Intuitive, Wearable Haptic Devices for Communication with Ubiquitous Robots

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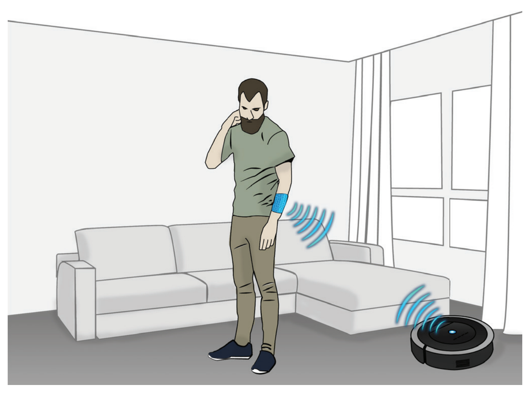
Motivation

Haptic devices:

- Allow private, salient, touch-based information transfer between humans and intelligent systems
- Must be intuitive, unobtrusive, and wearable to be ubiquitous
- Offer a wide range of potential applications, including communication between:



Human & Robots

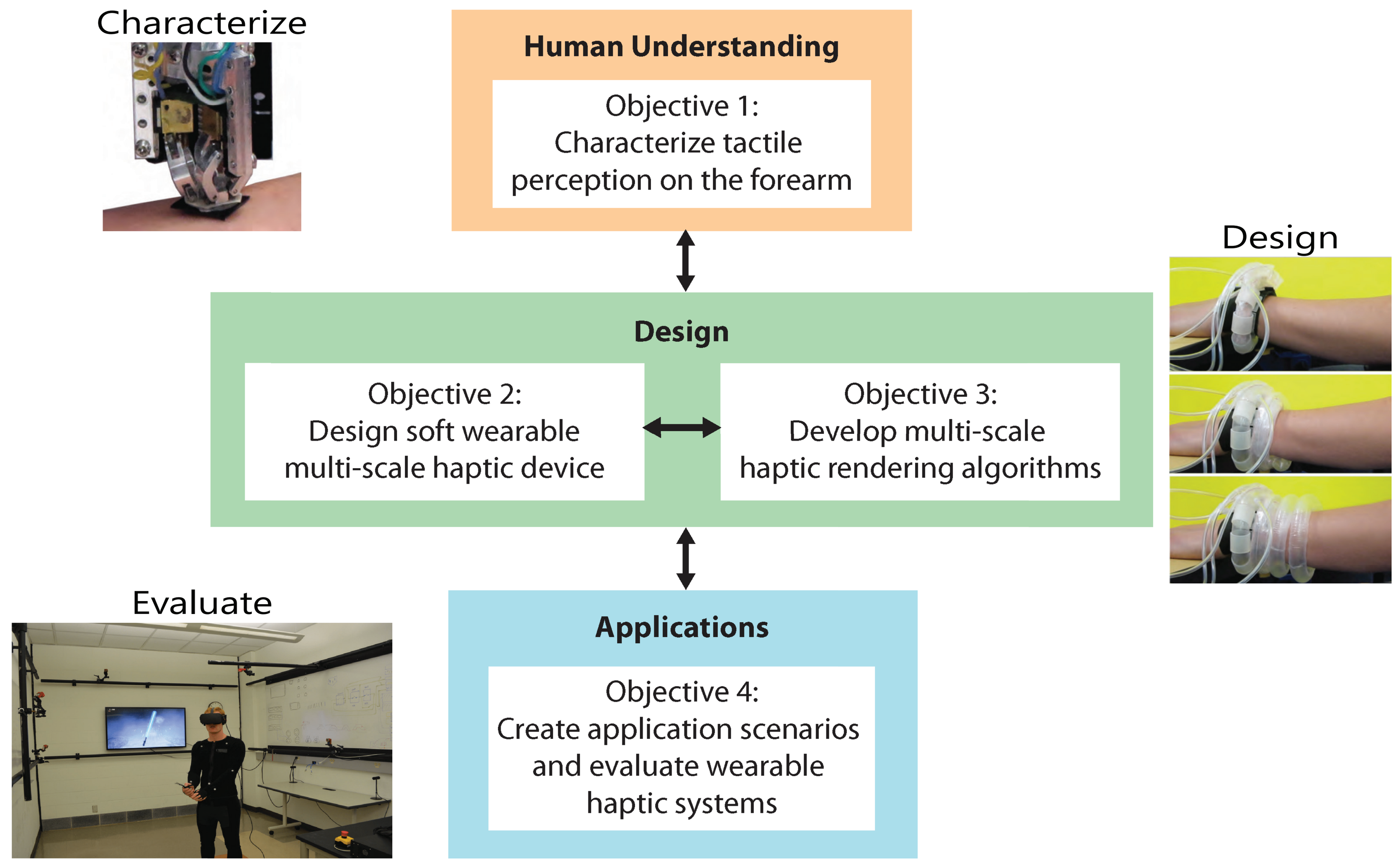
Human & Virtual Agents

Human & Humans

