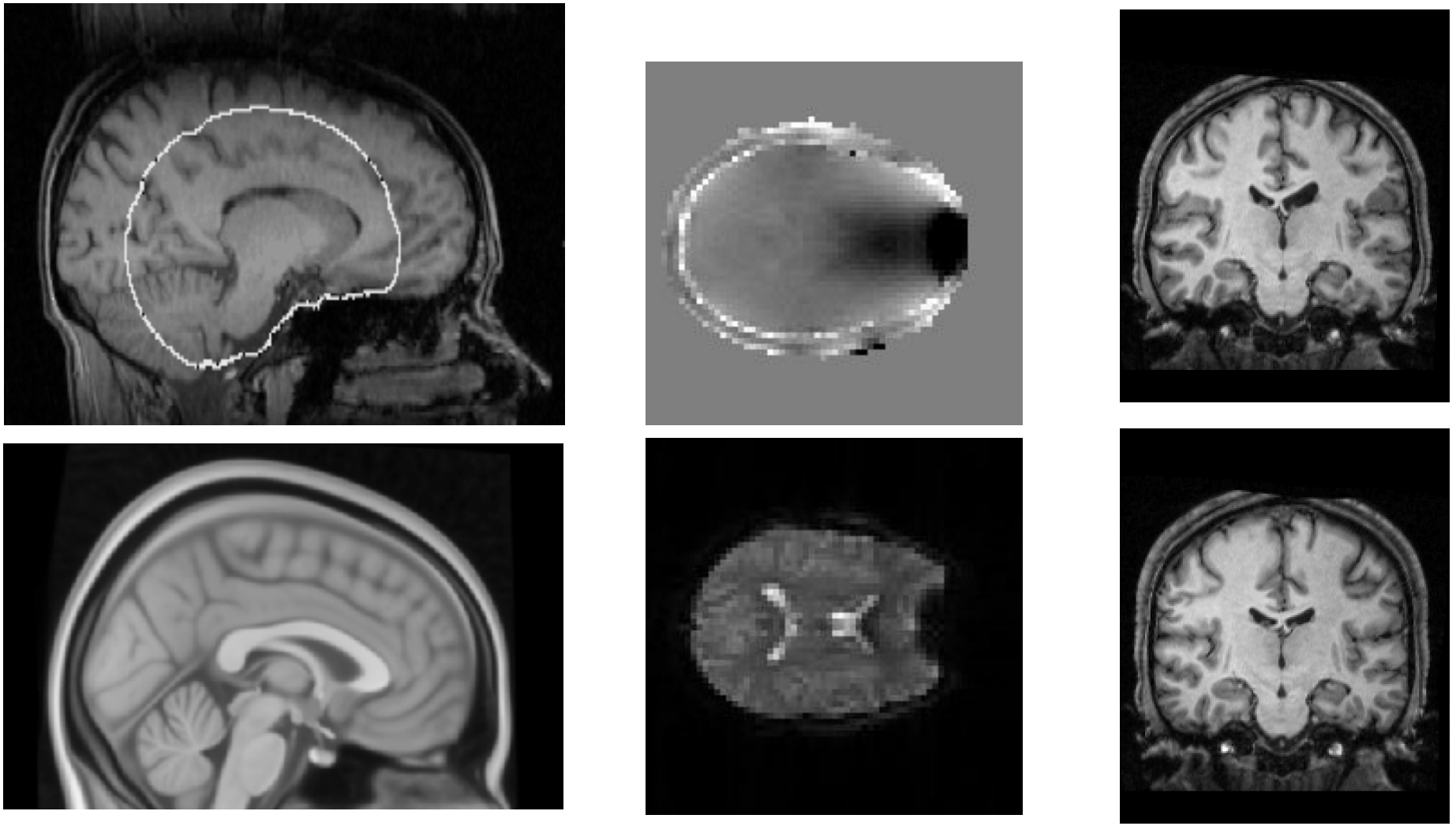
Registration: Single-Stage and Multi-Stage Applications

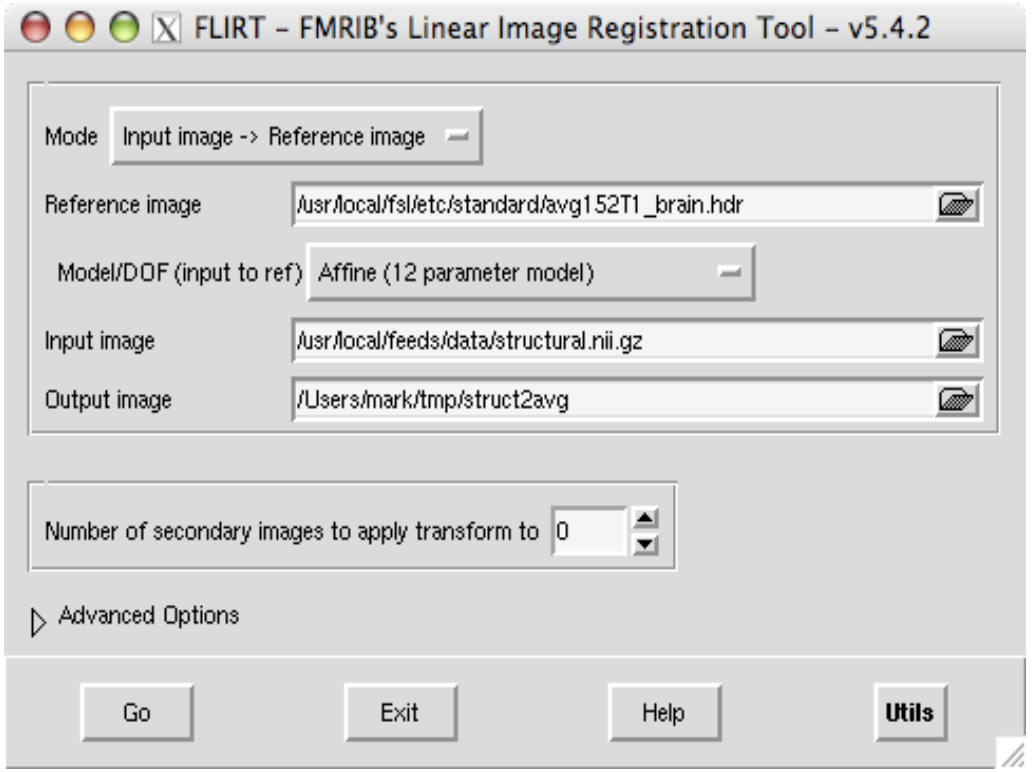


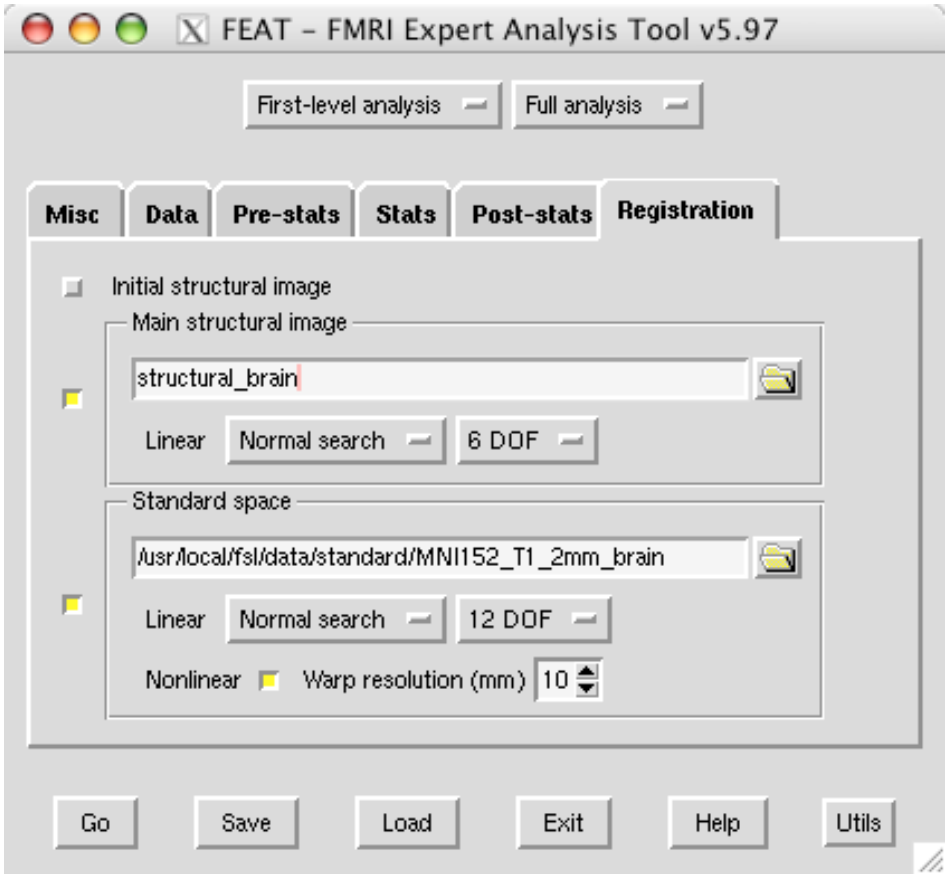
Registration with FSL

Two main tools:

