Overview

- SPM Components
- Spatial Transformations
- Comments

SPM: Overview

- Library of Matlab and C functions
- "Point-&-click" graphical user interface
- Consists of 4 general components
  - Preprocessing
  - Model Specification & Fitting
  - Inference & Results Interrogation
  - Supplemental Tools

SPM: Preprocessing

- Elimination of systematic variation before statistical modeling
- "Realign"ment
  - Intrasubject registration
  - Motion correction
  - "Realign & Unwarp"
    - Correct EPI effects of movement-dependent changes in susceptibility
- "Coregister"ation
  - Intrasubject, in*ter*modality registration
  - Registration of MR images with different TR/TE
  - PET-MR registration

SPM: Preprocessing

- Slice timing
  - Adjust for variable acqusition time over slices
  - SPM's slice timing can induce artifacts; use UM's
- Spatial "Normalize"ation
  - In*ter*subject registration
  - Register subject anatomy to atlas space
- Spatial "Smooth"ing
  - Blur data into submission...
    - To satisfy random field theory assumptions
    - For intersubject analyses
- "Segment"ation into GM/WM/CSF
  - Usually not directly used
  - Useful for structural studies

SPM: Model Specification & Fitting

- "Basic models"
  - t-tests (Two sample, One sample, Paired)
  - Regression
- "fMRI"
  - "design" Specify the design
  - "data" Specify the data for a existing design
- "Review design"
  - Examine correlation of predictors
  - Power spectrum of experimental effects
- "Estimate"
  - Fit a specified model

SPM: Inference & Results Interrogation

- "Results" button
- First brings up "Contrast Manager"
  - Can define single (t) or sets (F) of contrasts
- Then shows MIP in Graphics window
  - MIP = Maximum Intensity Projection
  - Glass Brain
  - Can "surf" by dragging cursor

SPM: Inference & Results Interrogation

- Interactive window
  - p-values
    - Corrected for whole brain or subregion
  - Plotting of time courses
  - "Overlays"
    - Superimpose results on other images
  - Current location and value

SPM: Miscellaneous Tools

- "Display"
  - Display an image with orthogonal sections.
  - Check intensity values
  - Change origin
  - Change world space
    - I.e. apply rotations/translations to mat file
- "Check Reg"
  - Display multiple images
  - *Essential* tool for assesing estimated or assumed alignment of images.
  - All images are displyed in the space of the first image.

SPM: Miscellaneous Tools

- "ImCalc"
  - Image calculator
  - Give one or more images, perform Matlab arithmatic and write out result
- "Utils"
  - Change directory
    - Results are written to current directory!
  - delete files, etc.

SPM: Miscellaneous Tools

- "Rendering"
  - Sexy brains
- "Defaults"
  - Change defaults for one session.
  - To make permanant changes, edit `spm_defaults.m`
- "Help"
  - Some help
  - Also not "Tool tip" help balloons

SPM: Pipeline

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Spatial Transformations: Image File

- Data must be in analyze format
- `.img` Raw, binary data; single 3D volume
- `.hdr` Short binary header
  - Image dimension
  - Voxel size
  - Origin, in voxels
    - First element 1, not 0
- `.mat` Optional, SPM extension
  - Defines transformation from voxel to world space
  - If exists, `.hdr` voxel size & origin are ignored
  - Origin can be represented as mm location
    - e.g. between voxels

Spatial Transformations: Voxel vs. World Space

- Voxel Space
  - Just the original image
  - No reorientations or flips
- World Space
  - Space defined by `.mat` file
    - `.mat` - 4×4 homogeneous transformation matrix `M`
    - Let `v` be a voxel location indexed from (1,1,1)
    - Then `w=M*[v;1]` is that location in world space
  - Has units of *mm*
  - Can represent rotations, translations and flips

Spatial Transformations: Coregistration & Realignment

- Coregistration & Realignment are rigid body transformations
  - Subject's doesn't change size or warp between scans
    - Well, actually...
- Each requires a "Target" and an "Object"
  - Target — Fixed image
  - Object — Image that is transformed
- SPM modifies the .mat file of the *object* image
  - Unless you explicitly ask it to, it doesn't write out an image

Spatial Transformations: Coregistration & Realignment

- This is very cool!
  - You have 1000 images
  - You realign 2nd through the 1000th to the 1st
    - Target=1st, Object=2nd-1000th
  - Instead of doubling the disk space required by writing out 1000 images, you only need to modify the `.mat`'s!