- Information transmission via touch is limited by location and distribution of human mechanoreceptors
- Many haptic devices are designed to be worn at the fingertips, which have a very high density of mechanoreceptors, yet these devices preclude the natural use of the hands

Objectives

This research effort 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

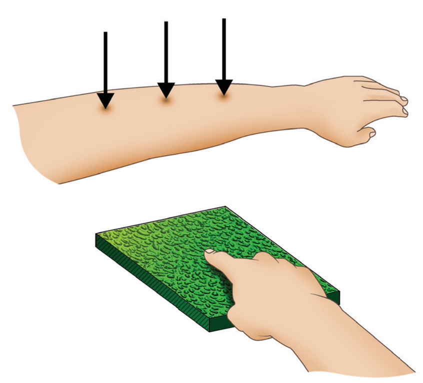


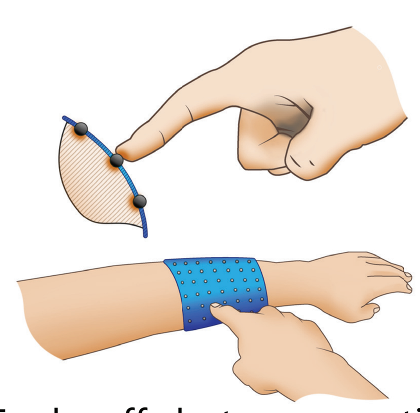
Approach

To achieve this vision of rich, natural, and effective communication, we propose soft wearable haptic devices that are mounted on the arm. We will consider:

