Hierarchical Deep Convolutional Network for Analysis of Motor task EEG Data

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Abstract: Electroencephalography (EEG) is one of the most popular non-invasive neuroimaging technique used to study brain activity while the subject is performing some well-defined task. Analysis of EEG data to improve understanding of underlying neural activity is typically hypothesis-driven and requires the investigator to quantify certain features of the EEG time-series. However, this could lead to sub-optimal feature selection. Alternatively, data-driven approaches like deep learning allow discovery of the optimal feature set from available data. Convolutional Neural Networks (CNNs), a popular class of deep networks, have recently been applied to computer vision datasets with great success and have also been used for classification tasks in neuroscience-related applications.\textsuperscript{1} To visualize discriminative features that allow the network to perform a classification task, we use a method called cue-combination for Class Activation Map (ccCAM) which is inspired by existing methods in the literature\textsuperscript{2} and modified for neuroscience applications. Specifically, the deep convolutional architecture, combined with ccCAM is applied on EEG data collected from human subjects to study the effect of exercise on motor learning. Our results reveal discriminative features within specific frequency band (19-31 Hz) that is a subset of the beta-band, which has been found to be significantly modulated by exercise in previous studies\textsuperscript{3}. They also reveal that activity in this frequency band propagates across different regions of the cortex while performing a fixed force hand-grip task. To the best of our knowledge, this has not been studied previously. Collectively, our results demonstrate the potential of deep learning frameworks for identifying a more informative feature space in neuroimaging data in a completely data-driven manner, which can in turn yield a better understanding of brain function as well as more efficient therapeutic applications.

References:


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