An introduction to OpenViBE: Basic EEG signal acquisition, processing and visualization

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The OpenViBE tool to read brain signals

The OpenViBE **acquisition server**
- A generic interface to read from multiple devices
- 40+ brain recording devices supported, and growing!
The OpenViBE tool for designing BCIs

The OpenViBE **designer**
- Creating a BCI by assembling boxes
- One box = one processing module
The OpenViBE designer: an example

- Acquisition: << Reading EEG signals being measured
- Filtering: << Filtering EEG in a given frequency band
- Channel Selection: << Selecting sensors
- Visualization: << Visualizing processed signals in real-time
An OpenViBE box

- **Box Input-Output**

- **Data types**
  - Streamed matrix (data matrix)
  - Signal (Data with a sampling rate and channels – subtype of streamed matrix)
  - Stimulation (Event with a name and a date)
Box settings

- Settings are available by double-clicking on the box
Exercise 1

- Warm-up: display EEG signals by

  1. Selecting “Generic Oscillator” as driver in the acquisition server then “connect” then “read”
Exercise 1

2. copying the OpenViBE scenario below and running it (play)

Control panel: Start and stop the BCI!
Exercise 1

- Offline version – with file reading
Selecting an EEG file
- Double click on the box
- Select file “leftHandMovements.gdf” available on the tutorial page http://openvibe.inria.fr/openvibe-tutorial-nec22/
• Press “play”
Visualizing events (a.k.a Stimulations)

To do: connect the « stimulations » input/output (purple)

Stimulations colors and names (click on « signal display » then on « stimulation colors »)

The stimulations (events) are displayed as dotted lines
Exercise 2

Visualizing sensorimotor rhythms (SMR)
• Need to select the SMR-related channels (e.g., C4)
• Need to band-pass filter the signals in the SMR (e.g., µ: 7-13 Hz)
• You can do this with the following boxes:

   ![Temporal Filter](image)
   ![Channel Selector](image)

• Notes: you can check [http://openvibe.inria.fr](http://openvibe.inria.fr) for documentation
• The documentation of a box is also available by pressing F1 when the cursor is over the box
Visualizing SMR
Computing EEG band power

1s of Raw EEG at C3

Band-pass filtering in 8-12 Hz

8-12 Hz band power for channel C3

Temporal average

Power estimation (squaring)
Exercise 3

• Compute the SMR band power on 1s long sliding windows

Note: to ease the signal visualization in that case, you can set the « Time Scale » setting of the signal display from 10 to 100
Visualizing Mu band power continuously
Spatial Filtering

- Ex: Laplacian filters
  - LapC4 = 4*C4 – FC2 – FC6 – CP2 – CP6
A simple Neurofeedback scenario: Alpha/Theta ratio neurofeedback

- Computing and visualizing alpha power in C4

Right click on the signal display >> rename box… >> name it “Alpha power”
A simple Neurofeedback scenario: Alpha/Theta ratio neurofeedback

- Adding the theta power to the scenario

1 - Copy-paste this set of boxes

2 - Change the frequency range (4-7 Hz)

3 – Rename the display
The Window Manager
The Window Manager
A simple Neurofeedback scenario: Alpha/Theta ratio neurofeedback

- Computing the alpha over theta ratio

Add a “SimpleDSP”, and right click on it to add an input

Use the “A/B” formula (ratio of first input over second input)
A simple Neurofeedback scenario: Alpha/Theta ratio neurofeedback

- Plug-in the simple DSP box and visualize the result!
A simple Neurofeedback scenario: Alpha/Theta ratio neurofeedback

You can add « fancy » visualizations, see « advanced visualization » boxes
Exercise 4: Neurofeedback reward

Automatically display a reward picture when the users’ alpha/theta ratio crosses a given threshold!

You will need the following two boxes:

(And to define your threshold value)

- **Sign Change Detector**: Sends a given stimulation when the input signal changes sign
- **Display cue image**: Displays a given picture when receiving as input a given stimulation
Neurofeedback reward scenario

1 – Subtracts the threshold value

2 – Defines (box settings) the (reward) stimulation to send when the threshold is crossed

3 – Defines (box settings) the image to display when receiving the reward stimulation
Going Further - in brief

- Communication with other software/applications

- Rapid prototyping

Designing protocols with Lua in OpenViBE by Laurent Bougrain

Quick prototyping in OpenViBE in Python by Thomas Prampart
Machine Learning in OpenViBE in brief

- Using machine learning
  - various classifiers: LDA, sLDA, SVM, Neural Network, Riemannian geometry classifiers (MDM, fgMDM, TSC, etc), etc.
  - various data-driven spatial filters (CSP, RCSP, XDAWN, etc.)

Calibration (training)  
Use (testing)
Machine Learning in OpenViBE in brief

- Typically: several scenarios when using machine learning

1 - Training data acquisition scenario
2 - Classifier training scenario
3 - Online feedback scenario
Machine Learning in OpenViBE in brief

- Similar principle for spatial filters

Calibration (training)

Use (testing)

Hands-on Machine Learning in OpenViBE by Laurent Bougrain
Thank you for your attention!

Any question?

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