Project Assignment – Signals and Systems Track

Hand Gesture Classification Based on EMG signals

Responsible Lecturer: Justin Dauwels (J.H.G.Dauwels@tudelft.nl)

Context

Hand gesture recognition can be beneficial in many practical applications, for example, monitoring the recovery process of patients, translating gestures to human languages, human-computer interaction, to name just a few. Generally speaking, two major approaches for hand gesture recognition are available, including vision-based approaches and bio-signal-based approaches. Although vision-based ones have already achieved satisfactory results by taking advantage of recent computer vision techniques, the limitation is that it requires a huge amount of camera-captured images and computational resources. In contrast, bio-signal-based approaches are more efficient in terms of data and computation, and what is more important is that bio-signal-based approaches directly links myographic signals with hand gesture, revealing how signals brain sends to arm control hand gestures. The challenge is that myographic signals collected with sensors sometimes can be noisy and less interpretable. To overcome this challenge and reliably predict hand gestures based on such signals, one should carefully perform data pre-processing and feature selection. In this Final Project Assignment, you will explore data features and develop an ML model that enables accurate hand gesture classification.

Purpose

By developing this assignment, you will put into practice all the learning concepts introduced so far in Lectures 1 to 5. You will develop strategies for hand gesture recognition and solve practical questions that arise when developing an ML model. This assignment covers this course learning objectives (LOs): LO3, LO4 and LO5.

Resources

You can consult with the TAs on Practicums on Week 5 and 6. You will receive feedback from a Lecturer on Week 7.

Instructions

Activities

You will be using data consisting of signals collected from MYO Thalmic bracelets worn on users' forearms. The bracelet is equipped with eight sensors equally spaced around the forearm that simultaneously acquire myographic signals. The raw EMG data for 36 subjects are recorded while they performed series of static hand gestures. The subjects perform two series, each of which consists of six (seven) basic gestures. Each gesture was performed for 3 seconds with a pause of 3 seconds between gestures.

Below is a description of the dataset and table 1 is an illustration:

The file consists of 10 columns

- Column 1: Time - time in ms;
- Column 2-9: Channel – eight EMG channels of MYO Thalmic bracelet;
- Column 10: Class – the label of gestures, with the following correspondence:
  - 0 - unmarked data,
  - 1 - hand at rest,
  - 2 - hand clenched in a fist,
  - 3 - wrist flexion,
  - 4 – wrist extension,
  - 5 – radial deviations,
  - 6 - ulnar deviations,
  - 7 - extended palm (the gesture was not performed by all subjects);

- Column 11: Subject number.

time	channel1	channel2	channel3	channel4	channel5	channel6	channel7	channel8	class	label
1	1e-05	-2e-05	-1e-05	-3e-05	0e+00	-1e-05	0e+00	-1e-05	0	1
5	1e-05	-2e-05	-1e-05	-3e-05	0e+00	-1e-05	0e+00	-1e-05	0	1
6	-1e-05	1e-05	2e-05	0e+00	1e-05	-2e-05	-1e-05	1e-05	0	1
7	-1e-05	1e-05	2e-05	0e+00	1e-05	-2e-05	-1e-05	1e-05	0	1
8	-1e-05	1e-05	2e-05	0e+00	1e-05	-2e-05	-1e-05	1e-05	0	1
9	-1e-05	1e-05	2e-05	0e+00	1e-05	-2e-05	-1e-05	1e-05	0	1

Table 1: Illustration of Data

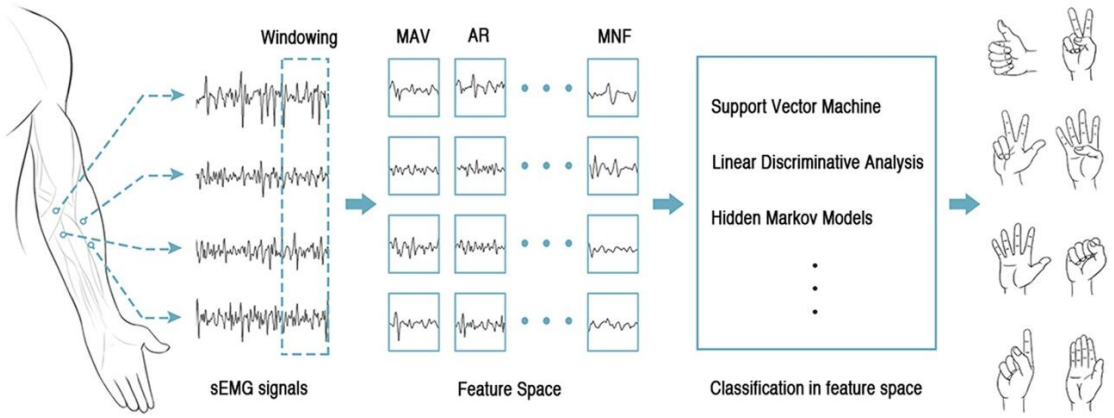
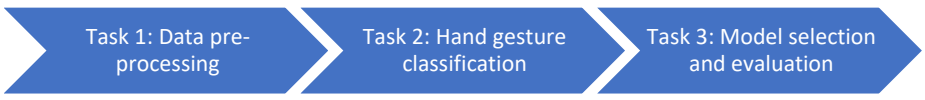


Fig. 1: Goal of the Project

The goal is to predict hand gestures given eight channels of EMG signals as illustrated in Fig. 1. Three tasks are planned for this Final Project Assignment, as shown below. Task 2 and 3 can be done in parallel.



Task 1

Perform data pre-processing activities, this may include data preparation, data cleaning, normalization, standardization, feature analysis, feature selection and feature construction.

Task 2

Develop a model that allows you to predict the hand gesture for new unseen EMG signals. Provide arguments for the choice and design of your final model(s). Provide arguments for the assessment and validation procedure of your final model(s).

Task 3
Develop an ensemble model that allows you to combining results of multiple diverse models to predict the hand gesture more accurately for new unseen operational scenarios. Provide arguments for the choice and design of your final model(s). Provide arguments for the assessment and validation procedure of your final model(s).

Other instructions
- You will work in pairs.
- Decisions need to be made together, but Tasks can be done individually.
- We recommend splitting the tasks. Any member must be capable of arguing any decision made.
- At least one of the models must be a *deep neural network (Lecture 6)***.**
- One report per pair. The report must follow the proposed structure with a maximum number of pages of 10.
- Deadline: Week 9.

Deliverables
1. Final Project Report (see instructions below)
2. Project Assignment Python code

Report Structure
- Members, emails, student numbers.
- Summary (less than 200 words)
- Detailed ML pipeline (include workflow figure).
- Task 1: selected options, argumentation for the selection, model(s) developed, results, validation, comparisons.
- Task 2: argumentations for the model(s) developed, validations, results, comparisons.
- Task 3: argumentations for the model(s) developed, validations, results, comparisons.
- Conclusions (less than 200 words)

Assessment Criteria
You will be evaluated based on a predefined rubric. Check the course Brightspace page to get access to the rubric.

The Project Final Report can be considered *inadmissible*, which will render a FAIL grade for the group, if
- English is not understandable (e.g., full of typos).
- Deep neural networks were not used (as one of the tested models).
- Figures are not legible.
- The report does not follow the proposed structure.

If the report is considered *admissible*:
- English will *not* render extra points.
- Quality of the Python code will *not* render extra points.

Submission Instructions
Please submit your Final Project Report in a PDF format and your Python code in Brightspace before the deadline.