FNIRT & *FLIRT*

(FMRIB's Non-Linear/Linear Image Registration Tool)





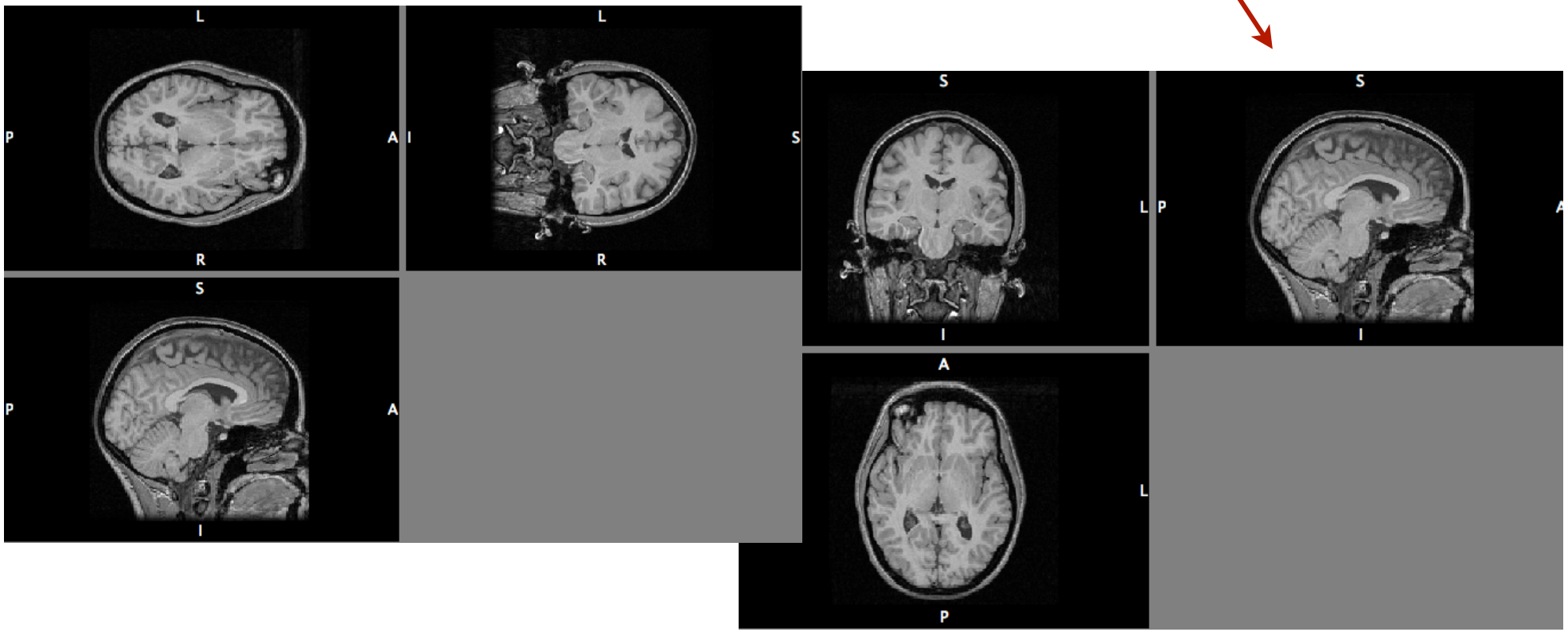
Both tools used by FMRI and Diffusion tools

(FEAT, MELODIC & FDT)

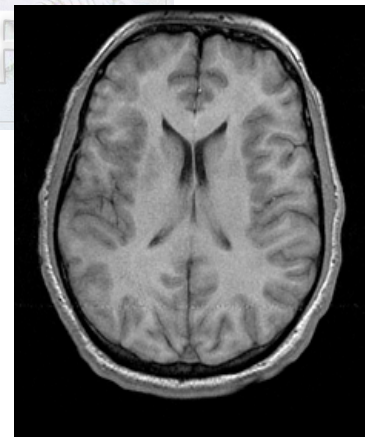
Preliminary Steps

Recommended steps:

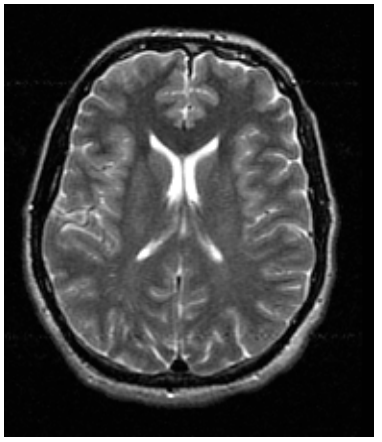
- Reorientation (fslreorient2std)
- Brain Extraction (BET)
- Bias-field correction (FAST - see later)



Note that labels are correct in both cases



Single-Stage Registration



Scenario:

Have two (or more) different types of images from the *same subject*

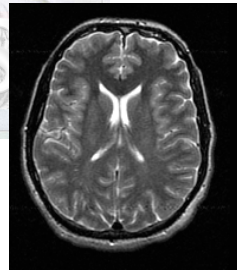
For example, T_1-weighted and T_2-weighted images

Objective:

Have images aligned so that, for example, they can be used for multi-modal segmentation

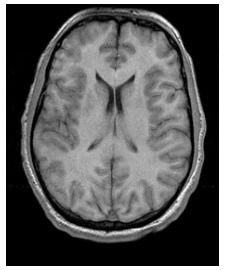
Solution:

FLIRT with 6 DOF (rigid-body)



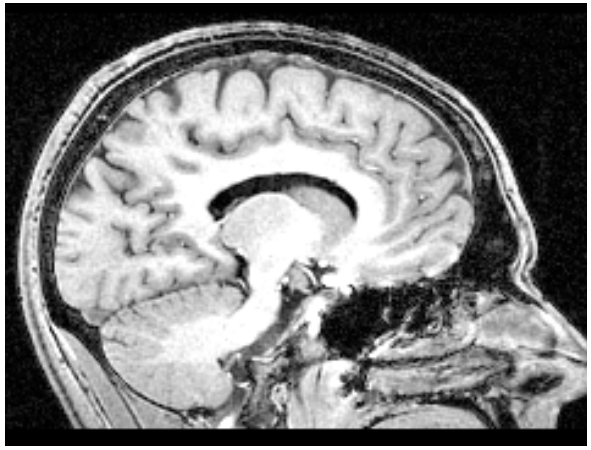
Input

Single-Stage Registration

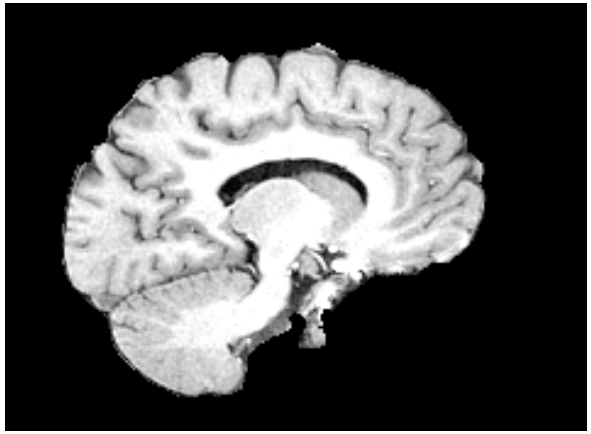


Reference

- Single subject ⇒ 6 DOF = FLIRT
- T_2-wt to T_1-wt ⇒
  multi-modal cost function
  (e.g. default of correlation ratio)
- Run *brain extraction* on *both images*
- Choose image with better resolution
  or contrast as the reference
- Always check your output

