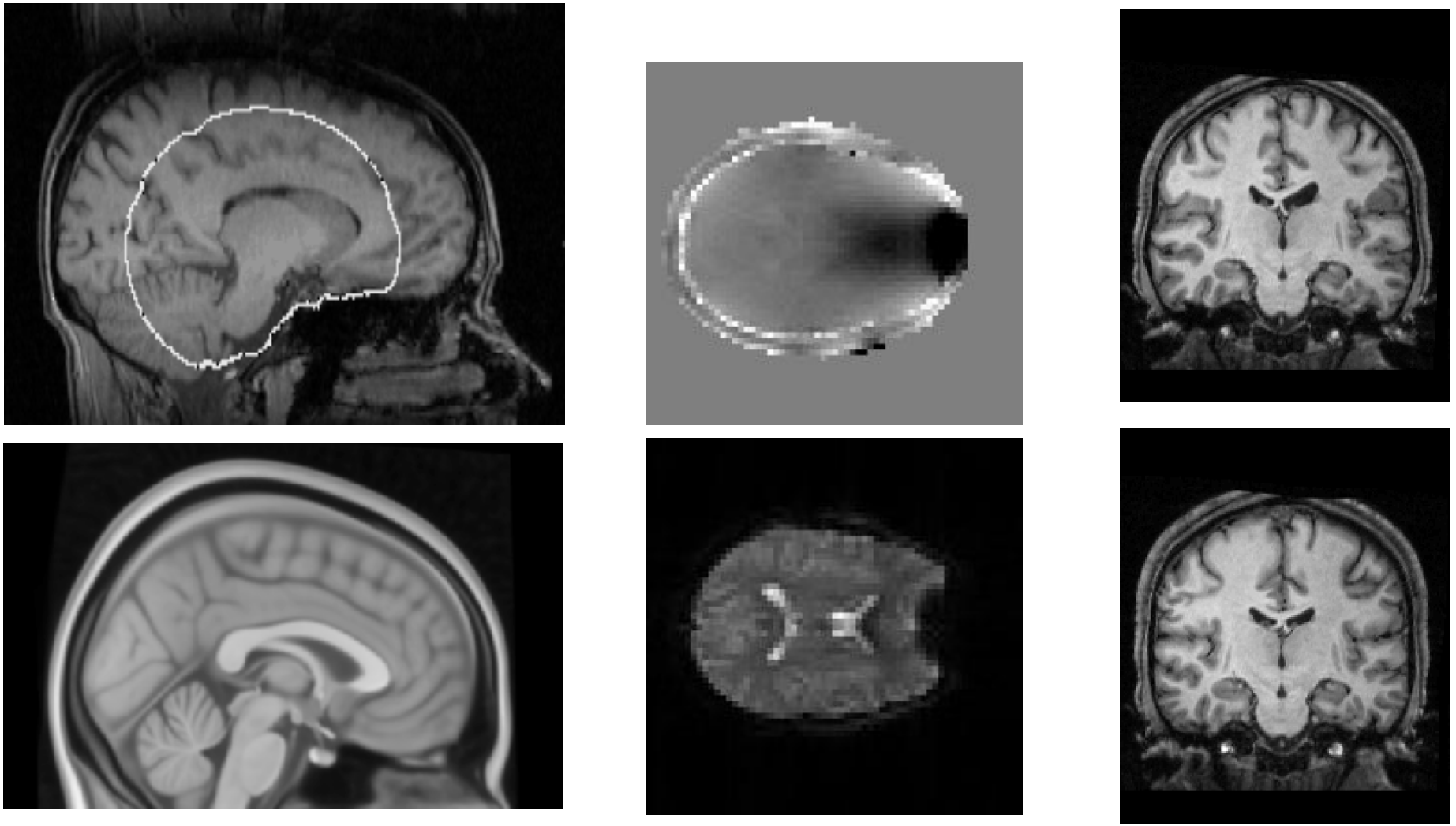
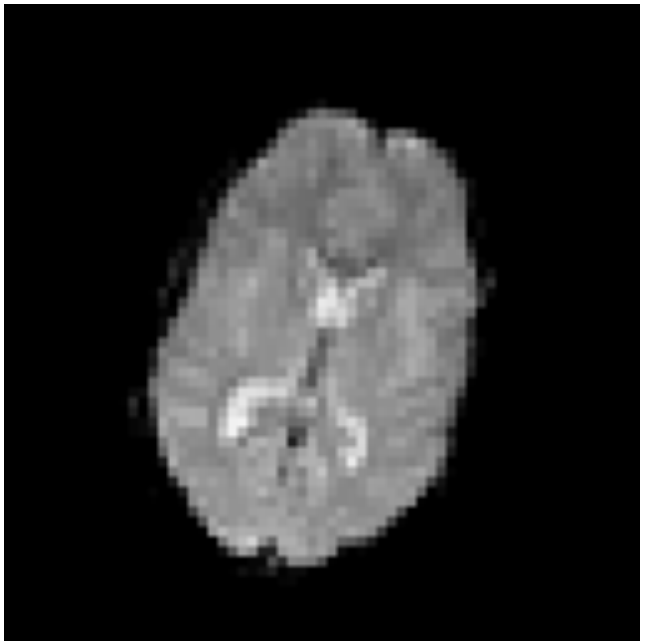
