Project 4

Neurorobotics & Neurorehabilitation 2022/2023

Objective:
Students are asked to analyze the data collected during an experiment with 5 healthy subjects controlling the avatar of a wheelchair during a virtual race via joystick.

Data description:
Data has been recorded with 16-channel EEG amplifier (g.USBamp, g.Tec) at 512 Hz. Electrodes were placed accordingly to the 10-20 international layout. Position and order of the electrodes are reported in Figure 1A. Events in the GDF are reported in Figure 1C.

The task:
Participants were asked to control the avatar of a wheelchair during a virtual race via joystick (Figure 1B). The race consisted in a track composed by the repetition of four different sectors: turn right, turn left, light, straight. Subjects were allowed to send two discrete commands to the game (via joystick) to make the avatar turn right or left when a turn occurred. If a wrong turning command was delivered in the turning sectors, the avatar was penalized. If a turning command was wrongly sent in the straight or light sectors, the avatar was penalized. Subjects were istructed to deliver always the correct command.

However, the control had 20% of probability to invert the user's command, and thus to provide the wrong command to the game (e.g., turning left instead of right). Furthermore, the control had 20% of probability to send a random command every 4 seconds in the straight or light sectors. We assume that such as a faulty control would generate error potentials.
Data: https://cloud.dei.unipd.it/index.php/s/9jbBAiBqkxSb6wT

Assignments:
Students are asked to investigate the presence of error potentials during the game and classify them. In particular, two types of analyses are requested:

1. Grand average analyses on the whole population and on representative subjects
   a. Process the data and apply the convenient filters;
   b. Identify and extract the most suitable features;
   c. Report the achieved results.

2. Analyses on BMI decoding on each subject (use a leave-on-out strategy [run-based])
   a. Calibration phase:
      - In the trainset: process the data, compute the features, select the most disciminant features;
      - Create a classifier based on those features.
   b. Evaluation phase:
      - In the testset: process the data, compute the features, and extract those already selected during the calibration phase;
      - Use this data to evaluate the classifier created during the calibration phase;
   c. Report on the achieved results in terms of (but not limited to): trial accuracy (trainset/testset), ROC curve and AUC (trainset/testset)

Reference:
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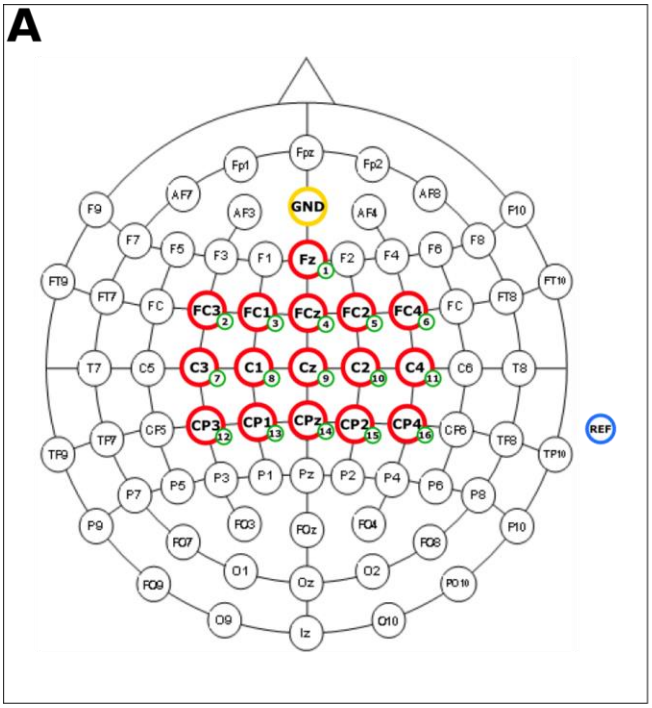
Perrin X et al. Brain-coupled interaction for semi-autonomous navigation of an assistive robot. Robotics and Autonomous Systems, 58(12):1246-1255, 2010.
doi: 10.1016/j.robot.2010.05.010

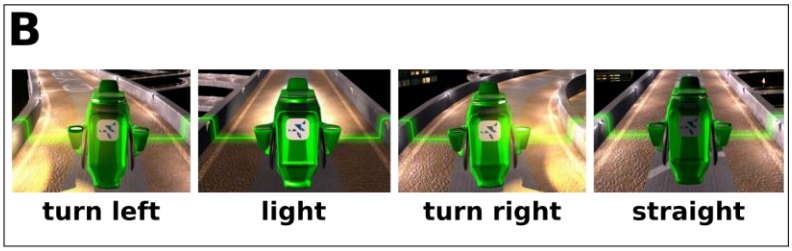
Iwane F et al. Spatial filters yield stable features for error-related potentials across conditions. IEEE International Conference on Systems, Man, and Cybernetics (SMC), pp. 000661-000666, 2016. doi: 10.1109/SMC.2016.7844316.

Iturrate I et al. Teaching brain-machine interfaces as an alternative paradigm to neuroprosthetics control. Sci Rep 5:13893, 2015. doi: 10.1038/srep13893

Iwane F et al. Invariability of EEG error-related potentials during continuous feedback protocols elicited by erroneous actions at predicted or unpredicted states. J Neural Eng. 18(4), 2021 doi: 10.1088/1741-2552/abfa70

Lopes-Dias C et al. Online asynchronous decoding of error-related potentials during the continuous control of a robot. Sci Rep 9:17596, 2019. doi: 10.1038/s41598-019-54109-x





C

Description	Decimal value
Race start	800
Race end	8800
Avatar enters in sector: Turn left	201
Avatar enters in sector: Light	202
Avatar enters in sector: Turn right	203
Avatar enters in sector: Straight	204
User sent command: Turn left	101
User sent command: Turn right	103

Figure 1: A) 16-channel layout. Red circles indicate the electrode positions, small green circles the electrode number; B) Example of the virtual race and the four different sectors in the track. C) Event codes in the GDF