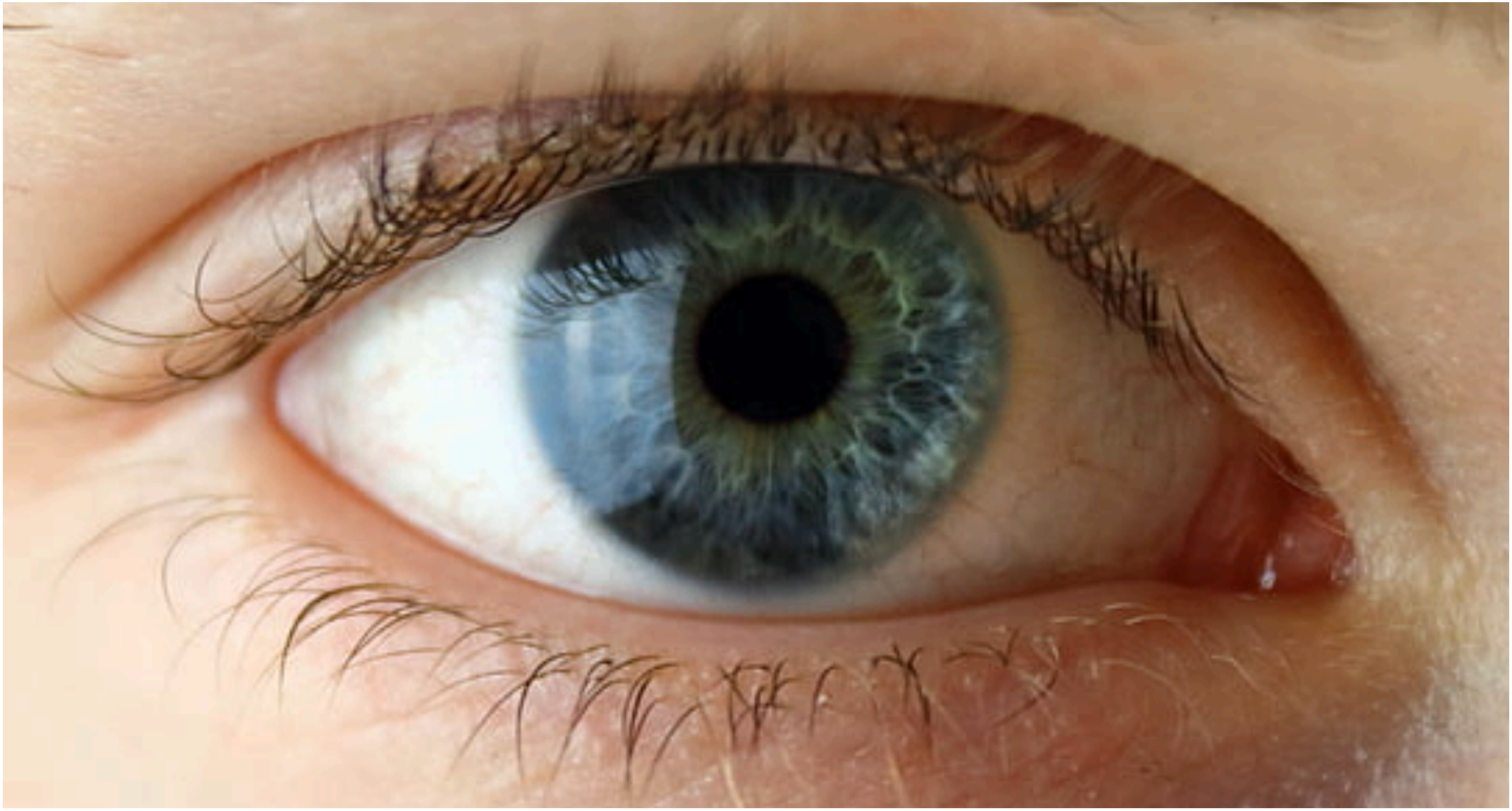


BET



Artefaction Detection Device

LOOK AT YOUR DATA!



www.pickpik.com

Visual Check

Always assess registration quality visually!

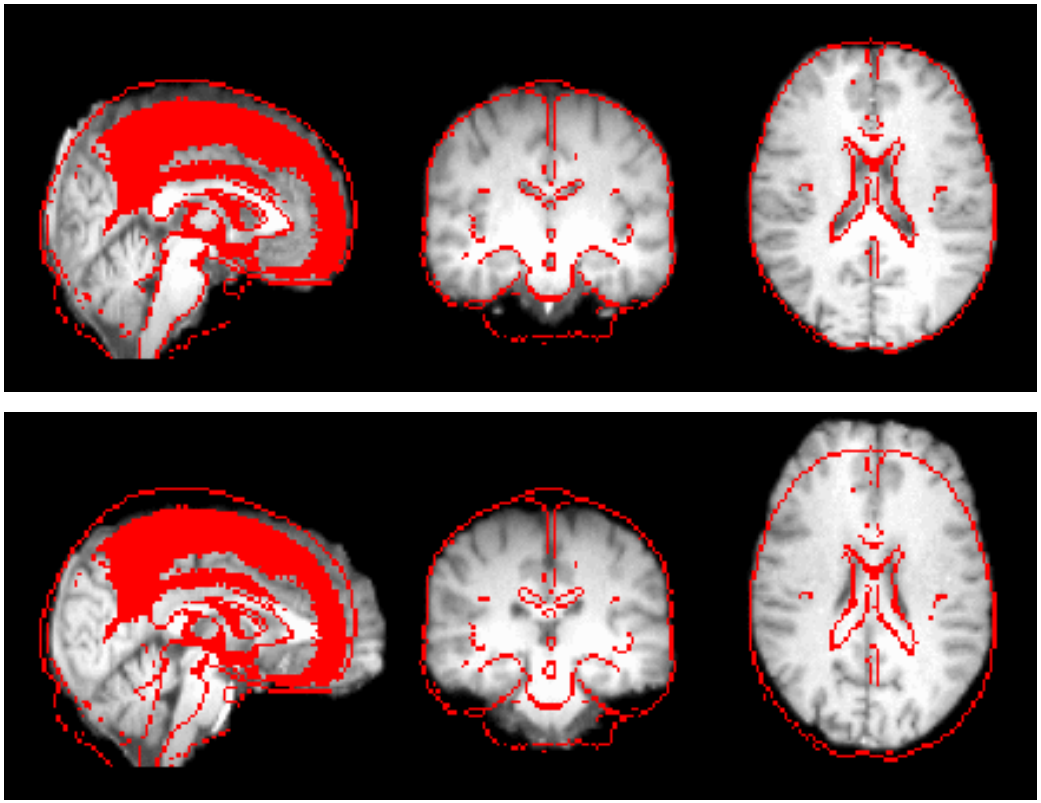
Can use:

- *FSLeyes* (using overlay or flicking between images)
- *slices* for a static view use (as in FEAT)

slices T2_to_T1im T1im

Grayscale from first image

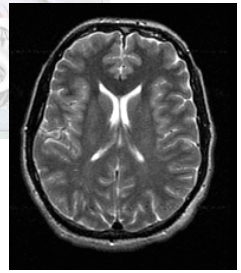
Red edges from second image



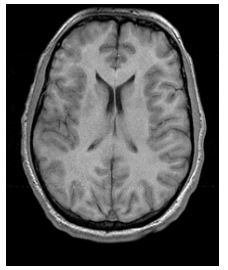
✔

✘

Registration in FSL



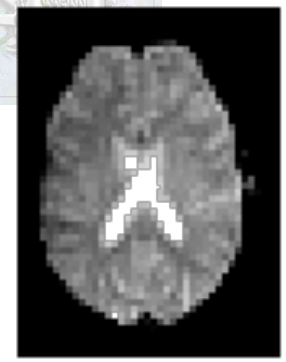
Input

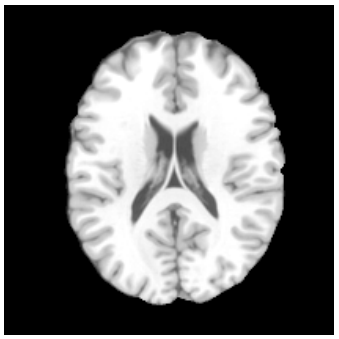


Reference

- In FSL the ***reference image*** controls the *FOV and resolution of the output image*
- Transformations are given:

  from input space ***to*** reference space
- Inverse transformations can easily be calculated to go from reference space to input space when needed
- Can overlay images in FSLeyes with different FOV or resolution: i.e. images can be in different spaces and resolutions
- Images can be ***resampled*** into a different space by applying a previously derived transformation





Multi-Stage Registration

Scenario:

Doing a functional (or diffusion) study

Have EPI and T_1-weighted of each subject

Objective:

Need to register images to a common (standard) space to allow the group study to be performed

Solution:

2-stage registration with FLIRT & FNIRT (in FEAT)

