A Selective Acceleration and Multi-resolution Approach to Multi-echo Imaging

S. Banerjee[1], C. V. Morze[2], D. A. Kelley[1], P. J. Beatty[1], D. B. Vigneron[2], and E. T. Han[1]

[1]Applied Science Laboratory, GE Healthcare, Menlo Park, California, United States, [2]Radiology and Biomedical Imaging, University of California San Francisco, San Francisco, California, United States

Introduction: Multi-echo sequences provide a time-efficient means to acquire – in a single scan - multiple images, each at a different clinically relevant contrast weighting. Parallel imaging has the potential to further increase the time efficiency of such sequences, but its application can be limited by the SNR (or lack thereof) available at the longest acquired echo time. To overcome this limitation, this work proposes a scheme that selectively applies parallel imaging to the higher SNR echoes, while reducing the spatial resolution and maintaining Nyquist sampling of the lower SNR echoes. We demonstrate the efficacy of this method for two applications: 3D dual-echo GRE angiography/venography (MRAV) [1] and 2D dual-echo spin echo for PD and T2 weighted imaging [2].

Method: In the dual-echo acquisition, the earlier (higher SNR) echo was accelerated by a factor of R, while the later (lower SNR) echo was acquired – with reduced resolution - at the Nyquist sampling rate. The resolution for the lower SNR echoes was increased by using a fractional ky acquisition with homodyne reconstruction. Calibration data obtained from the Nyquist-sampled second echo was used to reconstruct the accelerated first echo. The accelerated sampling pattern for the first echo and full and fractional-ky lower-resolution sampling patterns for the second echo is shown in Figure 1. To demonstrate our technique, two normal volunteers who provided their informed consent were imaged on a 3T GE Signa HDx scanner (Waukesha, WI). A 3D dual-echo spoiled gradient echo sequence with a fly-back trajectory was used for acquiring MRAV images: in-plane acquisition matrix of 384x312; scan time of 5:11 mins per slab with 20 slice locations. A 2D dual-echo spin echo sequence was used to acquire simultaneous PD and T2-weighted images: 384x288 matrix, scan time of 7 mins. Offline processing simulated an R = 2 acceleration of the first echo. The accelerated first echo was reconstructed using the ARC algorithm [3], with 12 central ky lines from the second echo as calibration lines. Data from the second echo was processed to simulate smaller ky dimensions for different partial-ky fractions.

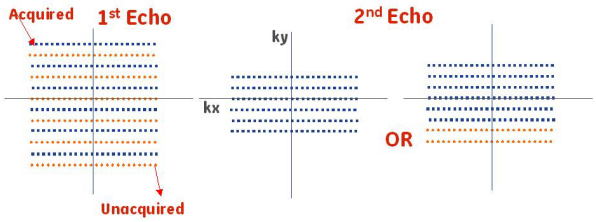

Figure 1: Sampling patterns for the first and second echo

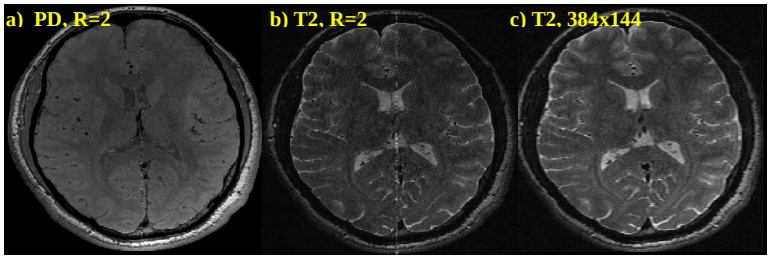

Figure 3: PD image with R=2 (a) and T2 image with 384x144 full ky matrix (c) preserved image quality in half of the original scan time while acceleration of both echoes compromised the quality of the T2 image (b).

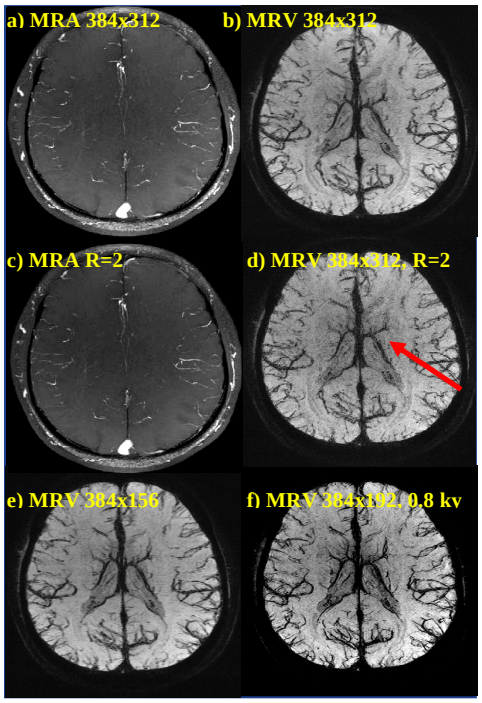

Figure 2: Acceleration of both echoes deteriorates MRV image (d) but selective acceleration of MRA (c) and 384x192 .8 ky acquisition for MRV (f) preserves vessel depiction in half the original scan time.

Results and Conclusion: Acceleration of first echo by 2 (Fig. 2c) and acquisition of 156 ky lines corresponding to a matrix of 384x192, .8 ky fraction for the second echo (Fig. 2f) preserved the arterial and venous depictions, in half of the original scan. In this case, acquisition of 156 ky lines corresponding to a 384x156 full ky matrix led to a slightly blurred image with insufficient resolution (Fig. 2e) and acceleration of both echoes led to degraded image quality and loss of small vein visualization in the MRV image (Fig. 2d). For the dual echo spin echo imaging, acceleration of the first echo by 2 folds (Fig. 3a) and acquisition of 144 ky lines corresponding to a 384x144 matrix; full ky acquisition (Fig. 3c) produced good image quality while acceleration of both echoes led to degradation of the T2 weighted image (Fig. 3b). In both the applications, the ARC algorithm could reconstruct the undersampled data from the first echo using calibration data from the second echo without any artifacts or image degradation, in spite of the significant image contrast differences between the two echoes. This work enables the acceleration of multi-echo imaging sequences without compromising the image quality of the lower SNR echoes.

References: [1] Du et al 2008 MRM 59:954-958 [2] Ahn et al 1992 AJNR 13:1169-77
[3] Beatty et al. ISMRM 2007, 1749