Muscle Sensor KI 2 Instructions

Overview

This KI pre-work will involve two sections. Section A covers data collection and section B has the specific problems to solve. For the problems section, only answer the questions relating to the class/classes in which you are currently enrolled. If you are not enrolled in one of the classes, you are not required to answer the questions under that class heading. If you are enrolled in both classes, you must solve all the problems. Please state in which classes you are enrolled on the front of your pre-work. All students must get the measurement results with a partner. For all problems involving MATLAB make sure to include results along with code.

EMG Background

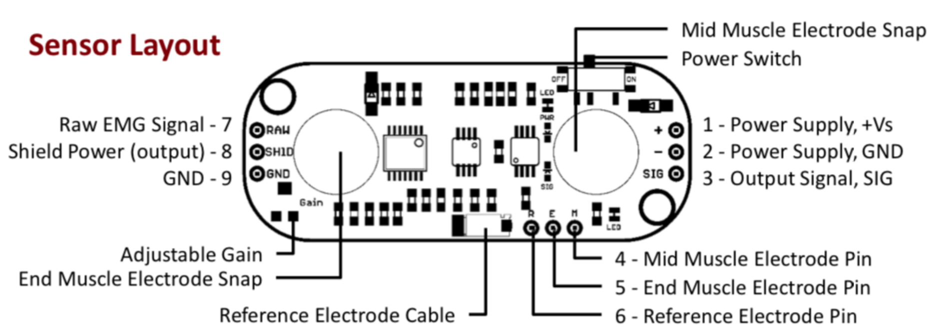
This activity utilizes electromyography or EMG to observe and measure muscle activity. Electromyography uses probes to measure the electrical activity that occurs during the usage of skeletal muscles. Motor neurons transmit electric signals to the muscles when they need to contract. These electric signals can be observed through electrodes being placed on the skin over the specific muscle. EMG is very common in the medical field and can help with diagnosis of muscle and nerve disorders. This technique is also common in research and can help with tasks such as seeing how much of the muscle is being utilized during a contraction. In this activity we will be measuring the electrical impulses that occur when the bicep is flexed.

*If you feel uncomfortable with the electrodes and measuring process please talk with your TA.

Components Needed:

- MyoWare Muscle Sensor (provided in lab)
- 3 Muscle Electrodes (provided in lab)
- Analog Discovery (**BRING YOURS**)

***NOTE:** Biomedical devices involving the human body are subject to substantial noise from the surrounding environment. The human body acts as an antenna and can pick up noise from sources such as power lines. Therefore, we want to follow the steps described below to capture as little noise as possible in our measurements.

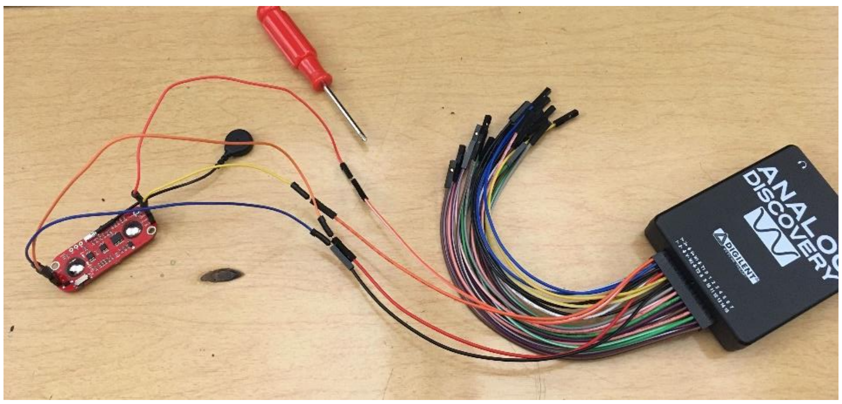


A) DATA COLLECTION

Measurement Instructions

1. Build the measurement circuit using the board, provided connections, and Analog Discovery.

- Connect the +5V from the Analog Discovery to the “+” terminal on the board.
- Connect the Gnd from the Analog Discovery to the “–” terminal on the board.
- Use the “raw” output of the board as the input to channel 1 of the Analog Discovery.
- Connect the negative input of channel 1 to the “gnd” pin on the board.
- A green light should appear on the board if it is receiving power.