Mechanoreceptor density on glaborous skin on the hand & hairy skin on the arm

Passive touch in contrast to active exploration

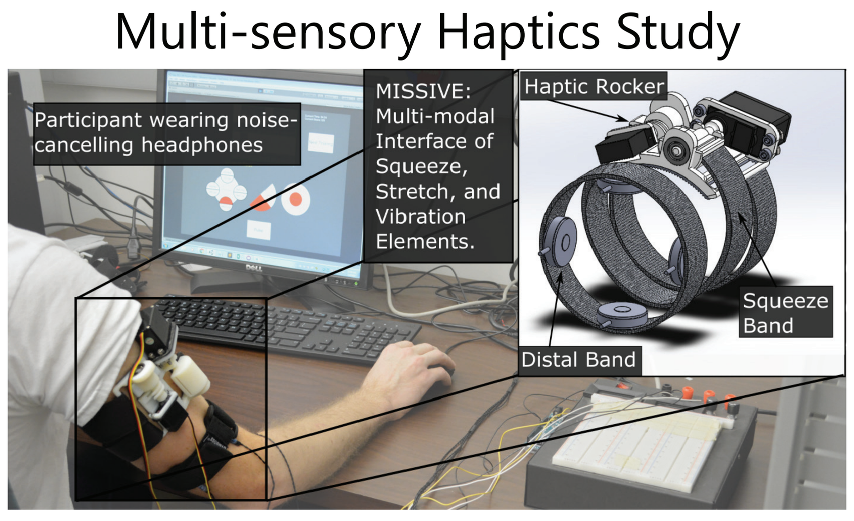




Trade-offs between spatial distribution & multi-modal haptics

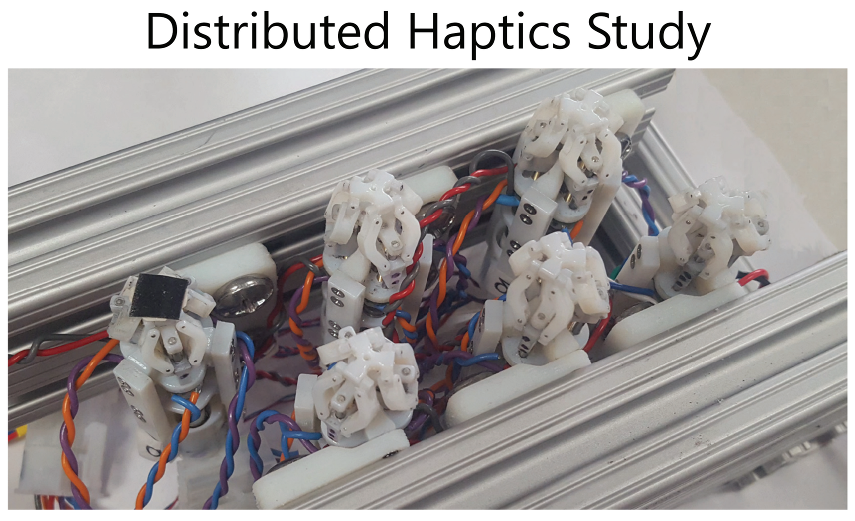
We will investigate tactile simulation on the arm in two scenarios:

Multi-sensory Haptics Study



MAHI Lab MISSIVE Wearable Device

Distributed Haptics Study



CHARM Lab Tactor Testbed

Research Plan

Characterization

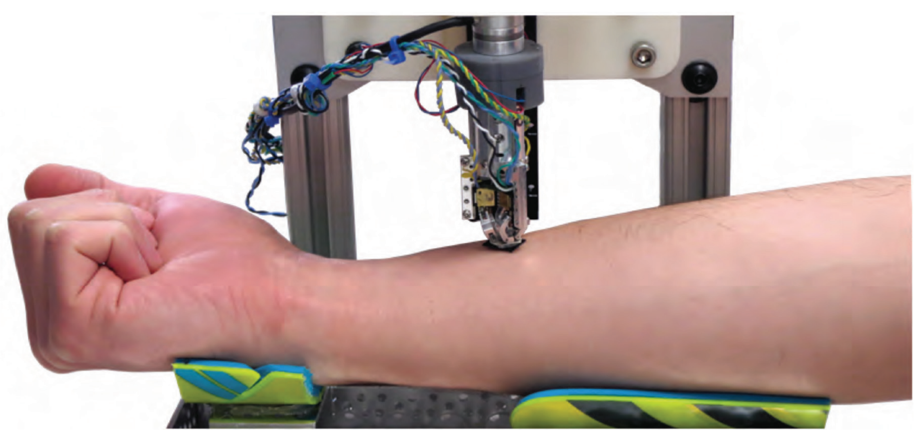
Psychophysical studies are needed to rigorously quantify human perceptual capabilities. Thus, we take a two-pronged approach to define requirements for tactile stimulation on the arm.

1) Understand perception of co-located multi-modal haptic feedback on the arm:

	Stimulus & Conditions		Measurements
Multi-Modal	Vibration	4 radially distributed tactors	Absolute threshold
	Radial squeezing	Binary on-off	Just noticeable difference
	Stretching	null, clockwise, counterclockwise	Information transfer (IT)
	Temporal pattern	150 to 350 msec pulses	Open response
	Spatial pattern	single- and multi-modality	
Distributed	Spacing	Center-to-center distance of 2-4 cm	Absolute threshold
	Tactor contact Area	0.5 to 1 cm diameter circles	Just noticeable difference
	Deformation direction	8 directions at 45° intervals	Continuity (Likert scale)
	Deformation magnitude	0.1 to 4.0 N (normal and tangential)	Open response
	Temporal Pattern	Determined by pilot	

Dimensions of tactile display/perception to be studied. Combinations of these individual dimensions will also be tested

2) Investigate perception while varying spatial and temporal distribution of haptic feedback on the arm:

