Comparison of Reconstruction Algorithms for Undersampled PR imaging

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Introduction: Projection reconstruction (PR) is one of the earliest imaging techniques in MRI. Recently the use of undersampled PR techniques has received renewed interest. Since the data sampling of PR is nonrectilinear, image reconstruction using PR data requires gridding the data onto Cartesian points before applying the inverse fast Fourier transform. A conventional gridding method involves the use of a convolution kernel, such as Kaiser-Bessel window function [1]. More recently, several gridding algorithms, including block uniform resampling (BURS) [2] and iterative next-neighbor gridding (INNG) [3], were proposed. Both of the algorithms do not need data density compensation. The BURS algorithm involves matrix inversion using singular value decomposition (SVD) and thus is sensitive to noise. In INNG algorithm, image reconstruction is performed by iteratively scaling image matrices to sizes greater than the targeted matrix. The INNG has been compared to other algorithms. The results show that INNG can lead to accurate reconstruction with a sufficiently large scaling factor. It also results in fewer errors as compared to the other algorithms. Given the increased interest in undersampled PR, this work compares the filtered backprojection (FBP), conventional gridding using Kaiser-Bessel function (KB), and INNG algorithms using undersampled PR data.

Methods: In the FBP algorithm**,** a rho filter was applied to the data without additional filtering. For the KB algorithm, a Kaiser-Bessel function of width 4 with a shape parameter of 2π was used. The data density was compensated using an iterative method proposed by Pipe and Menon [4]. For the iterative reconstruction algorithm, the facilitated INNG was implemented. The scaling factor s was 2, 4, and 8 with corresponding iteration number of 7, 5, and 18 [3]. In order to investigate the characteristics of the algorithms, point spread functions (PSFs) were reconstructed using synthetic 32-, 64-, 128-, and 256-view PR data. The signal-to-noise ratios (SNRs) were determined and compared using phantom images, which were acquired from a uniform cylinder phantom. Finally, 32-, 64-, and 128-view in vivo knee images were used to access the performance of these algorithms.

Results and Discussion: Figure 1 shows the comparison of full-width at the half-maximum (FWHM) of FBP, KB, and INNG PSFs. It shows that KB provides the narrowest FWHMs and FBP the widest. In Figure 2, intensity profiles of 32- and 64-view PSFs were compared. It shows that the artifact tails due to undersampling are somewhat higher for FBP. Further FBP also leads to a smaller artifact-free zone. The SNR comparison in Figure 3 shows that INNG provides thevbest SNRs and FBP the worst. The performance of the algorithms is assessed using in vivo knee images shown in Figure 4. Although INNG provides the best SNR as shown in Figure 3, it does not provide enough spatial resolution to reveal structure details and leads to somewhat blurry images as shown in Figure 4. On the other hand, FBP and KB provide better and best structure details in the reconstructed images. As compared to INNG and FBP, KB results in a better tradeoff between SNR and spatial resolution.

Conclusion: Three image reconstruction algorithms, FBP, KB, and INNG, were compared using undersampled PR data. The results show that INNG leads to the best SNR. However, comparison of in vivo images indicates that this may be because INGG reconstruct fewer high frequencies as compared to FBP and KB. In summary, as compared to INNG and FBP, conventional Kaiser-Bessel gridding algorithm provides a better tradeoff between SNR and spatial resolution for undersampled PR imaging.

References:

[1] O'Sullivan, IEEE Trans Med Imaging 4:200-207, 1985

[2] Rosenfeld, MRM 40:14-23, 1998.

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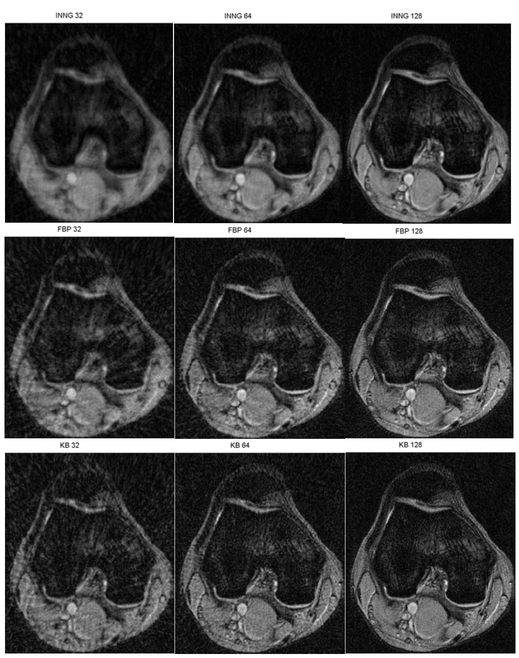

Figure 4. Knee images reconstructed using 32-, 64-, and 128-view (left to right) PR data. From top to bottom: INNG, FBP, and KB.

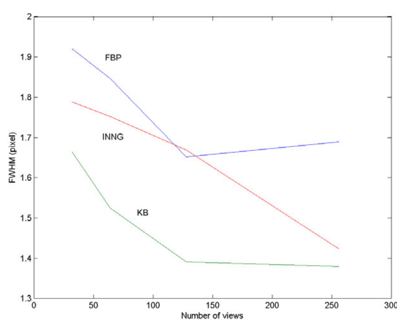

Figure 1. FWHM of FBP, KB, and INNG PSFs.

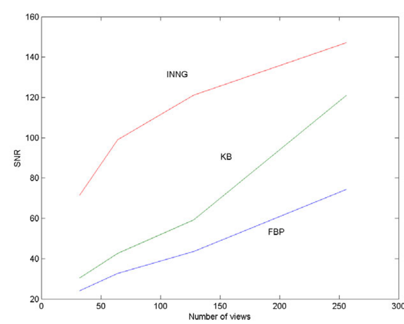

Figure 2. Comparison of SNR.

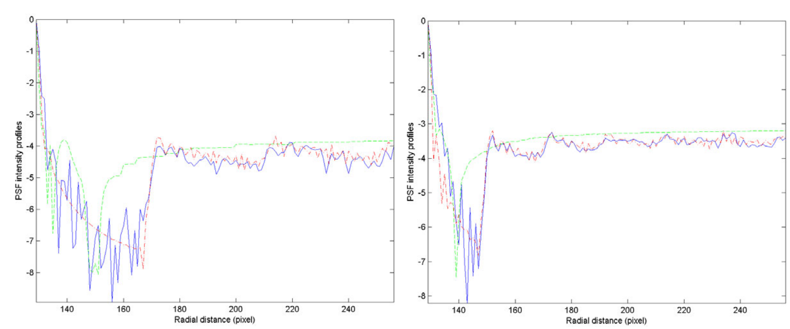

Figure 3. Intensity profiles of 32- (left) and 64-view (right) PSFs. Profiles from FBP (dashed line), KB (dash-dotted line), and INNG (solid line) were compared on a logarithm scale.