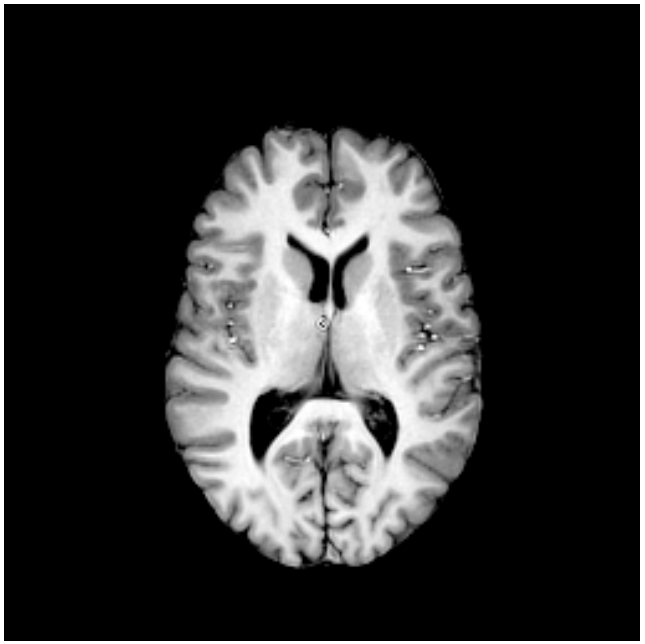
Registration: Cost Functions, Interpolation and Masks