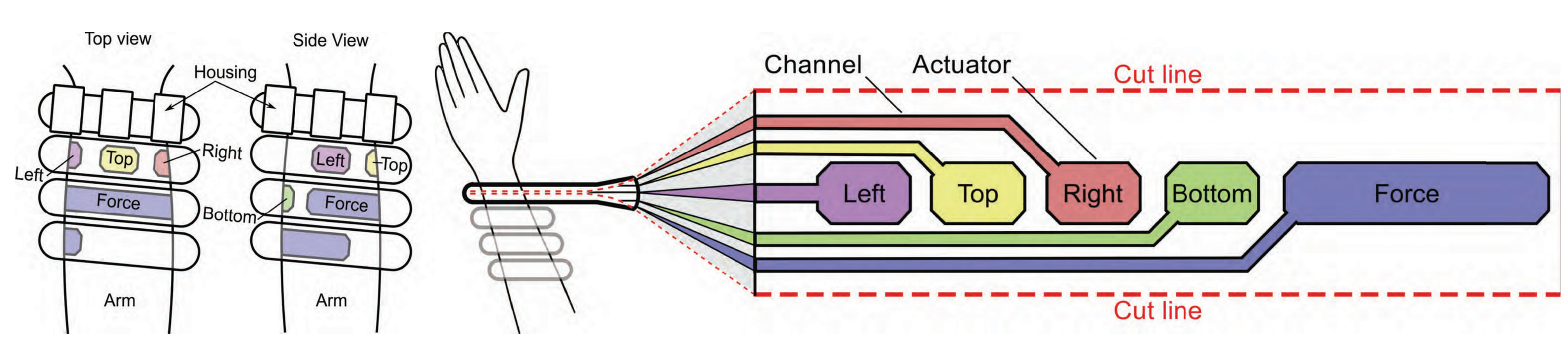


A prototype device to develop tactor array design & perform preliminary direction discrimination tests

MISSIVE device capable of providing skin stretch, pressure & vibrotactile feedback

Design

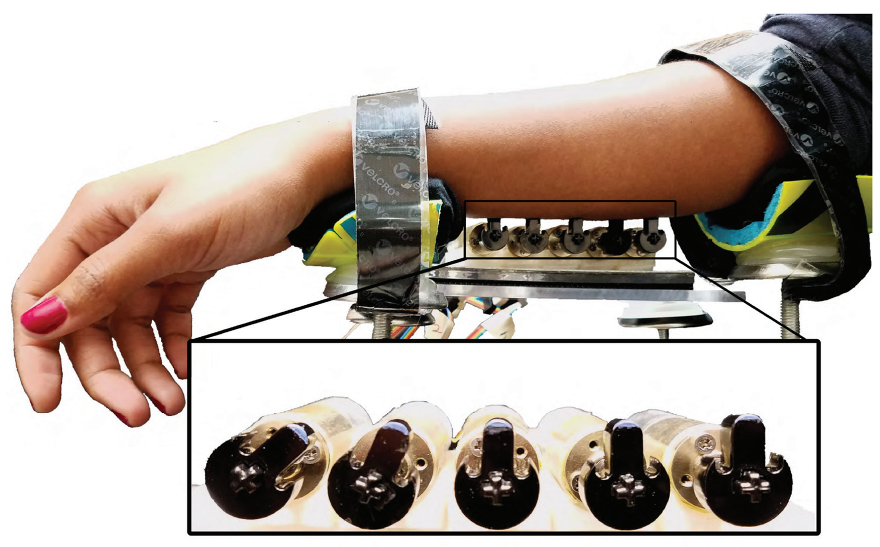
Proposed soft pneumatic array will have multi-sensory haptic display elements: vibration, radial squeezing, and stretching



The design of the CHARM Lab HapWRAP. Pneumatic pouches can be inflated to provide directional cues & squeezing force is provided by a 22cm long WRAP tube

This device will be controlled using multi-scale haptic rendering algorithms based on our investigations into:

- Temporal and spatial patterns on the skin
- Passive sensing and active exploration
- Application scenarios and testing evaluations



Haptic rendering with 1-D array conducted with CHARM Lab sequential forearm skin slip device

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