# BME 4503C Midterm EMG and ECG

The materials needed are a computer, Biopac software and hardware, and Matlab (Signal Processing Toolbox).

Instructions: Electromyography (EMG) is a technique used to measure and record the electrical activity produced by muscles. Electrocardiography (ECG) is a technique used to measure the electrical activity of the heart. The goal of this lab is to analyze and compare EMG and ECG signals through data processing techniques. You will collect, visualize, and process data to understand the characteristics, noise, and physiological significance in EMG/ECG signals.

The Biopac system (BSL Home) includes a compact, single-channel MP41 Data Acquisition unit, 40EL Electrode Lead Set, BSL 4 Software, and DEL503 pre-gelled Disposable Electrodes. Gauze and a battery are included.

A close-up of a cable

Description automatically generated A hand holding a device

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**Fig. 1: 40EL Electrode Lead Set Fig. 2: MP41 Data Acquisition Kit**

In your experiment, you will do the following:

1. You will collect the signal of the Biopac system through Lab 01. Instructions for setting up and downloading the Biopac software are below:
   1. Download the FIU VPN (<https://network.fiu.edu/vpn/> ). The VPN must be downloaded and connected to FIU Wi-Fi to install and use the Biopac software.
   2. Install the zip file attached to the assignment for Mac or Windows. Once downloaded, you will have to extract it to run the software installation package. Follow the BSL Instructor’s Guide for any troubleshooting necessary.
   3. Once the software is downloaded, assemble and connect to the MP41. The YouTube video will show you how to start your first lesson and how the system should look when assembled (<https://www.youtube.com/watch?v=L3a9CFR2I8o> ).
   4. Open L01- Electromyography (EMG) (Hardware must be connected and on to see the lessons window). Your file name should be ‘BME4503C Group # Midterm.’ This file will be uploaded with your lab report.
   5. Do not follow the instructions provided in the lab. Instead, click ‘record’ and acquire data for one minute before clicking ‘suspend.’ This will be your data for resting state. You need to click onto the next window and click ‘record’ again. Then, you can acquire data for one minute and click ‘suspend.’ While acquiring for one minute, perform muscle contractions where the electrodes are placed at 10 second intervals. Perform contractions at varying clench intensities. Click ‘stop’ to end the lesson and move on to data analysis.
   6. Then choose Edit > Data Window > Copy Wave Data. This will save the signal data to your clipboard. Paste data into an excel sheet with a column populated by the length of time of the recording for each condition. Import the excel sheet into Matlab.

A screen shot of a computer

Description automatically generated**Fig. 3**: Example of the signal you would get if EMG electrodes were placed on the forearm.

1. After completing L01- EMG, perform Lesson 5 – Electrocardiography (ECG).
   1. During data analysis you will follow instructions for collecting ECG data under the following conditions:
      1. Supine for 20 seconds
      2. Seated for 20 seconds
      3. Deep breathing
      4. Instead of recording ‘After exercise’ for 60 seconds, repeat the data acquisition step for EMG where the muscle is contracted at 20 second intervals.
   2. Follow the same steps above for exporting data to Matlab.

**Data Analysis**

1. Signal Processing

Your primary objective is to clean and analyze the collected EMG and ECG signals using appropriate filtering techniques. Follow the steps below to process and interpret your data.

**A. Noise Identification & Removal**

Your raw signals will likely contain different types of noise. Apply filtering techniques to improve signal quality.

* **Common Noise Sources:**
  + **Powerline Interference (50/60 Hz noise):** Caused by electrical equipment in the environment.
  + **Motion Artifacts:** Movement of electrodes can introduce slow drifts in the baseline.
  + **Baseline Wander:** Low-frequency drifts, especially in ECG, due to breathing or electrode movement.
* **Filtering Techniques:**
  + **Bandpass Filter:** Use a bandpass filter to retain only the relevant frequency range.
    - EMG: 0–500 Hz
    - ECG: 0.5–150 Hz
  + **Notch Filter (50/60 Hz):** Apply to remove powerline interference (a common noise source in physiological signals recorded from the bodily surface).
  + **High-pass Filter (0 - 0.5 Hz):** Can be used to remove baseline wander.
  + **Low-pass Filter (up to 500 Hz for EMG, 150 Hz for ECG):** Removes high-frequency noise.

