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Estimation of diffusion parameters from magnitude MR images

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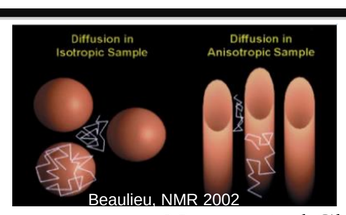
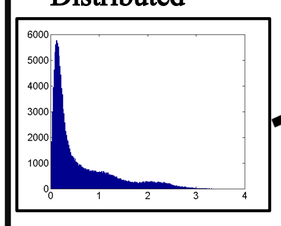
Introduction

Diffusion MR images characterize the underlying fiber architecture



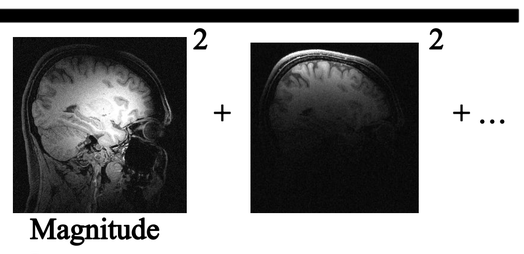
Noise

Rician Distributed



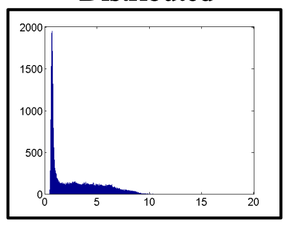
Histogram Of Magnitude Image

$\sqrt{\text{Magnitude Image}^2 + \text{Magnitude Image}^2 + \ldots}$



Magnitude Image

Non-central Chi Distributed



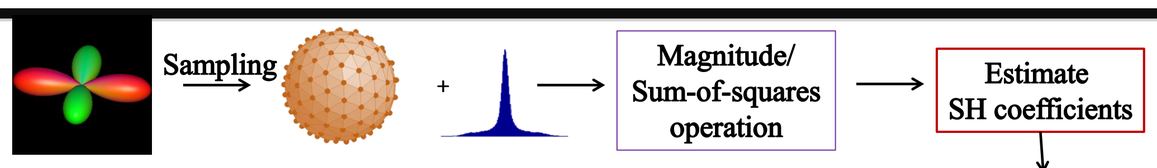
Histogram Of SoS Image

- Rician or non-central chi(NCC) Negative log likelihood (NLL) is complicated and non convex!!!

New estimation technique:

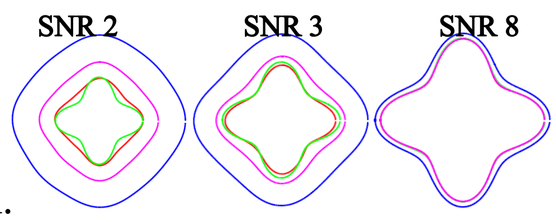
- Optimizes Rician/NCC NLL
- Iterative method - based on majorize-minimize approach
- Each iteration has a least square fomulation

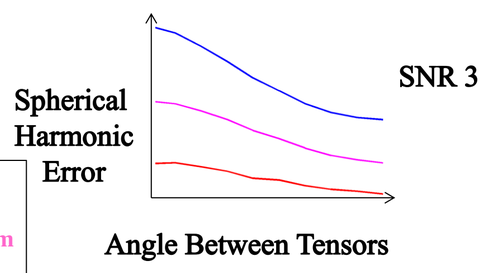
Simulation



- A noisy voxel with two tensors was simulated
- SH coefficients were estimated from this noisy data using the Rician NLL based MM approach.
- Diffusion profile and absolute error were calculated

Rician NLL based estimation gives more accurate results!!!





