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
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)
Single-Stage Registration

- Single subject $\Rightarrow$ 6 DOF = FLIRT
- $T_2$-wt to $T_1$-wt $\Rightarrow$
  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
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)

\[ \text{slices } T2_{\text{to T1im}} \text{ T1im} \]

Grayscale from first image

Red edges from second image
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*)

6

DOF

6

DOF

DOF

≥12

≥12

FLIRT

FNIRT**
Registration for FMRI Analysis (FEAT)

NB: actually need brain extracted and original images for FNIRT
Registration for FMRI Analysis

Summary registration, FMRI to standard space

Registration of example func to highres

Registration of highres to standard
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)
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
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)