



Slicer3 Tutorial

Registration Library Case 27:

DTI MRI pre-op planning:

align DTI with FLAIR and T1, extensive pathology

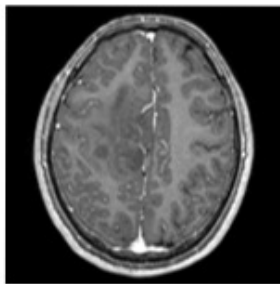
Dominik Meier, Ron Kikinis, Danielle Pace

June 2011

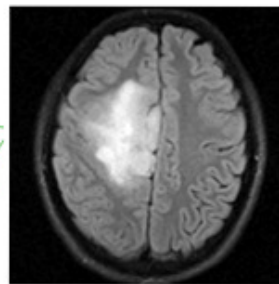
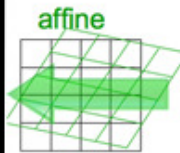


Introduction

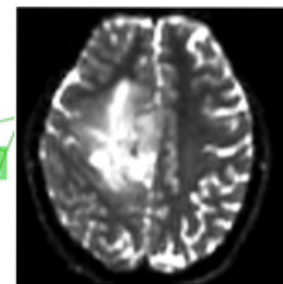
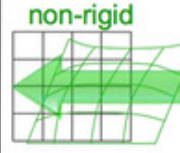
- This is an example dataset of an MRI exam obtained for pre-operative planning. We seek to align the DTI with the structural reference T1 scan to transfer information about critical fiber pathways.
- There is extensive pathology in the right hemisphere and acquisition-related distortion in the DTI data
- The FLAIR provides T2-weighted contrast more similar to the DTI baseline than the T1, which makes it a good target for registration. However it has low axial resolution (4mm thick slices) that make it suboptimal as final space in which to resample the DTI.
- We therefore follow a 2-step approach: 1) we register the FLAIR to the T1 and resample to the same isotropic resolution as present in the T1; 2) we then register the DTI to the resampled FLAIR.



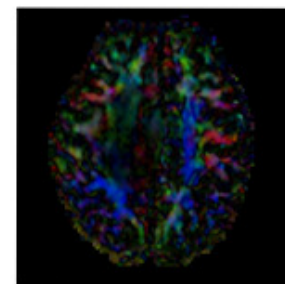
fixed image/target
T1



fixed image/target
FLAIR



moving image 2a
DTI baseline



moving image 2b
DTI tensor



Modules Used

- To accomplish this task we will use the following modules:

- Volumes Module



- Diffusion Tensor Estimation Module

Modules: Diffusion Tensor Estimation

- BRAINSFit Registration Module

Modules: BRAINSFit

- Data Module



- Resample Scalar/Vector/DWI Volume

Modules: sample Scalar/Vector/DWI Volum

- Resample DTI Module

Modules: Resample DTI Volume



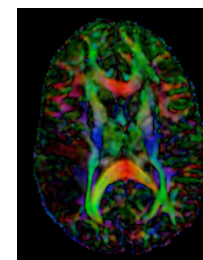
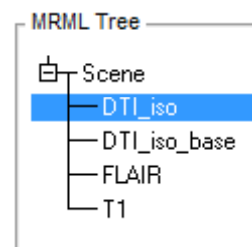
Prerequisites

- Slicer version 3.6.1 or later
- **Example Dataset:** download and extract the dataset for this tutorial: Slicer3_BRAINSFITRegistration.zip, which should contain this tutorial, all original and some intermediate solution data files.
- Tutorials to complete first (optional):
 - Slicer3Minute Tutorial
 - Loading and Viewing Data
 - DTI tutorial



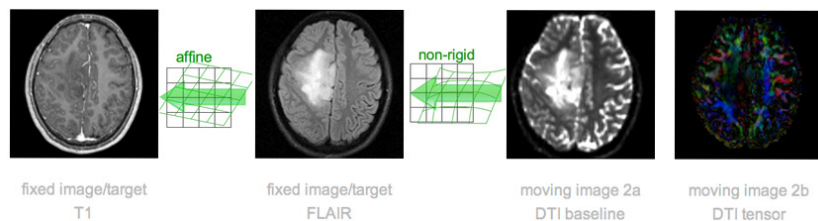
Load Patient Data

- Open the .mrml scene RegLib_C27_Short_Data.mrml using **File -> LoadScene**
- Input data:
 - T1 = structural T1 MRI
 - FLAIR = T2 MRI
 - DTI_iso_base = DTI baseline
 - DTI_iso = DTI tensor image
- To view the DTI tensor image:
 - Select DTI_iso in the Volumes module
 - Select Scalar Mode: Color Orientation





