Toolbox for enhanced fMRI activation mapping using anatomically adapted graph wavelets

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Toolbox for enhanced fMRI activation mapping using anatomically-adapted graph wavelets

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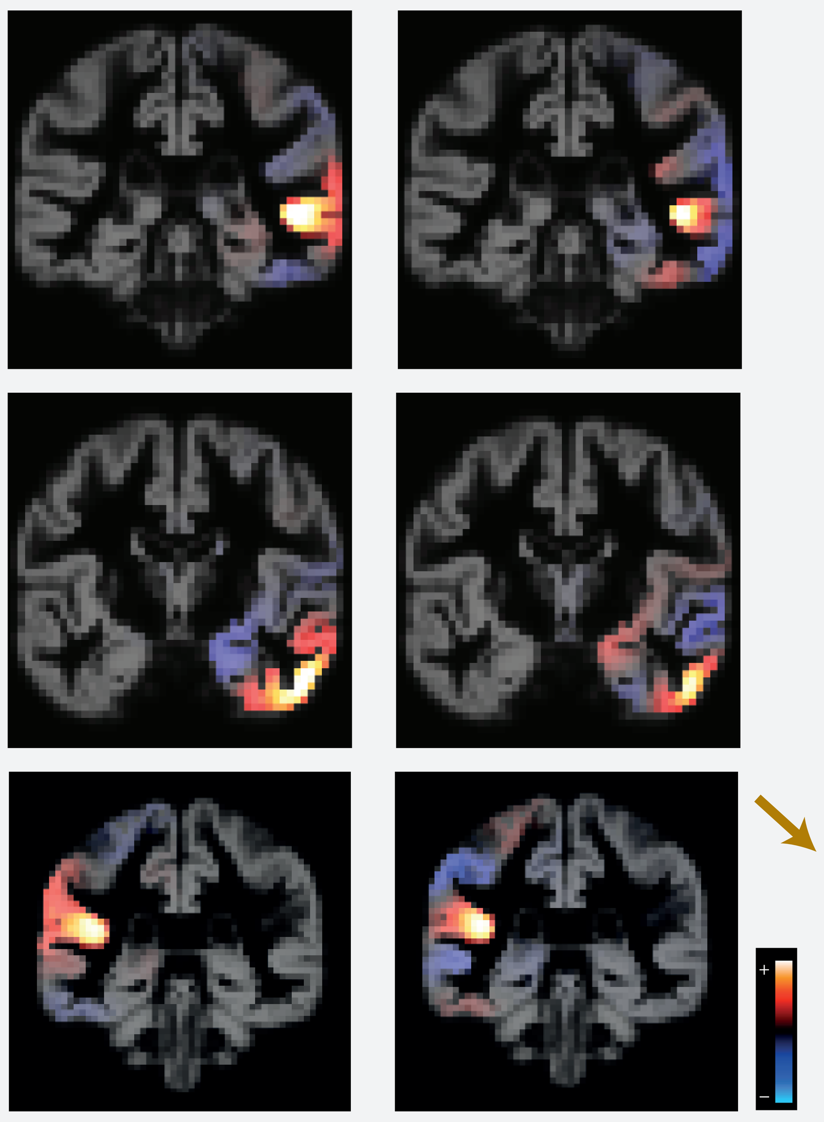
graph-based
gwSPM
wavelet-based

