Accelerated Parallel Traveling Wave MR and Compressed Sensing Using a 2-Channel Transceiver Array

Maryam Vareth[1,2], Anita Flynn[3], Wei Bian[1,2], Ye Li[1], Daniel B. Vigneron[1,2], Sarah J. Nelson[1,2], and Xiaoliang Zhang[1,2]

[1]*Radiology and Biomedical Imaging, UC San Francisco, San Francisco, CA, United States,* [2]*UC Berkeley/UCSF Joint Graduate Group in Bioengineering, San Francisco, CA, United States,* [3]*EECS, UC Berkeley, Berkeley, CA, United States*

Target Audience

Signal processing engineers interested in parallel imaging for traveling wave MRI [1-3].

Purpose

We aimed to demonstrate new parallel imaging and compressed sensing acquisitions for traveling wave MRI, using a two-element microstrip transmission line resonator array. This approach avoids the use of complicated multimodal parallel traveling wave methods, as described in [4].

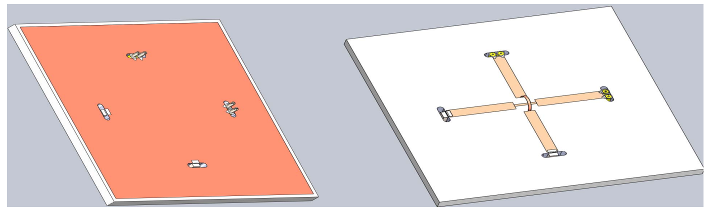

Figure 1. A 2-channel traveling wave transceiver array, fabricated on a teflon substrate as orthogonal copper-foil microstrip transmission line resonators, was used to acquire images for the parallel-imaging reconstruction experiments.

Methods

A pair of microstrip resonators, designed as shown in Figure 1, were situated orthogonally and jumpered at their crossover point to minimize coupling between channels (each tuned to 298 MHz and matched to 50 ohms). This 2-channel antenna was placed 50 cm from a water phantom in a 7 T scanner and images were acquired with a 2D GRE sequence. An undersampling pattern with an acceleration factor of 1.3 in each direction was designed with Poisson-disc sampling density as shown at left in Figure 2. This sampling pattern was applied post-acquisition of the fully sampled individual channels and total acceleration factor is 1.8. Three algorithms for reconstructing undersampled data, GRAPPA, SPIRiT and L1-SPIRiT, were implemented in the Matlab programming environment (The Mathworks, Natick, MA, USA) and tested on the sampled images.

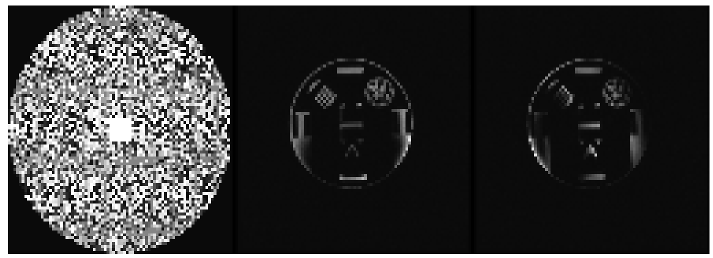

Figure 2. Left: Poisson-disc undersamping pattern with acceleration factor of 1.3 for each channel. Middle and right: Individual fully sampled channels from a 7 T scanner using a 2D GRE sequence (TR=250 ms, TE=3.2ms, 90^o flip angle, 31.25 kHz bandwidth, 3 averages).

Results and Discussion

Figure 3 compares and contrasts the reconstructed images. For each pair, a relative error figure of merit was calculated as:

$$\varepsilon = \frac{\left\| I - \hat{I} \right\|_{frobenius}}{\left\| I \right\|_{frobenius}}$$

Reconstruction Algorithm	Relative Error
GRAPPA	0.066
SPIRiT	0.219
L1-SPIRiT	0.205

All methods give an acceptable reconstruction for this high SNR image. The relative error indicates that the GRAPPA method outperforms SPIRiT and L1-SPIRiT for this case, but further studies are needed with different types of images and noise levels in order to determine whether this holds for other configurations.

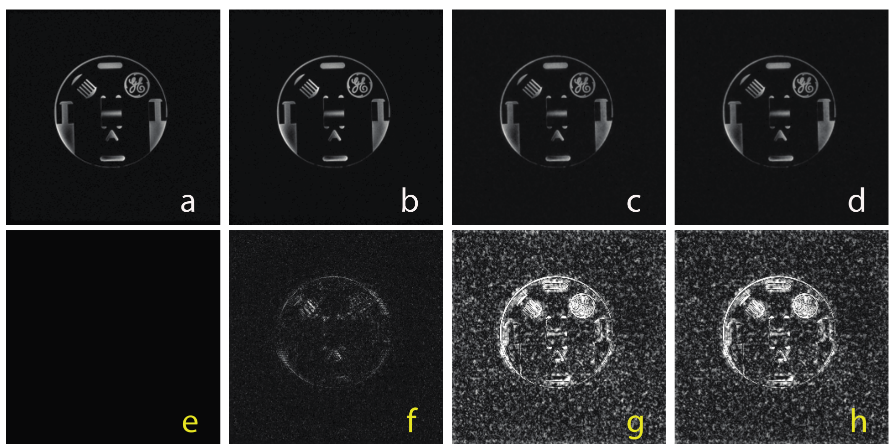

Figure 3. Top row: Reconstructed images. a) Sum-of-squares, b) GRAPPA [5], c) SPIRiT [6] and d) L1-SPIRiT [7]. Bottom row: Difference images between each reconstructed image and the original.

Conclusion

By using a very simple technique, with only two transceiver elements, accelerated parallel-imaging and compressed-sensing traveling wave MR can be achieved.

References

[1] Brunner, et al. *Nature*, 457(7232):994-998, 2009. [2] Webb, et al. *Mag. Res. Med.*, 63(2):297-302, 2010. [3] Pang, et al. *Mag. Res. Med.*, 67(4):965-978, 2012. [4] Brunner, et al. *Mag. Res. Med.*, 66(1):290-300, 2011. [5] Griswold, et al. *Mag. Res. Med.*, 47(6):1202-1210, 2002. [6] Lustig, et al. *Mag. Res. Med.*, 58(6):1182-1195, 2007. [7] Lustig, et al. *Mag. Res. Med.*, 64(2):457-471, 2010.

Acknowledgments

This work was supported in part by NIH research grants EB008699 and P41EB013598, and also by a grant from GE Healthcare.