k-t ESPIRiT for Accelerating Proton Resonance Frequency Shift MR temperature mapping

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Target audience:

Researchers and clinicians interested in Real-time MR thermometry.

Purpose:

Proton resonance frequency shift (PRFS) [1] method is widely used in thermometry, and high spatiotemporal resolution necessary forits clinical application. However, acceleration of data acquisition for PRFS requires phase sensitive reconstruction, due to the importance of phase accuracy in PRFS mapping. K-t SENSE [2] is efficient in dynamic imaging, but suffers from difficulty to estimate accuracy sensitivity maps that preserve phase information. Lustig et.al has recently proposed ESPIRiT[3] as an effective method in for sensitivity estimation. In this work, we proposed k-t ESPIRiT as a combination of ESPIRiT and k-t SENSE for phase sensitive reconstruction. The proposed method was compared to k-t FOCUSS [4], a widely used acceleration method for dynamic imaging, to evaluate its efficiency on highly accelerated PRFS.

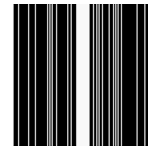

Fig 1 The sampling pattern in kx-ky

Method:

K-t ESPIRiT: In this work, vectorized central k-space blocks from all frames were stacked to form a hybrid calibration matrix. Sensitivity maps were estimated form this hybrid calibration matrix, and exploited by k-t Sparse SENSE for image reconstruction. The sampling pattern is shown in Fig1.

Phantom Data: A set of bowl of water phantom data were acquired by a GRE sequence (TR/TE=100/5ms, FA=40°, matrix size: 128×128, FOV=200×200). This phantom is an Acylindrical 0.8-little bowl of water with 6 tubes containing 10% fat. An 8 channel head coil was used to acquire 50single-slice measurements in the transverse plane as the sample cooled from41.9°C to 38.2 °C in 20 minutes.

Fully sampled K-t FOCUSS K-t ESPIRiT K-t FOCUSS ERR K-

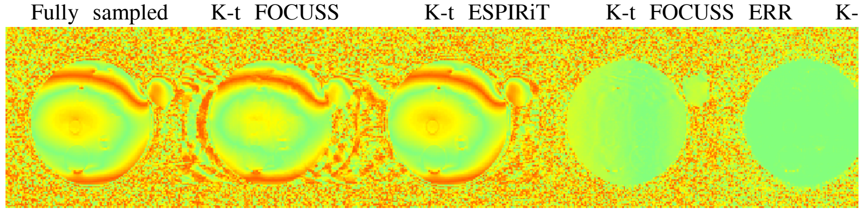

Fig 2 reconstructed phase maps and error map of k-t FOUCUSS and k-t ESPIRiT

Application on PRFS: The fully-sampled data was retrospectively under-sampled with a reduction factor of 6 using Poisson-disc Sampling [5] along in the ky-t domain, with 12 ACS lines for each frame. The under-sampled data was reconstructed by k-t FOCUSS and k-t ESPIRiT respectively. Subsequently, the reconstructed images were evaluated by PRFS [6] thermometry. ROI (region of interest) is in the center of the field with 20×20 pixels.

Results:

Phase maps reconstructed by k-t ESPIRiT is quite similar to the fully-sampled reference, while those by k-t FOCOUSS have much more errors (Fig.2). Fig. 3 compares the temperature evolution curves. The temperature curve of k-t ESPIRiT is closer to the reference compared to k-t FOCUSS. RMSE of the estimated temperature by k-t FOCUSS is nearly 10 times of that by k-t ESPIRiT, and maximum temperature error of k-t ESPIRiT is also lower than k-t FOCUSS.

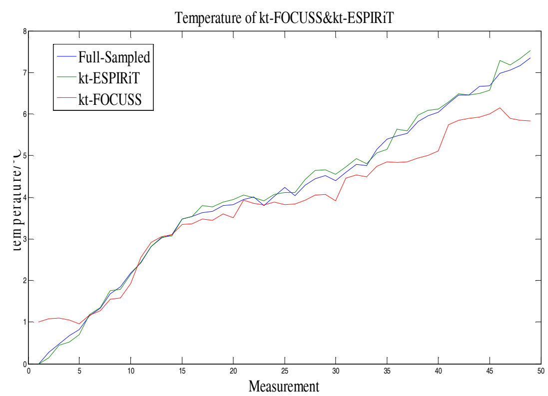

Fig 3 The temperature evolutioncurves at a reduction factor of 6 after an initialization process of 50 frames.

Table 1 Maximum Temperature & RMSE of the ROI

	Kt-ESIRiT	**Kt-FOCUSS**
RMSE in ROI	0.021	0.21
Maximum error in ROI/°C	0.17	0.53

Discussion and Conclusions:

K-t ESPIRiT is proposed in this work as a new reconstruction method for accelerated dynamic imaging. Phantom experiments demonstrate that our method outperforms k-t FOCUSS at reduction factors of 6 in the fidelity of the phase. Therefore, temperature calculated from the images reconstructed by k-t ESPIRiT is much more accurate than k-t FOCUSS. Further experiments can be conducted in-vivo with higher acceleration factors.

References:

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