

A Transfer Learning Approach for Adaptive Classification in P300 Paradigms

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Introduction: The P300 is one of the most widely used brain responses in BCIs today, popularized by none other than the P300 speller itself. However, most systems still require significant subject-specific training to achieve accurate, reliable classification of brain signals. We present an approach to classification that allows for classification with zero subject-specific data and also improves as data is collected. It does this through the use of data from other subjects in order to intelligently regularize the subject-specific solution with a prior over the weight vector. This approach has already been validated on spectral data [1] and so by validating on P300 data as well we show that it is a classification technique that is agnostic to how features are computed from the EEG time series so long as there are multiple subjects or sessions involved. We further introduce a novel method for estimating parameters that drastically reduces the time necessary to implement transfer learning.

Material, Methods and Results: To validate our approach in direct comparison with other approaches on the data we opted to use pre-processing and classification code from a previously validated dataset [2]. Data and code were used as it includes data from both patients and healthy subjects. All participants performed a six-class P300 paradigm over two sessions on two different days. We tested both approaches by taking varying amounts of subject-specific training data from the first session to learn a decision boundary both with our approach and the one from [2]. Then, classification accuracy was computed on the remaining data. In contrast to the approach in [1] we did not cross-validate to determine the mixing coefficient between the prior over previous subjects and the subject-specific data but rather used an iterative maximum-likelihood procedure, which shortened the time to compute the prior over previous subjects to less than five minutes. For each level of subject specific data we generated 50 random partitions into test and training in order to estimate the distribution of single-trial classification accuracies.

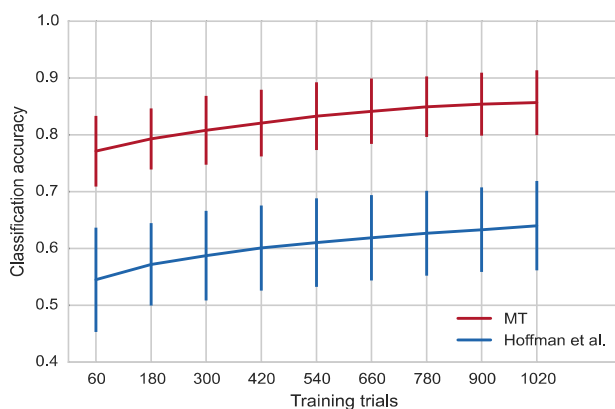


Figure 1. Plot of single-trial classification accuracy in P300 paradigm for best single-subject approach versus our novel transfer learning approach, averaged over all subjects with 95% confidence interval. Red shows accuracies achieved with our approach and blue shows accuracies with the approach published in [2]

Discussion and Significance: The problem of varying signal statistics across sessions has been widely documented in source identification and classification approaches alike for BCIs.

However, the most widely-used methods for dealing with this in the classification domain tend to involve only looking at single subject data. To date, there is no easily applicable paradigm that can deal with both spectral and time-domain features across multiple datasets. Our results show that the method we previously proved to be effective for transfer learning in the case of spectral features can be effortlessly applied to time-domain features as well. While the high number of samples makes the decomposition approach in [1] unnecessary, the regular regression approach is robust to unequal trials from both conditions through the use of bootstrapping, and straightforward both to understand and use. We hope that the popularization of this and related techniques allows for a general increase in the use of transfer learning throughout the field.

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References

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- [2] Ulrich Hoffmann, Jean-Marc Vesin, Touradj Ebrahimi, Karin Diserens. An efficient P300-based brain-computer interface for disabled subjects. *Journal of Neuroscience Methods*, 167(1): 115-125, January 2008. ISSN 0165-0270, <http://dx.doi.org/10.1016/j.jneumeth.2007.03.005>.