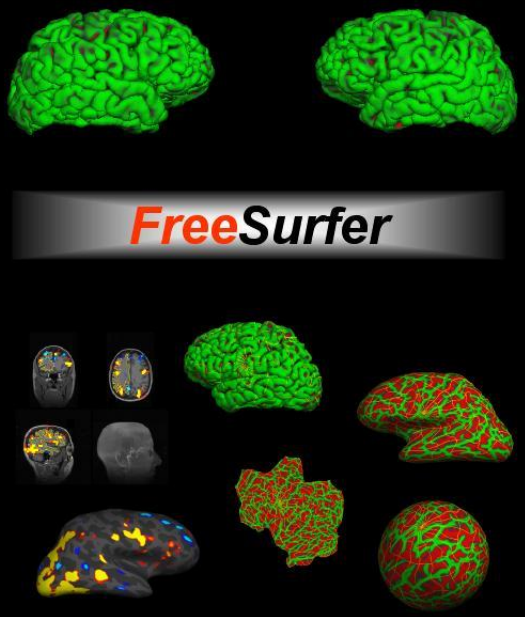


More Registration Techniques

MGH 1811 MASSACHUSETTS GENERAL HOSPITAL

registration tool summary

- mris_register

- fslregister: bet + flirt
- bbregister

- mri_robust_register

- mri_cvs_register
  - mris_register
  - mri_nl_align

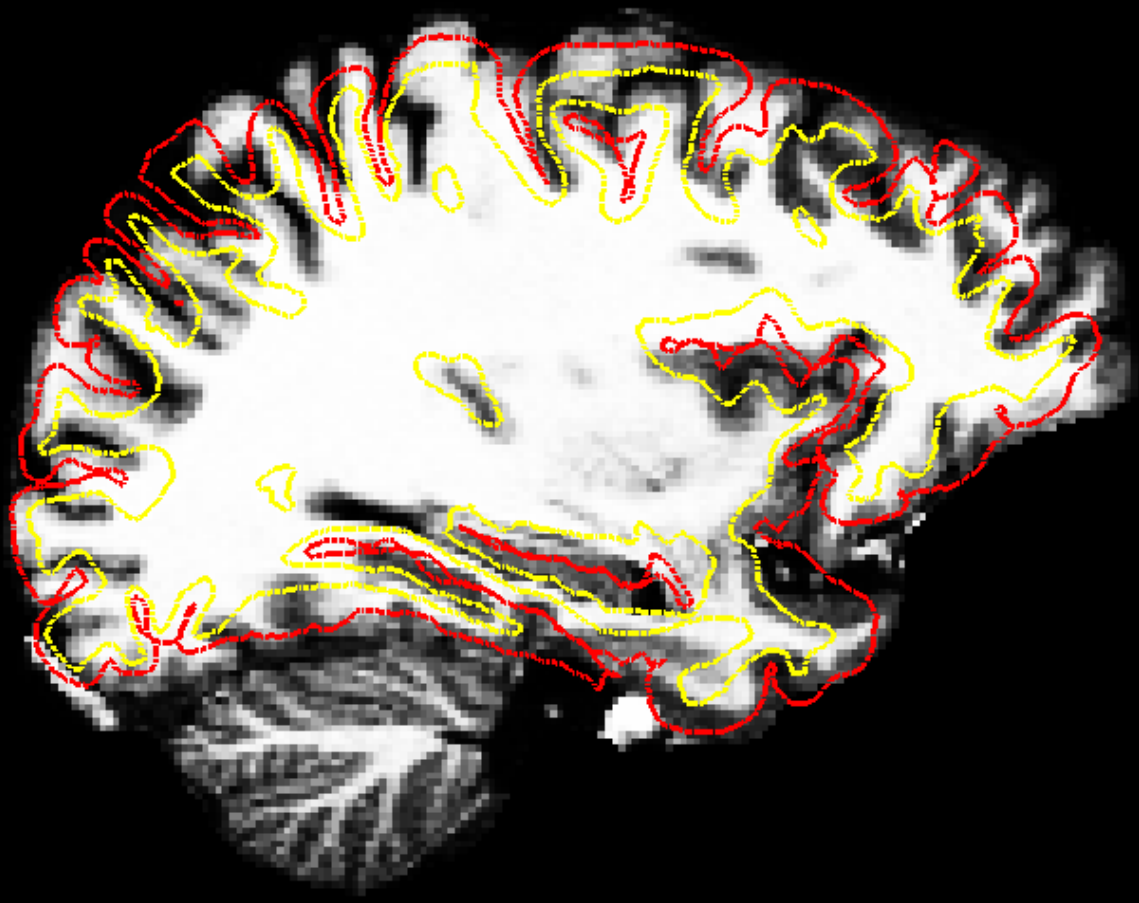
registration morph summary

- .dat, .lta, .xfm, .fslmat: encode rigid and affine transformations
  - mri_vol2vol
- sphere.reg: encodes spherical morph
  - mris_resample
- .m3z: encode nonlinear volumetric morphs
  - mri_vol2vol

A new registration solution?

