MODEL-BASED SUPER-RESOLUTION RECONSTRUCTION OF T2 MAPS

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Introduction: High-resolution isotropic T2 mapping of human brain with multi-echo spin-echo acquisitions (MESE) is difficult due to the slice thickness limitation of a 2D sequence. Furthermore, if used as a 3D acquisition, SAR limits are easily exceeded due to the high power deposition of non-selective refocusing pulses. Here, we propose a method to reconstruct 1-mm^3 isotropic T2 maps based on multiple 2D MESE acquisitions. To compensate for the prolonged scan time due to multiple acquisitions, data were highly (10-fold) undersampled.

Methods: Data from a multipurpose phantom and four healthy subjects were acquired at 3T (MAGNETOM Skyra, Siemens Healthcare, Erlangen, Germany) with a 10-fold accelerated GRAPPATINI prototype sequence (1). (60 slices, (1x1x4) mm^3 resolution, (256x240x240) mm^3 FOV, TR=5.4s, ΔTE=10ms, ETL=16, TA=4:31min). The acquisition was repeated four times, and for each scan, the FOV was rotated in 45° steps about the longitudinal axis (total TA=18:04min). The reconstruction integrated super-resolution (SR) (2) and model-based (3) approaches (see Eq. 1). A high-resolution image $\boldsymbol{x_n}$ was estimated by minimizing the difference to LR k-space $\boldsymbol{y_{n,c}}$ with $\boldsymbol{S_c}$ coil sensitivities, $\mathbf{T}$ four 45° rotations, $\downarrow$ downsampling to LR grid, $\mathbf{F}$ Fourier transform and $\mathbf{P}$ undersampling. Next, the image corresponding to the signal-model $\hat{\boldsymbol{x}}_{\boldsymbol{n}} = \boldsymbol{M_0 exp}(-\frac{\boldsymbol{TE}}{\boldsymbol{T2}})$ was calculated by fitting a monoexponential decay onto $\boldsymbol{x_n}$, intrinsically estimating $\boldsymbol{T2}$ and $\boldsymbol{M0}$. The weighting factor $\boldsymbol{\lambda}$ balanced data and model consistency.

$$\underset{T2,M_0,x_n}{argmin} \sum_n^N \sum_c^C \| PF\{\downarrow TS_c x_n\} - y_{n,c} \|^2 + \lambda \| x_n - \hat{x}_n \|^2 \quad (1)$$

Fully sampled MESE images were acquired for comparison.

Results: High-resolution isotropic T2 maps from the phantom and one subject are shown in Fig.1. In comparison with the fully sampled acquisition, the SR-reconstructed images demonstrated improved resolution in all three dimensions (see also Fig. 2).

Conclusion: The proposed method shows feasibility for high-resolution relaxometry based on a MESE acquisition which may enable its wide application in studying small brain structures and changes in their physical properties

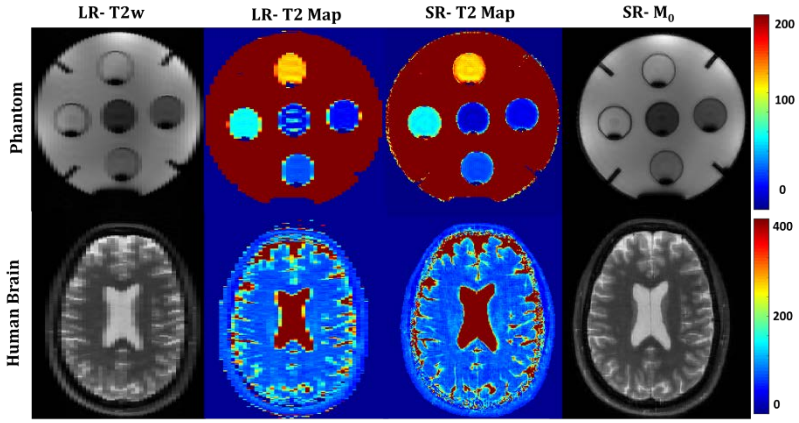

Figure 1: LR T2w images, LR T2 map, SR T2 maps and M_0 reconstructed for phantom (top row) and human brain (bottom row). The colorbar represents T2 values in ms.

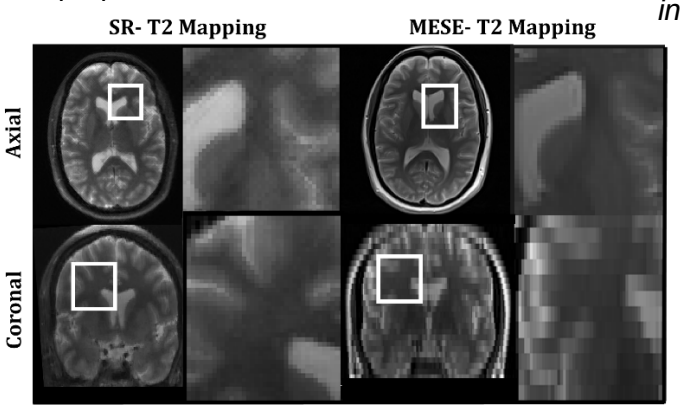

Figure 2: Axial and Coronal view of T2-weighted images reconstructed with SR-T2 mapping and fully sampled MESE images. Zoomed-in images depict the better resolution in both planes for SR volumes as compared to conventional sequence.

References: 1. Greenspan et al. MRI 2003. 2. Hilbert et al. JMRI 2018. 3. Bano et al. ISMRM 2018.

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