Bidspm: an spm-centric bids app for flexible statistical analysis

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Introduction:

Great strides have recently been made in standardizing the format of neuroimaging data with initiatives such as the Brain Imaging Data Structure (BIDS, Gorgolewski et al. (2016)) and pipelines like fmriprep (Esteban et al. (2019)). However, the statistical analysis phase of the typical neuroimaging process requires a significant amount of flexibility, which often leads to non-reproducible and heterogeneous scripts. Additionally, scientific publications often lack critical contextual information, making it hard to replicate the analyses from published studies. Even when analysis scripts are shared, they may lack transparency, making it difficult to understand and apply the same model to different datasets.
To address these issues, the BIDS Statistical Model (https://bids-standard.github.io/stats-models/) was recently developed to promote automated model fitting pipelines (see for example fitlins: https://github.com/poldracklab/fitlins). However, there is no integration of the BIDS statistical model with SPM12. bidSPM is a BIDS app to fill this gap and make it easier to leverage this new tool.

Methods:

The philosophy of bidSPM is to take standardized data and configuration files as input and to return standardized outputs. This should minimize how much code researchers have to write. bidSPM uses the BIDS app CLI (Gorgolewski et al. (2017)) to provide a standardized way to run fMRI analysis of a BIDS dataset with SPM12 and several of its complementary toolboxes. Analyses can be done at the subject and group level, on the whole brain or in a region of interest. Additionally, the bidspm pipeline can be a preparatory step for different kinds of analyses, whether task-free (resting-state) or task-based univariate and multivariate studies.
To run a statistical analysis, bidSPM only requires as inputs:
- a valid raw BIDS dataset
- its BIDS derivatives (preprocessed by fmriprep or by bidSPM itself)
- a bids stats model JSON file.
The BIDS stats model is used to define the input data, the variables and the confound variables to include in the general linear model (GLM), the contrasts to estimates as well as several options for HRF convolution, model estimation, results to display…
Having a single JavaScript Object Notation (JSON) file to define one analysis allows researchers to easily create several models. bidSPM can then help choose the best model as it can perform bayesian model selection via the model assessment, comparison and selection (MACS) toolbox (Soch J (2018)) of SPM12.
This feature can be relevant to compare 1) different cognitive models for a given task, 2)

denoising strategies. This approach provides a principled way to choose a model for a given dataset without having to peek at the results, and thus may also help prevent procedural over-fitting (Yarkoni and Westfall (2017)).

Results:

In the end bidSPM outputs follow the BIDS derivatives conventions and GLM results are stored in a NIDM results (Maumet et al. (2016)) allowing researchers to upload their results to Neurovault (https://neurovault.org, Gorgolewski et al. (2015)) in a couple of clicks. Additionally, bidSPM can easily provide 4D maps of a subject's GLM output (beta / t-maps) to allow further analysis using MVPA classification frameworks or RSA tools, making it a bridge connecting different frameworks.

Conclusions:

bidSPM provides researchers with a flexible way to run statistical analysis using SPM12 with a single JSON file and only a few lines of code based on data formatted in BIDS.
bidSPM can be run on MATLAB or Octave and is also packaged as docker image and is available on github (https://github.com/cpp-lln-lab/bidSPM) and dockerhub (https://hub.docker.com/repository/docker/cpplab/bidSPM/).
We hope that this tool will make it easier for the community to adopt practices that lead to more reproducible results by relying on standardised pipelines that are easily shareable.

Modeling and Analysis Methods:

Bayesian Modeling
Exploratory Modeling and Artifact Removal
Univariate Modeling [2]

Neuroinformatics and Data Sharing:

Workflows [1]

Keywords:

FUNCTIONAL MRI
MRI
Open-Source Code
Open-Source Software
Statistical Methods
STRUCTURAL MRI

[1|2]Indicates the priority used for review

Abstract Information

My abstract is being submitted as a Software Demonstration.

Yes

Please indicate below if your study was a "resting state" or "task-activation" study.

Resting state
Task-activation

Healthy subjects only or patients (note that patient studies may also involve

healthy subjects):

Patients

Was any human subjects research approved by the relevant Institutional Review Board or ethics panel? NOTE: Any human subjects studies without IRB approval will be automatically rejected.

Not applicable

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Not applicable

Please indicate which methods were used in your research:

Functional MRI
Structural MRI
Computational modeling

For human MRI, what field strength scanner do you use?

3.0T
7T

Which processing packages did you use for your study?

SPM

Provide references using author date format

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