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 \ \  / / / __|   Visualized statistics toolbox for SPM software
  \ V /| \__ \   This software version: 23-Jul-2018
   \_/ |_|___/   Copyright Robert J Ellis
```

Documentation for `vis`: probability distributions, ROI value extraction, and one- and two-dimensional plots for SPM 5/8/12

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```
Operation to perform:
    [1] Kernel density estimation of PDF
    [2] Histogram outline
    [3] Surface plot (axial)
    [4] 2D plots (Scatter, Bland-Altman, Q-Q plot)
    [5] Six-figure plot (X vs. Y)
    [6] Extract parameter values
    [7] Parcellate activation clusters
    [8] [change directory]
    [9] [quit]
```

Updates:

- July 2018
  - Minor bug fixes

- November 2017
  - **Improvement:** Plots empirical cumulative distribution functions rather than sorted cases
  - **Improvement:** Uses Kernel Density Estimation (by Zdravko Botev) rather than histogram outlines
  - Confirmed compatibility with SPM12 (version: 20 Oct 2016)
  - Confirmed compatibility with Matlab R2015a (required borrowing some SPM12 functions).
  - Confirmed automatic image reslicing works in SPM{5/8/12}.
  - Options now called from command window (not pop-up window) for easier access
  - Minor bug fixes
  - Start-up time improved
  - No functions require the use of the Matlab stats toolbox

- September 2013
  - New features:
    - 1. kernel density estimation of probability distributions (Botev et al., 2010)
    - 2. “six-plot”: conveniently plots several plots at once (probability density, box plots, scatter plots, Bland-Altman plots)
  - Better color separation on plots:
    - http://www.mathworks.com/matlabcentral/fileexchange/29702
  - Easy exporting of figures:
    - http://www.mathworks.com/matlabcentral/fileexchange/23629

- March 2013
  - Checked compatibility with SPM12b
  - Launching the program will initiate an automatic check to make sure that SPM is part of the path, and will prompt for user to identify the directory if not

- September 2012
  - If running in **SPM8**, will automatically reslice masks to match dimensions of the target image
  - If running in **SPM5**, user should ensure that masks are already resliced to match the dimensions of the target image
  - Q-Q plot requires the MATLAB stats toolbox; other functions should work independently of that toolbox

Installation:

- Unzip *vis.zip* into your target directory (preferred: *matlab/spm{5/8/12}/toolboxes/vis*)
- Ensure that this folder is on the Matlab path using `pathtool`

- **Note:** The "sample_data" folder contains images used to illustrate the features of `vis`:
  - five first-level **con*.nii images** (con_0006 to con_0010) from the SPM "face_rfx" data set, and
  - a second-level **spmT*.nii image**, derived from the second-level analysis of the 12 contrast images (0006 to 0017) from that same data set
  - three region of interest (ROI) masks, created using Mathew Brett's excellent MarsBaR program:
    i. A sphere centered at [x x x]
    ii. A sphere centered at [x x x]
    iii. A sphere centered at [x x x]

Version compatibility:

- `vis` is designed to work under the following SPM / Matlab pairings:

  - SPM5 (rev. 1807, compatible with Matlab R13SP1 to R2006b);
  - SPM8 (rev. 6313, compatible with Matlab R14SP3 to R2015a); and
  - SPM12 (rev. 6906, compatible with Matlab R2007a to R2017b)

- However, if any of the following errors appear in conjunction with using SPM5 or SPM8 on a more recent version of Matlab, it is recommended that you upgrade to SPM12:
  - `No method 'delete' with matching signature found for class 'matlab.ui.control.UIControl'.`

- Also, if you alternate between different versions of SPM on the same machine, you may need to type `clear classes` (as prompted by Matlab) before launching `imcalc`

Function dependencies

- **List the freeware functions that are called**
- **Corrcoef_octave**
- **Prctile_nist**
- **Qqplot_rje**
- **Ecdf_rje**

General Instructions:

- To launch the program, at the >>, type `vis`
  - **Note:** Launching the program will initiate an automatic check to make sure that SPM is on the Matlab path, and will prompt for user to identify the main SPM directory if not. `vis` will be added to the top of the Matlab path, which is essential for proper functioning.

Options in detail:

[1] Kernel density estimation of probability density ...

