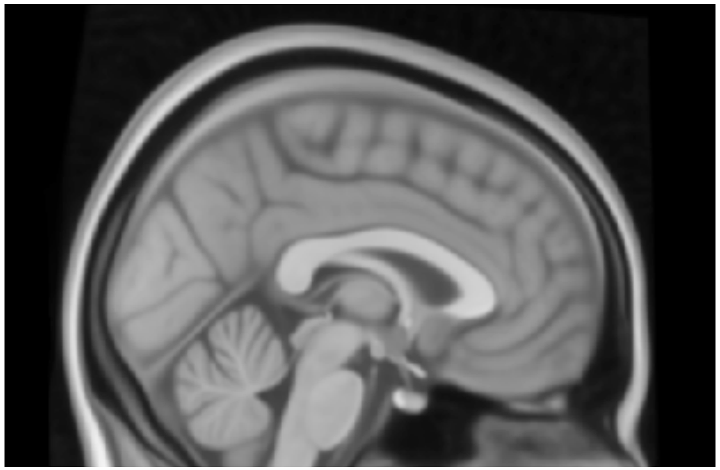
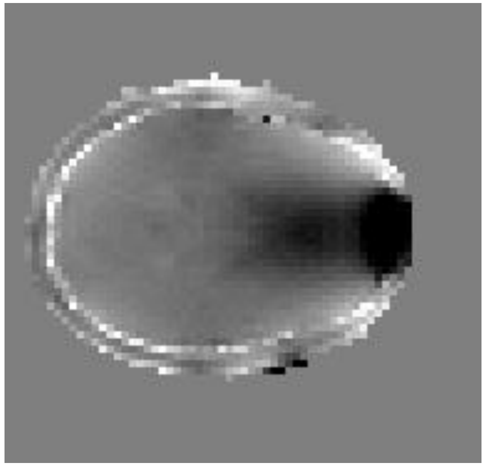
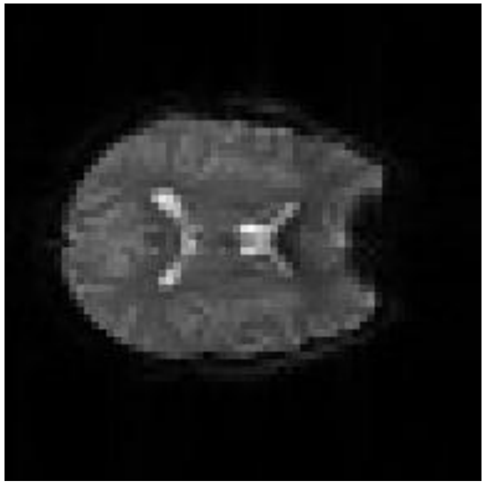
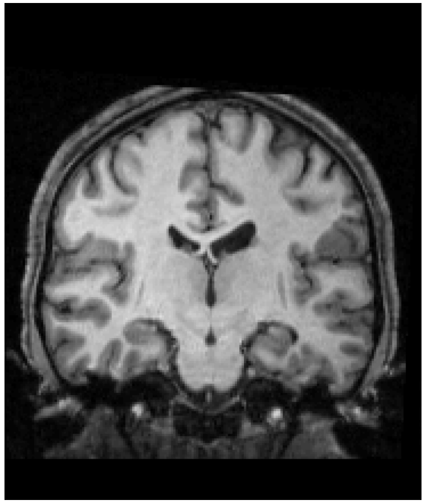
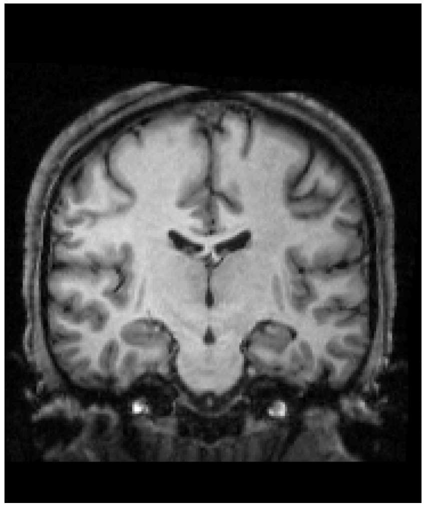
Registration: Cost Function Weighting and Small FOV



