

Accelerated data acquisition for B_0 -distortion correction using interlaced q-space sampling in diffusion MRI

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Motivation & Introduction

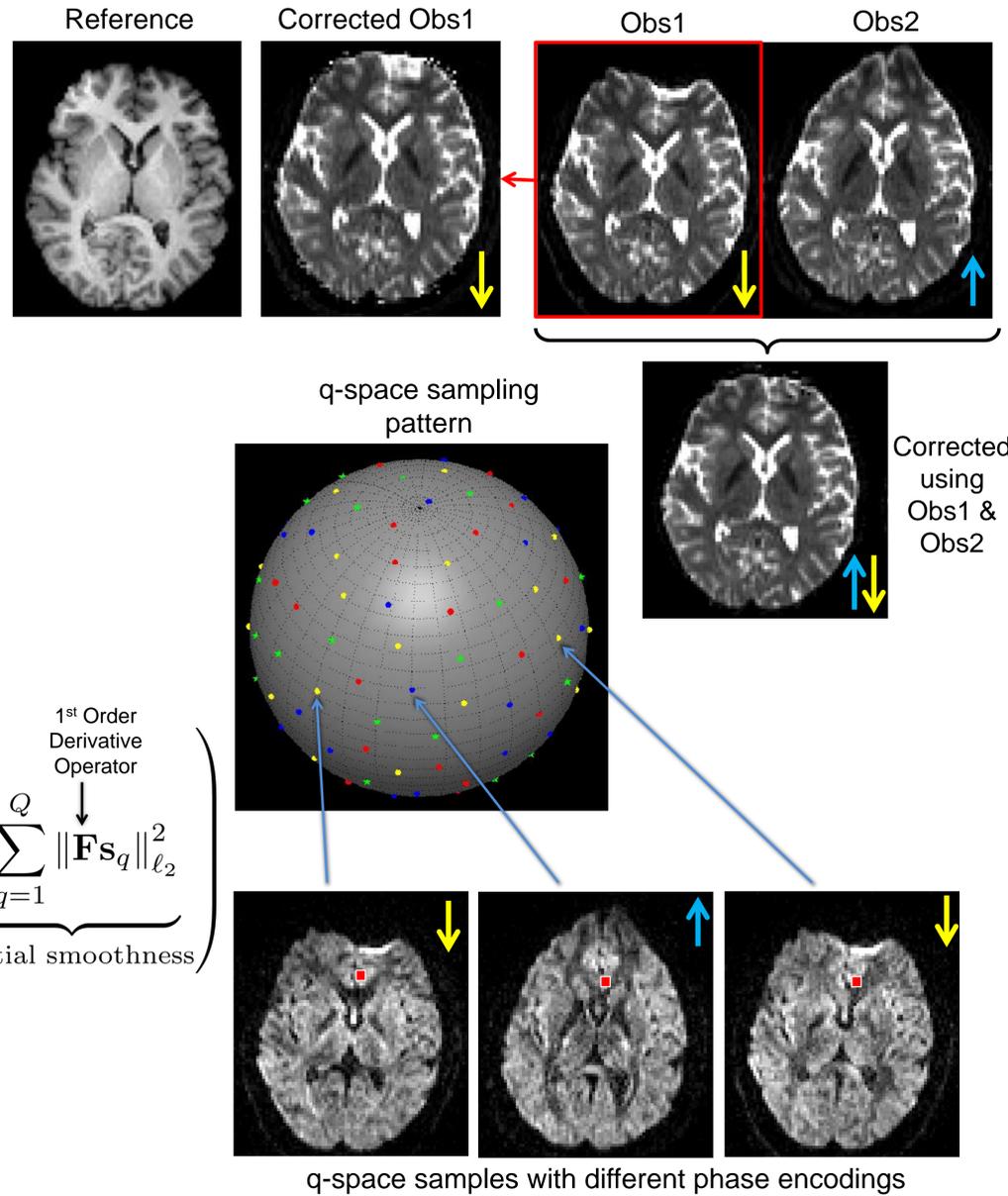
- Diffusion MRI (EPI scan) + B_0 field inhomogeneity = Geometric Distortion
- Distortion limits accuracy of multi-modal analysis
- Reconstruction from distorted images can be highly ill-posed
- Need “more” observations to reconstruct accurately
- More observations = Longer scan time = Larger cost!

Our approach:

- Exploit known “structure” of diffusion data in q-space
- Reduce number of required observations for accurate reconstruction
- Data is smooth in q-space (on surface of sphere)
- Borrow information from neighboring q-space samples
- Joint reconstruction all diffusion images

$$\hat{\mathbf{C}} = \arg \min_{\mathbf{C} \in \mathbb{R}^{V \times N}} \left(\sum_{q=1}^Q \underbrace{\|\mathbf{D}_q \mathbf{s}_q - \mathbf{d}_q\|_{\ell_2}^2}_{\text{Data fidelity}} + \sum_{v=1}^V \alpha_v \underbrace{\|\mathbf{L} \mathbf{c}_v\|_{\ell_2}^2}_{\text{spherical smoothness}} + \beta \sum_{q=1}^Q \underbrace{\|\mathbf{F} \mathbf{s}_q\|_{\ell_2}^2}_{\text{spatial smoothness}} \right)$$

Deformation operator Observed data Laplace-Beltrami operator Spherical Harmonic coeff. 1st Order Derivative Operator
s.t. $\mathbf{S} = \mathbf{C}\mathbf{Y}$
Reconstructed correct diffusion Images



in-vivo Experiment

- Acquire *in-vivo* diffusion data (20 q-space samples) of a human subject with four different observations (Phase encoding directions - PED)
- Use “full” data to reconstruct reference images
- Sub-sample full data to create “single PED”, “Reversed Gradient (RG)” and “Interlaced (IPED)” dataset
- Compare performance of different method with reference both qualitatively and quantitatively

Conclusion & Future Work

- Proposed method reduces total scan time by a factor of two as compared to “Reversed gradient” method while showing similar/better performance
- Superior performance to single PED (observation) method
- Easy to implement in modern MRI scanners – does not require huge change to pulse sequence

Future work:

- Generalize method to different q-space sampling schemes
- Use correct noise models for low SNR images

References:

- Bhushan et al., *Improved B_0 -distortion correction in diffusion MRI using interlaced q-space sampling and constrained reconstruction*, Magnetic Resonance in Medicine, Accepted
- Bhushan et al., *Accelerating Data Acquisition for Reversed-Gradient Distortion Correction in Diffusion MRI: A Constrained Reconstruction Approach*, ISMRM, Salt Lake City, 2013, p. 55



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