask whatever questions I had regarding the project. In contrast, I still arranged weekly meetings with him for this fellowship but this time I have tried my best to avoid asking him any redundant questions that the answers could easily be found online or applied from my previous knowledge. What I have done instead was always strive to be the best that I could be for any task I was performing before requesting feedback from him during each meeting.

As asking good questions is the key to carrying out research in Human-Computer Interaction (HCI) and potentially the wider academic discipline, I learned that requesting academics feedback by showing them my current work done is always better than explicitly letting them guide me in approaching the task. On the other hand, working more independently is as well one of my supervisor's expectations for his PhD students, which is my exact goal in the next few years.

6 Conclusion

Despite a confounding factor being detected in Part 2 of the study that causes slightly inconsistent users performance on the first trajectory, the fellowship was overall successful, as I not only reignited a project that had been abandoned since the pandemic and achieved more than my supervisor has expected but also built strong relationships with lots of Masters and PhD students when inviting them to my user study, in which I have additional chances to ask them any questions with regards to my upcoming Master's year and future PhD study. Showing the academic poster I have made to my supervisor and senior PhD students to gain feedback allows me to refine it in a way that is ready to be presented for my PhD interviews and top HCI conferences.

Lastly, I cannot be more grateful for being offered by my supervisor the opportunity to work inside the Postgraduate office throughout my entire fellowship, a place exactly where the research group I want to get into at this time next year. My experience for KURF along with the 3rd year's individual project constitutes the best memories of my degree that I will forever remember and makes me more hungry to become my supervisor's PhD student commencing October 2023.