A framework for systematic comparative evaluation of analysis methods for rs-fMRI data

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Background: For a thorough assessment of the properties of statistical data analysis methods for a specific application, it is required to test the method of interest with many different parameter configurations on many different datasets. For example, testing the result validity or convergence properties of a blind source separation (BSS) algorithm on functional MRI data requires multiple runs of the algorithm with different parameter settings like the number of resulting components. Here, we present a framework in R for systematic method evaluation and testing, consisting of a job generator to automatically create analysis programs for different methods, parameter and datasets which can be run in parallel on a supercomputing cluster, and a database to store meta information about the computed results.

Methods: The framework is implemented in R using a MySQL database as back-end. The R package dplyr provides the interface for the access to the meta information in the database for further analysis. Currently, the job generator creates jobs for the SLURM scheduler for parallel computing on supercomputers (and can be easily adapted for other scheduling systems) based on analysis templates in the form of data analysis scripts in R along with a set of hyperparameters.

As an example, task data from 100 subjects from the Human Connectome Project (unprocessed, social task) are analyzed with three blind source separation (BSS) algorithms to compute temporally independent components: deflation-based adaptive FastICA, JADE, and SOBI. For these three BSS algorithms, the Pearson correlations between the theoretical stimulus response and all resulting temporally independent components are computed.

Results: The architecture of the framework is shown in Figure 1. Figure 2 (top) shows the distribution of the correlation coefficients calculated for each subject between the theoretical task response and the best-matching component time series for different numbers of components used in the decomposition for adaptive FastICA (left), JADE (center), and SOBI (right). The proportion of subjects where the algorithm with 2000 iterations did not converge is shown in Figure 2 (bottom) for adaptive FastICA, JADE, and SOBI in the same order.

Conclusions: The proposed framework for systematic assessment of statistical data analysis methods can be used for performing comprehensive quantitative comparisons between different analysis methods and parameterizations with little overhead due to the