Conclusion

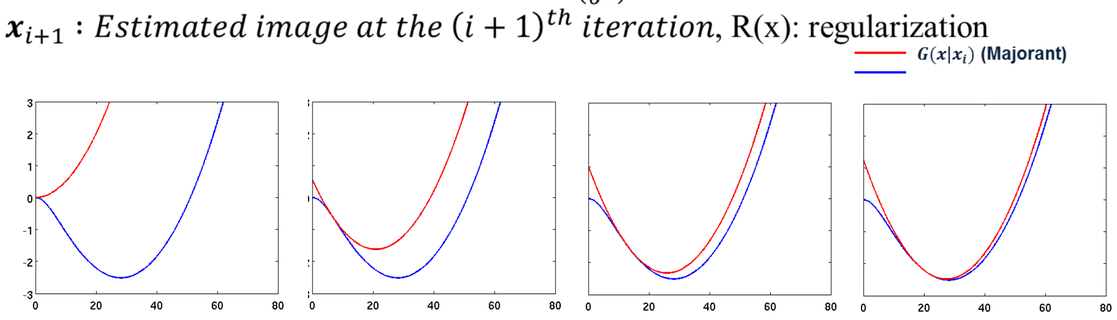
1. Accurate Rician/NCC modeling can substantially improve HARDI estimation
2. Noise modeling is enabled by new MM framework
   - Iterative solution of simple least-squares problems
3. Approach is easily generalized to other diffusion models and/or to include additional constraints

Method

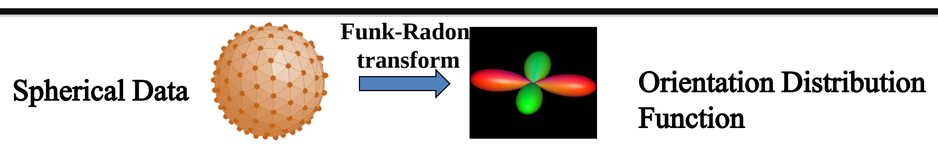
$$\boldsymbol{x}_{i+1} = \arg\min_{\boldsymbol{Ax}\geq 0} \frac{1}{2\sigma^2} \|\boldsymbol{Ax} - \tilde{\boldsymbol{y}}(\boldsymbol{x}_i)\|^2 + \mathcal{R}(\boldsymbol{x})$$

where $\boldsymbol{A}$ is a dictionary : $x \quad y$, $\tilde{\boldsymbol{y}} = \boldsymbol{y}\frac{I_n\left(\frac{x_i y}{\sigma^2}\right)}{I_{n-1}\left(\frac{x_i y}{\sigma^2}\right)}$, $\boldsymbol{y}$: *Observed image*,

$\boldsymbol{x}_{i+1}$: *Estimated image at the* $(i+1)^{th}$ *iteration*, R(x): regularization



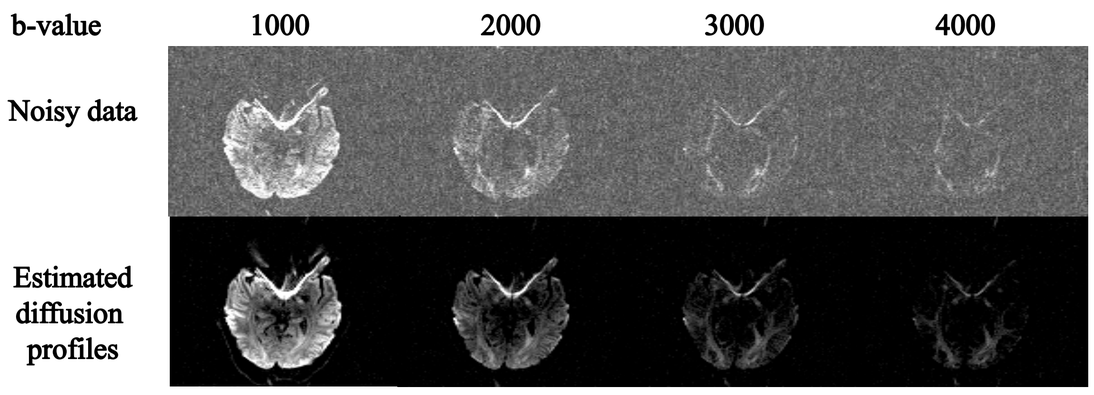
HARDI data pipeline



$\boldsymbol{A}$: Spherical Harmonic basis

Real Data

- **Acquired 32 channel diffusion data**
- **Estimated SH coefficients using proposed NCC MM method**



Discussion & Future Work

- The noise parameters need to be estimated and given as input parameters.
- When have complex data use Gaussian estimation !!!
- Give a reasonable initialization like ST estimate
- Use Rician/NCC modeling to improve multi-shell diffusion data acquisition

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