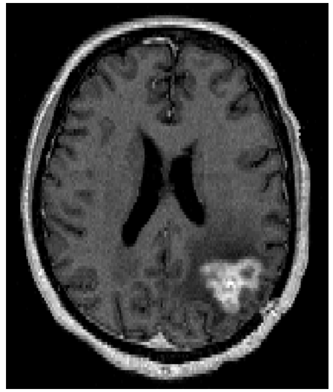








Pathological Image Registration



Scenario:

Have images containing a known pathology (or artefact) which looks different in different images

For example, some sequences (e.g. FLAIR) highlight lesions that are hard to see in other sequences

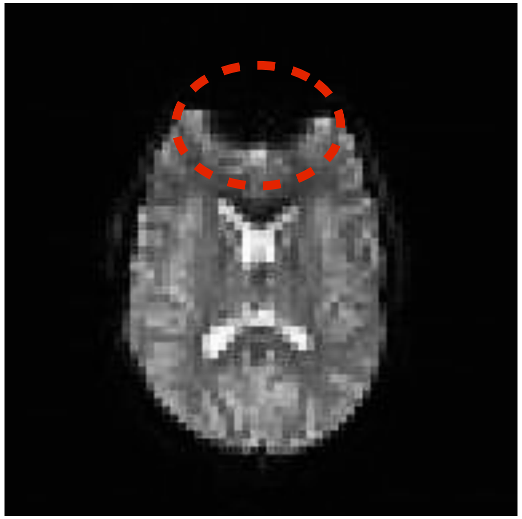
Objective:

Align the images based on the healthy tissue, but "ignoring" the area of the pathology (or artefact)

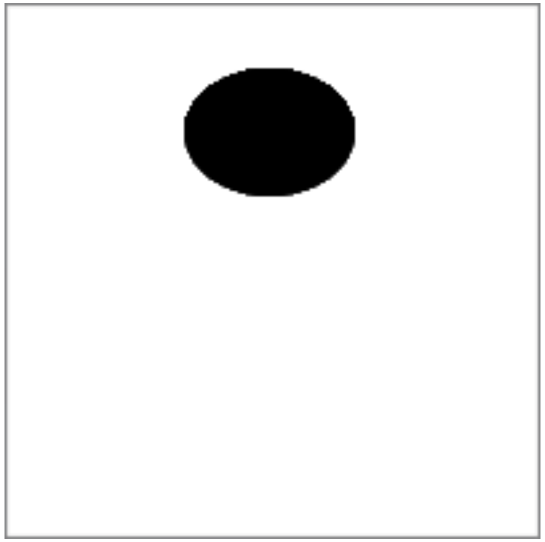
Solution:

Cost-Function Weighting (FLIRT or FNIRT)

