Quantitative Evaluation procedure for

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

Quantitative Evaluation

This document provides a procedure for using the data sets and MATLAB scripts contained in this project for quantitative evaluation of analyzed data. After processing any of the data sets provided (available in files Trial_*tt*.tar.gz) using a DW-MRI analysis method of your choice, you can use the procedure described here to obtain the following quantitative results of your analyzed data (with respect to the ground-truth of fibers):

1) Estimated fiber orientation errors (in degrees), and
2) False-positive (spurious fibers) and false-negative (missing fibers) rates.

See the document "QuantitativeMetrics.pdf" for details of the metrics.

The MATLAB scripts generate and save figures (as .png files) and results (as MATLAB .mat files) to aid further analysis.

The results of your DW-MRI analysis must be converted to two NIfTI format files:

1. <sourcePrefix>_fiberMap.nii (containing the number of fibers estimated in each voxel), and
2. <sourcePrefix>_fiberDir.nii (containing the estimated fiber orientations).

The format of these files, and encoding the estimated fiber directions, must be identical to that of the ground-truth files – see the relevant section of "Contents of sim_dwi_brain.pdf" for details.

Getting Started

1) Download "quantitativeEval.tar.gz" from the "Downloads" page of the project's NITRC website and extract the files. This package contains the ground-truth of fiber orientations, example analyzed data (files: exResults_fiberMap.nii and exResults_fiberDir.nii), and the required MATLAB .m scripts.

2) Download and add to your MATLAB path the following utilities, available from MATLAB Central:

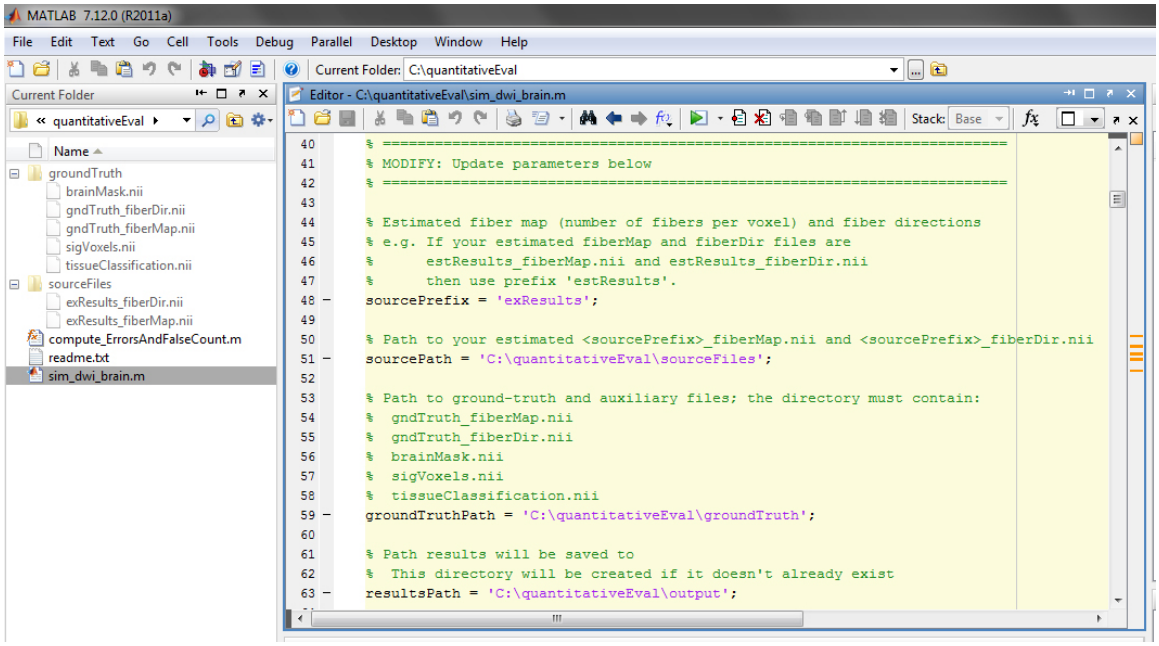
    a. "Tools for NIfTI and ANALYZE image" by Jimmy Shen for reading NIfTI files. http://www.mathworks.com/matlabcentral/fileexchange/8797

