Estimation of diffusion parameters from magnitude MR images

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Maximum likelihood HARDI Estimator

Noisy Diffusion Data → Noise Modeling → Estimated Profile

Introduction

Diffusion MR images characterize the underlying fiber architecture

- 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 formulation

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!!!

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

Method

\[ x_{i+1} = \arg \min_{x} \frac{1}{2\sigma^2} \| Ax - \tilde{y}(x_i) \|^2 + R(x) \]

where \( A \) is a dictionary, \( y \), \( \tilde{y} = y \cdot e_{\eta(x)} \), \( y \): Observed image,

\( x_{i+1} : \) Estimated image at the \((i + 1)\)th iteration, \( R(x) \): regularization

HARDI data pipeline

A : Spherical Harmonic basis

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