Intuitive, Wearable Haptic Devices for Communication with Ubiquitous Robots

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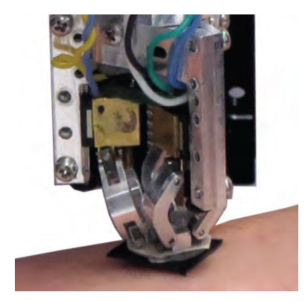
Motivation and Objectives

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.

Human Understanding

Objective 1: Characterize tactile perception on the forearm



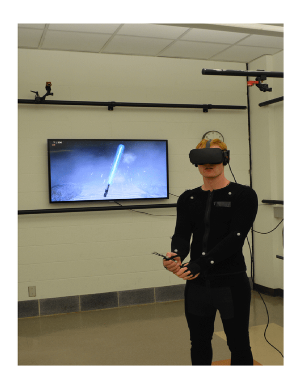
Design

Objective 2: Design soft wearable multi-scale haptic device

Objective 3: Develop multi-scale haptic rendering algorithms

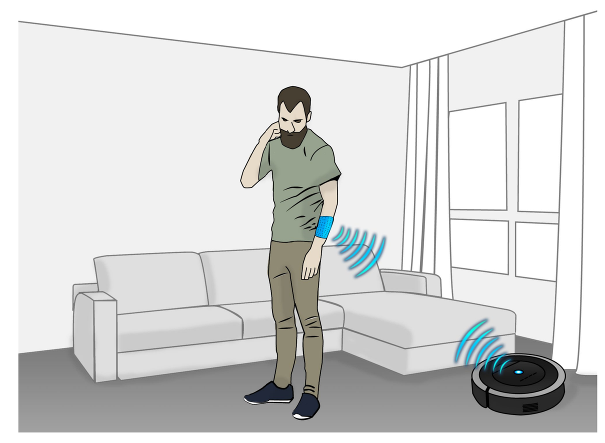
Applications

Objective 4: Create application scenarios and evaluate wearable haptic systems

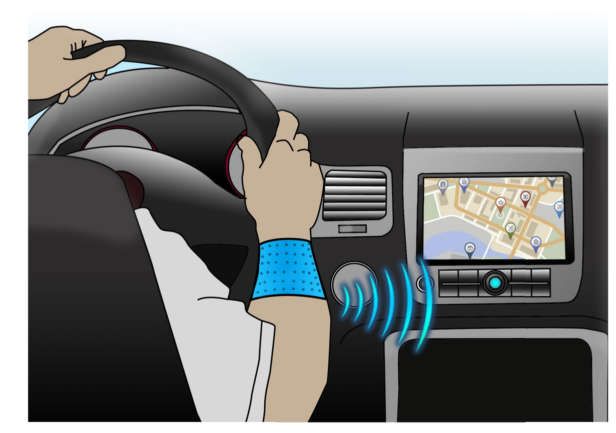


Broader Impacts

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



Humans and Robots



Humans and Agents

Humans and Humans

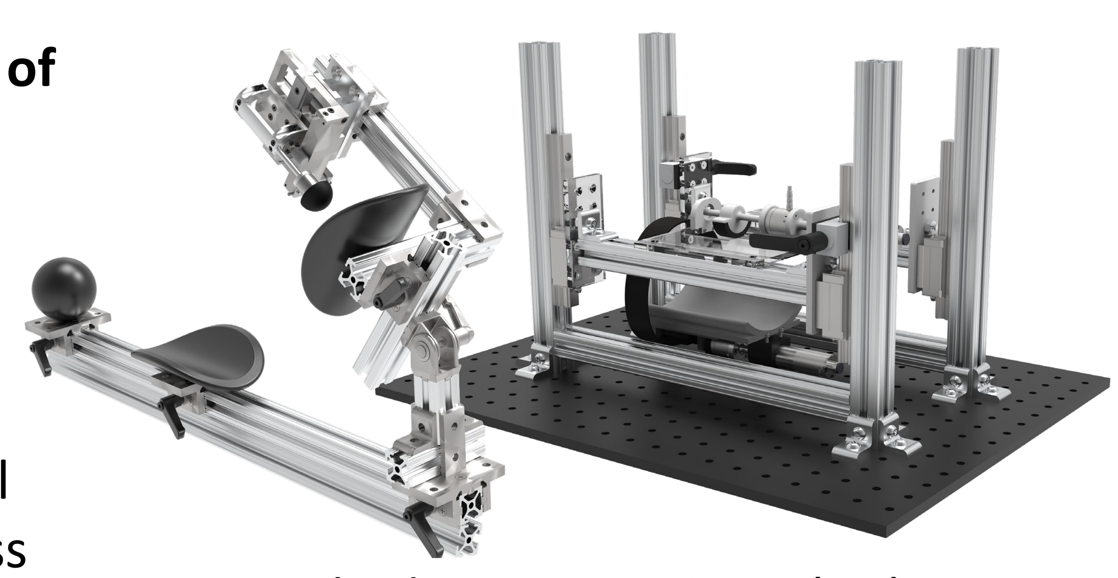
This communication will improve human health and quality of life by facilitating safe and efficient human-machine interactions, guidance and feedback, and aging in place.

