

# MriCloud DTI Processing Pipeline

## 1: Data Upload

### 1-1: Web interface

DTI processing can be initiated by choosing “DTI Processing” in the top menu bar.

BrainGPS Home Segmentation ▾ **DTI Processing** surface mappings ▾ My job status Data Sources About Terms Contact Signout

### DTI Mapping

Warning: Due to limited storage space, all jobs and their results will be deleted from our server after 60 days from submission date, please download results in time.

Warning: All visualization in MriCloud follows the Radiology convention: the image left is the patient right. We are aware of inconsistency in the definitions of image orientations in DICOM, Analyze, and other file types. We guarantee the right-left orientation ONLY WHEN the raw DICOM files FROM scanners (not from PACS and other data archiving systems) are converted to the 4D Raw-Image format using the programs we offer for Windows OS. Click [here](#) to download the program. This software extract the images and created a 4D raw image matrix. In addition, Data Parameter File (.dpf) is created to keep the image parameter information, which is in the ASCII format. If the data are exported from other software or the images are touched by external software during the preparation, the users have the responsibility to identify the right-left orientation, regardless of our labeling. This can be done by inspecting the images in our output files and compare them with another visualization program you trust, preferably the scanner vendors' console or workstations. One important option in this conversion program is if the gradient table should be rotated based on oblique scan parameters. Whether this option needs to be activated could depend on the scanner type, the operating system, and the DICOM version. The best way to judge is to scan DTI with a severely oblique angle and see the impact of the option.

**Upload zip file**

To start over, refresh the page

**+ Zip**

**Files selected**

**SELECT FILE FORMAT**

4D-Image & Diffusion parameter file (.dpf/.raw) ▾

**SELECT PROCESS TYPE**

Image QC + DTI Mapping ▾

**SELECT PROCESSING SERVER**

Computational Anatomy Science Gateway ▾

**DESCRIPTION**

write job description here

**Progress**

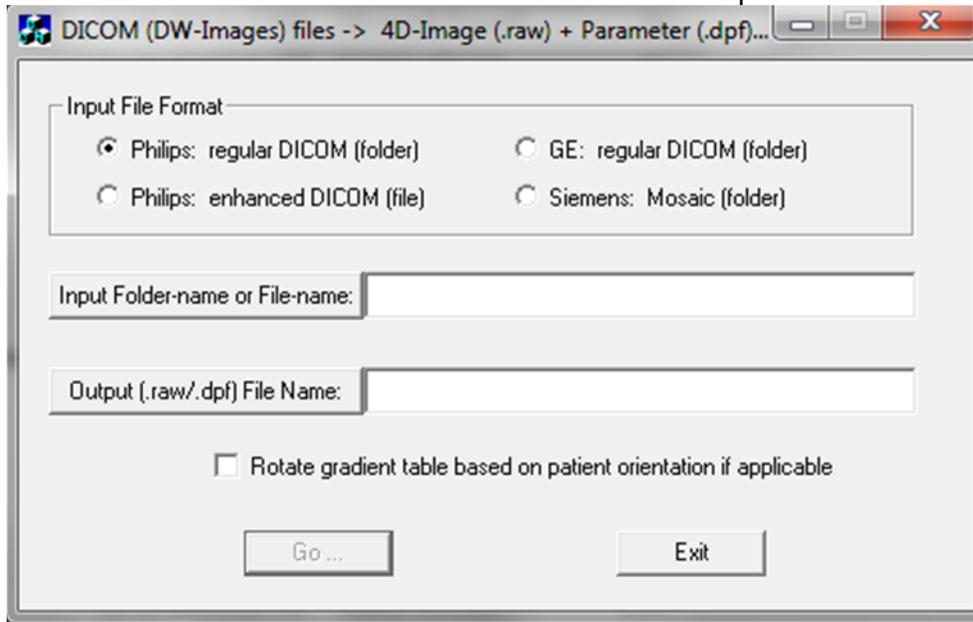
Submit

To avoid any HIPPA issues, data need to be first converted to a raw data format with a parameter file called Data Parameter File (.dpf). For this conversion, a local executable file can be downloaded from this web page by clicking “here” in the top description section. This executable is called “DwiDcm2DpfRaw.exe.” This conversion eliminates all personal IDs from the file. Also, this conversion works only for DICOM files directly from scanners. Many PACSs and other third-party software modify the DICOM format and thus they are not supported.

