4-12-2024

How Adjusting Surface Electrode Voltages Affects Referred Sensation Quality

Jeffrey Quintanilla-Flores
Hope College

Justin Egbuzie
Hope College

Marianna Urdaneta
Hope College

How adjusting surface electrode voltages affects referred sensation quality

Justin Egbuzie, Jeffery Quintinilla-Flores, Marianna Urdaneta, Dr. Katharine Polasek
Hope College Department of Engineering

Introduction

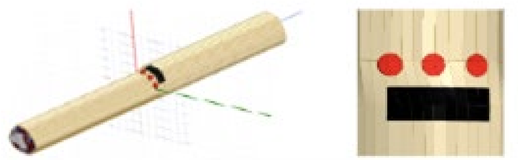
Phantom Limb Pain is the sensation of pain or discomfort in an individual's limb that no longer exists. This typically occurs when an individual undergoes an amputation, where the limb was surgically removed. It is caused by loss of sensory input and by malformations in neuron reconfiguration. So our treatment plan is to use electrical stimulation to be able to generate non-painful sensation in the phantom limb.

The goal of this summer research was to test model predicted electrode voltages and understand how each electrode contributed to the outcome.

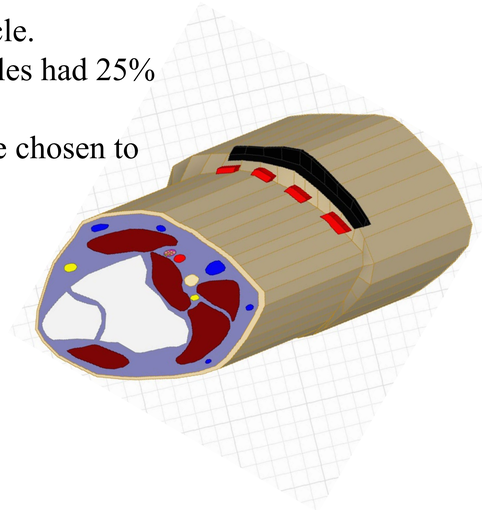
Modeling

Arm Model

- Inputs are electrode voltages on skin
- Model predicts activation in nerve (output)
- Percent of axons activated was determined for each fascicle.
- Selective activation was used to describe when 1-3 fascicles had 25% greater activation than the others.
- Electrode voltages that produced selective activation were chosen to test experimentally

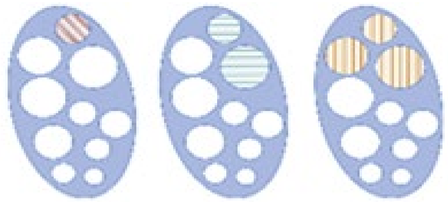


Model B (3 Electrode)



Example of Selective Activation

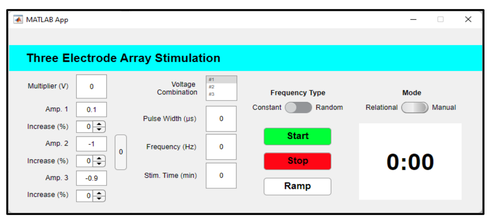
- Model predicted 418 selective combinations
  - Lots of similarity in terms of activation
- Three distinct activation were identified

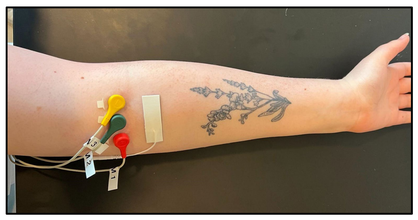


Experiment & Analysis

Experimental Setup

- Different levels of voltages were applied to each electrode.
  - Goal: To produce the most sensation without it being uncomfortable for the subject.
- Tested different electrode positions





	Electrode 1	Electrode 2	Electrode 3
1	–	–	–
2	–	–	+
3	–	+	–
4	–	+	+
5	+	–	–
6	+	–	+
7	+	+	–
8	+	+	+

– = No Change (NC)

\+ = +15%

Factorial Analysis

We used factorial analysis to apply small changes in voltages to each electrode

- Goal: Understand how each electrode contributes to sensation quality

Electrode Relationship

- We use these following heatmaps to visually see how each relationship is different
- Found a new relationship based on testing new HeatMaps

Data Analysis

- We used an ANOVA single factor analysis test

Results

- Four subjects have participated to date
- They all had similar sensations (except for one subject that gave us promising results.
- All subjects had sensation across their whole forearm, some rarely felt it across their forearm to their hand.
- Only one felt localized sensation in their hand.
- Electrode 2 has the largest impact on our results
- P-value for this analysis was 0.8 which means it's not significant
- Having only 4 subjects up to this point heavily impacts our results

Single Factor Interaction

Factor	Avg	Std. Dev	Std. Error
E1	0.03	0.23	0.115
E2	0.11	0.07	0.036
E3	0.06	0.22	0.112
Loc	0.12	0.72	0.361
Rel	-0.39	0.22	0.109

Conclusions

- Every subject has a different amount of voltages that they can handle
- Challenging to get best sensations without any contractions
- As for the future, we need to experiment with more participants
- Create new relationships that have the best results for most participants.
- Move towards testing with subjects who have amputated limbs

This material is based upon work supported by the National Science Foundation under Grant No. DUE-2029372 and Grant No. CBET-1805447.