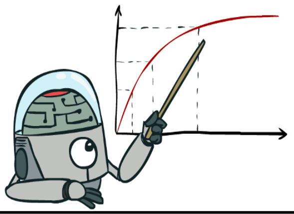
Lab 1: Intro to LSL and EMG Signals



ABSTRACT

The goal of this lab experiment is to introduce the student to biopotential and how they can be recorded using the Cleve Med BioRadio 150 and "BioCapture" software. This experiment includes data collection and analysis of electromyograms EMG. Students are expected to learn how to use Lab Stream Layer, BioRadio 150, Myo Armband, and EMG data analysis.

Please read through the entire document before completing the lab.

1 FILES

There are two files you will **edit**:

1. *Lab_1_emganalysis.ipynb*: Jupyter notebook that guides you through the EMG analysis process
2. *config.ini*: Config file for setting code paths and directories.

All other files should not be touched.

2 BACKGROUND

The human body is very complex and consists of many systems including mechanical, electrical, and chemical systems. The electrical system within the human body includes electrical potentials that propagate down nerve cells and muscle fibers. Numerous events that occur the body such as brain functions, muscle movements and eye movements are invoked by these electrical potentials. Physiological potentials arise from the ionic currents that flow in an out of the nerve and muscle cells of the human body. These biopotentials are typical measured using various electrodes in combination with electronic instrumentation. Through the collection of data from biopotentials further insight can be acquired on how the different systems within the human body are functioning.

2.1 EMG Signals

There are three categories of muscles in the body including cardiac, smooth, and skeletal muscles. Focus will be placed on skeletal muscles are for they are the muscles attached to the bones and are under voluntary control. Muscles are attached to bones via tendons and during a muscle contraction the tendon pulls the bone and movement occurs. Muscle contraction is invoked by an action potential and it can be measured with electrodes on the surface of the skin. The measurement of these action potentials is called an electromyogram or EMG. As like EEG, EMG is also a summation of all the action potentials occurring in a muscle during a period. A single action potential, an average, lasts for 1-3 milliseconds and can relate to a muscle contraction lasting, on average, 10-100 milliseconds. A contraction as a result of a single action potential is referred as a twitch. Twitches occurring in high frequency are called a tetanus response and are further categorized as fused and unfused. In unfused tetanus the twitches are still noticeable, whereas in fused tetanus individual twitch can no longer be distinguished. Most muscle contractions correspond to action potentials with frequencies in the range of 8 – 25 Hz.

EMG can be recorded from the surface of the skin with a frequency ranging from 2–500Hz and amplitude between 50uV – 5mV. Movement artifacts within an EMG are generally lower in frequency and can be attenuated with a high pass filter. A simple method for processing an EMG signal is to rectify the signal (take the absolute value) and determine the average value of the waveform. Another method is to find the average power of the EMG signal by calculating the RMS power or root mean squared power of the waveform.

2.2 Electrodes

The type of electrodes used to measure biopotentials are dependent on the biopotentials being recorded and their application. The two electrodes used in this lab are the metal plate snap electrodes and the gold cup electrodes. The metal plate snap electrodes are composed of a small silver or silver plated with chloride disc surrounded by a foam padding with an adhesive. The metal plate snap electrode can perform DC readings with low noise and small drift, making them suitable for ECG, EMG, and EOG recordings. The gold cup electrodes are most common is EEG reading for their small size an ease of placement. The gold cup electrodes require a paste to adhere the electrode to the skin.

2.3 Safety Precautions

Before performing the experiment, it is important to know and exercise caution with regards to some of the potential safety hazards associated with bioinstrumentation. There has been a great amount of effort placed by the designers of the BioRadio 150 to ensure the user is never connected directly to ground. If a user is directly connected to ground, equipment failure could result in electrical currents passing directly through the user and to the ground. When used in normal operation the BioRadio 150 couples the user using battery powered RF isolations. However, it is extremely important that you do not attempted to dissemble the BioRadio at any time and in any way. Also, for extra precautionary measures, while using the BioRadio 150 avoid meeting large sources of ground such as the back of a PC, power supplies, function generators, oscilloscopes, etc.

3 CODE SET-UP

- Download and extract zip file from https://github.com/BioRobotics-Spring-2020/Lab_1_2022.git
- Open a command prompt
- Check the python version in the prompt
  ```
  py
  ```
  - If python 3.7.3 (or 3.7.9) does not pop up, type software center in the windows search bar. Then search for python and install python 3.7.3
  - (You can type exit() and enter in the command prompt to exit the python kernel.
- Update pip
  ```
  py -m pip install --upgrade pip -user
  ```
- Change your current directory (cd) to the download lab folder
- Install required libraries using
  ```
  py -m pip install -r requirements.txt -user
  ```

- Edit the path to where you want to store your physiological data in config file (config.ini).