In this page, you can see that there are several option items for data format, data processing, and computation servers but at this moment, no selections are provided (only one option can be selected in each pull-down menu).

### 1-2: Data preparation in local computers

The screenshot below shows the interface of DwiDcm2DpfRaw.exe.



We assume that all DICOM files of raw diffusion-weighted images (DWIs) are stored in one directory. Only one of the DICOM files needs to be specified and all files within the same directory are automatically read. The output files are a raw image file (\*.raw) and a parameter file (\*.dpf).

If there are more than two repeated DTI data, stored in separate directories, they need to be combined. In any case, the data in each directory need to be converted separately. In an example below, two sets of DICOM files stored in two separate directories were converted to 601.raw/601.dpf and 701.raw/701.dpf files. To combine them, one of the dpf files needs to be manually modified. For example, the contents of the 601.dpf are (this is automatically generated by DwiDcm2DpfRaw.exe);

---

Begin

```
ImageWidth: 256  
ImageHeight: 256  
ImageSlices: 70
```

```
ProcSliceStart: 0  
ProcSliceEnd: 69
```

```
FieldOfView(X): 212.0000  
FieldOfView(Y): 212.0000  
SliceThickness: 2.2000
```

```
B-Value: 700
```

```
SwapBytes: No  
ImgNoiseLevel: 10
```

```
Begin_Of_Gradient_Table
```

```
0: 0.000000, 0.000000, 0.000000  
1: -0.978747, 0.198562, -0.051255  
2: -0.201929, -0.976746, 0.072049  
3: -0.035757, 0.080867, 0.996083  
4: 0.100129, 0.023255, -0.994696  
5: -0.096230, 0.152618, -0.983535
```

6: -0.160238, 0.127393, -0.978866  
7: -0.331720, -0.027696, -0.942915  
8: -0.229307, -0.401323, -0.886819  
9: -0.034654, -0.880897, -0.472052  
10: 0.179059, -0.363184, -0.914409  
11: 0.488783, -0.299203, -0.819537  
12: 0.168451, 0.547780, -0.819484  
13: 0.781784, -0.056217, -0.621032  
14: 0.700209, -0.509669, -0.500005  
15: 0.002314, -0.966216, -0.257892  
16: 0.771895, 0.229139, -0.592951  
17: -0.840693, -0.339238, -0.422081  
18: -0.870490, 0.254967, -0.421094  
19: -0.287928, 0.807178, -0.515388  
20: -0.809282, 0.325019, -0.489338  
21: -0.812719, -0.565379, -0.140791  
22: -0.365158, -0.741186, -0.563326  
23: -0.148155, -0.958531, 0.243470  
24: 0.360617, -0.932424, -0.025302  
25: 0.996607, -0.082461, 0.000004  
26: 0.962654, -0.270243, 0.018448  
27: 0.760943, -0.648408, -0.021841  
28: 0.045685, -0.940303, 0.337094  
29: -0.314395, -0.949154, 0.018486  
30: -0.515431, -0.720788, 0.463473  
31: -0.691326, -0.706981, 0.149337  
32: -0.984777, 0.139608, -0.104010  
33: 100.000000, 100.000000, 100.000000

End\_Of\_Gradient\_Table

InputImgFile:

C:\Data\1001\_140116\_11\_3\_2014\_17\_39\_19\1001\_140116\SCANS\Image4D\_601.raw

InputImgOrder: Gradient\_By\_Gradient

OutFileTensor: Tensor.dat

OutFileRefB0: RefB0.dat

OutFileMeanDwi: MeanDwi.dat

OutFileEigenVal0: EgVal0.dat

OutFileEigenVal1: EgVal1.dat

OutFileEigenVal2: EgVal2.dat

OutFileEigenVec0: EgVec0.dat

OutFileEigenVec1: EgVec1.dat

OutFileEigenVec2: EgVec2.dat

OutFileFA: FaMap.dat

OutFileRA: RaMap.dat

OutFileVR: VrMap.dat

OutFileColorMap0: ColorMap0.dat

OutFileColorMap1: ColorMap1.dat

OutFileColorMap2: ColorMap2.dat

End

---

To combine the 601.raw and 701.raw, a new line (indicated by a red color) has to be added;

