Introduction to the assignment

Over the next few weeks, we're going to learn about and contemplate an emerging technology that involves using EMG sensors to detect facial expressions. In this case, a person could wear sensors on their face. When they make a facial expression, the muscle activation is detected by the sensors. The signal from this is analyzed and an estimation is made about the expression.

Here's the suggested way to go through this week's assignment:

1. Read through this entire document.
2. Write yourself a note about what you learning goals and/or desired behaviors are for this week (in the context of this class)
3. Sign up as working on Option A, Option B, or both. Note whether you prefer to work independently or collaboratively.
    a. If you prefer to work collaboratively, please reach out to others interested in the same. We'll try to do sign-up at the end of class, so that people can coordinate quickly.
4. Read the two papers on emotion recognition in EMG (see Part 1). You don't need to understand the details of the papers, just read through them quickly for context and exposure to one way of thinking about this.
5. Work on Option A or Option B (or both if you want in whatever ratio or configuration that makes sense with your other commitments and interests).
6. Write a reflection on your learning goals and/or intended behaviors (noted at the beginning of the week). Submit this on Canvas in this assignment.
    a. You are also welcome to submit other documentation if you like to use Canvas as a record or you want me to look at something.
    b. **For your reflection, please discuss**:
        i. What were your initial goals (that you set at the beginning of the week)? How well did you progress toward them? How did they change (if applicable)?

ii. What did you do for neurotech this week (what did you work on)? You don't need to break down each piece of the assignment into extreme detail, but it would be helpful to hear something like: "I read both of the suggested papers and took notes for class discussion. Then I worked on the data analysis part of the assignment because I want to build these skills. I made it through the book chapter with the example dataset. I started to work with the fEMG data set and was able to make the time series plots, but I ran out of time before I could do the statistical comparison part."
iii. What is one thing that you learned this week?
iv. What did you like about this assignment, and/or what suggestions do you have to improve the assignment?
v. What did you like about how you engaged this week and/or what would you like to change next week?

General commentary on assignment

You are welcome to collaborate on any parts of this assignment (might be more fun, but adds schedule complexity).

You should try to spend an appropriately scaled amount of time on this work to support your learning (recognizing that you may need to scale down your overall work time due to other obligations). You don't need to finish everything. Do what's right for your learning and your physical and mental health.

This is about learning, making connections, and having fun. While we're working on a specific example here, this type of contextual thinking and general analysis process are used for lots of areas. If you're having trouble connecting this to other things, talk to Sam.

If you're feeling stressed about this assignment or the flexibility, feel free to reach out to Sam (Zoom chat is probably the easiest).

Part 1 (everyone does this so we're all on the same page)

Read these two papers that provide some information about attempts to classify facial expressions and/or emotions using EMG. You can add comments/questions on the shared doc via google comments if you want.

This paper provides an overview of emotion categorization and the classification process. Don't worry about the details.

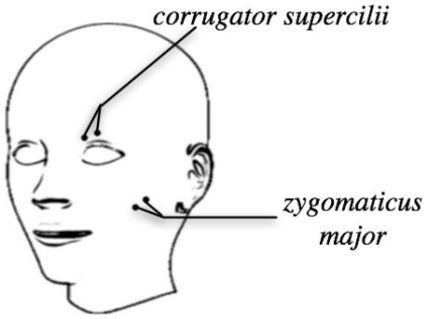
Jerritta, S., et al. "Physiological signals based human emotion recognition: a review." 2011 IEEE 7th International Colloquium on Signal Processing and its Applications. IEEE, 2011. (Links to an external site.)

This paper talks most about the overall classification process and steps in feature selection. You don't need to deeply understand the math or the details of the signal processing or feature selection. This is just intended to give an example of the general process used in this kind of work. This paper uses 3 neural networks instead of other types of machine learning like support vector machines or linear discriminant analysis. You can just consider the neural networks to be a black box classifier. Also, the fonts are oversized in figures 3-5, blocking part of the figure. These figures are just intended to show the structure of the neural networks and you can ignore them.

