

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

Quantitative metrics

Analyzed data sets can be evaluated against the ground-truth in terms of fiber orientation error, rate of spurious fibers (false-positives), and rate of missing true fibers (false-negatives). The fiber orientation and false rate metrics are consistent with those used in (Daducci et al., 2014).

Individual fiber orientation error

The fiber orientation error is the angular separation between pairs of estimated and actual fiber orientations, and lies in the range 0–90°. In this study, we report individual fiber orientation errors for the unique pairing of estimated and actual fiber orientations that yields the minimum total orientation error (for each voxel). Each estimated fiber orientation is paired with only one actual fiber orientation from the ground-truth.

For a single estimated fiber in a voxel, its orientation error is:

$$\theta = \frac{180}{\pi} \cos^{-1}(|\mathbf{d}_{estimated} \cdot \mathbf{d}_{ground-truth}|)$$

where the unitary vectors $\mathbf{d}_{estimated}$ and $\mathbf{d}_{ground-truth}$ are the orientations, respectively, of the estimated fiber and the closest of the ground-truth fibers in the voxel; and \cdot denotes the dot product.

False-positive and false-negative rate

The number of incorrect fibers (either false-positives or false-negatives) was computed as the signed difference between the number of estimated and actual fibers (from the ground-truth) on a voxel-by-voxel basis. In this way, +1 indicates a single spurious fiber, whereas -2 indicates two missing fibers.

The total number of false-positives and false-negatives are computed separately and expressed as a percentage of the actual number of fibers present; positive false rates (> 0%) indicate false-positives (spurious fibers) while negative false rates (< 0%) represent false-negatives (missing fibers). For example, for voxels containing 3 fibers, a false rate of -66% indicates that (on average) 2 of 3 fibers are not detected.

References

Daducci, A., Canales-Rodríguez, E. J., Descoteaux, M., Garyfallidis, E., Gur, Y., Lin, Y. C., ... & Ramirez-Manzanares, A. (2014) Quantitative comparison of reconstruction methods for intra-voxel fiber recovery from diffusion MRI. *IEEE Transactions on Medical Imaging*, 33(2), 384-399.