
GUIDE TO
DIFFUSION CONNECTOME PIPELINE
(DCP)

MARCH 2023

STATE KEY LABORATORY OF COGNITIVE NEUROSCIENCE AND LEARNING
IDG/MCGOVERN INSTITUTE FOR BRAIN RESEARCH
BEIJING NORMAL UNIVERSITY, BEIJING, CHINA

Table of Contents

1	Installation	2
2	Procedure	2
2.1	Input Files	2
2.2	Preprocess	3
2.3	Parcellation	3
2.4	Tractography	3
2.4.1	Single-tensor fiber tracking	3
2.4.2	Multi-tensor fiber tracking	4
2.5	Network Construction	5
2.6	Matrix Merge	5
2.7	Network Analysis	6
2.8	General Setting	6
3	Output Files	6

1 Installation

- Environment: Matlab R2010b or higher
- Add DCP path to Matlab search path:
 - Click ‘Set Path’
 - Click ‘Add with Subfolders...’ button in the popup dialog
 - Select the ‘DCP’ folder on the machine
 - Click ‘OK’ button then Click ‘Save’ Button
- Add SPM12¹ path to Matlab search path
- Type ‘DCP’ in the command window of matlab

2 Procedure

2.1 Input Files

The input files must be organized into specified structure (Figure 1). Under the selected folder, each subject has one folder which includes two separate sub-folders for DTI and T1 files separately. In the right of the button ‘Select’, users can choose to process ‘All subjects’(default) or process specified subject by typing the sequence number of the subject(1 or 2 or 3...). If input dMRI data is in NifTI format, the required files and their

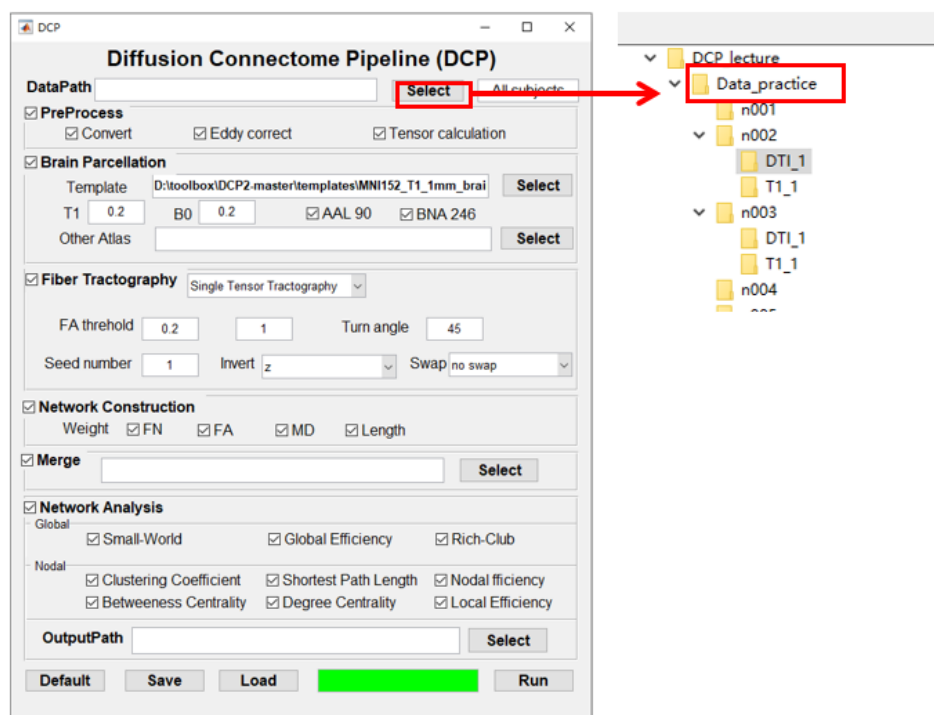


Figure 1: Organization of input files

¹<https://www.fil.ion.ucl.ac.uk/spm/>

names should be:

- *.bval, *.bvec, *.nii in DTI folder
- co*.nii in T1 folder

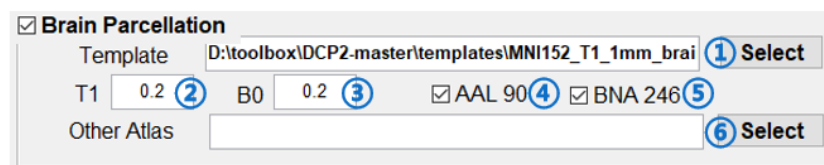
If the files are generated from FSL's bedpost, the '*.bedpostX' folder is needed. It is noted that the name of each subject's folder can't start with digit.

