Function-Structure Integration in FreeSurfer

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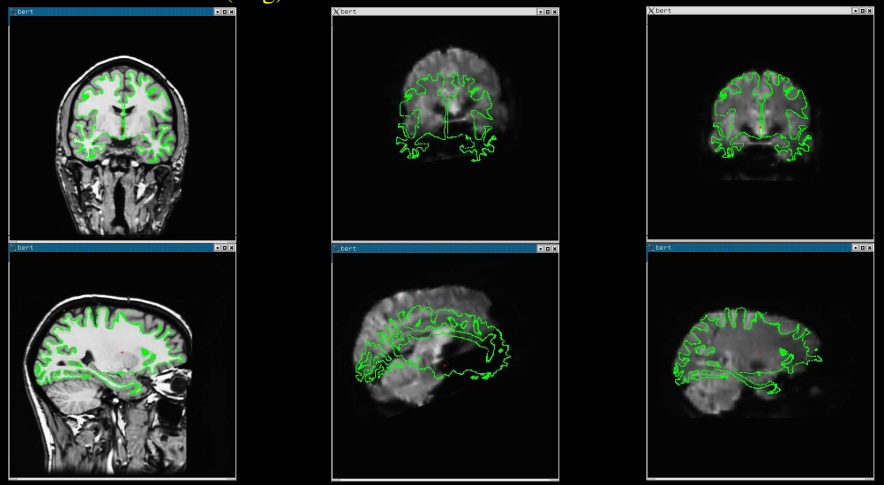
Outline

- Registering FEAT à FreeSurfer Anatomical
  - Automatic (FLIRT)
  - Manual (tkregister2)
- Viewing FEAT output on Anatomical
- Sampling FEAT output on the surface
  - Individual
  - Common Surface Space (Atlas/fsaverage)
- Mapping FreeSurfer Segmentations to FEAT
- Group Analysis

Registration

FreeSurfer Anatomical (orig)

Template Functional



Note: Registering the template functional volume to the anatomical volume is sufficient to register the template to the surface.

FreeSurfer Registration

FreeSurfer Subject-Specific
- Volumes
- Surfaces
- Thickness
- ROIs

Registration

Your Data/Software
- fMRI (FSL, etc)
- EEG/MEG
- DTI
- …

Registration Matrix
- Affine 4x4
- As many as 12 DOF (usually 6)
- Text file

Automatic Registration

First: analyze your data with FEAT (No Smoothing)

reg-feat2anat –featdir fbert1.feat –subject bert

Uses FLIRT to perform 6DOF registration:
fbert1.feat/example_func.nii.gz
$SUBJECTS_DIR/bert/mri/brainmask.mgz

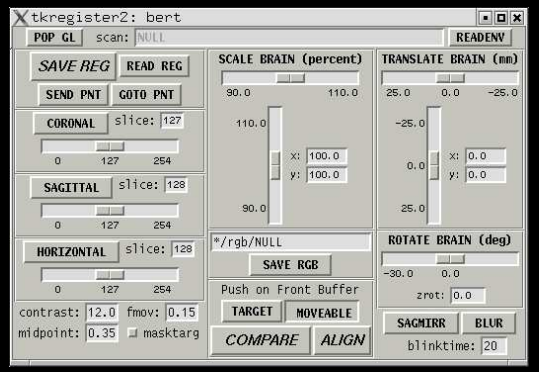
Creates FreeSurfer registration matrix:
fbert1.feat/reg/freesurfer/anat2exf.register.dat

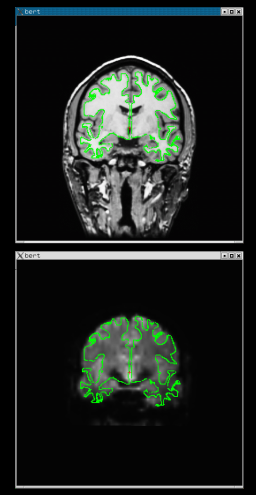
Also creates: fbert1.feat/reg/freesurfer/anat2std.register.dat
This matrix maps standard space to anatomical space and can be used when combining data within subject across data sets

reg-feat2anat --help

Manual Registration

- reg-feat2anat –feat fbert.feat --manual
- Visually inspect registration
- Manually edit registration (6 DOF)
- Cf Manual Talairach registration