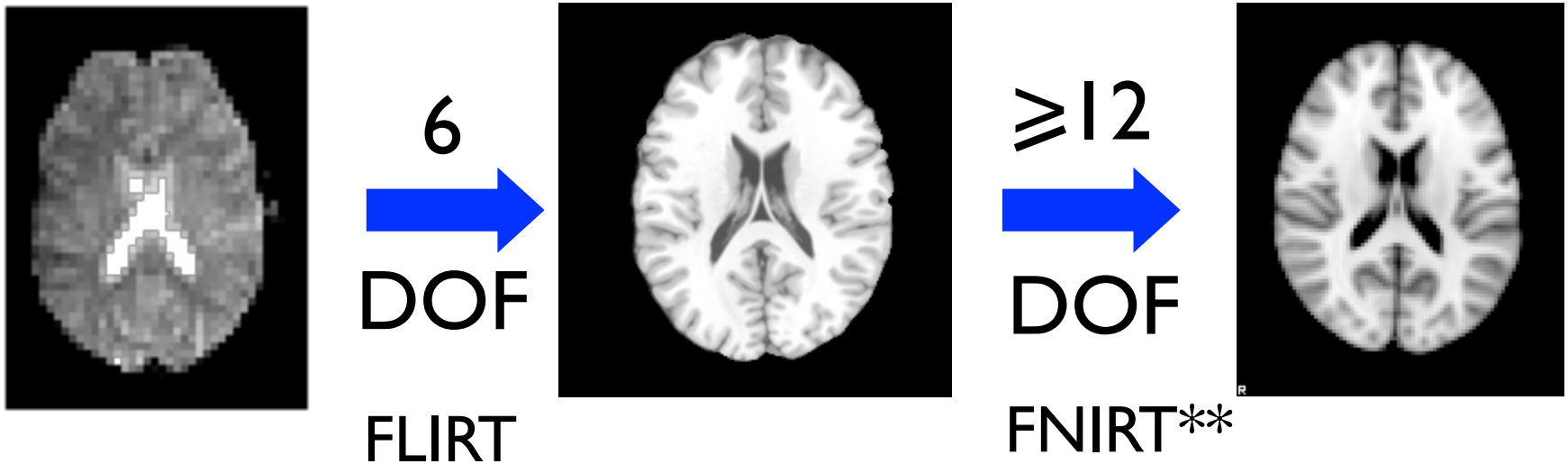
Two Stage Registration

Registering very different images is difficult due to:

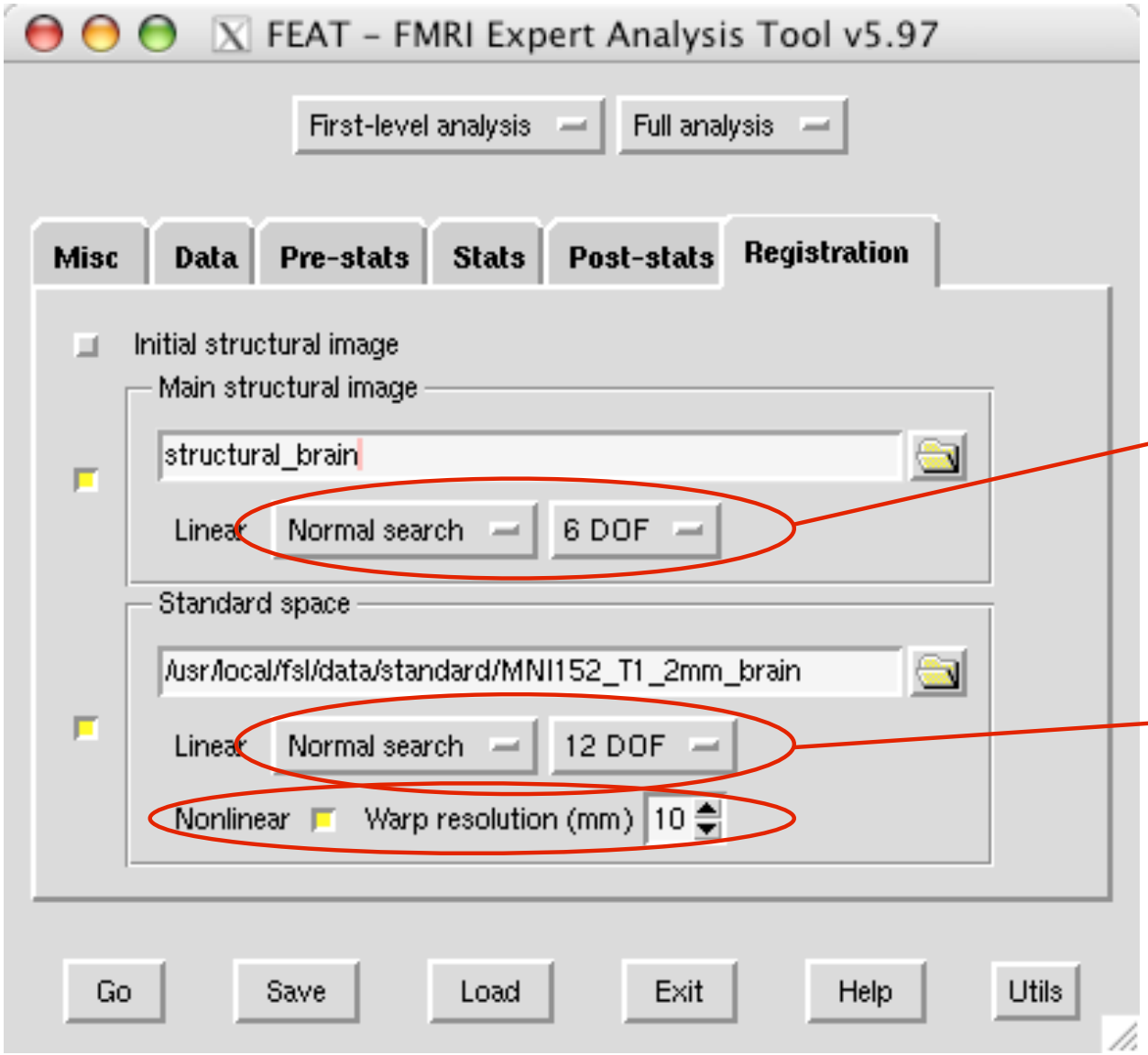
- Differences in individual anatomies
- Different contrasts in various modalities
- Distortions which differ between images

To register an EPI to a standard space template (e.g. MNI152) use a structural intermediate image

Automatically done by FEAT GUI (some user control)
Need to manually run brain extraction (not on EPI usually*)

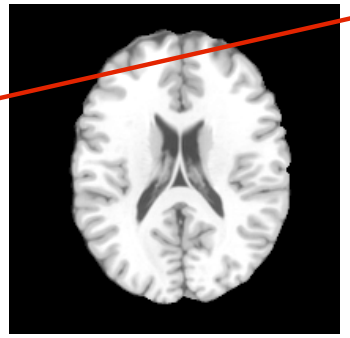


Registration for FMRI Analysis (FEAT)



FMRI
(implicit)

