Deep Learning for One-Class Classification of Cognitive Tasks from fMRI data

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fMRI is currently one of the leading methods of monitoring brain activity during cognitive tasks.

Since the seminal papers of Cox and Savoy[1], Mitchell[2], Just et al[3] and others, there has been substantial progress in showing that machine learning techniques can perform well on determining the cognitive task from the fMRI, at least in certain circumstances. These works typically use various two-class machine learning techniques.
In two-class learning both training and testing data are taken from two different classes and the classifying system is supposed to tell them apart from each other.

One class techniques, however, are less advanced. One-class learning means that training of the system is done only using data from a class; and after training, the system is supposed to be able to delineate between the trained class and "everything else". There is a sense in which this is the natural setting for such brain monitoring; since it tells if the brain is actually performing a certain activity or not; and not whether its setting is closer to class A or class B. This is not the same as letting class B be "everything else" since one cannot find representable data for "everything else".

Work by Hardoon and Manevitz (2005)[4] showed that this was possible in principle albeit with relatively low success rates.

Their method used auto-encoding techniques.

Further work by Boehm, Hardoon and Manevitz (2011)[5] showed that the success can be raised to over 90% (and thus comparable to the two-class methods) by using extreme feature selection techniques including genetic algorithms.

In our work, we show how these genetic algorithm feature selection techniques can be replaced by more recent deep learning techniques on the auto-encoder and related methods.

Deep learning in neural networks stands for networks containing multiple layers of features.

The advanced deep learning is used in a certain architecture that auto-detects the features previously selected by genetic algorithms. It does so using no further techniques besides the deep learning model itself.

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1 David D. Cox , Robert Savoy (2003). fMRI 'Brain Reading': detecting and classifying distributed patterns of fMRI activity in human visual cortex. NeuroImage 19 (2): 261-270

2 "Training fMRI Classifiers to Detect Cognitive States across Multiple Human Subjects ," X. Wang, R. Hutchinson, and T. M. Mitchell, Neural Information Processing Systems 2003. December 2003.

3 Just MA, Cherkassky VL, Keller TA, Kana RK, Minshew NJ: Functional and anatomical cortical underconnectivity in autism: Evidence from an fMRI study of an executive function task and corpus callosum morphometry. Cerebral Cortex, in press.

4 D. R. Hardoon and L. M. Manevitz. fmri analysis via one-class machine learning techniques. In Proceedings of the Nineteenth IJCAI, pages 1604-1605, 2005.

5 Omer Boehm, David R. Hardoon and Larry M. Manevitz,Classifying Cognitive States of Brain Activity via One-Class Neural Networks with Feature Selection by Genetic Algorithms, International Journal of Machine Learning and Cybernetics, Volume 2 (3), Pages 125-134, 2011