Intro to Neural Engineering | AUT 2021

Homework 1 (10 points total)
Due Wednesday, October 13th by 3:00PM PST

Directions: Answer each question in complete sentences. All answers must fit on this page.

1. You are trying to develop a brain-computer interface (BCI) that restores motor function for a person with stroke. For your recording system, you need to decide between using electrocorticography (ECoG) or single neuron action potentials. Which of these two recording modalities would you choose? Justify your choice by briefly describing the benefits of your chosen modality over the other. **2pts**

- I would choose electrocorticography (ECoG). One reason for choosing ECoG over single neuron action potentials is because the single neuron action potentials disappear from recording electrodes over time due to glial encapsulation of electrodes. Another reason for choosing ECoG over single neuron action potentials is it is able to be chronically recorded while also having a high bandwidth/frequency.

2. You implant a Utah Array in the primary motor cortex of a non-human primate to record single neuron activity. You find that as time goes on, the signal quality diminishes until you can no longer record any of the signals. Give two reasons why this occurs, and describe how you would overcome these limitations in the future. **1pt**

- One reason this occurs is because of glial encapsulation of electrodes.
- Another reason could be an electrode failure of the insulation peeling back, which makes the impedance go down and the signal frequency also goes down (abiotic mode of failure).
- The way I would overcome these limitations in the future would be by using an even smaller electrode (less than 10 μm).

3. You are designing solutions to help people with foot drop, which commonly develops following spinal cord or peripheral nerve injury. Foot drop makes it more difficult to lift the front part of the foot, which results in uneven gait and increases the chances of tripping. One strategy to alleviate foot drop is to use electrical stimulation to activate the muscles that lift the front part of the foot during a specific phase of the gait cycle. Where would you choose to record from (central vs. peripheral nervous system) to accurately identify when to turn the stimulator on (include specific location/region)? Justify your choice by briefly describing the benefits of your choice over the other. **2pts**

- I would choose to record from the peripheral nervous system, specifically in the peripheral nerves in the leg region (like the common peroneal nerve) to accurately identify when to turn the stimulator on. The common peroneal nerve in the leg would give us access to the activity in foot (especially the front part). I would choose the peripheral nervous system over the central nervous system because it is very difficult to record chronically from the spinal cord since it moves around and there are the bones around it so it is difficult to record for more than a few minutes. Another reason why I would choose it is because it has less of an immune response than the central nervous system.

4. Coding and Dataset Analysis

Directions: Please submit your answers to the following questions and attach the code you used to answer these questions. We have provided some starter code to help you get started with this assignment.

Direct electrical stimulation can be used to activate neural populations for a variety of applications, one of which is to provide artificial haptic feedback (sense of touch) by stimulating the primary somatosensory cortex, known as S1. In one experiment, researchers would either tap the subject's finger with a touch probe, or electrically stimulate S1 to artificially evoke a similar sense of touch. The patient was then asked to push a button when they felt a touch sensation. The goal of this coding assignment is to compare the reaction times between the real vs. stimulated touch sensations.

The provided dataset includes:

- button - a vector containing the button press signal, in samples
- t_estim - vector of when electrical stimulation was delivered, in seconds
- t_probe - vector of when touch probe stimulation was given, in seconds
- fs - sampling frequency

Questions:

1. How many times was electrical stimulation and touch probe stimulation given, respectively? 1pt
    - electrical stimulation: 60 times
    - touch probe stimulation: 37 times
2. How many total button presses occurred? 1pt
    - # of total button presses: 97 presses
3. What is the average reaction time of electrical stimulation and haptic touch respectively? 1pt
    - Average reaction time of electrical stimulation: 0.2463938381025727 seconds
    - Average reaction time of haptic touch: 0.052088480863425185 seconds
4. Plot a histogram of the reaction times of the two conditions (estim vs. touch) in the same plot with appropriate labels. 2pts