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Exploring sparse connectivity in the motor system using multivariate autoregression analysis

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Background

Multivariate autoregressive (MAR) models can be used in the identification of causal relations from functional MRI time series. Connectivity information is extracted from large neural networks combining graphical modeling methods and Granger causality. The aim of this paper is to demonstrate the feasibility of working with the MAR models to identify functional circuits in the human motor system, and demonstrates their application to data of motor performance in patients with Parkinson's disease (PD).

Methods

In this work we incorporate a family of linear methods called penalized linear regression that were designed to deal with problems having a large set of variables (i.e.

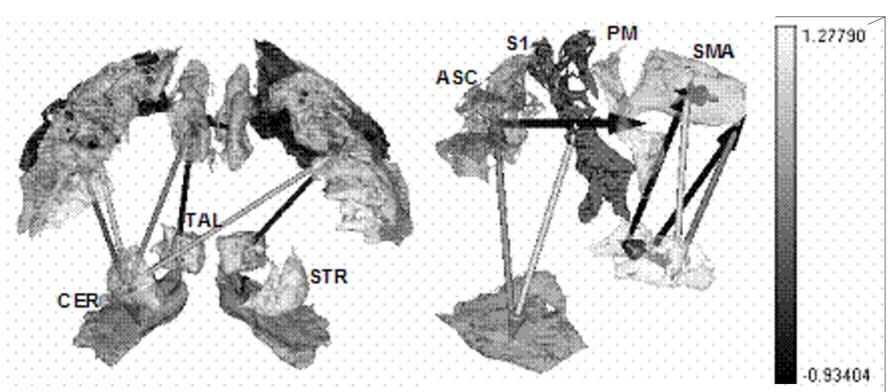

Figure 1

Realistic rendering of effective connections in the motor system. Note involvement of areas related to motor performance. **M1**: Primary motor cortex, **S1**: Primary somatosensory cortex, **PM**: Premotor cortex, **SMA**: Supplementary motor area, **ASC**: Associative parietal cortex, **STR**: Striatum, **TAL**: Thalamus, **CER**: Cerebellum.

Table 1: Effects of L-Dopa treatment on strength of inter-regional path coefficients

Connection	OFF Medication	ON Medication
ASC – PRE	0.035	0.789
TAL – PM	0.062	0.154
TAL – SMA	0.093	0.256
STR – TAL	0.018	-0.386
TAL – SMA	0.093	0.256

brain structures) and a relatively small set of observations (i.e. fMRI time points). One parkinsonian patient with early stage akinetic PD was studied by fMRI during the "drug-off" state and after reaches the "drug-on" state (table 1).

Results

The statistically most relevant connections from the connectivity matrix, in parkinsonian state, are summarized in the realistic rendering shown in Figure 1. These results indicate that the components of the basal ganglia-thalamus-cortical circuit were functionally connected to each other, but also functional connections in the cortico-cerebello-thalamo-cortical pathway are evidenced.

Conclusion

In opposition to widely spread methods for connectivity analysis, the proposed algorithm does not rely on preconditioned connections between regions from anatomical models. The penalized regression techniques expand the basic idea of ordinary least squares by means of the addition of new terms to the minimization equation. Our results support that MAR models form a valuable and feasible approach to study functional circuits in the human motor system, in normal and disease condition.