# Intent detection and somatosensory feedback

## ***#11:*** *mock exam*

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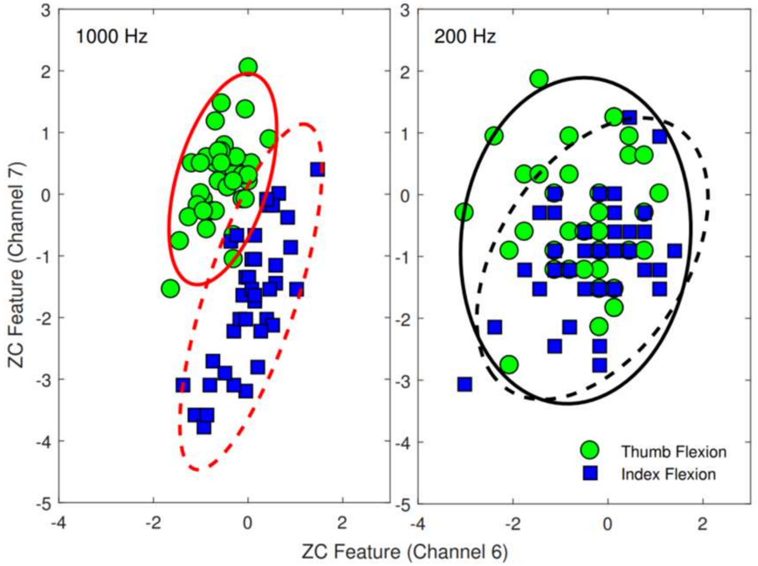



**Figure 2.** Differences in EMG patterns between using: (**left**) a 1000 Hz sampling rate; and (**right**) a 200 Hz sampling rate. ZC features are extracted from two different EMG channels (6 and 7) during thumb flexion (green circle markers and solid lines) and index flexion (blue square markers and dashed lines). Samples are from Subject 1 of Database 3.

EMG patterns related to two actions. Reproduced from Angkoon Phinyomark, Rami N. Khushaba and Erik Scheme, *Feature Extraction and Selection for Myoelectric Control Based on Wearable EMG Sensors*, MDPI Sensors 2018, 18, 1615

The *rubber hand illusion.* See Botvinick M, Cohen J., *Rubber hands 'feel' touch that eyes see.* Nature. 1998 Feb 19;391(6669):756. doi: 10.1038/35784. PMID: 9486643.

# Lecture #11:

Mock exam

- we‘ll give you three questions,
- for each of them you‘re given 20‘

- then we‘ll have a 5‘ discussion
- at the end, general discussion.

# Question #1 (30%):

- Force myography: how does it work? how can it be used for myocontrol?
- Describe qualitatively its characteristics, especially in comparison to electromyography.
- Suppose you have 20 force sensors available, each one of them changing its resistance proportionally to the applied force:
  - what kind of filtering would you apply to them, and
  - what features would you extract from them

  in order to optimise myocontrol based on them?

# Solution to question #1:

- Force myography works by detecting the deformation of the body part of interest; force (pressure) sensors are used to determine the amount of muscle bulging.

- w.r.t. EMG, FMG is cheaper, the electronics is simpler, and it provides a more stable signal; moreover it does not incur the usual EMG problems, e.g., sweat and muscle fatigue. as opposed to this, it can be severely affected by motion artefacts, i.e., if you bump into the socket FMG will report a spike.

- Signals obtained from 20 proportional force sensors will have more or less the same bandwidth of the actions to be detected, so
  - **filtering:** just some low-pass filtering is required (say cutoff frequency at $20Hz$), to remove high-frequency electromagnetic disturbance
  - **features:** the signals can probably be used as-they-are.

# Question #2 (40%):

Imagine you want to use IMUs to detect the pose of the hand with respect to the chest.

1. Where would you place the IMUs? (You can draw an image or describe it)
2. How would you compute the pose (position/orientation) with the recorded sensor data?
3. Imagine the orientation you determined for the IMU at your shoulder has an error of 5°, how would this affect your computed pose?
4. Describe an alternative way to determine the pose of the hand with respect to the chest!

# Solution to question #2:

Imagine you want to use IMUs to detect the pose of the hand with respect to the chest.

1. Where would you place the IMUs? (You can draw an image or describe it)

   1 at the hand, 1 at the forearm, 1 at the upper arm, 1 at the chest

2. How would you compute the pose (position/orientation) with the recorded sensor data?

   Model a kinematic chain and compute the joint angles based on the measured IMU orientations

3. Imagine the orientation you determined for the IMU at your shoulder has an error of 5°, how would this affect your computed pose? (you can draw a picture or write an equation)