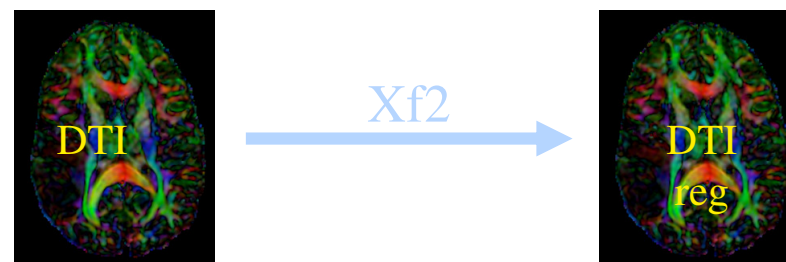
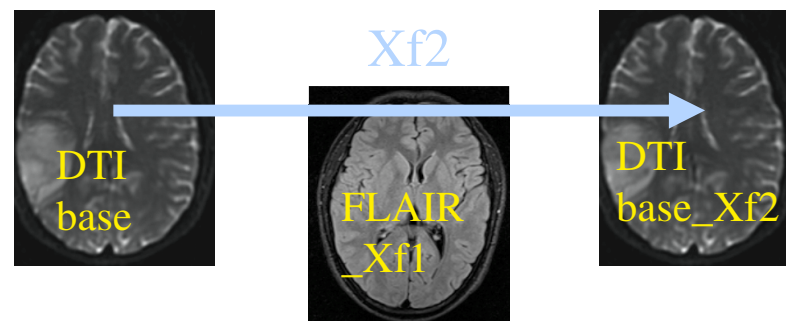
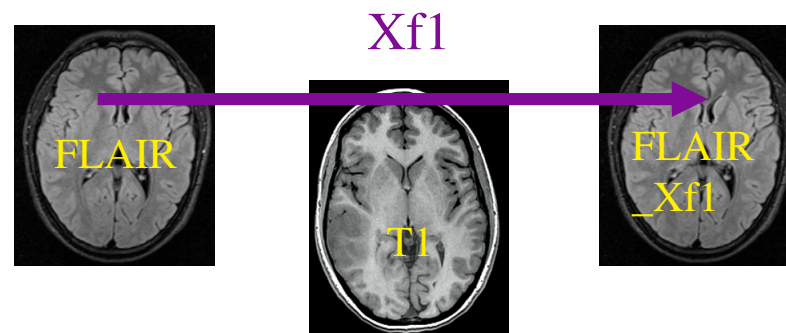
Registration Strategy



1. Register the FLAIR scan to the T1 (affine)
2. Register the DTI_baseline to the registered FLAIR
3. Apply the second transform to the DTI volume.

The reason for these 2 steps is that best registration quality and robustness is achieved when image contrast and/or resolution are similar. A registration of the DTI_baseline to the T1 is a large step in both image contrast and resolution / FOV and likely to fail

