CSE 599E

Lecture 3:
Recording/Stimulation Techniques

What’s on the menu?

- Recording and Stimulation Techniques
  - Invasive
  - Semi-Invasive
  - Non-Invasive
Components of Brain-Computer Interfacing

Invasive Recording

Intracellular Recording at the Soma

Extracellular Recording near the Soma
Intracellular Recording using Patch Clamp

Extracellular Recording using Multielectrode Arrays

Array of silicon electrodes with platinum-plated tips

(Work of Andersen & colleagues, Caltech)
From Spikes to Firing Rate

Extracellular spike train

- Rectangular Window (100 ms)
- Sliding Window (100 ms)
- Gaussian Window ($\sigma = 100$ ms)
- Causal Window ($1/\alpha = 100$ ms)

From Firing Rates to Tuning Curves:
Tuning Curve of a Neuron in Primary Motor Cortex (M1)

Spike trains as a function of hand reaching direction

Cosine Tuning Curve

Preferred direction
Movement Direction can be Predicted from a Population of M1 Neurons’ Firing Rates

Population vector = sum of preferred directions weighted by their firing rates

Actual arm movement direction

Population vectors (decoded movement direction)

Actual arm movement direction

Somatotopic Organization of M1 (a.k.a. the “homunculus”)
Semi-Invasive Recording

Electrocorticography

(photo courtesy Seattle Times)
Optical Imaging

- Oregon Green calcium sensitive dye stained neurons
- Transgenic mouse expressing green fluorescent protein (GFP) in a subpopulation of neurons

Non-Invasive Recording
Electroencephalography (EEG)

Measures electrical fluctuations caused by post-synaptic potentials from thousands of neurons oriented radially to scalp

- Tens of microvolts range
- Poor spatial resolution (cm$^2$)
- Good temporal resolution (ms)

Example of EEG Oscillatory Potentials

- Beta (13-30 Hz)
- Alpha (8-13 Hz)
- Theta (4-8 Hz)
- Delta (0.5-4 Hz)
Magnetoencephalography (MEG)

Measures magnetic fields produced by activity of thousands of cortical neurons oriented perpendicular to the cortical surface

- Magnetic fields not distorted by skull and scalp
- Better spatial resolution than EEG
- Expensive and bulky

Functional Magnetic Resonance Imaging (fMRI)

- Measures changes in blood flow due to increased activation of neurons in an area
- Relies on paramagnetic properties of oxygenated and deoxygenated hemoglobin in the blood
- Produces images showing blood-oxygenation-level-dependent signal changes (BOLD)
Example fMRI Images (word reading task)

Functional Near-Infrared Spectroscopy (fNIR)
Stimulation

Extracellular Microelectrodes

- Examples: Cochear implant, DBS
Microstimulation can alter decision making

(Hanks et al., 2006)

Transcranial Magnetic Stimulation (TMS)
Next Class:  
Signal Processing and 
Machine Learning for BCI