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Decoding primary color responses in EEG signals with deep learning in the source space

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Introduction: The brain's response to visual stimuli of different colors might be used in a brain-computer interface (BCI) paradigm. Allowing the user to control certain elements in its environment by looking at corresponding signs of different colors could serve as an intuitive interface. This paper presents work on the development of a classifier for red, green, and blue (RGB) visual evoked potentials (VEPs) in recordings performed with electroencephalography (EEG).

Material, Methods and Results: The classifiers developed in this work were trained and tested on a dataset of primary colors (RGB) visual stimulation. The dataset contains 60-channel EEG recordings from 31 subjects. The RGB colors were displayed on a screen in front of the subjects for intervals of 1.3 seconds, in random order with 140 repetitions for each color. Three convolutional neural networks (CNNs) were explored for this classification task: A graph CNN (GCNN) [1], EEGnet [2], and deep convNet [3]. Intra-subject classifiers were developed for all 31 subjects. EEGnet and DeepCNN were trained in both electrode and source space. The best classifier, deep convNet using all electrodes, yielded an average accuracy of 77%. A previous study developing classifiers for the same dataset, using conventional machine learning, reported an average accuracy of 74.43% for a subset of subjects [4]. In this study, the same subset achieved an average accuracy of 84%. The best classifier was found using the deep ConvNet [3].

Discussion: The results indicate that it is possible to distinguish between the primary color responses. The hyperparameters of the three networks employed in this work have been left unchanged (except for some modifications necessary for integration). Considering this, it is reasonable to assume that some tuning of these hyperparameters could yield better results. The classifiers were expected to perform better in source space than electrode space, however, this was in general not the case. This unexpected result could be attributed to the fact that all three neural networks were originally developed for use in electrode space.

Significance: The results of this work demonstrate that it is possible to classify between primary color responses in EEG recordings. The results also show that deep learning methods can be suitable alternatives to traditional machine learning for decoding primary color responses.

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