

The Toolbox `besa_image_analysis`

Purpose

The toolbox `besa_image_analysis` creates grand averages and performs a statistically comparison of two groups of images exported from BESA Research to MATLAB. The toolbox accepts two types of input:

- MATLAB structures transferred from BESA Research using the MATLAB interface.
- BESA image ASCII files (*.dat)

Software requirements

- **BESA Research 5.3** for the MATLAB export feature
- The current version of the free **Fieldtrip** MATLAB toolbox. It is provided by the Donders Institute for Brain, Cognition and Behaviour in Nijmegen (Netherlands). It can be downloaded for free at <http://fieldtrip.fcdonders.nl>.
- The statistics options require the **MATLAB Image Processing Toolbox** (this will not be required anymore with later versions of Fieldtrip that will be released soon). Grand averaging and plotting the result is possible without this toolbox.

Data requirements

Analysis can be performed only on 3D volume images that have been exported from BESA Research with specified options **Current image** and **Voxel amplitude**. Surface minimum norm images are not supported.

Only images computed with the same 3D grid size (default in BESA Research: 7mm) can be compared.

Usage

Use this toolbox in MATLAB as:

```
besa_image_analysis
```

or

```
besa_image_analysis (besa_image_all)
```

Here, *besa_image_all* is a struct variable that contains multiple 3D images as transferred from BESA Research. If no input parameter is specified, the toolbox will prompt for image files or a previously saved structure (*.mat file). Detected image information is then displayed in a dialog window in which analysis parameters can be specified.

Parameter Specification – The dialog window

The dialog window allows to select two image groups for comparison. Information on the available image data (datafile, condition, latency, type, grid size) is displayed. In each list (with the exception of type and grid size), multiple entries can be selected. If no entry in a list is highlighted, all entries are interpreted as selected.

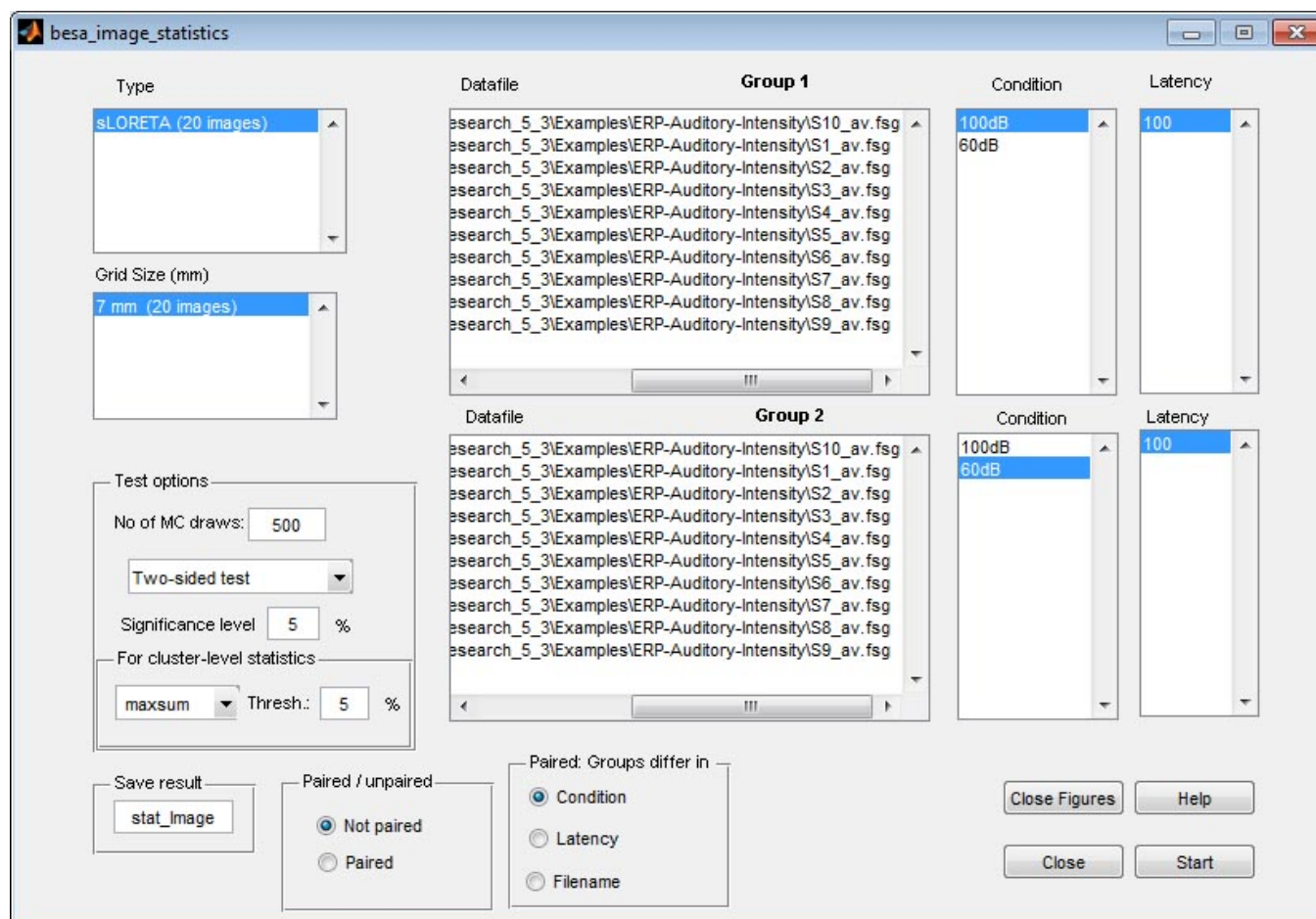


Image selection:

The dialog window contains the following lists that allow to specify the two groups of images to be analyzed:

- **Type:** All available image types, e.g. “LAURA” or “LORETA” and the number of corresponding images.
- **Grid size:** Image grid size of all available images and the number of images the corresponding images.

