

This is a toolkit provided with the MATLAB software package that accompanies the article:
Advancing motion denoising of multiband resting-state functional connectivity fMRI data
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This software uses user-specified volume censoring parameters to obtain a vector of volumes censored using LPF-FD and GEV-DV methods using a given matrix of motion parameters (MPs), a resting-state fMRI time series (either a voxel or greyordinate time series) and a brain mask. These methods may be used separately or in tandem, and using images that are either pre-loaded into MATLAB or loaded using user-specified file names.

This software requires MATLAB R2017b or later running on any operating system. This was created and tested using MATLAB R2019b. This software does not require any non-standard software.

Installation of this software consists of downloading, copying, or moving all functions into a directory accessible to your MATLAB installation. If downloaded as a zip file, all functions should be unzipped to a single folder before use. Unzipping this software is expected to take less than one minute on a normal desktop computer.

1. [censoredVolumes,lpffdCensoredVolumes,lpfdvCensoredVolumes] = ...

getCensoredVolumes(timeSeries,brainMask,MPs,TR,LPF_FD_Threshold,DV_GEV_d)

This function returns a boolean (logical) vector of censored volumes using combined LPF-FD and GEV-DV based volume censoring, given a time series (either as a 4D matrix of voxel time series, or a 2D matrix of greyordinate time series), a gray matter mask (3D matrix, or 1D with columns corresponding to greyordinates), a matrix of motion parameters (MPs), the TR (required for low-pass filtering), and the desired LPF-FD threshold and DV-GEV d. It calculates the censored volumes using LPF-FD by calling **lpffdCensoredVolumes** and the censored volumes using GEV-DV by calling **lpfdvCensoredVolumes**.

Inputs

- I. **timeSeries:** The time series data to be used in order to calculate LPF-DV. This should be either in the form of a 4D matrix of voxel time series or as a 2D matrix of greyordinate time series. If voxel time series, then time should be the 4th dimension, as is the default when reading a nifti using `niftiread`. If greyordinate time series, then time should be the 1st non-singleton dimension (e.g., it can be either 1 x 1 x 1 x 1 x time x greyordinate, or time x greyordinate).
- II. **brainMask:** The grey matter mask to be used when calculating LPF-DV. If **timeSeries** was passed in as voxel time series, then **brainMask** should be a boolean 3D matrix of voxels in the same space as **timeSeries**. If **timeSeries** was passed in as greyordinate time series, then **brainMask** should be a boolean row vector of greyordinates to use.
- III. **MPs:** The motion parameters (MPs) to use when calculating LPF-FD. Dimension 1 (across rows) should be time x MP, where time is rows and MP is columns. The first 3 MPs (i.e., `MP(:,1:3)`) should be translation in units of mm. The last 3 MPs (i.e., `MP(:,4:6)`) should be rotation in units of degrees.
- IV. **TR:** The repetition time (TR) of the time series data, in units of seconds (e.g., 0.72).
- V. **LPF_FD_Threshold:** The LPF-FD threshold desired by the user for LPF-FD volume censoring.
- VI. **DV_GEV_d:** The GEV-DV d parameter desired by the user for run-adaptive volume censoring of LPF-DV.

Outputs

- I. **censoredVolumes:** A boolean column vector denoting whether a frame is targeted for removal (true) or not targeted for removal (false) by either LPF-FD or GEV-DV. It is produced by a logical “or” operation on **lpffdCensoredVolumes** and **lpfdvCensoredVolumes**.
- II. **lpffdCensoredVolumes:** A boolean column vector whether a frame is targeted for removal (true) or not targeted for removal (false) by LPF-FD volume censoring only.
- III. **lpfdvCensoredVolumes:** A boolean column vector whether a frame is targeted for removal (true) or not targeted for removal (false) by GEV-DV volume censoring only.