- Surface-based (2D) registration does an excellent job of aligning cortical folds, but does not apply to non-cortical structures (e.g. basal ganglia).
- Volumetric (3D) registration applies to the entire brain but does not, in general, align folding patterns.
- Goal: combined their strength

Why aligning folds in the volume is hard…

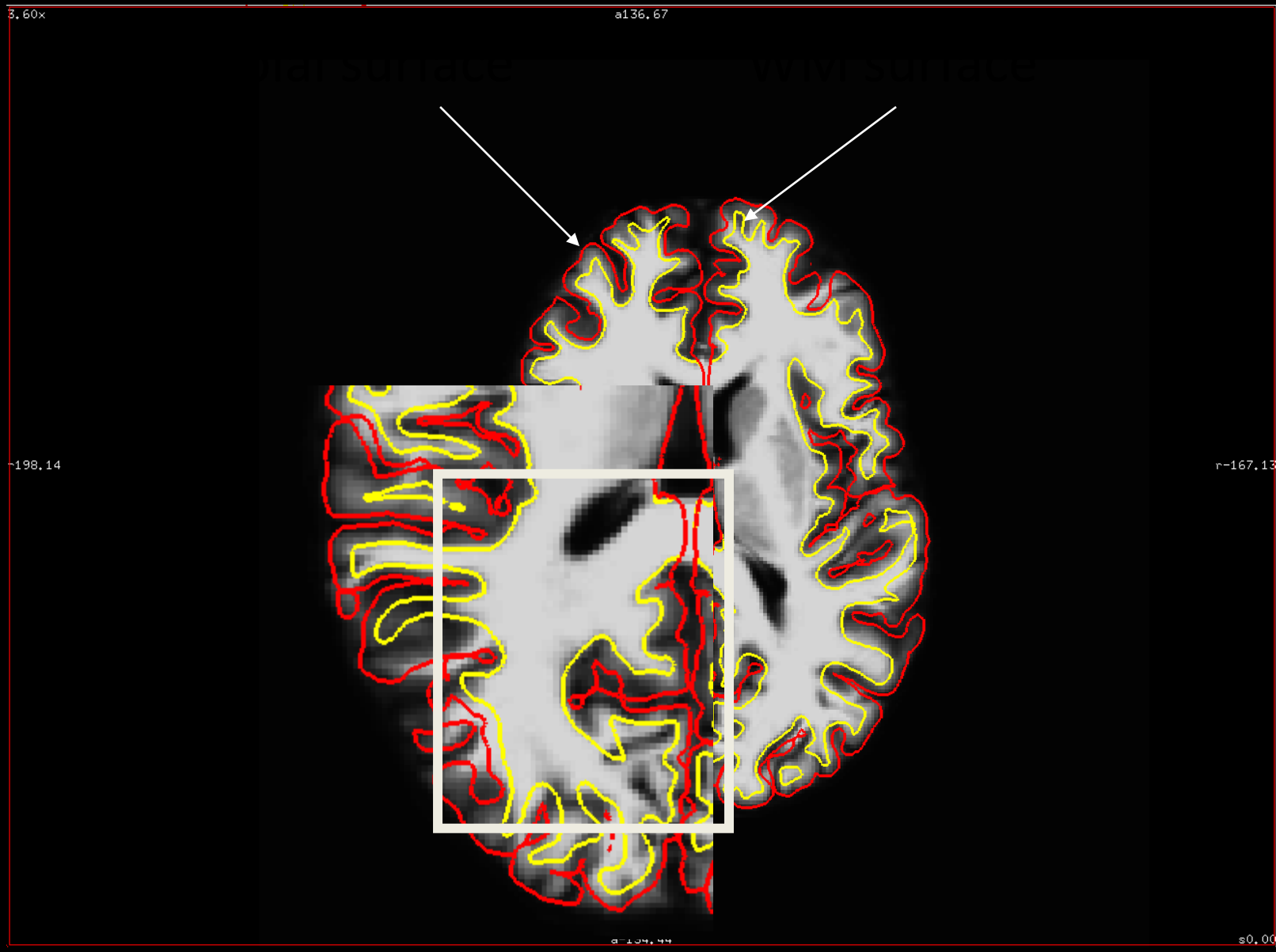


Affine transform of surfaces from one subject mapped to another.

Template

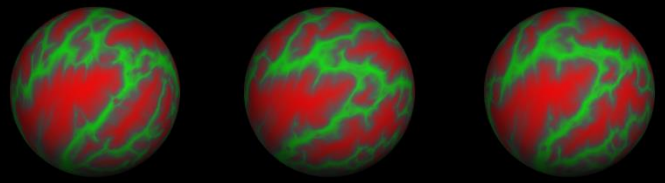
Affine

Nonlinear

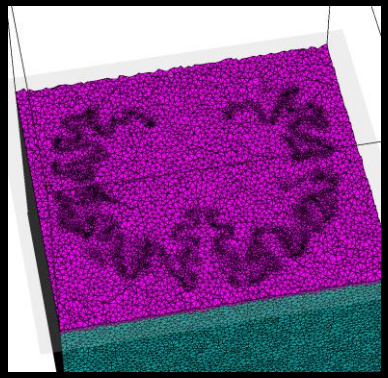


Combined volumetric and surface-based registration (CVS)