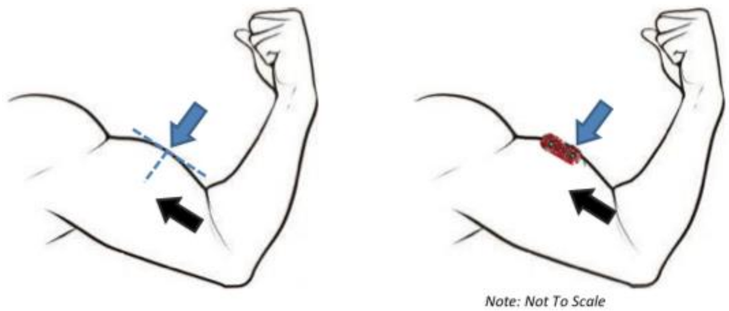


The “raw” signal is the direct output and will give the RAW EMG signal. This is shown below.

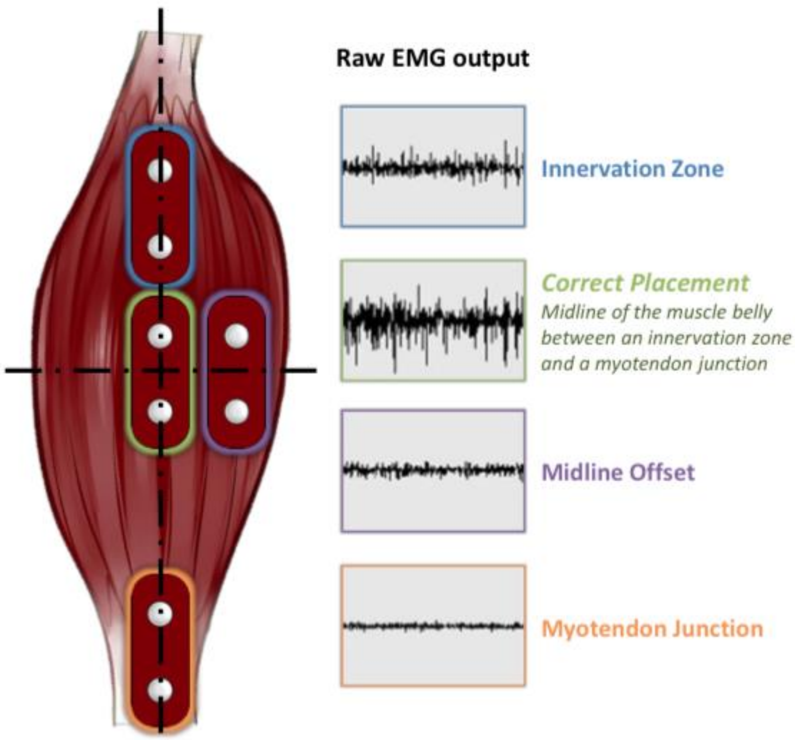
2. Connect MyoWare board to volunteer.

- Wash the arm or area of skin where the sensor is going to be placed. (This is important for noise free signals. It removes skin oils and dirt that can disrupt the signal/ electrode connection)
- Snap the electrodes into the MyoWare board BEFORE removing adhesive protective layer.
- When ready to stick onto the arm/muscle, peel off adhesive protectors and stick to the midline of the muscle.

- Sensor should be parallel or in line with muscle (Example below)
    - Reference wire should be placed on an adjacent muscle or bony area
    - Any muscle/muscle group can be used. (The bicep is easy to flex/control and can be moved close to the sensor, so it is recommended)
- When the board is getting a reading the red signal light should be illuminated. (This might be a pulse and not a constant light)