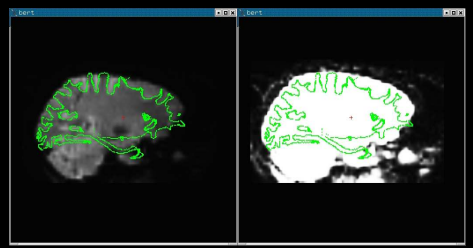


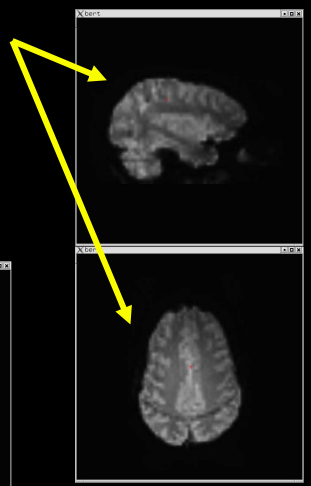


tkregister2 --help

Tips

- Rigid = 6 DOF = No stretching
- Use CSF to get a sense of where the folds are
- Avoid using B0 distortion regions
- Avoid using ventricles
- Warning about “edge” of the brain
- Same Subject, Left-Right Flips

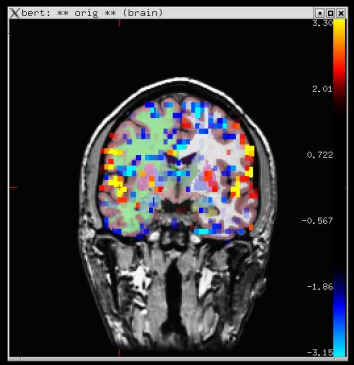




Viewing Functional Activation on the Volume

tkmedit bert orig.mgz -aux brain.mgz
-overlay ./fbert1.feat/stats/zstat1.nii.gz
-overlay-reg ./fbert1.feat/reg/freesurfer/anat2exf.register.dat
-fthresh 2.3 –fmax 4.3 -seg aparc+aseg.mgz

Visual, Auditory, Motor



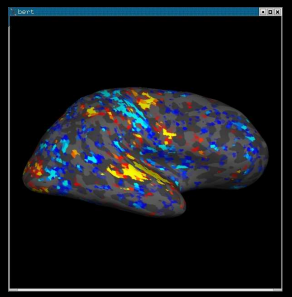
Thresholds depend on the nature of the data,
Eg, for zstat image, 2.3 means z > 2.3
Can be changed with
View->Configure->FunctionalOverlay

Can display any functional data, eg,
zstat, fzstat, cope, pe, etc

Viewing FEAT Stats on the Surface

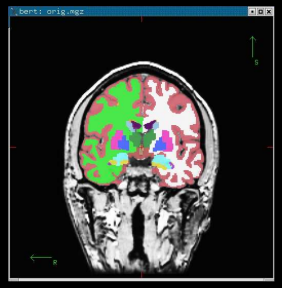
tksurfer bert rh inflated
-overlay ./fbert1.feat/stats/zstat1.nii.gz
-overlay-reg ./fbert1.feat/reg/freesurfer/anat2exf.register.dat
-fthresh 2.3 -fmid 3.3 -fslope 1

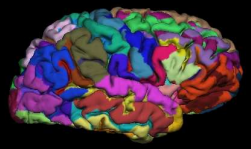
Visual, Auditory, Motor

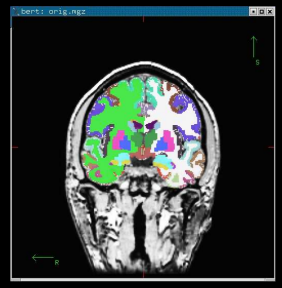


Can display any functional data, eg,
zstat, fzstat, cope, pe, etc

Mapping Automatic Segmentations







aseg.mgz lh.aparc.annot aparc+aseg.mgz

$FREESURFER_HOME/FreeSurferColorsLUT.txt

Mapping Automatic Segmentations

aseg2feat --feat fbert.feat –aseg aparc+aseg

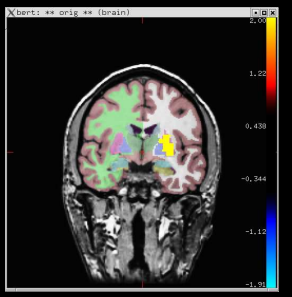
In the functional FOV, creates:
fbert1.feat/reg/freesurfer/aseg+aparc.nii.gz

