RIT Department of Computer Science
MSc Thesis Pre-Proposal:
Data Representation for Motor Imagery Classification

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1 Problem Statement

Recent advances in small-scale and non-intrusive methods for measuring brain activity have increased the potential for brain-controlled interfaces (BCI) [2] for both the professional medical community all the way to the hobby-driven and DIY communities. Both NeuroSky and Emotiv are driving forces behind the progress of this technology and offer communities dedicated to helping bring together like-minded developers to improve the state-of-the-art approaches as applied to electroencephalography (EEG). OpenBCI takes a slightly different approach in that they have open-sourced the software and libraries need for interfacing with their system along with the hardware schematics used for building their boards, the Ganglion and the Cyton. The hardware limitations may be starting to be addressed. However, interpretation of the generated signals remains a difficult challenge [5] that is still primarily addressed by leading research labs and large medical facilities.

Solving problems in this domain requires teams to be proficient in numerous domains running the gamut from neuroscience to computer science [3]. As such, research towards progressing BCI systems has not matched the pace of the developing potential of the requisite hardware. Rather, many projects and work tends to focus on approaches which focus on gathering signals from specific areas of the brain. Namely, these signals have been used to measure levels of attention and relaxation. In fact, both NeuroSky and Emotiv have proprietary algorithms for transforming signals measured from the prefrontal locations of the International 10-20 system into values which represent how focused or relaxed a user is at a given point in time.

1.1 Motivation

Based on the aforementioned concern, it would prove fruitful to provide both researchers and hobbyists an intermediary step between the distinct theoretical aspects involved in advancing the capabilities of BCI systems. That is, provide a method for the subject matter experts, in this case, the neuroscientists, to communicate and provide the information and data to the computer scientists in such a manner that it is able to leverage the current state of the art methods for data analysis and classification.

1.2 Thesis Statement

The research towards this thesis will focus on addressing the issue of this domain gap. This involves developing a method for representing the multivariate time-dependent signals collected by an EEG. Additionally, this data representation will be tested in order to verify that it is both able to be intuitively interpreted by subject matter experts as well as artificial intelligence engineers. Finally, it will be applied to a specific use case and a user will attempt to use their mind in order to move a character through a simple game on a computer.

1.3 Related Work

When approaching the problem of classification of motor imagery events, subject matter experts often perform manual feature extraction [6] based on the theoretical underpinnings of the neuroscience involved. Often, these features take the form of Hjorth Parameters [7], Fourier or Laplacian transforms, or wavelet transforms These features are then fed into machine learning classifiers, such as LSTM RNN or logistic regression models [1]. However, it is often the case that accuracy is used as a metric of evaluation, although the events are often considered under the oddball paradigm. Another method of evaluation is a transient analysis of the system with regards to the timing involved in recognizing and classifying an event [4].

2 Methodology

This effort will require both a hardware and software component. For the hardware, this will be the Ganglion board. OpenBCI develops this board and an open-source library for interfacing with the data stream. For the software, it will be written in Python and will make use of the numerous machine learning and AI libraries provided by the community, such as Keras and Scikit-learn. These tools will be used in the development of a method of representing the signals generated by the Ganglion. This will take the form of an image, where each image generated correlates to a single data sample which would typically be fed into a machine learning algorithm, such as a recurrent neural network. This method of preparing the data will be compared against other state-of-the-art techniques for performing motor imagery classification.

3 Evaluation

Due to the thesis statement proposing a novel approach for preparing the data in a specified form, it is difficult to assert an outright rejection of hypothesis. Thus, the expected outcome is a comparison against state-of-the-art models in terms of ability to classify the events as well as ability to directly interpret the data representation. The possible outcome is then both quantitative (with regards to comparison against other classification techniques) and subjective (due to relying on interpretation by a subject matter expert). To this point, the work described hereto will be considered complete following creation of a library to generate and analyze the EEG data representation images and comparison against existing models.

References

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