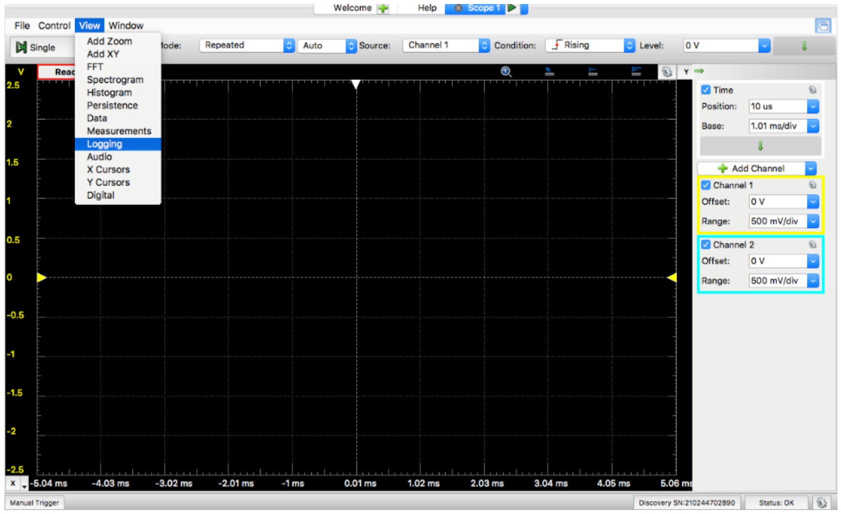


Example Sensor Location for Bicep

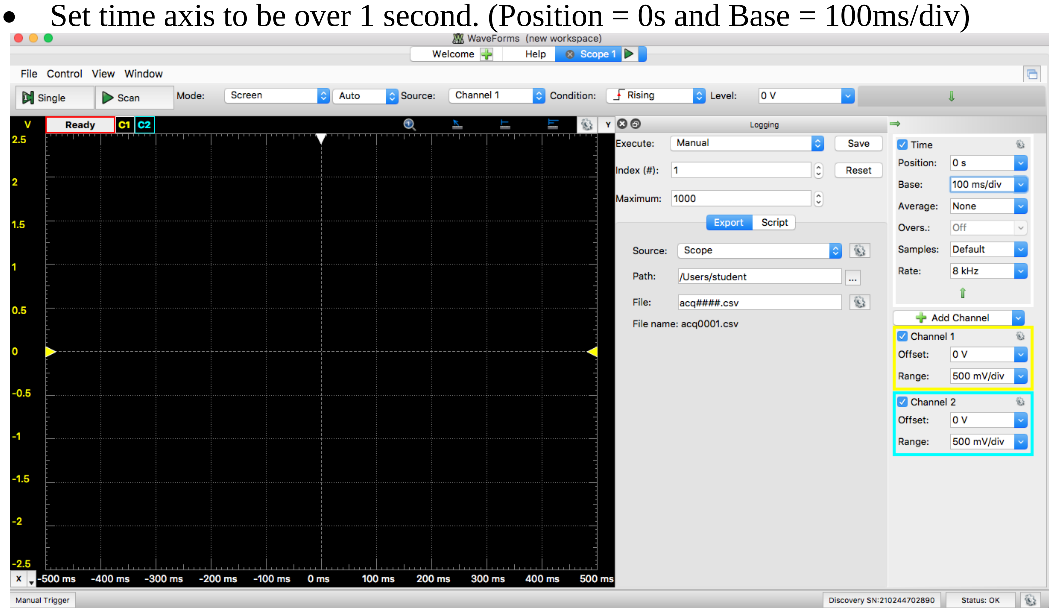


3. Record Data with Analog Discovery

- Open the Analog Discovery and open the scope tab.
- Go to View -> logging



- Set time axis to be over 1 second. (Position = 0s and Base = 100ms/div)



- Set the Path to be where you want the data file to be stored. Set the file name to be something you will remember for the data you are collecting. (i.e. student1_Flexed)
- Have the volunteer try different states such as flexed, relaxed, relaxed to flexed, etc.
- When ready to record, preform the desired activity and press "Save". The "Save" button will save the values currently displayed on the scope window as a csv (comma separated value) file. These can be opened in Excel and imported into MATLAB for further analysis.

