Intuitive, Wearable Haptic Devices for Communication with Ubiquitous Robots

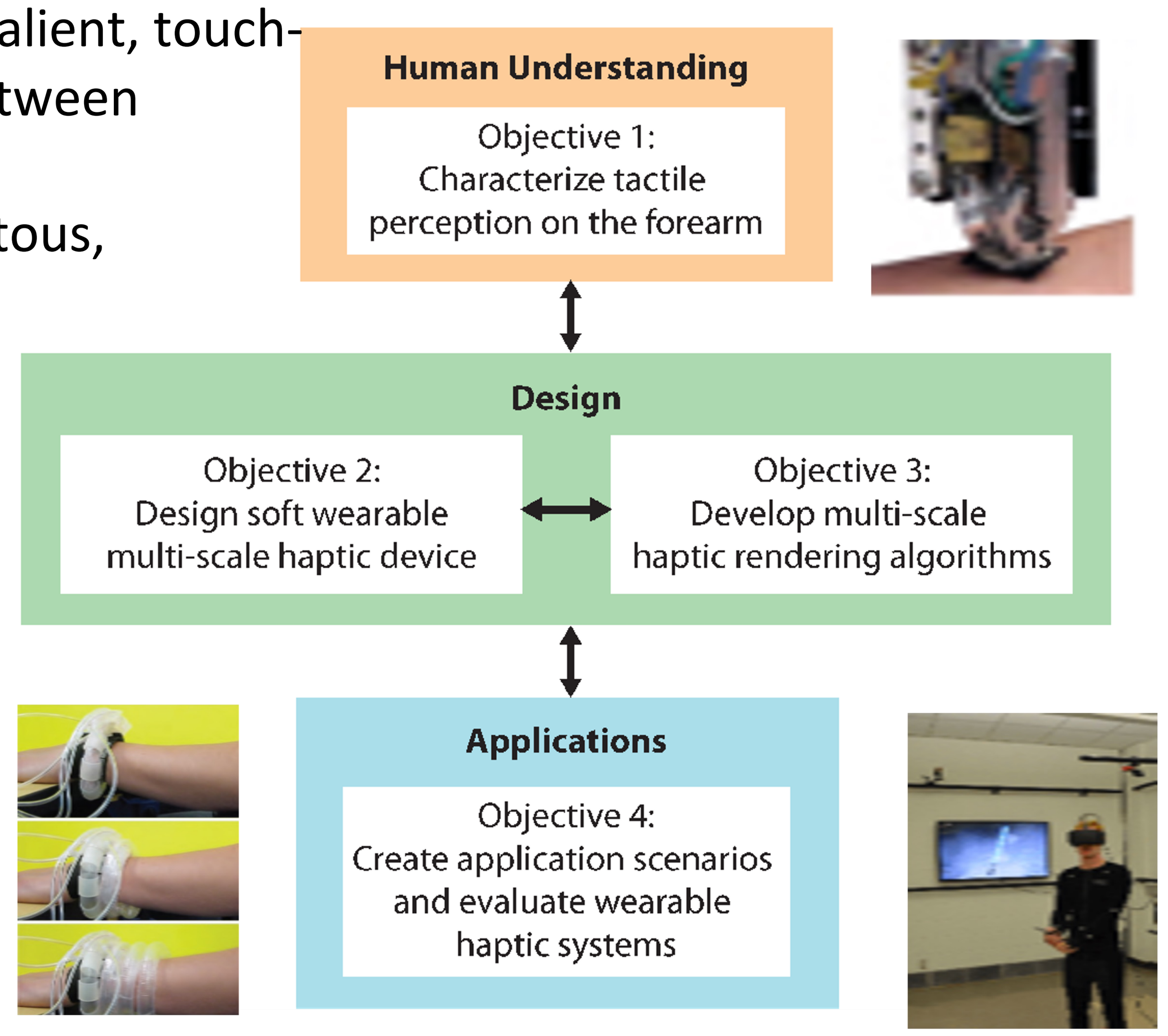
Marcia K. O'Malley
Rice University

Allison M. Okamura
Stanford University

Motivation and Objectives

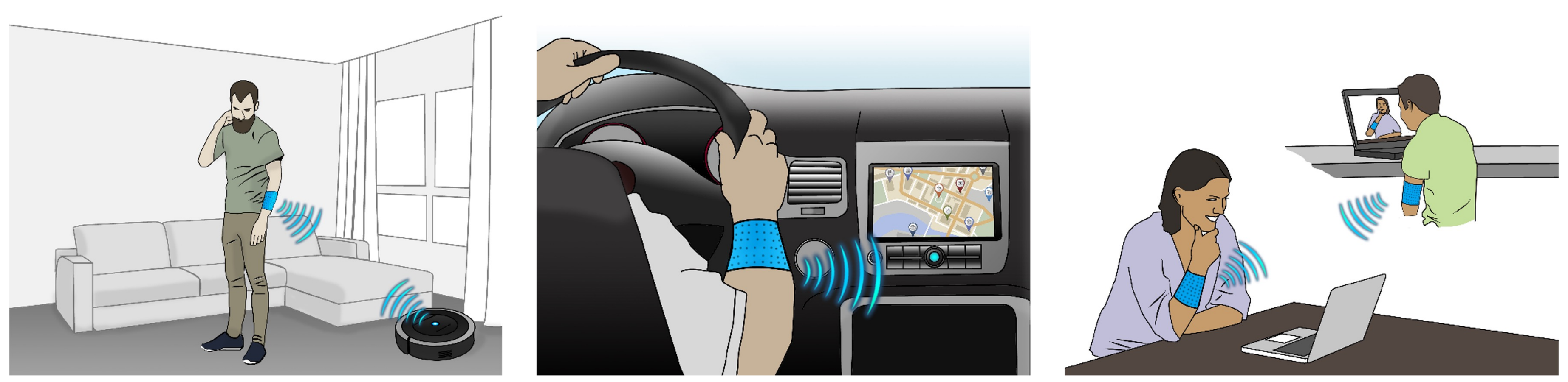
Haptic devices allow private, salient, touch-based information transfer between humans and intelligent systems. In order to be ubiquitous, the devices must be intuitive, unobtrusive, and wearable.

Our project aims to overcome the inherent trade-off between where we want to place devices for maximum wearability and where the skin exhibits the highest density of touch receptors.



Broader Impacts

Haptic Devices offer a wide range of potential applications, including communication between:



Humans and Robots | Humans and Agents | Humans and Humans