---

Begin

ImageWidth: 256  
ImageHeight: 256  
ImageSlices: 70

ProcSliceStart: 0  
ProcSliceEnd: 69

FieldOfView(X): 212.0000  
FieldOfView(Y): 212.0000  
SliceThickness: 2.2000

B-Value: 700

SwapBytes: No  
ImgNoiseLevel: 10

Begin\_Of\_Gradient\_Table

0: 0.000000, 0.000000, 0.000000  
1: -0.978747, 0.198562, -0.051255  
2: -0.201929, -0.976746, 0.072049  
3: -0.035757, 0.080867, 0.996083  
4: 0.100129, 0.023255, -0.994696  
5: -0.096230, 0.152618, -0.983535  
6: -0.160238, 0.127393, -0.978866  
7: -0.331720, -0.027696, -0.942915  
8: -0.229307, -0.401323, -0.886819  
9: -0.034654, -0.880897, -0.472052  
10: 0.179059, -0.363184, -0.914409  
11: 0.488783, -0.299203, -0.819537  
12: 0.168451, 0.547780, -0.819484  
13: 0.781784, -0.056217, -0.621032  
14: 0.700209, -0.509669, -0.500005  
15: 0.002314, -0.966216, -0.257892  
16: 0.771895, 0.229139, -0.592951  
17: -0.840693, -0.339238, -0.422081  
18: -0.870490, 0.254967, -0.421094  
19: -0.287928, 0.807178, -0.515388  
20: -0.809282, 0.325019, -0.489338  
21: -0.812719, -0.565379, -0.140791  
22: -0.365158, -0.741186, -0.563326  
23: -0.148155, -0.958531, 0.243470  
24: 0.360617, -0.932424, -0.025302  
25: 0.996607, -0.082461, 0.000004  
26: 0.962654, -0.270243, 0.018448  
27: 0.760943, -0.648408, -0.021841  
28: 0.045685, -0.940303, 0.337094  
29: -0.314395, -0.949154, 0.018486  
30: -0.515431, -0.720788, 0.463473  
31: -0.691326, -0.706981, 0.149337  
32: -0.984777, 0.139608, -0.104010  
33: 100.000000, 100.000000, 100.000000

End\_Of\_Gradient\_Table

```
InputImgFile:  
C:\Data\1001_140116_11_3_2014_17_39_19\1001_140116\SCANS\Image4D_601.raw  
C:\Data\1001_140116_11_3_2014_17_39_19\1001_140116\SCANS\Image4D_701.raw
```

```
InputImgOrder: Gradient_By_Gradient
```

```
OutFileTensor: Tensor.dat  
OutFileRefB0: RefB0.dat  
OutFileMeanDwi: MeanDwi.dat
```

```
OutFileEigenVal0: EgVal0.dat  
OutFileEigenVal1: EgVal1.dat  
OutFileEigenVal2: EgVal2.dat
```

```
OutFileEigenVec0: EgVec0.dat  
OutFileEigenVec1: EgVec1.dat  
OutFileEigenVec2: EgVec2.dat
```

```
OutFileFA: FaMap.dat  
OutFileRA: RaMap.dat  
OutFileVR: VrMap.dat
```

```
OutFileColorMap0: ColorMap0.dat  
OutFileColorMap1: ColorMap1.dat  
OutFileColorMap2: ColorMap2.dat
```

```
End
```

---

After this modification, 601.raw, 701.raw, and 601.dpf are zipped and ready for data upload.

One important option is “Rotate gradient table.” It is very difficult to provide a definite answer about whether this option needs to be checked or not because it varies depending on the manufacturers, file formats, and versions. Our experience with Siemens and Philips so far suggested that they need to be checked. We advise to perform a test in which severe oblique angle is applied.

### **1-3: Data upload**

Data can be uploaded through “+Zip” button.

