Using OpenViBE in practice: a step-by-step tutorial

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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 pour 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 workshop page http://openvibe.inria.fr/the-4th-international-openvibe-workshop/
• 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:

• Notes: you can check 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

**Time based epoching**: Sliding window analysis: epoch the continuous signals

**Simple DSP**: Apply a math operation on each sample

**Signal average**: Average the signal over an epoch
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
Designing simple BCI/EEG protocols

• How to display instructions/stimulus at specific times and record EEG at these times?

• Generating events:
  • By using OpenViBE Stimulations (events) and the Lua stimulator
  • Lua is a simple script language

• Displaying stimulus when receiving the stimulations:
  • Display Cue Image box (visual stimulus)
  • Sound Player box (audio stimulus)
Simple protocol
Lua stimulator

- Sends stimulation according to a script-defined timing
- Ex: sending 1s-long stimulations every 3s

```lua
function initialize(box)
    local box = box
    dofile(box:get_config("${Path_Data}" .. "/plugins/stimulation.lua")
    -- defining protocol timings
    stimulus_duration = 1
    number_of_trials = 10;
    inter_trial_interval = 2
    end

function process(box)
    local t = 0
    -- for each trial
    for i = 1, number_of_trials do
        -- send a stimulation to display a stimulus
        box:send_stimulation(1, OVIK_StimulationId_Label_01, t, 0)
        t = t + stimulus_duration
        -- after the required time, send a different stimulation to stop the display of the stimulus
        box:send_stimulation(1, OVIK_StimulationId_VisualStimulationStop, t, 0)
        t = t + inter_trial_interval -- wait for some time before the next trial starts
    end
end
```
The whole scenario for Event Related Potential analysis

Reading EEG signals

Recording EEG signals tagged with events in .ov (OpenViBE format) and GDF (General Data Format)

More info and examples: [http://openvibe.inria.fr/recording-erps/](http://openvibe.inria.fr/recording-erps/)
Going Further - in brief (1)

- 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.)
Going Further - in brief (1)

- Typically: several scenarios when using machine learning

1. Training data acquisition scenario
2. Classifier training scenario
3. Online feedback scenario
Going Further - in brief (2)

- Similar principle for spatial filters

Calibration (training)

- Communication with other software/applications

Use (testing)

- Rapid prototyping
Summary

- With OpenViBE you can design easily and rapidly various BCIs or real-time neuroscience systems and experiments
- Free and open-source
- Various scenarios of standard BCIs available and provided
- Can be (and is continuously) extended with new modules (boxes), drivers (new EEG devices) and functionalities
Thank you for your attention!

Any question?

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