FLEXIBLE HEMODYNAMIC COUPLING IN EEG-FMRI: CIRCUMVENTING THE GLM BY STRUCTURED COUPLED MATRIX-TENSOR FACTORIZATION

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ABSTRACT

Simultaneous measurement of EEG and fMRI is gaining importance in brain studies, thanks to the highly complementary spatiotemporal resolution of the two involved modalities. The General Linear Model (GLM) has been a standard workhorse to jointly analyse the heterogeneous datasets that stem from these measurements, and although this model is widely applied, it relies on several assumptions. In the 'standard' approach, a single 'canonical' hemodynamic response function (HRF) is used, which describes the expected BOLD signal in fMRI resulting from an impulse event in a reference stimulus time series. Hence, the HRF waveform is considered invariant over the different brain regions and even over different subjects in a group study. We argue that, although the GLM has its merit as a simple and attractive model to make sense of multimodal neural data, this restriction obfuscates the interpretations that can be drawn through its use. On the other end of the spectrum, blind source separation (BSS) techniques such as independent component analysis can be used to decompose both EEG and fMRI data into a set of constituting sources, in which case (by definition) no model of the neurovascular coupling is assumed. We aim to tackle this issue by taking a hybrid data-driven estimation approach, that still models the fMRI time series analogously to the GLM. That is, we first structure the EEG and fMRI data as a third-order tensor with temporal, spatial and spectral modes, and a matrix with temporal and spatial modes, respectively. Through a coupled matrix-tensor factorization (CMTF), we can blindly identify spatial, temporal and spectral patterns of the underlying neural sources of the data. However, by imposing a structural coupling relationship between the temporal patterns of the EEG sources and those of the fMRI sources (convolution with an unknown HRF) we can incorporate extra knowledge about the signals' characteristics, compared to more simple BSS techniques. In this way, the 'true' HRF itself is found in a data-driven fashion, without requiring prior knowledge. We provide extensions to our method, to account for spatial modulation and smoothness of the HRF wavevorm. As a proof of concept, we show the feasibility of the proposed approach in the case of synthetic, multimodal datasets. As future work, we will apply this method on a real dataset of EEG-fMRI recordings from epileptic patients, where we aim to localize the irritative zone, responsible for the generation of interictal epileptic discharges. Results will then be compared to those which are obtained through the standard GLM approach.

REFERENCES

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