- Spherical alignment



- Elastic propagation of cortical registration results in the 3D volume



- Volumetric alignment of sub-cortical regions

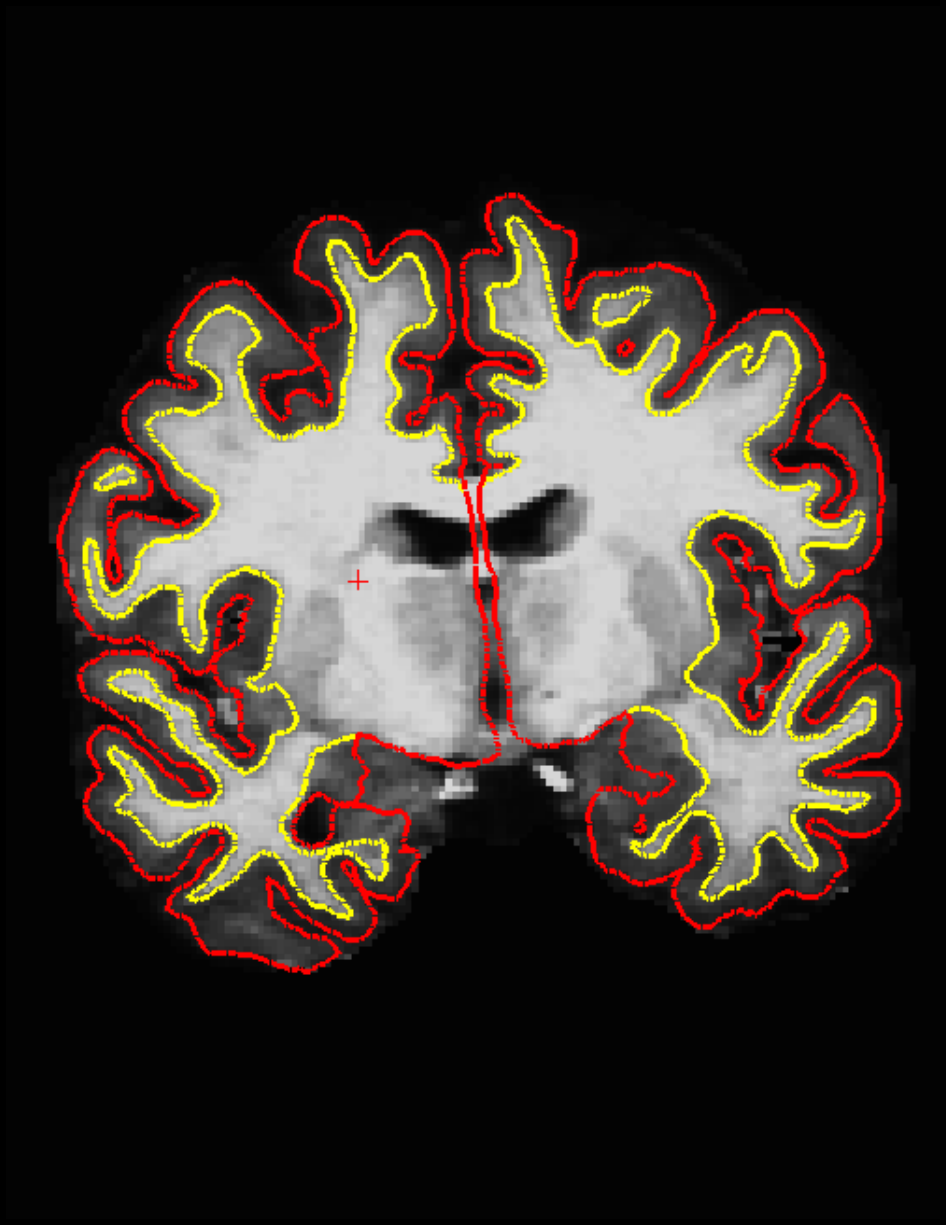
Resulting morph

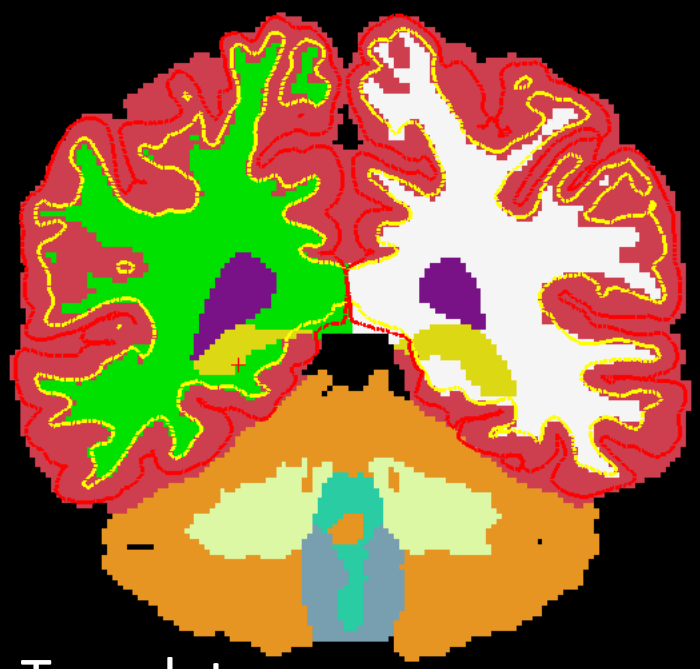
Template

Elastic

CVS

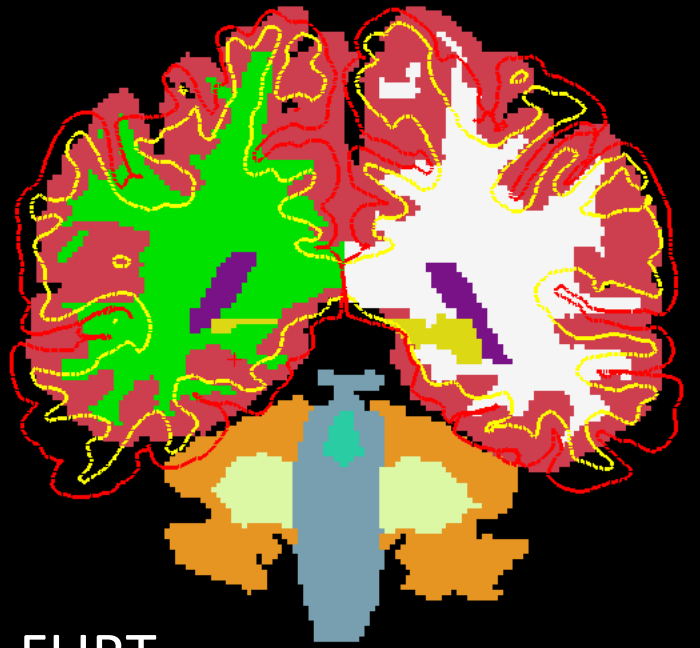
Template



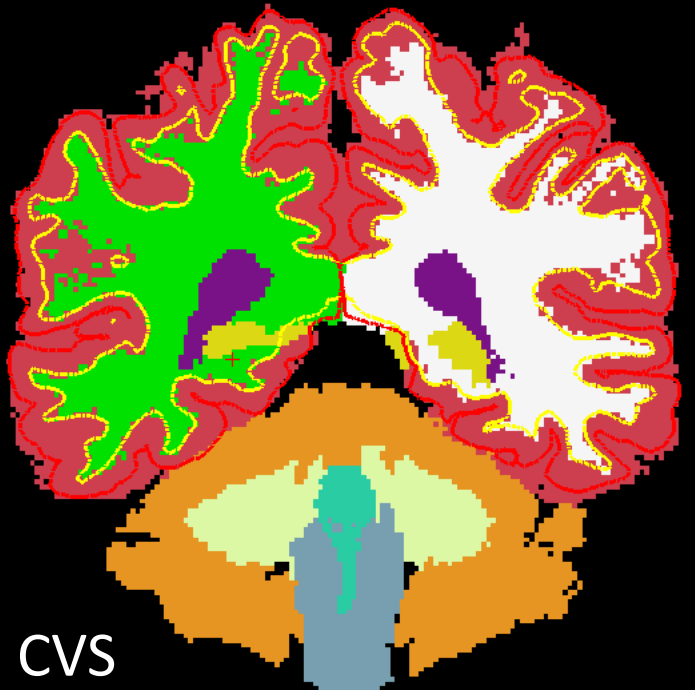


Template

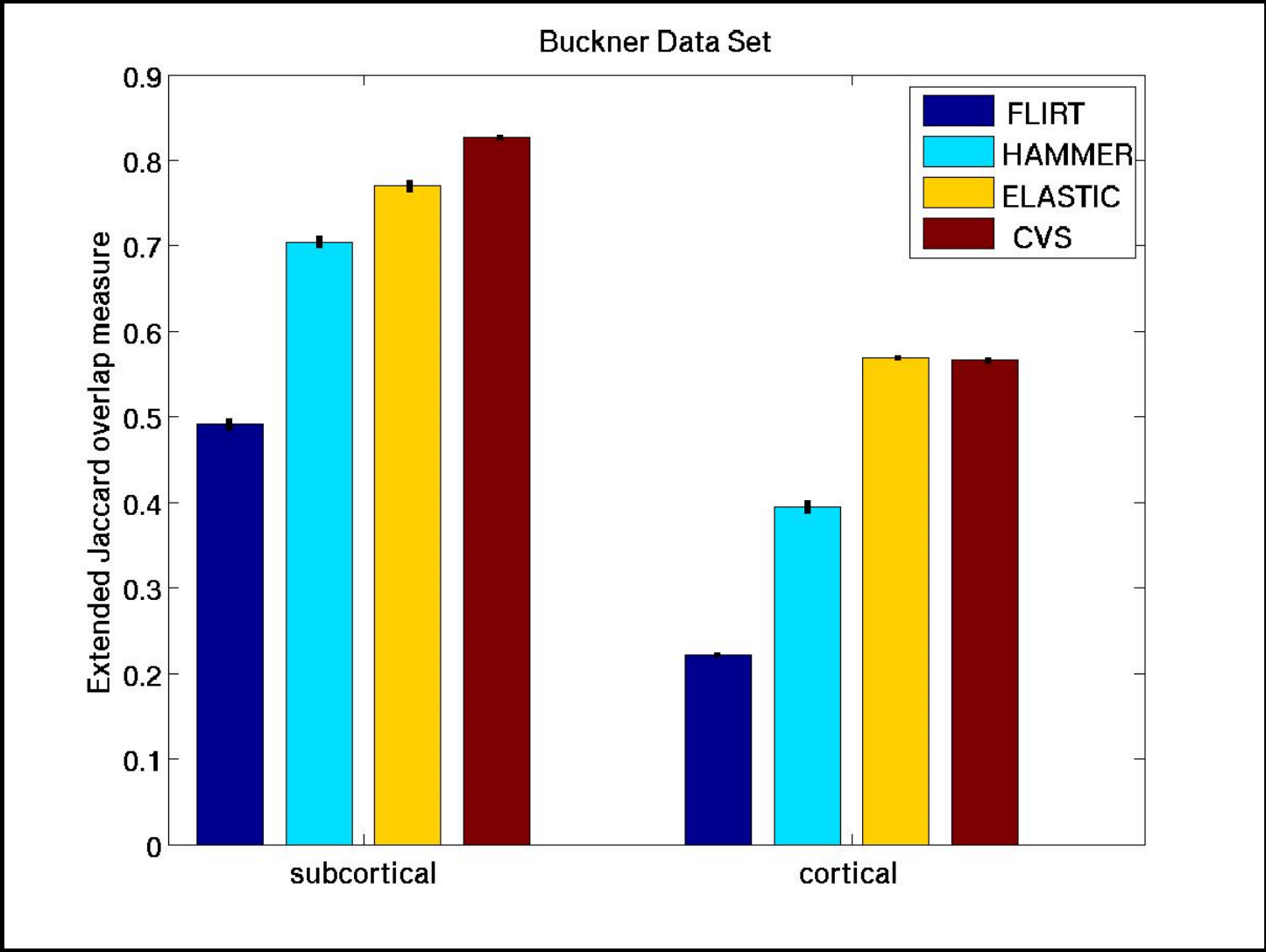
HAMMER



FLIRT



CVS



Extended Jaccard Coefficient measures: 20 cortical and 21 sub-cortical labels. (The vertical lines represent the standard error of the mean of the measurement.)

G.M. Postelnicu*, L . Zöllei*, B. Fischl: "*Combined Volumetric and Surface Registration*", IEEE Transactions on Medical Imaging (TMI), Vol 28 (4), April 2009, p. 508-522

mri_cvs_register --mov subjid

- registering the subject to, by default, the CVS atlas space
- make sure that the SUBJECTS_DIR for *subjid* is correctly set

Optional Arguments

-- template subjid	: subjid for template subject
-- templatedir dir	: recon directory for template (default is SUBJECTS_DIR)
--outdir dir	: output directory for all the results (default is SUBJECTS_DIR/subjid/cvs)

… and many more: use --help

mri_cvs_register

Optional Arguments (cont)

--step1

Only do step 1 (spherical registration).