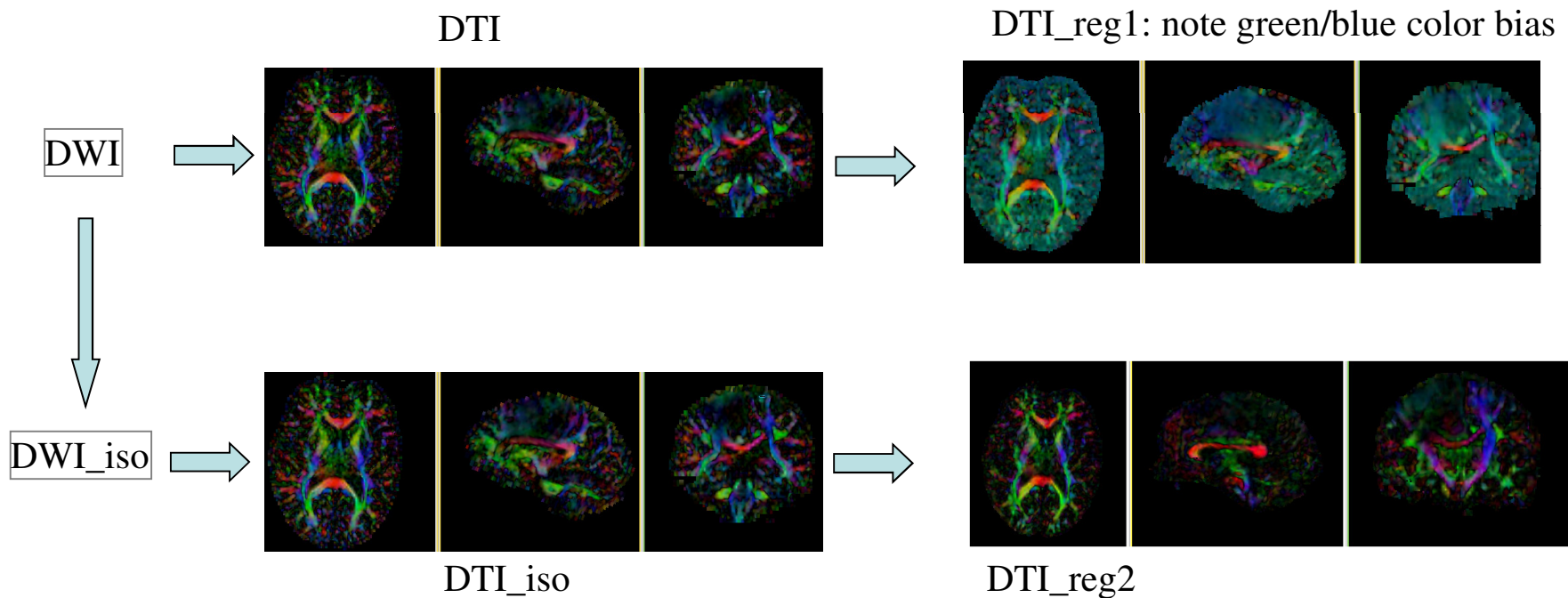
We register to the T2 after it is aligned with the T1. Registering to the original T2 and then moving to the T1 would require concatenating transforms in a form not currently supported, or alternatively would require additional resampling which would reduce DTI image quality.





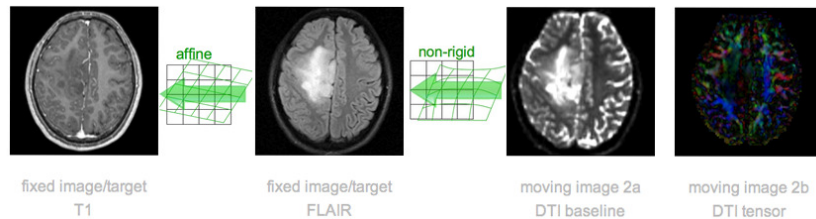
Resolution & Anisotropy Issues

- The original DWI image has a voxel size of $1.96 \times 1.96 \times 3$ mm. The DTI estimation and subsequent rotation of the tensor data can lead to strong interpolation artifacts: in this case directionality in the z-direction (inferior-superior) will “blur” across slices and lead to a systematic bias/offset in the final resample DTI image (DTI_reg1).
- It is therefore recommended to first resample the DWI to an isotropic resolution similar to the target space, and then perform DTI estimation and registration (DTI_reg2).





Registration Strategy



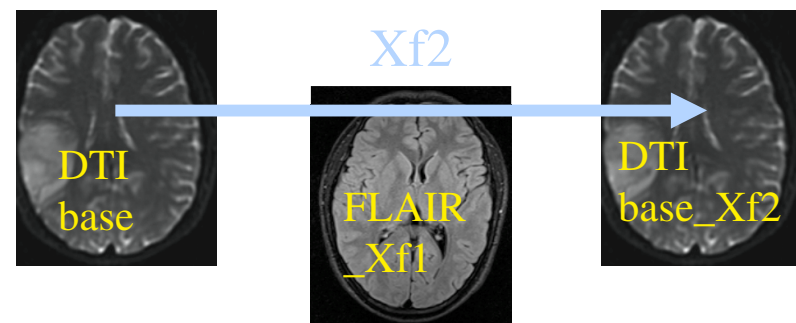
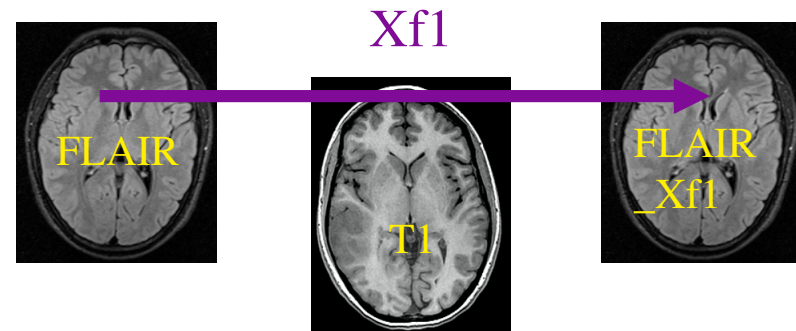
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Register T2 (FLAIR) -> T1

