# GRAPPA Operator Enhanced Initialization for Improved Multi-channel Compressed Sensing

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## Introduction

The combination of partially parallel imaging (PPI) and compressed sensing has shown great potential for fast imaging [1, 2]. Fourier transform of the partially acquired data is conventionally used as the initialization of the iterative reconstruction algorithm. A good initialization is crucial for the convergence speed and accuracy of an iterative algorithm. In this work, it is proposed to use GRAPPA operator [3] to efficiently generate initialization for multi-channel compressed sensing. Using self-feeding Sparse SENSE [4] as a specific example of multi-channel compressed sensing algorithm, experimental results show that the proposed method can not only reduce the required number of iterations, but also improve the accuracy.

## Theory

Fig. 1 demonstrates the rationale of the proposed scheme. Fig. 1a is the trajectory of the partially acquired data with net acceleration factor 5. Fig. 1c is the Fourier transform of the partially acquired data. Fig. 1c has low spatial resolution and serious aliasing artifacts. By applying GRAPPA operator, each acquired data is extrapolated to four adjacent locations. Fig. 1b shows the *k*-space trajectory after GRAPPA operator. The green dots are the results of GRAPPA operator. The net reduction factor was decreased to 1.55. Fig. 1d shows the corresponding image. Compared to Fig. 1c, Fig. 1d has higher image quality. It is proposed to use Fig. 1d instead of Fig. 1c as initialization for iterative reconstruction algorithm. Since GRAPPA operator has small convolution kernel, the improvement of the initialization is computationally very efficient.

## Methods and Results

A set of 3D brain data, acquired on a Philips 3T system with an 8-channel head coil, was used in the experiment. 3D FFE sequence with matrix size 227×115×256 and TR/TE 25/5.9 ms was used for data acquisition. The fully acquired data set was artificially under-sampled using sampling pattern shown in Fig.1a. The net acceleration factor was relative to the disk, not the matrix size. The full *k*-space data was used to generate the reference image for root mean square error (RMSE) calculation. Self-feeding sparse SENSE was used as the reconstruction algorithm. Number of iterations in Fig. 2 means the iteration of two sub-problems in the algorithm. The numerical algorithm proposed in Ref. [5] was used to solve the *I*-subproblem: prior information regularized SENSE. All methods were implemented using the Matlab programming environment, and were processed on an xw4100 HP workstation with two 3.2 GHz CPUs and 2 Gb RAM. Figs. 1 and 2 show the results. Because the kernel size of GRAPPA operator is as small as 1 × 8, the generation of enhanced initialization only took 0.2 second. The total reconstruction time for Fig. 1f was 10.5 seconds. On the contrary, using Fig. 1c as initialization, the total reconstruction needed 63 seconds by using the same reconstruction algorithm.

## Discussions and Conclusion

From Fig. 2, it can be seen that using the enhanced initialization can decrease the required number of iterations for even lower RMSE. The extra computational cost for the enhancement of initialization using GRAPPA operator is very low. The accuracy of GRAPPA operator has been experimentally proved in Refs. [4, 6]. In this example, Cartesian data with Poisson disk pattern was used as an example to explain the proposed method. For radial or spiral trajectories, GROWL [6] can be used as generalized GRAPPA operator for enhanced initialization.

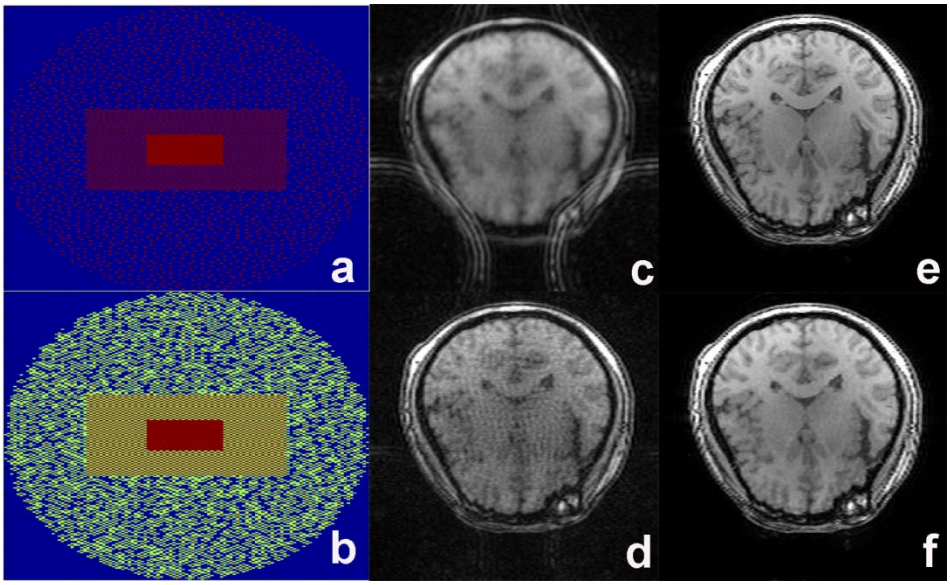


**Fig. 1: A** slice of a 3D data set with Poisson disk trajectory. a) initial *k*-space trajectory with net reduction factor 5; b) *k*-space trajectory after GRAPPA operator. This step took 0.2 second; c) and d) are images corresponding to a) and b). e) reference image. f) result of the proposed method.

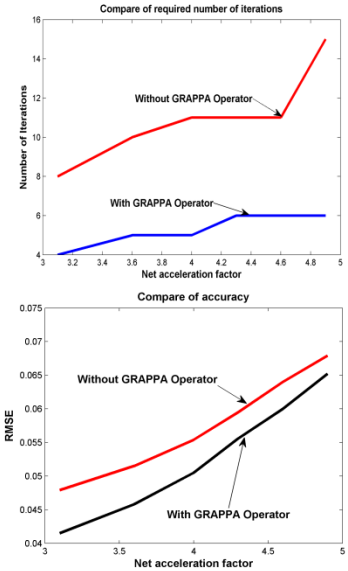


**Fig. 2**. Comparison of self-feeding Sparse SENSE with and without using enhanced initialization on required number of iterations and accuracy

**References :** [1] King KF., ISMRM 16. 2008; 1488. [2] Liang D. , et. al. MRM 2009;62(6):1574-1584 [3] Griswold MA. , et. al. MRM 2005;54:1553-1556 [4] Huang F., et. al. MRM 2010;64(4):1078-1088 [5] Barzilai J., et. al. IMA Jour Num Anal 1988;8(1):141-148. [6] Lin W. , et. al. MRM 2010;64(3):757-766