This communication will improve human health and quality of life by facilitating safe and efficient human-machine interactions, guidance and feedback, and aging in place.

Our project is broadening participation in STEM through haptics education (including online teaching and outreach programs), mentorship of a diverse population of students, and focus on making technology accessible to a wide variety of users.

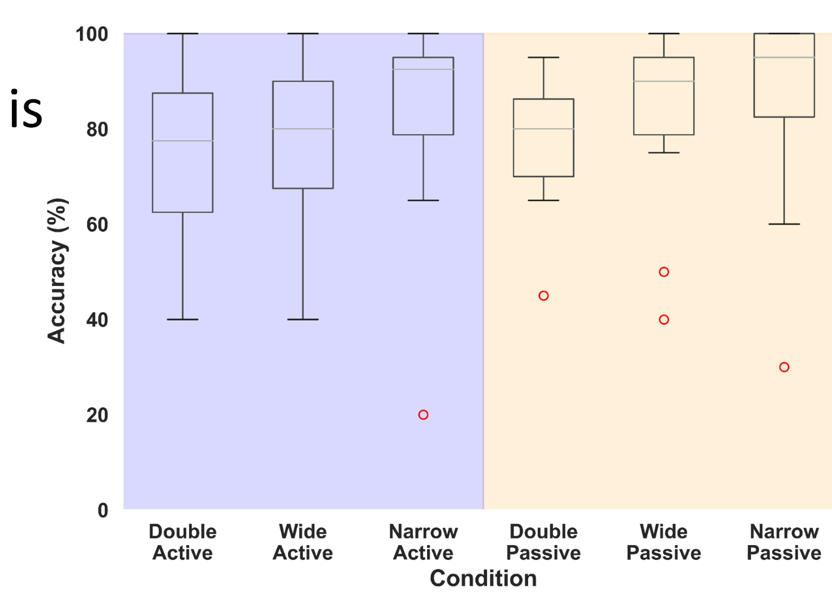
Research Activities and Results

Assessing perception of multi-sensory cues with Snaptics

- Snaptics[1] (snaptics.org) is an open-source, low-cost platform for accessible prototyping of haptic devices
- Modules offer vibration, stretch, and twist cues with untethered, battery-powered operation
- Human-subjects evaluation showed that a wearable made of Snaptics modules could deliver perceptually distinct cues to users[1]