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

Testbeds for Assessing Perception of Cutaneous Cues[1]

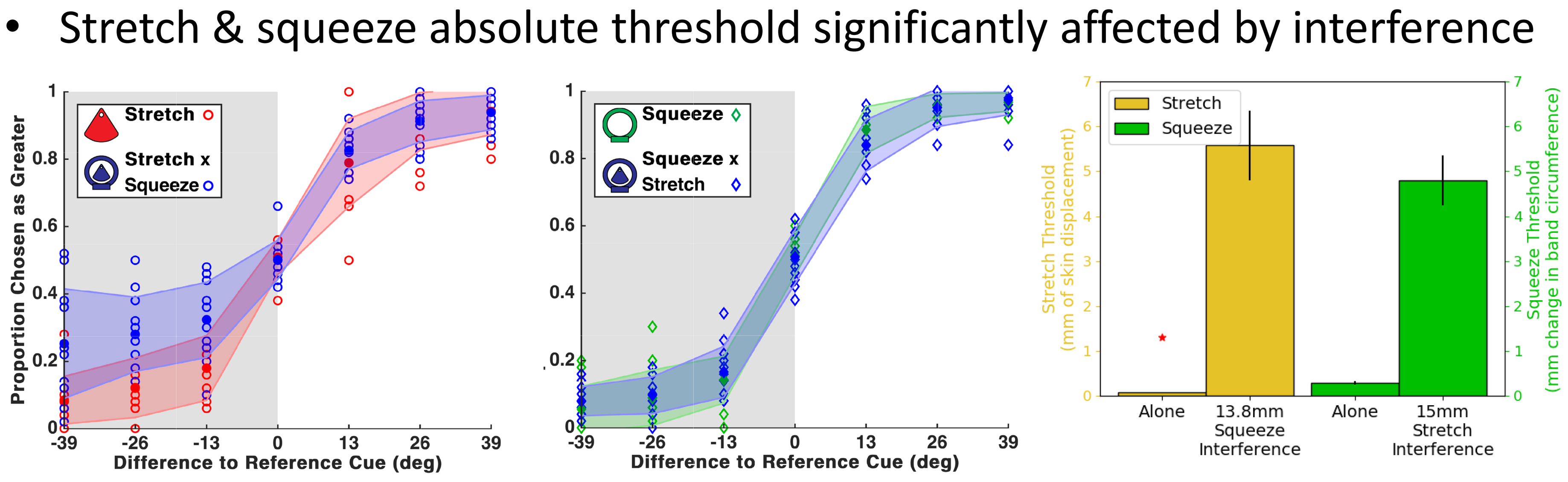
- Developed AIMS (Adjustable Instrumented Multisensory Stimuli) Testbed to flexibly test and compare haptic cues
- Developing PHD (Psychophysical Haptics Device) testbed to assess the impact of forces and surface area on tactile sensitivity



PHD Testbed AIMS Testbed

Psychophysical Testing Results[2]

- Stretch JND significantly affected by squeeze interference
- Squeeze JND is not affected by stretch interference
- Stretch & squeeze absolute threshold significantly affected by interference



Applications of Wearable Haptics[3]

- TASBI (Tactile And Squeeze Bracelet Interface) - Multisensory squeeze and vibration for virtual interactions in AR/VR
- Syntacts - Open-sourced software/hardware framework to simplify vibrotactile haptics