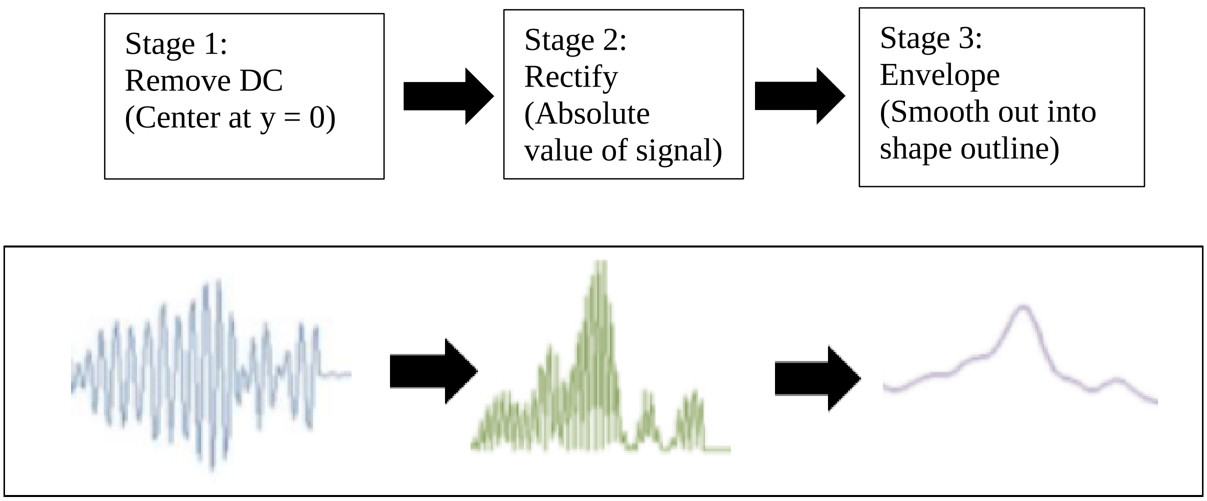
- Record several data pieces for flexed, relaxed, and flexed to relaxed states. Plot one example from each of these states in MATLAB and attach to your report.

Images for MyoWare board used above were used from the MyoWare datasheet: https://cdn.sparkfun.com/datasheets/Sensors/Biometric/MyowareUserManualAT-04-001.pdf

B) PROBLEMS

ECE 202 Students - analog detection

Raw data, like that collected above, must normally be processed before it can be used in diagnosis or state recognition. In our case we want to design a system that will tell us if the muscle is flexed or relaxed based on the EMG reading. This can be done with the three-stage system, shown below.



Stage 1:

For stage 1 we want to remove the DC component of the signal so that it will be centered at y = 0 instead of some other offset. Explain how you would remove the DC component from the raw signal. Design a general circuit to perform the operation explained. (*Hint: briefly research notch filters and/or high pass filters*). Attach a drawing of your circuit and provide element values for any components used. If results are not ideal or do not match data explain why.

Stage 2:

For our basic signal classification technique, the most important part of the signal is the magnitude of fluctuation or voltage spikes observed. Due to this the positive or negative values of a spike are not important. To simplify the signal and make it easier for stage 3 we want to rectify the signal or make the readings entirely positive. Explain how you would rectify this signal. Design a general circuit to perform this operation. (*Hint: Look at previous labs where a signal was made completely positive*) Attach a drawing of your circuit and provide values for any components used.

Stage 3:

From the rectified signal it would be helpful to have a general outline of the shape. Then a threshold value could be decided and if the reading went above that value the muscle could be classified as flexed. Explain how you would “smooth out” the signal from stage 2 to get the envelope or outline. (*Hint: Look into low pass filters*). Design a general circuit to perform this operation. Attach a drawing of your circuit and provide values for any components used. Note this does not need to be perfect but should demonstrate a knowledge of low pass filters and how to implement them for this task.

ECE 303 Students - digital detection

All problems must be completed in MATLAB.

