NAZARBAYEV UNIVERSITY

Electrical & Computer Engineering
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A low-cost EMG sensor for real-time data acquisition

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Presentation Layout

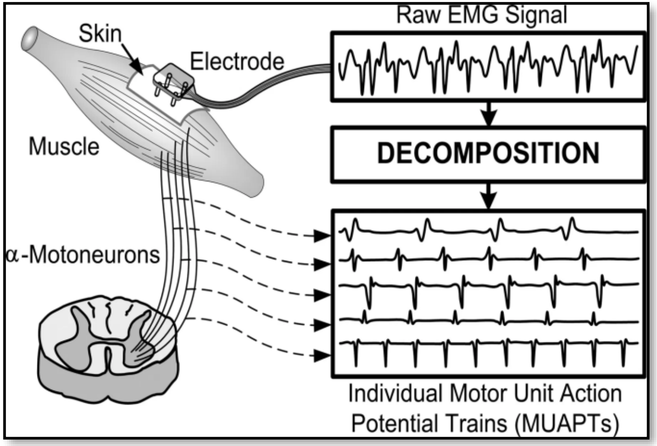
- Project background
- Aims & objectives

- Processing and classification stages
- EMG sensor
- Conclusion and future steps
- References

Project background (1/2)

- **What is a myoelectric prosthesis?**
  - An *artificial limb* actuated through surface electromyography signals (sEMG) and aimed to restore the necessary functions of an intact hand

- **What is an sEMG signal?**
  - A sum of *individual* electrical pulses in a muscle recorded by electrodes during muscle contraction



Project background (2/2)

- sEMG is a non-stationary bio-signal
  - sEMG amplitude: **0.5 - 2 mV**
  - sEMG useful frequency band: **20 – 300 Hz**
  - Total gain of the circuit: **~=1000**

