Mid-Air Haptics for Control Interfaces

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Abstract
Control interfaces and interactions based on touch-less gesture tracking devices have become a prevalent research topic in both industry and academia. Touch-less devices offer a unique interaction immediateness that makes them ideal for applications where direct contact with a physical controller is not desirable. On the other hand, these controllers inherently lack active or passive haptic feedback to inform users about the results of their interaction. Mid-air haptic interfaces, such as those using focused ultrasound waves, can close the feedback loop and provide new tools for the design of touch-less, un-instrumented control interactions. The goal of this workshop is to bring together the growing mid-air haptic research community to identify and discuss future challenges in control interfaces and their application in AR/VR, automotive, music, robotics and teleoperation.

Author Keywords
Haptics; Mid-air haptics; Touch-less interaction; Gestural controllers; Interface design; Music; Teleoperations; Robotics.

ACM Classification Keywords
H.5.2 User-Interfaces (Input devices and strategies, Interaction styles, User-centered design)

Background
Gesture based control interfaces in 2017 are almost ubiquitous in our daily lives. We use gestures to

Figure 1: Example hand tracking technologies (top to bottom): Intel's RealSense, Leap Motion, Microsoft's HoloLens, and META 2.

interact with our appliances, smartphones, electronic devices and, more recently, virtual and augmented environments. The widespread availability of these solutions has been made possible by a new generation of tracking devices and gesture recognition techniques (Intel's RealSense, Leap Motion etc. see Figure 1), which have progressively become more accurate, precise, and affordable.

Among the plethora of gesture based interfaces available on the market, touch-less systems allow users to interact with products and services in mid-air, without the need for any physical contact with the controller itself (see e.g. Figure 3). In particular, touch-less controllers are more and more popular in the context of AR/VR applications: Microsoft's Hololens allows the user to control the OS embedded in the AR system by hand tracking and gesture while Leap motion have concentrated their efforts on providing software tools to enable hand tracking in conjunction with VR headsets.

However, the immediateness provided by touch-less controllers has a significant draw-back: the lack of force or tactile feedback coming from the interaction with a physical device. Studies performed in several domains have highlighted haptic feedback benefits in guaranteeing accurate interaction performance: Keele [9] showed that haptic feedback is a key component in expert music performance; Hoggan et al. [10] demonstrated that users prefer and perform better on a touchscreen that also provides tactile feedback.

The latest developments in mid-air haptic technology have made it possible for designers to build touch-less interfaces that also incorporate tactile feedback. Such technologies include, for example, mid-air focused ultrasonic haptic interfaces [1, 2, 3], air jets [4], air cannon [5], phemto-lasers [6], each of which is suitable depending on the desired application. Most of these technologies currently exist only in research laboratories, but commercial solutions are also available.

Workshop Goals

This workshop will primarily focus on the challenges and design issues related to multi-modal touch-less control interfaces of the future, with specific emphasis on focused *ultrasonic mid-air haptics* (see Figure 2).

The workshop aim is to:

1. connect a growing community of touch-less haptic researchers, application and product designers,
2. facilitate an open discussion between academia and industry on the challenges they face when creating touch-less controller interfaces,
3. address the above-mentioned challenges in a crowdsourcing and open manner.

For example, we would like our attendees to reflect on challenges linked to both limitations in state-of-the-art, mid-air haptic technologies (both hardware and software), and haptic feedback design paradigms:

- What kind of feedback can we generate effectively and which kind of mid-air haptic technology is more suitable for *specific applications*?
- How can we use *perceptual effects*, such as haptic illusion to generate better feedback in control applications?

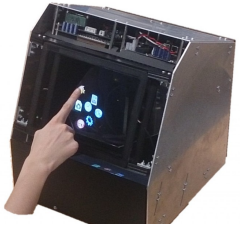

Figure 2: Example ultrasonic mid-air haptic platforms: Ultrahaptics (top), HaptoMime (middle), Haptogram (bottom).

- In the context of AR/VR, we may wish to have true *portable* haptic-enabled, touch-less controllers. What is the roadmap toward a miniaturized and portable mid-air haptic device?
- Do mid-air haptic control interfaces always require visual or audio feedback as well? When are multi-modal experiences suitable?
- What are the latency requirements in music, robotics and tele-operation applications and how can mid-air haptic feedback be used in this space?

These are only some of the possible questions that, we believe, are central to our understanding of how to work with mid-air haptic feedback. The overarching goal of this workshop is to bring together members of the haptics and HCI communities whose experience cover a wide range of possible applications for this new and exciting technological interface (see Figure 3).

This one-day workshop will feature *demos and brainstorming sessions*, and define *use-case scenarios,* which will help participants discuss and explore new ways to design more compelling haptic feedback applications.