2.2 Preprocess

Preprocessing includes three steps: (1) converting DICOM to NIFTI; (2) eddy-current and head movement correction; and (3) computing diffusion tensor metrics. If users have dMRI data in NIFTI format, the 'convert' step can be skipped.

2.3 Parcellation

The instructions of parcellation are shown in Figure 2. If custom atlas is used, users should put the '.nii' file of the atlas under the '**templates**' folder which is under DCP folder.



- ① Select template used for normalization
- ② The threshold of t1 bet
- ③ The threshold of b0 bet
- ④ Use AAL 90 cortical regions atlas
- ⑤ Use BNA 246 cortical regions atlas
- ⑥ Use custom atlas which was warped to individual space

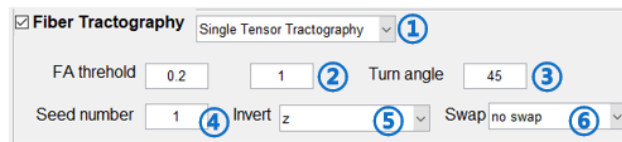
Figure 2: Instructions of parcellation

2.4 Tractography

Deterministic fiber tracking is used to reconstruct all possible fibers. Users can choose single-tensor or multi-tensor fiber tracking algorithm according to acquisition parameter of their data.

2.4.1 Single-tensor fiber tracking

The instructions of single-tensor fiber tracking are shown in Figure 3.



- ① Choose single/multiple tensor tractography
- ② Set FA threshold to select mask voxels
- ③ Set turning angle threshold to restrict tracking
- ④ Set number of random seed points in each voxel
- ⑤ Invert the orientation of bvecs to fit tracking
- ⑥ Invert the orientation of volume to fit tracking

Figure 3: Instructions of single-tensor tracking

2.4.2 Multi-tensor fiber tracking

If the files are generated from FSL's bedpost, multi-tensor fiber tracking should be chosen. Multi-tensor fiber tracking is performed by using *track* and *procstreamlines* command in Camino². Since Camino can only run on Linux OS, users need to call the command by Docker.

- Install **Docker Desktop**³.
- Pull and run the image by typing the command in cmd:

```
docker pull forsaint/docker_camino
docker run forsaint/docker_camino
```

If it succeeds, the 'forsaint/docker_camino' will appear in the local images on Docker Desktop (Figure 4).

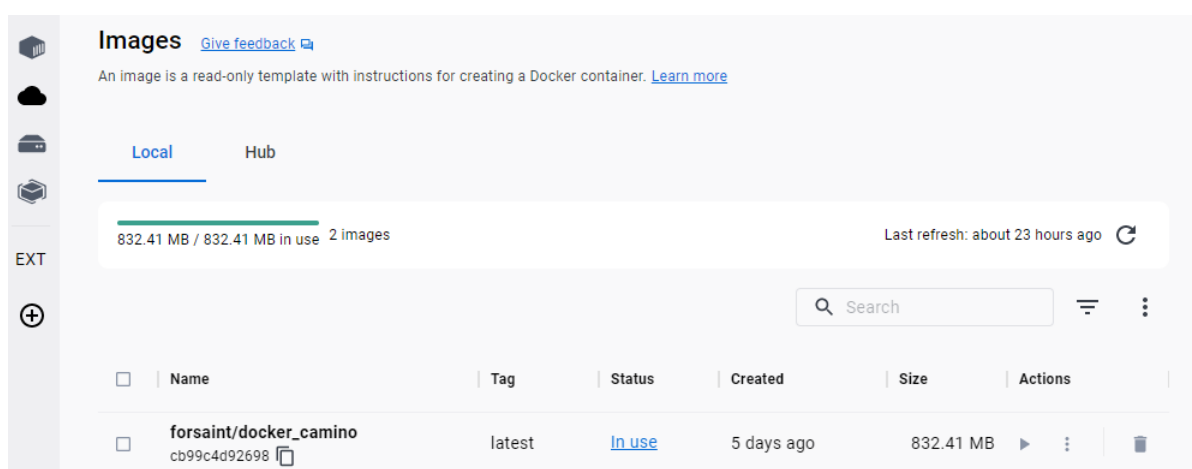
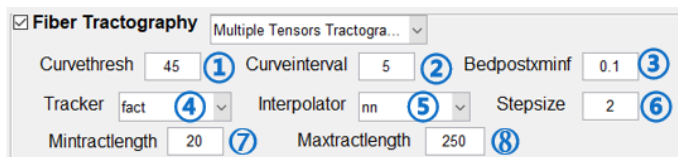


Figure 4: Docker image pulled successfully

²<http://camino.cs.ucl.ac.uk/>

³<https://docs.docker.com/desktop/>

The instructions of multi-tensor fiber tracking are shown in Figure 5.