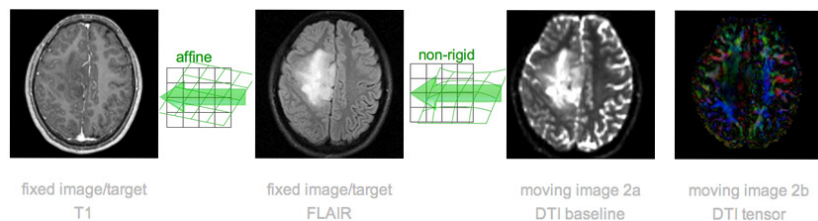
1. Go to the “BrainsFit” module (under Registration tab)
2. Input:
Fixed Image: T1
Moving Image: FLAIR
3. Output
Check boxes for: “rigid”, “affine” registration phases
Slicer Linear Transform: Create new, rename to “Xf1_FLAIR-T1_Affine”
Output Volume: Create new, rename to “FLAIR_Xf1”
Registration Parameters: All defaults, except:
Number of Samples 200,000
4. Evaluate alignment: T1 and FLAIR_Xf1
Choose T1 as the background, FLAIR_Xf1 as the foreground, and toggle the fade slider
5. Evaluate change: FLAIR and FLAIR_Xf1
Choose FLAIR as the background, FLAIR_Xf1 as the foreground, and toggle the fade slider
Note FLAIR_Xf1 is resampled to the same resolution as T1

The screenshot shows the BrainsFit registration module interface with several settings highlighted in red ovals:

- Input Parameters:**
 - Fixed Image Volume: T1
 - Moving Image Volume: F.R
- Registration Phases To Use:**
 - Initialize with previously generated transform: e
 - Initialize Transform Mode: useNone useCenterOfH useGeom
 - Include Rigid registration phase:
 - Include ScaleVersor3D registration phase:
 - Include ScaleSkewVersor3D registration phase:
 - Include Affine registration phase:
 - Include BSpline registration phase:
- Output Settings (At Least One Output Must Be Specified.):**
 - Slicer BSpline Transform: None
 - Slicer Linear Transform: X_e
 - Output Transform: e
 - Output Image Volume: FL...f1
 - Output Image Pixel Type: float short ushort int uint uchar
- Registration Parameters:**
 - Transform Type: [empty]
 - Number Of Iterations: 1500
 - Number Of Samples: 200000
 - Minimum Step Length: 0.005
 - Transform Scale: 1000
 - Reproportion Scale: 1
 - Skew Scale: 1
 - Number Of Grid Subdivisions: 14,10,12
 - Maximum B-Spline Displacement: 0