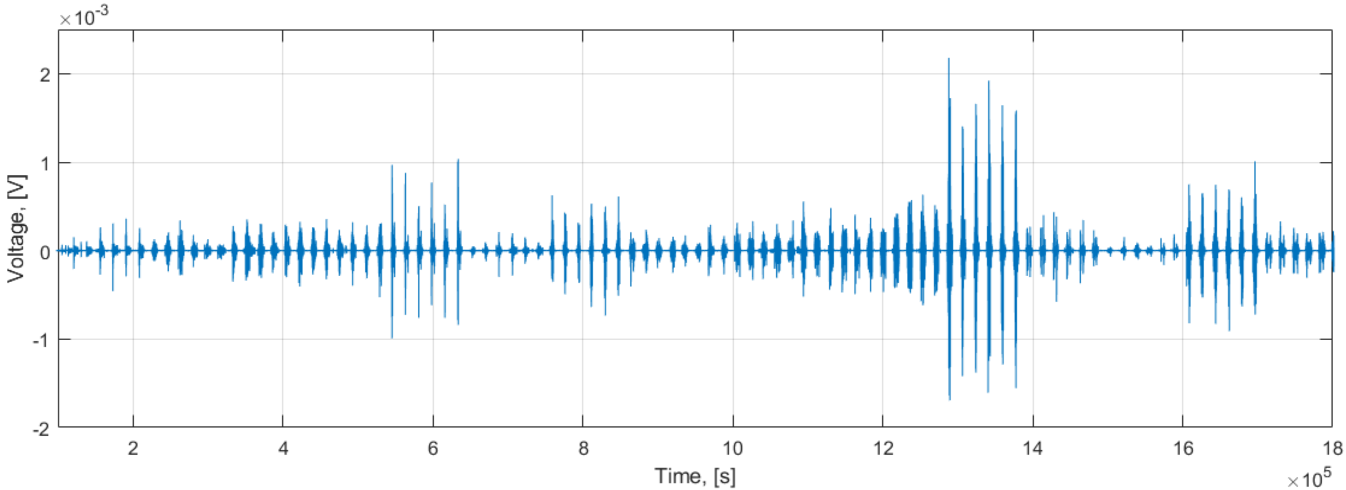


Figure 1. The raw EMG signal

Aims & objectives

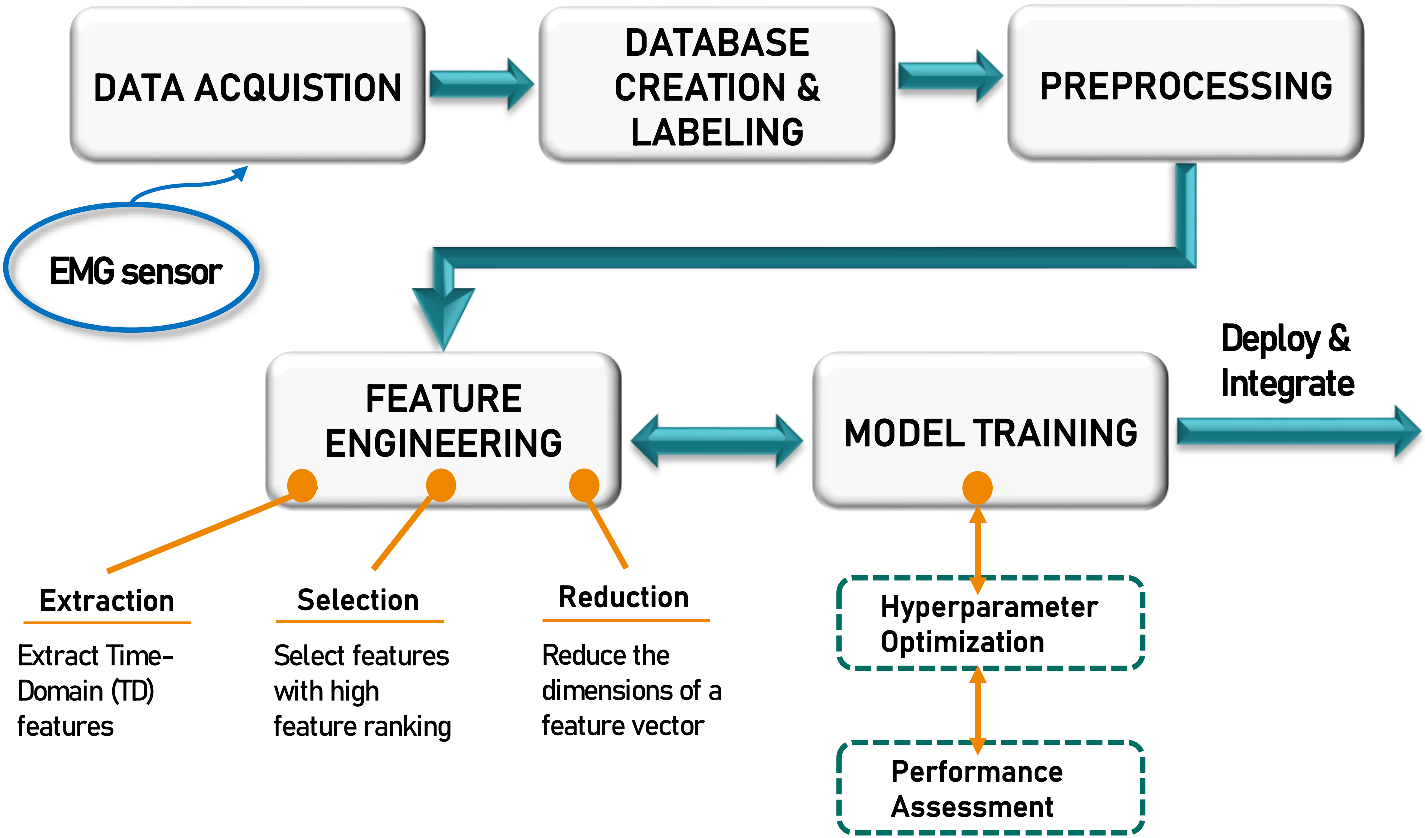
Aims

- Develop a *real-time* sEMG signal processing & classification model for a myoelectric prosthesis design
- Produce an efficient and cost-effective myoelectric hand prototype

Objectives

- Make a comprehensive study of the most relevant sEMG PR models
- Apply *filtering*, *feature extraction and classification* algorithms resulting into highest classification metrics and real-time performance
- Implement the model on a microcontroller

Processing and classification stages



EMG sensor [1/4]

Differential/Instrumentation Saturation:

- Common-mode signals from adjacent equipment (up to 1.5 V)
- DC potentials at different parts of the body of $\pm 500\ mV$
- Raw AC EMG signals are of **0.5 -2** mV

The unwanted **DC signals** could be x*300-400* times of EMG signals, also amplified by the Differential Amplifier, causing it to saturate.

