Description of files included with

Simulated DW-MRI Brain Data Sets for Quantitative Evaluation of Estimated Fiber Orientations

This file accompanies the NITRC project 'Simulated DW-MRI Brain Data Sets for Quantitative Evaluation of Estimated Fiber Orientations' (http://www.nitrc.org/projects/sim_dwi_brain) and describes the format of the data available for download.

- *If you make use of this work, please cite the articles listed in "References.pdf"*

Summary

This project contains anatomical (T_1-weighted SPGR) and diffusion-weighted (DWI) data sets, as well as supplementary files (DWI brain mask, and ground-truth of fiber orientations), text files listing DWI gradient directions, and MATLAB scripts (.m files) for evaluating estimated fiber orientations. The image data is provided in NIfTI (.nii) file format and is compatible with tools such as FSL, MRtrix, ITK-SNAP, AFNI, and DSI Studio.

- When using such programs to process DWI data, sometimes it will be necessary to re-format the gradient direction table and/or 'flip' (multiply by -1 the x, y, z values given) one or more gradient directions in accordance with the convention of axes (e.g. positive is to the) used by the program.

- The ground-truth of fiber orientations is given in two files: gndTruth_fiberMap.nii (number of fibers per voxel) and gndTruth_fiberDir.nii (x, y, z components of up to 3 fiber orientation vectors per voxel).

- For details of the ground-truth and diffusion model used to generate the synthetic data, refer to the document "Ground-truth and Data Synthesis.pdf".

- Evaluating estimated fiber orientations with the MATLAB scripts is documented separately in "Quantitative Evaluation.pdf".

- For reading/writing NIfTI files with MATLAB, the "Tools for NIfTI and ANALYZE image in MATLAB" toolbox (http://www.mathworks.com/matlabcentral/fileexchange/8797 or http://research.baycrest.org/~jimmy/NIfTI/) by Jimmy Shen is recommended.

Coordinate System

Whenever physical coordinates (x, y, z) are referred to, the convention used throughout is:

+x is Left → Right
+y is Posterior → Anterior
+z is Inferior → Superior

This is sometimes referred to as "Neurological" convention, written (+x, +y, +z) = RAS.

Data set matrix/voxel sizes
All data is given as multi-dimensional arrays stored as NIfTI files. The first 3 dimensions are spatial (x, y, z) and remaining dimension (if any) is file specific.

- Anatomical: matrix size (166 x 256 x 256), voxel size (1.0 x 1.0 x 1.0) mm
- DWI: matrix size (128 x 128 x 60 x n), voxel size (2.4 x 2.4 x 2.4) mm
- brainMask: matrix size (128 x 128 x 60), voxel size same as DWI
- Ground-truth fiberMap: matrix and voxel size same as brainMask
- Ground-truth fiberDir: matrix size (128 x 128 x 60 x 9), voxel size same as DWI
- Volume Fractions: Free diffusion compartment (f_0) and fiber compartment (f_1, f_2, f_3) fractions: matrix and voxel size same as brainMask

Brain mask: brainMask.tar.gz
Binary mask with same matrix, voxel size, coordinate system as DWI volumes, can be used to select only the brain region of the DWI data for analysis.

Diffusion gradient directions: gradientFiles.tar.gz
Contains text files listing the diffusion gradient directions; individual files are named:

*nnn*_GradDir_*zz*B0.txt

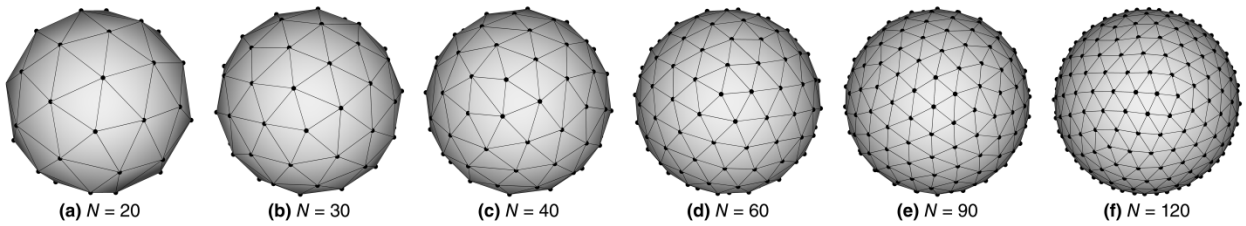
where *nnn* = number of diffusion-weighted gradient directions (20, 30, 40, 60, 90, 120); see below.
zz = number of non-diffusion weighted (b-zero) volumes (one b-zero volume for every 10 diffusion-weighted volumes).

