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Deterministic Approach to Generating Optimal Ordering of MRI Measurements

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Technology description

Generating a set of uniformly-distributed points on the surface of a sphere via a deterministic scheme is important for biomedical imaging and engineering applications, especially MR imaging. A point set generated through the minimization of electrostatic potential based on Coulumb’ s law is the current gold standard. However, minimizing the electrostatic potential of a set of one thousand or more points remains computationally challenging and time-consuming.

It is well accepted that uniformity of the diffusion gradient schemes plays an important role in the final estimate of any diffusion MRI or diffusion tensor-derived quantities. Several methods have been proposed to generate optimal orderings of gradient directions; however, existing methods to generate highly uniform and antipodally symmetric points on the sphere are iterative and inefficient and may take from many minutes to several hours to complete. The methods are based on global optimization algorithms that require processing times on the order of hours or days to generate the ordering for a set of relatively few (150) points. A computationally efficient method for generating a highly uniformly distributed set of points on the sphere that exhibit antipodal symmetry is needed. Preferably, the method would determine optimal orderings of points within the set for medical imaging applications such as 3-D radial MRI and diffusion MRI. UW–Madison researchers have developed a system and method for generating and ordering a highly uniform point set that defines acquisition parameters for MRI. The ordering of the points is optimized for the particular imaging task at hand. For example, the point set is generated to be antipodally symmetric for diffusion-weighted imaging applications.

The medical imaging system contains a processor configured to generate a point set that defines MRI acquisition parameters and includes points that are uniformly distributed on the surface of a sphere. The processor also determines an order in which the points in the point set are to be temporally arranged by minimizing electrostatic energy potentials. The processor communicates the ordered point set with an MRI system and acquires MRI data in accordance with the MRI acquisition parameters. In the case of k-space sampling, the MRI system is directed to acquire k-space data from a subject using the determined MRI acquisition parameters and the order in which the points in the point set are to be temporally arranged. From the acquired k-space data, an image of the subject is reconstructed. In the case of diffusion imaging, the MRI system is directed to apply the diffusion gradients using the

determined MRI acquisition parameters and point ordering. Diffusion parameters can be estimated from the acquired diffusion-weighted images.
The Wisconsin Alumni Research Foundation (WARF) is seeking commercial partners interested in developing systems and methods for calculating and selecting a temporally and spatially optimum k-space sampling pattern or diffusion gradient direction set for medical imaging applications.

Additional Information

Koay C. G., Hurley S. A. and Meyerand M. E. 2011. Extremely Efficient and Deterministic Approach to Generating Optimal Ordering of Diffusion MRI Measurements. Med. Phys. 38, 4795-4801.
Koay C. G., Hurley S. A. and Meyerand M. E. 2011. Extremely Efficient and Deterministic Approach to Generating Optimal Ordering of Diffusion MRI Measurements. Med. Phys. 38, 4795-4801.

Application area

3-D projection reconstruction of medical images
3-D selective radiofrequency pulse design in MRI
Diffusion-weighting direction design and selection in diffusion MRI

Advantages

Improves quality of reconstructed images resulting from biomedical imaging methods by reducing artifacts
Produces a highly uniform and favorably ordered set of points on a sphere tailored for specific medical imaging applications
Produces optimally ordered points that allow for robust measurements in the event that a scan is stopped before completion

Institution

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