

DTI preprocessing using `imagen_diffsl`

Objective:

All subjects were processed with `imagen_diffsl`. This script preprocesses all dti data from the different centers participating to the Imagen project (<http://www.imagen-europe.com>) using FSL tools (<http://www.fmrib.ox.ac.uk/fsl/>).

Configuration:

`Imagen_diffsl` needs FSL to be installed on your system and properly set up (<http://www.fmrib.ox.ac.uk/fsl/fsl/downloading.html>). The script was tested on FSL 4.1.6. Before running this program for the first time, the general path needs to be set. Open the script with an editor and modify the `pdir` variable according to where you want to save the preprocessed data (e.g. `pdir=/Imagen/dti`). The script will create one folder per subject in this directory.

FSL pipeline:

The pipeline consists in the following steps:

- Eddy current and motion correction using an affine registration and the first volume of the dti data as reference.
- After registration, a brain extraction is applied to remove non-brain tissues and a first estimation of the diffusion tensor is achieved for each voxel.
- If available, a B0 unwarping is applied using the magnitude and phase images from the fieldmap acquisition. The correction direction is defined automatically (default is y).
- After B0 unwarping, a brain extraction is applied and a second estimation of the diffusion tensor is achieved for each voxel.

Imagen centers:

Imagen includes eight neuroimaging centers. Each center has its own specificities in term of scanner and sequences which are summarized in the following table:

id center	center	scanner	dti set	TE dti	B0 images	TE1 B0	TE2 B0	dwel time	dti resolution	B0 resolution
1	LONDON	GE	1	104	2	14.8	17.1	616	128x128x60	64x64x36
2	NOTTINGHAM	Philips	1	104	1	7.1	2.1	737	128x128x60	160x160x36
3	DUBLIN	Philips	1	104	1	~ 7.1	~ 2.1	~ 737	128x128x60	64x64x36
4	BERLIN	GE	3	~ 104	0	NA	NA	636	128x128x60	NA
4	BERLIN	Siemens	1	104	2	4.63	7.09	580	128x128x60	56x64x36
5	HAMBURG	Siemens	1	104	2	4.63	7.09	580	128x128x60	56x64x36
6	MANNHEIM	Siemens	1	104	2	4.63	7.09	580	128x128x60	56x64x36
7	PARIS	Siemens	1	~ 104	2	4.63	7.09	580	128x128x60	56x64x36
8	DRESDEN	Siemens	1	104	2	4.63	7.09	580	128x128x60	56x64x36

Input:

The general use is:

```
imagen_diffsl <mag> <phase> <dti> <center>
```

- o `mag` is the raw magnitude image from the fieldmap.
- o `phase` is the raw phase image from the fieldmap.
- o `dti` is the 4D image including the diffusion weighted images.
- o `center` is the center id between 1 and 8.

All images must be in ANALYZE, NIFTI or NIFTI.GZ and coming from XNAT. The reasons are the naming convention (000003726191s006a1001) and the reconstruction procedure (dcm2nii) used in XNAT.

For centers concatenating fieldmaps (magnitude and phase images in a 4D image) like Nottingham and Dublin, you may replace the magnitude with NA and the phase with the 4D image:

```
imagen_diffsl NA 000038429243s601a1006 000038429243s901a1009 2
```

For Berlin with three dti sets and without fieldmap from the GE scanner, you need to specify only the three dti images (no correction distortion is applied):

```
Imagen_diffsl 000021053574s006a1001 000021053574s007a1001 000021053574s008a1001 4
```

For Berlin with one dti set and with fieldmaps from the Siemens scanner, you need to specify 41 instead of 4 for the center id:

```
imagen_diffsl 000014178831s006a1001 000014178831s007a2001 0000014178831s016a1001 41
```

Output:

subject_mag	the raw magnitude image
subject_phase	the raw phase image
subject_phase_w	the wrapped phase image
subject_phase_uw	the unwrapped phase image
subject_phase_rads	the rad/sec phase image
subject_dti	the raw dti data
subject_dti.bval	the b values
subject_dti.bvec	the gradient directions
subject_dti_ecc	the eddy current corrected dti data
subject_dti_ecc_mask	the brain mask after eddy current correction
subject_dti_ecc_brain	the brain extracted and eddy current corrected dti data
subject_dti_ecc_brain_??	the diffusion measures from the first tensor estimation*
subject_dti_ecc_dc	the eddy current and distortion corrected dti data
subject_dti_ecc_dc_mask	the mask after eddy current and distortion correction
subject_dti_ecc_dc_brain	the brain extracted and distortion corrected dti data
subject_dti_ecc_dc_brain_??	the diffusion measures from the second tensor estimation*
subject_dti_ecc.log	transformation matrix during the affine registration
subject_dti_ecc.rotation	total angle rotation in radians and flag for 2 and 5 degrees
subject_dti_ecc_dc.log	cost values after distortion correction (smaller is better)
subject_dti_ecc_brain_tf.log	summary of the tensor fitting after eddy current correction
subject_dti_ecc_dc_brain_tf.log	summary of the tensor fitting after distortion correction

```

*:
_V1 - 1st eigenvector
_V2 - 2nd eigenvector
_V3 - 3rd eigenvector
_L1 - 1st eigenvalue
_L2 - 2nd eigenvalue
_L3 - 3rd eigenvalue
_RD - radial diffusivity
_MD - mean diffusivity
_FA - fractional anisotropy
_MO - mode of the anisotropy (oblate ~ -1; isotropic ~ 0; prolate ~ 1)
_S0 - raw T2 signal with no diffusion weighting

```

Examples:

```

imagen_diffsl (give the help text)
imagen_diffsl 000015059321s504a2001.nii.gz 000015059321s404a2001.nii.gz 000015059321s005a1001.nii.gz 1
imagen_diffsl NA 000038429243s601a1006.nii.gz 000038429243s901a1009.nii.gz 2
imagen_diffsl NA 000099104307s701a1007.nii.gz 000099104307s801a1008.nii.gz 3
imagen_diffsl 000021053574s006a1001.nii.gz 000021053574s007a1001.nii.gz 000021053574s008a1001.nii.gz 4
imagen_diffsl 000014178831s006a1001 .nii.gz 000014178831s007a2001.nii.gz 0000014178831s016a1001.nii.gz 41
imagen_diffsl 000005437200s004a1001.nii.gz 000005437200s005a2001.nii.gz 000005437200s007a1001.nii.gz 5
imagen_diffsl 00000642263s006a1001.nii.gz 00000642263s007a2001.nii.gz 00000642263s007a1001.nii.gz 6
imagen_diffsl 000061538083s004a1001.nii.gz 000061538083s005a2001.nii.gz 000061538083s012a1001.nii.gz 7
imagen_diffsl 000069867258s008a1001.nii.gz 000069867258s009a2001.nii.gz 000069867258s009a1001.nii.gz 8

```

Troubleshooting:

A “warning” can appear during the B0 mapping correction. In this case, the distortion correction is still applied in the y direction but the script did not find an improvement after correction. Those data need to be considered very carefully.

Availability:

The preprocessed data can be found in the Imagen database (<https://imagen.cea.fr>) under Data/Fsl/Tensor Fitting

Authorship:

Herve Lemaitre¹, Yannick Schwartz², Vincent Frouin² and Jean-Luc Martinot¹ have participated sufficiently in the processing to take authorship responsibility when these data are used.

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