SPM12b Release Notes

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This is SPM12b, the beta version of the next major release of SPM[1]. Public updates are taking place frequently until the final release (see spm_update.m). We are always interested to hear feedbacks and comments from SPM users - please contact us at fil.spm@ucl.ac.uk. If you happen to find any bug, please report them at the same email address. Thank you!

SPM is free but copyright software, distributed under the terms of the GNU General Public Licence as published by the Free Software Foundation (either version 2, as given in file spm_LICENCE.man, or at your option, any later version)[2].
SPM is developed under the auspices of Functional Imaging Laboratory (FIL), The Wellcome Trust Centre for NeuroImaging, in the Institute of Neurology at University College London (UCL), UK.

1 Temporal processing

2 Spatial processing

There have been changes to much of the functionality for spatially transforming images – particularly with respect to inter-subject registration. This is a small step towards reducing SPM to a more manageable size [1].

2.1 Normalise

Spatial normalisation is no longer based on minimising the mean squared difference between a template and a warped version of the image. Instead, it is now done via segmentation [2], as this provides more flexibility. For those of you who preferred the older way of spatially normalising images, this is still available via the "Old Normalise" Tool. However, the aim is to try to simplify SPM and eventually remove the older and less effective [5] routines.

Deformation fields are now saved in a form that allows much more precise alignment. Rather than the old sn.mat format, they are now saved as y_*.nii files, which contain three image volumes encoding the x, y and z coordinates (in mm) of where each voxel maps to.

Note that for spatially normalising PET, SPECT and other images that have spatially correlated noise, it is a good idea to change the smoothness setting on the user interface (from 0 to about 5 mm).

2.2 Segment

The default segmentation has now been replaced by a slightly modified version of what was unimaginatively called "New Segment" in SPM8. For those of you who preferred the older way of segmenting images, this is still available via the "Old Segment" Tool. The aim, however, is to try to simplify SPM and eventually remove the older functionality that works less well. Both implementations are based on the algorithm presented in [2], although the newer version makes use of additional tissue classes, allows multi-channel seg-

[1] http://www.fil.ion.ucl.ac.uk/spm/software/spm12/
[2] http://www.gnu.org/copyleft/

mentation (of eg T2-weighted and PD-weighted images), and incorporates a more flexible image registration component.

Changes to the SPM8 version of "New Segment" include different regularisation for the deformations, some different default settings, as well as re-introducing the re-scaling of the tissue probability maps (which was in the old segment, but not the new). In addition, the tissue probability maps were re-generated using the T2-weighted and PD-weighted scans from the IXI dataset[3]. This was initially done in an automated way (by enabling a hidden feature in spm_preproc_run.m, which allows the necessary sufficient statistics for re-generating the templates to be computed), with some manual editing of the results to tidy them up. Note that eyeballs are now included within the same class as CSF. Separating eyeballs from other non-brain tissue allows the nonlinear registration part to be made more flexible, but the disadvantage is that intra-cranial volumes are now fractionally more difficult to compute. However, the cleanup step (re-introduced from the old segmentation routine, and extended slightly) should allow eyeballs to be removed from the fluid tissue class.

3 fMRI Statistics

4 EEG/MEG

4.1 DCM

- The routine evaluating cross spectra (`spm_dcm_data_csd`) now performs a moving window cross spectral analysis (based on an eighth order MAR model) to remove (nonstationary) fluctuations in the cross spectra. This is achieved by performing a singular value decomposition on the time-dependent cross spectra and retaining only the principal spectral mode.

- The data features used for inverting dynamic causal models of cross spectral density now include both the cross spectra per se and the cross covariance functions. These are simply concatenated to provide a greater latitude of data features to compute free energy gradients. Heuristically, the cross spectra inform gradients that affect low frequencies, while the covariance functions allow high frequencies to be fitted gracefully. This means that any frequency dependent precision can be removed.

