

Parameter estimation in diffusion-weighted magnetic resonance imaging

Supervisor: Dr. Peter T. While, Ph.D., Department of Radiology and Nuclear Medicine, St. Olav's University Hospital, Peter.Thomas.While@stolav.no

Project Type: Computation / Simulation / Image processing

Main Aim: To explore the accuracy and precision of various approaches to parameter estimation, using simulated diffusion-weighted MRI data, to enable the optimization of diffusion protocols for improving cancer detection.

Description: Magnetic resonance imaging (MRI) is a powerful, non-invasive, medical diagnostic tool that is capable of providing detailed anatomical and functional images of the human body. MRI uses special combinations of magnetic fields to excite nuclear spins within tissue and then studies the signal induced as these spins relax back to their original states. The induced signal is spatially encoded, and can be made to contain particular information about the molecular environment under study.

In diffusion-weighted MRI, the induced signal is made sensitive to the diffusion of water molecules. The standard approach is to generate several MR images with different diffusion-weightings (b -values), and then to fit a mono-exponential curve on a pixel-wise basis to obtain a 2D map of a single parameter called the apparent diffusion coefficient (ADC). Diffusion-weighted MRI has become an important technique in the detection of stroke and cancer.

In reality, the decay curves generated in diffusion-weighted MRI are generally not mono-exponential. Therefore, in the pursuit of new biomarkers, more sophisticated diffusion models have been developed containing additional parameters. However, MRI images are inherently noisy, and this greatly affects the precision and accuracy with which these various diffusion parameters can be estimated. As such, interest also lies in optimizing the diffusion-weighted imaging protocol (e.g. the b -values) and in using more sophisticated methods for parameter estimation (e.g. Bayesian analysis).

The general goal of this project is to assess the performance of one or more diffusion models, and/or one or more methods for parameter estimation, using simulated diffusion-weighted MRI data. Simulated data permits specification of the true parameter values, which allows direct quantification of the accuracy and bias of the parameter estimation in the presence of noise. If time permits, the analysis will be used in the optimization of diffusion protocols, and tested on real MRI data.