Sampling Order Optimization for contrast preservation in accelerated prospective 3D MRI

Sampling Order Optimization for enhanced contrast in real-time accelerated prospective 3d MRI

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Introduction/Purpose:

The main purpose of this study is to implement accelerated prospective MRI in hospitals in order to reduce scan time. For accelerated MRI using compressed sensing and parallel imaging (CS-PI) reconstructions, the choice of subsampling pattern plays an important role in preserving image quality[1, 2]. In addition to it, in certain clinical MRI sequences (eg. efgre3d), the sampling order also becomes very important to avoid loss of contrast in the images. In this work, we show how variation in sampling order affects image quality and also prove that a modified subsampling pattern with an optimized sampling order enhances contrast in accelerated prospective 3d MRI.

Methods/Subjects:

The scanning was performed on a 1.5T GE Signa Horizon HDX scanner with an 8 channel head coil. 8 subjects were recruited under the healthy volunteer ethics protocol. Fully sampled and accelerated scans (R=3) using the efgre3d sequence was performed for various subsampling patterns and orders of sampling. The scan time was reduced from 8:08 minutes for fully sampled scans to about 2:42 minutes for accelerated scans. Reconstruction was performed using ℓ_1-ESPIRiT algorithm which is a CS-PI reconstruction technique. The next step in this study is to receive radiological assessment to validate the clinical utility of the accelerated MR images.

Results:

Figure 1a and 1b show the same fully sampled pattern with and without sampling order optimization. The corresponding reconstructed images from the fully sampled patterns are also shown. Figure 2a shows a modified subsampling pattern (R=3) with an optimized sampling order whereas figure 2b shows a standard poisson-disc subsampling pattern (R=3) without sampling order optimization. The corresponding reconstructions using ℓ_1-ESPIRiT are also shown.

Discussion:

In efgre3d sequence, for each line of kspace, a readout gradient is applied after an inversion pulse for a duration of 9.6 ms. The samples collected at the beginning of the readout gradient have better contrast due to the saturation of the magnetization towards the end of the readout gradient. Therefore, it is important that the central kspace data which contains most of the contrast information in the image is acquired towards the beginning of each readout gradient. The colourbar on the sampling patterns in figures 1 and 2 illustrate the time at which the samples are collected during each readout gradient. It can be seen that in the patterns with optimized sampling order, the central kspace samples are collected towards the beginning of

each readout gradient. This shows that sampling order optimizaton is necessary to preserve contrast in accelerated prospective 3d MRI using efgre3d sequence.