- The inversion routines for event related potentials (`spm_dcm_erp`) and complex cross spectra (`spm_dcm_csd`) now use more precise (hyper) priors on data feature noise (with an expected log precision `hE` of eight and a log precision of eight). Effectively, this means that, a priori, we expect these data features to be essentially noiseless – because they accumulate information from long timeseries, with many degrees of freedom.

- To ensure the quantitative veracity of the hyperpriors, the data are scaled to have a maximum amplitude of one (for evoked responses) and a variance of 16 (four cross spectral density analysis).The scaling of the exogenous and endogenous input (`U`) in the equations of motion has also been adjusted, to ensure that the neural mass and mean field models used in DCM produce an ERP with a maximum height of about 1 and autospectra with about unit variance.

- The amplitude of evoked responses, and the spectral responses (shown in terms of autospectra and covariance functions) can now be visualised – for all models – using the survey of models button in the `Neural_models` demo.

5 Utilities

5.1 DICOM Import

The DICOM dictionary has been updated to reflect changes to the standard over the last decade or so. It is now based on the 2011 edition[4].

5.2 Deformations

The deformations utility was completely re-written to provide additional flexibility. This was largely to facilitate the re-write of what lies behind the "Normalise" button.

[3] http://www.brain-development.org/
[4] http://medical.nema.org/standard.html

6 Tools

6.1 Dartel

Much of C the code (in the mex functions that do most of the work in Dartel) has been extensively re-written to make it work more effectively, and to provide a framework on which to base the "Shoot" and "Longitudinal Registration" toolboxes.

6.2 Shoot

This toolbox is based on the work in [3], and is a diffeomorphic registration approach similar to Dartel, although much more theoretically sound. Evaluations show that it achieves more robust solutions in situations where larger deformations are required. The eventual plan will be to replace Dartel with this toolbox, although more work needs to be done in terms of user interfaces etc.

6.3 Longitudinal Registration

SPM12 incorporates a new longitudinal registration approach [4], which replaces the old "high-dimensional warping" toolbox. It essentially now involves a group-wise intra-subject modeling framework, which combines diffeomorphic [3] and rigid-body registration, incorporating a correction for the intensity inhomogeneity artifact usually seen in MRI data. Recently, systematic bias in longitudinal image registration has become a more notable issue. The aim of this toolbox is to estimate volume changes that do not depend on whether the first time point is aligned to the second, or vice verca.

6.4 Old Segment

The default segmentation approach in SPM12 is now based on what was known as "New Segment" in SPM8. This toolbox keeps the old segmentation approach available to those who wish to continue using it, although we plan to eventually phase out the older approach.

6.5 Old Normalise

The default spatial normalisation approach in SPM12 is now based on what was known as "New Segment" in SPM8. This toolbox keeps the old normalisation approach available to those who wish to continue using it, although we plan to eventually phase out the older approach. See [5] to see how poorly the old normalisation approach works. It was definitely time for it to go.

7 Batch Interface

References

[1] J. Ashburner. SPM: a history. *NeuroImage*, 2011.

[2] J. Ashburner and K.J. Friston. Unified segmentation. *NeuroImage*, 26:839–851, 2005.

[3] J. Ashburner and K.J. Friston. Diffeomorphic registration using geodesic shooting and Gauss–Newton optimisation. *NeuroImage*, 55(3):954–967, 2011.

[4] J. Ashburner and G. Ridgway. Symmetric diffeomorphic modeling of longitudinal structural mri. *Frontiers in Neuroscience*, 6(197), 02 2013.

[5] A. Klein, J. Andersson, B.A. Ardekani, J. Ashburner, B. Avants, M.-C. Chiang, G.E. Christensen, D.L. Collins, J. Gee, P. Hellier, J.H. Song, M. Jenkinson, C. Lepage, D. Rueckert, P. Thomson, T. Vercauteren, R.P. Woods, J.J. Mann, and R. Parsey. Evaluation of 14 nonlinear deformation algorithms applied to human brain mri registration. *NeuroImage*, 46(3):786–802, 2009.