If the loaded structure contains more than one image type, it is necessary to first select a type and/or grid size. Selection then restricts the displayed datafiles, conditions and latencies to those available for this image type and grid size.

- **Datafile:** Names of the datafiles for which the images have been generated.
- **Condition:** Available conditions.
- **Latencies:** Available latencies (in ms).

Parameters of the statistical test:

The statistical analysis is performed using the advanced statistical tests implemented in the *Fieldtrip* toolbox. They address the multiple comparisons problem by first clustering the data and performing the hypothesis test using a cluster-based test statistic. It is strongly advisable to read the tutorials on the *Fieldtrip* homepage (e.g., http://fieldtrip.fcdonders.nl/tutorial/cluster_permutation_timelock) and the introductory articles describing the background and the technique on http://fieldtrip.fcdonders.nl/references_to_implemented_methods#statistical_inference_by_means_of_permutation for an understanding of the parameters in the Test Options panel.

- **Nr of MC draws** (Fieldtrip: *cfg.numrandomization*): Number of draws for the Monte Carlo estimate of the permutation p-value. Default: 500
- **Drop-down menu** (Fieldtrip: *cfg.tail*): Specify whether to perform a two- or one-sided test.
- **Significance level** (Fieldtrip: *cfg.alpha*): Critical alpha-level for controlling false alarm rate. (Note: In Fieldtrip, the alpha parameter has to be explicitly halved for a two-sided test. Here, this is done within the application). Default: 5%.
- **Paired / Unpaired** panel: Select whether images in the two groups are paired. If so, also specify in which property (name, condition, or latency) the two members of the pair differ from each other. A paired comparison requires that each image of the first group has a matching partner in the other group differing only in the specified property.

Parameters for cluster-level statistics:

- **Thresh.** (Fieldtrip: *cfg.clusteralpha*): Threshold for determining whether sample is candidate for clustering (based on t-values quantifying the effect of an experimental condition at each sample)
- **Drop-down menu** (Fieldtrip: *cfg.clusterstatistic*): Select the method to determine test statistic after selected samples are clustered and the sum of the t-values in each cluster is taken (default: maxsum).

Store results of the statistical test:

- **Edit field in panel “Save result”**: The output of the statistical test is saved in a MATLAB variable ‘stat’ that is stored to disc to a file whose name can be specified here. The default name is ‘stat_image’.

Control buttons:

- **Start**: Start the analysis. Grand averages are calculated and the statistical group comparison is performed.
- **Close Figures**: Closes the figures generated by the toolbox.

The results of the analysis

The result of the image analysis is provided both graphically and as text information.

Figures:

The following figures are created:

- Figures 1 and 2: Averaged images of both groups
- Figure 3: The difference between the two group averages (group 1 – group 2)
- Figure 4: Result of the statistical comparison between the two groups: Only the significantly different clusters are shown in color, everything else is grayed.

If Figure 4 shows only gray color, no significantly different activity between the two groups was found. If they the whole brain is displayed in color, the whole brain volume was found to be significantly differently activated between the two groups.

Text output in the MATLAB command window:

During execution of the toolbox, information about the process is displayed in the command window. Some of this is feedback from *Fieldtrip* applications, e.g. information about clustering.

Also provided is information

- on the groups prior to sorting
- on the group members (including name, condition, latency , type and grid size)
- on the test settings: paired or not, the factor in which groups differ - important only for paired comparisons (and batch mode)- , and number of Monte Carlo draws
- on the number of clusters found by the test, and whether any are significant.

File output:

The result of the statistical test is also stored in a MATLAB variable 'stat' (generated by *Fieldtrip*) that is saved on disc in a file named as specified in the dialog window under 'Save result'. This variable 'stat' contains intermediate and final results of the test. For example, the fields 'posclusters' and 'negclusters' of this variable contain the number of detected image clusters together with their p-values. (for an detailed explanation, please refer to the *Fieldtrip* tutorials).

Defining the default input and output folders (optional):

Optionally, input and output path of the toolbox can be specified by editing the first section of the MATLAB file *besa_image_analysis.m*

- **OutputPath:** The directory in which the output of the statistical test as well as the user configuration are saved. Default: MATLAB userpath.
- **InputPath:** The directory from which files are to be loaded. Default: MATLAB userpath.

Short summary:

In short, to use the toolbox, the following steps are recommended:

Preparation:

- Download the latest *Fieldtrip* version and ensure that it is installed in a folder that is contained in the MATLAB search path.
- Optionally, modify the input and output path in file *besa_image_analysis.m*.

Data analysis:

1. Create 3D volume images in BESA Research and either transfer them to MATLAB using the BESA Research – MATLAB interface, or store them to disc as image ASCII files (*.dat).
2. In MATLAB, call *besa_image_analysis(besa_image_all)* (when having transferred the images directly to MATLAB) or *besa_image_analysis* (when the images are stored on disc).
3. The dialog window of the toolbox opens. If there is more than one image type or grid size in the loaded data, please make a selection. This updates the datafile, condition and latency lists.
4. Select your data and analysis settings. Adjust the number of Monte Carlo draws to the desired level. If desired, enter the name of the MATLAB variable that will contain the result of the analysis (default: *stat_image*)
5. Press the *Start* button to start the analysis and display the results.