Cost Function Weighting



weighting image

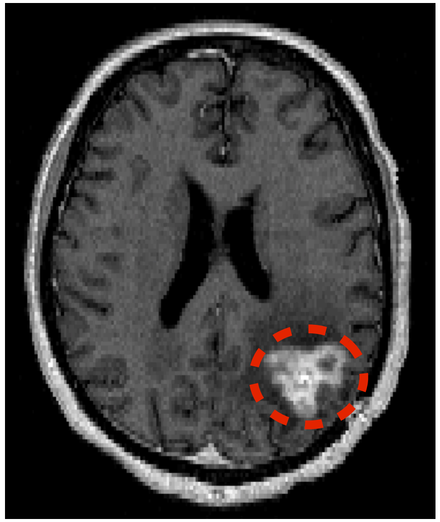


black=0; white=1

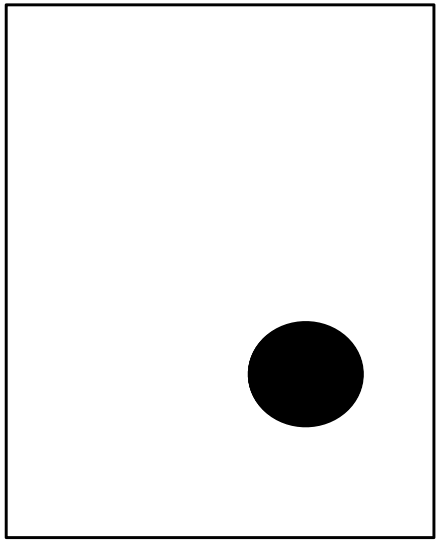
Artefacts and pathologies introduce *non-matching* image regions

Cost (similarity) functions assume that all of the images can be matched

Use a *weighting image* to down-weight non-matching regions



weighting image



Cost Function Weighting

- *All* FLIRT & FNIRT cost functions can be weighted
- Weighting for reference image, input image or both
- Voxel weights are *relative*, reflecting its importance in overall matching

  - Zero, or small, values for corrupted areas

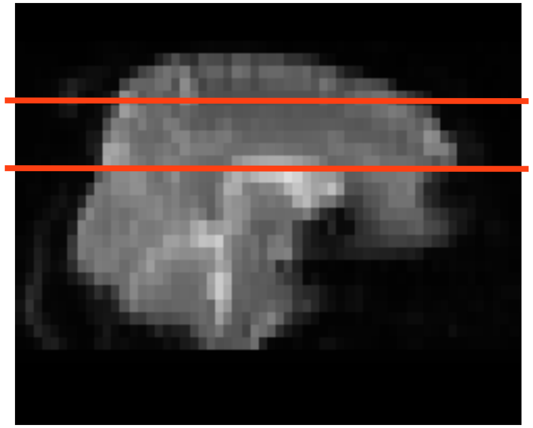
    e.g. gross pathology or artefact

  - Large values for important areas/regions

    e.g. ventricular matching

- Do *not* assign zero to the background as then the brain/background contrast is lost

Small FOV Registration



Scenario:

Functional study using a small FOV (e.g. a few slices)

Often done to obtain better resolution scans over ROI

Objective:

Get activation results registered well to the full brain (and standard space)

