A Model-based Reconstruction Technique for Inversion Recovery Prepared Radially Acquired Data

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Introduction: MR parameter mapping is usually performed by tracking the evolution of the magnetization after a suitable preparation. Especially for short relaxation times, this can be difficult and measurements have to be performed in segmented fashion or with low spatial resolution. In [1], we proposed a Model-based Acceleration of Parameter mapping (MAP) algorithm in conjunction with radial data acquisition, capable of fully resolving an exponential signal evolution after saturation magnetization preparation. In this work, the MAP technique was extended for inversion recovery (IR) prepared datasets. This allows quantifying $T_1$ from a radial single-shot dataset using only one single magnetization preparation.

Materials and Methods: According to [2], the magnetization $M(T)$ in an IR snapshot FLASH experiment can be modeled by the mono-exponential function

$$M(T) = M_0 - (M_0 + M_2) \cdot \exp(-T_1/T_2)$$

(1)

($T_1$: inversion time, $M_0$: equilibrium magnetization, $T_1$: apparent relaxation time, $M_2$: steady-state magnetization of the tissue in presence of continuous RF excitation). Utilizing this model as prior knowledge allows characterizing $M(T)$ by only the three parameters $M_0$, $M_2$ and $T_1$. For small flip angles $\alpha$, these parameters can be used to derive the actual longitudinal relaxation parameter $T_1 = T_1^\prime \cdot [ (M_0 + M_2)/M_0 = 1 ]$.

In this work, Eq. 1 was included in the MAP algorithm presented in [1] in order to fully resolve the evolution of the signal after IR magnetization preparation from only one single IR preparation. The proposed IR-MAP technique reconstructs one image for every acquired radial projection as well as an $M_0$, $M_2$ and $T_1$ map. It is initialized by separately gridding every single projection of the radially acquired k-space data using self-calibrating GROG [3] and Fourier transforming these k-spaces into image space. Subsequently, a least-squares fit of Eq. 1 is applied pixel by pixel, yielding a set of parameters.

In conclusion, the proposed IR-MAP reconstruction algorithm allows quantifying the longitudinal relaxation parameter $T_1$ from one single magnetization preparation, leading to extremely short acquisition times of about 7 s for a human brain. Compared to the SR preparation used in the first M1 implementation in [1], the signal-to-noise ratio is increased by a factor of approximately 2.

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