BCI DATA ANALYSIS COMPETITION: RESULTS, LESSONS LEARNED AND THE FUTURE

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In an effort to foster development of machine learning techniques and evaluate different algorithms for BCI systems, we announced a data analysis competition during the NIPS*2001 Brain Computer Interface Workshop (December 2001). Three EEG data sets involving separate BCI tasks were provided. Participants were asked to follow a few simple rules:

1. All data sets should be evaluated single-trial--do not average across multiple trials.
2. Report the statistics/metrics outlined in the description of each dataset.
3. Use of these datasets implies that the participant agrees to cite the origin of the data in any publication (see each dataset description for bibTeX entry).
4. Please do not cheat! In some cases we have given labels for both training and test data, or because of limited data size a leave-one-out validation is required. You are on your honor to do the evaluation properly and unbiased (minimum bias at least).

The three datasets in the competition included:

EEG self-paced key typing (courtesy of Benjamin Blankertz and Klaus-Robert Mueller, Fraunhofer FIRST, and Gabriel Curio, FU-Berlin). This dastset consists of 513 trials of 27 electrode EEG recordings from a single subject. While sitting in a normal chair, relaxed arms resting on the table, fingers in the standard typing position at the computer keyboard (index fingers at 'f','j' and little fingers at 'a',';') the subject was instructed to press the aforementioned keys with the corresponding fingers in a self-chosen order and timing. The task was to classify EEG potentials as being associated with left or right finger movement.

EEG synchronized imagined movement task (courtesy of Allen Osman, University of Pennsylvania). The task of each of 9 subjects during the EEG Synchronized Imagined Movement data set was to imagine moving his or her left or right index finger in response to a highly predictable timed visual cue. The goal of competition participants was to classify EEG recordings as belonging to left or right imagined movement. EEG was collected using 59 sensors and there were 90 trials for each subject (45 left and 45 right)

Wadsworth BCI Dataset (courtesy of Gerwin Schalk, Wadsworth Center) The data set consists of 64 electrode EEG recordings from 3 subjects. The task of each subject was to move a cursor on a video screen to 1 of 4 predetermined positions. Each target position differed only in vertical location. Horizontal coordinates were identical for each target position. The objective of this contest was to classify EEG recordings as belonging to the correct target position.

We will describe the datasets in further detail, present results from the competition and discuss lessons learned. We will also have an open discussion on the general utility of such competitions for promoting algorithm development in BCI and identify opportunities for a future competitions. More details can be found at http://newton.bme.columbia.edu/competition.htm.

BCI2000 IMPLEMENTATION OF A FOUR-CHOICE APPLICATION

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Many labs are developing and testing BCI systems that are intended to provide new communication channels to those with severe motor disabilities. These systems focus on different brain signals, use different signal processing methods, and control different output devices. Many factors (e.g., the chosen brain signals, feature extraction methods, translation algorithms, output devices) determine the performance of each BCI system. To optimize BCI performance, the alternatives for each factor need to be compared, combined, and tested systematically. In response to this requirement, we have developed a documented general-purpose BCI research and development platform, called BCI2000, that is based on a general model of the BCI process and can incorporate alone or in combination any of the different possible BCI input signals (from neuronal spikes to slow cortical potentials), processing methods, and outputs.

BCI2000 consists of four modules (signal acquisition, signal processing, output control, and operating protocol) that communicate through a network-capable protocol. Each of the four modules can be executed on any machine on a network (e.g., the interface to the investigator may run on a different machine), and each module can be changed without affecting any other module.

As an example of the utility and practical applicability of BCI2000, we will demonstrate its implementation of a spelling paradigm. In this paradigm, the system calculates mu and/or beta rhythm amplitude at one or several scalp locations and uses the result to control cursor movement. In each trial, the cursor moves from left to right at a constant rate with its vertical movement controlled by the user's EEG. The user's goal is to hit the correct one of four possible targets on the right edge of the screen. After an initial screening protocol and training, users can achieve accuracies of 70%-95% (note that accuracy in the absence of any user control would be 25%).

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