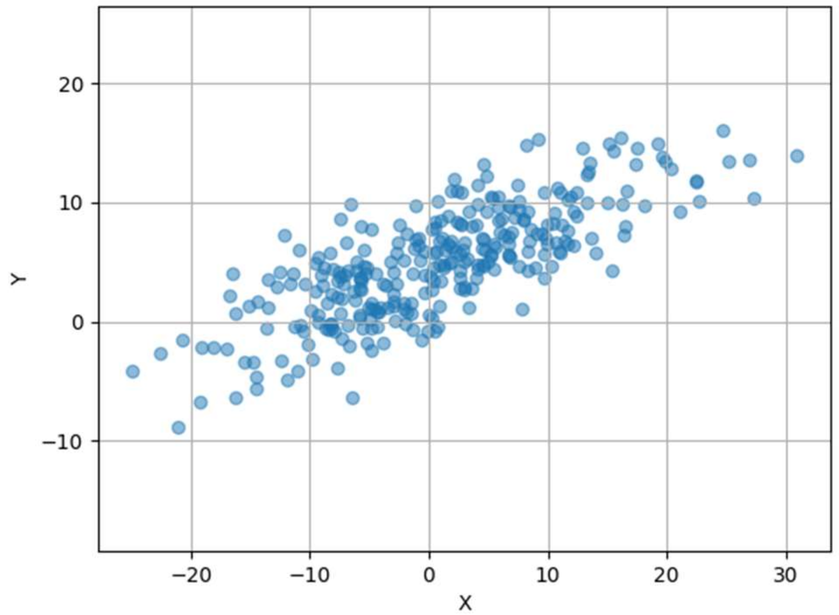
   (distance between the shoulder joint and the hand) $\cdot 2 \cdot \sin(\frac{5°}{2})$ (isosceles triangle)

4. Describe an alternative way to determine the pose of the hand with respect to the chest!

   Use a motion capturing system (visual tracking), extract the pose of the chest and the hand and compute the 6D distance inbetween

# Question #3 (30%):

Imagine you get a data set with feature x and feature y and datapoints which are distributed like at the figure on the upper right.




1. Draw the eigenvectors in the figure and approximate them visually
2. Is a positive/negative correlation visible? Is a strong or weak correlation visible?
3. You have another signal with the values of the table below. Normalize it!

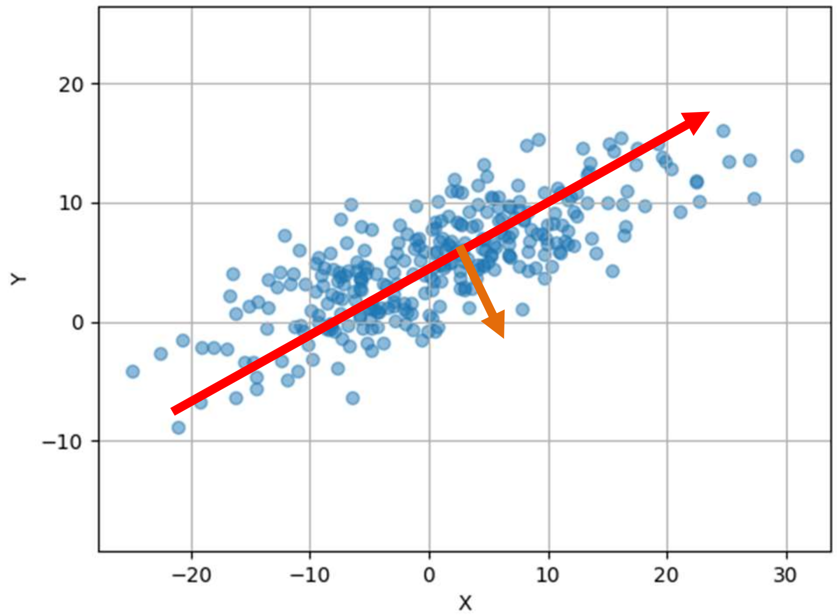
$$x_{norm} = \frac{x-\mu}{\sigma} \; with \; \sigma = \sqrt{\frac{\sum(x_i-\mu)^2}{N}} \; and \; \mu = \frac{\sum x_i}{N}$$

| | | | | | |
|---|---|---|---|---|---|
| 6.3 | 3.8 | 5.3 | 3.7 | 3.5 | 4.4 |

4. Does the correlation coefficient change in case you normalize your data before?

# Solution to question #3:

Imagine you get a data set with feature x and feature y and datapoints which are distributed like at the figure on the upper right.




1. Draw the eigenvectors in the figure and approximate them visually

2. Is a positive/negative correlation visible? Is a strong or weak correlation visible?

   Strong positive correlation

3. You have another signal with the values of the table below. Normalize it!

$$x_{norm} = \frac{x-\mu}{\sigma} \; with \; \sigma = \sqrt{\frac{\sum (x_i-\mu)^2}{N}} \; and \; \mu = \frac{\sum x_i}{N}$$

| | | | | | |
|---|---|---|---|---|---|
| 6.3 | 3.8 | 5.3 | 3.7 | 3.5 | 4.4 |
| 1.8 | -0.7 | 0.8 | -0.8 | -1 | -0.1 |

$\mu = 4.5, \sigma = 1$

4. Does the correlation coefficient change in case you normalize your data before? No!