- ①② Default parameters mean checking at 5mm intervals and terminate tracking if the curvature exceeds 45 degrees
- ③ Compartments where the mean_f is less than the threshold are discarded and not used for tracking
- ④ Set tracking algorithm
- ⑤ Set interpolator algorithm
- ⑥ Step size for euler and rk4 tracking
- ⑦ Streamlines shorter than Mintractlength mm will be discarded
- ⑧ Streamlines longer than Maxtractlength mm will be truncated

Figure 5: Instructions of multi-tensor tracking

2.5 Network Construction

The instructions of network construction are shown in Figure 6.

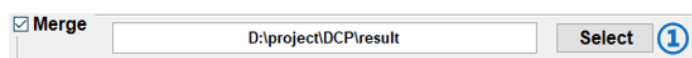


- ① Use fiber number as edge weight
- ② Use mean FA as edge weight
- ③ Use mean MD as edge weight
- ④ Use mean fiber length as edge weight

Figure 6: Instructions of network construction

2.6 Matrix Merge

In this step, the matrixes of all subjects will be merged into one single .mat file. The instructions of matrix merge are shown in Figure 7. The 'merge' step can't be executed alone without the boxes selected in 'network construction' step.

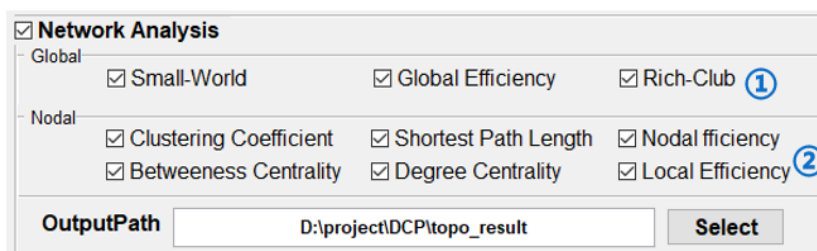


- ① Select the resultant file

Figure 7: Instructions of merge

2.7 Network Analysis

The instructions of network analysis are shown in Figure 8. The 'network analysis' step can't be executed alone without the path selected in merge step.



① Compute global topological properties of networks

② Compute nodal topological properties of networks

Figure 8: Instructions of network analysis

2.8 General Setting

The functions of buttons at bottom are shown in Figure 9. The subject names and status are shown in the green box. When 'finished' shows up, it means the pipeline finishes.



① Reset Defaults

② Save the configuration

③ Load the configuration

④ Monitor running process

⑤ Start running data

Figure 9: Instructions of buttons at bottom

3 Output Files

Under each subject's folder, three output folders named 'DCP_' are generated (Figure 10).

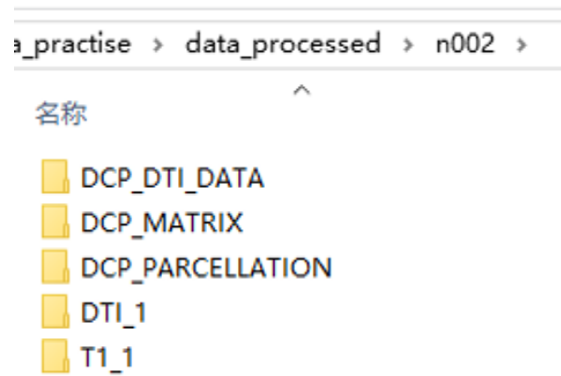


Figure 10: output folders

- DCP_DTI_DATA

If inputs are raw images in DICOM or NIfTI format, the files generated under DCP_DTI_DATA folder are shown in figure 11.