Mithbavkar, Shraddha Atul, and Milind Shantilal Shah. "Recognition of Emotion Through Facial Expressions Using EMG Signal." 2019 International Conference on Nascent Technologies in Engineering (ICNTE). IEEE, 2019.

Option A: Data analysis of time series data

I collected data while wearing 2 sets of EMG sensors on my face (data here: https://drive.google.com/open?id=1T8DRFgj3qk3ZV5XnILNAS1tPIchyQLo6).



The data for the zygomaticus major are channel 1 or *data_ch1*, and the data for the corrugator supercilii are channel 2 or *data_ch2*. I made a series of facial expressions. I chopped the data up into 409 trials or “epochs”. In each trial, I made a particular facial expression starting around the 0 millisecond mark (see *times_ms* for timepoints in ms). There are 1000 points in each trial, representing 1000 measurements (one every 4 ms… or what is called a 250 Hz sampling rate). The *labels* variable tells you which facial expression I was attempting to make. These different labels are often referred to as different “conditions” of the experiment. Here’s a key:
A: angry… I clenched my jaw and furrowed my brow

B: blinking… I was just relaxed and blinking here (not all blinks are capture, but these are some examples)
F: frown… I tried to look sad and pout a little
S: smile… I smiled, just thinking about you learning to analyze this data… such joy
U: unstructured… this was intended to be some rest time, but should probably be ignored for now (something looks a little weird in it)

For this assignment, let's focus on the comparison between smiling and frowning (but you're welcome to look at any of the other data too). As we think about applications that might use EMG to detect facial expressions, we're going to start with a comparison of two extreme ones and see how similar these signals look.

For this assignment, you can choose to only look at 1 channel of data, or you can look at both.

The very guided path through this assignment is to work through Chapter 2 of this textbook very kindly lent to us by Mark Kramer and Uri Eden, two awesome professors that I used to work with (this is a draft version of their book). Start by using the EEG data example and then attempt the prompts below.

The less guided path is to attempt to make the plots below, referring to the aforementioned book or other resources to help you along your way.

1) Make separate plots for each condition (smiling, frowning) that show all of the trials at once. Using imagesc may be a good approach. What do you observe?
2) Compare the mean time course for the two conditions by showing them on the same plot. Include separate lines to indicate 95% confidence intervals around each time course. What do you observe?
3) Challenge: Determine which time periods are statistically different between the two conditions. Explain what you observe. What might we need to consider in making a comparison like this (either from a statistics or an experimental design standpoint).

Option B: Research potential EMG expression detection applications

1. Brainstorm potential applications of an EMG-based system that can detect facial expressions (either intentional posed facial expressions or small microexpression reactions… see the assigned papers for more details). Try to put some ideas in here by Saturday.
    a. This document is meant to give you a common place to share ideas. Feel free to edit and adapt it however you like or create a new place for communal ideas.

https://docs.google.com/spreadsheets/d/1EfsKIsXY3_EDCKEYMz2p87O7JooAKQnmZgZukwkF07s/edit?usp=sharing

b.

2. Choose one or more applications to investigate (or find new ones), and do some research about it (users, technology, current research). Create a slide (https://docs.google.com/presentation/d/12QdS9keoIXbAoDPepKCbyKnfwNAhWlvKESLyVULcdhc/edit?usp=sharing) for each potential application with key points, illustrations, images, etc to describe the application. Note: These do not all have to be good or even positive ideas. It may be helpful to work through this for an idea that you think is a negative application of this technology.
   Here are some prompts to consider and help explain the idea to others:
   a. What's the idea for an application?
   b. Who might it affect and how?
   c. What's the current status of this idea: already exists in consumer world, in active research, only an idea right now, etc.

If you're feeling too restricted by having an application space that is limited to facial expression recognition with EMG sensors, you are welcome to extend the bounds of this. In order to help us stay thematically connected as a class, I suggest extending this to examples of EMG sensors that can detect intended arm/hand position or EEG sensors that can detect physiological responses to events in a person's environment.