Organizers

The workshop organizers have extensive experience in organizing and participating in many similarly themed workshops. They have published high-impact work in this area, and many hold funding for continuing research in this field.

Marcello Giordano is a Haptic Researcher at Ultrahaptics, where he is responsible for the design and evaluation of haptic interactions. He holds a Ph.D. in Music Technology from McGill University (Montreal, Canada), and his work on haptic perception and feedback design in music has been issued in several peer-reviewed publications.

Orestis Georgiou leads the advanced research cluster (ARC) at Ultrahaptics and is also the main link between Ultrahaptics and its academic partners. Dr. Georgiou has also published over 50 articles in leading journals and conferences of Mathematics, Physics, Engineering, Computer Science and Medicine.

Brygida Dzidek holds a PhD in Haptic Interface Contact Mechanics from the University of Birmingham, UK. She has expanded expertise over the new generation of tactile interfaces with user feedback, to be introduced in the VR/AR electronic applications. Brygida is an author of several high impact publications on haptic feedback interfaces and tactile devices. She is also a Member of IEEE Robotics & Automation Society and is in the Technical Committee on Haptics, as well as a reviewer for the IEEE Transaction of Haptics Journal.

Loïc Corenthy is team leader of the *Applications Team* at Ultrahaptics. He previously worked on the design of haptic rendering algorithms for volumetric datasets with applications in neuroscience. This work was published in the IEEE Transactions on Haptics.

Jin Ryong Kim is a senior researcher at Electronics and Telecommunications Research Institute (ETRI) in Korea. His current research focuses on designing and creating novel interaction with haptics technology to amplify human satisfaction through enriched user experiences. He is currently leading a project focusing on finger interactions with mid-air haptic feedback in VR including piano playing and keyboard typing. He has

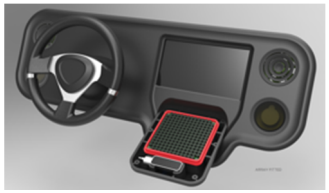

Figure 3: Example applications of ultrasonic mid-air haptics, from top to bottom: automotive controls [11], VR , AR, Music [7].

several publications in haptics conferences and journals including the IEEE World Haptics Conference, Haptics Symposium, EuroHaptics, and the IEEE Transactions on Haptics.

Sriram Subramanian is a professor at Sussex University with a focus on designing interactive systems for novel touch, tactile and visual elements. He is a co-founder of Ultrahaptics and has organized many workshops at CHI, MobileHCI and other conferences (e.g., @CHI 2016, @CHI 2013 and @MobileHCI 2012).

Stephen Brewster is Professor of HCI in the Department of Computing Science at the University of Glasgow, UK, specializing in Multimodal Human-Computer Interaction, sound and haptics and gestures. He has organized several scientific events and is also the General Chair of CHI 2019.

Website

The workshop call for participation will be available online at:
https://www.ultrahaptics.com/news/events/chi-2018/

An online registration form (e.g. via Google Forms) will allow interested researchers to submit their expressions of interest.

Once finalized, the program of the workshop will be posted online. A post-workshop section will be available on the website after the conference with extra material, presentations from the workshop attendees, sketches, videos and notes from the workshop sessions.

Pre-Workshop plans

1. Workshop advertisement

Our call for participation will be available on the workshop's website and distributed to the haptics and HCI community via forums, mailing lists, and social media. The organizers have excellent connections in both academia and industry and will make sure that key people in relevant communities (HCI, haptics, robotics, automotive, music, AR/VR) will be made aware of the workshop and inform their network of peers.

We wish to be a broad church and are hoping to welcome researchers from both academic and industrial backgrounds as well as practitioners of varying seniority, interests and expertise.

2. Workshop expressions of interest format

Participation will require the submission of a short expression of interest (around 750 words) in which applicants will have to highlight their main research focus. They should also mention at least one research theme they would like to address during the workshop. This theme could be a technological issue, design-oriented challenge or a personal vision of how this emerging field should evolve. Themes should be linked to the applicant's personal research or product design experience.

3. Applications review and selection

These expressions of interest will be reviewed to assess their relevance to the workshop topics: If we receive more than 20 applications, we will select those that have the best potential to positively foster diverse discussion. At the same time, we will do our best to ensure that new comers to the filed, such as less

experienced researchers or students, will have a chance to be selected as participants.

4. Definition of the workshop program
After the selection process, the organizers will communicate with the selected participants to identify themes that emerge from the expressions of interest. They will define the workshop's structure by selecting three to four main discussion topics. The organizers will also identify discussion leaders for each theme. These discussion leaders will be chosen from the participants (based on their approval). The main organizer will discuss with each, bringing them up to speed on why they were chosen and what is the broad appeal of their theme.