--step2

Only do step 2 (elastic registration).

--step3

Only do step 3 (volumetric registration).

--noaseg

Do not use aseg volumes in the volumetric registration pipeline (default is 0). Setting this option could shorten significantly the time of registration, however, might also take away from the accuracy of the final results.

mri_cvs_register

Optional Arguments (cont)

--nocleanup

Do not delete temporary files (default is 0).

--keepelreg

Do not delete elastic registration (default is 0) outcome.

--cleanall

Recompute all CVS-related morphs that might have been computed prior to the current CVS run (def = 0).

--cleansurfreg

Recompute CVS-related surface registration morphs that might have been computed prior to the current CVS run (def = 0).

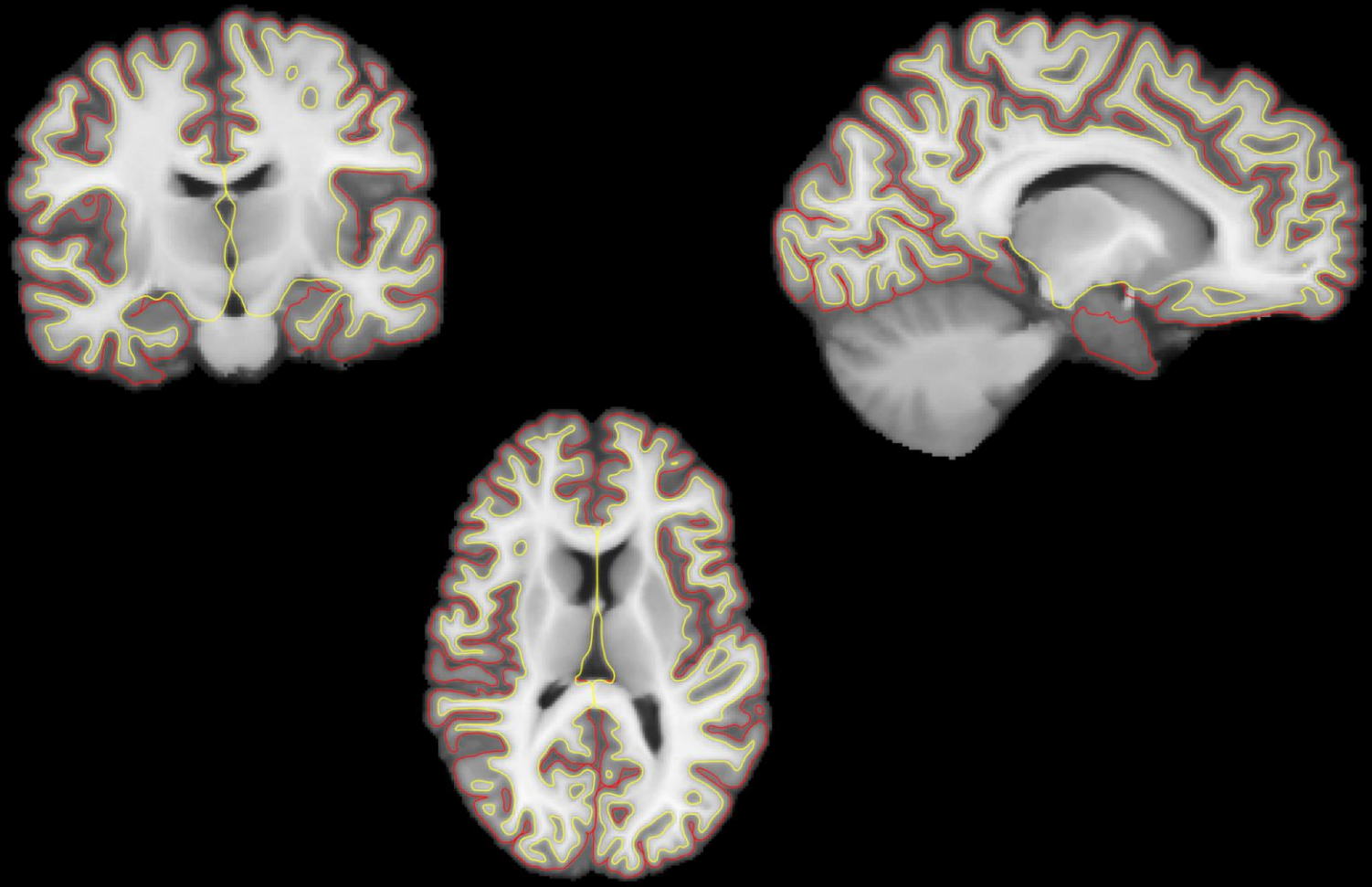
--cleanelreg

Overwrite /recompute the CVS-related elastic registration morph that might have been computed prior to the current CVS run (default is 0).

