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

**Signal acquisition test**
Display the signal of Laplacian around Oz and the power spectrum of the average of all electrodes.

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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 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 XX/openvibe-2.1.0 > share > openvibe > scenarios > signals
  • Select file “bci-motor-imagery.ov”
• Press “play”
Exercise 2

Visualizing sensorimotor rhythms (SMR)
- Need to select the SMR-related channels (e.g., C3/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 - GPL](image)
![Channel Selector](image)

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

1s of Raw EEG at C3

8-12 Hz band power for channel C3

Band-pass filtering in 8-12 Hz

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 – FC4 – C2 – C6 – CP4
A simple Neurofeedback scenario: Alpha/Theta ratio neurofeedback

- Computing and visualizing alpha power in C3

Right click on the signal display
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 the simple DSP and visualize the result!
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

Display cue image

Sound Player

Configure Display cue image settings
- Display images in full screen: false
- Scale images to fit: false
- Clear screen Stimulation: OVTk_StimulationId_VisualStimulationStop
- Cue Image 1: $(Path_Directory)/plugins/simple-visualisation/p300-magic-card/01.png
- Stimulation 1: OVTk_StimulationId_Label_01

Configure Sound Player settings
- PLAY trigger: OVTk_StimulationId_Label_01
- STOP trigger: OVTk_StimulationId_VisualSteadyStateStimulationStop
- File to play: $(Path_Directory)/plugins/stimulation/ov_beep.wav
- Loop: false

Configure Lua Stimulator settings
- Lua Script: C:/MySlides/OpenViBEWorkshop2018/OpenViBEscenario/ERP_1Stimulus.lua
- Override settings with configuration file
- Load... Save... Default Revert Apply Cancel
Lua stimulator

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

```lua
function initialize(box)
    local t = 0
    local stimulus_duration = 1
    local number_of_trials = 10:
    local inter_trial_interval = 2
    dofile(box:get_config("${Path_Data}" .. "/plugins/stimulation/lua-stimulator-stim-codes.lua")
    -- defining protocol timings
    stimulus_duration = 1
    number_of_trials = 10:
    inter_trial_interval = 2
    end

function process(box)
    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, etc.)
  • various data-driven spatial filters (CSP, RCSP, XDAWN, etc.)

Calibration (training)  Use (testing)
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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