Título: OPTIMIZED ACQUISITION AND ESTIMATION TECHNIQUES IN DIFFUSION MRI FOR QUANTITATIVE IMAGING

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Resumen: Diffusion-Weighted Magnetic Resonance Imaging (DW-MRI) is able to measure intrinsic properties of tissue structure non-invasively. By applying diffusion-weighting, DW-MRI is sensitive to microscopic water displacements, with multiple applications for tissue characterization, diagnosis and treatment monitoring. Nevertheless, the application of these long and powerful diffusion-weighting gradients results in compelling imaging challenges. Consequently, this Thesis focuses on the optimization of the Spin Echo (SE) Diffusion-Weighted Imaging (DWI) sequence to improve image quality and estimation of the diffusion-related parametric maps.

As far as image quality is concerned, traditional SE DWI acquisition experiences artefacts from signal dephasing due to bulk motion, Concomitant Gradients (CGs), and Eddy Currents (ECs) which decrease image quality and complicate image interpretation. Additionally, it also suffers from severe signal attenuation due to the long Echo Time (TE) needed to achieve strong diffusion-weightings. Multiple approaches have been proposed to diminish these DWI artefacts, from synchronization, gating, and complex DWI sequences such as the Twice Refocues

Spin Echo (TRSE) to the application of diffusion-weighting gradients with nth-order motion-nulling and/or EC-nulling. Nevertheless, these techniques generally result in suboptimal acquisitions with long TEs. In this Thesis, we propose a versatile formulation for the design of optimized diffusion-weighting gradient waveforms that alleviates the previous drawbacks while minimizing the TE of the acquisition.

The estimation of the diffusion-related parametric maps is usually affected by several confounding factors such as low accuracy and precision, and lack of repeatability and reproducibility, partially caused by the previous artefacts. These confounding factors appear in both the monoexponential and the Intravoxel Incoherent Motion (IVIM) Diffusion-Weighted (DW) signal models, and hinder the establishment of their diffusion-related parametric maps as quantitative imaging biomarkers. Accuracy of the estimates, particularly of the Apparent Diffusion Coefficient (ADC) of the monoexponential DW signal model, can be increased by using the appropriate estimator. However, the set of diffusion-weightings (i.e., set of b-values) that increases the precision of the estimated parametric maps remains unclear. In this Thesis, we derive the Cramér-Rao Lower Bound (CRLB) of both DW signal models under the assumption of DW to be affected by Rician distributed noise, and propose a formulation for the optimization of the set of b-values that maximizes the noise performance (i.e., minimizes the variance and maximizes the precision) of the estimated diffusion-related parametric maps.