Basic Registration Concepts

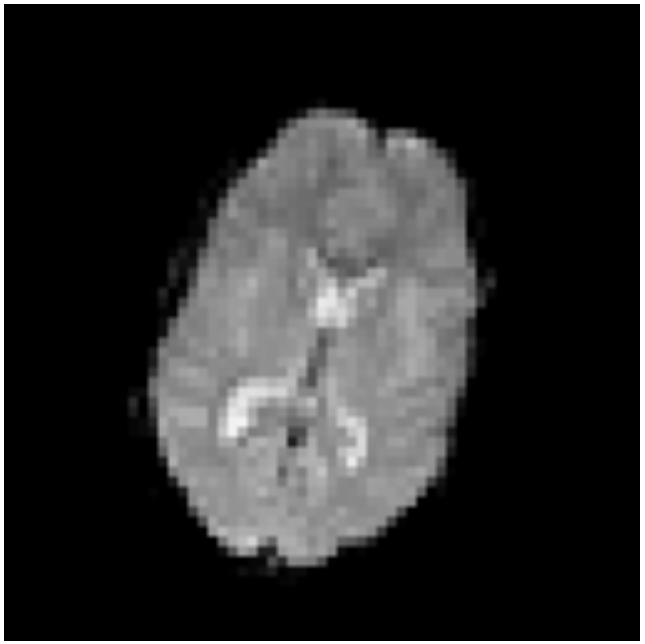


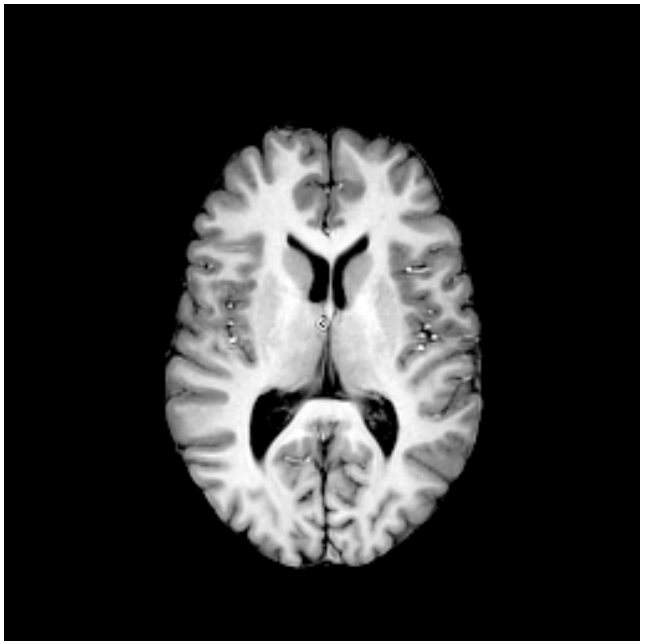


Need to understand:

- Image "spaces"
- Spatial Transformations
- Cost Functions
- Interpolation

Basic Registration Concepts





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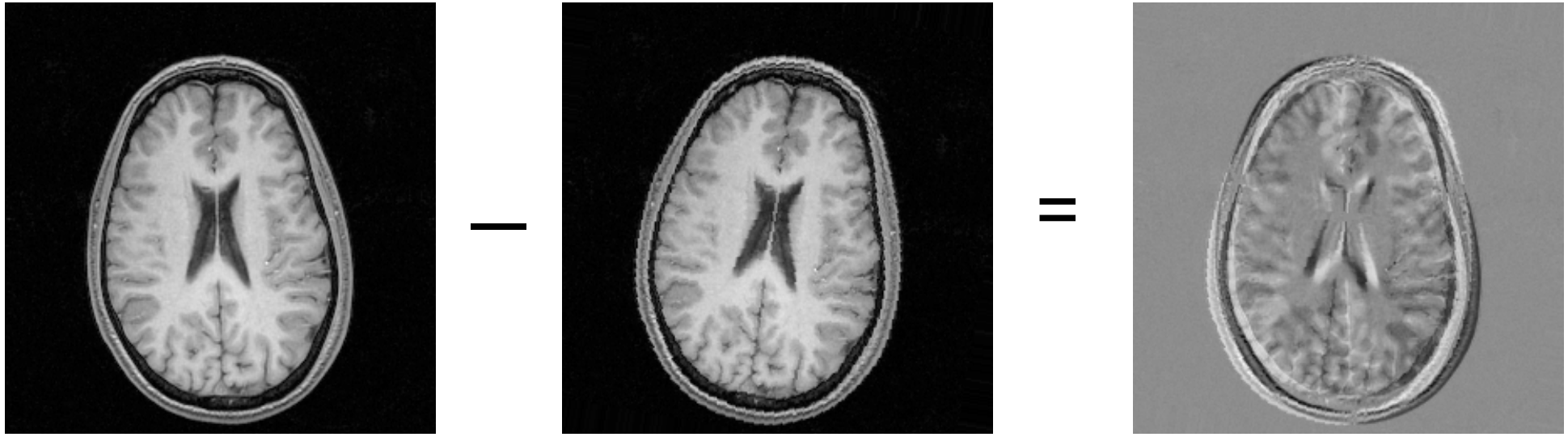
Cost Function

Measures "goodness" of alignment

Seek the minimum value

Several main varieties



Similarity function is opposite (maximum sought)

FLIRT: Cost Functions

FMRIB's
Linear
Image
Registration
Tool

FLIRT: Cost Functions

Important: Allowable image modalities

Less important: Details

Least Squares	***Same modality*** (exact sequence parameters)
Normalised Correlation	***Same modality*** (can change brightness & contrast)
Correlation Ratio	***Any MR modalities***
Mutual Information	***Any modalities*** (including CT, PET, etc.)
Normalised Mutual Info.	***Any modalities*** (including CT, PET, etc.)
BBR	***Within-subject EPI to structural*** (see later)

FNIRT: Cost Functions

FMRIB's
Non-linear
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FNIRT: Cost Functions