- KDE is useful for directly characterizing the probability density; doesn't require specifying histogram bins, etc.
  - vis uses the adaptive (variable-bandwidth) Gaussian kernel density estimation by Botev et al. (2010), which returns a valid density estimate even when multiple modes are present within a sample data series. The method has already been implemented in Matlab (Botev, 2011).
  - *References*
    - Botev et al., 2010. Kernel density estimation via diffusion. Annals of Statistics, 38(5): 2916-2957.
    - Botev, 2011. Kernel Density Estimator (Matlab Central File Exchange).

- *Select image(s) to analyze:*
  - in the *sample_data* folder, select `con_0006.img` to `con_0010.img` (5 files)
- *Use inclusive mask / ROI mask?: [1] yes; [2] no:*
  - [2] is the default; will read in all non-zero (or non-NaN) values in the image
  - If choosing [1], will be prompted to *Select inclusive mask:*
    - all values in the to-be-analyzed image within the inclusive mask will be read in, and the histogram calculated on those values
- The KDE result will be displayed in Matlab **Figure 101**; example below

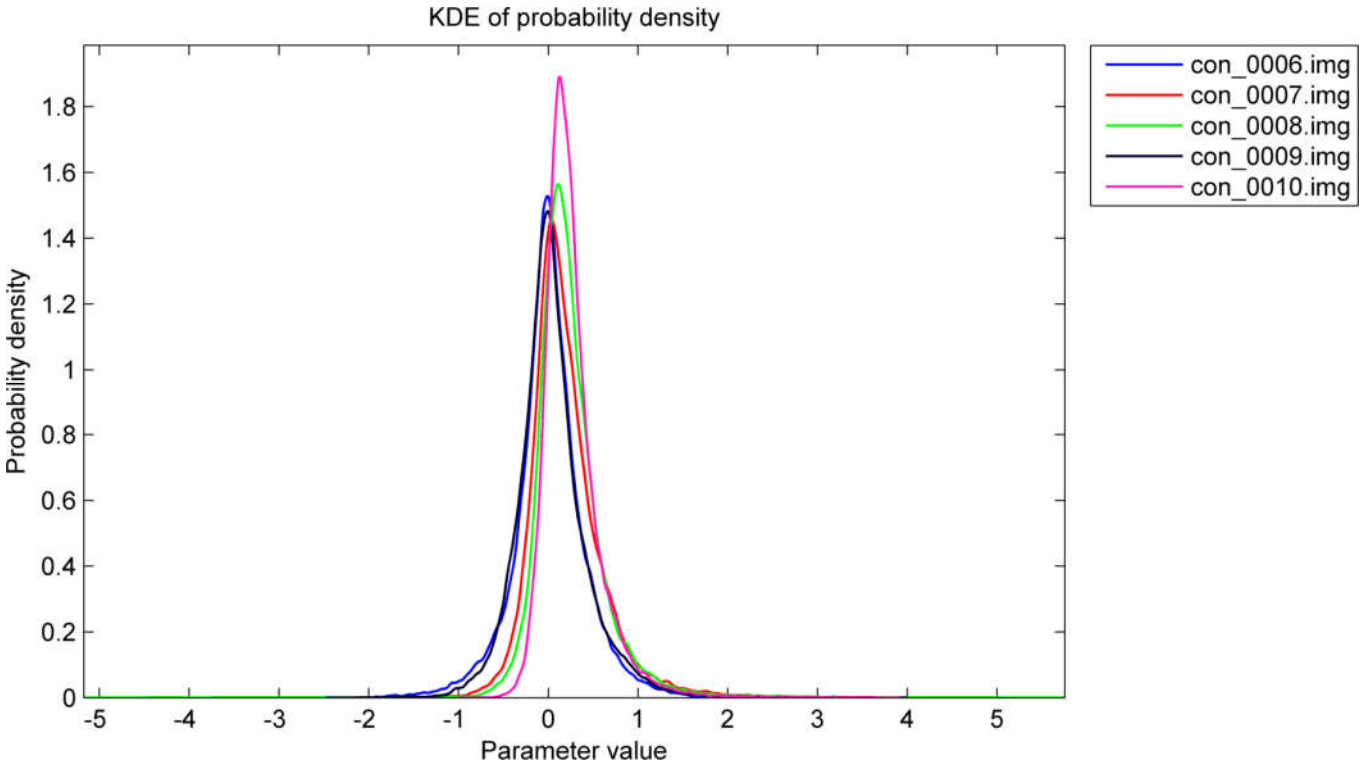


Figure 101. Kernel density estimates of all non-zero voxels.