Spatial Transformations: Coregistration

- `.mat`'s handy for coregistration
- e.g. Coregister
  - Target: Functional space, 7 slices
    - e.g. 7 slice, low resolution anatomical in space of func's, "t1_gre"
  - Object: Structural space
    - e.g. high resolution anatomical, 120 slices difference space, "t1_spgr"
- Reslicing an image, creating "t1_spgr-gre"
  - You get a 7 slice, low resolution SPGR

Spatial Transformations: Coregistration

- But don't have to reslice
  - t1_spgr's world space now corresponds to t1_gre
  - The `.mat` file has captured the transformation *without* throwing away any information

Spatial Transformations: Easy to forget about `.mat`'s

- Easy to forget about `.mat`'s
  - If you want to start over and re-do registration *must delete the .mat's*!

Spatial Transformations: Left is Right is Left is Right is ...

- Two conventions for images
- Neurological
  - ⇀ On the screen, Left is Left side of subject
  - ⇀ As if standing behind the patient
- Radiological
  - ⇀ On the screen, Left is Right side of subject
  - ⇀ As if standing at the foot of the patient
- Standardard in clinical radiology is, um, radiological
- SPM2 and SPM99 differ on their conventions
  - ⇀ Be very careful!

Spatial Transformations: Rad. vs. Neuro., SPM2 vs. SPM99

- SPM99
  - ⇀ Analyze images read and written in *Neurological* format
    nb: Official Analyze standard specifies Radiological format
  - ⇀ **Exception:** Spatial Normalization reads in Radiological (by default; switchable to Neurological)
  - ⇀ Default set by `sptl_Ornt` in `spm_defaults.m`
- SPM2
  - ⇀ Analyze images *consistently*, always assumed to be *Radiological* (by default; switchable to Neurological)
  - ⇀ Default set by `defaults.analyze.flip`
    - – `flip` = 0 ⇔ Neuro.
      `flip` = 1 ⇔ Rad. (SPM2 default; *diff. from SPM99!*)

Spatial Transformations: Left is Right is Left is Right is ...

- Best to make a lab convention
  - ⇀ fMRI Lab produces everything in neurological!!!
  - ⇀ SPM99
    - – Set `sptl_Ornt` to Neurolgical option
  - ⇀ SPM2
    - – Set `defaults.analyze.flip` to 0, Neurolgical
- If paranoid
  - ⇀ Tape a vitaman E capsule to head and call me in the morning
    (Note location of capsule in acquired images)

SPM: SPMese Decoder Ring

- “Spatial Normalization”
  - ⇀ Intersubject registration
- “Coregistration”
  - ⇀ Intermodality registration (intrasubject)
- “Registration”
  - ⇀ Intrasubject registration (movement corr)
- “Results”
  - ⇀ Inference
- “Interscan Interval”
  - ⇀ TR

SPM: Perspective

- SPM tries to be a “sole source”, turn key solution for fMRI
- At this point, *there can be no such thing!*
  - ⇀ This is impossible in a cutting edge, rapidly evolving field where each dataset has 10’s of millions of observations!!!
- Don’t let SPM be a black box!
- Understand what each component does
- Understand how to get at the data
  e.g. using ’Display’ and ’Check Reg’ alot.

SPM: Alternatives

- VoxBo
  - ⇀ Started as independent coding (and validation!) of SPM methods in IDL
  - ⇀ Uses random field theory, etc
  - ⇀ Easy to do to parallel computing; easy to automate
- FSL
  - ⇀ Started as extentions to MEDx
  - ⇀ Best temporal autocorrelation modeling available
    - – Regularized ACF fit at every voxel
  - ⇀ Most sophisticated group modeling available
    - – Between and within subj. variance estimated
  - ⇀ Better design specification UI, easy to automate