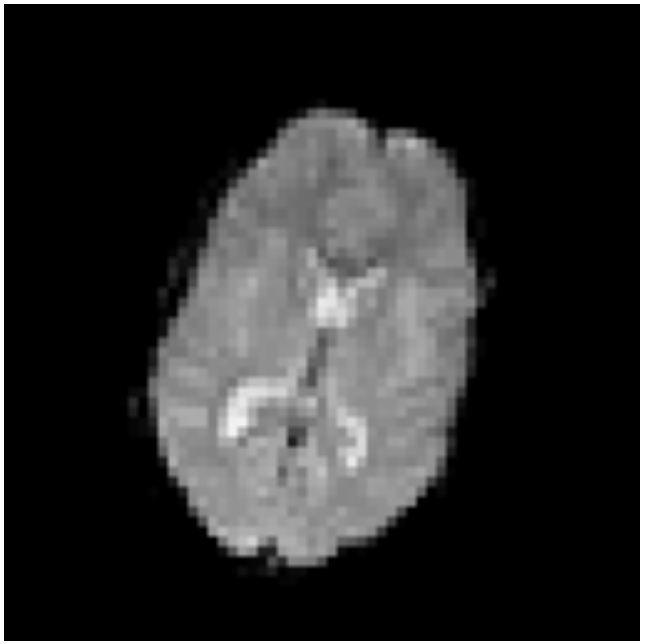
- *Only uses Least Squares* as cost function
  so *images must be of the same modality/sequence*
- Also includes an explicit model for bias field (RF inhomog.)
- Estimate displacement field *and* RF bias field together
- Options exist to control bias field (turn off/on, smoothness)