Create Text Summary Table (nvox, mean cope, std cope, etc)
mri_segstats --seg fbert1.feat/reg/freesurfer/aparc+aseg.nii.gz
--nonempty --ctab-default --in fbert.feat/stats/cope1.nii.gz
--sum fbert1.sum.txt

Can summarize any functional data, eg,
zstat, fzstat, cope, pe, etc

Make and View ROI

Make a binary mask of the left putamen:
Note: 12 = Left Putamen,
see $FREESURFER_HOME/FreeSurferColorsLUT.txt
fslmaths
./fbert1.feat/reg/freesurfer/aparc+aseg.nii.gz
-thr 12 -uthr 12
./fbert1.feat/reg/freesurfer/lh.putamen.nii.gz



tkmedit bert orig.mgz -aux brain.mgz
-overlay ./fbert1.feat/reg/freesurfer/lh.putamen.nii.gz
-overlay-reg ./fbert1.feat/reg/freesurfer/anat2exf.register.dat
-fthresh 0.5 -seg aparc+aseg.mgz

Within-Subject, Cross-Run Analysis

- Analyze each run with FEAT (dataX.feat)
- Combine runs with GFEAT (standard space)
- mean_func.nii.gz – avg of example_func in std space
- Register each run (not .gfeat) with reg-feat2anat.
- dataX.feat/reg/freesurfer/anat2std.register.dat
- All runs (X) should be very close

Verify the registration
tkregister2 –mov data.gfeat/mean_func.nii.gz
--reg anat2std.register.dat --surf

Use anat2std.register.dat the way you would anat2exf.register.dat

Surface-based Group Analysis

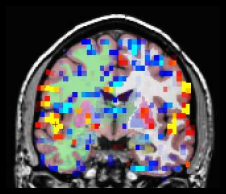
mris_preproc --out lh.cope1.nii.gz --target fsaverage --hemi lh
--iv fbert.feat/stats/cope1.nii.gz fbert.feat/reg/freesurfer/anat2exf.register.dat
--iv fgreg.feat/stats/cope1.nii.gz fgreg.feat/reg/freesurfer/anat2exf.register.dat
--iv fsally.feat/stats/cope1.nii.gz fsally.feat/reg/freesurfer/anat2exf.register.dat
--iv fpat.feat/stats/cope1.nii.gz fpat.feat/reg/freesurfer/anat2exf.register.dat

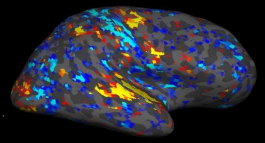
Volumes Registrations

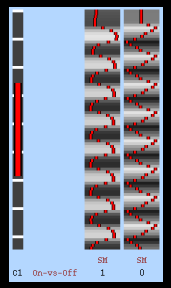
- lh.cope1.nii.gz – "volume-encoded surface file": dim 1974 x 1 x 83 = 163842
- dim nframes = number of subjects
- Can map any functional data, eg, zstat, fzstat, cope, pe, etc
- fsaverage – defines common space (spherical surface)
- mri_glmfit (FreeSurfer), randomise (FSL), flame (FSL), melodic (FSL)

Practical Data

- Sensory-motor study
- Blocked Design (15sec OFF, 15 sec ON)
- One subject – "bert"
- Two runs (TR=3, 85 time points)
- FEAT has been run on both runs (FWHM=5
- Combined with GFEAT
  - FFx
  - One-Sample Group Mean (OSGM)
- Actually, all analysis steps already performed!







Practical

- Automatic registration (<5 min)
- Manual registration
- View FEAT results on subject's anatomy (aparc+aseg)
- View FEAT results with tksurfer
- Map aparc+aseg to Functional Space
- Verify GFEAT registration
- View GFEAT results in volume and on surface
- "Higher-Level" analysis with mri_glmfit
  - Cross-Run
  - Fixed-Effects (FFX), One-Sample Group Mean (osgm)