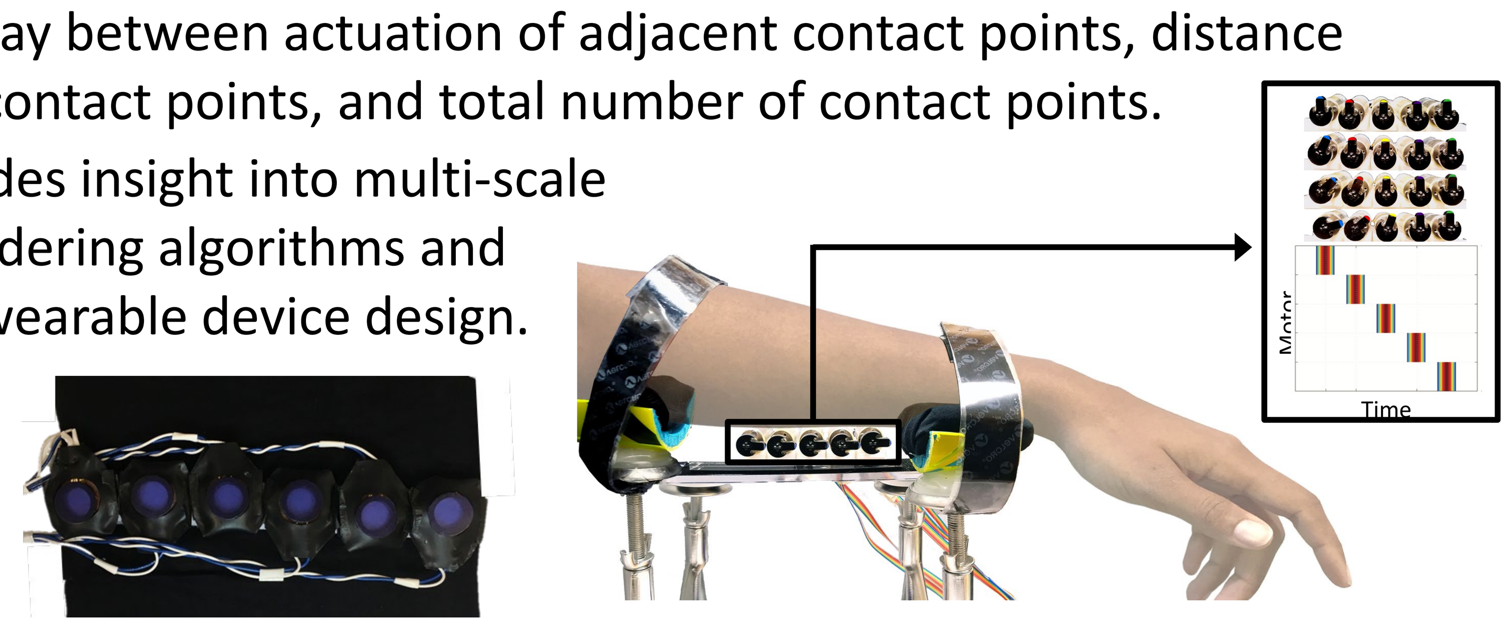
[1]**J. J. Fleck, Zook, Z. A., Tjandra, T. W., and M. K. O'Malley.** (2019) A Cutaneous Haptic Cue Characterization Testbed. *IEEE World Haptics Conference*. 319-324.

[2]**Z. A. Zook, J. J. Fleck, T. W. Tjandra and M. K. O'Malley.** (2019) Effect of Interference on Multi-Sensory Haptic Perception of Stretch and Squeeze. *IEEE World Haptics Conference*. 371-376.

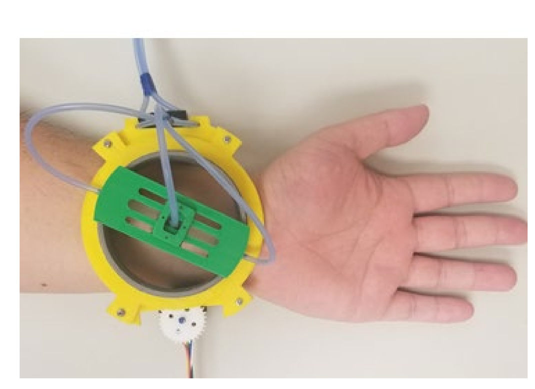
[3]**E. Pezent , A. Israr, M. Samad, S. Robinson, P. Agarwal, H. Benko, & N. Colonnese**. (2019) Tasbi: Multisensory Squeeze and Vibrotactile Wrist Haptics for Augmented and Virtual Reality. *IEEE World Haptics Conference* 1-6.

Use of Haptic Illusions for Tactile Stroking[1, 2]

- We characterized the perceived sensation from adjusting actuation speed, delay between actuation of adjacent contact points, distance between contact points, and total number of contact points.
- This provides insight into multi-scale haptic rendering algorithms and effective wearable device design.



3-DoF Wearable Haptic Device[3]



- We use soft actuators for linear motion and a DC motor for rotation.
- The device delivers normal, shear, vibration, and torsion feedback cues.

Simultaneous Vibrations Delivered to the Forearm and Fingertips[4]

- We investigate effects of simultaneous vibrations from a wearable device to both the fingertips, forearm, and fingertips and forearm together.
- This allows us to quantify the effects of body-mounting haptic devices with vibration stimuli.

[1]**C. M. Nunez, S. R. Williams, A. M. Okamura, and H. Culbertson** (2019) Understanding Continuous and Pleasant Linear Sensations on the Forearm from a Sequential Discrete Lateral Skin-Slip Haptic Device. *IEEE Transactions no Haptics*, 12(4):414-427.

[2]**C. M. Nunez, B. N. Huerta, A. M. Okamura, and H. Culbertson** (2020) Investigating Social Haptic Illusions for Tactile Stroking (SHIFTS). *IEEE Haptics Symposium*, Accepted.

[3]**K. T. Yoshida, C. M. Nunez, S. R. Williams, A. M. Okamura, and M. Luo** (2019) 3-DoF Wearable, Pneumatic Haptic Device to Deliver Normal, Shear, Vibration, and Torsion Feedback. *IEEE World Haptics Conference*, 97-102.

[4]**S. R. Williams and A. M. Okamura** (2019) Display of Simultaneous Vibrotactile Rhythms on the Fingertips and Forearm. *IEEE World Haptics Conference*, Work-in-progress paper.

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