    b. "Remove Outliers" by M Sohrabinia for removing outliers from data that would otherwise significantly skew results. http://www.mathworks.com/matlabcentral/fileexchange/37211

    c. "export_fig" by Oliver Woodford for saving MATLAB figures to PNG files. http://www.mathworks.com/matlabcentral/fileexchange/23629-exportfig

3) Edit “sim_dwi_brain.m” to indicate the filenames and directories for your data. To run the analysis on the example results provided, only the variables for directories need to be changed.

   An example of the MATLAB window is below.



Analyzing Results

Run the script “sim_dwi_brain.m”; the script will pause once the figures are displayed, and you will be prompted to press a key to continue. For the default values and example results, the output in MATLAB should be:

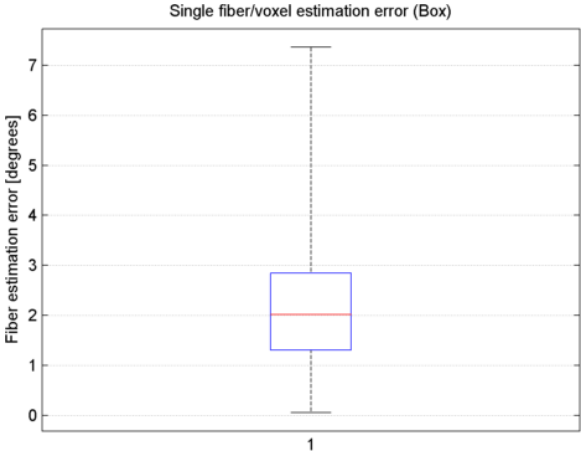
```
Loading all NIfTI data sets...done!
Select voxels in ground-truth for evaluation...done!
Initialization of data structures...done!
Computing fiber estimation errors...done!
Fiber estimation summary...

fiberEstSummary =

           0          0          0          0          0          0
           1       1383          0       1382          1          0
           2       9692          0       8233       1401         58
           3       1457          0       1225        197         35

Collating quantitative results...done!
Plot figures...done!
Press any key to continue...
Saving images...done!
Saving results to .mat file...done!

*** EVALUATION COMPLETE !!! ***
```

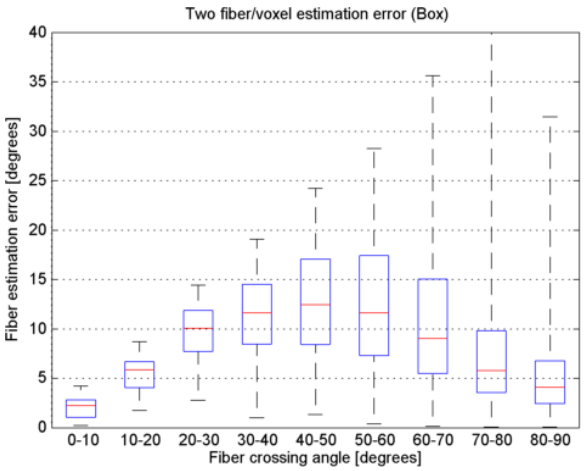
The ‘fiberEstSummary’ matrix (above) should be interpreted row-wise, with each row corresponding to voxels with 0, 1, 2, or 3 fibers in the ground-truth, respectively (as indicated in Column 1). The columns, left-to-right, are:

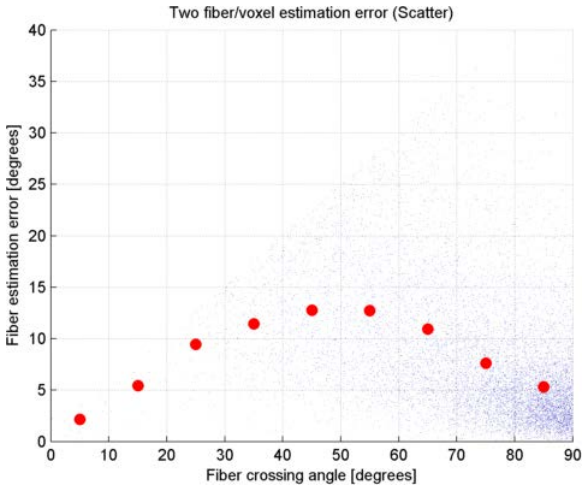
- Column 1: Number of fibers/voxel (0, 1, 2, or 3).
- Column 2: Number of voxels in the ground-truth having ‘number of fibers/voxel’ indicated by column 1.
    - Ex: There are 9692 voxels in the ground-truth containing 2 fibers.
- Column 3—6: Number of voxels with 0, 1, 2, or 3 fibers/voxel, respectively, in the analyzed data.
    - Ex: Of the 9692 voxels containing 2 fibers in the ground-truth, the corresponding voxels in the analyzed data had 8233 voxels with 1 fiber, 1401 voxels with 2 fibers and 58 voxels with 3 fibers.
    - For each row, the sum of columns 3 to 6 should equal the corresponding value in column 2.

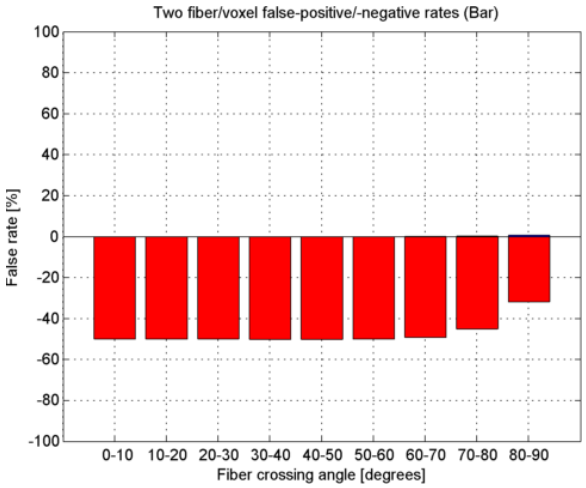
From the ‘fiberEstSummary’ matrix one can determine the number of false-positives and false-negatives.

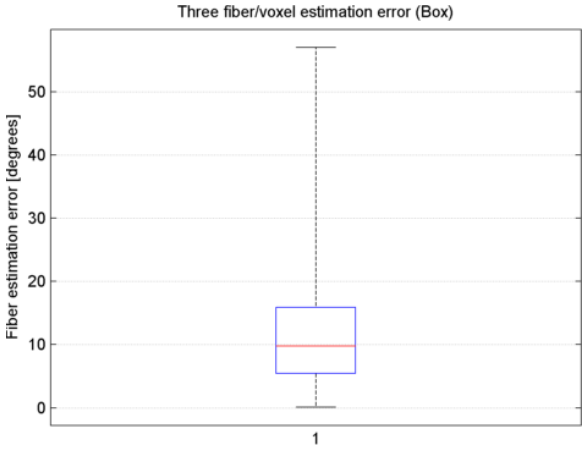
Figures produced by analysis of the example results:






Two fiber/voxel estimation error (Scatter)
Fiber estimation error [degrees]
Fiber crossing angle [degrees]
0
5
10
15
20
25
30
35
40
0
10
20
30
40
50
60
70
80
90


Two fiber/voxel false-positive/-negative rates (Bar)
False rate [%]
Fiber crossing angle [degrees]
100
80
60
40
20
0
-20
-40
-60
-80
-100
0-10
10-20
20-30
30-40
40-50
50-60
60-70
70-80
80-90


Three fiber/voxel estimation error (Box)
Fiber estimation error [degrees]
0
10
20
30
40
50
1