2. [censoredVolumes,lpffdCensoredVolumes,lpfdvCensoredVolumes] = ...

getCensoredVolumesFromNifti(fileNameDataNifti,fileNameBrainMask3D,MPs,LPF_FD_Threshold,DV_GEV_d)

This is a wrapper for **getCensoredVolumes** that opens a nifti or cifti time series using `niftiread`. It is identical, except that instead of taking in time series and a gray matter mask, it takes in the file name of the time series and the file

name of the gray matter mask. The repetition time (TR) is obtained from the nifti header. It opens them using `niftiread` and calls `getCensoredVolumes`; the outputs are identical.

Inputs

- I. **fileNameDataNifti4D**: The file name of the nifti RSFC time series.
- II. **fileNameBrainMask3D**: The file name of the nifti gray matter mask.
- III. **LPF_FD_Threshold**: The LPF-FD threshold desired by the user for LPF-FD volume censoring.
- IV. **DV_GEV_d**: The GEV-DV d parameter desired by the user for run-adaptive volume censoring of LPF-DV.

Outputs

- I. **censoredVolumes**: A boolean column vector denoting whether a frame is targeted for removal (true) or not targeted for removal (false) by either LPF-FD or GEV-DV. It is produced by a logical “or” operation on **lpffdCensoredVolumes** and **lpfdvCensoredVolumes**.
- II. **lpffdCensoredVolumes**: A boolean column vector whether a frame is targeted for removal (true) or not targeted for removal (false) by LPF-FD volume censoring only.
- III. **lpfdvCensoredVolumes**: A boolean column vector whether a frame is targeted for removal (true) or not targeted for removal (false) by GEV-DV volume censoring only.

3. **[lpffdCensoredVolumes] = lpffdCensoredVolumes(MPs,TR,LPF_FD_Threshold)**

This function returns a logical vector denoting which volumes are targeted for removal using LPF-FD based on input motion parameters, the TR (for low-pass filtering), and an LPF-FD threshold desired by the user.

Inputs

- I. **MPs**: The motion parameters (MPs) to use when calculating LPF-FD. Dimension 1 (across rows) should be time x MP, where time is rows and MP is column. The first 3 MPs (i.e., `MP(:,1:3)`) should be translation in units of mm. The last 3 MPs (i.e., `MP(:,4:6)`) should be rotation in units of degrees.
- II. **TR**: The repetition time (TR) of the time series data, in units of seconds (e.g., 0.72).
- III. **LPF_FD_Threshold**: The LPF-FD threshold desired by the user for LPF-FD volume censoring.

Outputs

- I. **lpffdCensoredVolumes**: A boolean column vector whether a frame is targeted for removal (true) or not targeted for removal (false) by LPF-FD volume censoring only.

4. **[lpfdvCensoredVolumes] = lpfdvCensoredVolumes(timeSeries,brainMask,TR,DV_GEV_d)**

This function returns a logical vector denoting which volumes are targeted for removal using GEV-DV based on input time series, a gray matter mask in the same space as the input time series, the TR (for low-pass filtering), and a GEV-DV d parameter desired by the user.

Inputs

- I. **timeSeries**: The time series data to be used to calculate LPF-DV. This should be either in the form of a 4D matrix of voxel time series or as a 2D matrix of greyordinate time series. If voxel time series, then time should be the 4th dimension, as is the default when reading a nifti using `niftiread`. If greyordinate time series, then time should be the 1st non-singleton dimension (e.g., it can be either 1 x 1 x 1 x 1 x time x greyordinate, or time x greyordinate).
- II. **brainMask**: The grey matter mask to be used when calculating LPF-DV. If **timeSeries** was passed in as voxel time series, then **brainMask** should be a boolean 3D matrix of voxels in the same space as **timeSeries**. If **timeSeries** was passed in as greyordinate time series, then **brainMask** should be a boolean row vector of greyordinates to use.
- III. **TR**: The repetition time (TR) of the time series data, in units of seconds (e.g., 0.72).
- IV. **DV_GEV_d**: The GEV-DV d parameter desired by the user for run-adaptive volume censoring of LPF-DV.

Outputs

- I. **lpfdvCensoredVolumes**: A boolean column vector whether a frame is targeted for removal (true) or not targeted for removal (false) by GEV-DV volume censoring only.

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