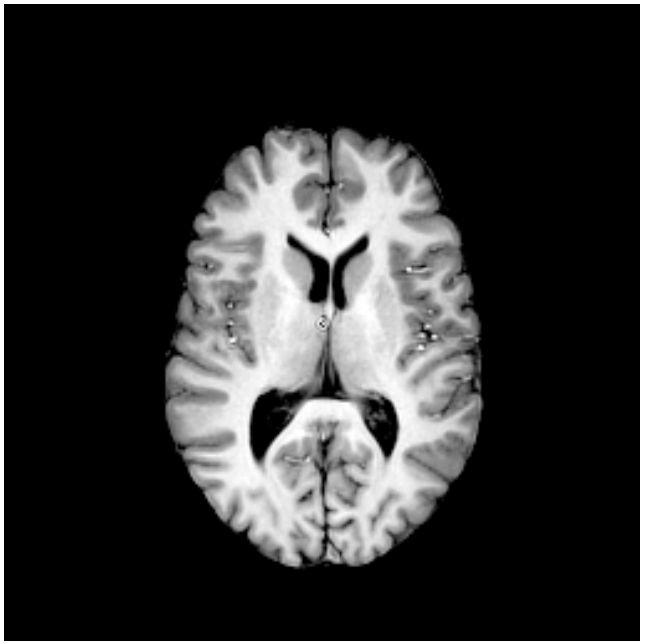
Without RF modelling

Template

With RF modelling

Basic Registration Concepts





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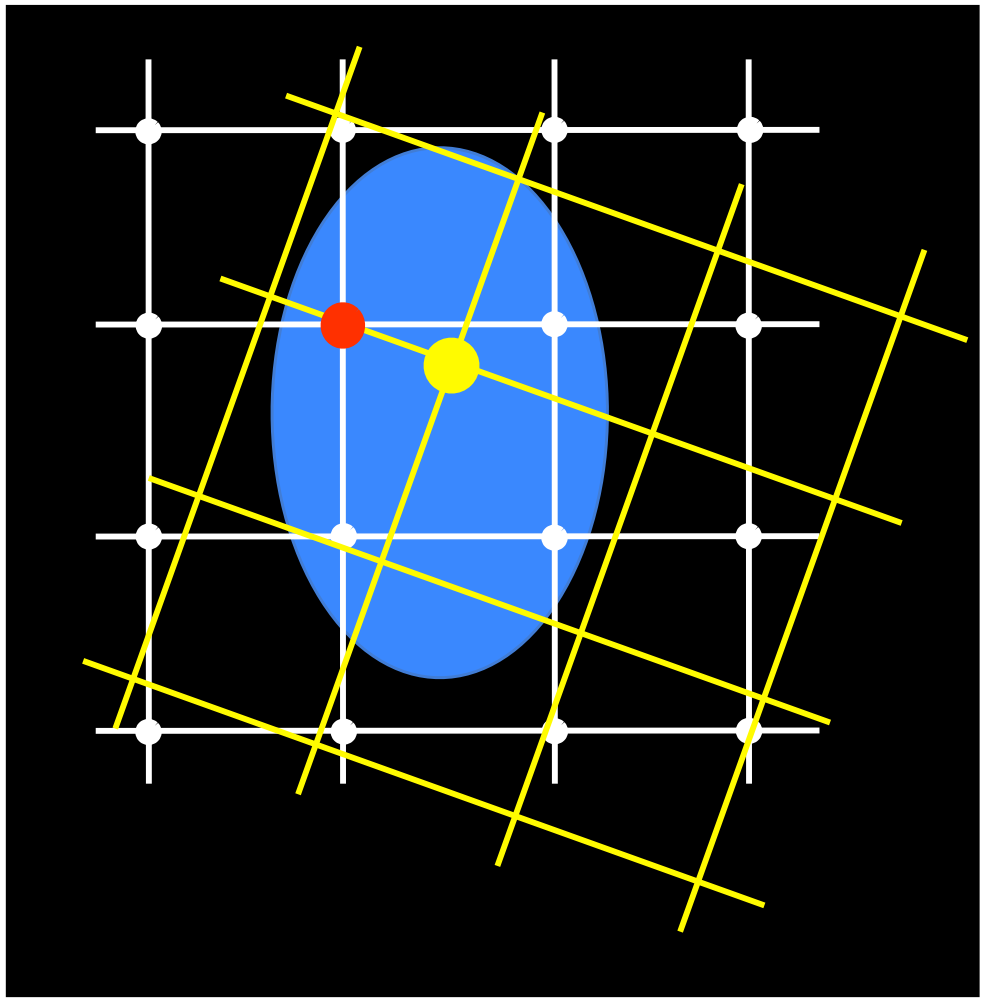
Interpolation

