Lab 3 report

February 24, 2025

Lab was completed by Pavel Kuklin, github: `https://github.com/GuestKP/Sensors_labs/tree/master/SnS_Lab3` and Andrey Yanov, github: `https://github.com/Anryan2/Sensors_and_sensing_lab`

1 Topic

The topic of 3 lab is EMG sensor

2 Purpose

- Learn how to connect the EMG sensor
- Apply a EMG sensor to the motor control

3 Description of the sensor application

Electromyography (EMG) is the subject which deals with the detection, analysis and utilization of electrical signals emanating from skeletal muscles. The field of electromyography is studied in Biomedical Engineering. And prosthesis using electromyography is achieved under Biomechatronics. The electric signal produced during muscle activation, known as the myoelectric signal, is produced from small electrical currents generated by the exchange of ions across the muscle membranes and detected with the help of electrodes. Electromyography is used to evaluate and record the electrical activity produced by muscles of a human body. The instrument from which we obtain the EMG signal is known as electromyograph and the resultant record obtained is known as electromyogram.

4 List of used equipment

- EMG Amplifire
- 2 pcs of batteries of crone
- Arduino UNO board

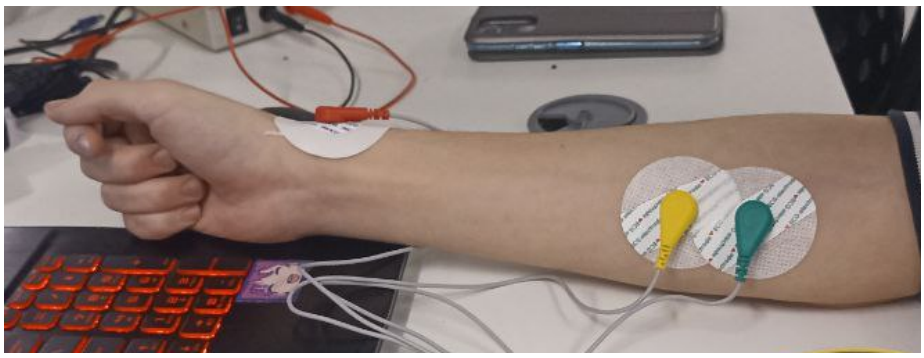
- BLDS Motor MF4005

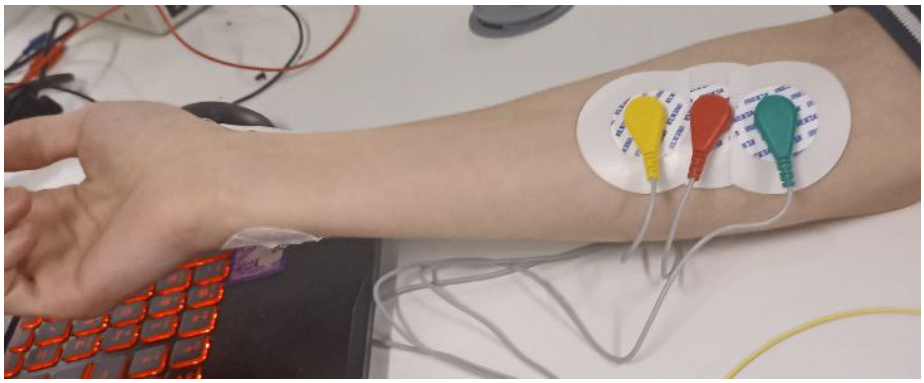
5 List of tasks

1. Connect the EMG sensor to the analogue output on esp32 (or another board).
2. Select the muscle on which to attach the electrode. Test different electrode placements and select the one that maximizes the sensor response when the muscle is tensed.
3. Calibrate the EMG sensor. Try to remove base shift and apply some simple filtering to remove drift. Describe the experiments and calculation methods in as much detail as possible.
4. Connect the motor and the EMG sensor. Set up position control on 90 degrees when you tensing your muscles.
5. Make a video when your system works in one direction.
6. Set up the controls and figure out a method of how to turn the motor in two directions 90 degrees. You can use the optional EMG sensor.
7. Make a video when your system works in two directions.