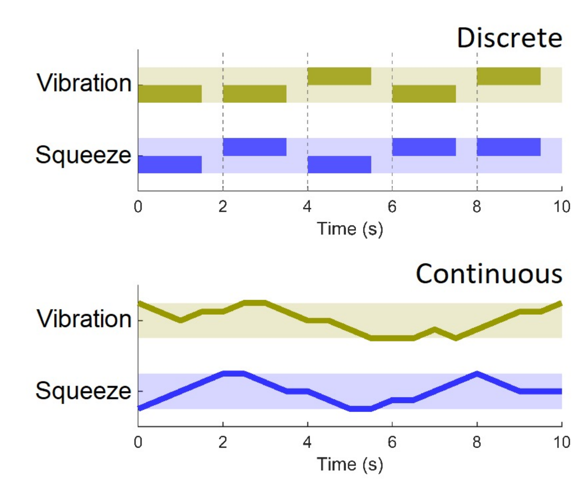
Perception of tactile sequences

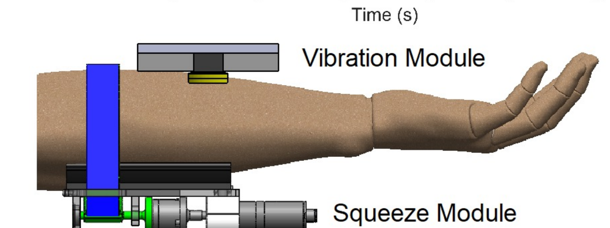
- Perception of tactile sequences is affected by focus direction user agency over feedback[2]



Can users accurately perceive multi-sensory cues that are continuous rather than discrete?

- Unlike with discrete cues, masking is not observed when users are asked to perceive continuously presented squeeze and vibration cues