The list of discussion topics, workshop program and selected expressions of interest will be made available via the workshop website.

5. Workshop recording and documentation
Finally, the organizers will arrange for the recording and documentation of the workshop. Much of this material will be used for disseminating on social media but will also form the basis for future publications and foster new collaborations between participates.

Workshop structure

The workshop will be organized around the discussion topics that emerged from the selection process. The workshop will last for one full day and start with an introductory session in which the organizers will present the program and each participant will give a short, two-minute presentation of their work and research interests. These may be accompanied by short video clips or demos.

The session moderators will each give a 15-minute, mini-keynote to introduce their respective scopes and set their expectations and directions.

We will then have three to four brainstorming sessions, in which participants will discuss one of the emerging topics. Each session will have a moderator (chosen from the participants before the workshop), who will be experts in one of the proposed application fields. They will be asked to steer the discussion towards the selected emerging topic, while keeping it as interesting and relevant as possible for all the workshop attendees. Our aim is to encourage participants to discuss challenges they face when designing haptic feedback and exchange ideas and design paradigms. Each of these sessions should last approximately 30 minutes. For each session participants will be asked to agree on a specific use-case that explains the challenges of designing mid-air, haptic feedback.

These use cases will be used in a final group session in which participants and organizers try to generate design ideas for one or two use cases. The use cases will be chosen at the beginning of the session based on attendees' preferences. The organizers will lead this session and will make sure to encourage participation from all attendees. This session should not last more than two hours.

There will be at least three coffee and biscuit breaks during which participants will have a chance to present to each other and interact with demos or posters.

We will end the workshop by collecting participants feedback on the day and by discussing further opportunities to organize workshops focused on similar

topics or even a specific track in a relevant future conference (such as CHI or Siggraph Emerging Technologies).

A tentative workshop plan is shown below:

- Coffee, tea and biscuits (15 minutes)
- Introduction and welcome (10 minutes)
- 2-minute presentations (45 minutes)
- 4x Session mods mini-keynote (60 minutes)
- Lunch (60 minutes)
- 2x brainstorming sessions (60 minutes)
- Coffee, tea and biscuits (15 minutes)
- 2x brainstorming sessions (60 minutes)
- Coffee, tea and biscuits (15 minutes)
- Open discussion (90 minutes)
- Future plans (15 minutes)
- Workshop close

Post-workshop plans

The outcome of each of the brainstorming and final group sessions will be made available to participants on the workshop website and will be in the form of videos and organized notes, highlighting the design ideas and research challenges that emerged from the discussions. A note taker and sketch artist will be hired to attend all the sessions and produce high quality notes and diagrams of the discussion topics and use cases.

These notes will later be made available to a wider audience, using more formal means of distribution (for example in the form of a publication). This possibility will be discussed with the attendees after the conference.

It is hoped that this gathering will serve as a platform for, not only increasing awareness of research activities in this space, but also hands-on experience and opportunities for future collaborations. We believe that the workshop will help build a stronger, closer research community for the design of mid-air haptic technology and interactions and foster future communication between attendees.

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CALL FOR PARTICIPATION

Mid-Air Haptics for Control Interfaces

The design and evaluation of control interfaces and interactions based on touch-less gesture tracking devices has become a ubiquitous research topic in both industry and academia. Touch-less devices offer a unique interaction immediateness, which makes them ideal for applications where direct contact with a physical controller is not desirable. On the other hand, these controllers inherently lack of any active or passive haptic feedback to inform the users about the results of their interaction. Mid-air haptic interfaces, such as those using focused ultrasound waves, can close the feedback loop, and provide researchers with new tools to design touch-less un-instrumented control interactions.

The goal of this workshop is to bring together a group of experts in disciplines ranging from haptic research to product design and multi-modal interaction. We want to foster discussion about the challenges in the design and implementation of feedback using mid-air haptic interfaces in applications related to *AR/VR, automotive, music, robotics and teleoperation.*

We invite potential participants to submit a 2-page (750 words) abstract in the format of an ACM Extended Abstract. This abstract should show how the applicant's work fits into the topics of the workshop, and should include a theme that the applicant feels is important to the field, and would generate valuable discussions during the workshop. In case of a multi-authored abstract, it should be made clear which authors will be attending the workshop.

According to the number of applications, we might need to limit the number of accepted participants, and the number of participants per submitted proposal. For each accepted paper, at least one author will have to register to both the workshop and at least one day of the conference.

Important information:

Workshop Website: https://www.ultrahaptics.com/news/events/chi-2018
Format: ACM extended Abstract, 2 pages
Submission Deadline: 2nd February 2018
Acceptance Notification: 20th February 2018