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%%% README for Peak Detection Software %%%

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References:

- Adler, R. "The Geometry of Random Fields.", (1981), Vol. 62, SIAM.

- Cheng, D., Schwartzman, A., (2015a), "Distribution of the height of local maxima of Gaussian random fields", Extremes 18 (2), 213-240.

- Cheng, D., Schwartzman, A., (2015b), “On the explicit height distribution and expected number of local maxima of isotropic Gaussian random fields”, preprint, arXiv:1503.01328.

- Cheng, Dan, and Armin Schwartzman, (2017) "Multiple testing of local maxima for detection of peaks in random fields", The Annals of Statistics 45.2 : 529-556.

- Cheng, D., Schwartzman, A., (2018), "Expected number and height distribution of critical points of smooth isotropic Gaussian random fields", Bernoulli 24 (4B), 3422-3446.

- Chumbley, J., et al, (2010), "Topological FDR for neuroimaging.", Neuroimage 49.4 : 3057-3064.

- Moran, J. M., Jolly, E., Mitchell, J. P., (2012), "Social-cognitive deficits in normal aging. J Neurosci 3 (16), 5553-5561.

Requirements:

- Matlab
- SPM12
- make_nii.m/write_nii.m/save_nii_hdr from NIfTI_tools (https://www.mathworks.com/matlabcentral/fileexchange/8797-tools-for-nifti-and-analyze-image)

General Description:

This package provides different function for inference on peaks in isotropic random fields. It implements methods from different articles provides a data analysis example and simulations comparing the performance of the different approaches as reported in Schwartzman Telschow (2018).

Description of Functions:

Adler_peakFDR.m:

Computes p-values, the critical threshold and detected peaks exceeding a pre-threshold v in smooth Gaussian fields using the overshooth distribution in Theorem 3.6.1 Adler (1981) for stationary fields. As shown in Cheng Schwartzman (2018) this approximation is valid even under non-stationarity. Inference is done by the Benjamini-Hochberg (BH) procedure.

Chumbley_peakFDR.m:

Computes p-values, the critical threshold and detected peaks in smooth Gaussian fields using the method in Chumbley (2010) and applies BH procedure for inference.

CS_peakFDR.m:

Computes p-values, the critical threshold and detected peaks in smooth Gaussian fields using the STEM algorithm as in Cheng Schwartzman (2017).

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estim_kappa.m:

Estimates the value of kappa for a random field assuming isotropy as in Cheng Schwartzman (2017).

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find_locMax.m:

This function finds the non-boundary local maxima above a threshold u of a random field and returns the heights and the locations in descending order by height.

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fitGLM2fMRIvolume.m:

Fits a general linear model to an fMRI volume and returns the beta and residual maps as well as a Wald statistic if a contrast is specified.

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peakHeightDensity.m:

Computes the peak height density for a isotropic Gaussian field as derived in Cheng Schwartzman (2015ab/2018)

PvalueTable_heightDistr.m:

Computes a p-value table for the height distribution using the formulas derived in Cheng Schwartzman (2015/2018) and is merely used to significantly speed up the computation time of CS_PeakFDR.m by using it as an input into PvalueTable_heightDistr.m, since CS_PeakFDR.m is slow for large numbers of peaks.

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quartic_kernel.m:

Computes values of the quartic kernel.

SmoothField3D.m:

Generates stationary, isotropic or nonstationary Gaussian and non-Gaussian random fields with mean zero and variance one (if no binning is used) using either a Gaussian smoothing kernel or a quartic kernel. If binning is used, the field does not have variance one and should be divided by the variance estimated from a large sample, since theoretical values are not possible to implement for all versions of binning over a 3D domain.

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smoothfMRIvolume.m:

Smooths a fMRI volume, i.e. a 4-D array, using spm_smooth from SPM12.

SPM_peakFDR.m:

This function is a slight modification of spm_uc_peakFDR where we only changed the part of finding local maxima to make it compatible with the rest of this package.

Table_peakFDR.m:

Computes p-values, the critical threshold and detected peaks using a table of p-values as generated by 'PvalueTable_heightDistr.m'.

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trueFDRcontrol.m:

Computes the asymptotic true level of FDR control for an isotropic Gaussian process derived from smoothing white noise over a 3D domain with Gaussian covariance function.

Description of Scripts:

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kappaEstimator_simulation.m

This script provides the simulations for the estimation of kappa as reported in Schwartzman and Telschow (2018).

PeakDetection3d_PowerFDR_simulation.m

This script provides the simulations for the FDR and power of different methods of peak detection as reported in Schwartzman Telschow (2018).

PeakDetectionAnalysis_DataExample.m

This script provides the example of the data analysis of the Moran data as reported in Schwartzman Telschow (2018).

PeakHeight3d_simulation.m

This script provides the simulations for the p-value distribution of the peak heights in 3D for different types of random fields as reported in Schwartzman Telschow (2018).

PeakHeight3d_T_simulation.m

This script provides the simulations for the p-value distributions of the overshoot in 3D for different fields and methods as reported in Schwartzman Telschow (2018).

Plot_FDRPower.m

This script plots the results reported in Schwartzman Telschow (2018) of the FDR and Power simulations carried out by PeakDetection3d_PowerFDR_simulation.m.

Description of Data

The file sub049_regr_data_fwhm0.mat contains pre-processed data of subject 49 of the Moran study [Moran (2012)] together with the design matrix and the analyzed contrast. For more information consult Moran (2012) and Schwartzman Telschow (2018).