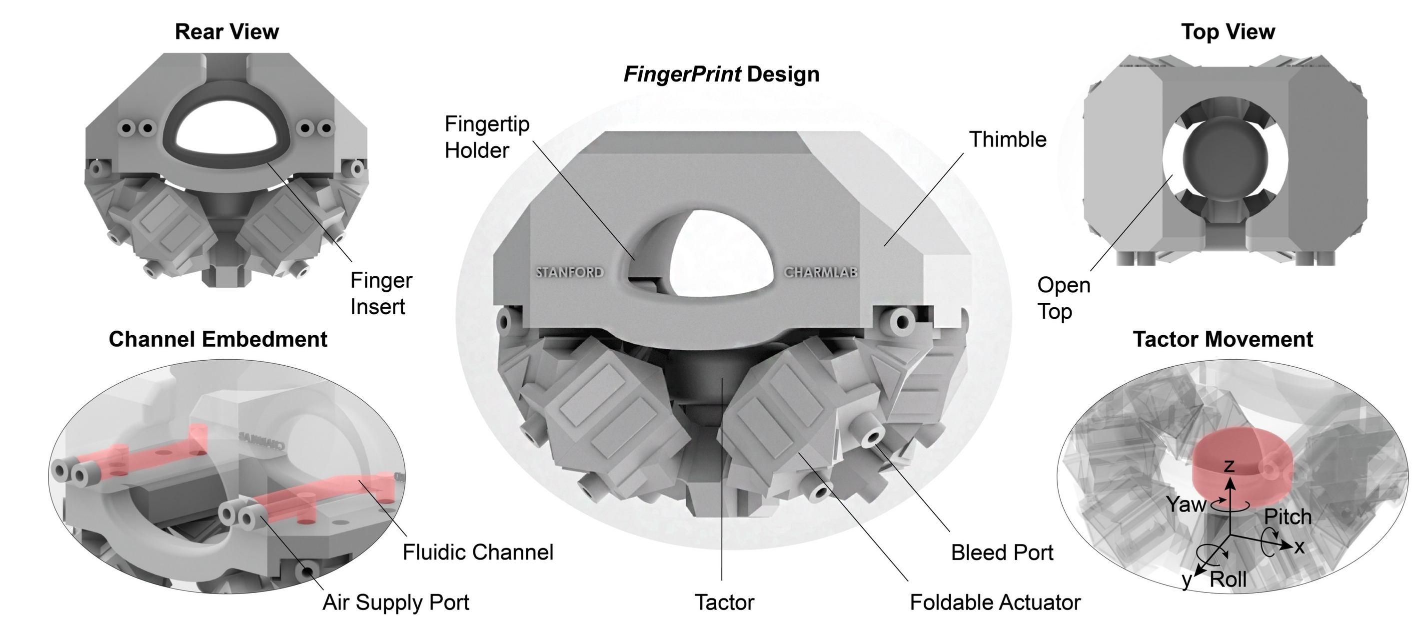




[1]**Z. A. Zook, O. O. Ozor-Ilo, G.T. Zook, and M. K. O'Malley.** (2021) Snaptics: Low-Cost Open-Source Hardware for Wearable Multi-Sensory Haptics. *IEEE World Haptics Conference*, 925-930.
[2]**Z. A. Zook and M. K. O'Malley** (2022) Effect of Focus Direction and Agency on Tactile Perceptibility. Proceedings of the Eurohaptics Conference (to appear)

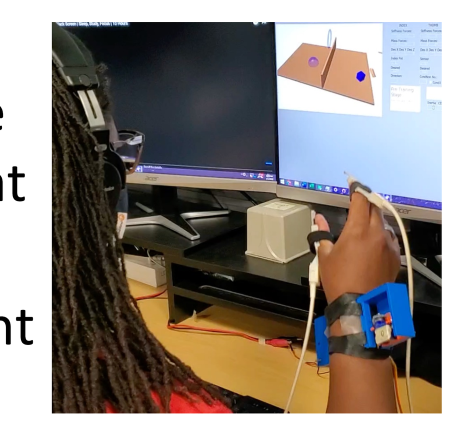
3-D Printed Soft Wearable Haptics

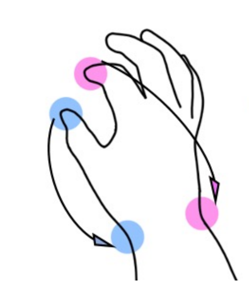
Using a combination of soft material robotics and origami robotics techniques, we developed a 3-D printed wearable haptic device called FingerPrint[3]. It displays 4 degrees of freedom of haptic feedback (normal force, twist, and 2 degrees of freedom of shear) in a compact form factor.



Mapping Fingertips to Wrist

Haptic feedback to the wrist can communicate information that would normally be received at the fingertips, such as during manipulation of virtual objects[4]. We found that several different mappings can successfully communicate realistic forces from a virtual environment, but users prefer congruent mappings[5,6], e.g. with the index finger is mapped to the dorsal side of the wrist, and the thumb is mapped to the ventral side.





[3]**Z. Zhakypov and A. M. Okamura (2022)** FingerPrint: A 3-D Printed Soft Monolithic 4-Degree-of-Freedom Fingertip Haptic Device with Embedded Actuation. In Int'l. Conf. on Soft Robotics (RoboSoft), In Press.
[4]**M. Sarac, T. M. Huh, H. Choi, M. R. Cutkosky, M. Di Luca, and A. M. Okamura (2022)** Perceived Intensities of Normal and Shear Skin Stimuli using a Wearable Haptic Bracelet. IEEE Robotics and Automation Letters, In Press.
[5]**M. Sarac, M. di Luca, and A. M. Okamura**, Perception of Mechanical Properties via Wrist Haptics: Effects of Feedback Congruence, Submitted.
[6]**J. E. Palmer, M. Sarac, A. A. Garza, and A. M. Okamura** (2022) Haptic Feedback Relocation from the Fingertips to the Wrist for Two-Finger Manipulation in Virtual Reality, Submitted.

2022 NRI & FRR Principal Investigators' Meeting
April 19-21, 2022

RICE | mahi Mechatronics and Haptic Interfaces Lab | Stanford University | charmlab

Award ID#: 1830163, 1830146