--cleanvolreg

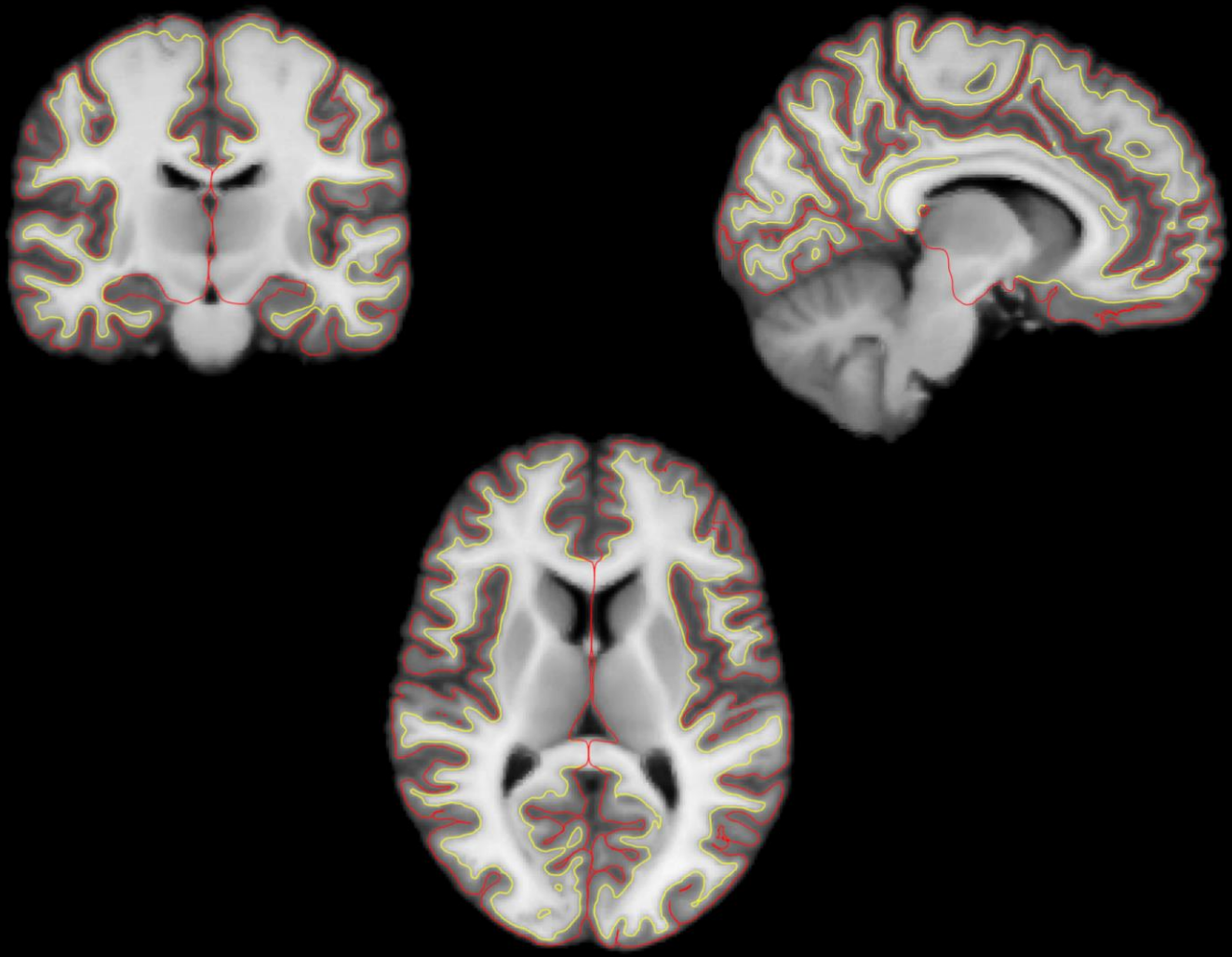
Overwrite / recompute CVS-related volumetric morphs that might have been computed prior to the current CVS run (default is 0).

CVS atlas



path: $FREESURFER_HOME/subjects/cvs_avg35

CVS atlas in MNI152 space



path: $FREESURFER_HOME/subjects/ cvs_avg35_inMNI152/

related commands

- mri_cvs_check
  - checking whether all files needed for a successful CVS registration are present
- mri_cvs_data_copy
  - copying the CVS-relevant recon directories over to a new location
- mri_vol2vol
  - applying the CVS registration morph to files corresponding to the *moving* subject

Applying CVS morphs

mri_vol2vol

1. applying CVS morph to aseg file

```
mri_vol2vol     --targ templateid --m3z morph.m3z \
                --noDefM3zPath --mov asegvol \
                --o asegvol2CVS --interp nearest \
                --no-save-reg
```

2. applying morph to corresponding diffusion file

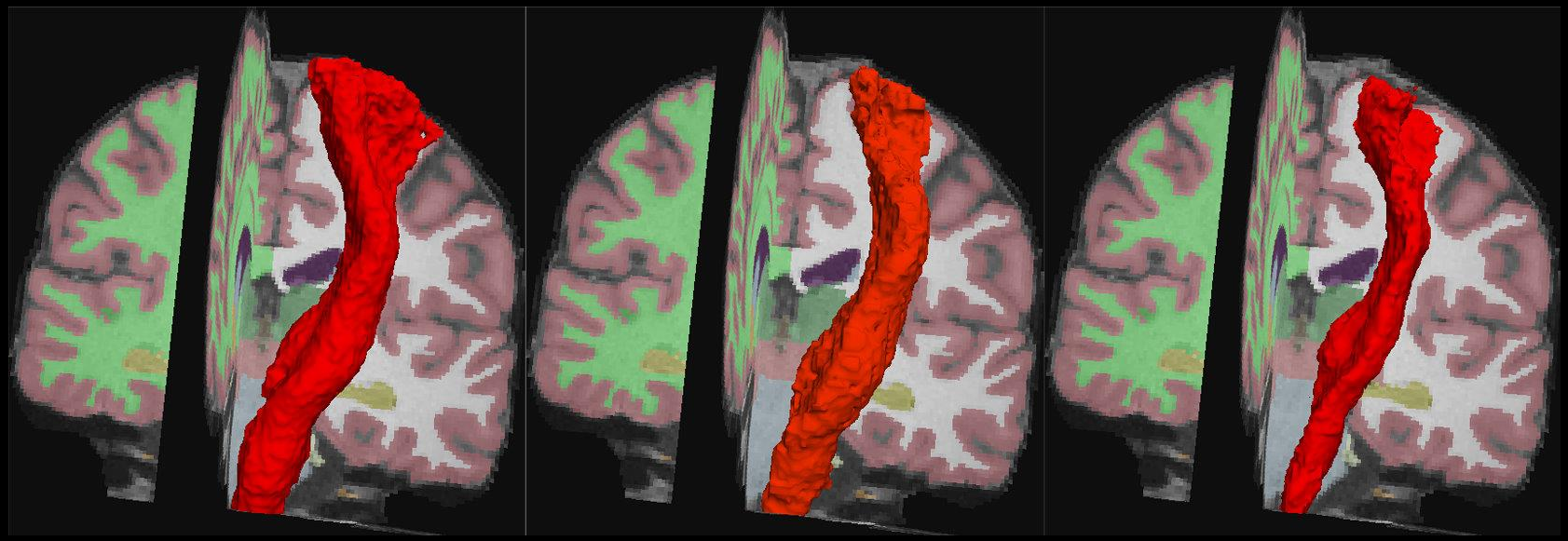
```
mri_vol2vol     --targ templateid --m3z morph.m3z
                --noDefM3zPath --reg 2anat.register.dat
                --mov diffvol --o diffvol2CVS
                --no-save-reg
```