*Hint:* MATLAB has built-in functions like butter, filtfilt, and bandpass for applying these filters (must have the signal processing toolbox downloaded).

**B. Normalization**

Since EMG and ECG signals have different amplitude scales, normalization ensures a fair comparison. Must be done through Matlab.

1. EMG Measurements

**Table 1.1**

|  |  |  |
| --- | --- | --- |
| **Clench #** | **Root Mean Square** | **Mean Absolute Value** |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |

Compute the Root Mean Square (RMS) of the signal to assess muscle activation. Determine Mean Absolute Value (MAV) to quantify muscle effort and use these values to compare muscle activity throughout each clench.

1. ECG Measurements
   1. Identify and estimate the time duration of the cardiac cycle, P-R interval, the QT Interval, and R-R interval.
      1. Key feature extraction:
      2. **R-peaks (QRS Complex):** Use findpeaks() to detect R-wave peaks.
      3. **P-R Interval, R-R Interval, and Q-T Interval:** Can compute using MATLAB’s diff() function.
   2. Fill out the table below

**Table 2.1**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Recording: Condition | **Cardiac Cycle**  **1 2 3** | | | **Mean** (calculate) |
| Supine |  |  |  |  |
| Seated |  |  |  |  |
| Start of inhale |  |  |  |  |
| Start of exhale |  |  |  |  |
| During muscle contractions |  |  |  |  |

* Compare the filtered signals and raw data for the EMG and ECG muscle contraction recording condition. Assess how muscle activity influences heart rate (e.g., increased clench intensity vs. R-R interval shortening).

# Deliverables:

1. Please include a saved file from the Biopac software with all your acquired data and a Matlab **.m (code) and .mat (processed date) file**.
2. Please capture a video of yourself recording EMG and ECG data. This can be uploaded to YouTube and provided as part of the deliverable as a link (Please do not try to upload or email the actual video file).
3. Submission of a 1-4 page lab report, written according to the lab report template provided in Canvas.
4. Please read the instructions carefully and follow ALL the requirements in text form.

**Helpful material for this laboratory experience:**

* Biopac EMG Guide: [**https://www.biopac.com/wp-content/uploads/EMG-Guide.pdf**](https://www.biopac.com/wp-content/uploads/EMG-Guide.pdf)
* Review on Mean Absolute Value (MAV): [**https://www.khanacademy.org/math/statistics-probability/summarizing-quantitative-data/other-measures-of-spread/a/mean-absolute-deviation-mad-review**](https://www.khanacademy.org/math/statistics-probability/summarizing-quantitative-data/other-measures-of-spread/a/mean-absolute-deviation-mad-review)
* Matlab Resources on documentation
  + [**https://www.mathworks.com/help/signal/ref/findpeaks.html**](https://www.mathworks.com/help/signal/ref/findpeaks.html) **- findpeaks()**
  + [**https://www.mathworks.com/help/matlab/ref/double.diff.html**](https://www.mathworks.com/help/matlab/ref/double.diff.html) **- diff()**
  + [**https://www.mathworks.com/products/signal.html**](https://www.mathworks.com/products/signal.html) **- Matlab Signal Processing Toolbox overview and tutorials**

The emphasis of this midterm is data processing and analysis. Experiment with filtering methods to see what type of signal you can achieve.

I look forward to reading your reports. If you have any issues, please get in touch with me or stop by VH333 for help.

**NOTE**: If your group is able to eliminate the use of Biopac software and communicate directly with the Biopac acquisition kit through Matlab only, you would get an A in the class!