Registration Strategy



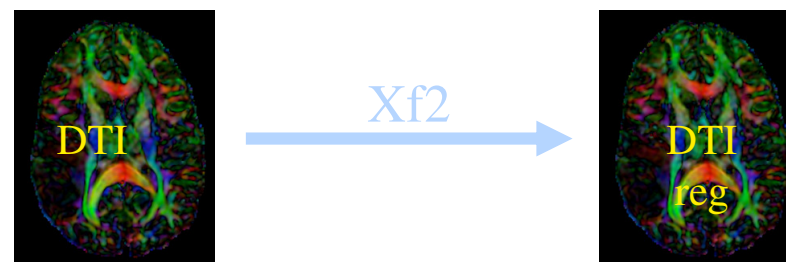
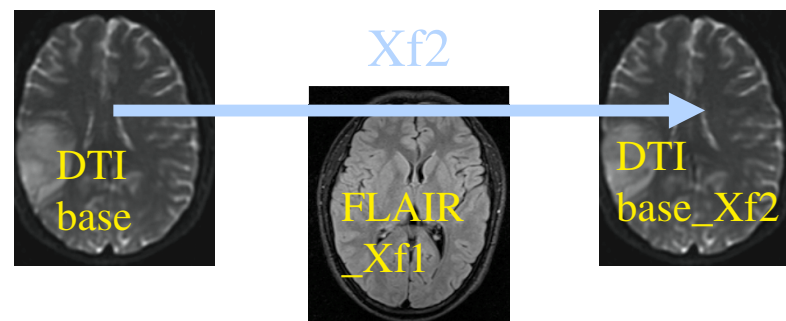
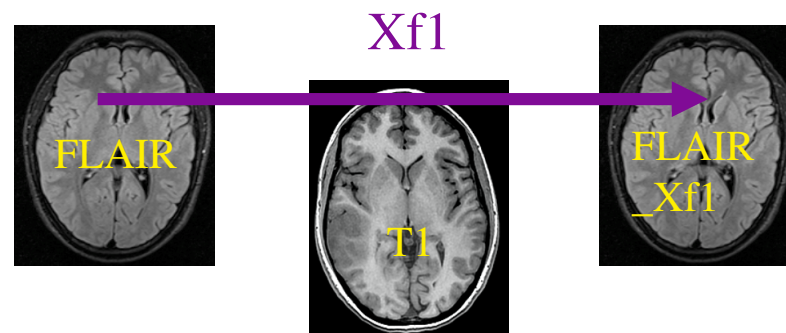
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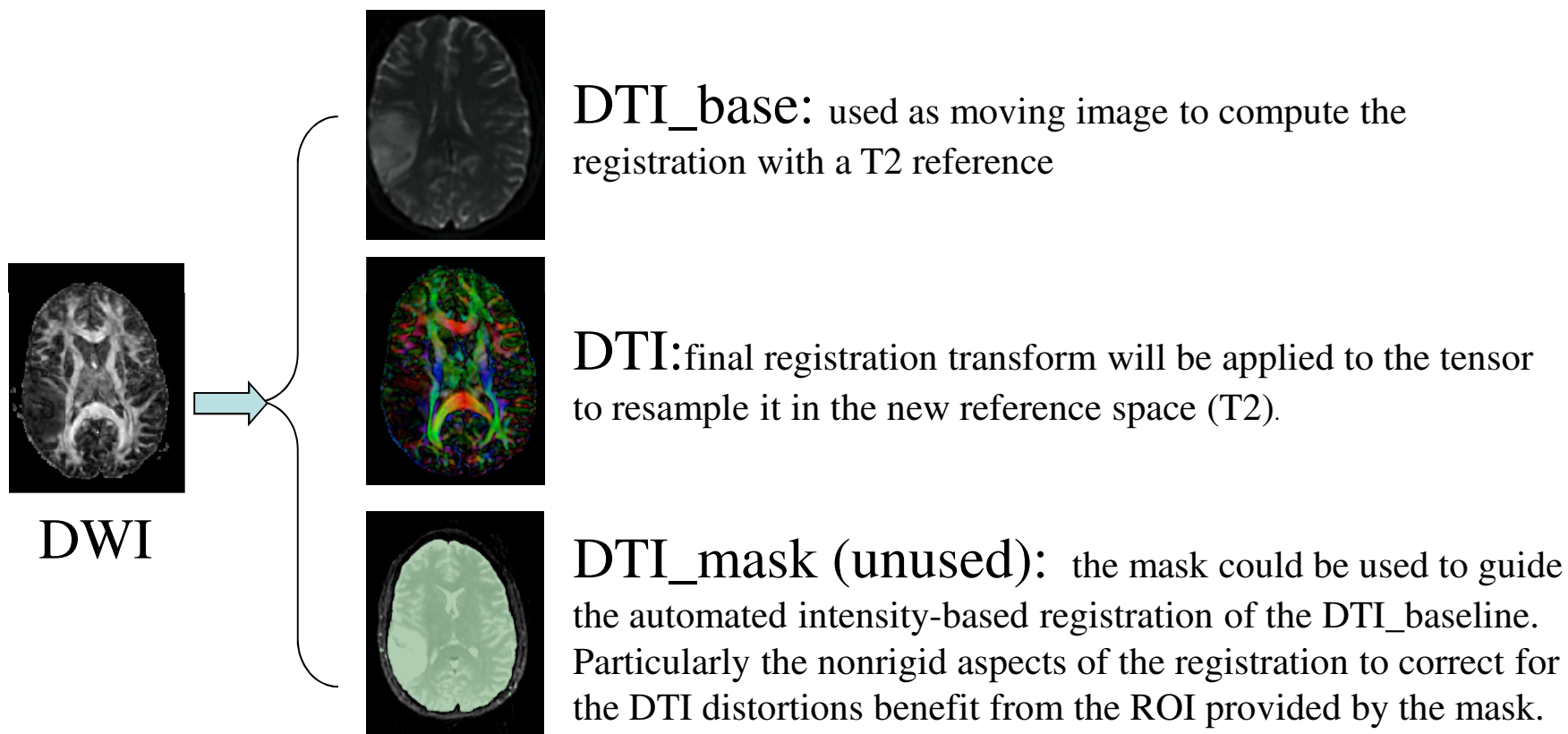




