Mid-Air Haptics and Displays: Systems for Uninstrumented Mid-Air Interactions

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Abstract

A fundamental shift is underway in how we interact with our computers and devices. Touchless sensing products are being launched across consumer electronics, home, automotive and healthcare industries. Recent advances in haptics and display technologies has meant that interaction designers can also provide users with tactile feedback in mid-air AND display visual elements wherever the user needs them without in anyway instrumenting the user. The overarching goal of this workshop is to bring together a group of researchers spanning across multiple facets of exploring interactions with mid-air systems to discuss, explore, and outline research challenges for this novel area. We are especially interested in exploring how novel display and haptic technology provide users with more compelling and immersive experiences without instrumenting them in anyway.

Background

Recent advances in hand-tracking algorithms have helped bring into the marketplace a new range of devices that allow developers to add mid-air gestures capabilities to a range of products and services. For example, Leap Motion [e] is exploring the integration of their sensor to the dashboard of cars. More recently, Google introduced Soli, a radar-based tracking system,



(a) Ultrahaptics



(b) Haptomime



(c) Haptoclone



(d) Mistable

Figure 1: Mid-air haptics and/or visual systems

which like Elliptic Labs (a sonar-based system) can detect mid-air gestures without line-of-sight.

All these technologies are ushering a new era of interaction where the user does not have to reach to physically touch any interface element but can conveniently interact with the device just by gesturing at it. This is leading us towards a fundamental shift in how we interact with our computers and devices. **Touchless sensing products** are now being launched across the consumer electronics, home, automotive and healthcare industries.

Touchless sensing is a key enabler for supporting user interactions in mid-air. Recently Song et al. demonstrated a system that can support in-air gestures around an unmodified mobile device by using the builtin RGB camera [d]. Similarly, Elliptic Labs uses small ultrasound sensors in mobile devices to offer 180 degrees gesture sensing up to two metres allowing multi-layer interactions and hand-position tracking [c].

But advances in haptics and display technologies has meant that interaction designers can also provide users with tactile feedback in mid-air AND display visual elements wherever the user needs them without in anyway instrumenting the user. For example, systems like Ultrahaptics [g] and AIREAL [f] can produce mid-air haptics with either ultrasound or vortex rings respectively. Systems such as Mistable [a] can offer an interactive floating fog-based display. HaptoMime combines ultrasound haptics with a floating virtual screen to enable users to see and feel objects in midair [h]. And recently, Haptoclone [i] creates a telepresence system with haptics by using two workspaces that can clone each other's lightfield and forcefields. A selection of these systems can be seen in Figure 1.

Since these are all imminent technologies, we want to look at challenges in combining haptics and displays for mid-air interactions when considering designing the future. The following are examples of scenarios that could serve as starting points for such discussions.

- "We look beyond the flat screen and keyboard by using mid-air gestures, haptics and displays to create natural 3D user interfaces."
- "When approaching a new touchless sensing device such as a touchless faucet or hand-dryer, I would like to be informed on how to interact with it. The visual feedback would inform me of where to place my hand and how to gesture, and the tactile feedback would guide and confirm my actions."
- "Gestural systems are ideally great for interaction because they are flexible but because they are more complex, there is a higher chance for false positives and misses. How can we design visual and haptic feedback to support a fully-free gestural system?"

Some of the challenges include ways in which we can combine these novel systems to support both singleuser interactions as well as co-located multi-user collaborations. For example, systems like Mistable [3] have been shown to support simple collaboration cases but might fail to support more intense collaborations.

A second challenge with most of these emerging technologies is that many of them remain in a proof-of-

concept state. Systems like HaptoMime have demonstrated technical feasibility but have not been integrated in an environment where a user works with the system to accomplish a specific task. With limited insights into problems users might face from in-context use of these systems it is hard to elicit detailed userfeedback.

These new systems will also bring on the challenge of conventions and standardization. Norman [b] discusses issues with creating natural user interfaces, as conventions can be different across cultures, product design and even time. Will the users be able to learn how to use this new technology without much issue or will they be trying to use it in the traditional manner and thus creating issues?

