k-t ISD compressed sensing reconstruction for T1ñ mapping: A study in rat brains at 3T

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Introduction: $T_{1\rho}$ relaxation is a potential mechanism to investigate low frequency motional processes in tissues and received increased interests for clinical applications [1,2]. However, $T_{1\rho}$ imaging suffers from long scan time, susceptibility to motion and high specific absorption rate (SAR). We present the use of *k-t* Iterative Support Detection (*k-t* ISD), a recently proposed compressed-sensing (CS) method where the partial support prior is utilized besides sparsity prior [3], for $T_{1\rho}$ map reconstruction, and evaluate its utility for accurate $T_{1\rho}$ quantification.

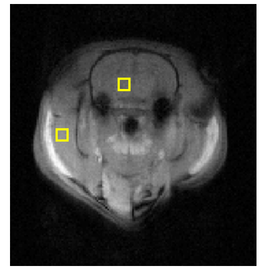

Fig. 1. $T_{1\rho}$-weighted image of a rat brain and its two ROIs

Methods: $T_{1\rho}$ imaging was performed with a Philips 3T clinical scanner with a dedicated rat-brain coil. A rotary-echo spin lock pulse [4] was implemented in a spoiled gradient echo sequence (TR/TE=5.0/2.6ms, FA=40º, pixel size =0.5×0.62mm^2, thickness=2mm) to acquire $T_{1\rho}$-weighted ($T_{1\rho}$w) images with the spin-lock times (TSL) of 1, 10, 20, 30, 40 and 50ms at a spin-lock frequency of 500Hz. The delay time after each segmented acquisition was set as 6000ms to restore the equilibrium magnetization prior to the next $T_{1\rho}$ preparation. The variable-density random sampling pattern was generated to simulate different reduction factors of R=3, 4, 6, 8, 10, 12, 14, and 16, with 8 central phase encodings fully sampled. $T_{1\rho}$ weighted images were reconstructed by solving a truncated ℓ_1 minimization problem: $\min \|\boldsymbol{\rho}_\Delta\|_1 \quad s.t. \|\mathbf{d} - \mathbf{F}\boldsymbol{\rho}\|_2 \le \varepsilon$ (1), where **d** is the acquired data in *k-t* space, $\boldsymbol{\rho}$ is the image series represented in *x-f* space, $\boldsymbol{\rho}_\Delta$ denotes the truncated $\boldsymbol{\rho}$ excluding the known support, **F** is the Fourier transform along the *k-t* direction, and ε is noise level. $T_{1\rho}$ maps were obtained by a pixel-wise fitting of the reconstructed $T_{1\rho}$ weighted images data with TSLs according to $M=M_0 \cdot exp(-TSL/T_{1\rho})$. Maps obtained from CS with different reduction factor (R) were compared with the original map (reference) without CS using paired student's t-test with a significant p-value level of 0.05. Mapping results in two representative ROIs in brain and muscle (Fig. 1), were also statically analyzed among different maps.

Results: The $T_{1\rho}$ maps (goodness of fit>0.8) derived with different CS reduction factors are given in Fig. 2, where R=0 map is the reference. Their difference maps compared with the reference are shown as in Fig. 3. Generally, no remarkable differences were found in CS reconstructed $T_{1\rho}$ maps from the reference. The map difference increased with the reduction factor. Fig. 4 depicts the box plotting of the $T_{1\rho}$ values in the general map, brain and muscle ROIs respectively. For the brain ROI, only when the R was 12 or 16, the corresponding $T_{1\rho}$ map was significantly different from the reference ($p<0.05$). For the muscle ROI, maps with R> 8 were significantly different from the reference ($p<0.05$). Given appropriate reduction factors, the developed CS approach ensured reliable estimation of $T_{1\rho}$ map.

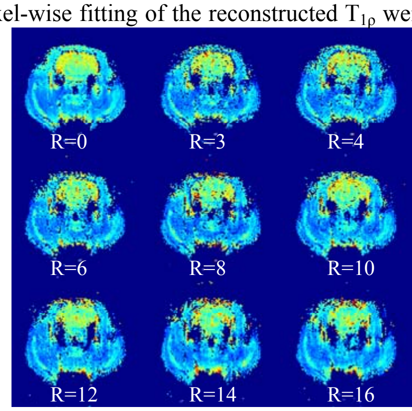

Fig. 2. $T_{1\rho}$ maps (with R^2>0.8 revision) derived from the images with different reduction factors

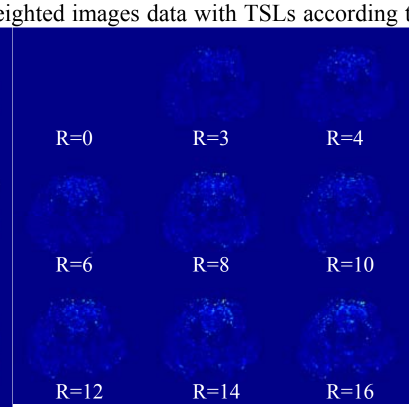

Fig. 3. $T_{1\rho}$ difference maps, compared with the reference map

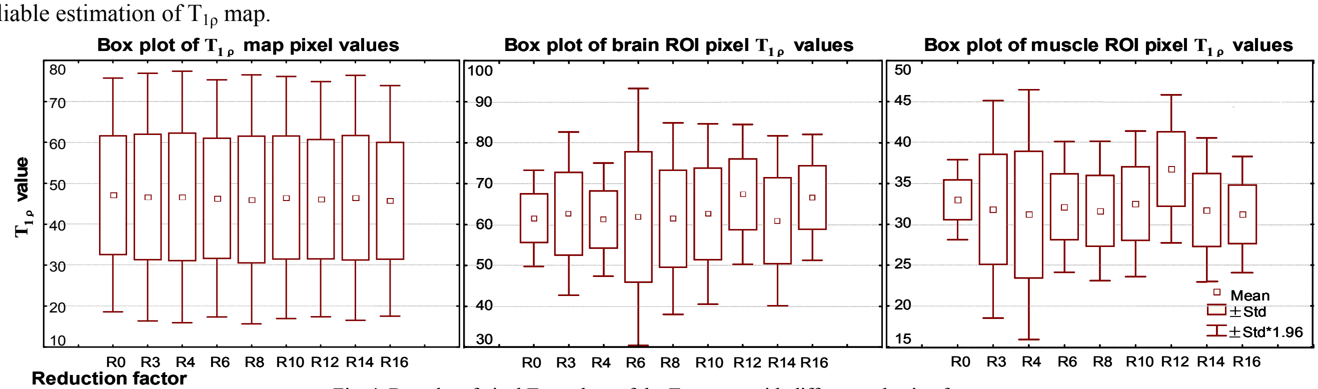

Fig. 4. Box plot of pixel $T_{1\rho}$ values of the $T_{1\rho}$ maps with different reduction factors

Conclusion: The *k-t* ISD method was successfully applied to accelerate $T_{1\rho}$ imaging. The experimental results demonstrate that $T_{1\rho}$ maps can be estimated reliably from accelerated scans. The *k-t* ISD is promising for accurate $T_{1\rho}$ quantification with remarkably reduced scan time and SAR.

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References: [1] Wheaton AJ et al, Radiology, 231:900-5(2004); [2] Wang YX et al, Radiology, 259:712-9(2011); [3] Liang D et al. MRM, in press, (2011); [4] Charagundla SR. et al, JMR, 162:113-121(2003).