20210602_212407001Heads015a1001.bval	2023/3/1 12:01	BVAL 文件	1 KB
20210602_212407001Heads015a1001.bvec	2023/3/1 12:01	BVEC 文件	2 KB
20210602_212407001Heads015a1001.nii	2023/3/1 12:01	NII 文件	626,689 KB
bval	2023/3/1 12:02	文件	2 KB
bvec	2023/3/1 12:02	文件	4 KB
DATA_4D.nii	2023/3/1 12:02	NII 文件	1,253,377 KB
dti_45_0.2_1.trk	2023/3/1 12:38	Track File	216,413 KB
dti_adc.nii	2023/3/1 12:33	NII 文件	17,409 KB
dti_b0.nii	2023/3/1 12:33	NII 文件	8,705 KB
dti_dwi.nii	2023/3/1 12:33	NII 文件	8,705 KB
dti_e1.nii	2023/3/1 12:33	NII 文件	17,409 KB
dti_e2.nii	2023/3/1 12:33	NII 文件	17,409 KB
dti_e3.nii	2023/3/1 12:33	NII 文件	17,409 KB
dti_exp.nii	2023/3/1 12:33	NII 文件	17,409 KB
dti_fa.nii	2023/3/1 12:33	NII 文件	17,409 KB
dti_fa_color.nii	2023/3/1 12:33	NII 文件	13,057 KB
dti_tensor.nii	2023/3/1 12:33	NII 文件	104,449 KB
dti_tracker.log	2023/3/1 12:38	文本文档	1 KB
dti_v1.nii	2023/3/1 12:33	NII 文件	52,225 KB
dti_v2.nii	2023/3/1 12:33	NII 文件	52,225 KB
dti_v3.nii	2023/3/1 12:33	NII 文件	52,225 KB
eddy_bvec	2023/3/1 12:28	文件	4 KB
eddy_DATA_4D.nii.gz	2023/3/1 12:28	GZ 文件	1,082,443 KB
eddy_DATA_4D.txt	2023/3/1 12:27	文本文档	15 KB

Figure 11: Files in folder 'DCP_DTI_DATA'

20xxxHeadxxx.bval, .bvec, .nii: Converted files from DICOM images.

bval, bvec, DATA_4D.nii: b-value table and gradient direction table, 4D DWI volume series.

.trk: Result of single-tensor fiber tracking.

dti_XXX.nii: Results of diffusion tensor metrics calculation.

eddy_xxx: Results of eddy-current and head motion.

If inputs are bedpost files, the files generated under DCP_DTI_DATA folder are shown in figure 12.










 camino_bedpost_track	2023/2/28 23:04	文件	125,008 KB
 camino_bedpost_track_post	2023/2/28 23:05	文件	108,995 KB
 dti_adc.nii	2023/2/28 22:54	NII 文件	14,291 KB
 dti_adc.nii.gz	2021/7/18 1:11	GZ 文件	2,507 KB
 dti_b0.nii	2023/2/28 22:54	NII 文件	14,291 KB
 dti_b0.nii.gz	2021/7/18 1:11	GZ 文件	2,488 KB
 dti_fa.nii	2023/2/28 22:54	NII 文件	14,291 KB
 dti_fa.nii.gz	2021/7/18 1:11	GZ 文件	2,547 KB
 wm_mask_dti.nii	2023/2/28 22:56	NII 文件	3,573 KB

Figure 12: Files in folder 'DCP_DTI_DATA' for bedpost

camino_bedpost_track: Result of multi-tensor fiber tracking.

camino_bedpost_track_post: Post-processing of the tracts.

