Rapid 3D-FFE MR Image Acquisition using Aliased k-space Acquisitions

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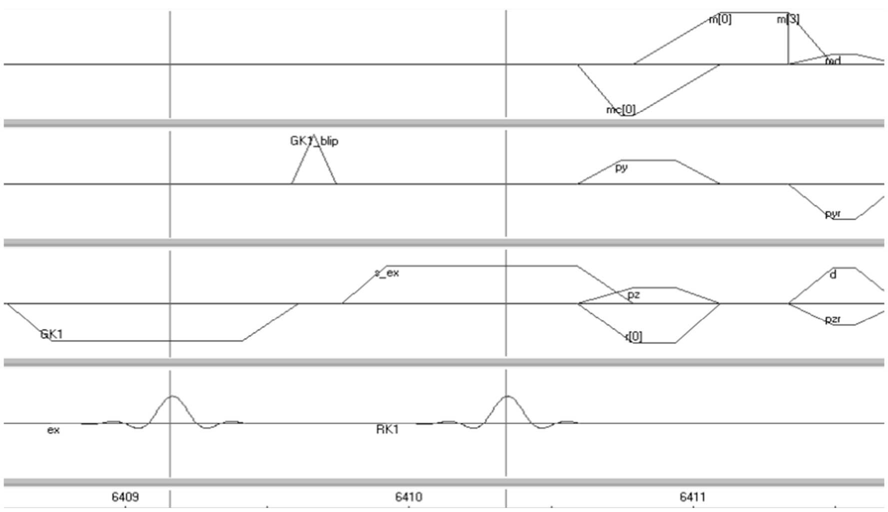
Target Audience: MR Physicists

Purpose:
The key penalty in accelerating an MRI scan through k-space sub-sampling is the resultant loss in acquisition SNR that inevitably occurs. Recently, a new method for preserving acquisition SNR through *simultaneous* acquisitions of distinct k-space phase encodes was presented [1]. In this approach, an excitation module comprising RF pulses and gradients was inserted into a sequence of choice to overlap and acquire distinct k-space phase encodes. This accelerates a scan as all phase encodes could now be acquired in a duration shorter than that of a typical scan. This "aliased k-space" was then restored during reconstruction using the coil receiver sensitivity profiles. Depending on the k-space aliasing pattern, voxel size increased during acquisition thus resulting in an SNR increase with scan acceleration. Here we present our ongoing work of using aliased k-space acceleration techniques in 3D MRI acquisitions with the eventual goal of accelerating 3D dynamic MRI acquisitions for contrast enhanced perfusion studies.

Material and Methods:
An excitation module comprising RF pulses and gradients as described in figure-1 was inserted into a T1 weighted 3D-FFE sequence to overlap and acquire distinct k-space phase encodes. This module was capable of accelerating 3D-FFE scans along any phase encode direction. This 3D FFE sequence was next tested using a 3T MRI scanner platform (Ingenia, Philips Healthcare, The Netherlands). Flip angles of 5° and 10° for the two RF pulses were used during our experiments (3D FFE, FOV=30cm*30cm, TR=7ms, TE=3.5ms, 32-channel head coil) Next, the raw aliased k-space phantom data was restored using a 3D reconstruction algorithm, which was an extension of the algorithm described in [1]. The coil sensitivity profiles were obtained using the techniques proposed in [2].



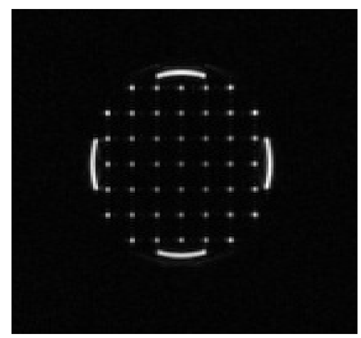


Fig 2: the restored phantom image obtained after using coil sensitivity profiles to unalias k-space along the primary phase encode axis.

Fig 1: RF excitation pulse *Rk1*, the phase encoding gradient blip *Gk1_blip* and the additional slice select gradient *s_ex* were the only additions to the 3D FFE pulse sequence. The inherent flexibility of the FFE product code was maintained and the sequence can be used as a standard FFE or as an EPI sequence.

Results: Figure 2 is the representative image of our RATE-3D-FFE scan. Our preliminary implementation of RATE to accelerate 3D-FFE sequence was able to produce two fold of reduction in scan time with respect to the routine 3D-FFE scan.

Discussion and Conclusion:
Our work demonstrates an example of successful implementation of RATE accelerated 3D-FFE sequence. Our ongoing work involves developing strategy to achieve even higher acceleration factors for 3D T1 acquisitions including testing the performance of the sequence on healthy subjects. The key factor in translating the gains in acquisition SNR into the post reconstruction output is the condition of the encoding matrix described in [1]. This parameter is entirely dependent on the aliasing pattern that is employed and the same can therefore be improved to enhance the gains in reconstruction SNR as well. Optimization of the same will enable the application of this sequence in 3D contrast enhanced perfusion studies.

Reference: [1] Arunachalam et al. MRM Early View August 2014, DOI: 10.1002/mrm.25392; [2] Pruessmann et al. MRM. 1999 Nov; 42(5):952-62