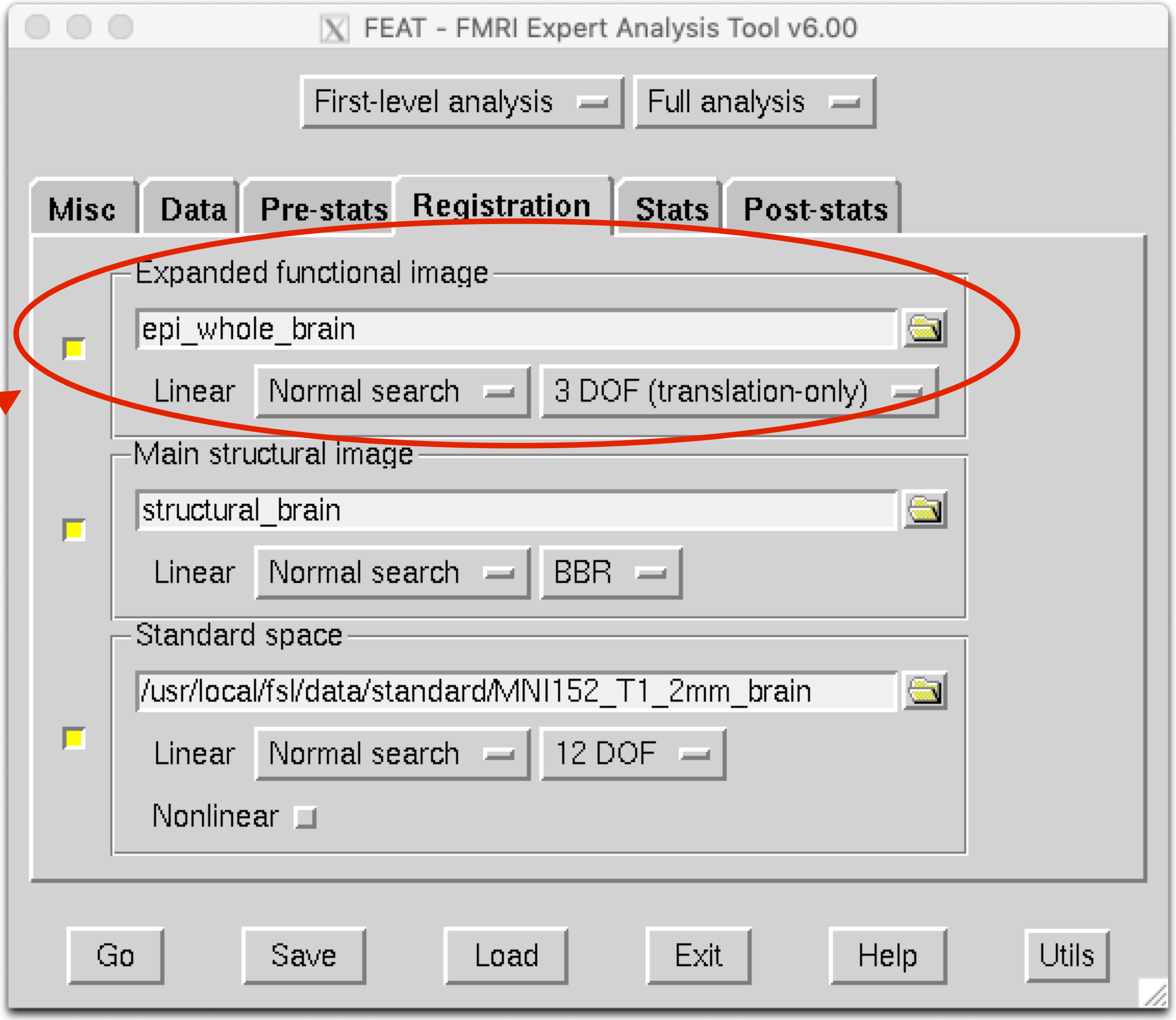
Solution:

Scan one whole-brain EPI and use a 3-stage registration

Registration within FEAT (small FOV)

If your FMRI scans only cover part of the brain...

Acquire *one* ***whole-brain EPI*** volume: it only takes a few seconds to scan but makes registration work *much* better



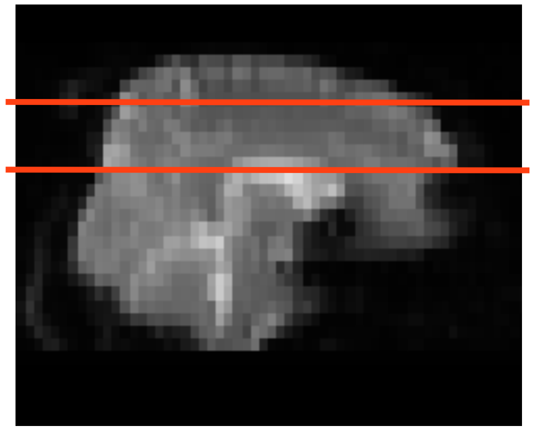
Then use the 3-stage approach

Partial Brain EPI & Unwarping

In partial FOV studies, registration is *massively* improved by multi-stage registration:

1. Partial Brain to Full Brain EPI
   - Desirable for full brain to contain exactly the same slices so that registration is simple (can be done without unwarping)
   - If slices are different or movement is significant, then unwarping should be applied (outside of FEAT)
2. Full Brain EPI to Structural
   - apply unwarping (full brain field map)
3. Structural to Standard

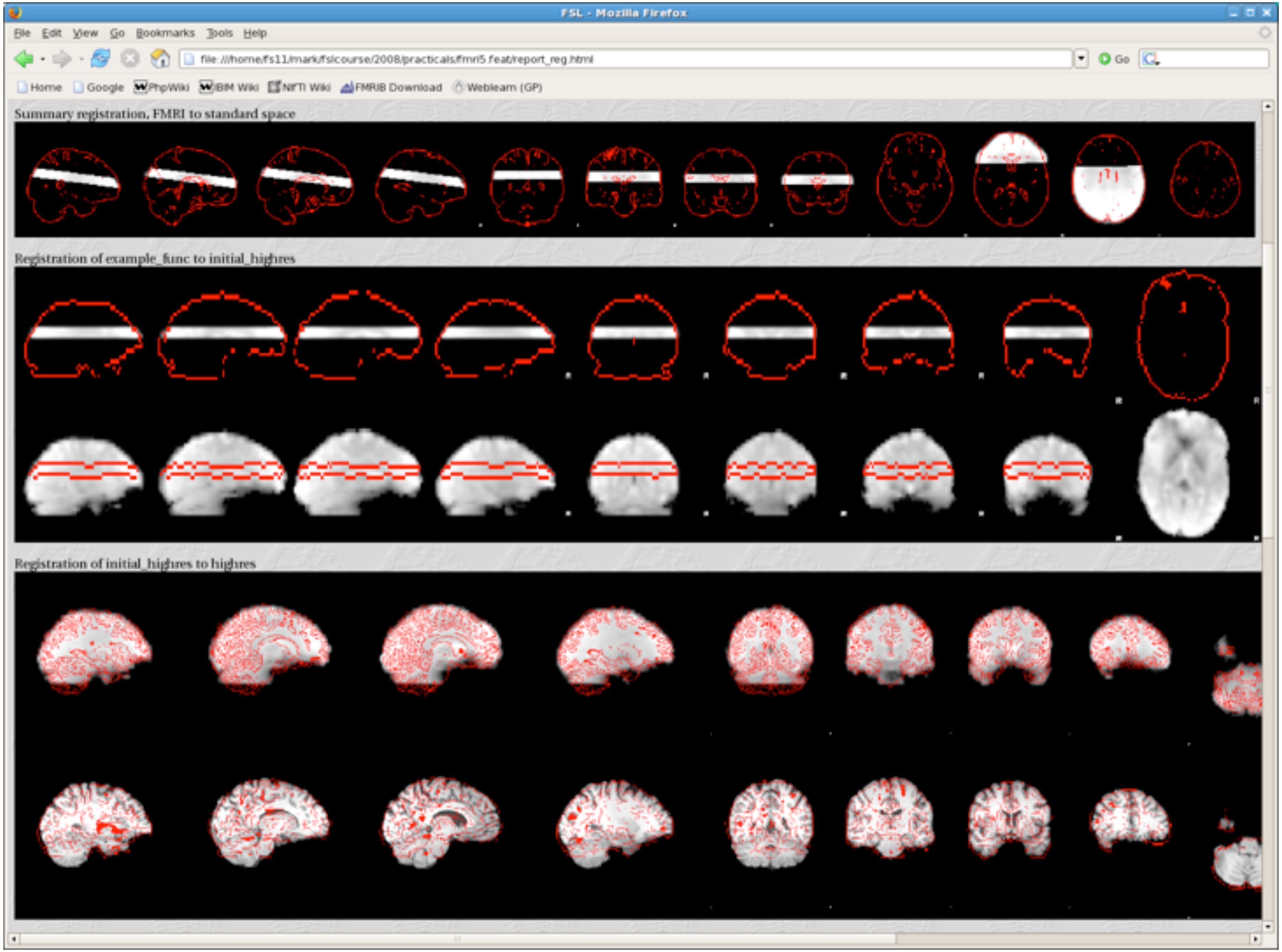
Partial Brain
FMRI timeseries



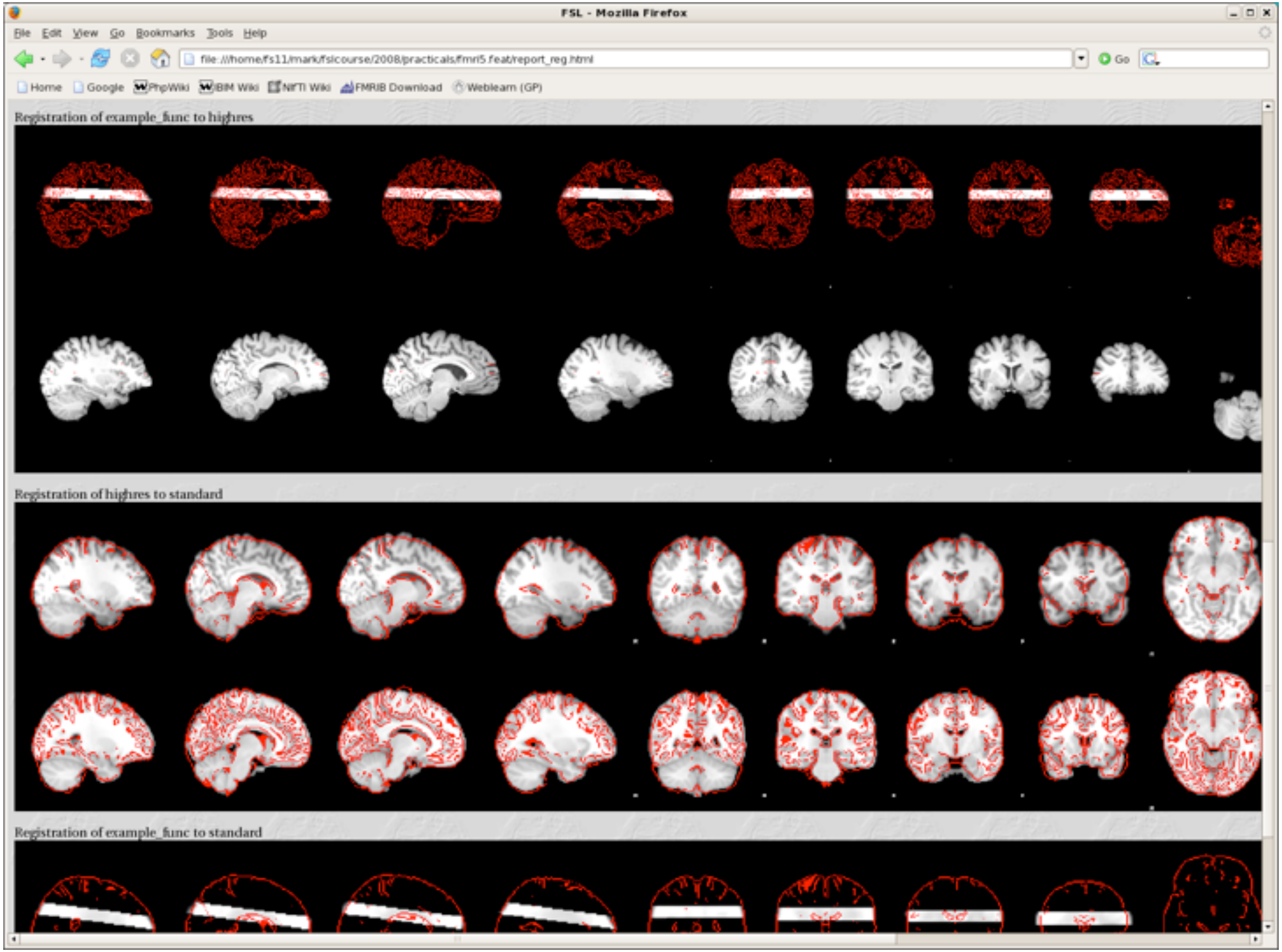
Full Brain
Single Image
(an extra acquisition - but only takes seconds!)

