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

\[ \hat{\mathbf{C}} = \arg \min_{\mathbf{C} \in \mathbb{R}^{V \times N}} \left( \sum_{q=1}^{Q} \left\| \mathbf{D}_q \mathbf{s}_q - \mathbf{d}_q \right\|_2^2 + \sum_{v=1}^{V} \alpha_v \left\| \mathbf{Lc}_v \right\|_2^2 + \beta \sum_{q=1}^{Q} \left\| \mathbf{F}s_q \right\|_2^2 \right) \]

**Reconstructed correct diffusion images**

\[ \text{Data fidelity} \quad \text{spherical smoothness} \quad \text{spatial smoothness} \]

**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
- 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