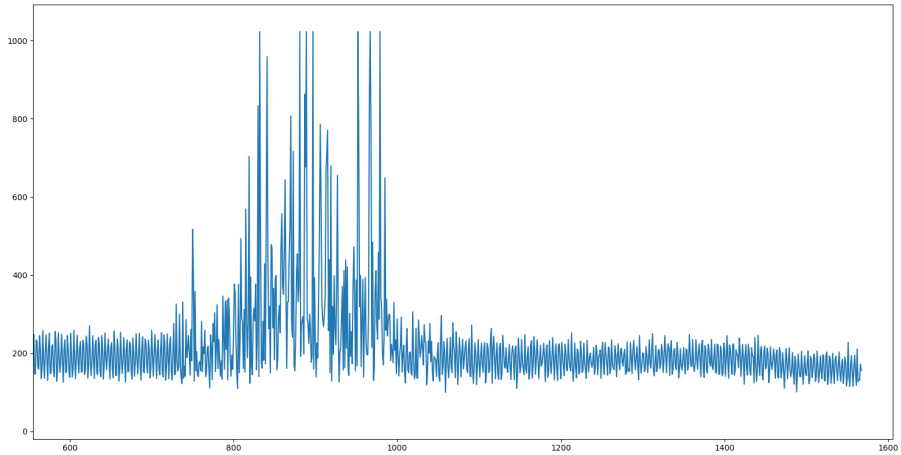
6 Solutions of tasks

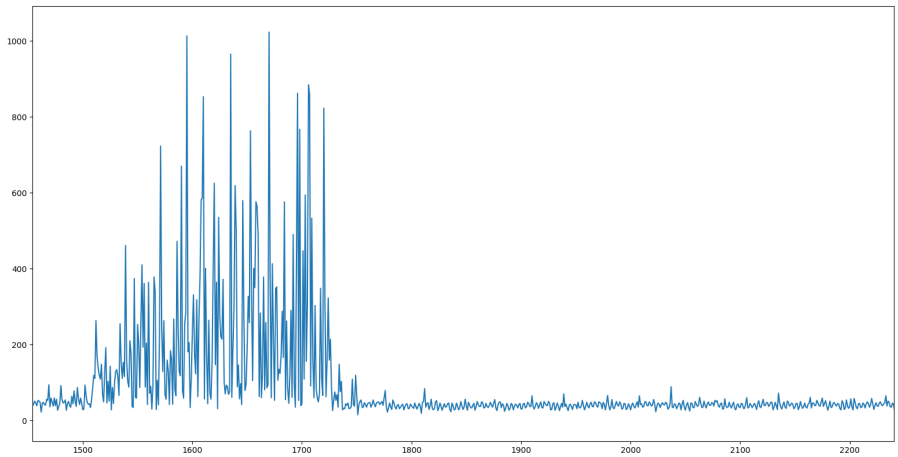
1. We connected EMG sensor on Arduino UNO. Also we get bipolar voltage to EMG sensor to let it detect electrical signals emanating from skeletal muscles with respect to a reference (ground).
2. We tried two different variants connections of electrodes to muscles.





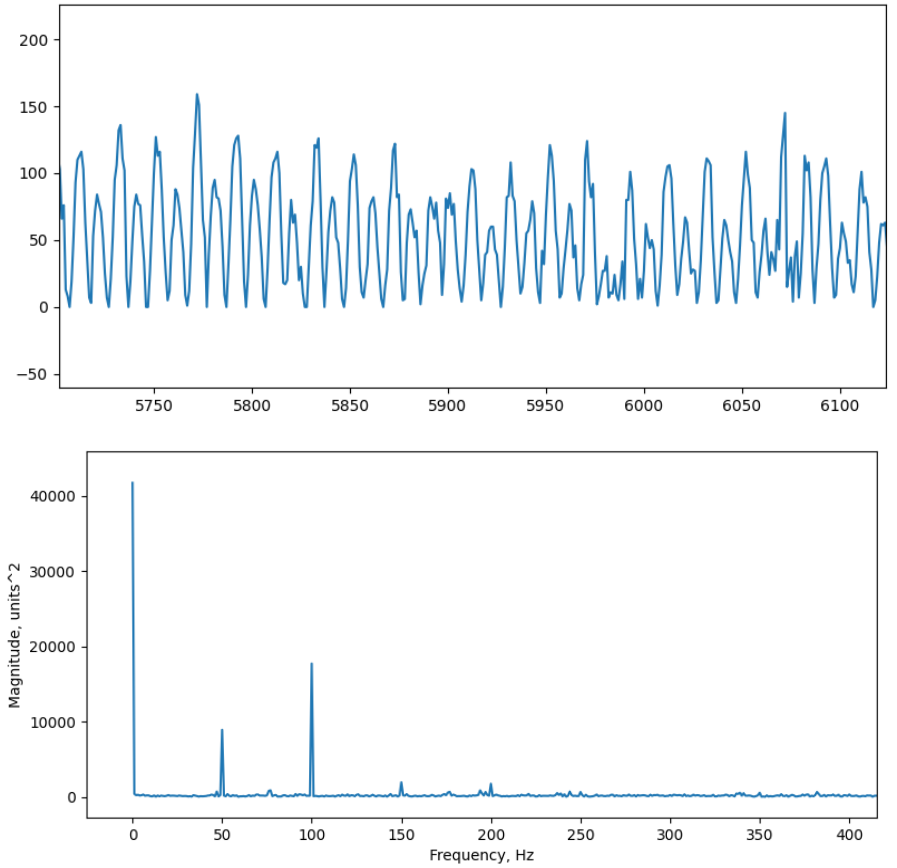
The second connection option gives more accurate signal. Graphs of signals over time correspondingly (high areas - muscle tension):





3. There was some noise when working with the sensor and collecting the data with sampling rate 1 KHz, but it was not as significant as the data obtained when straining and relaxing the muscles. In this respect, we were able to differentiate between moments of muscle tension without the need for additional filtering. Nevertheless, we initially filtered the data using two notch filters at 50 Hz and 100 Hz because the Fourier decomposition for noise gives peaks at these values, and then used the filtered values in an integral filter with a coefficient of 0.2.

   There are graphs for noise and Fourier decomposition:



   We have different noise on plots for connection comparison and filter creation (the latter has strong sine form). That is because these task were performed at different days with different environment, and during connection comparison we did not have motors connected.

4. We connected motor and EMG sensors and control them to

   - Rotate motor in one direction on 90 degrees when muscles are tensed.

- Rotate motor in the opposite direction on 90 degrees when muscles are tensed.

There are videos demonstrating of the works of the systems:

- One direction:
  `https://drive.google.com/file/d/1Jnwz8FfOyzEw05xmVTaoX-H3YbTbA3id/view?usp=sharing`
- Opposite directions:
  `https://drive.google.com/file/d/1Bgl-VJ15iruUpjiy98QffpXeyby041tV/view?usp=sharing`