

Dynamic Autocalibrated Parallel Imaging using TGRAPPA

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Synopsis:

In this study increased data acquisition efficiency in dynamic parallel imaging has been achieved by using a time interleaved acquisition scheme in combination with autocalibrated GRAPPA. In this approach no additional auto calibration signals (ACS) need to be acquired, since the signal from the adjacent time frames is used to assemble a full set of ACS lines for an improved GRAPPA reconstruction. This eliminates the main drawback of conventional GRAPPA, namely the need to acquire additional reference lines.

Introduction:

Several different methods have been described to speed up the acquisition time by decreasing the number of phase encoding steps. Parallel imaging techniques use multiple receiver coils to remove aliasing artifacts, resulting from undersampled k-space trajectories. In this study, we combine the interleaved sampling pattern (Fig.1) used in UNFOLD [1] and TSENSE [2] with the GRAPPA [3] reconstruction. In this method, lines from adjacent time frames can be combined to form a complete set (full spatial resolution) of ACS lines. This has the advantage that no extra lines need to be acquired, thereby realizing the full image acceleration. For this study, we have used TGRAPPA reconstructions with acceleration factors of 2, 3 and 4 in real-time (non-gated), free breathing cardiac studies.

Methods:

The experiments were performed on a Siemens Sonata 1.5 Tesla whole body scanner using an 8-channel coil from NOVA Medical. A TrueFISP sequence was chosen for real time non breath-held cardiac imaging to acquire multiple frames with acceleration rates of 2, 3 and 4. The imaging parameters were TE=1.11ms, TR=2.22ms, FOV=29.2cm x 36.0cm, 8mm slice thickness matrix=60 x 128, $\alpha=50^\circ$. The frame rate was accelerated from approximately 7.5 fps (R=1) to 30 fps (R=4). In Fig. 1 the time interleaved acquisition scheme is schematically shown for an acceleration factor of 4. The ACS lines required for the GRAPPA reconstruction were assembled by combining the data from adjacent frames. Afterwards, a normal GRAPPA reconstruction was performed using the full set of 60 ACS lines.

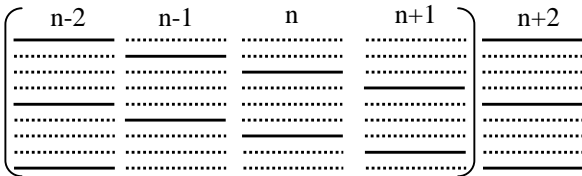
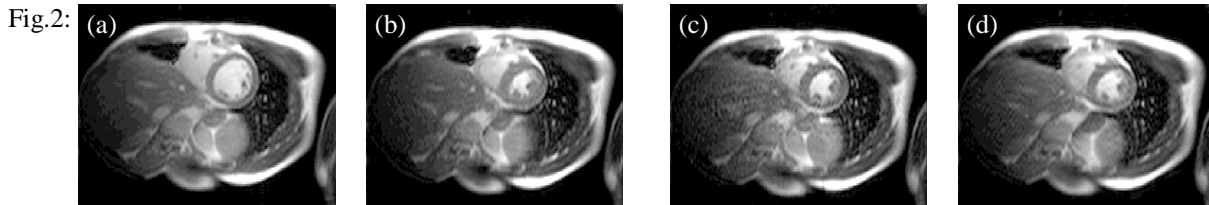


Fig. 1: Schematic description of the time interleaved acquisition scheme for an acceleration factor of 4. To reconstruct the frame n of the time series, a complete set of ACS lines assembled from adjacent frames is used.

Results:

Figure 2 shows example images for acceleration rates (a) R=1 (unaccelerated), (b) R=2, (c) R=3 and (d) R=4. As can be seen, excellent image quality is obtained for each acceleration. It also appears that the SNR is adequate even at frame rates as high as 30 fps.



Conclusion:

With this approach no extra ACS lines need to be acquired for reconstruction, thereby leading to an increase in speed compared to normal GRAPPA. The reconstruction coefficients are updated dynamically so that good reconstructions can be acquired even in cases where the coils are moving during the acquisition. In this work, a simple combination of ACS lines from adjacent time frames was used. However, more advanced temporal interpolation schemes could also be implemented [2]. Excellent artifact suppression has been demonstrated when used in the free-breathing acquisitions shown here. Additionally, an optional temporal filter may be applied after the TGRAPPA reconstruction to further suppress any residual artifacts. However, the presented images without temporal filtering show nearly no artifacts up to an acceleration factor of 4, even with normal breathing.

References:

- [1] Madore et al. [1999], MRM 42:813-828
- [2] Kellman et al. [2001], MRM 45:846-852
- [3] Griswold et al. [2002], MRM 47(6):1202-1210

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