Computational MR imaging
Laboratory 4: Reconstruction of non-Cartesian k-space data
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1. **Radial sampling pattern:**

   1.1 The radial sampling trajectory on the simulated k-space data for the first 40 golden-angle spokes and 384 sampling points along each spoke is illustrated below. The Nyquist sampling requirement for this case is $384 \times \pi/2 \cong 602$ projections to completely free of aliasing artifacts.

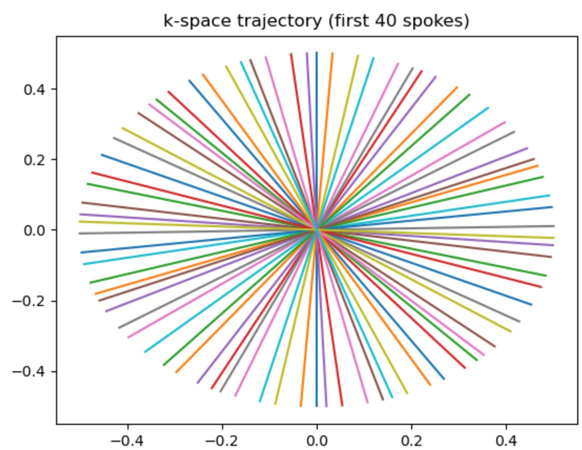

Figure 1: Radial sampling trajectory with golden angle increment.

2. **Basic gridding reconstruction:**

   2.1 The acquired 2D non-Cartesian k-space and it's results Cartesian k-space after gridding with the triangular kernel is presented in Figure 2:

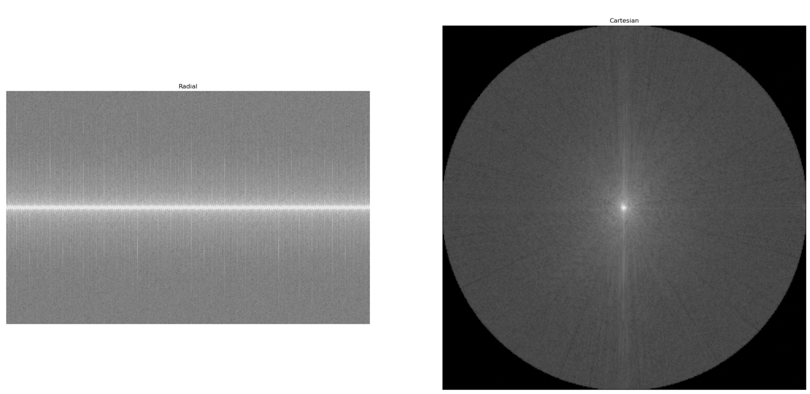

Figure 2: Radial k-space(left) and Cartesian k-space(right) after gridding.

2.2 The reconstruction result of the Cartesian data is presented in Figure 3:

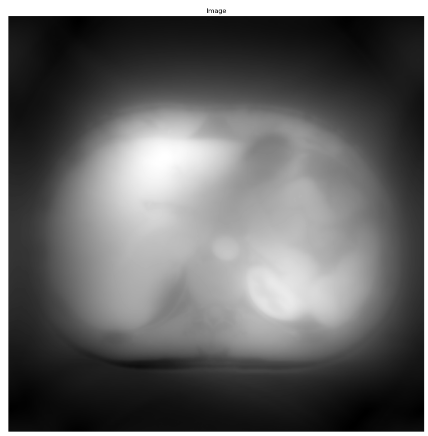

Figure 3: Reconstruction result (384x384).

2.3 (a) The image is very blurred and non-uniformly bright. This is due to non-uniform weighting of the acquired k-space samples and samples at the center being acquired multiple times.

(b) This image shows the axial view of the abdomen. The liver and stomach can be identified.

3. **Density compensation:**

3.1 It is clear that the non-uniform weighting of radial k-space has to be compensated for. This is done using a Ramp filter.