The method

Abstract

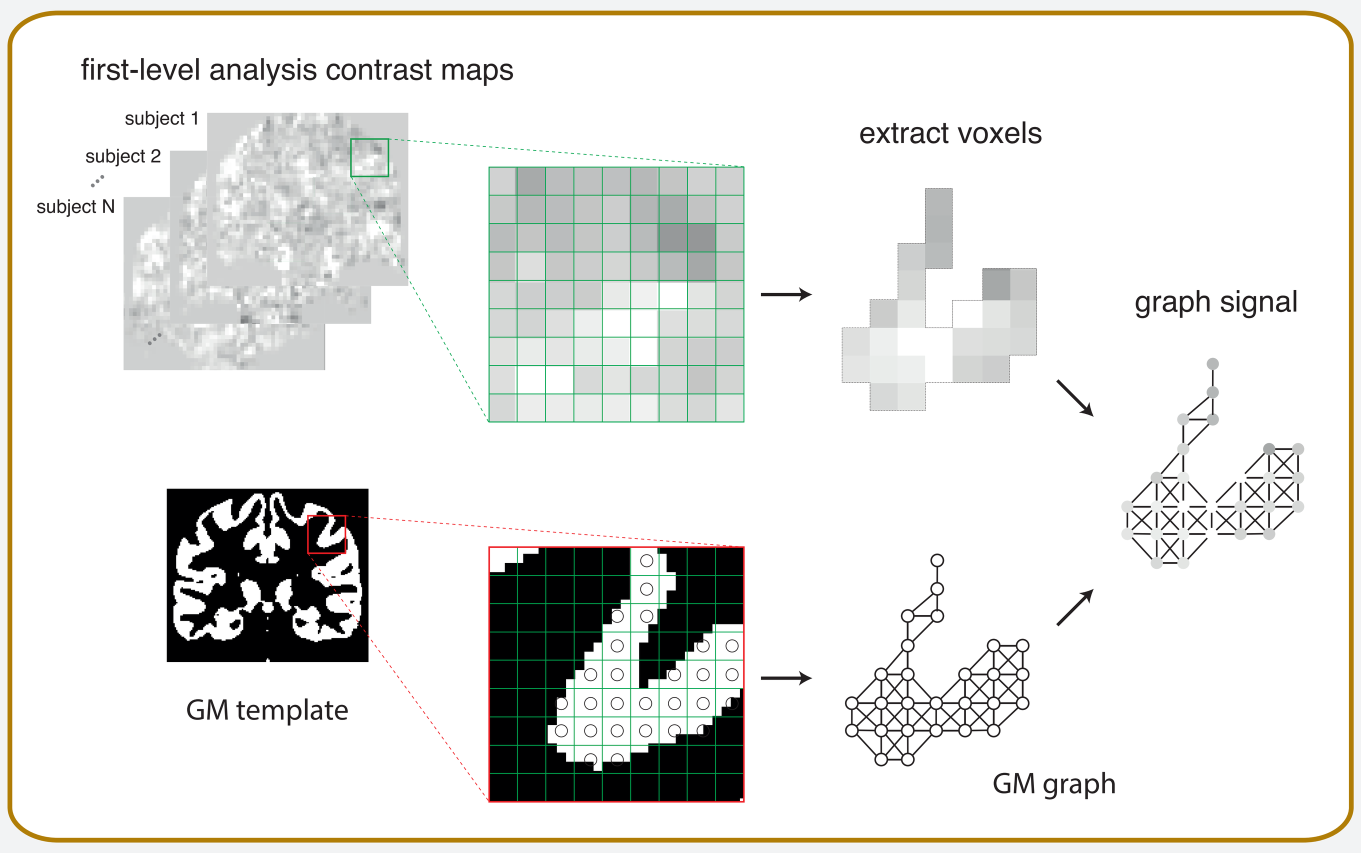
In fMRI studies with evoked activity, brain activity is detected by voxel-wise GLM fitting, followed by statistical hypothesis testing. Statistical parametric mapping (SPM), one of the most popular classical methods, relies upon Gaussian smoothing to deal with the multiple-comparison correction. As an alternative, we have recently introduced a graph-based framework for fMRI brain activation mapping [1]. The graph is designed such that it encodes the topological structure of the gray matter (GM). The approach exploits the spectral graph wavelet transform [2] for the purpose of defining an advanced multi-scale spatial transformation for fMRI data. The use of spatial wavelet transforms has the benefit of providing a compact representation of activation patterns. The framework extends wavelet-based SPM (WSPM) [3], which is a framework that combines wavelet processing of non-smoothed data with voxel-wise statistical testing while guaranteeing strong FP control. Here, we present an implementation of the proposed framework as a user-friendly, SPM-compatible toolbox that deals with multi-subject studies.

Anatomically-adapted graph wavelets*



* wavelet = a spatially localized function

Mapping an fMRI contrast map to a graph signal



Realizations of six wavelets that are adapted to the topological structure of the gray matter is illustrated. For ease of visual interpretation, the wavelets are overlayed on a template gray matter. Note that the wavelets are constructed in 3D space, and diffuse in 3D space, but only a single coronal slice of each is displayed.

