SPM8 (r4010) Release Notes

These Release Notes summarise the main changes that were made in the latest release of the SPM8 software, between r3684 (14 January 2010) and r4010 (21 July 2010).

Dynamic Causal Modelling for fMRI

There have been substantial changes to Dynamic Causal Modelling (DCM) for fMRI. These changes are sufficiently major to make any (model) comparison with previous versions unwise. Structurally, the integration and model inversion routines have been re-written to handle both one and two-state DCMs, both bilinear and nonlinear DCMs and both deterministic and stochastic DCM. These three sorts of DCMs [multiple states per region, activity-dependent modulation of connections and the modelling of physiological (state) noise] can now be combined in any fashion. The difference between one and two-state models rests upon the number of hidden neuronal states per region. In two state models, DCM models an excitatory and inhibitory population for each region. Furthermore, positivity constraints are applied to the effective connectivity (in accord with known neuroanatomical constraints). In two-state mode, connections and bilinear effects are treated as previously (as in the one-state model) and pertain to excitatory extrinsic connections among nodes in the DCM graph. However, intrinsic connections refer the inputs to excitatory populations. This ensures that the specification of both one and two-state models remains the same. The difference between bilinear and nonlinear is as previously; where nonlinear systems allow for activity-dependent modulation of connections. The key difference between deterministic and stochastic DCM relies upon generalised filtering (and generalised coordinates of motion) to make inferences about the parameters (effective connectivity) and hidden physiological states. In stochastic mode, the exogenous (experimental) inputs are treated as prior expectations on fluctuations in neuronal input to each region.

In addition to the simplification and rationalization of the different DCMs for fMRI above, we have revised some of the prior densities on the coupling and hemodynamic parameters. Some of these revisions have been for simplicity (and to remove redundancy). Others have been made in the light of inverting stochastic models. These changes mean that the model evidence will not be the same as in previous versions and any model comparison should use a consistent version (i.e., prior beliefs).

Technically, the integration routines have been optimized and simplified. This is particularly relevant for the integration (solution) required for nonlinear DCMs. This should now be about an order of magnitude faster than in previous versions. The inversion of stochastic DCMs relies upon a different sort of system identification (called generalized filtering). See `spm_LAP.m` for details.

Please refer to this version as *DCM10* in papers and publications.

A.C. Marreiros, S.J. Kiebel, and K.J. Friston. **Dynamic causal modelling for fMRI: A two-state model**. NeuroImage, 39:269-278, 2008.
K.E. Stephan, L. Kasper, L. Harrison, J. Daunizeau, H. den Ouden, M. Breakspear, and K.J. Friston. **Nonlinear Dynamic Causal Models for FMRI**. NeuroImage, 42(2):649-662, 2008.
K.J. Friston, K.E. Stephan, Baojuan Li, and J. Daunizeau. **Generalised Filtering**. Mathematical Problems in Engineering, 621670, 2010.

Improved Estimation of FWHM Smoothness & Resel Count

Random Field Theory depends critically on the smoothness of the image noise, as estimated by the Resel count and FWHM. While SPM has always allowed anisotropic smoothness (i.e. *x*, *y* and *z* FWHM different), it always assumed that form of the anisotropy follows the canonical axes. This assumption has been relaxed, and the Resel count is now estimated with a fully arbitrary (anisotropic and freely rotated) smoothness matrix. (Technically, $|\Lambda|$ is now computed from the full 3-by-3 gradient variance matrix, instead of just the diagonal of that matrix).

SPM for M/EEG

Integration with FieldTrip

Thanks to the help of the FieldTrip developers, this version of SPM now contains a streamlined version of FieldTrip (in the *external* folder of your SPM installation) with the same layout of files and folders than the original distribution. It means that you can update the FieldTrip version in SPM by downloading and unzipping a new version on top of the existing version.

If you are updating SPM8 from a previous version, you have to remove the folders `fieldtrip`, `fileio`, `forwinv` and `ctf` in the `external` directory before installing the updates. Alternatively you can download and install a full version of SPM that already contains all the updates and from which these folders have already been removed.