Application of CVS to tractography

- Goal: fiber bundle alignment
- Study: compare CVS to methods directly aligning DWI-derived scalar volumes
- Conclusion: high accuracy cross-subject registration based on structural MRI images can provide improved alignment

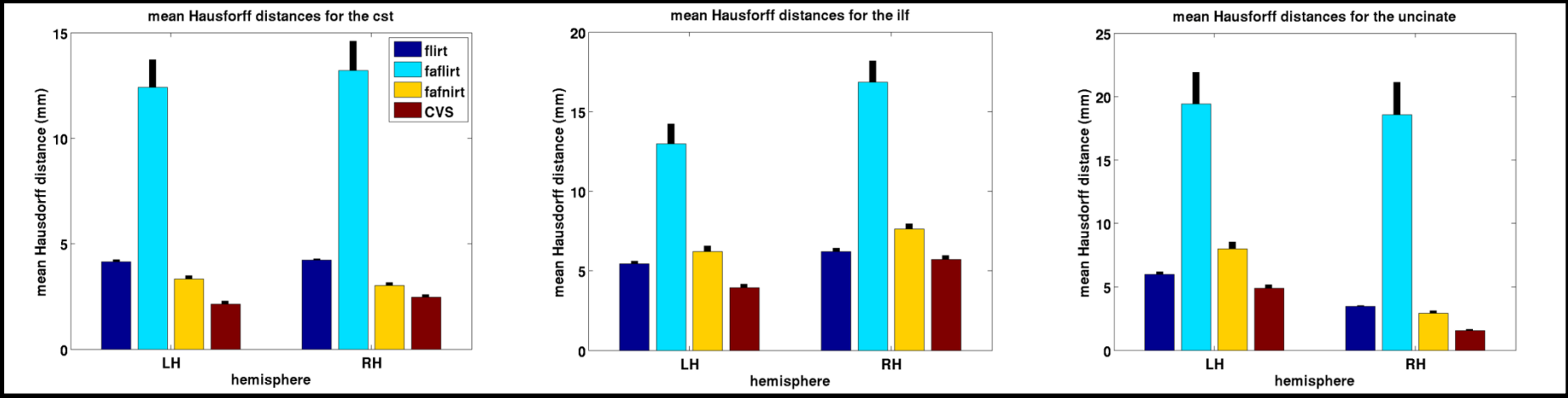
- Zöllei, Stevens, Huber, Kakunoori, Fischl: "*Improved Tractography Alignment Using Combined Volumetric and Surface Registration*", NeuroImage 51 (2010), 206-213

Average tracts after registration mapped to the template displayed with iso-surfaces