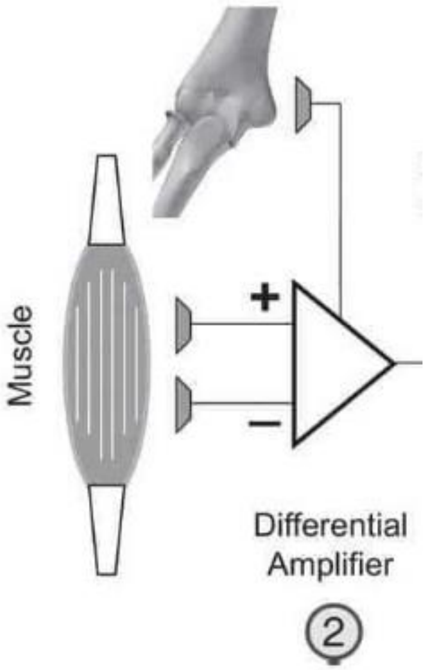


Figure 2. EMG signal acquisition

Solutions:

1) Limit the input gain of the Diff. Amp/INA to not to amplify DC
2) Implement the integrator/LP filtering to remove the differential DC
3) Apply high gain in the output stage of the Diff. Amp/INA to boost the AC (EMG) signal of interest

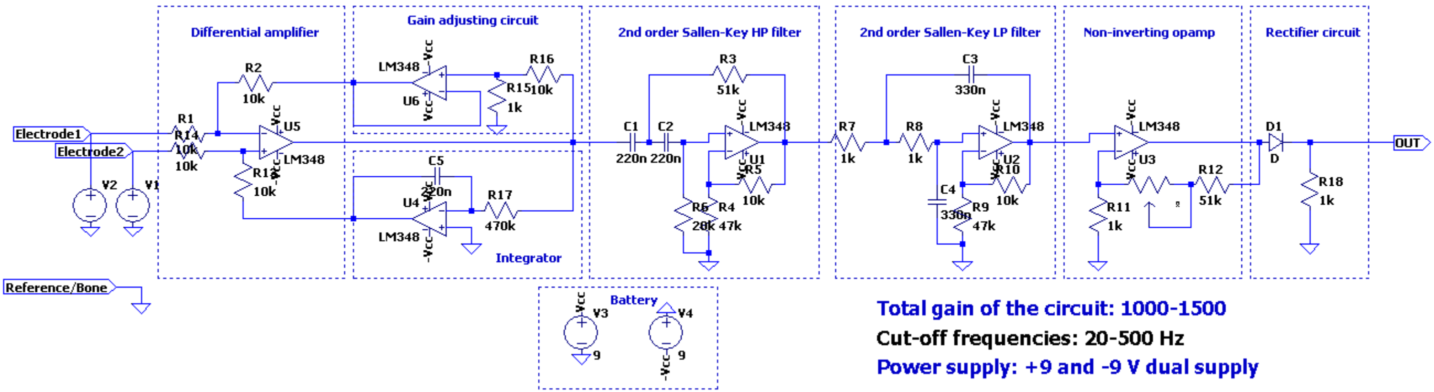
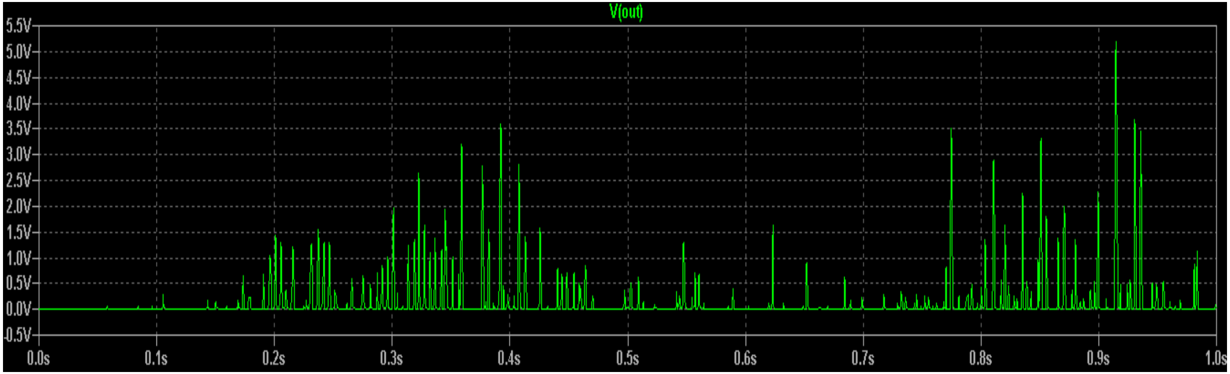