FLIRT

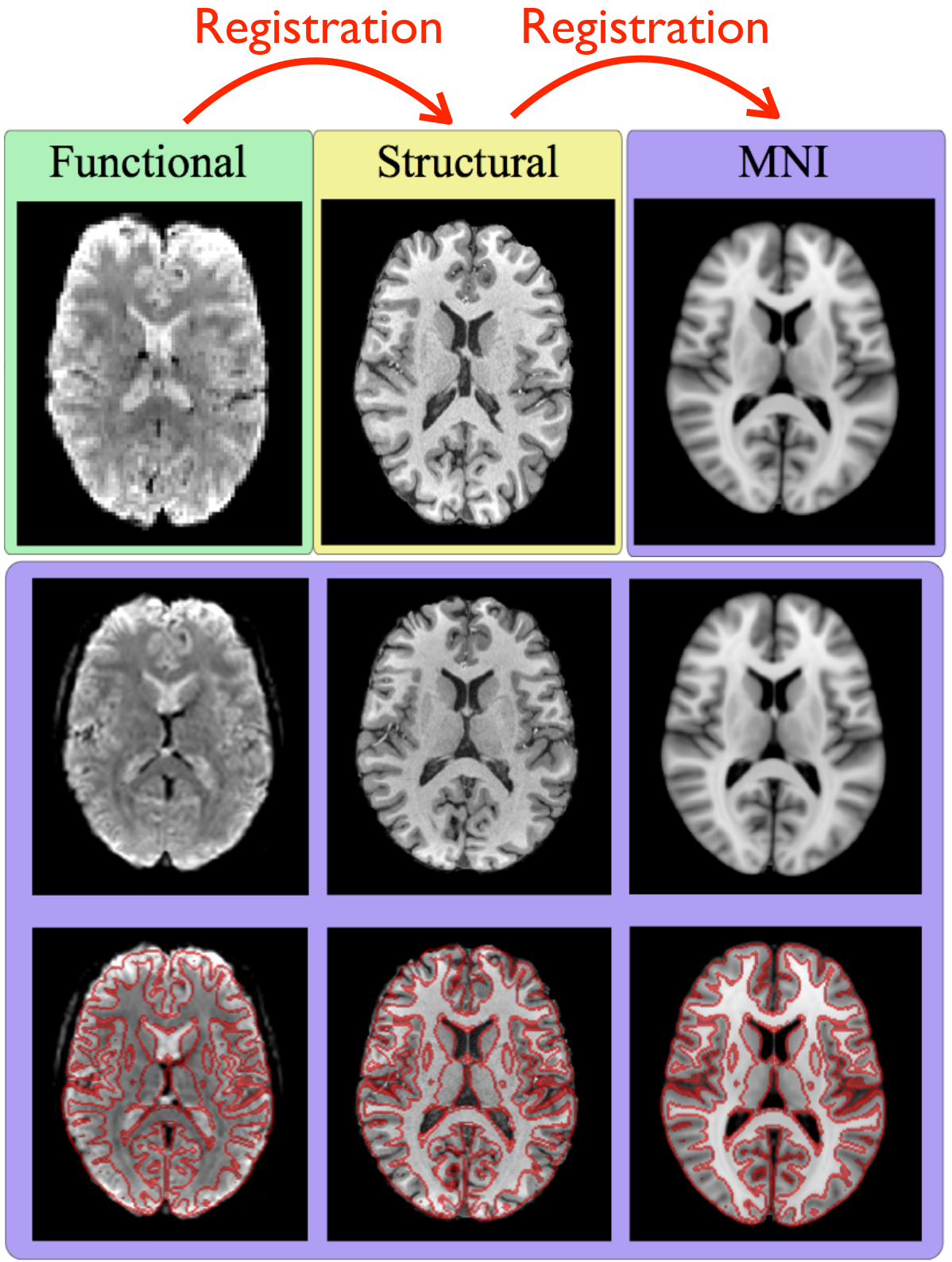


Main
Structural

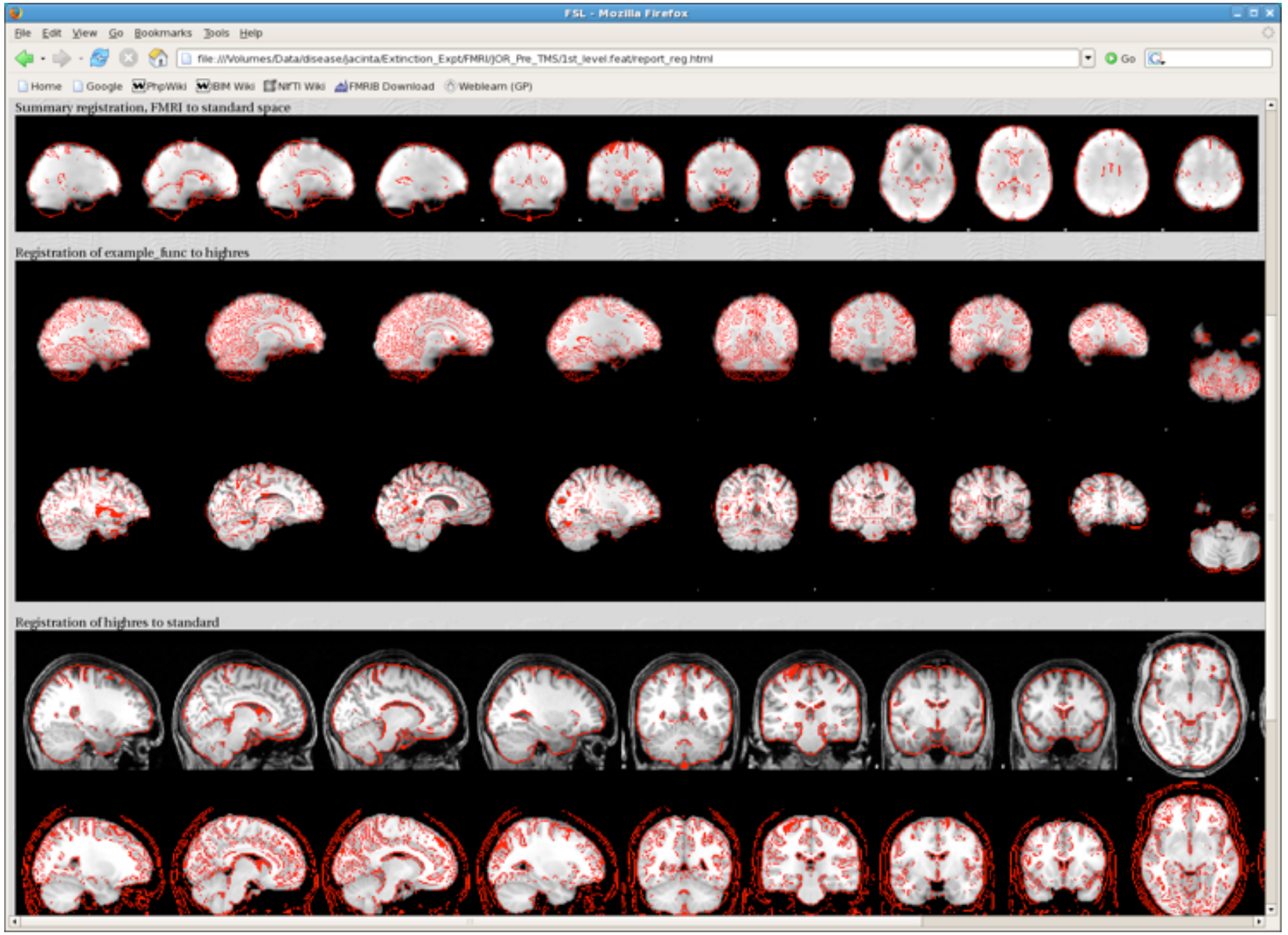
FLIRT
+
FNIRT

Standard

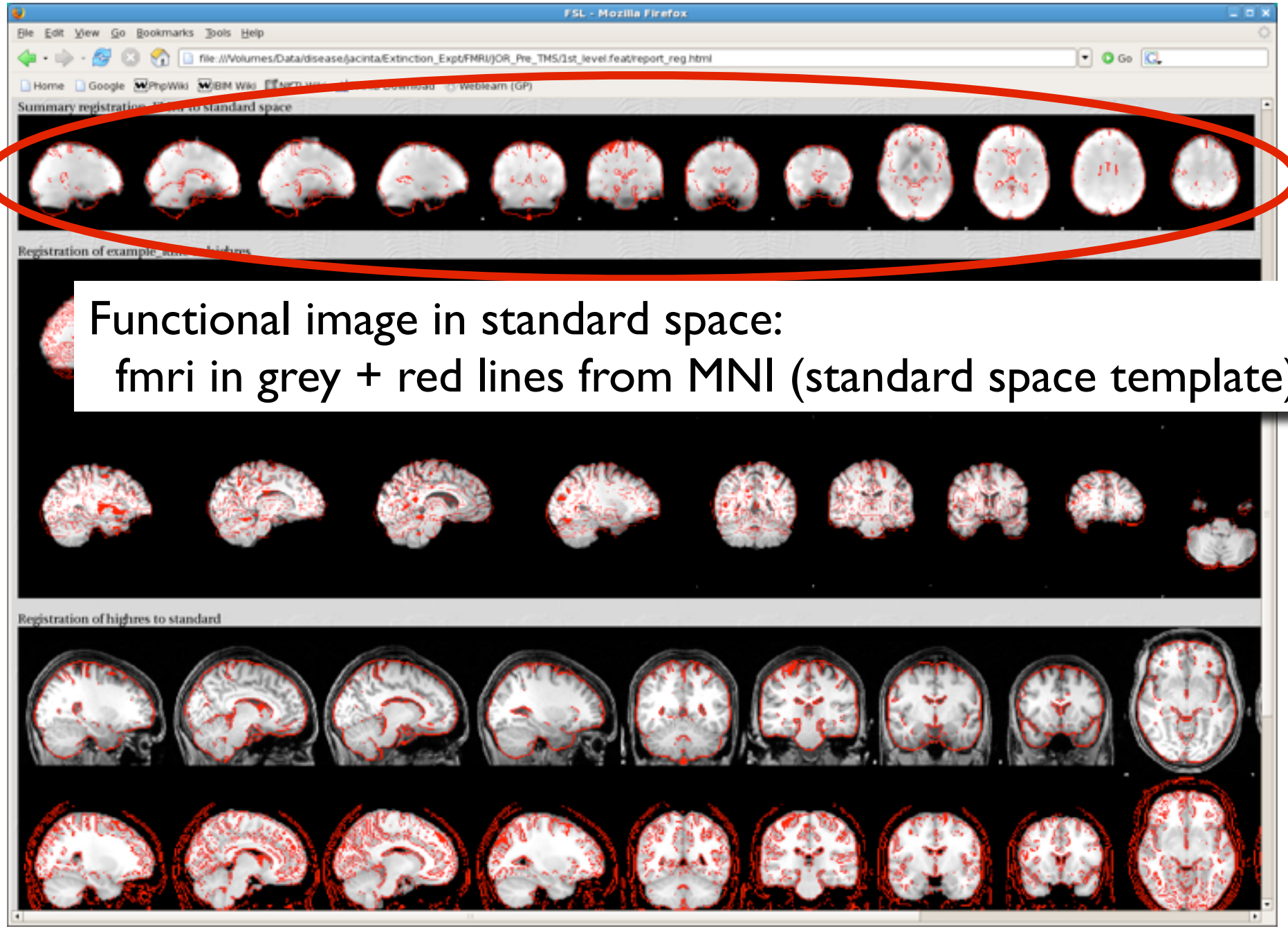
NB: actually need brain extracted ***and*** original images for FNIRT