- DCP_PARCELLATION




























	bet_dti_b0.hdr	2023/3/1 12:35	HDR 文件	1 KB
	bet_dti_b0.img	2023/3/1 12:35	光盘映像文件	4,352 KB
	bet_dti_b0.nii	2023/3/1 12:35	NII 文件	4,353 KB
	bet_dti_b0_mask.hdr	2023/3/1 12:35	HDR 文件	1 KB
	bet_dti_b0_mask.img	2023/3/1 12:35	光盘映像文件	4,352 KB
	bet_dti_b0_mask.nii	2023/3/1 12:35	NII 文件	4,353 KB
	bet_T1.hdr	2023/3/1 12:35	HDR 文件	1 KB
	bet_T1.img	2023/3/1 12:35	光盘映像文件	4,866 KB
	bet_T1.nii	2023/3/1 12:36	NII 文件	4,866 KB
	c1rbet_T1.nii	2023/3/1 12:37	NII 文件	4,353 KB
	c2rbet_T1.nii	2023/3/1 12:37	NII 文件	4,353 KB
	c3rbet_T1.nii	2023/3/1 12:37	NII 文件	4,353 KB
	c4rbet_T1.nii	2023/3/1 12:37	NII 文件	4,353 KB
	c5rbet_T1.nii	2023/3/1 12:37	NII 文件	4,353 KB
	fdti_b0.hdr	2023/3/1 12:35	HDR 文件	1 KB
	fdti_b0.img	2023/3/1 12:35	光盘映像文件	8,704 KB
	fT1.hdr	2023/3/1 12:35	HDR 文件	1 KB
	fT1.img	2023/3/1 12:35	光盘映像文件	9,732 KB
	iy_rbet_T1.nii	2023/3/1 12:37	NII 文件	52,225 KB
	rbet_T1.nii	2023/3/1 12:36	NII 文件	4,353 KB
	rbet_T1_seg8.mat	2023/3/1 12:37	MATLAB Data	5,933 KB
	T1.nii	2023/3/1 12:01	NII 文件	9,732 KB
	T1_b0.tiff	2023/3/1 12:37	TIFF 文件	492 KB
	waal90.nii	2023/3/1 12:37	NII 文件	4,353 KB
	waal90_b0.tiff	2023/3/1 12:37	TIFF 文件	495 KB
	wBN246_1mm.nii	2023/3/1 12:37	NII 文件	4,353 KB
	wBN246_1mm_b0.tiff	2023/3/1 12:37	TIFF 文件	494 KB

Figure 13: Files in folder 'DCP_PARCELLATION'

bet_dti_b0*: Individual T1 image is coregistered to its corresponding individual b0 image and brain mask generates.

***bet_T1*:** Individual T1 image that is coregistered to the b0 image space is mapped into ICBM152 template, generating a nonlinear transformation matrix.

T1_b0.tiff, waal90*, wBN246*: Prior atlases in the standard space are warped to individual native dMRI space.

- DCP_MATRIX



















 waal90_dti_45_0.2_1.trk	2023/3/1 12:39	Track File	77,220 KB
 waal90_dti_45_0.2_1_dti_fa.mat	2023/3/1 12:39	MATLAB Data	16 KB
 waal90_dti_45_0.2_1_dti_fa.txt	2023/3/1 12:39	文本文档	127 KB
 waal90_dti_45_0.2_1_dti_md.mat	2023/3/1 12:39	MATLAB Data	16 KB
 waal90_dti_45_0.2_1_dti_md.txt	2023/3/1 12:39	文本文档	127 KB
 waal90_dti_45_0.2_1_FNum.mat	2023/3/1 12:39	MATLAB Data	5 KB
 waal90_dti_45_0.2_1_FNum.txt	2023/3/1 12:39	文本文档	127 KB
 waal90_dti_45_0.2_1_Length.mat	2023/3/1 12:39	MATLAB Data	17 KB
 waal90_dti_45_0.2_1_Length.txt	2023/3/1 12:39	文本文档	127 KB
 wBN246_1mm_dti_45_0.2_1.trk	2023/3/1 12:40	Track File	66,246 KB
 wBN246_1mm_dti_45_0.2_1_dti_fa.mat	2023/3/1 12:40	MATLAB Data	43 KB
 wBN246_1mm_dti_45_0.2_1_dti_fa.txt	2023/3/1 12:40	文本文档	947 KB
 wBN246_1mm_dti_45_0.2_1_dti_md.mat	2023/3/1 12:40	MATLAB Data	42 KB
 wBN246_1mm_dti_45_0.2_1_dti_md.txt	2023/3/1 12:40	文本文档	947 KB
 wBN246_1mm_dti_45_0.2_1_FNum.mat	2023/3/1 12:40	MATLAB Data	12 KB
 wBN246_1mm_dti_45_0.2_1_FNum.txt	2023/3/1 12:40	文本文档	947 KB
 wBN246_1mm_dti_45_0.2_1_Length.mat	2023/3/1 12:40	MATLAB Data	45 KB
 wBN246_1mm_dti_45_0.2_1_Length.txt	2023/3/1 12:40	文本文档	947 KB

Figure 14: Files in folder 'DCP_MATRIX'

waal90xxx_fa: Matrix constructed with aal90 atlas and using FA as edge weight.

waal90xxx_md: Matrix constructed with aal90 atlas and using MD as edge weight.

waal90xxx_FNum: Matrix constructed with aal90 atlas and using fiber number as edge weight.

waal90xxx_Length: Matrix constructed with aal90 atlas and using fiber length as edge weight.

wBN246xxx: Matrix constructed with BN246 atlas, same as aal90 atlas.