Wintermute command-line tool

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Wintermute command-line tool is a still experimental software for manipulating brainwaves (EEG) and related metrics using audiovisual stimulation and machine learning. It requires an EEG-device used to measure brainwaves and then select based on live measurements a stimulus to change EEG towards target value.

Results of manipulation are a bit random but quite often one gets wanted changes when compared to watching a blank (no) stimulus or a random stimulus. Currently, the changes seem to only happen when one watches and listens the stimulation and brain resets quite quickly after the end of optimized stimulation. Therefore, the health effects of the machine-learning (science) based brainwave entrainment are speculative.

The EEG-devices supported are currently Interaxon Muse and BrainAccess HALO devices. The software is distributed under GPL license so if you want to contribute to add support for more EEG-devices please contact the maintainers (Tomas Ukkonen).

Compilation

Usage

To use software with Interaxon Muse devices you have to have Mind Monitor app installed (requires payment) to your phone which contacts to Muse device and sends measurements to computer (configure IP value of your computer in WLAN and UDP port 4545 in Mind Monitor settings). After this you can use precomputed models and measurements to maximize PLV value of brain (focus and intelligence) using a command:

```
./wintermute --execute --fullscreen
```

This shows stimulus in fullscreen mode (fullscreen is more effective) for 5 minutes and reports average distance to target value (smaller is better). To compare effect caused by optimized stimulus to blank or random stimuli you can use commands:

```
./wintermute --blank --execute --fullscreen
```

```
./wintermute --random --execute --fullscreen
```

To use BrainAccess HALO device, you need to setup LSL output to the local wifi WLAN (Use BrainAccess Board) and set `wintermute` to use LSL device and LSL stream name and type (EEG).

```
./wintermute --execute --fullscreen --device=lsl --lsl-names=<stream_name>,EEG
```

You can use similar commands to compare optimized stimulus with HALO device with blank or no random stimulus.

Other Targets

There are 14 possible target values (within range of 0 and 1) which can be optimized for. The target values are:

1: Delta brainwaves (power spectrum)

2: Theta brainwaves (power spectrum)

3: Alpha brainwaves (power spectrum)

4: Beta brainwaves (power spectrum)

5: Gamma brainwaves (power spectrum) (Use: 1.0 for alertness)

6: Total Power in brainwaves (power spectrum)

7: Spectral Entropy of brainwaves (Use: 0.0 for sleep, 1.0 for alertness)

8: Phase Difference of brainwaves

9: Phase Slope Index of brainwaves

10: Phase Locking Value (PLV) (Use: 1.0 for focus and intelligence)

Additionally, it is possible to try to calculate independent components (ICA) from EEG signals and calculate their spectral entropy, phase difference, phase slope index and phase locking values but except for superfast computers, calculating of linear ICA cannot be computed for live measurements and stimulation because CPUs are too slow for ICA calculations so ICA is disabled as the default.

You need to compute prediction models for each target separately, new prediction models are computed from measurements using command:

```
./wintermute --optimize --model-dir=<model-dir> --device=<mindmonitor/lsl> '
```

```
--target=-1,-1,-1,-1,-1,-1,-1,-1,-1,-1,-1,-1,-1,-1
```

In the command, target sets optimization target (14 signals), signals which are negative are not used and target values must be within range 0-1. Optimization is done using CPU (and not GPU) and takes with modern CPU about 3 days per target.

If you use have computed models for other targets than PLV, you can execute stimulus using command:

```
./wintermute --execute --model-dir=<model-dir> --device=<mindmonitor/lsl> '
```

```
--target=-1,-1,-1,-1,-1,-1,-1,-1,-1,-1,-1,-1,-1,-1
```

Own Measurements

For the best results, you need to optimize prediction models to your own brain measurements. In practice, one should measure brain responses to random stimuli with several one hour long measurement periods. To do measurements, create a new model directory and measure responses using command:

```
./wintermute --measure --model-dir=<model-dir> --device=<mindmonitor/lsl>
```

After measurements, you need to also calculate prediction models for each target.

It Doesn't Work

It possible to get poor results (worse results than blank or random stimulus). Here are few things to get better results:

- do measurements in windowed model but execute stimulus using fullscreen mode with less distractions

- make sure that EEG-device have good connections to brain so measurements are not bad or noisy

- do measurements many times during different time of day to get better prediction models

- don't use multiple signal targets in execute, only optimize for a single signal value and only use targets 0 (min) or 1 (max).

- do measurements using multiple persons for more general prediction models

You can expect to typically get 5-10% change in EEG metrics and 0% change with more complex targets.