1. Perform the following signal processing tasks on two time series, one from a flexed muscle and one from a relaxed muscle.
    a. Find the first moment of the signal as a function of the observation time. In order to perform this task, you should obtain the first moment for the first *t* seconds and repeat the analysis for different times *t*.
    b. Find the variance of the signal as a function of observation time *t*.
    c. Comment on your results on a and b considering the central limit theorem.
2. Develop an algorithm to find the transition points between flexed and relaxed states (and vice versa) based on the local fluctuations, i.e., the variance within a short (sliding) time window. Comment on the time resolution of your algorithm and the accuracy in detecting individual states.

KI2: Wearable Sensor – Social Responsibility

Wearable sensors are a new trend in technology and are becoming more and more popular every day. Personal trackers have widespread use in different fields. Examples of such sensors are health trackers such as glucose monitoring devices or monitors for patients with Parkinson's disease. Overcrowded hospitals, healthcare costs, chronic diseases that cannot be treated in the hospital setting, and the ever ageing population has created the need for health monitoring, which these devices provide [1]. Wearable biometrics are very popular in different sports as well. They help players in their training by keeping track of their heart rate, skin temperature, pulse and other informative data [2]. In addition to that, fitness trackers are everywhere these days. People are relying on them to track their workouts, sleeping routines, diet, etc.

Wearable sensors are becoming a part of the modern life-style providing many benefits but along with popularity becomes some concerns. When it comes to healthcare, although these devices provide an opportunity for physicians to get a better understanding of how patient deals with his condition outside of the hospital setting, some believe such technology could create a gap between the patient and the doctor by proving a DIY approach to medicine [1]. Sport players are being pressured by their teams to wear trackers during practice, giving access to their coaches and team managers to monitor their personal data. Although this type of monitoring can help player's performance, at the same time, it's also an invasion to their privacy and the data collected can even cost the players a significant amount of money in their next contract [2]. In early 2018, US military started refining its privacy policies after they realized a fitness app mapping people's exercise habits could reveal sensitive information on security forces around the world as the maps created by the app could've made the US bases identifiable [4].

With rising popularity of wearable sensors, many people have doubts whether there are enough regulations to protect the users' data. The truth is, when it comes to data protection laws, there is so much room for improvement. Moving in that direction, the General Data Protection Regulation (GDPR) was approved by the EU Parliament in April 2016 and finally enforced in May 2018. It gives people more control over their personal data and forces companies to ensure the safety of collecting, processing, and storing personal data. Any organization that holds or uses data on citizens of the European Union wherever they are located is subject to these new rules. In cases of violation, European regulators can fine companies up to 4% of annual global sales, which for the big tech firms could sum up to billions of dollars [3].

Scenario

Assume you are a design engineer working for a company manufacturing wearable fitness trackers. The device collects users' personal data, including sleeping routine, eating habits, and location. You believe your company is not taking enough security measures to guarantee the confidentiality of users' data. Raising security measures could cost the company a lot of money, and the current system is technically not breaking any laws.

Please answers each of the following questions in one or two sentences.

1. Do you think further actions are required to guarantee the security of users' data?
2. Is it your responsibility to raise the issue to your superiors? Please explain.

3. How do you feel about designing a product in the US when that device might be illegal in another country? Would you work for an employer that encourages that?

Bibliography

[1] H. Saumtally, "Wearable devices in medicine: ethical and legal implications," 22 01 2014. [Online]. Available: http://trinitynews.ie/wearable-devices-in-medicine-ethical-and-legal-implications/. [Accessed 2 6 2018].

[2] J. Venook, "The Upcoming Privacy Battle Over Wearables in the NBA," 10 5 2017. [Online]. Available: .https://www.theatlantic.com/business/archive/2017/04/biometric-tracking-sports/522222/. [Accessed 5 4 2018].

[3] I. Kottasová, "What is GDPR? Everything you need to know about Europe's new data law," 21 6 2018. [Online]. Available: http://money.cnn.com/2018/05/21/technology/gdpr-explained-europe-privacy/index.html. [Accessed 28 6 2018].

[4] J. Berlinger and M. Vazquez, "US military reviewing security practices after fitness app reveals sensitive info," 29 10 2018. [Online]. Available: https://www.cnn.com/2018/01/28/politics/strava-military-bases-location/index.html. [Accessed 6 5 2018].