The overarching goal of this workshop is to bring together a group of researchers spanning across multiple facets of exploring interactions with mid-air systems to discuss, explore, and outline research challenges for this novel area. We are especially interested in exploring how novel display and haptic technology provide users with more compelling and immersive experiences without instrumenting them in anyway.

This one-day workshop will guide discussion and brainstorming activities to provide critical discourse and insights into the challenges facing this emerging area.

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.

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

Hiroyuki Shinoda and his colleagues at University of Tokyo demonstrated the world first midair ultrasonic haptic display in SIGGRAPH 2008 and touchable aerial image in SIGGRAPH 2009. After showing Haptomime in 2014, they achieved a literal 3D haptic hologram, and subsequently demonstrated Haptoclone, a symmetric mutual telexistence system by 3D midair haptics and glasses-free 3D display.

Sue Ann Seah is currently the lead researcher of the team that designs haptic effects at Ultrahaptics. She has several publications in HCI conferences including CHI, UIST and Interact. Her projects have ranged from working on the Ultrahaptics technology up to understanding touch and designing a morphing haptic glove in a space exploration context in Exoskin. She is very keen on integration of mid-air haptic technologies with mid-air display technologies to enhance the users' experience.

Eve Hoggan is a researcher at Aalto University in Finland. Her current research focuses on haptic feedback, multimodal interaction, and smart materials, in particular, flexible shape-changing displays. The aim of her research is to use varying form factors and modalities to create more expressive methods of interaction between humans and technology.

Loïc Corenthy is a member of the team that designs haptic effects at Ultrahaptics. He previously worked on the design of haptic rendering algorithms for volumetric datasets with application in neuroscience. This work was published in the journal IEEE Transactions On Haptics. During his master, he worked on the integration of haptics and 3D sound in the context of arthroscopic surgery simulators. The results of the experiment were presented in the ASME 2010 World Conference on Innovative Virtual Reality.

Website

The workshop call for participation will be hosted by the Interact Lab (Subramanian's research group) at http://www.interact-lab.com

We can create a dedicated space to also include postworkshop developments such as the illustrative sketchnotes we plan to create (see Workshop Structure for details) and the roadmap that might become part of an ACM Interactions publication.

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Pre-workshop Plans

The goal of the workshop is to build a community around this topic to discuss issues and exchange ideas. We wish to be a broad church that is appealing to academic researchers, industrial researchers as well as designers and practitioners. We will solicit participation by distributing our call for participation in the workshop to a wide range of forums and mailing lists. We will also target key stakeholders within the relevant industry sector to participate in the workshop. For example, the organizers have excellent links to researchers within the touchless sensing industry (e.g., Leap Motion, Intel and Elliptic Labs). We will ensure that the right person within these organizations are made aware of this workshop and gently nudged towards participating.

We recognize that there is a very short time-window within which we are expected to solicit position papers from interested participants and this acts as an unfortunate filter in inviting participants from with a wide spectrum of interest. We will therefore have a very simple and straightforward strategy to recruit participants for the workshop.

All interested participants will have to fill out a short (no more than 750 words) expression of interest to participate. In particular, the expression of interest will ask participant to identify 1 or 2 specific areas that they wish to steer the discussion on the workshop days. These expressions of interest will only be reviewed to check that they are within scope of the workshop and if we receive more than 20 such expressions of interest, we will further select participants to ensure there is a healthy balance of representatives from the different sectors.

Following this selection of participants we will familiarize participants with each other's expressions of interest and coordinate communication through a mailing list. In particular, the organizers will have a Skype discussion to identify 3 to 4 discussion themes that emerge from the expressions of interest. We 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 identified theme leader to bring them up to speed on why they were chosen and what is the broad appeal of that theme.

Finally, the organizers will recruit two visual notetakers or graphics recorder from the local area to sketchnote the event for the day. The workshop organizers have a dedicated budget available to hire such a person. We request the workshop organizers to waive the registration fee for these artists. The photographs of these sketches will become outputs of the workshop that will be widely disseminated.