The wavelets shown in each row are centered around the same location in the gray matter, the ones on the left have a smoother spatial profile compared to the ones on the right. A distinct set of wavelets is constructed for each location in the gray matter, but those of only three locations are displayed here.

The toolbox

Inputs to the algorithm:
T1 structural scans & first-level analysis contrast maps for a set of subjects.
The data for each subject should be co-registered.

step 1 — Gray matter (GM) template construction

step 2 — Construction of a whole brain GM graph & graph signals

The graph consists of two subgraphs that separately encode the structural connectivity of the cerebral and cerebellar GM.

The graph signals are constructed from first-level contrast maps after their normalisation to the template space.

step 3 — Second-level analysis with SPM

Input: first level contrast maps that were normalised to the defined template domain.

Output: the resulting SPM.mat is used in the following steps.

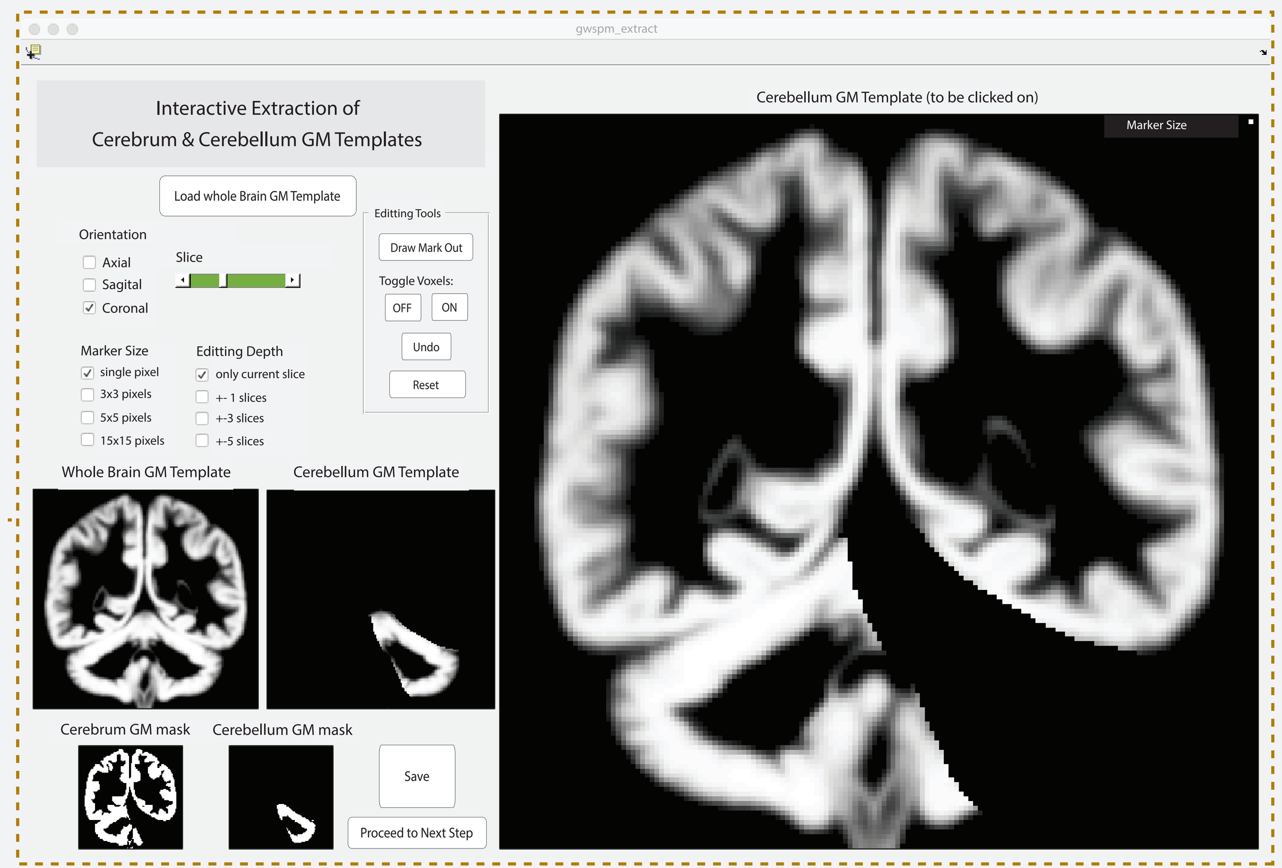
step 4 — GM-adapted wavelet transform design & decomposition of data

