Cartesian 3D-SHORE with Laplacian Regularization

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1 Introduction

The following is a description of the algorithm used to generate submissions to the Sparse Reconstruction Challenge for Diffusion MRI (SPARC dMRI) of the MICCAI 2014 Workshop on Computational Diffusion MRI. A total of three submissions were generated for the challenge #1 using the three-shells datasets with 20, 30, and 60 gradients per shells (b-values of 1000, 2000, and 3000 s/mm^2). We pre-processed the data using a 3D Non-Local Means denoising [1] on each DWIs separately.

2 Method description

We used the 3D-SHORE Cartesian basis [2] with a Tikhonov regularization on the Laplacian to fit the dMRI signal. We solve the optimisation problem $\min_x \frac{1}{2}\|E - \Phi \cdot c\|_2^2 + \frac{\lambda}{2}\|R \cdot c\|_2^2$ where E is the normalized diffusion signal, Φ is the system matrix of size (number of q-points)$\times$(number of basis elements) (eq. 23 in [2]), c is the coefficient vector and R is the regularization matrix. We recast this optimization problem as a Quadratic Program and constrained the reconstructed signal at $\mathbf{q} = \mathbf{0}$ to be 1. We note that the present technique makes no attempt to promote sparsity on the coefficient vector.

For all datasets, we used $\lambda = 0.005$ and a maximal radial order (N_{max}) of 8 for the 30 and 60 gradients per shell datasets and 6 for the 20 gradients per shell dataset in the construction of Φ.

From the fitted coefficients c, we analytically compute the sth order "radial moment" of the propagator $\int_0^\infty P(r\mathbf{u})r^{2+s}\,\mathrm{d}r$ (eq. 33 in [2]). For example, Tuch's diffusion ODF (dODF) corresponds to $s = -2$ and the classical dODF to $s = 0$. The ODFs are computed on a sphere of 5780 points with $s = 2$, promoting sharp angular profiles. The maxima extraction is performed discretely on min-max normalized ODFs and points with a relative amplitude ≥ 0.5 that are maximal inside a 25° neighbourhood are considered as true maxima.

The signal estimation is obtained by $E_{est} = \overline{\Phi} \cdot c$ where $\overline{\Phi}$ is a new system matrix computed from the desired q-points coordinates.

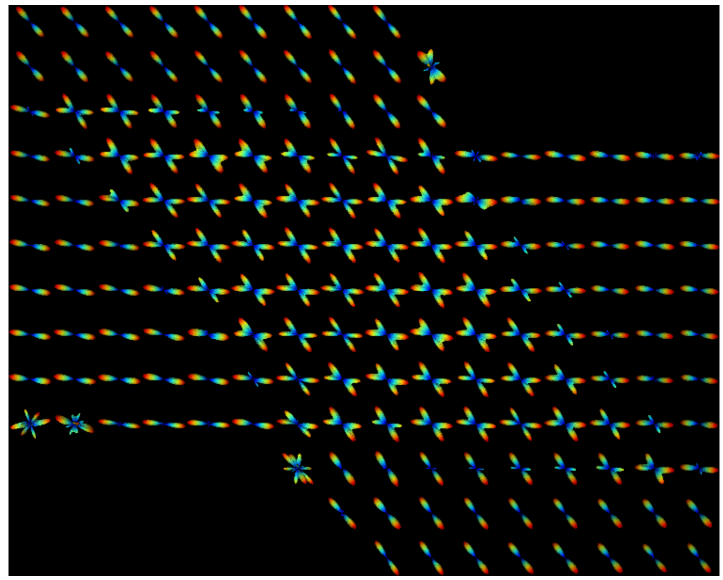

Figure 1: ODFs estimated from the 3-shells with 60 gradients directions per shell dataset.

References

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