Sparse Radial *k-t* SPIRiT for Dynamic Liver Imaging

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Target Audience: To those who are interested in accelerated hepatic imaging

Purpose: Clinical applications of dynamic contrast enhanced (DCE) liver imaging are limited due to the low temporal and spatial resolution. Golden angle radial trajectory[1] is a promising technique to achieve high spatiotemporal resolution. The reconstruction of under-sampled golden angle radial trajectory is a key to obtain clinically acceptable images. Recently, radial *k-t* SPIRiT [2] has been demonstrated to have improved reconstruction accuracy in phase contrast MRI with golden angle radial trajectory. In this work, we incorporate sparsity constraint into radial *k-t* SPIRiT (sparse radial *k-t* SPIRiT) for the reconstruction of dynamic liver images with golden angle radial trajectory, which greatly reduces artifact and noise level.

Theory: In [2], radial *k-t* SPIRiT takes advantage of the spatial and temporal correlation of *k-t* space to interpolate the missing data. For dynamic liver imaging, due to its data redundancy along temporal dimension, we can incorporate transform sparsity along temporal dimension into radial *k-t* SPIRiT to reduce artifacts and noise, which enables higher acceleration factor. The objective function for sparse radial *k-t* SPIRiT reconstruction is formulated as follows:

$$\underset{f}{\text{argmin}}(\|\mathcal{F}f-y\|_2^2+\lambda\|(G-I)f\|_2^2+\mu\|\Psi f\|_1),$$

where f is the estimated *k-t* space, y is measured data, G is spatiotemporal interpolation kernel, I is identity matrix, Ψ is a sparsity transform, λ and μ are weighting parameters. In this work, total variation along temporal dimension was used due to the similarity between adjacent frames.

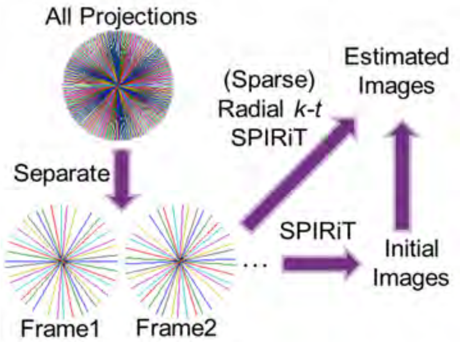

Fig 1. Steps for reconstruction

Methods: Both phantom and *in-vivo* liver images were acquired with T1-weighted Fast Filed Echo (T1w-FFE) sequence using golden angle stack-of-star trajectory on a 3T system (Philips, Best, the Netherlands). For phantom, 200 spokes (TR=9.2ms, TE=4.2ms, FA=10°) was acquired continuously in 60 seconds with an eight channel head coil (Invivo Corp, Gainesville). For in-vivo case, 256 spokes (TR=3.14ms, TE=1.4ms, FA=5°) was acquired continuously in 59 seconds with a 32 channel cardiac coil (Invivo Corp, Gainesville).

For image reconstruction, the whole dataset was separated to frames of 21 spokes without overlapping. Then, they were reconstructed by sparse radial *k-t* SPIRiT and radial *k-t* SPIRiT (for comparison). To reduce the iteration needed in reconstruction, images reconstructed from SPIRiT are used as initial image. The reconstruction scheme is indicated in Fig. 1. Finally, signal-to-noise ratio was computed by: $\text{SNR}=\text{mean}(\text{I}_{\text{rois}})/\text{std}(\text{I}_{\text{roin}})$, where I_{rois} the region of interest (ROI) of liver and I_{roin} is in a part of background.

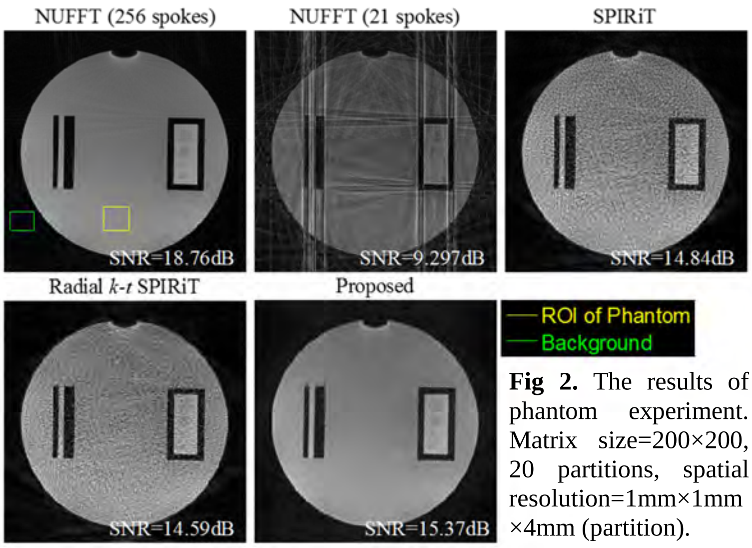

Fig 2. The results of phantom experiment. Matrix size=200×200, 20 partitions, spatial resolution=1mm×1mm ×4mm (partition).

Results: Fig.2 shows the results of phantom experiment. Compared to SPIRiT and radial *k-t* SPIRiT, greatly reduced noise level was observed when sparsity constraint is incorporated. *In-vivo* liver results are shown in Fig. 3. Striking artifacts caused by under-sampling were significantly reduced in the image reconstructed by the proposed method. Compared to SPIRiT and Radial k-t SPIRiT techniques, reconstructed image for our method has a lower noise and artifact level.

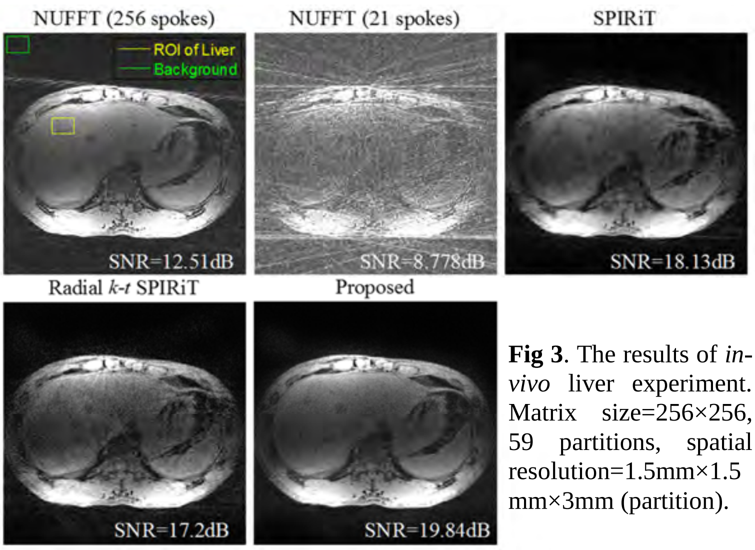

Fig 3. The results of *in-vivo* liver experiment. Matrix size=256×256, 59 partitions, spatial resolution=1.5mm×1.5 mm×3mm (partition).

Discussion and Conclusion: In this work, the feasibility of sparse radial *k-t* SPIRiT reconstruction method has been proved for golden angle stack-of-star trajectory for dynamic imaging. By phantom and in-vivo experiments, improved image quality were achieved compared with traditional SPIRiT and radial *k-t* SPIRiT.

Reference: [1] S. Winkelmann, et al. IEEE TMI, 2007; 26(1):68-76, [2] C. Santelli1, et al. MRM, 2014; 72(5):1233-1245