We take this opportunity to remind SPM users that only the main SPM folder has to be added to the MATLAB path – all the required other paths are added automatically when SPM is started or by executing the following:

```
>> spm('defaults', 'eeg'); % or fmri or pet
```

If you need to 'clean' your MATLAB path, you can run the following:

```
>> d = spm('Dir');
>> while true, try, spm_rmpath; catch break; end; end
>> addpath(d); savepath;
```

If you use MATLAB interface to set the path, it means that you have to use the "Add Folder…" button and not "Add with Subfolders…".

MATLAB requirements

The MathWorks' Signal Processing toolbox is not required anymore in SPM8. It used to be called during filtering and downsampling but it has been replaced by an open source alternative from Octave. Some signal processing toolbox dependencies may still exist in FieldTrip code included in SPM.

Octave Signal Package: http://octave.sourceforge.net/signal/

Group inversion

The facility for group inversions has been made considerably more robust (using an iterative generalized eigenvector solution to the 'average' lead-field over subjects). This means that group inversion of MEEG data should no longer depend on the order in which subjects are specified and should provide more robust and accurate MAP reconstructions for subsequent second (between-subject) level analysis.

Problems with using SPM to test for between-subject effects in contrasts based on source reconstructed MEEG data have been finessed by lower bounding the standard error of a t-test that forces very low variance and effect-size voxels to shrink to 0. This is hidden (in `spm_contrasts.m`) because it will not affect normal SPMs (where the scaling of the data is roughly uniform over the image). Note that F-contrasts should not be used and that different t statistics are expected to be observed if they are computed from the same input images but using another software package.

Contrasts of reconstructed MEEG responses

When computing time-frequency MAP contrasts one can now enter a series of time-windows (separated by semicolons) and contrasts will be computed for each time-window (using the same frequency window). These are all normalized together (with different trials if specified). i.e., the global normalization is the same for all contrasts and conditions within subject. The smoothing and thresholding of the time-frequency MAP contrasts are now much simpler (and only one image is created (with no `w_` or `sw_` prefix). The smoothness parameter (only accessible via scripts or the batch system) now controls the Laplacian smoothing on the mesh, while the Gaussian smoothing is trivial (1 voxel FWHM) and just creates a cortical rim for smoothness estimation.

Batch interface for M/EEG

The structure of the M/EEG part of the batch system has been upgraded. The changes are mainly cosmetic, aimed at making the structure and the names of the batch subfields more sensible. An unfortunate side effect is breaking compatibility with existing saved batches. The simplest solution is to rebuild the batches with the new release of SPM. It is also possible to fix the old batches by finding the differences and updating the structures manually, but that is probably not justified in most cases. We hope that the new structure will be stable from now on so this will not happen again.

Imaging source reconstruction tools for M/EEG are now accessible in the batch interface. There are three tools: (1) for specifying the forward model (this can be used to prepare forward models for beamforming), (2) for running the inversion, and (3) for summarizing

inversion results and writing them out as images. All the tools can take multiple datasets as input. When multiple datasets are provided as input to the inversion tool it performs group inversion.

New tool for time-frequency analysis

Time-frequency analyses in the batch interface are now based on plug-in functions (similarly to the artifact detection tool released previously). In addition to wavelet transform that was available before it is now also possible to use Hilbert transform, tapered FFT and multitaper method (both SPM and FieldTrip implementations) for estimating time-frequency decomposition. Additional methods can easily be added as plug-ins.

DCM for induced responses

A serious bug was fixed in DCM for induced responses when used with the 'ECD' option. The problem was that the 3 orthogonal components of a source were not combined correctly which resulted in mixing activity between different sources. We recommend the users who could be affected by it to re-do their analyses.

Improved support for the Yokogawa MEG system

In collaboration with T. Sander-Thoemmes from Berlin and R. Oostenveld from Nijmegen we improved the support of Yokogawa MEG systems in FieldTrip and SPM. This relies on a new version of the Yokogawa library released by the manufacturer that we got permission to include in SPM. Sensor types should now be automatically recognized. Fiducials will be read automatically if there is a file with the same name as the data file and extension `.mrk`. Alternatively, fiducials can be imported using the "Prepare" interface from a `.mrk` file with a different name or from an ASCII file exported from the Yokogawa software (with extension `.txt` and `–coregis` in its name).