Registration
Registration
Functional
Structural
MNI
MNI Space

Registration for FMRI Analysis

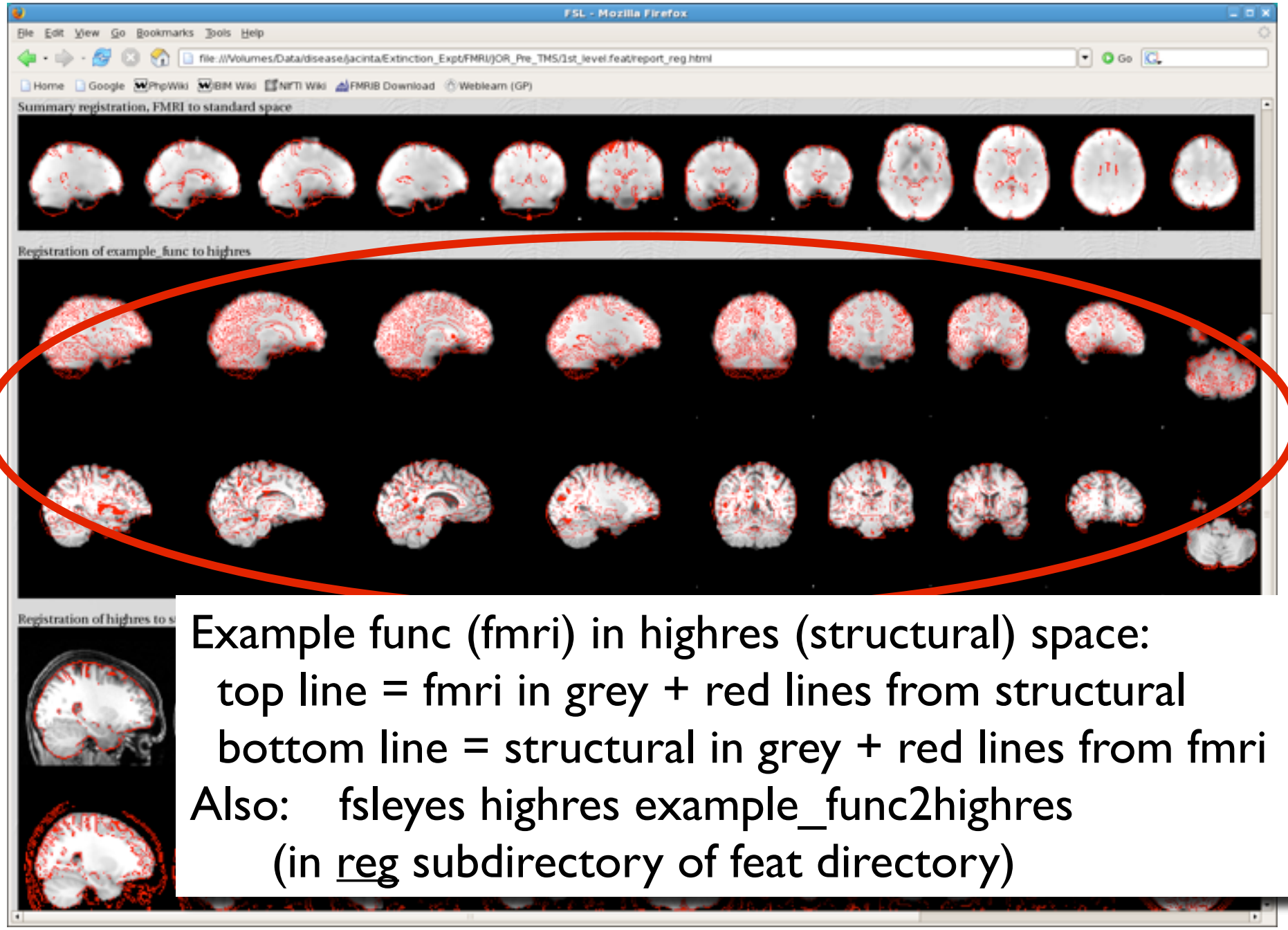


Registration for FMRI Analysis



Functional image in standard space:
fmri in grey + red lines from MNI (standard space template)

Registration for FMRI Analysis



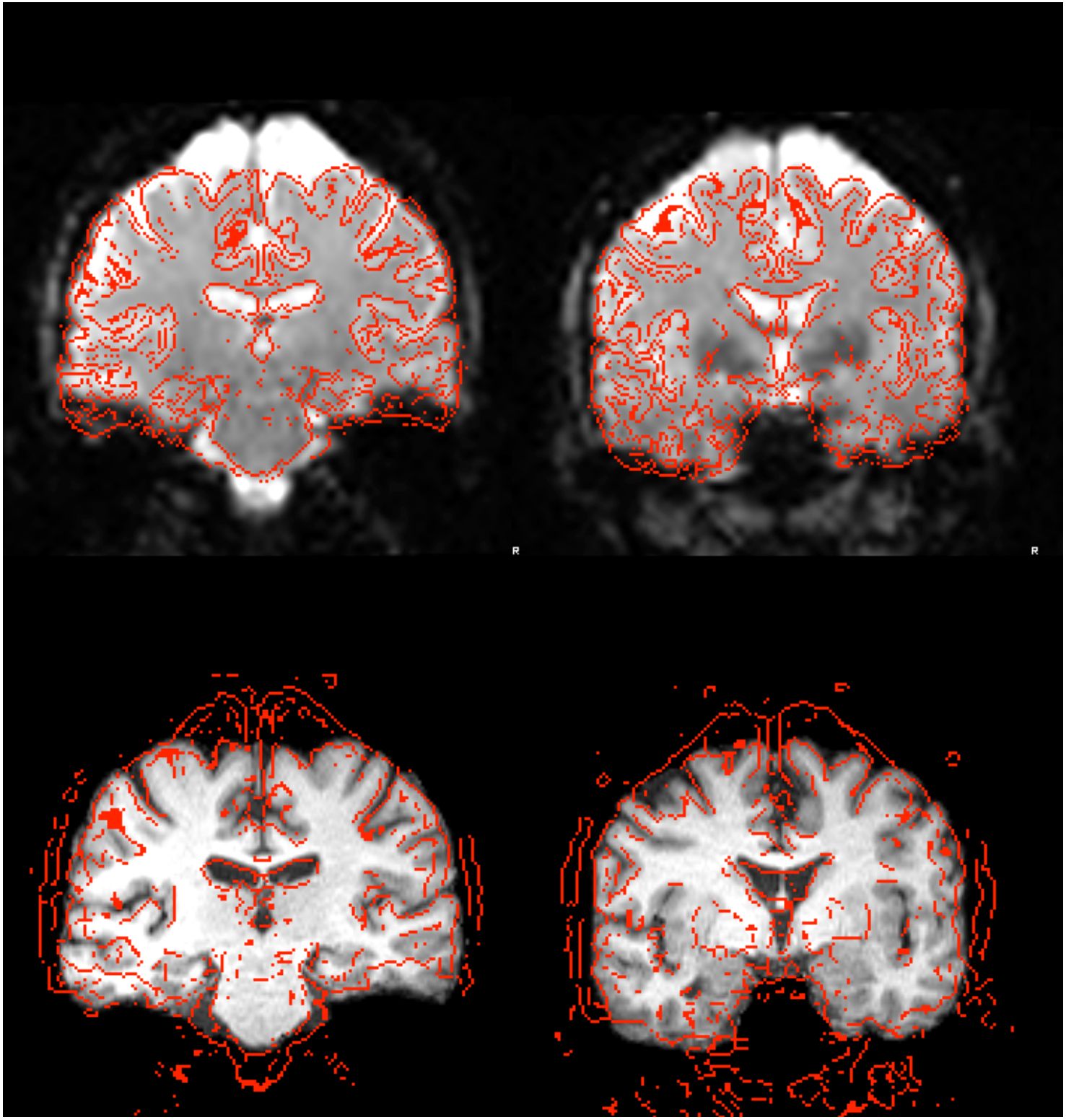
Example func (fmri) in highres (structural) space:

top line = fmri in grey + red lines from structural

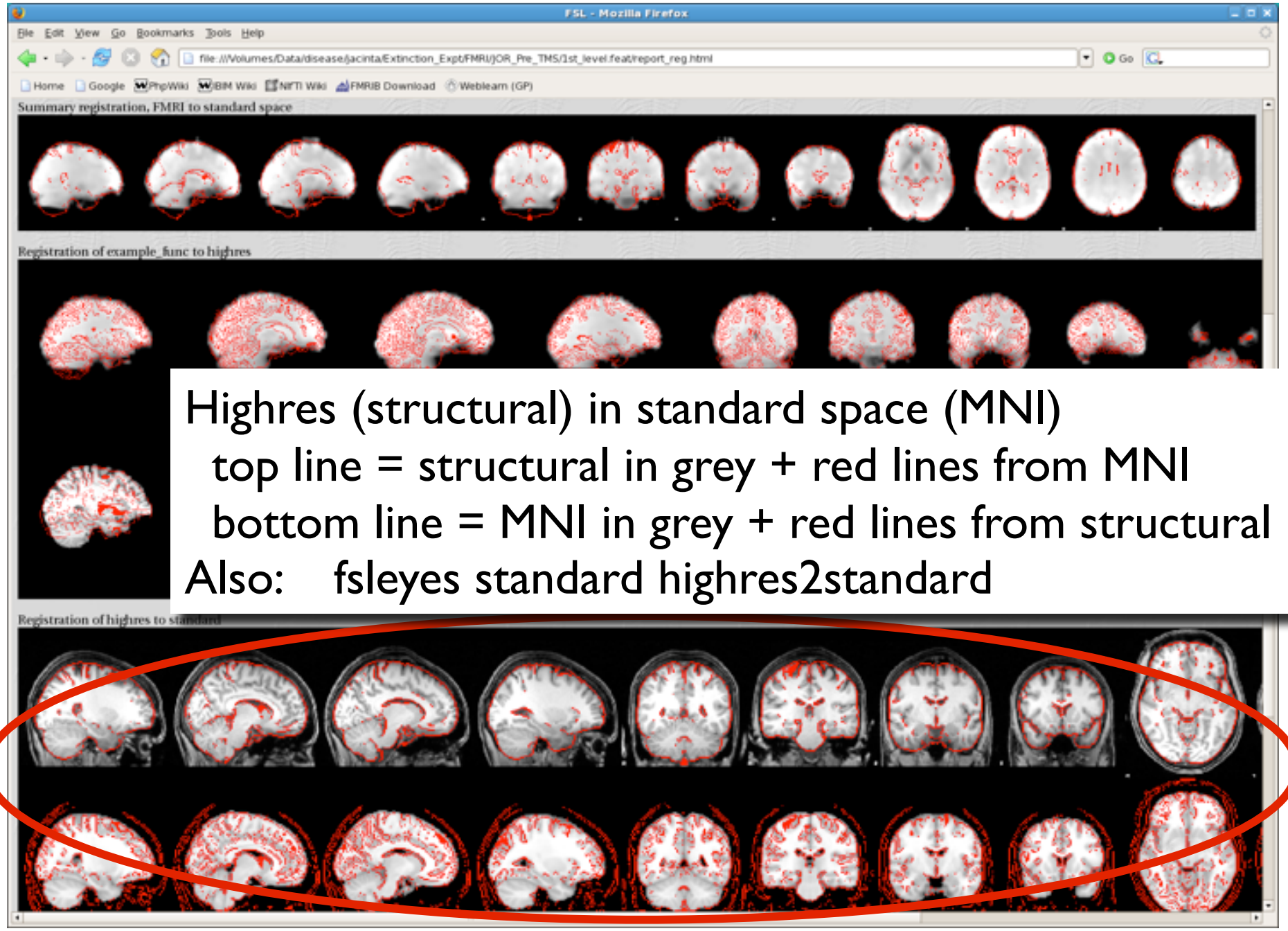
bottom line = structural in grey + red lines from fmri

Also: fsleyes highres example_func2highres

(in reg subdirectory of feat directory)


R
R

Registration for FMRI Analysis

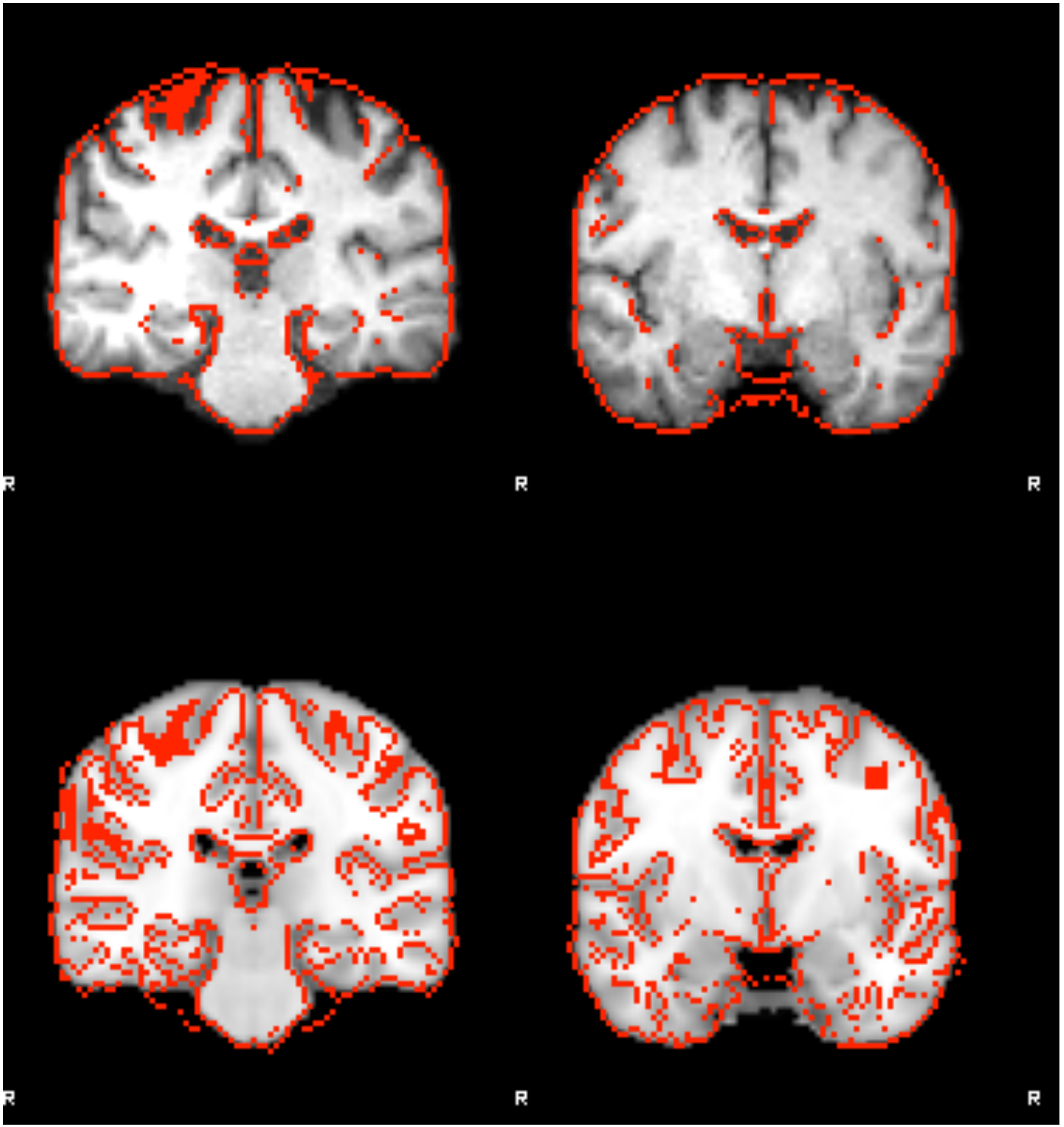


Highres (structural) in standard space (MNI)

