# MuLES: An Open Source EEG Acquisition and Streaming Server for Quick and Simple Prototyping and Recording

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## Motivation

Electroencephalography (EEG) is a non-invasive technique that measures the electrical activity in the cerebral cortex evoked by neurons' synchronized firing. Some of the applications of EEG include:

- Medical diagnosis (epilepsy, sleep disorders, dementia, etc)
- Brain-computer interfaces (BCIs)
- Neurofeedback

The burgeoning availability of new portable consumer grade EEG devices has reinforced the use of EEG in traditional research and clinical fields and has opened the doors to its utilization in novel domains such as **neurogaming**, **live performance** and **arts**.

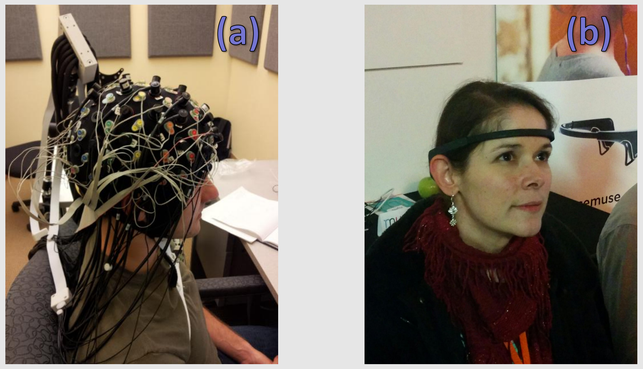



*Figure 1. EEG devices **(a) Clinical** and **(b) Consumer grade***

Although they offer many advantages (e.g. portability and affordability), consumer grade devices present some drawbacks such as:

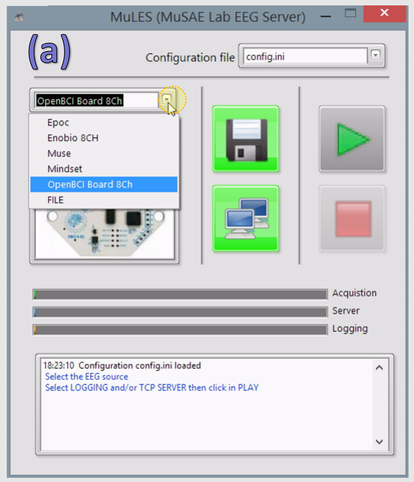
- Each device possesses its own API, SDK or driver, hindering the development of device-indepentent applications
- Extensive programming experience required
- Poorer signal quality

## Solution

**MuSAE Lab EEG Server (MuLES)** is an open source EEG acquisition and streaming server that aims at creating a standard interface for portable EEG headsets. It provides a minimalist graphical user interface (GUI) to allow **quick** and **simple** interfacing with different portable EEG consumer devices.

## Features

- Current support for 5 different consumer grade EEG devices
- Recording of EEG data in standard formats
- Streaming of EEG data (from devices or files) using TCP/IP
- Support for multiple instances simultaneously to allow connecting to various EEG devices at the same time on the same computer
- Triggers can be sent both locally and remotely
- Clients for different programming languages provided
- Simple GUI allowing recording and streaming of data with a few clicks




**Try MuLES out!**

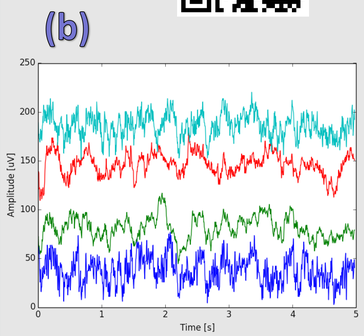



*Figure 2. **(a) MuLES graphical user interface** and **(b) EEG signals***

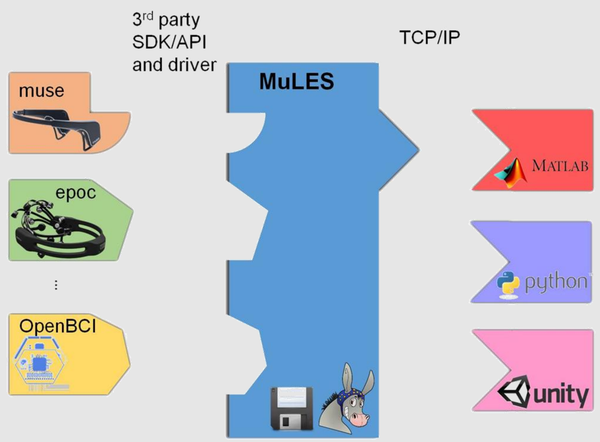



*Figure 3. **Architecture of MuLES**: EEG devices are connected through their respective drivers, EEG data is recorded and communication to external client applications is done using the TCP/IP*

## Use case and applications

A preliminary version of MuLES was used during a 36-hour hackathon (WearHacks Montreal 2014) to develop a neurogaming project titled **neuralDrift,** where **two players** wear consumer **EEG headsets** that send data to a remote computer through **MuLES**. The data is analysed in real-time in order to infer each player's intent; the results are sent to a **robot** that is **collaboratively controlled.** http://neuraldrift.net/


*Figure 4. Collaborative EEG-based game **neuralDrift** and robot close-up. Courtesy of the neuralDrift team.*

## Future work

Future versions of MuLES will include:

- Compatibility with other operative systems
- Support for non-EEG devices (such as electrocardiography, galvanic skin response and temperature sensors)
- Computation of basic features such as frequency transforms
- Example clients in other programming languages and software frameworks such as Unity

## Acknowledgments

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