DWI -> DTI conversion (done for you)

The anisotropic DWI has been previously resampled to isotropic resolution. It was then converted to a DTI tensor image that can be used for fiber tracking and other forms of quantifying diffusion.

This conversion produced 3 new volumes:





Register DTI baseline to FLAIR

1. Go to the “BrainsFit” module
2. Input:
Fixed Image: FLAIR_Xf1
Moving Image: DTI_iso_base
3. Output:
Check boxes for: “rigid”, “affine” + “B-spline” registration phases
Slicer B-spline Transform: Create new, rename to “Xf2_DTI-FLAIR_Bspline”
Output Image Volume: Create new, rename to DTI_iso_base_Xf2
Registration Parameters: All default except
Number of Samples 200,000 ,
Number of Grid Subdivisions 5,5,3
4. Evaluate alignment: FLAIR_Xf1 and DTI_iso_base_Xf2
Choose FLAIR_Xf1 as the background, DTI_iso_base_Xf2 as the foreground, and toggle the fade slider
5. Evaluate change: DTI_iso_base and DTI_iso_base_Xf2
Choose DTI_iso_base as the background, DTI_iso_base_Xf2 as the foreground, and toggle the fade slider

Input Parameters

Fixed Image Volume 1

Moving Image Volume e

Registration Phases To Use

Initialize with previously generated transform

Initialize Transform Mode useMome useCenterOfH useGeom

Include Rigid registration phase

Include ScaleVersor3D registration phase

Include ScaleSkewVersor3D registration phase

Include Affine registration phase

Include B-spline registration phase

Output Settings (At Least One Output Must Be Specified.)