Second-level (fMRI) models

Two new design types for "second-level (fMRI) models" have been introduced. These design types are also suitable for between subject PET, MEG and EEG data. The two new design types are "One-way ANOVA" and "One-way ANOVA – within subject". These extend the notion of a two-sample t-test and a paired t-test (respectively) to more than two conditions. These two new options do not extend the functionality of SPM, as one-way ANOVA ere already implemented as a special case of full factorial and flexible factorial (for within subject) designs. But they make the same functionality available in an easier interface – fewer button presses and mouse clicks are required. In "One-way ANOVA" for example, you simply create as many cells as there are conditions e.g. 3 for a 3-way ANOVA. Then for each cell you enter the scans associated with that condition (e.g. the 3rd cell would contain the contrast images from condition 3 of all subjects). For "One-way ANOVA (within subject)" data is entered subject-by-subject. You enter all the scans for each subject and tell SPM what is the condition associated with each scan. For both design types you can have subjects with missing conditions.

Multivariate Bayes

The last update for multivariate Bayes (MVB) focused on classical inference about the mapping entailed by the multivariate model. Previously, this relied upon a cross-validation scheme, using a k-fold strategy. This has now been replaced with a (theoretically) more efficient scheme that uses the free-energy approximation to model's log-evidence to construct log-odd ratios (Bayes factors). The null distribution of these (Neyman-Pearson) optimal statistics is now accessed through re-randomization of the design matrix (or phase-shuffling in the context of serially correlated fMRI data). In brief, we have replaced the cross-validation proxy for relative model evidence with the free-energy bound and perform classical inference directly, through an empirical (re-randomization) null distribution.

K.J. Friston, C. Chu, J. Mourão-Miranda, O. Hulme, G. Rees, W.D. Penny, and J. Ashburner. **Bayesian decoding of brain images**. NeuroImage, 39(1):181-205, 2008.

Batch Interface

The BasicIO modules "Access part of MATLAB variable" and "File Selector (batch mode)" have got new options (output datatype and recursion option, respectively) so that existing jobs will not run without setting this option.

SPM defaults

The file `spm_defaults.m` has been streamlined, so that many defaults values have been moved into the configuration files of the batch system.

We remind SPM users writing batch scripts that this function should not be called directly (a warning will now be displayed). To set the SPM defaults, one should call:

```
>> spm('defaults','fmri'); % or the relevant other modality
```

And to get/set a particular value, one should use `spm_get_defaults.m`, e.g.:

```
>> maxres = spm_get_defaults('stats.maxres');
>> spm_get_defaults('stats.maxres',128);
```

Those of you who edit the `spm_defaults.m` file should be aware that this file will be overwritten when installing the updates. If this is affecting you, please email <spm@fil.ion.ucl.ac.uk> and describe what the parameters you are editing are and why, especially if they have been moved in the configuration files.

SPM8 Manual

New chapters are available in the PDF manual (in the *man* folder of your SPM installation) concerning Psychophysiological Interactions (PPI) and Bayesian Comparison of Dynamic Causal Models (fMRI). The corresponding datasets have been updated on the SPM website.

BMS: http://www.fil.ion.ucl.ac.uk/spm/data/dcm_bms/
http://www.fil.ion.ucl.ac.uk/spm/doc/manual.pdf#Chap:data:dcm_bms

PPI: http://www.fil.ion.ucl.ac.uk/spm/data/attention/#PPI
http://www.fil.ion.ucl.ac.uk/spm/doc/manual.pdf#Chap:data:ppi

Finally, some tools accessible in the Help menu of the SPM Graphics window should help you to detect new updates and check the integrity of your local installation of SPM.

Please assist us by reporting any bug you might observe to <spm@fil.ion.ucl.ac.uk>.