[2] Histogram outline …

- Note: the KDE method for direct estimation (option [1]) of probability density is likely a more useful visualization, assuming the number of voxels is high (e.g., > 1000 per ROI)
- *Select image(s) to analyze:*
  - in the *sample_data* folder, select `con_0006.img` to `con_0010.img` (5 files)
- *Use inclusive mask / ROI mask?: [1] yes; [2] no:*
  - [2] is the default; will read in all non-zero (or non-NaN) values in the image
  - If choosing [1], will be prompted to *Select inclusive mask:*
    - all values in the to-be-analyzed image within the inclusive mask will be read in, and the histogram calculated on those values
- values will be read in, and saved under variable `fstats`
- Use default of 50 bins? [1] yes; [2] no:
  - Can select a different min, max, and bin step size
- The histogram outline will be displayed in Matlab **Figure 102**
  - the mean, standard deviation, and skewness of the values will be displayed
  - See example plot below

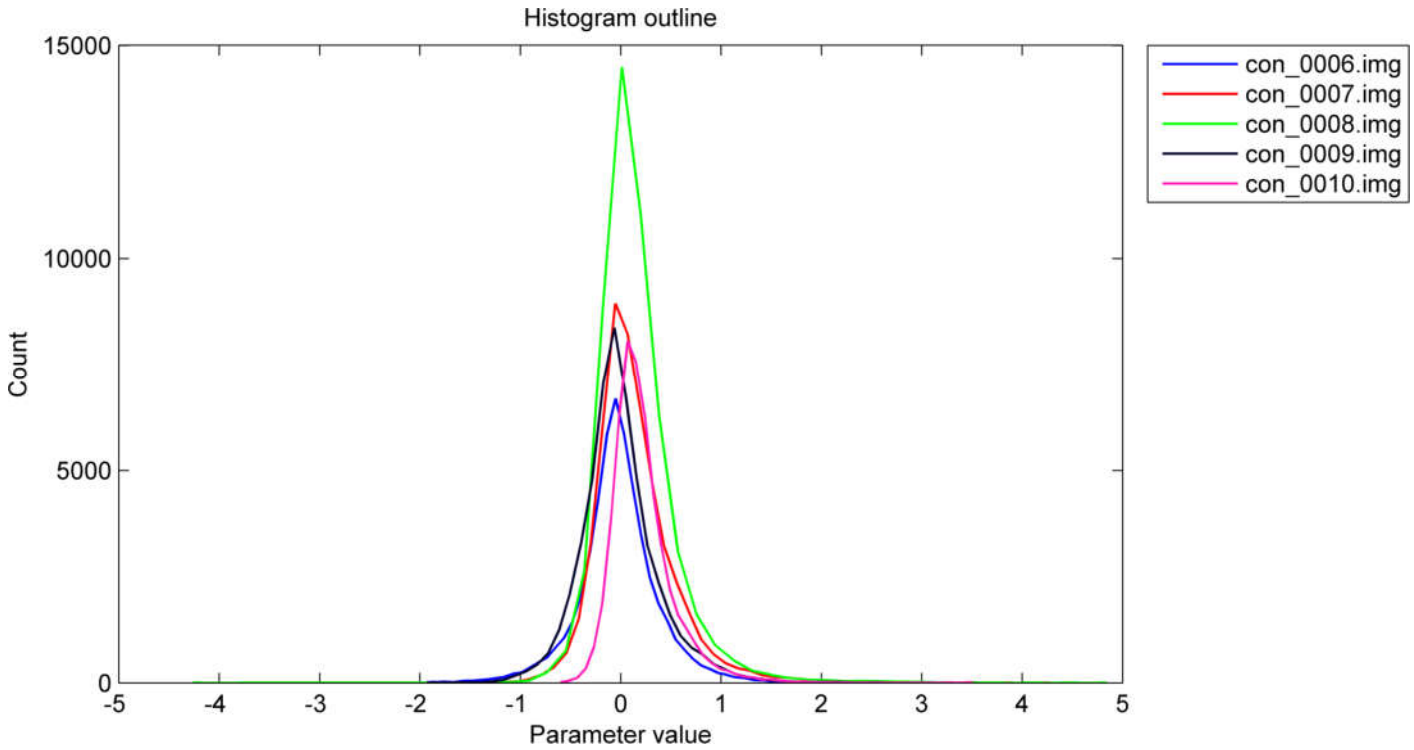


Figure 102. Histogram outlines of all non-zero voxels.