4 BIORADIO 150

This section guides you through setting-up and collecting data from the BioRadio 150 using Lab Recorder.

1. Review the setup movie for EMG in this link: https://www.youtube.com/watch?v=3L7jpQA_5AI
2. Placing the Electrodes (In a muscle area where you can collect strong signals) Place two electrodes at the inner side of the forearm or (close to the inner side of the wrist). Place two other electrodes at the outer side of the forearm or (close to the outer side of the wrist). Place one electrode at the elbow (muscle free area)
3. After the electrodes have been placed on the subject, connect one snap lead to each electrode. Then, connect those snap leads to the harness inputs for channels 1, 2, and the ground.
4. Plug in the "USB Receiver" into the PC
5. Open up the BioCapture Software and click on "connect" from the toolbar
6. Configure the BioRadio:
   There are two options for the Configuration of the BioRadio: the (Standard view) and the (Advanced view). Select the Standard view option. The main configuration Options are:

   a. Sampling Rate (Samples per second) also they measured in Hz and Resolution (number of bits per sample)
   b. Enable Channel: Select the number of channels in the Programmable list
   c. Select the type of each selected channel (EMG, EOG, or EEG).
   d. Deselect the fixed channels that includes other sensors.
      Note 1: The sampling frequency must be at the least twice the maximum frequency component of the collected signals.
      Note 2: Choose the appropriate values of the sampling rate and resolution such that the total transmission bandwidth is less than maximum bandwidth of the BioRadio 150.

7. Click program device
8. Click the green triangle in the tool bar to start seeing the EMG streams.
9. Check with the TA to make sure the signals look good. If so, then click the red square (stop).
10. In the windows search bar, search for BioRadio Connect and open it.

    a. If nothing is in the search bar, please unzip LSL/LSL-BioRadio.zip

11. Click search device and then click on connect device, then start streaming. You should see text populating the window now.

4.0.1 Collecting data using Lab Recorder The above process streams data from the BioRadio over a network. Now, we need to access this data stream. One such way is to use an application called Lab Recorder. Please follow these steps

- Open LabRecorder
  LabRecorder.exe from the downloaded github folder
- Set the storage location (make sure the file extension is .xdf or it will close without a warning)
- Click update to get all the LSL stream names. For now, it should just be a BioRadio.
- Select the stream you want to record
- Click on start/stop to start/stop recording the data.

5 MYO ARMBAND

The Myo Armband is an off-the-shelf device that collects sEMG and IMU data from the forearm. Follow these steps to set-up the device.

1. Plug in the Myo into the computer using a USB cable.
2. Unplug the Myo (this should turn it on).
3. In the windows toolbar, search for MyoConnect and open it.
4. (Optional) Follow the windows (if any) to get acquainted to the device.
5. Put the device on a forearm, where the blue log symbol is on the thickest part and the orange/blue bar is pointing to your hand.
6. Perform the sync gesture (flex your wrist so that your palm is pointing in front of you).

   a. You should feel a vibration. Keep flexing the wrist and rotate your arm until an icon pops up in the lower right that says myo is synced.
   b. If you are having trouble, use the black clips to make the device tighter

7. Go to http://diagnostics.myo.com/
8. Look at the EMG signals and IMU signals as you move your arm around. Check with the TA to make sure everything is working properly.

5.1 Recording Data with Code

Now we are going to use some of the code downloaded from Github to collect data from LSL.

1. Edit config.ini

   a. Directory should be the directory you want to save to
   b. Set participant name, session, and prefix to what you want (e.g., prefix to rock.csv)
   c. Make sure Myo is set to true and all other devices are set to False

2. From a command line, cd to the code directory and run
   ```
   py main.py
   ```
   If this does not work, try to double click the file to run it.
3. You should see text populate the command prompt that shows stream information.
4. hit ctrl+c to stop the collection process.
5. Check your csv file in the specified directory and make sure it filled out correctly.

6 DATA COLLECTION: ROCK, PAPER, SCISSORS

For each device, record data from each lab member using the previously specified methods (lab recorder and code for the BioRadio and Myo, respectively).

Your data should consist of 5 gestures each of Rock, Paper, and Scissors. Be sure to name files differently for each gesture.

Record 4 channels of data on either device from around your forearm so you can compare your results from the BioRadio 150 and Myo Armband.

7 DATA ANALYSIS

Please open the Lab 1 jupyter notebook and follow the directions there. You can download p18_emg.csv from MyCourses and put it in the Data folder.

8 ITEMS TO TURN IN

Please upload your jupyter notebook and a pdf of the notebook (with all the cells ran) to MyCourses. Create a lab report, based on the lab report example on MyCourses.