Can be run entirely within the FEAT GUI

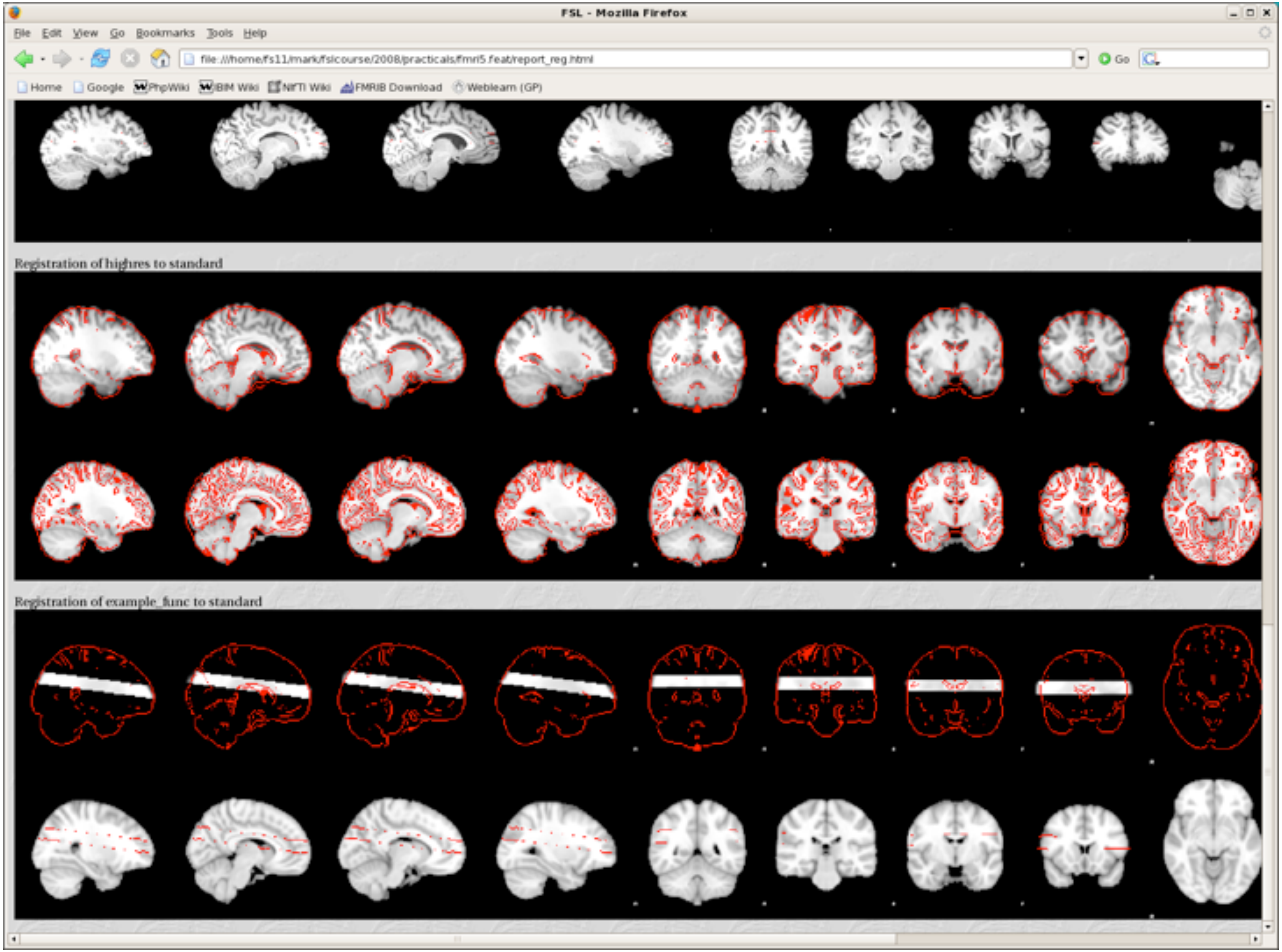
Registration within FEAT (small FOV)