Finds intensity values between grid points



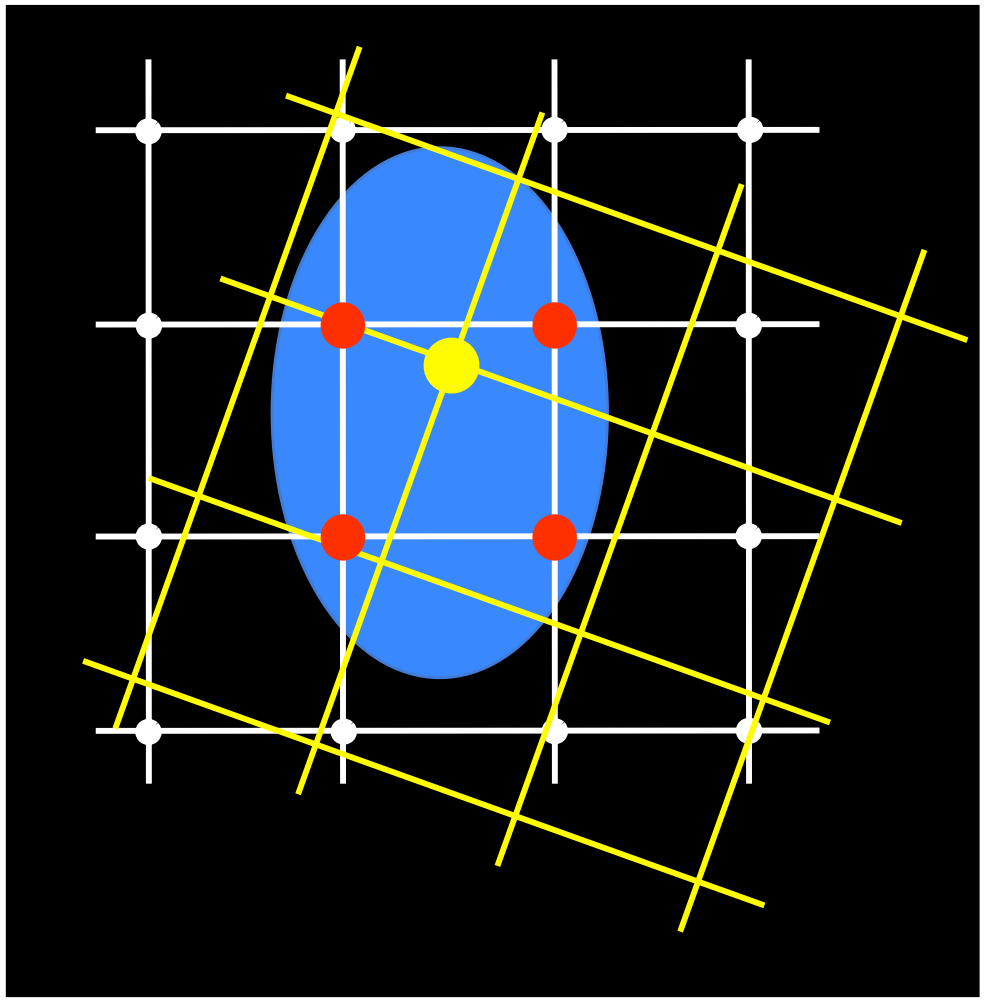
Various types include

- Nearest Neighbour
- Trilinear
- Spline
- Sinc
- k-Space methods

Fast, but blocky - can be used for discrete labels

Interpolation

Finds intensity values between grid points



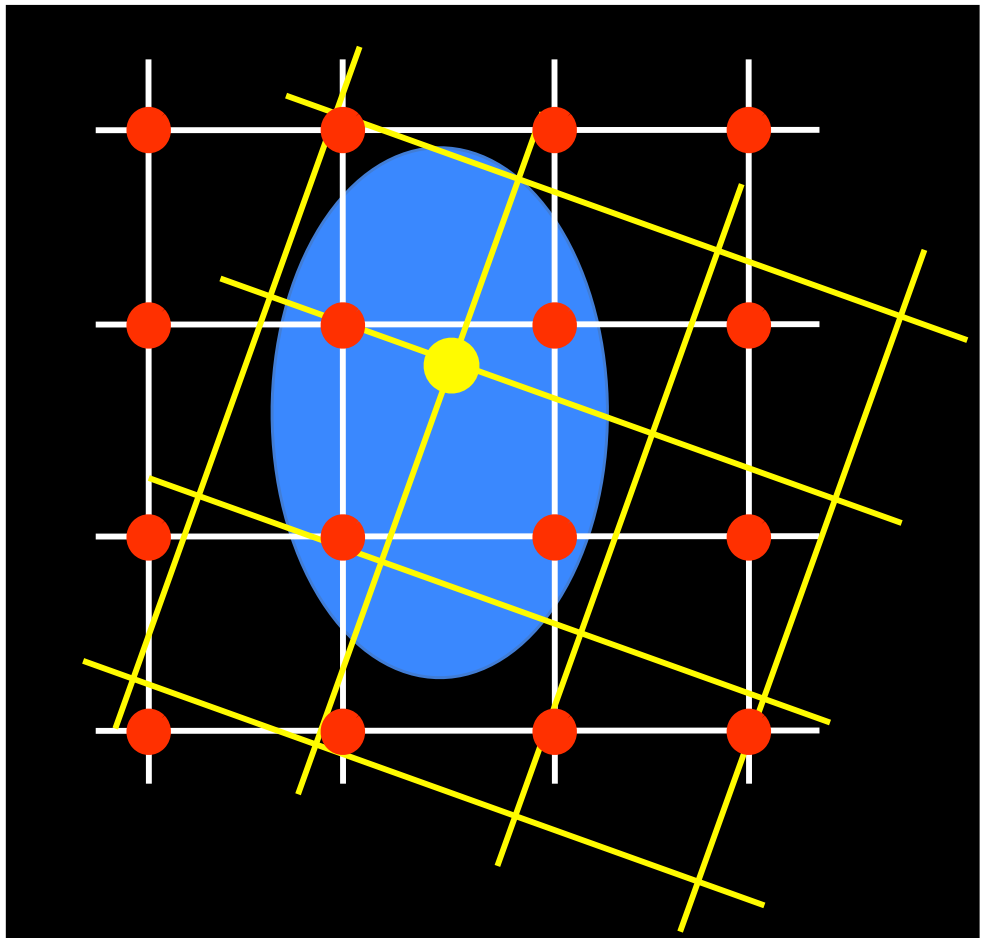
Various types include

- Nearest Neighbour
- Trilinear
- Spline
- Sinc
- k-Space methods

Fast, with some blurring - most common option

Interpolation

Finds intensity values between grid points



Various types include

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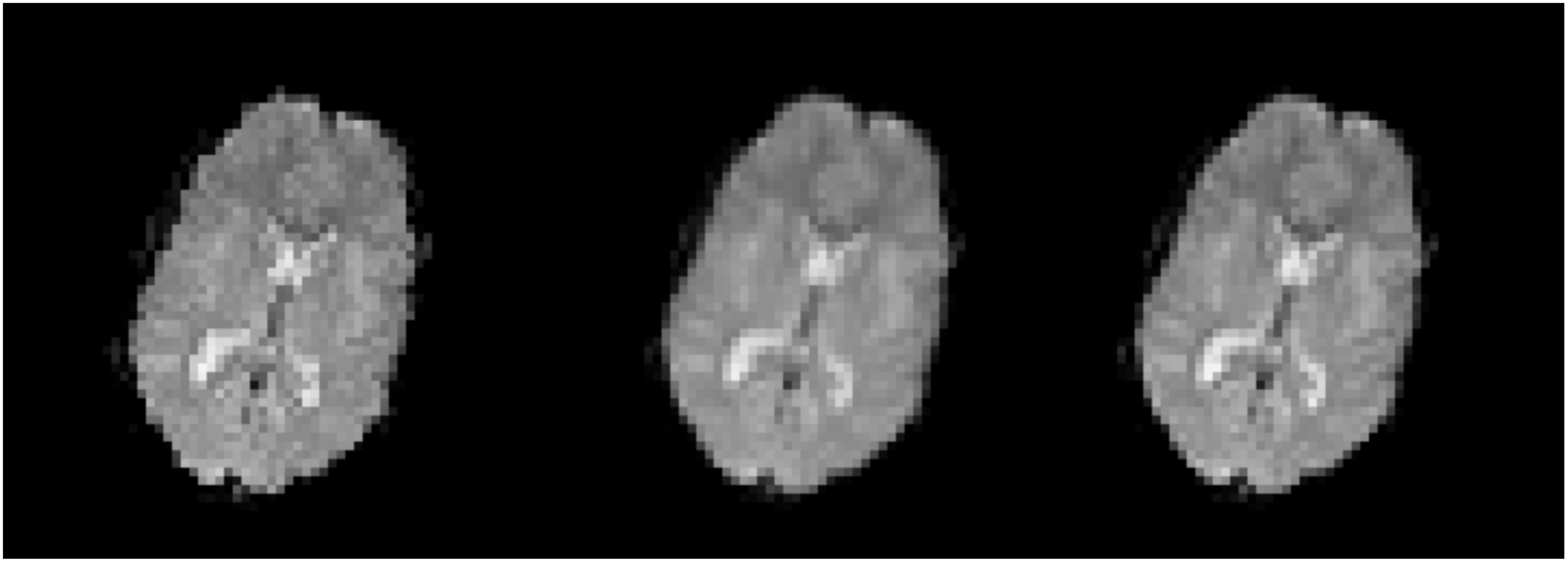
Slower (spline is fairly fast) - creates sharp images but can create values outside the original range

Interpolation



Nearest Neighbour Trilinear Spline

Affects accuracy of subsequent analysis

Important for *quantitative imaging*

Can affect size of artefacts

Applying Transformations

- Step 1: Estimating a transformation
  - finding the transformation
  - no resampling

Applying Transformations

- Step 1: Estimating a transformation
  - finding the transformation
  - no resampling
- Step 2: Resampling
  - *applying* a transformation
  - thus creating a new, modified image
- "Registration" can mean either
- Usually delay *resampling*
  as it *reduces image quality*
- Other terms: coregistration & spatial normalisation