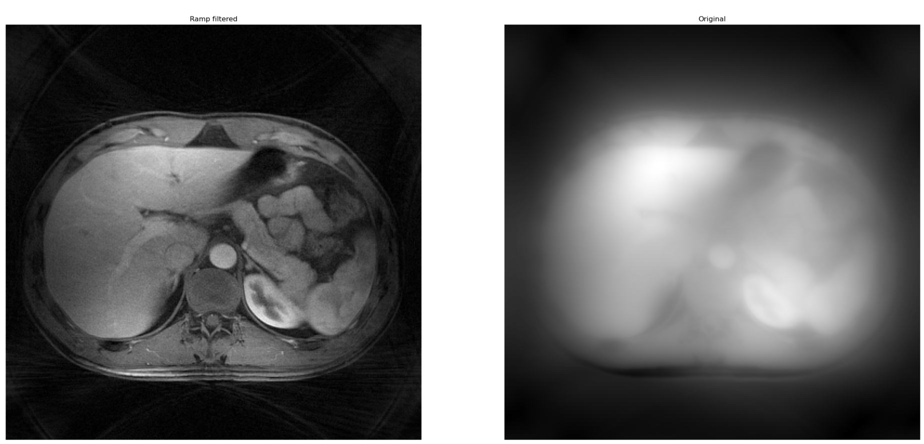

Figure 4: Density compensated (left), Without density compensation(right).

3.2 (a) While there is an improvement after applying the ramp filter, we still see a few artifacts. Aliasing is prominent towards top and bottom, streaking artifacts are visible and the central region appears slightly brighter than the edges.

(b) These artifacts can be accounted for by oversampling (aliasing) and de-apodizating (bright center) the k-space data.

4. **Oversampling:**

4.1 Reconstruction after oversampling the grid 1.5x & 2x times resulted in increasing the FoV in the image space. The over-sampled image is then cropped to the original size (384x384). These results are presented in Figure 5:

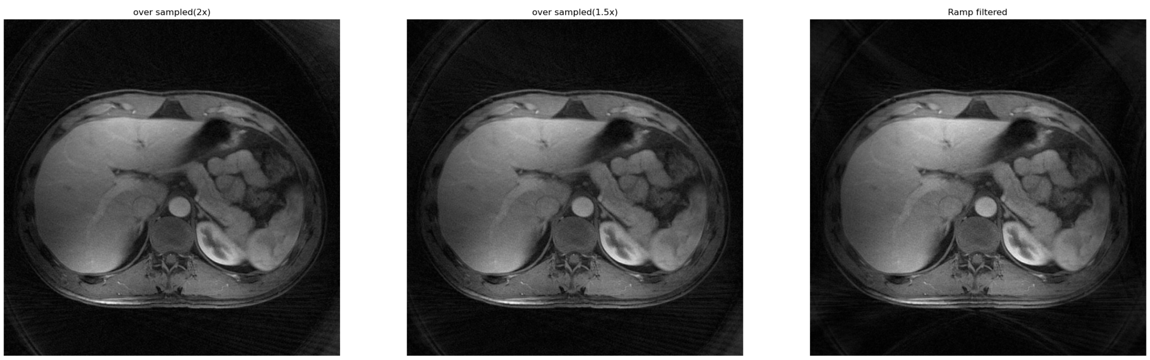

Figure 5: Over sampled 2x (left), 1.5x (center), Only ramp filtered (left).

(a) Both over-sampled results do not display any aliasing artifacts when compared with normally sampled ramp filtered image. However, streak artifacts toward the bottom left appear a little brighter.

(b) There also is no significant difference between the over-sampled images.

5. **De-apodization:**

5.1 The de-apodization function is computed in the image domain and applied to the gridded image oversampled by 2. This function is plotted in Figure 6:

Figure 6: De.apodization fuction in image domain.