[3] Surface plot (axial) …

- *Select the .img to analyze*
  - in the *sample_data* folder, select `con_0006.img`
- Enter the z slice location
  - default is the z origin (= 0 mm), specified within the file itself. To select another slice, enter the value in mm of the slice (e.g., `15` will return the slice at which z = 15 mm)
  - Note: It is assumed that the user will enter a "valid" value based on the resolution of the image (e.g., 3 x 3 x 3 mm); however, in the case of a discrepancy, the program will round down to the nearest slice (e.g., if `16` is entered, the program will analyze z = 15 mm)
- Results (displayed in Matlab **Figure 20**)
  - The color axis of voxel values is plotted on the right.
  - The image can be rotated in MATLAB using the  ton:
  - Note: in MATLAB, the x-axis values will increase from L to R

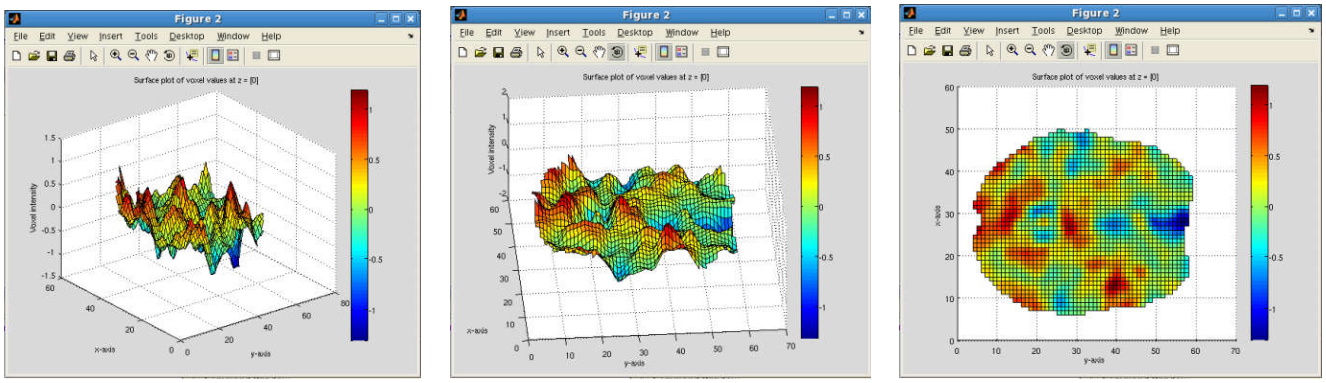


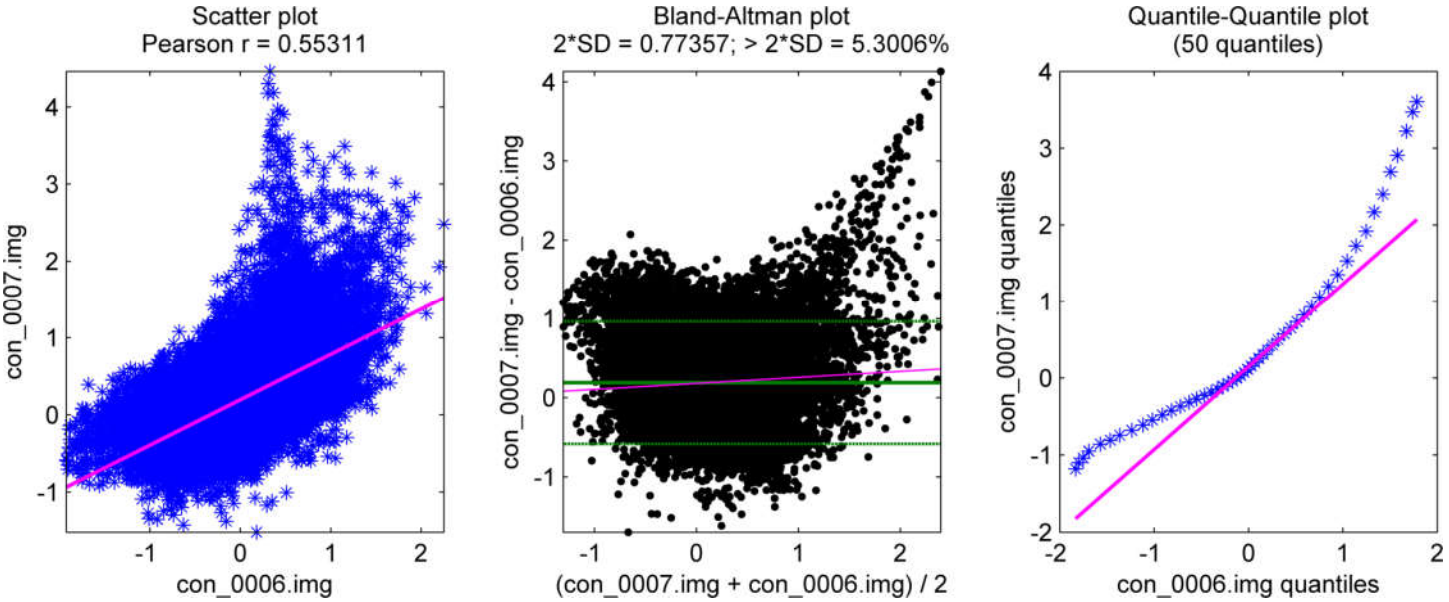
Figure 20. Different rotations of the surface plot.

[4] 2D plots (Scatter, Bland-Altman, Q-Q plot)

- **Note:** Can also be run in batch mode, with a set of *N* "Group1" and *N* "Group2" files.
  - Separate Figures (1001 to 1000+*N*) will be produced for each pair.

