# Interpolation and Averaging of Multi-Compartment Models


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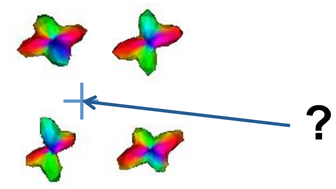
## Purpose

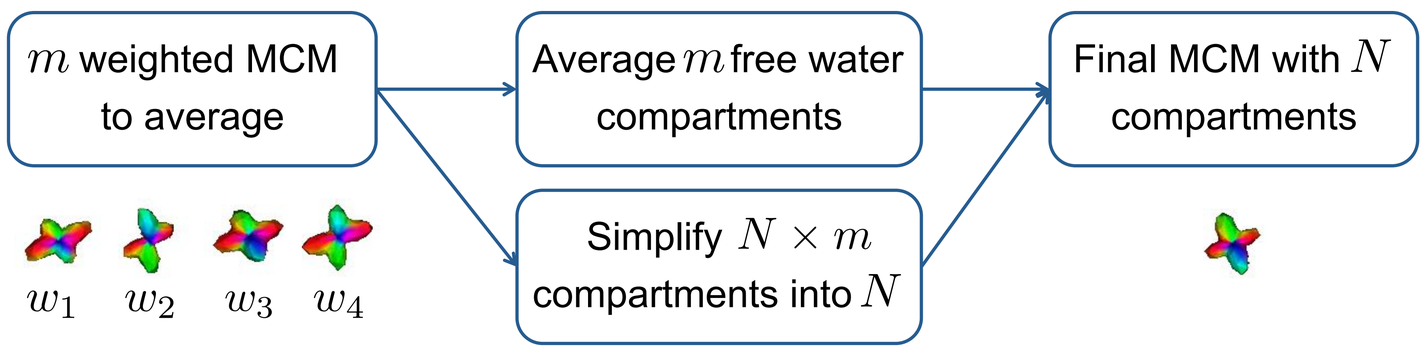
Need for generic interpolation of diffusion multi-compartment models (MCM) [1]

- Enable precise diffusion images registration, atlas construction
- Applicable to different multi-compartment models (multi-tensors, ball and stick, DDI…)




## Material and Methods

### Overall pipeline




Key components

- How to average free water compartments?
- How to simplify many compartments into $N$?

### Compartments simplification


Simplification needs: distance and averaging of fascicle compartments

- E.g. DDI fascicles [3]: independent sum of scaled vMF and cylindrical Gaussian

Free water components averaging

- Log-Euclidean mean of isotropic Gaussians

Four different DDI fascicles averaging methods

- Simple averaging
  - Euclidean average of the parameters
- Tensor averaging
  - Orientations considered as tensors
- Covariance analytic
  - Log-Euclidean mean of Gaussian covariances
- vMF based averaging
  - Riemannian mean of vMF parameters [4]
  - Other parameters as in covariance analytic

