Pitch #1

Perception of Multiple Pressure Contacts for an Arm-worn Haptic Sensory Prosthesis

(Alternate titles: for “Arm-worn Haptic Devices”, “Wearable Haptic Sensory Prosthesis”)

* Doings lots of perceptual tests on the arm with 2 points, helpful to inform future wearable haptic devices for a broad range of applications

Pitch #2

Perception of Multiple Pressure Contacts for a Wearable Proprioception Prosthesis

(Alternate titles: for a ….” Haptic Proprioception Prosthesis” or “(Intuitive) Proprioceptive Feedback”)

* Explicit focus on piezo2, deep pressure and proprioception restoration

Abstract

A host of medical conditions, including amputations, diabetes, stroke, and genetic disease, result in loss of touch sensation. Because most types of sensory loss have no pharmacological treatment or rehabilitative therapy, we propose a haptic sensory prosthesis that provides substitutive feedback. The wrist and forearm are compelling locations for feedback due to available skin area and not occluding the hands, but have reduced mechanoreceptor density compared to the fingertips. Focusing on localized pressure as the feedback modality, we hypothesize that we can improve on prior devices by using multiple points of pressure to provide valuable spatial and directional information as well as invoke a wider range of stimulus intensity via spatial summation, the cumulative perceptual experience from multiple stimuli. We conducted a battery of perceptual tests to characterize appropriate pressure intensity range and resolution for multiple points of pressure and evaluate

~~Additionally, differential pressure stimuli that engage underlying muscles can produce intuitive, directional cues.~~

// higher intensities and stimulating muscles allow for summative and cohesive interpretation of stimuli

to differential and directional

// And deep pressure that engages musculoskeletal system

1. Introduction

* Prevalence of loss of touch and its impacts. Elaborate on specific case for PIEZO-2 LOF. Motivates Need for Sensory Prostheses
* Previous work on haptic sensory prostheses, sensory substitution, wearable haptic feedback, deep pressure feedback. Wearable Haptic Feedback
* Spatial summation, lateral inhibition, open questions. Potential with spatial summation on a wearable.
* Aim 1
* Aim 2(?)

1. System Design and Setup

Wearable device design, force and position, Experimental Device and Setup

Software interface for user to interact with tests

1. Experimental Methods / Experiments / Tasks / Tests
   1. methods ought to account for fatigue and not restricting blood flow
   2. Evaluate spatial summation at light, moderate, deep pressure
      1. From previous work, at the same intensity, juxtaposing JND with 1 or 2 points reveals if summative or inhibitive effects are occurring
      2. To identify light moderate deep pressure per subject, first ASR
      3. JND at 3 quartiles, 1 and 2 points. Randomize order of 1 and 2 (alternative to quartiles, can use definition or guidance from NIH manuscript)
   3. Ordering pairs of stimuli on a continuum: magnitude
   4. Additional tests for directional / spatial (?)
      1. Idea #1: for each the pairs of stimuli, order intensity on continuum and ask folks to match each pair to a drawing that matches most:  
          o o, C\_\_\_\_\_ D, o o, C\_\_\_\_\_ D,
      2. Idea #2: do the ordering pairs with the devices next to each other and farther apart.
      3. Idea #3: for the pairs of stimuli, do separate continuums for light and deep touch
   5. Follow-up on previous study with virtual arm: mini version with no haptic feedback, maybe 1 pt before, 2 pt differential directional feedback, 2 point summative
      1. What mapping(s)
      2. Should I see if wider intensity range from 2 points alone helps with 1 dof task?

*“to stimulate two separate sets of receptors, but still evoke perception of a single site of stimulation (Greenspan et al. 1997).”* Follow up questions:

* Each poke has a spatial component and magnitude/intensity (optional: temporal)
* Is it actually perceived as a single site of stimulation or is there some spatial awareness/ differentiation/ information going on?
* Limitation of intensity continuum study is it doesn’t inquire about spatial information / differentiation. i.e. even if folks feel same magnitude of intensity, do folks feel a difference between 10 and 01 combinations? If so, folks are getting spatial information too (I guess there is spatial JND too, though not necessarily scope/interest of this paper)
  + Even if 01 and 10 feel the same, what about 21 and 12?
    - If 2 points have different nonzero magnitudes (1 light touch + 1 higher intensity), does it still feel like “a single site of stimulation” or 2 distinct independent points? what spatial information / gradient/ surface and/or direction cues is the person getting? Does spatial summation for magnitude / intensity take place (if so, what type/amount of summation is taking place)?
    - Can increasing poke 1 simultaneously decreasing poke 2 convey direction / gradient? ^v or v^ (temporal)
    - Or even 2 pokes of differing magnitude, i.e. a differential stimuli
    - Are summative and differential very different and/or opposing pitches?
    - My hunch: you can sum deep pressure magnitude/intensity across a larger area, i.e. entire muscle. Maybe even create gradient/directional cues too
    - My hunch: light touch multiple points might feel like unique separate points, more cognitive load to make sense of mapping. Whereas deep touch multiple points (near or far) stimulating the same muscle might allow for summative *and* directional cues that align more intuitively with proprioception
      * Could be summative intensity, direction, and shape/spatial:

o o o o vs oo )

oo

* If differential/directional becomes more interesting than wider range of intensity, is spatial summation the key phenomenon? Perhaps no
* Is there a way to quantify / calculate / model throughput of information from N points of pressure
  + With the JNDs, and weber fraction, can guestimate how many distinct distinguishable levels of pressure at a single point

1. Results and Discussion

References