Transforming Masks

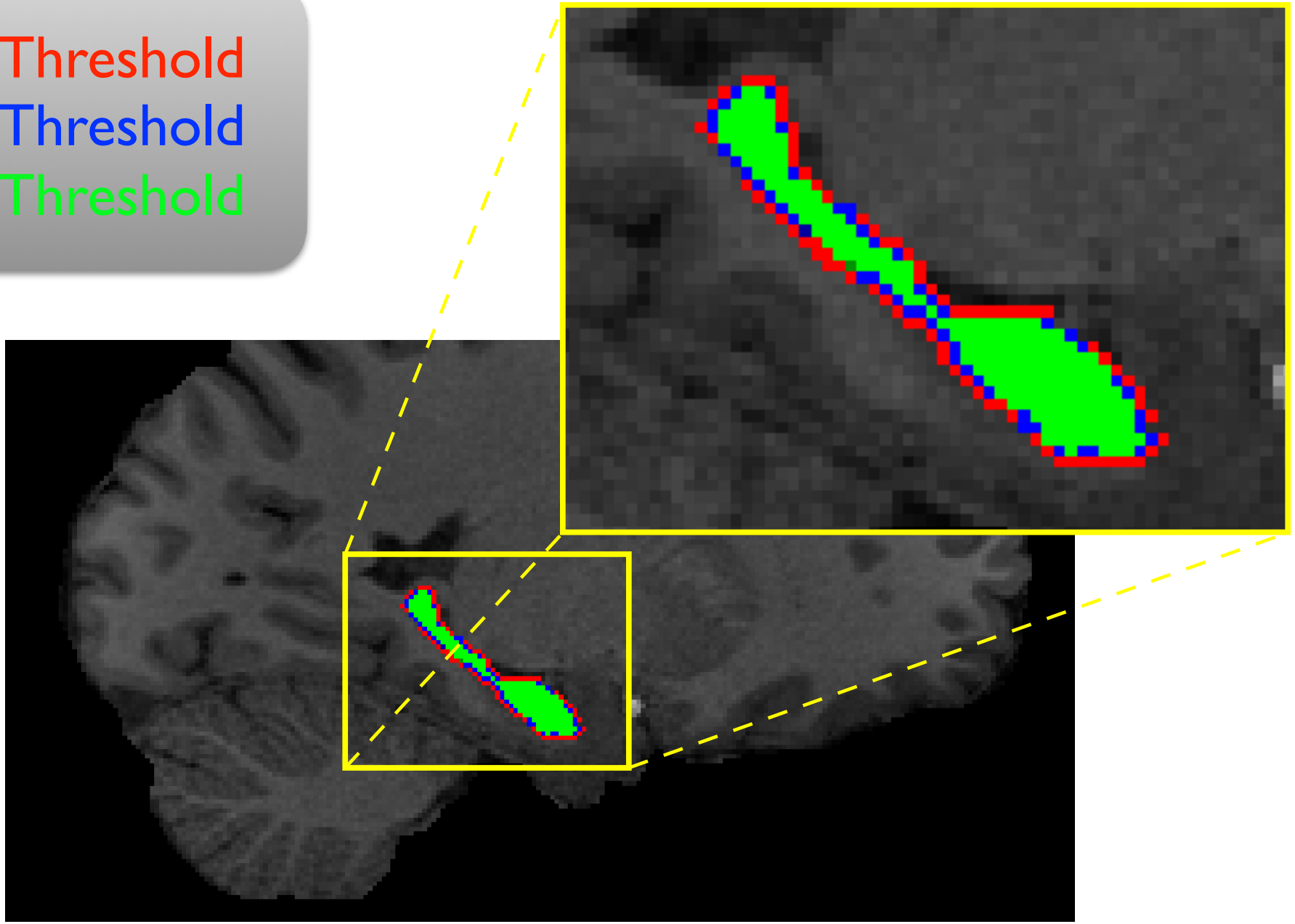
Mask values are normally 0 and 1 (integer format)
Interpolation gives values in between
if rounded to integer $\Longrightarrow$ mask "shrinks"

Ensure output datatype = float *(applywarp & flirt default)*
Re-threshold (binarize) the transformed mask

"Correct" thresholding depends on the particular case
- Threshold near 0.0 to include partial-volume edges
- Threshold near 1.0 to exclude partial-volume edges
- Threshold at 0.5 to keep the same size (approx)

Transforming Masks

0.1 Threshold
0.5 Threshold
0.9 Threshold



Registration: Cost Functions, Interpolation and Masks

Summary:

- Must choose an appropriate cost function
- Often many valid choices (depends on images)
- Interpolation used to resample images
- Often the interpolation is set within the tool
- When applying transforms want to minimise interpolation-related effects - delay resampling
- Transforming masks requires attention to interpolation and thresholding - depends on task