CEBL$_3$: A New Software Platform for EEG Analysis and Rapid Prototyping of BCI Technologies

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Introduction: Version 3 of the Colorado Electroencephalography and Brain-Computer Interfaces Laboratory (CEBL$_3$) is a new software platform, written in Python, that is designed to support all phases of Brain-Computer Interface (BCI) research and development [1]. CEBL$_3$ is being developed by the Colorado State University BCI Group and currently supports a variety of standard and cutting-edge features, including modules for signal processing, visualization, machine learning and a fully-functional Graphical User Interface (GUI). A major design goal of CEBL$_3$ is to allow researchers to rapidly progress novel ideas from the early experimental and analysis stages to fully functional BCI prototypes.

Motivation: Current BCI software packages are typically designed with one of two primary goals: offline analysis or performing interactive experiments [2]. For instance, EEGLAB and BCILAB are written primarily in MATLAB and easily permit exploratory analysis using standard or custom methods. However, they are not equipped with an extensive framework for developing new user interfaces or performing real-time experiments. On the other hand, software packages like BCI2000 and OpenVibe are well-suited for performing interactive experiments. However, they are written in C++ and require significant time and effort to implement new methods. The goal of CEBL$_3$ is to bridge this gap by providing a single BCI software platform that supports all stages of BCI development in a flexible, feature-rich and high-performance environment.

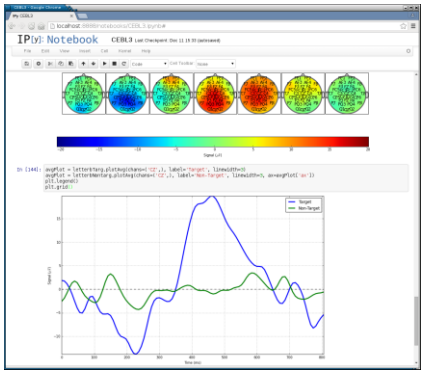

Figure 1. *A screen capture of CEBL$_3$ in an IPython notebook.*

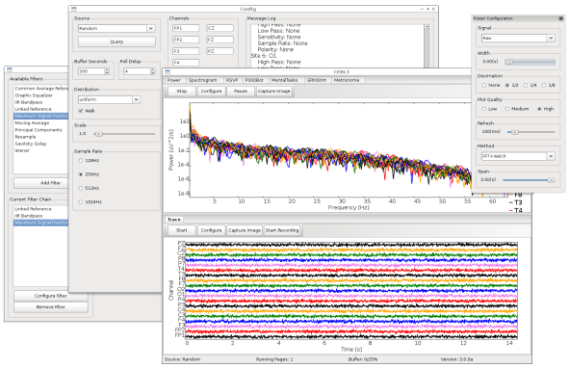

Figure 2. *A screen capture of the CEBL$_3$ graphical user interface.*

Results: In CEBL$_3$, researchers can begin by performing offline analysis in an IPython notebook, shown in Figure 1, using any of the provided analysis modules. CEBL3 also has integrated support for NumPy, SciPy and Matplotlib, which allows researchers to easily incorporate well-established and novel algorithms while maintaining computational performance. Promising approaches can then be placed into the GUI framework, shown in Figure 2, which is based on wxPython and a number of custom widgets. This allows for the rapid promotion of novel methods from offline analysis to fully functional BCI's. Presently, we have used CEBL$_3$ in a number experiments and demonstrations, including in-home experiments involving users with motor impairments.

Significance: CEBL$_3$ has the potential to increase the productivity of BCI researchers by promoting code-reuse and reducing the time required to place novel methods in an interactive framework. This may also encourage online experimentation and testing of novel BCI technologies in real-world use-cases.

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References:

[1] Colorado State University BCI Group. CEBL$_3$. Software. http://www.cs.colostate.edu/eeg/main/software/cebl3 Dec 2015.

[2] Clemens B, Andreoni G, Bianchi L, Blankertz B, Breitwieser C, Kanoh S, Kothe CA, et al. "BCI Software Platforms." *Towards Practical Brain-Computer Interfaces*, pp. 303-331. Springer, 2013.