Effect of truncated sampling on estimated fiber directions in q-space Imaging

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Method:
A single compartment Gaussian model mixed with background isotropic diffusion was used to generate noiseless q-space data as proposed in [4]. 

Results:
Table 1 illustrates the spatial variation in error when estimating the orientation of a single fiber, for the eight different simulation cases. The magnitude of the error (in degrees) is mapped via the color-bar shown, for all fiber directions indicated in Figure 1. The average error and standard deviation (σ) listed is of all fiber orientations (3712 data points) shown on each corresponding plot.

Discussion: The results clearly illustrate a fiber-orientation dependent error, which is reduced for full-sampling compared to truncated-sphere sampling, as would be expected. Also, in all cases, zero-padding in q-space is shown to uniformly distribute error that accumulates along orthogonal directions throughout all directions, and reduces the average fiber orientation error compared to non-zero-padding. Lastly, even in the case of noisy data, the corners of q-space, which are removed in truncated-sphere sampling, contribute to reducing fiber orientation error. This is most evident by the increased error in estimating fiber orientation for fibers oriented towards the corners (ϕ ≈ π/4 and θ ≈ π/2) of the spatial (and thus frequency) domain. The corners of q-space contribute to a spatially uniform pattern of fiber orientation errors, which should be of importance to fiber tractography. Even when zero-padding is used, errors accumulate along the directions of “missing” q-space data in the case of truncated-sampling. Our findings are consistent extensions to the two-dimensional k-space findings reported by Bernstein et al in [2]. Note, however that the truncated-sampling scheme would require 40% less data acquisition time than fully-sampled data, and this may justify the slight increase in error that results.