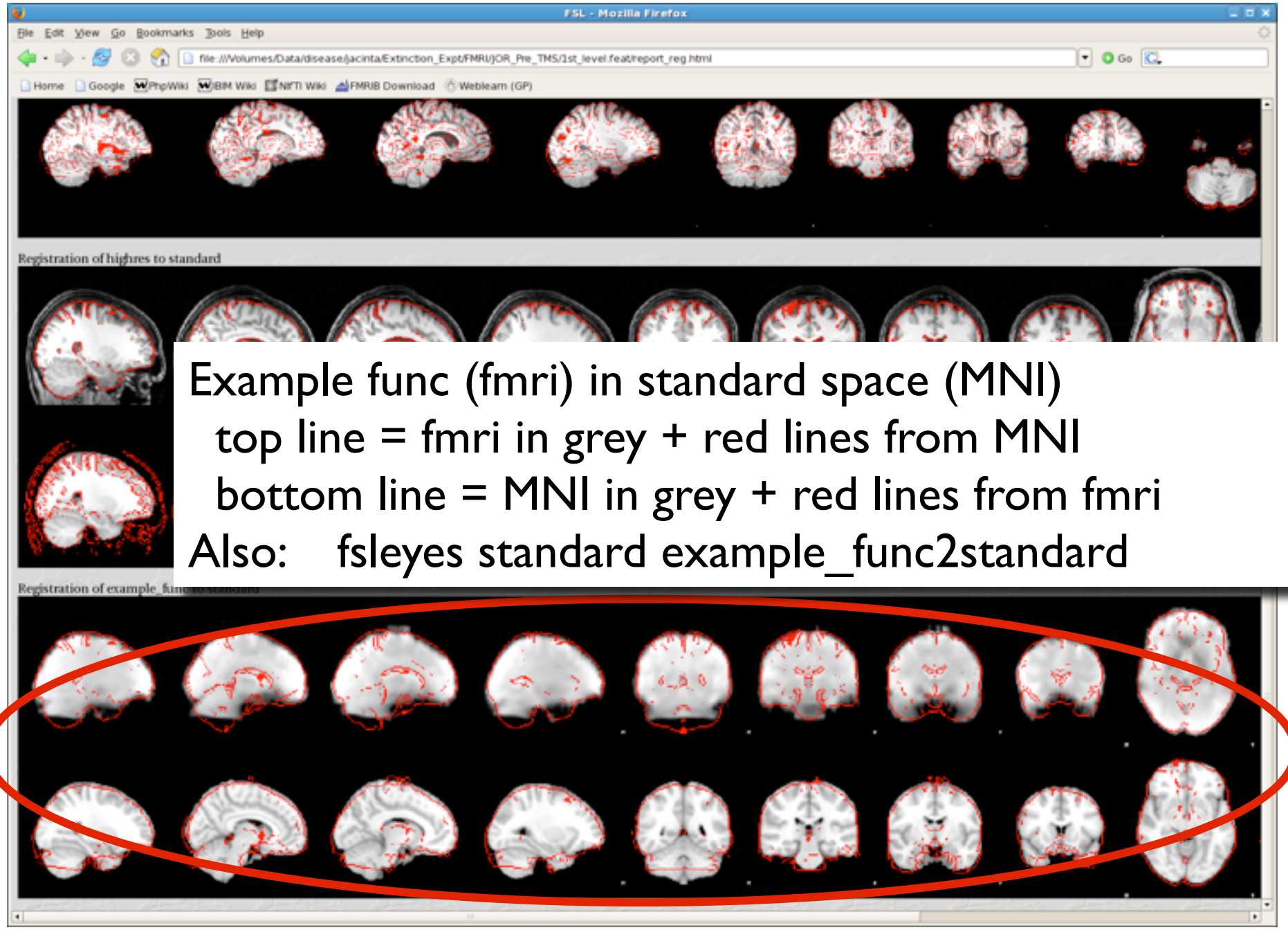
top line = structural in grey + red lines from MNI

bottom line = MNI in grey + red lines from structural

Also: fsleyes standard highres2standard


R
R
R
R
R
R

Registration for FMRI Analysis



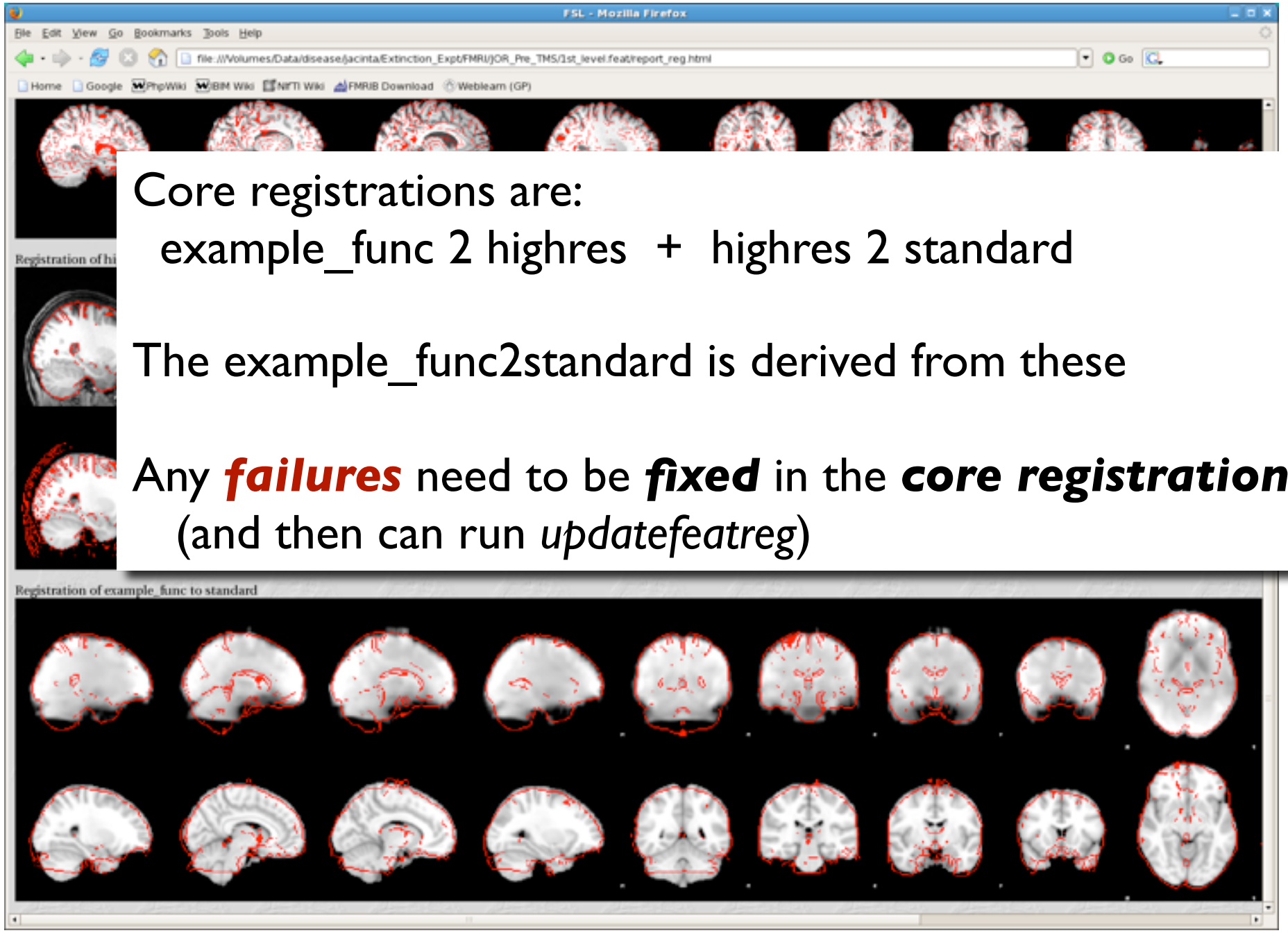
Example func (fmri) in standard space (MNI)

top line = fmri in grey + red lines from MNI

bottom line = MNI in grey + red lines from fmri

Also: fsleyes standard example_func2standard

Registration for FMRI Analysis



Core registrations are:

example_func 2 highres + highres 2 standard

The example_func2standard is derived from these

Any ***failures*** need to be ***fixed*** in the ***core registrations***

(and then can run *updatefeatreg*)

Registration: Single-Stage and Multi-Stage Applications

Summary:

- Preliminary processing using reorientation, brain extraction and artefact correction (e.g. bias field)
- Single-stage for structural images: choose spatial transformation, cost function
- Important to **visually check** results!
- Multi-stage for multiple modalities/spaces
- Each stage benefits from fewer differences
- Evaluate results for each stage (and combined)