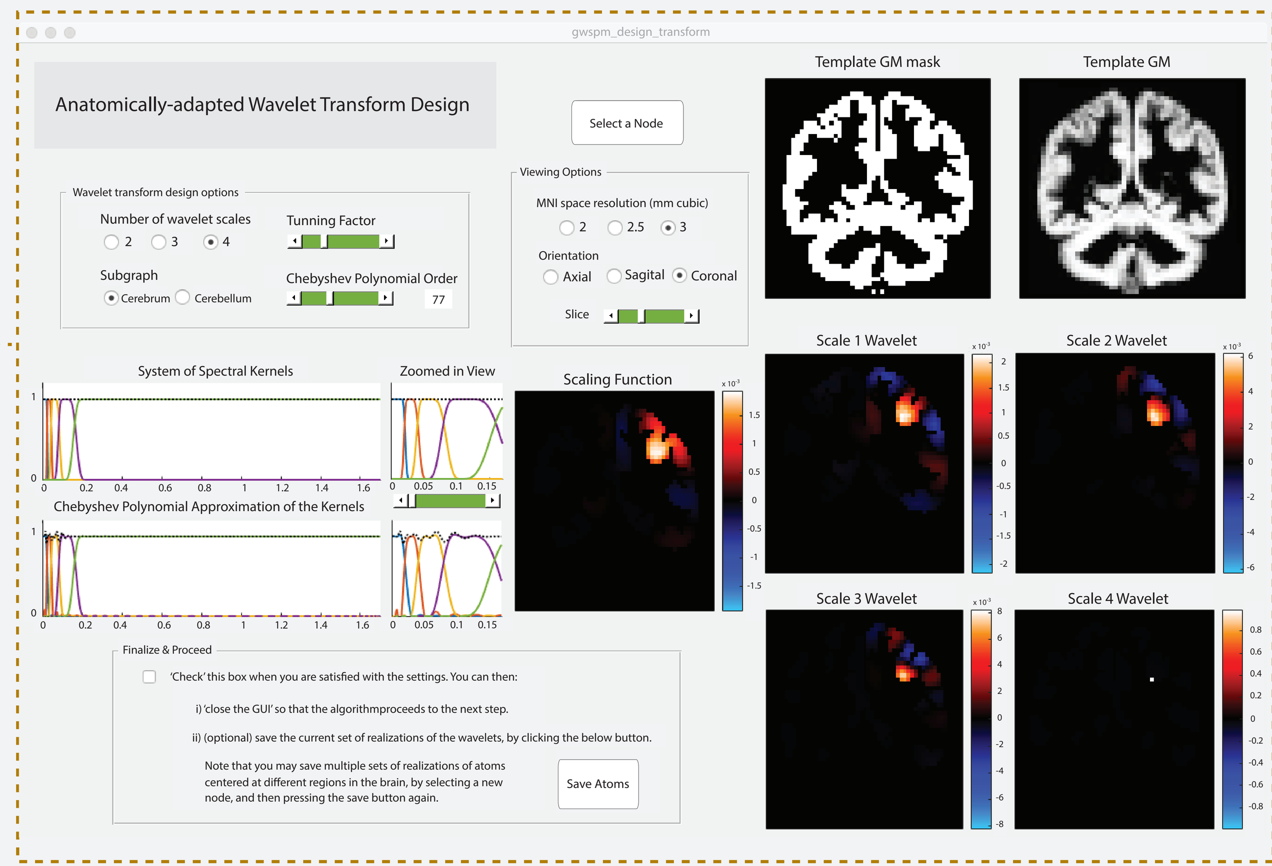
User interaction features:
tunning of graph wavelet design; construction & visulazation of realizations of wavelets at different scales, centered at different locations in GM.

step 5 — Integrated wavelet denoising & spatial statistical testing

The wavelet denoising and statistical inference method used in this step is based on the theory developed in [3].

step 6 — Display of results





Toolbox download

miplab.epfl.ch/software/

Contact

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References

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[2]. D.K. Hammond, et al., "Wavelets on graphs via spectral graph theory." Appl. Comput. Harmon. Anal. 30(2), 129-150,2011.
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