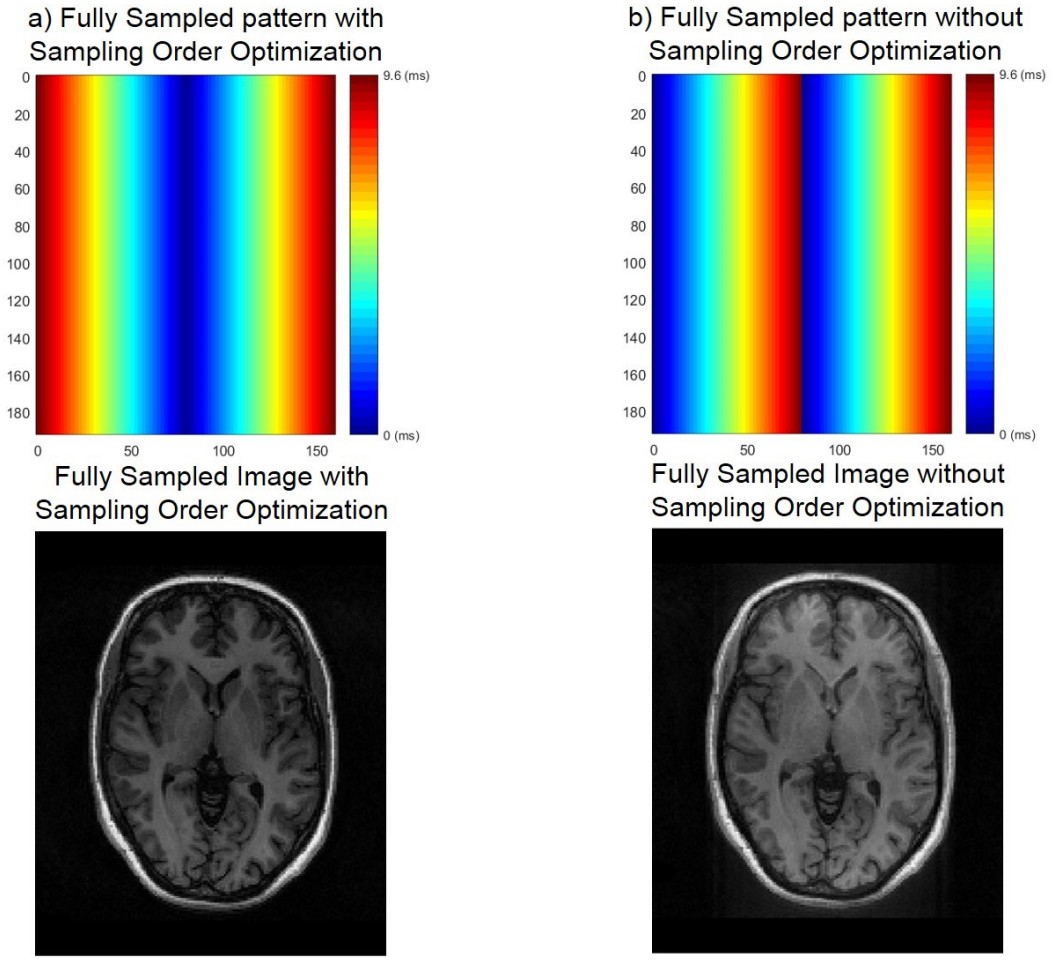

Figure 1: Figure 1: Figure 1a and 1b show the same fully sampled pattern (192x160) with and without sampling order optimization. The corresponding reconstructed images using using ℓ1-ESPIRiT algorithm are also shown.

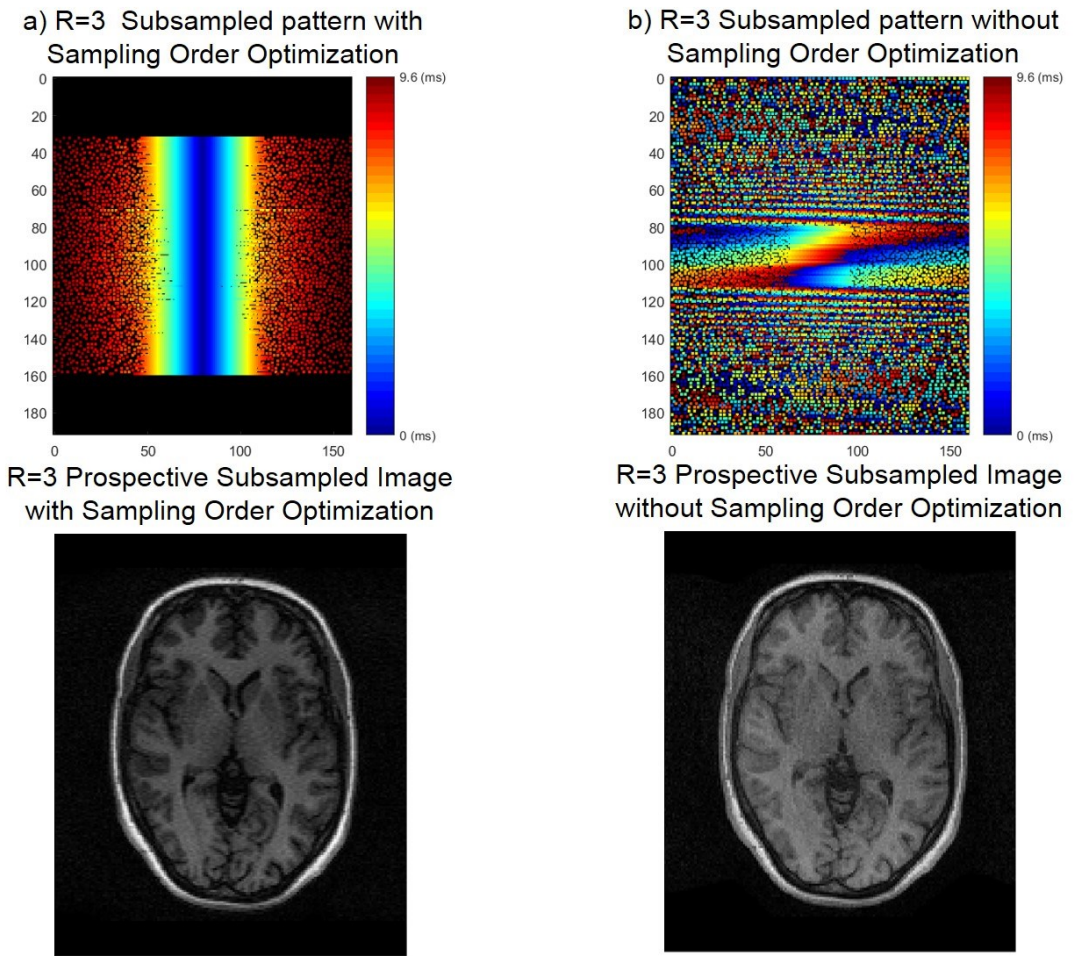

Figure 2: Figure 2a shows a modified subsampling pattern (R=3) with an optimized sampling order whereas figure 2b shows a standard poisson-disc subsampling pattern (R=3) without sampling order optimization. The corresponding reconstructions using ℓ1-ESPIRiT are also shown.

[1] M. Lustig, D. Donoho, and J. M. Pauly, "Sparse MRI: The application of compressed sensing for rapid MR imaging," *Magnetic Resonance in Medicine,* vol. 58, pp. 1182-1195, Dec 2007.

[2] M. Uecker, P. Lai, M. J. Murphy, P. Virtue, M. Elad, J. M. Pauly, *et al.*, "ESPIRiT-An Eigenvalue Approach to Autocalibrating Parallel MRI: Where SENSE Meets GRAPPA," *Magnetic Resonance in Medicine,* vol. 71, pp. 990-1001, Mar 2014.