Slicer B-spline Transform e

Slicer Linear Transform

Output Transform

Output Image Volume e

Output Image Pixel Type float short ushort int uint uchar

Registration Parameters

Transform Type

Number Of Iterations 1500

Number Of Samples 200000

Minimum Step Length 0.005

Transform Scale 1000

Reproportion Scale 1

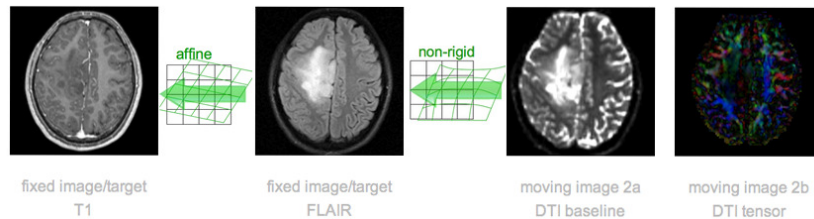
Skew Scale 1

Number Of Grid Subdivisions 5,5,3

Maximum B-Spline Displacement 0



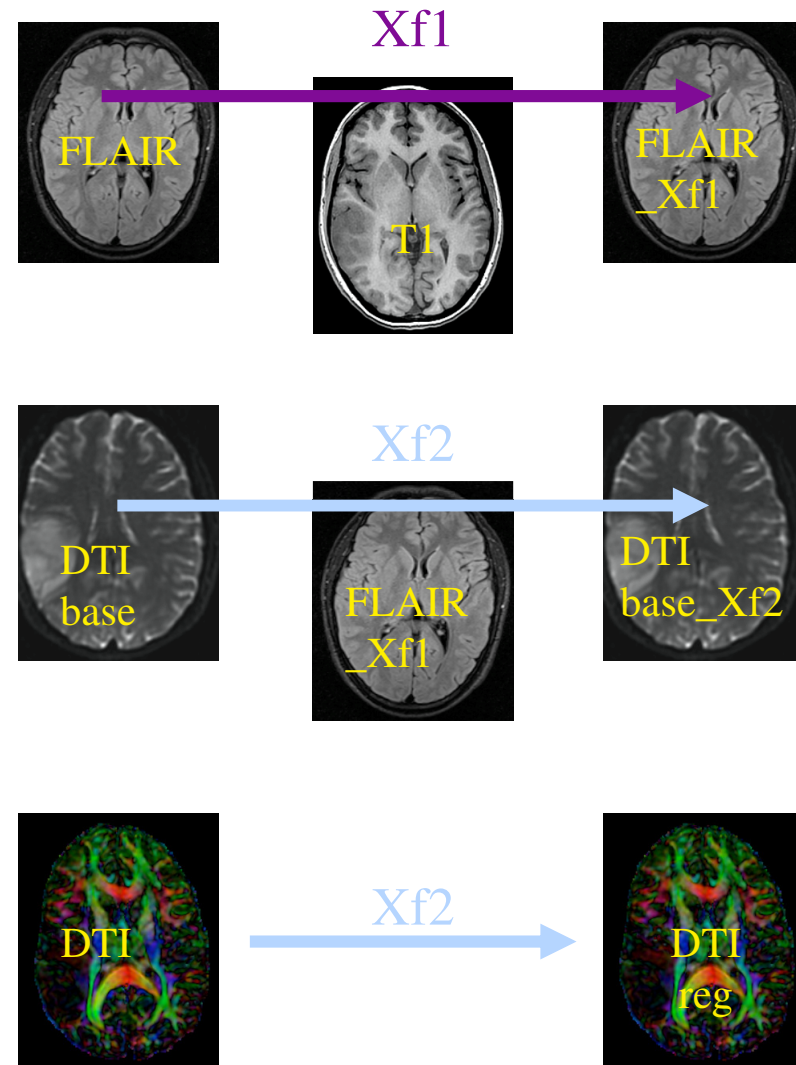
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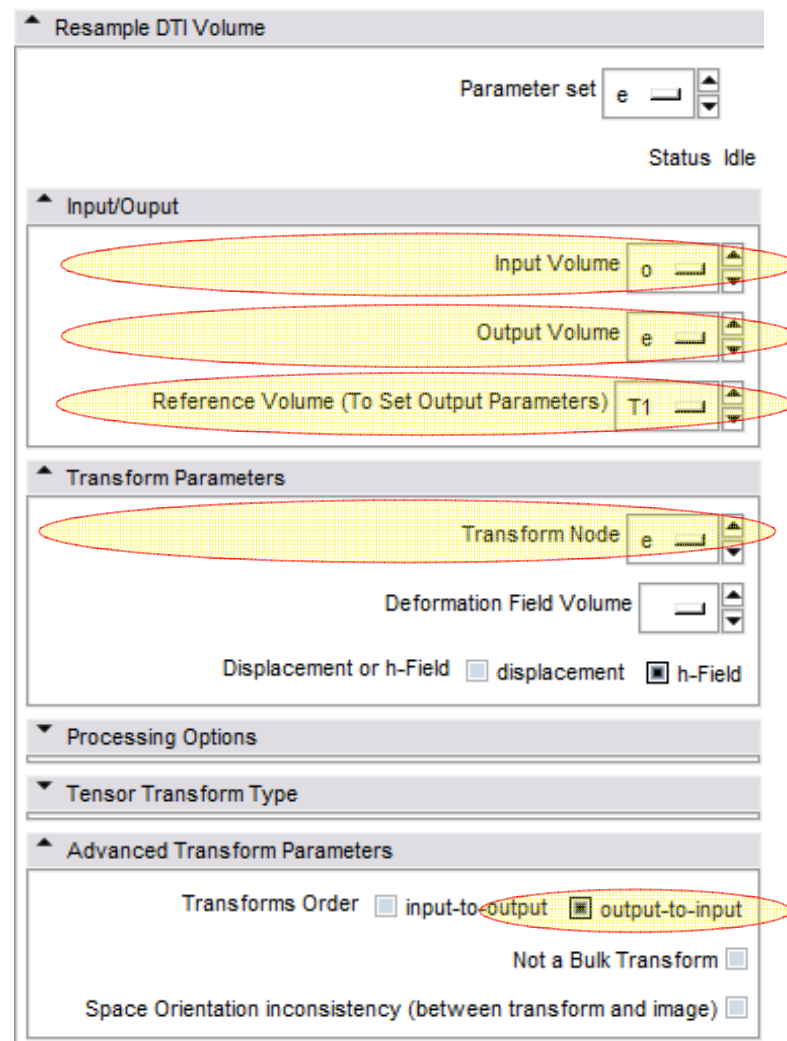


Resample DTI

The last step is to resample the DTI with the new transform (Xf2).