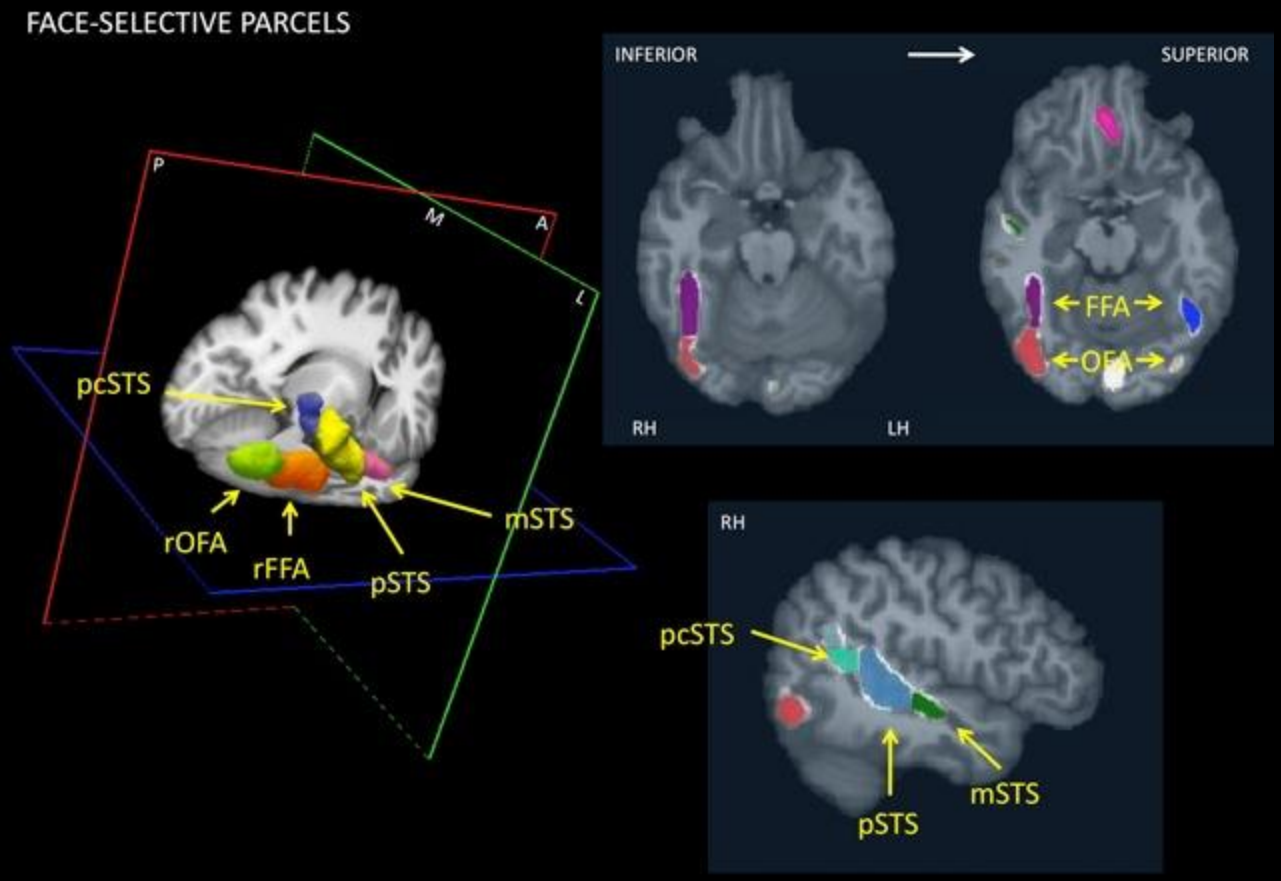
FLIRT FA-FNIRT CVS

Mean Hausdorff distance measures for three fiber bundles



CST ILF UNCINATE

Functional MRI analysis in CVS space



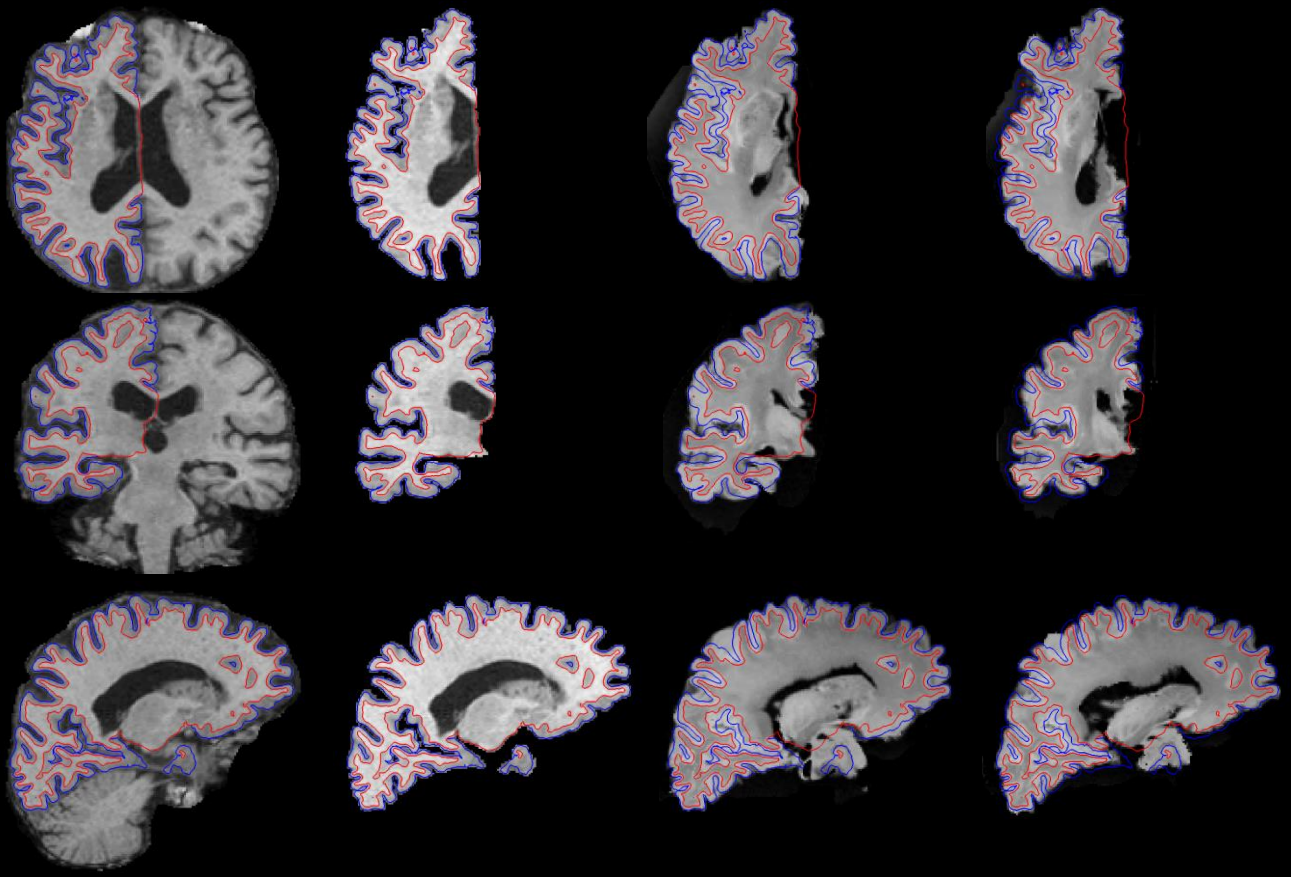
Collaboration with Kami Koldewyn, Joshua Julien and Nancy Kanwisher at MIT

Ongoing development

- Improve CVS capability to register ex-vivo to in-vivo acquisitions
- Implemented MI-based volumetric registration (for CVS step 3) to accommodate intensity profile differences
- Qualitative preliminary results on 4 subjects

- L. Zöllei, Allison Stevens, Bruce Fischl: *Non-linear Registration of Intra-subject Ex-vivo and In-vivo Brain Acquisitions,* Human Brain Mapping, June 2010
- L. Zöllei, B. Fischl, *Automatic segmentation of ex-vivo MRI images using CVS in FreeSurfer, HBM 2011*

Subject 1



Target (in-vivo) Masked target 2-step CVS CVS with MI