Report from Brainhack Global 2020 Montreal

Load fMRIprep confounds in Python

Project URL: https://github.com/htwangtw/2021_08_Wang_load-confounds

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1 Introduction

fMRIprep [1] is a popular minimal preprocessing software for functional MRI data. 'Minimal preprocessing' refers to motion correction, field unwarping, normalization, bias field correction, and brain extraction. Confound regression and smoothing are exculded from the workflow. Instead, fMRIprep provides users with a large set of potential confound regressors that covers many denoising strategies. The users will have to select the confound regressors for denoising in the subsequent analysis. Loading a sensible subset of confounds is difficult and error prone for many strategies, such as ICA-AROMA [2] and CompCor [3]. `load_confounds` can access confound variables and provides preset strategies for confound selections. The loaded format is competible with `nilearn` analysis functions such as `NiftiMasker` and the GLM modules. The aim is to provide a easy and foolproof API for users to perform subsequent denoising of `fMRIprep` output.

2 Progress

At Brianhack Global Montreal 2020, the aim is to prepare the package ready for a potential Beta release. To prepare for the release, related issues involves completing the strategies missing and improve the user experience with better examples and error messages. Several issues has been identified before Brainhack and the full discussion can be found under `load_confounds` GitHub issue page. Participants at Brainhack were encouraged to pick up existing issues from the list. The following issues have been discussed and/or resolved:

2.1 Strategies

We worked on three strategies:

- Added ICA-AROMA [2] (contributed by Hao-Ting Wang)
- Added Scrubbing [4](contributed by Steven Meisler)
- Improved the anatomical mask selection for anatomical CompCor [3] (contributed by Steven Meisler)

2.1.1 ICA-AROMA

ICA-AROMA are only applicable to `fMRIprep` output generated with `usearoma`. `fMRIprep` produces files with suffix `descsmoothAROMAnonaggr_bold` and output ICA components in the confounds file. The using the `descsmoothAROMAnonaggr_bold` output is the recommanded way of applying ICA-AROMA and implemented in `load_confounds` as a preset strategy. When passing regular fMRIprep output suffixed `descprepro_bold`, `load_confounds` retreives the noise independent compoenents for aggressive denoising.

2.1.2 Scrubbing

`load_confounds` provides the basic and full approach for scrubbing. Basic scrubbing approach flags time frames with excessive motion, using threshold on frame displacement and standardized DVARS to removes volumes above a given framewise displacement threshold. For full scrubbing described in Power et al [4], after censoring volumes as in the basic approach, the full approach further remove continuous segments containing fewer than 5 volumes.

2.1.3 Anatomical CompCor

`fMRIprep` uses three kinds of anatomical masks to compute CompCor components, WM, CSF and the combined of the two. The variable names refer to different anatomical masks are specified in the meta data. The previous iteration of `load_confounds` did not consider the metadata, hence the difference of masks were not taken into account. In the revised aCompCor approach, `load_confounds` provide selections of anaotomical maps (WM, CSF, and combined) to avoid regress relevant signal twice, which may introduce noise.

2.2 Demo

An executable demo using the nilearn developmental fMRI dataset (OpenNeuro ds000228) was added (contributed by Michael W. Weiss). The demo was adapted from an exisitng nilearn example on denoising 'Extracting signals from a brain parcellation'. This example notebook show how to extract signals from a brain parcellation and compute a correlation matrix, using different denoising strategies using the package.

2.3 Error message

New class `NotFoundConfoundException` was added for collecting all the missing parameter needed for the given noise component(s). A final error would be raised with the list of all parameters missing, rather than just the first encountered missing parameter. (Contributed by Michael W. Weiss and François Paugam)

2.4 Identify test dataset

OpenNeuro ds003 is adopted as the new test data, including all ICA-AROMA related components. However, non-steady-state volume and motion estmation mertic RMSD [5] are still missing. We consider to preprocess the nilearn demo dataset (OpenNeuro ds000228) with fMRIprep LTS release for getting all possible confounds for the future. (Discussions amongs Pierre Bellec, Hao-Ting Wang, Elizabeth DuPre, and Chris Markiewicz)

2.5 All contributor bot

`allcontributors` bot is added to track community contributions (Contributed by Pierre Bellec).

2.6 Add `load_confounds` to `nixtract`

In addition to the main package, there was a collaborative project with the developers of `nixtract`. `nixtract` is a tool that extract and process timeseries data from neuroimaging files. Annabelle Harvey and Dan Gale added `load_confounds` as a dependency of `nixtract` for reading fMRIPrep confound variables.

3 Results

`load_confounds` has now covered most of the noise components used in Ciric et al. [6]. The following noise components and a set of paramaters for dedicated approaches are supported.

- `motion` : the motion parameters including 6 translation/rotation (`basic`), and optionally derivatives, squares, and squared derivatives (`full`).
- `high_pass` : basis of discrete cosines covering slow time drift frequency band.
- `wm_csf` the average signal of white matter and cerebrospinal fluid masks (`basic`), and optionally derivatives, squares, and squared derivatives (`full`).
- `global` : the global signal (`basic`), and optionally derivatives, squares, and squared derivatives (`full`).
- `compcor` [3]: the results of a PCA applied on a mask based on either anatomy (`anat`), temporal variance (`temp`), or both (`combined`).
- `ica_aroma` [2]: the results of an idependent component analysis (ICA) followed by identification of noise components. This can be implementing by incorporating ICA regressors (`basic`) or directly loading a denoised file generated by fMRIprep (`full`).
- `scrub` [4]: regressors coding for time frames with excessive motion, using threshold on frame displacement and standardized DVARS (`basic`) and suppressing short time windows using the (Power et al., 2014) appreach (`full`).

`load_confounds` can produce the following strategies from Ciric et al. [6]. The following table highlights the relevant options:

Strategy	`high_pass`	`motion`	`wm_csf`	`global`	`compcor`	`ica_aroma`	`scrub`
`Params2`	x		`basic`				
`Params6`	x	`basic`					
`Params9`	x	`basic`	`basic`	`basic`			`full`
`Params9scrub`	x	`basic`	`basic`				
`Params24`	x	`full`					
`Params36`	x	`full`	`full`	`full`			`full`
`Params36scrub`	x	`full`	`full`				
`AnatCompCor`	x	`full`			`anat`		
`TempCompCor`	x				`temp`		
`ICAAROMA`	x		`basic`			`full`	
`AROMAGSR`	x		`basic`	`basic`		`full`	
`AggrICAAROMA`	x		`basic`	`basic`		`basic`	

The future direction is to integrate `load_confounds` as part of `nilearn` for better reach to wider range of users that can be benifited from the package. To facilitate the nilearn inegration, we will add `sample_mask` to support volume-sensoring based scrubbing and improve the `nilearn` `NiftiMasker` related feature.

Availability of Supporting Data
Supplemental material has not been provided. More information about this project can be found at: https://github.com/htwangtw/2021_08_Wang_load-confounds. This report is generated at: https://github.com/htwangtw/2021_08_Wang_load-confounds.

Competing interests
None

Author's contributions
HTW wrote the software, HTW wrote the report.

Acknowledgements
The authors would like to thank the organizers and attendees of Brainhack Global Montreal 2020. Especially, we would like to thank Elizabeth DuPre and Chris Markiewicz for discussions on the choice of test data.

Reviewers
No reviewers has been added yet.

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