This is done with the *Resample DTI Volume* Module, found in the *Diffusion / Utilities Set*

1. Go to the “Resample DTI Volume” module
2. Input/Output:
Input Image: DTI_iso
Output Volume: Create new DTI Volume, rename to DTI_iso_Xf2
Reference Volume: T1
3. Transform Parameters:
Transform Node: Xf2_DTI-FLAIR_Bspline
Under Advanced Transform Parameters: Check output-to-input
4. Evaluate change: DTI_iso and DTI_iso_Xf2
Open the Volumes module, for DTI_iso_Xf2, choose
Scalar Mode: Color Alignment
Choose None as the background
Toggle between DTI_iso and DTI_iso_Xf2 as the foreground





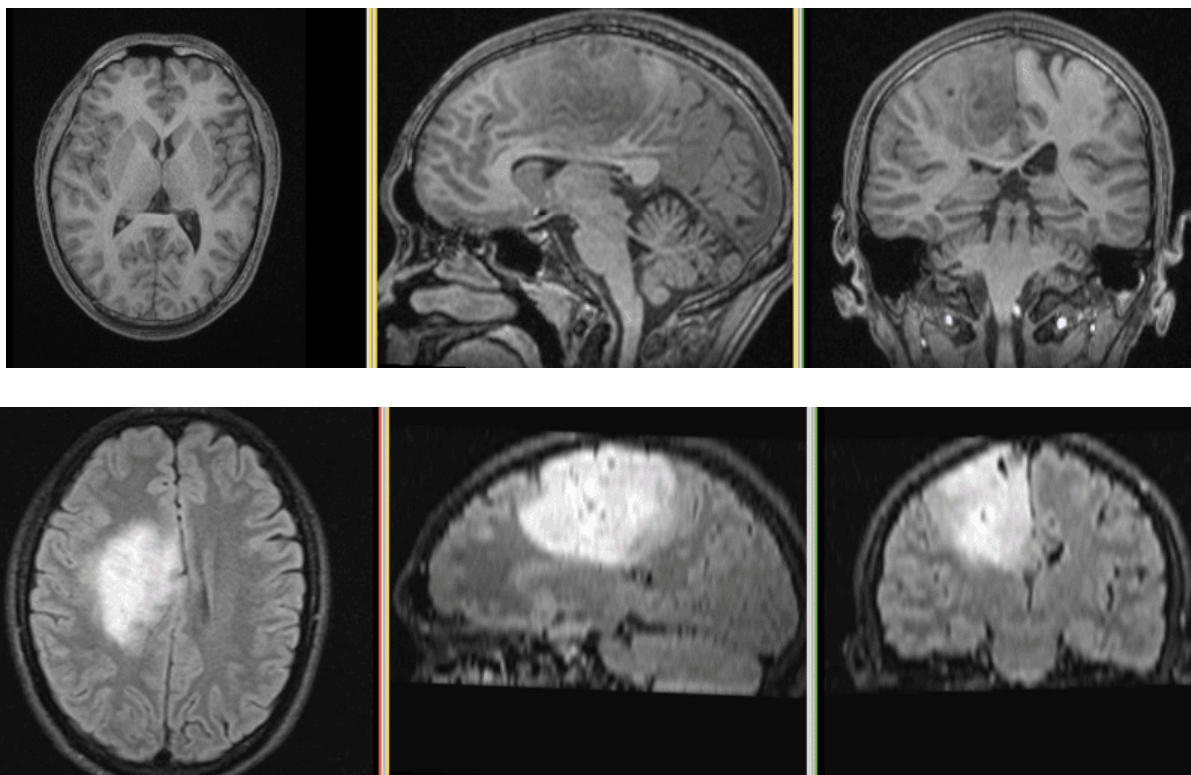
Results

We have now the DTI in the same orientation and resolution as the T1 reference scan.

For verification of the final registration results:

Choose T1 as the foreground, DTI_iso_Xf2 as the background, and toggle the fade slide

animated gifs, view in presentation mode





Acknowledgements



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