### **1-4: Data download**

Once the job is completed, the results are ready for download through “MyJobStatus.”

BrainGPS Home Segmentation DTI Processing surface mappings My job status Data Sources About Terms Contact Signup

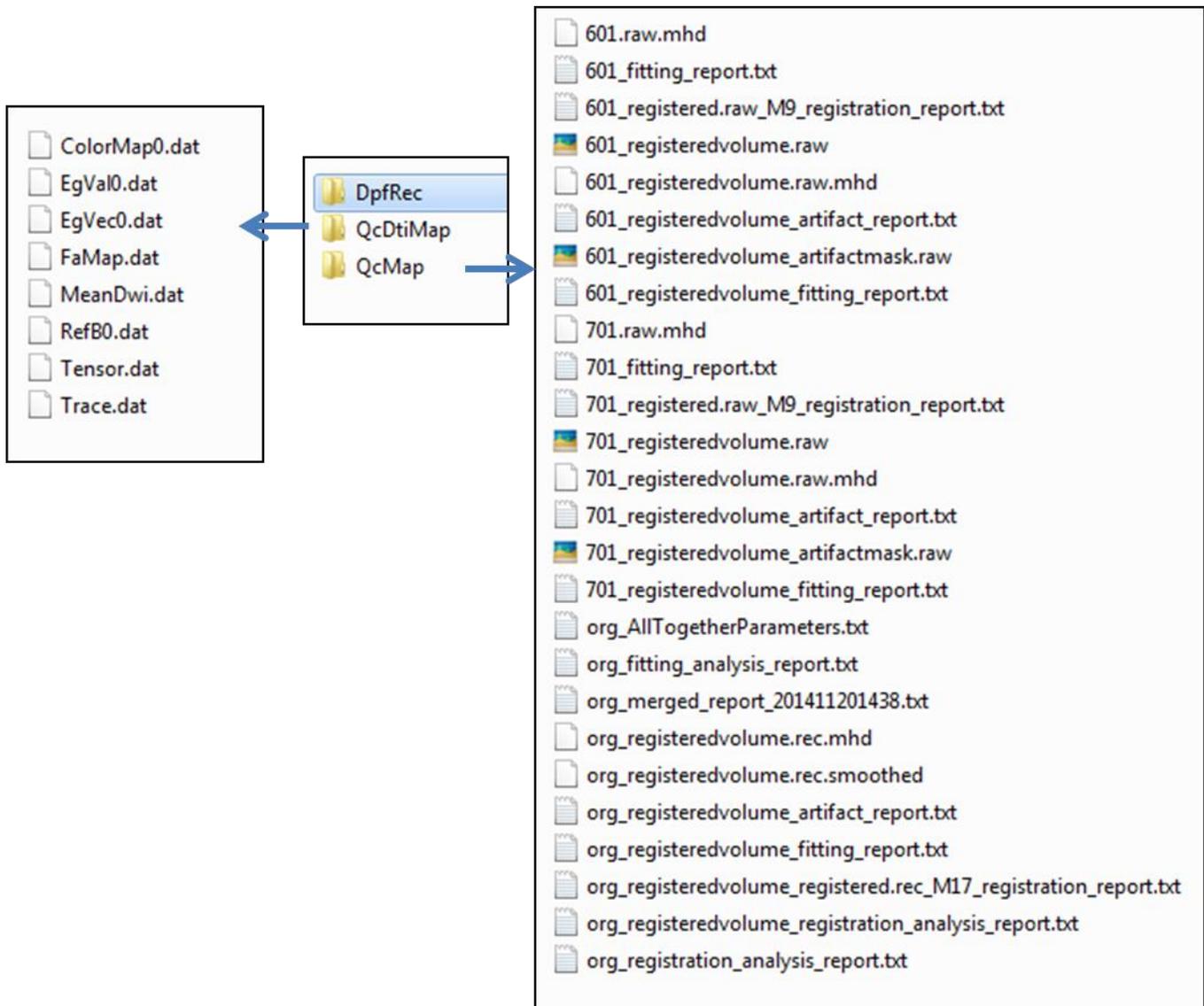
**JOB STATUS**  
Warning: Due to limited storage space, all jobs and their results will be deleted from our server after 60 days from submission date, please download results in time.