- **Example below shows a single pair of files.**

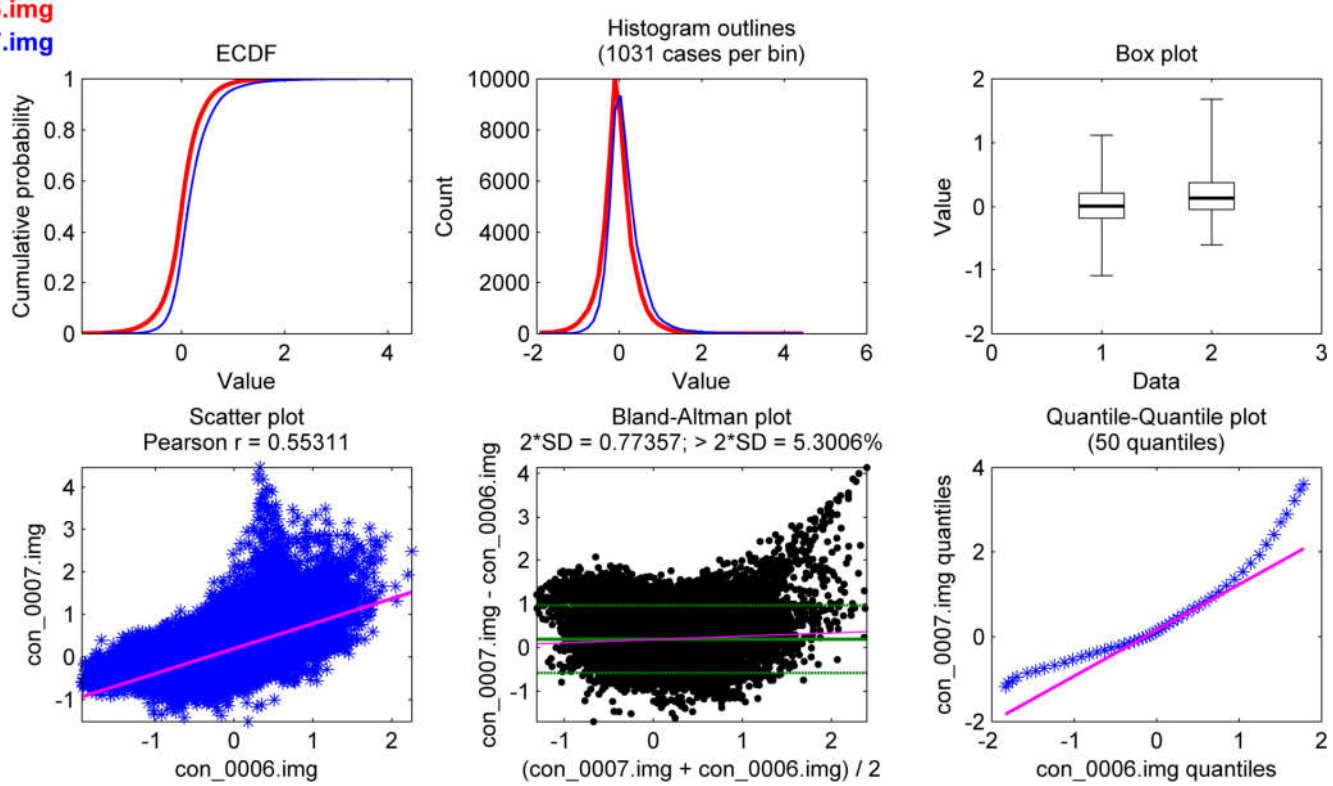
- *Select 2 files (x,y) to compare:*
  - in the *sample_data* folder, select `con_0006.img` and `con_0007.img`
  - (i.e., let's examine how similar the first-level activations are in two subjects)
- *Only include values above V? [1] yes; [2] no:*
  - for example, only positive values
  - if [1], enter the value at the prompt
  - if [2], then all file values will be included
- *Exclude voxels with zeros in [1] first, [2] second, or [3] either image?:*
  - [3] is the most logical choice; excludes voxels in which both images have value = 0
  - That is, all non-brain voxels will be eliminated from this step
- Program will check to make sure the 2 images have the same dimensions, and will terminate if they do not
- Results (displayed in Matlab **Figure 1001 … Figure 1000+*N*** (if *N* pairs of files are selected)
  - Left: Scatter plot will be created, with each axis labeled accordingly
    - The magenta line plots the regression of Y on X
    - Associated statistics are stored in variable `plot_stats`
    - Note: given the likely large size of the images (e.g., > 50,000 voxels), *p*-values will be non-diagnostic.
  - Center: Bland-Altman plot
    - The error bars (dashed green) are 1.96 * the SD, as in the typical presentation of a B-A plot
  - Right: Q-Q plot, showing 50 evenly spaced quantiles
    - The magenta line is the identity function



[5] Six-figure plot (X vs. Y)

- Similar to [4], but adds three additional plots:
  - Top left: Empirical CDFs