Workshop Structure

The workshop will be based around three or four key themes that will emerge from the expressions of interest. We expect the themes to span the areas of displays, haptics and other output mechanisms.

The workshop will last for 1 day and consist of 4 sessions. In the morning session, the organizers will give a small introduction to outline the goals of the workshop and the overall structure for the day.

Following this, we will have 3 to 4 brainstorming sessions one on each of the emerging topics. Each session will be led by the chosen discussion leaders and would involve all participants of the workshop. The visual note-taker will start creating sketchnotes based on ideas that arise during the brainstorm.

We expect each session to last about 20 mins followed by 10 mins general discussion between sessions. This would take a total of about 2hrs (we expect 1 of these sessions to be carried out post-lunch).

Specific outputs from these sessions will be in the form of specific roadmaps or challenges that need to be addressed. Some examples include

- a. New ideas of how to implement the technology ranging from practical to blue-sky
- b. Use-cases where these systems would be best suited to guide research/product design
- c. A list of different ways of implementing these system e.g implementations that co-locate input and output and implementations that don't
- d. A collection of potential the design complications that might emerge from our proposed designs.

Following this brainstorming session, we will specifically look at generating compelling use-cases and design challenges within each use-case. This would be a group session facilitated by one of the workshop organizers. Discussions from the previous sessions will feed into this and form the basis for developing an initial roadmap. The goal would be to create a roadmap that could serve as a starting point for any future researcher/ practitioner seeking to contribute to this emerging area.

We will finally discuss specific ways to build an ecosystem of researchers spanning across multiple facets of exploring interactions with mid-air systems. This discussion could look at organizing further workshops, developing a specific web-portal or creating a "demonstration" track in a relevant future conference (such as CHI or Siggraph E-tech).

Post-workshop plans

The workshop is designed to bring together researchers from a range of disciplines that can bring together their knowledge and expertise to help shape the future direction of this research area. It is hoped that this gathering will serve as a platform for increasing awareness and making contacts for future collaborations. In addition to this 'soft' outcome, the workshop organizers will synthesize outcomes of the day to produce an initial roadmap for the key challenges in the area. The organizers believe it too early for more formal publications from the workshop. The sketchnotes will be made available to all organizers and serve as a poster for post-workshop dissemination to other conference attendees.

The workshop organizers will also act on specific outcomes about how to build and sustain this community. We will assign specific roles to organizers before the end of the workshop. This will ensure that there are clear owners for each outcome and postworkshop plans do materialize.

Call for Participation Mid-Air Haptics and Displays: Systems, un-instrumented mid-air interactions

A fundamental shift is underway in how we interact with our computers and devices. **Touchless sensing products** are being launched across the consumer electronics, home, automotive and healthcare industries. Recent advances in haptics and display technologies has meant that interaction designers can also provide users with tactile feedback in mid-air AND display visual elements wherever the user needs them without in anyway instrumenting the user. The overarching goal of this workshop is to bring together a group of researchers spanning across multiple facets of exploring interactions with mid-air systems to discuss, explore, and outline research challenges for this novel area. We are especially interested in exploring how novel display and haptic technology provide users with more compelling and immersive experiences without instrumenting them in anyway.

This workshop will provide a forum to explore the four primary themes of research in this area: design, implementation, interaction, and evaluation. It will bring together a cross-disciplinary group of experts in haptics, display technologies, and other modalities for mid-air interactions.

We invite you to submit a 2-page expression of interest, in the ACM Extended Abstracts format, that describes current work, future directions, and/or significant challenges on the topic of the workshop. Ensure your paper describes a scenario that drives your vision for the area and try and capture specific theme you think the workshop should be discussing.

Please indicate which of the position paper authors will attend the workshop. Places are limited and we may need to cap the number of attendees per accepted paper. At least one author from each accepted paper must register for the workshop and at least one day of the conference.

Workshop website: www.interact-lab.com/mid-air Format: 2 pages in ACM Extended Abstracts Format Submission Mechanism: by email to first author Early Deadline for Submitting: 21-December 2015 Early Notification: 5th January 2016 Main Submission Deadline: 15th January 2016 Main Notification: 29th January 2016