**LIST OF YOUR JOBS** 6

ID	Submission Date	Job Type	Description	Status	Action	Delete
395	2014-10-01 23:34:30 UTC	T1PreProcessing	Elderly#21	finished	<a href="#">Download Result</a> <a href="#">View result</a>	<a href="#">Delete</a>
412	2014-10-07 13:33:26 UTC	T1PreProcessing		finished	<a href="#">Download Result</a> <a href="#">View result</a>	<a href="#">Delete</a>
473	2014-10-15 19:08:05 UTC	T1PreProcessing	#618	finished	<a href="#">Download Result</a> <a href="#">View result</a>	<a href="#">Delete</a>
477	2014-10-16 18:57:38 UTC	T1PreProcessing		finished	<a href="#">Download Result</a> <a href="#">View result</a>	<a href="#">Delete</a>
482	2014-10-27 19:43:54 UTC	T1PreProcessing		finished	<a href="#">Download Result</a> <a href="#">View result</a>	<a href="#">Delete</a>
495	2014-11-20 19:22:33 UTC	DTISeg	Test601_701	finished	<a href="#">Download Result</a>	<a href="#">Delete</a>

MriCloud  
Site created by AnatomyWorks. All Rights Reserved 2014

The following figure shows the structure of downloaded files;



There are three directories;

- DpfRec: This contains the submitted data.

- QcDtiMap: This contains the calculated DTI-derived images.
- QcMap: This contains intermediate files and quality control reports.

From “Tensor.dat” file in QcDtiMap, various tensor-derived images such as FA, color, and vector maps can be created in local computers, while most widely used images are already included in QcDtiMap. To generate other types of measures such as radial and axial diffusivity, “Tensor.dat” can be read by DtiStudio and various images are generated and saved.

## 1-5: QC reports

QcMap contains “\*\_registeredvolume.raw”, which are images after registration. There are several important features in the QC pipeline.

Registration and registration error reports: The registration is based on 9-mode affine transformation, in which both 6-mode rigid motion and 3-mode gradient-dependent Eddy-current distortion are simultaneously fitted and estimated using the normalized mutual information as the cost function. The detail is provided in [1]. Based on this registration, motion (translation and rotation) and Eddy current (X, Y, Z, and B0 components) are estimated and reported. The files that report these errors are “\*\_registration\_analysis\_report.txt” In this processing, the gradient vector for each diffusion-weighted image is also rotated with the subject motion.

Voxel rejection: Voxels with outlier intensities during tensor fitting are automatically rejected. “\*\_registdvolume\_artifactmask.raw” reports locations of all voxels that are rejected. From this file, a probabilistic map of voxel-by-voxel rejection rates can be calculated. Statistic summaries such as the slice-by-slice number of rejected voxels are reported in “\*\_registeredvolume\_artifact\_report”. In addition, if the number of rejected voxels reaches 5% of the size of the slice, the entire slice is rejected. The detail of outlier rejection is provided in [2].

Fitting quality report: The report of motion such as translation and rotation is accurate only when the post-processing registration works. In reality, when images are suffered from excessive motion, the image quality corrupts and the registration quality would be poor. In this case, the registration report is not reliable to judge the data quality. Therefore, we included report of tensor fitting quality before and after image registration. The table summary is provided in xxx\_registeredvolume\_fitting\_report.txt and xxx\_registeredvolume\_fitting\_report.txt.

## 1-6: Off-line population QC reports

As described above, each data carries a large amount of QC reports. In reality, the reported values such as motion (translation, rotation), eddy current, the number of rejected voxels, and fitting quality, are interpretable only after population data are acquired, from which outliers can be detected. We provide a MatLab code that read the QC reports from all subjects within a study and perform population-based analysis and outlier detection. This code is still being developed and your feedback would be appreciated.

[1] Penny W, et al., Statistical Parametric Mapping: The Analysis of Functional Brain Images, 1st Edition, Elsevier 2006.

[2] Li Y., et al., Image Corruption Detection in Diffusion Tensor Imaging for Post-Processing and Real-Time Monitoring PLOS ONE 2013; 8(10): e49764.