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Symmetric Diffeomorphic Registration in 3D

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This example explains how to register 3D volumes using the Symmetric Normalization (SyN) algorithm proposed by Avants et al. [Avants09] (also implemented in the ANTs software [Avants11])

We will register two 3D volumes from the same modality using SyN with the Cross Correlation (CC) metric.

```
import numpy as np
from dipy.align.imwarp import SymmetricDiffeomorphicRegistration
from dipy.align.imwarp import DiffeomorphicMap
from dipy.align.metrics import CCMetric
from dipy.core.gradients import gradient_table
from dipy.data import get_fnames
from dipy.io.image import load_nifti, save_nifti
from dipy.io.gradients import read_bvals_bvecs
import os.path
from dipy.viz import regtools
```

Let's fetch two b0 volumes, the first one will be the b0 from the Stanford HARDI dataset

```
hardi_fname, hardi_bval_fname, hardi_bvec_fname = get_fnames('stanford_hardi')

stanford_b0, stanford_b0_affine = load_nifti(hardi_fname)
stanford_b0 = np.squeeze(stanford_b0)[..., 0]
```

The second one will be the same b0 we used for the 2D registration tutorial

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DR-BUDDI (Diffeomorphic Registration for Blip-Up blip-Down Diffusion Imaging) Method for Correcting Echo Planar Imaging Distortions

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Abstract

We propose an echo planar imaging (EPI) distortion correction method (*DR-BUDDI*), specialized for diffusion MRI, which uses data acquired twice with reversed phase encoding directions, often referred to as blip-up blip-down acquisitions. *DR-BUDDI* can incorporate information from an undistorted structural MRI and also use diffusion-weighted images (DWI) to guide the registration, improving the quality of the registration in the presence of large deformations and in white matter regions. *DR-BUDDI* does not require the transformations for correcting blip-up and blip-down images to be the exact inverse of each other. Imposing the theoretical "blip-up blip-down distortion symmetry" may not be appropriate in the presence of common clinical scanning artifacts such as motion, ghosting, Gibbs ringing, vibrations, and low signal-to-noise. The performance of *DR-BUDDI* is evaluated with several data sets and compared to other existing

- $$\xi=\int_\Omega CC\left(I_{up}(\phi(\mathbf{x}))\,\mathscr{J}(\phi),\, I_{down}\left(\phi^{-1}(\mathbf{x})\right)\,\mathscr{J}(\phi^{-1})\right)d\Omega$$
- $$\xi_1=\int_\Omega CC(I'_{up}, I'_{down}, \mathbf{x})d\Omega$$
- $$\xi_2=\int_\Omega \left(CC\left(I_{up}(\phi_1(\mathbf{x},0.5)),\mathscr{S}\right)+CC\left(\mathscr{S}, I_{down}(\phi_2(\mathbf{x},0.5))\right)\right)d\Omega$$
- $$\mathscr{K}(\phi_1,\phi_2)=2\frac{I'_{up}\cdot I'_{down}}{I'_{up}+I'_{down}}$$
- $$\xi_3=\int_\Omega CC(\mathscr{K},\mathscr{S},\mathbf{x})d\Omega$$
- $$I''_{up}=I_{up}(\phi_1(\mathbf{x},0.5))\times|\mathscr{J}(\phi_1(\mathbf{x},0.5))|,$$
- $$I''_{down}=I_{down}(\phi_2(\mathbf{x},0.5))\times|\mathscr{J}(\phi_2(\mathbf{x},0.5))|$$
- $$\xi_4=\int_\Omega CC(I''_{up}, I''_{down}, \mathbf{x})d\Omega$$