A Density Compensation Function using Kaiser-Bessel Regridding

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Introduction

One of the most important aspects of reconstructing non-Cartesian data is computing the density compensation function (DCF). For example, in conventional radial imaging a Ram-Lak filter would be used to weight the data as a function of radial position to compensate for the divergence of the projections. As various undersampling acquisition schemes are investigated as mechanisms to achieve shorter scan times or higher frame rates, the DCF becomes more complex. Additionally, the problem is compounded in those acquisition methods that use view sharing. For example, researchers have investigated using a Golden-angle radial scheme with partial view sharing. This method allows for remarkable flexibility in choosing those data that are desired or rejected (motion for example). In fact, the entire reconstruction can be performed retrospectively with the sampling density varying depending on which data the user chooses in that particular reconstruction, and can subsequently change if the results aren't satisfactory. Therefore, the entire reconstruction, including the computation of the DCF must be very fast and flexible. We present a method for computing the DCF that uses the same programming used for interpolating the MR data onto a Cartesian grid. This approach is general in nature requiring only the knowledge of each sample's position in K-space and is simple to implement.

Methods

Phantom data were acquired on a Siemens Trio with a fast gradient echo sequence using radial projections in which the angle was advanced by the Golden angle (~111 degrees) on each repetition [1,2]. Data between temporal frames were shared using K-space Weighted Image Contrast (KWIC) [3]. This allows great flexibility in grouping projections into subframes and yields smoother sampling of the time signal intensity curves in post-contrast DCE_MR applications. However, the non-uniform angular sampling can give rise to streaking artifact. The radial data were reconstructed using three different density compensation functions. In the first, a traditional Ram-Lak filter was used. This method is widely used and is simple to implement. However, due to the variable angular density, streaking was expected. The second method used the actual K-space density as computed from the area between samples. This method is considered the gold standard and is as accurate as the care taken used to compute the area, but is more time consuming to process. The third method used the gridding approach in which the MR data were interpolated onto a Cartesian grid using a 5 x 5 Kaiser-Bessel kernel. As the data were processed through this routine, a point of unity intensity at the sample's location was also regridded onto a map. As each acquired sample was processed, the map was populated to create the density map (**Figure 1**). After all data and corresponding sample points were gridded, the MR data were divided by the density map to complete the compensation.

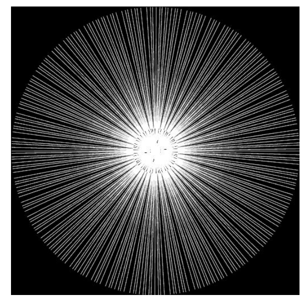

Figure 1. Density map of a Golden angle radial acquisition computed from the gridded trajectory.

Results

Phantom images are shown in **Figure 2** of the gridding method as compared to the Ram_Lak filter. The streaking artifacts have been completely eliminated using the gridding method. **Figure 3** shows nearly identical image quality between the gridded DCF and the direct computation of density by K-space area.

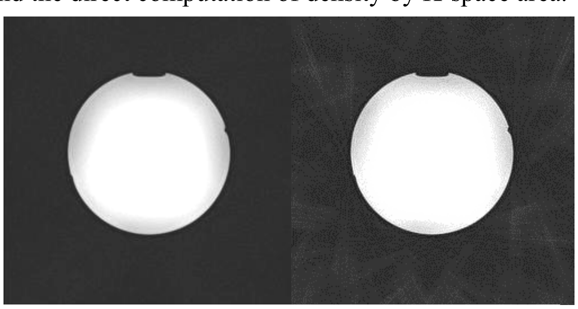

Figure 2. Images computed using gridded DCF **(left)** and Ram-Lak filter **(right)**

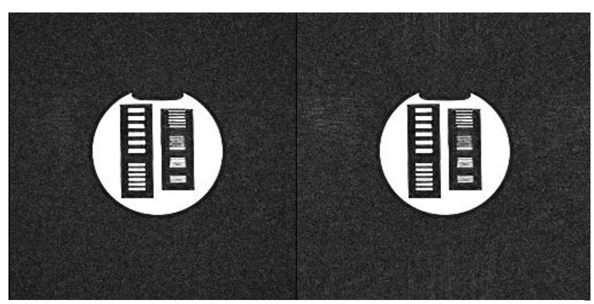

Figure 3. Images computed using trajectory gridding **(left)** and K-space area **(right)**

Conclusion: A density compensation function can be computed simply and quickly using a common Kaiser-Bessel interpolation function. The method can be used with any K-space trajectory and is rapid to compute.

[1] Winkelmann, S. IEEE Trans Med Imaging; 26:68-76, 2007. [2] Song HK, et al. Proc. ISMRM 2006, Seattle, p.3364
[3] Dougherty L, *et al*. Magn. Reson. Med., 57:220-225, 2007.