Figure 3. EMG sensor

EMG sensor [3/4]

Different raw EMG input:

Output signal:



EMG sensor [4/4]

If we do not want a rectified version of the processed EMG, we can shift our reference value (offset) from 0 V to 2.5 V (**Arduino** accepts 0-5V) using the schematic below.

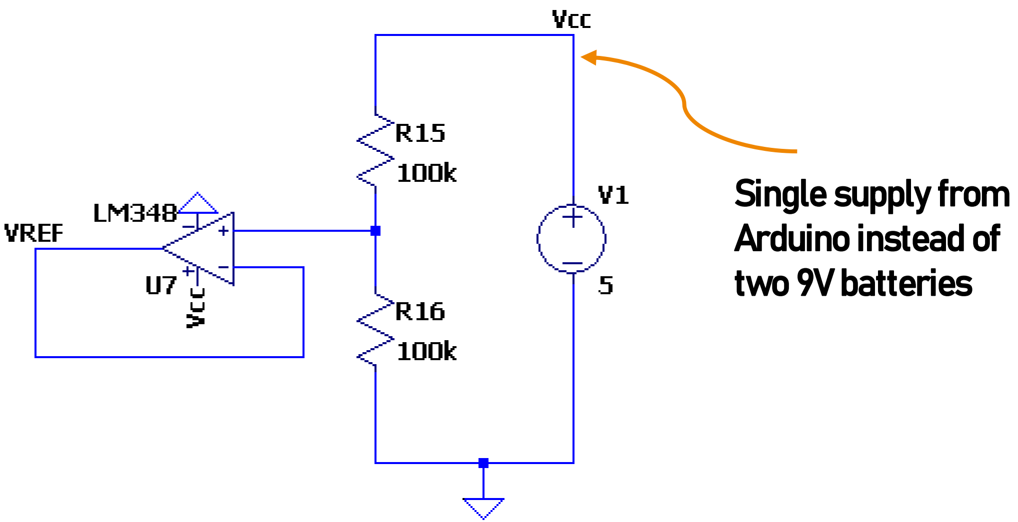


Figure 4. Voltage divider and voltage buffer to produce a new reference voltage of 2.5 V

Conclusion and future steps

- The reasons of the OpAmp saturation in real-time experiments were discussed

- The solutions to this problem, as well as the models of the modified EMG sensor were introduced

By the end of Capstone I, I plan to achieve:

✓ The dataset of EMG signals acquired from a DIY sensor

✓ Trained and optimized Pattern-Recognition (PR) model based on an ML algorithm

References

[1] M. Atzori and H. Muller, "The Ninapro database: a Resource for sEMG Naturally Controlled Robotic Hand Prosthetics", in *37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*, Milan, 2016.

[2] C. Spiewak, "A Comprehensive Study on EMG Feature Extraction and Classifiers", *Open Access Journal of Biomedical Engineering and Biosciences*, vol. 1, no. 1, 2018. Available: 10.32474/oajbeb.2018.01.000104.

[3] M. Atzori et al., "Electromyography data for non-invasive naturally-controlled robotic hand prostheses", *Scientific Data*, vol. 1, no. 1, 2014. Available: 10.1038/sdata.2014.53.

[4] M. Ortiz-Catalan, R. Brånemark and B. Håkansson, "BioPatRec: A modular research platform for the control of artificial limbs based on pattern recognition algorithms", *Source Code for Biology and Medicine*, vol. 8, no. 1, 2013.

Thank you!