Distances between DDI fascicles

- Defined as matching averaging schemes
- Used for affinity matrix computation

## Experiments

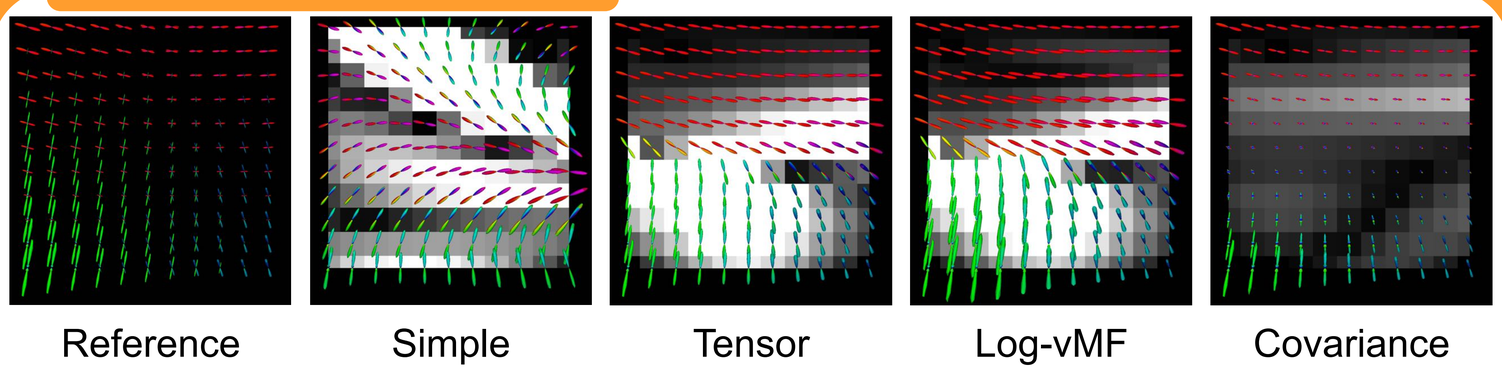
Fascicle averaging evaluation

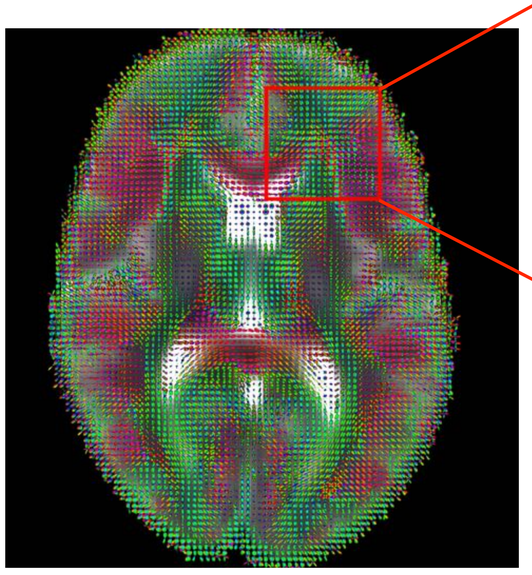
- Four corners image (one DDI fascicle at each corner)
- Reference: weighted combination of the corners
- Compute a single DDI fascicle at each position
- Error metric
  - Distance of simulated DWI signals to those of the reference

Controls atlas construction

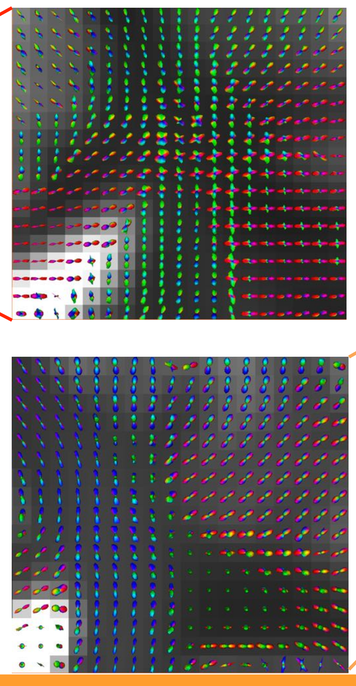
- Dataset of 20 controls
  - 3D T1, DWI on one shell (b=1000 s.mm$^{-2}$) with 30 directions
- Atlas computation from T1 images
- Apply transforms to DDI images
- Average registered DDI images using the proposed method

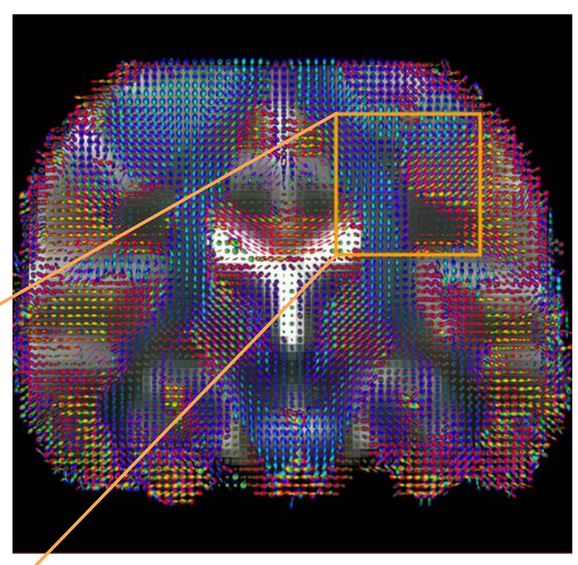
## Results



Atlas axial slice





Atlas coronal slice

## Conclusion

- New generic approach for MCM interpolation
  - Not limited to exponential family models
  - Needs only two model specific components
    - Distance between fascicles
    - Definition of fascicles mean
- Application to DDI interpolation
  - Four different average techniques
  - Covariance based average works best
  - Applied to atlas creation
- Future works
  - Automatic determination of the output number of fascicles
  - Use for MCM images registration


[1] E. Panagiotaki et al. Compartment models of the diffusion MR signal in brain white matter: A taxonomy and comparison. Neuroimage. 2012.
[2] A.Y. Ng et al. On spectral clustering: Analysis and an algorithm. Advances in neural information processing systems 2, 849–856 (2002).
[3] A. Stamm et al. A new multi-fiber model for low angular resolution diffusion MRI. ISBI 2012.
[4] T. McGraw et al. Von Mises-Fisher mixture model of the diffusion ODF. ISBI 2006.