In each text file, each row gives the diffusion gradient direction (g_x, g_y, g_z) and b-value (in s/mm^2) as:

g_x g_y g_z b-value

The b-zero volumes are listed first, followed by the diffusion-weighted volumes.

The six diffusion sampling patterns are illustrated below.



Ground-truth of fiber orientations: groundTruth.tar.gz
Contains two files: gndTruth_fiberMap.nii and gndTruth_fiberDir.nii define the ground-truth of fiber orientations and can be used for quantitative evaluation of estimated fiber orientations using the MATLAB scripts (see "Quantitative Evaluation.pdf" for how to do this).

gndTruth_fiberMap.nii The number of fibers (either 1, 2, or 3) in each voxel in the ground-truth.

gndTruth_fiberDir.nii The (x, y, z) components of the fiber orientation vectors given in the order (x_1, y_1, z_1, x_2, y_2, z_2, x_3, y_3, z_3). In case of fewer than 3 fibers per voxel, the second and/or third vector components are zero.

Quantitative evaluation: volumeFractions.tar.gz

Contains two files: freeFraction.nii (3D data set) and fiberFraction.nii (4D data set) which are the volume fractions of the free (isotropic) diffusion compartment (f_0), and the individual fibers (f_1, f_2, f_3), respectively. Refer to the diffusion signal model in "Ground-truth and Data Synthesis.pdf" for complete details. Specifically note that $\sum_{k=1}^{3} f_k = 1$ and so when accommodating a free diffusion compartment these fractions are intended to be used in the signal model such that $f_0 + (1 - f_0) \sum_{k=1}^{3} f_k$

The volume fractions are *not* required for any data analysis or quantitative comparison performed by the software tools. They are provided to enable generation of your own synthetic data (using the ground-truth fiber direction information) with your own custom diffusion models and/or parameters to synthesize the diffusion-weighted signal.

Synthetic diffusion-weighted data: Trial_*tt*.tar.gz

- Each Trial_*tt*.tar.gz file is almost 4GB in size as it contains 18 DW data sets.

Each Trial_*tt*.tar.gz file (where *tt* is the number, 1—10) is one set of synthetic image data; each set of data is identical except the noise realization. One can pool the results of analysis of each trial so there is greater evaluation of the effect of noise.
The file Trial_*tt*.tar.gz file contains 18 diffusion-weighted data sets with file name:

SimDWI_SNR*ss*_GradDir*nnn*_B*zzz*_T*tt*.nii

Where *ss* is the SNR of the simulated data (9, 18 or 36)
nnn is the number of diffusion-gradient directions (20, 30, 40, 60, 90 or 120)
zz is the number of b-zero volumes (one b-zero for every 10 diffusion-gradient directions)
tt is the trial number

For example, Trial_01.tar.gz will contain the files:

SimDWI_SNR09_GradDir020_Bz02_T01.nii
SimDWI_SNR09_GradDir030_Bz03_T01.nii
SimDWI_SNR09_GradDir040_Bz04_T01.nii
SimDWI_SNR09_GradDir060_Bz06_T01.nii
SimDWI_SNR09_GradDir090_Bz09_T01.nii
SimDWI_SNR09_GradDir120_Bz12_T01.nii

SimDWI_SNR18_GradDir020_Bz02_T01.nii
SimDWI_SNR18_GradDir030_Bz03_T01.nii
SimDWI_SNR18_GradDir040_Bz04_T01.nii
SimDWI_SNR18_GradDir060_Bz06_T01.nii
SimDWI_SNR18_GradDir090_Bz09_T01.nii
SimDWI_SNR18_GradDir120_Bz12_T01.nii

SimDWI_SNR36_GradDir020_Bz02_T01.nii
SimDWI_SNR36_GradDir030_Bz03_T01.nii
SimDWI_SNR36_GradDir040_Bz04_T01.nii
SimDWI_SNR36_GradDir060_Bz06_T01.nii
SimDWI_SNR36_GradDir090_Bz09_T01.nii
SimDWI_SNR36_GradDir120_Bz12_T01.nii

Quantitative evaluation: quantitativeEval.tar.gz
MATLAB scripts for quantitative evaluation of fiber estimation results. See "Quantitative Evaluation.pdf" for complete details.