Optimum SNR Data Compression for Complex Arrays

S. B. King[1], M. J. Smith[1], and B. Tomanek[2]
[1]Institute for Biodiagnostics, National Research Council of Canada, Winnipeg, Manitoba, Canada, [2]Institute for Biodiagnostics (West), National Research Council of Canada, Calgary, Alberta, Canada

Introduction

The number of receive channels on clinical MRI systems is now as high as 128, allowing the possibility for highly accelerated parallel MRI and increased SNR. To lessen the demands for data handling and processing, data compression methods are being explored (1-4). With a head array of 8-azimuthally distributed elements, the eigenmode method (2) demonstrated N/2 channel compression in hardware, retaining nearly 100% SNR. Here eigenmode channel compression is investigated, comparing uniform vs. non-uniform array distributions of more complicated head and torso arrays.

Methods

A 24-channel head array (D = 24cm, L = 20cm) consisting of three z-rows of eight equal-size azimuthally distributed array elements (*Fig.1a*) was compared to a benchmark 8-channel head array (D = 24cm, L = 20cm) consisting of one row of eight equal size azimuthally distributed array elements. Two anterior torso arrays were compared, the first benchmark 6-channel anterior array consisting of 2 rows of three 14cm x 14cm loops distributed evenly left-right, while the second 11-channel anterior array consisted of 11 elements centered above the heart in a honeycomb arrangement, smaller size in the center and increasing in size away from center. Head phantom (D = 20cm, L = 30cm) and torso phantom (W = 40cm, H = 26 cm, L = 64cm) models were used with physiological conductivity/permittivity parameters. For each array element full-wave B- and E-fields were numerically modeled in SEMCAD X (Schmid & Partner Engineering AG (SPEAG), Zurich, Switzerland) at 123.2 MHz, and then SNR and eigenmode channel compression was calculated in Musaik (SPEAG, Zurich, Switzerland).

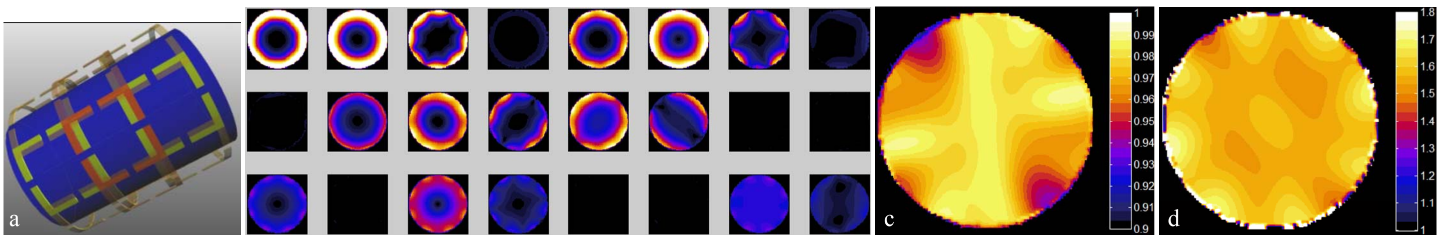

Fig. 1: (a)24-Ch. model; (b)24-eigenmodes (axial, z=0); (c)SNR of best 12-channels relative to all 24-channels. (d)SNR of best 8-channels relative to benchmark 8-channel head array at z = -L/3.

Results

Using the 24-ch. array (*Fig.1a*), eigenmode SNR maps were calculated for axial (*Fig.1b*) and sagittal (*Fig.2a*) planes. In certain planes, some eigenmodes have little SNR (*Fig.1b*) and with several (9-pairs) degenerate modes resembling the quad/antiquad pairs of Ref. (2), further channel reduction is immediately possible; reduced to 16-channels with nearly 100% SNR retention; to 12-channels (*Fig.1c*) with nearly 97% SNR. Relative to the benchmark 8-channel head array, reducing to 8-channels results in central SNR gain of 20% at z=0 and 60% at z = -L/3(*Fig.1d, Fig.2c*). To investigate channel compression over the whole volume (slice independent) with the same set of eigenmodes , a sagittal plane shows >90% SNR retention for 12-channels (*Fig.2b*), and with 8-channels SNR gains ranging up to 200% relative to the benchmark 8-channel array (*Fig.2c*).

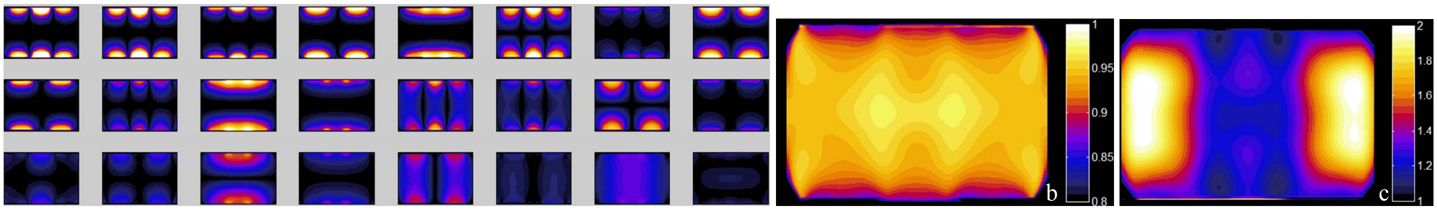

Fig.2: (a)24-eigenmodes (sagittal, x=0); (b)SNR of best 12-channels relative to all 24-channels; (c)SNR of best 8-channel relative to benchmark 8-channel array.

The 11-channel torso array is an example of an array with less uniformly distributed elements. Fig.3 shows that the best 6-eigenmode channels at z=0 result in 95% SNR retention relative to all 11 channels in a cardiac ROI (*Fig.3a*), and greater than 200% anterior SNR gain relative to the benchmark 6-channel anterior torso array (*Fig.3b*). A sagittal SNR map (*Fig.3c*) demonstrates that this compression choice is limited to central slices, meaning that different compression choices may be needed for other slices within the ROI.

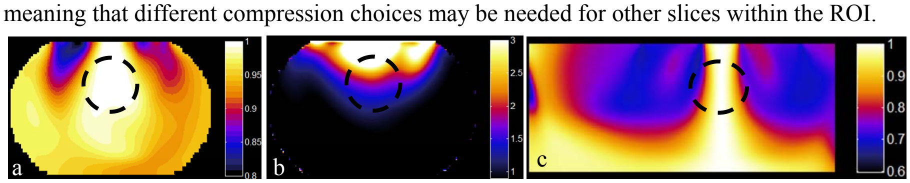

Fig.3: Axial(a,b) and sagittal(c) SNR of best 6 eigen-channels of 11-ch torso array relative to; (a,c) all 11-channels, (b) benchmark 6-channel torso array.

Discussion/Conclusions

Analysis of complex volume array designs reveals that significant (N/2) channel compression is possible while retaining >95% SNR and showing that symmetric, uniformly distributed array elements, as in the 24-channel head array considered, leads to more degeneracy and quad/antiqued pairs, and ultimately, whole-volume channel compression is possible, making permanent hardware channel compression an option. This may allow users of MRI systems with less receiver channels to achieve the SNR of higher channel MRI systems.

References

[1] King SB, et. al. Concepts Magn Reson Part B (Magn Reson Eng) 2006; 29B(1): 42-49. [2] King SB, et. al, Magn. Reson. Med. 63:1346–1356 (2010); [3]Alagappan V, et.al.. Magn Reson Med 2007; 57:1148–1158 [4] Buehrer M, et.al.. Magn Reson Med 2007; 57:1131–1139.