gwSPM: a toolbox for graph wavelet-based statistical parametric mapping

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graph-based wavelet-based **gwSPM**

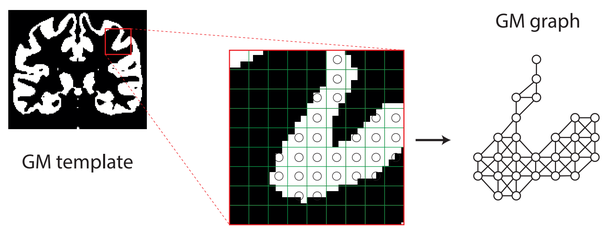
The method

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 designed graph encodes the topological structure of the gray matter (GM) based on neighbourhood connectivity. Pial surfaces are exploited to prune out anatomically unjustifiable connections, for instance at touching GM across banks of sulci. The approach exploits the spectral graph wavelet transform [2] as means of providing 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 proposed scheme extends wavelet-based SPM (WSPM) [3], a framework that combines wavelet processing of non-smoothed data with voxel-wise statistical testing while guaranteeing strong FP control. We present an implementation of the proposed framework as a user-friendly, SPM-compatible toolbox.

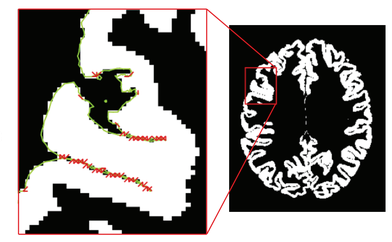
Gray Matter Graph Design

neighbourhood connectivity encoding

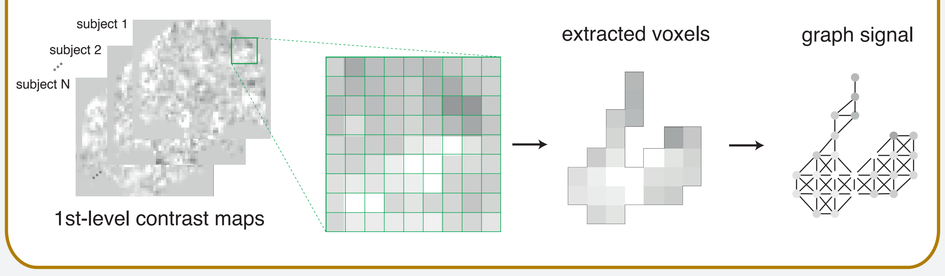


pruning out anatomicaly unjustifiable connections

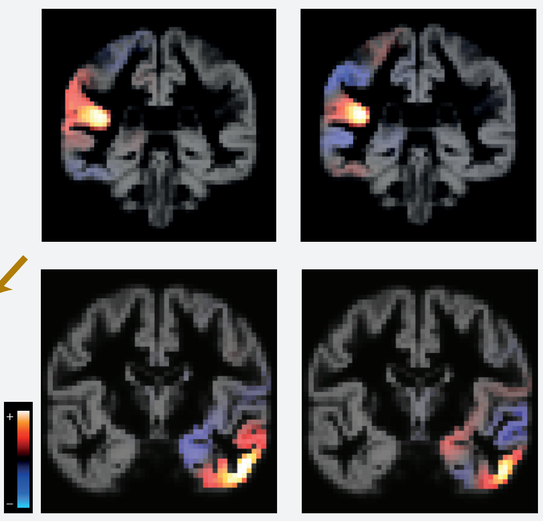
Due to limited voxel resolution, some gyri may be adjacent in a Euclidean sense but anatomically non-adjacent. By exploiting pial surface extractions, anatomically unjustifiable connections are pruned out.
The pial surface is shown in green. Pruned edges are shown as red bars.



fMRI Graph Signals



Anatomically-adapted graph filters



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

The filters shown in each row are centered at 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 filters is constructed for each voxel in the gray matter, but those of only two locations are displayed here.

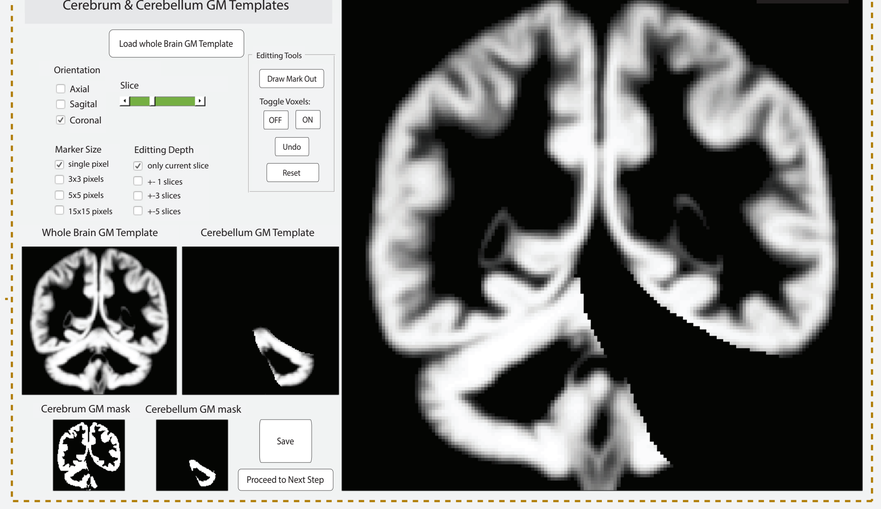
The toolbox

Inputs to the algorithm:

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

step 1

GM template construction



step 2

Construction of a whole brain GM graph & graph signals

The graph consists of two subgraphs that separately encode the topology 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

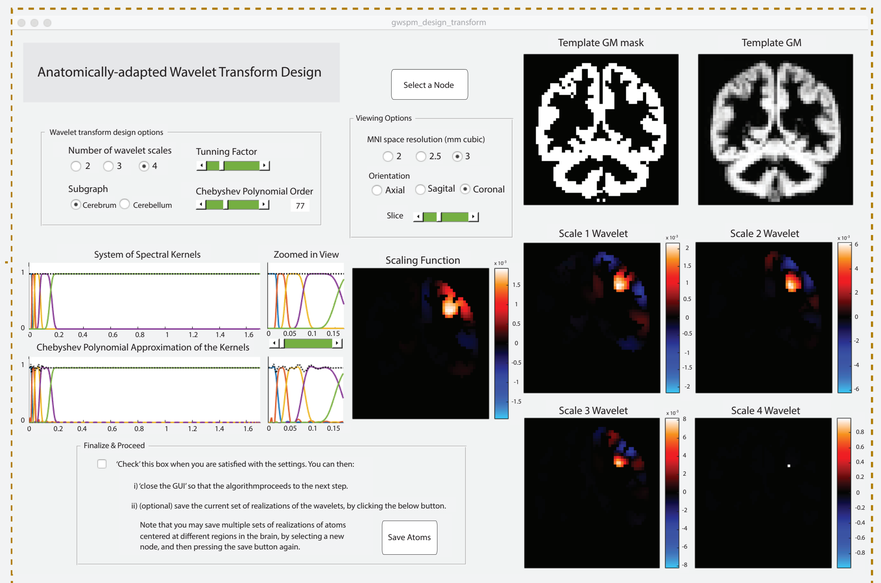
Input: first level contrast maps that were normalised to the defined template domain.

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 and regions.



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].

References

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[3] D. Van De Ville, et al., "Integrated wavelet processing and spatial statistical testing of fMRI data." NeuroImage 23, 1472-1485, 2004.

Toolbox download

bme.lth.se/staff/behjat-hamid/software/ | miplab.epfl.ch/software/

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