Registration within FEAT (small FOV)



Registration within FEAT (small FOV)



Troubleshooting Registrations

- *Check the images:* voxel sizes, artefacts, large bias field
- *Check the brain extraction:* look for large/consistent errors
- *For EPI:* acquire and use fieldmap to unwarp distortion
- *For FMRI or diffusion:* use multi-stage registration (e.g. via GUIs) with a structural image for best results
- *If pathologies/artefacts exist:* use cost-function deweighting
- *If images are nearly aligned:* try limiting the search
- *For FLIRT:* can try different cost functions
- *For FNIRT:* check initial affine alignment is OK
- *For small FOV:* acquire whole-brain EPI for multi-stage reg

Advanced Registration

2D - 3D Registration

Severe Pathology

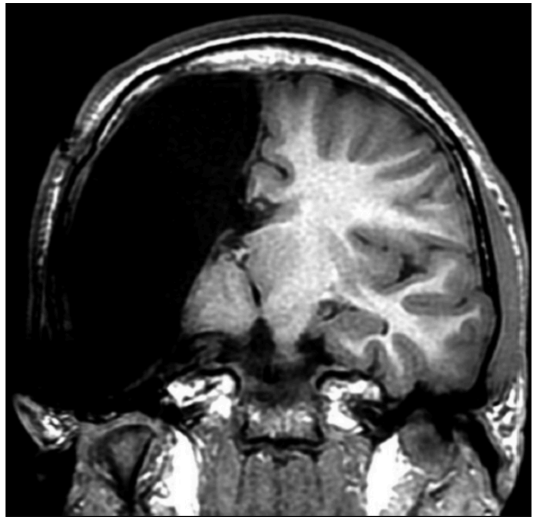
Surface-based Registration

e.g. connectivity-driven (FMRI)

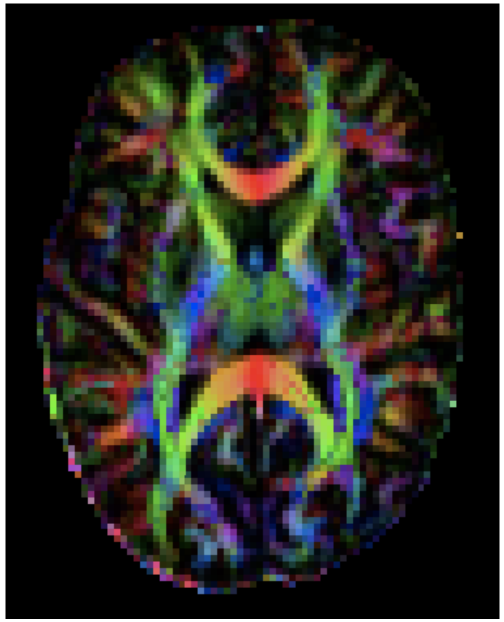
Other Image Modalities

e.g. diffusion imaging data

MR Spectroscopic Imaging (MRSI)



from Lew, S. M. (2014) *3*(3), 208.



Registration: Cost Function Weighting and Small FOV

Summary:

- Pathologies, artefacts and inconsistencies create problems for registration
- Can mitigate this with cost function weighting
- Important to keep the background (weight=1)

- Small FOV is very challenging to register
- Use whole brain scan to help with multi-stage registration