Dynamic parallel MRI using the temporal GRAPPA-Operator (TGRAPPA-Operator)

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Introduction: TSENSE [1] and TGRAPPA [2] have been presented for dynamic parallel MRI. Both methods are based on a time-interleaved phase encoding (PE) scheme and allow self-calibrated parallel imaging. Several adjacent undersampled time frames are assembled to compose a fully Fourier-encoded data set used for calibrating the reconstruction process. Here, we present an approach based on the GRAPPA-Operator [3] allowing one to reduce the number of adjacent time frames required for the calibration process. Therefore, the TGRAPPA-Operator approach should reduce the sensitivity to motion during calibration.

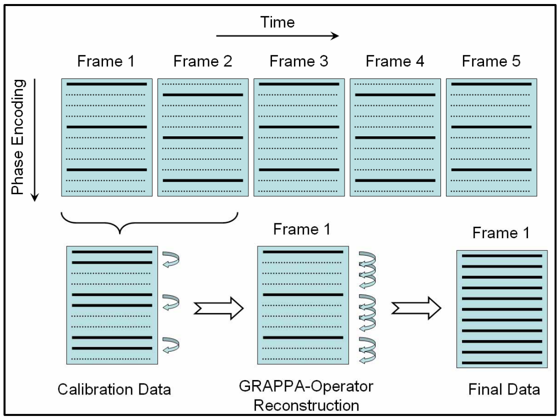

Figure 1

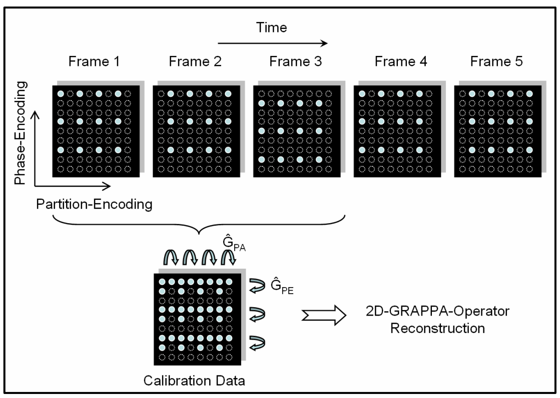

Figure 2

Theory and Methods: The GRAPPA-Operator is an extension of conventional GRAPPA. In 2D MRI, missing k-space data is reconstructed by repeatedly applying a coil weighting matrix to the collected data. In dynamic imaging, this coil weighting matrix can be derived by assembling two adjacent undersampled data sets acquired with a time interleaved PE scheme (Fig 1). While TSENSE/TGRAPPA require *R* adjacent frames for the reconstruction of images undersampled by a factor of *R*, only 2 frames are required using the TGRAPPA-Operator. This approach can be extended to 3D MRI with parallel imaging acceleration along two dimensions. Missing data is reconstructed by splitting the 2D reconstruction process into two separate 1D reconstructions. Two coil weighting matrices are required for reconstructions along the PE and the partition encoding (PA) direction. Regardless of the acceleration, only three adjacent time-interleaved frames have to be merged to calculate the coil weighting matrices (see Fig 2).

A 2D non-gated free-breathing cardiac experiment was performed on a 1.5 T scanner equipped with a 32-channel coil array. Accelerated (*R*=4) images were acquired using alternating PE offsets (1,2,1,2, …). Two adjacent frames were merged to calculate the coil-weights for a GRAPPA-Operator reconstruction of a single frame (see Fig 1). In addition, a 3D cardiac cine experiment was performed within a single breath-hold and acceleration along two dimensions (*R*=4×2=8). For calibration, 5 adjacent frames were merged to calculate the coil weights for image reconstruction.

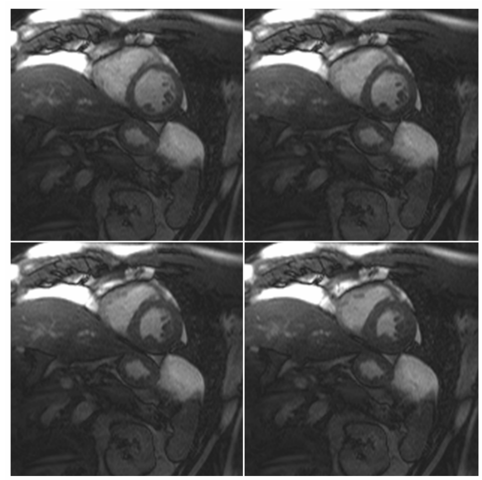

Figure 3: Results from the free-breathing 2D experiment (R = 4, 15 fps)

Results and Discussion: Fig 3 and Fig 4 demonstrate the successful implementation of this approach. The results from Fig 4 show similar reconstruction quality as conventional TGRAPPA (not shown here). In conclusion, the TGRAPPA-Operator for dynamic MRI allows one to reduce the number of adjacent time frames required for calibration. Therefore, this approach is more robust against motion and should be suited for free-breathing 3D cardiac applications. Also, interventional applications should benefit as the transient response to change is minimized with higher acceleration factors.

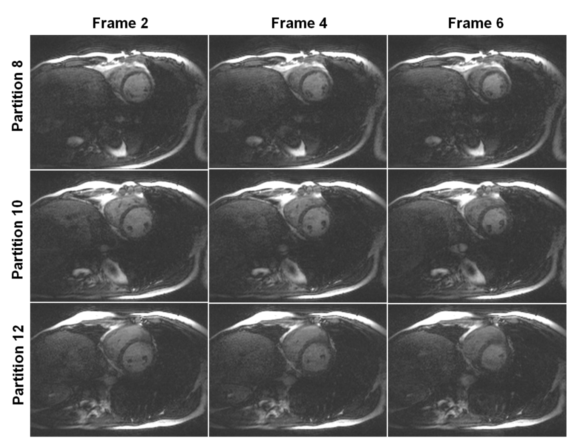

Figure 4: Results from the 3D experiment (R=4×2=8)

References: [1] Kellman P, et al. MRM. 2001;45(5):846-52. [2] Breuer FA, et al. MRM. 2005;53(4):981-5. [3] Griswold MA, et al. MRM. 2005;54(6):1553-6.