    - X in **red**, Y in **blue**
  - Top center: Histogram outlines (bin size is auto selected)
    - X in **red**, Y in **blue**
  - Top right: Box plots

con_0006.img
con_0007.img



[6] Extract parameter values …

- [details to come]

[7] Parcellate activation clusters …

- [details to come]
-
- Purpose:
    - To provide greater flexibility in parcellating clusters of activation, beyond the AAL or Anatomy SPM toolboxes; specifically, the user can specified **any desired labeled brain atlas**; e.g., Harvard-Oxford, LONI, SRI24, etc.; for a large list, see here and here).
    - For an example, see Ellis et al.
- Select atlas: use **lpba40_spm5_corrected_3mm.nii** in the sample_data folder
-
    - Input: either [1] a statistic image or [2] a cluster (integer) image; and an Atlas (will be resliced to match the statistic image if needed)
- If [1]
- Will prompt for a threshold
- Note: will treat the supra-threshold activation as a *single* mask
- If [2]
- Matrix will be the number of voxels for each atlas region (rows), separate for each cluster (column)
- first column will be atlas index; first row will be cluster image value

Runs from vis_getvol

Select statistic image or select cluster image

Select Atlas

You will need to download the LPBA40 atlas from here: http://www.loni.usc.edu/atlases/
LPBA40 labels are from here: http://neuro.imm.dtu.dk/wiki/LPBA40

[8] change directory

- Self explanatory

[9] quit

- Will remove the /spm_fxns subfolder from the Matlab path to avoid complications with subsequent interactions with SPM