5.2 The reconstruction results from steps 2 to 5 are summarized in Figure 7:

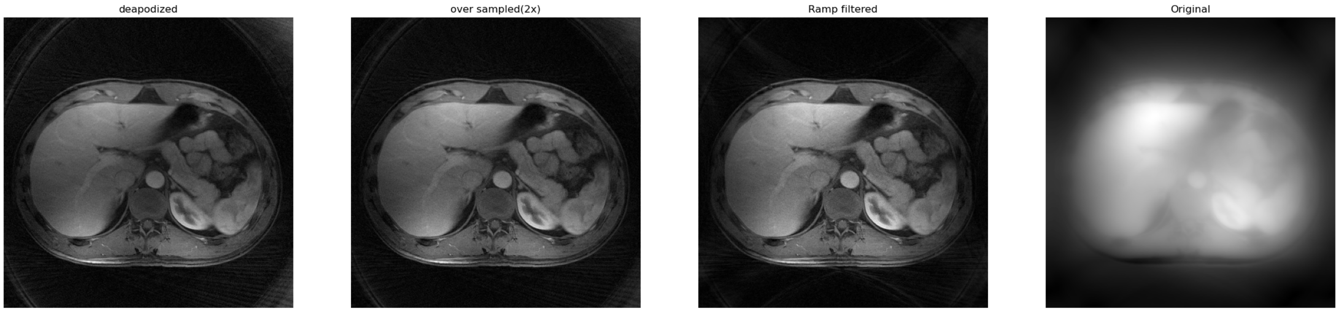

Figure 7: De-apodized, over-sampled(2x), Ramp filtered & Unfiltered reconstructions (left to right).

5.3 The reconstruction after De-apodizing the over-sampled image results in the central image appearing a little darker while the image edges appear brighter when compared to the image result with Apodization (over-sampled 2x). The streaking artifacts at the bottom also appear brighter in comparison.

6. **NUFFT toolbox::**

6.1 The reconstruction results using the NUFFT toolbox for over sampling rates 1.5x & 2x are compared with gridding reconstruction using the triangular kernel in Figures 8 and 9:

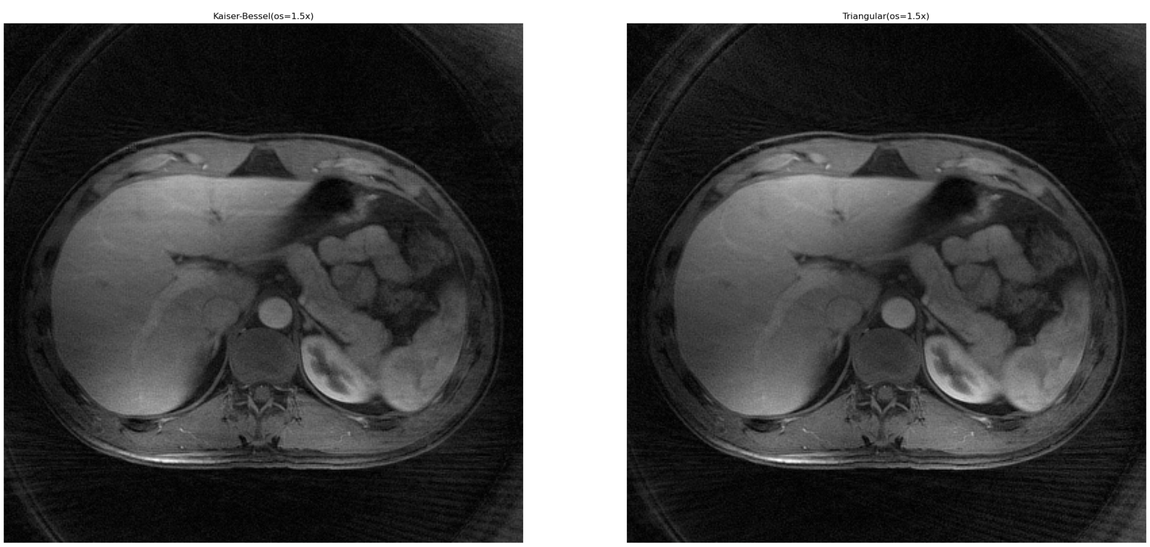

Figure 8: Kaiser-Bessel vs Triangular (os=1.5x).

6.2 (a) On comparing the images at the anatomic ROI for over sampling rate= 1.5, the NUFFT toolbox (Kaiser Bessel) appears to produce a slightly darker reconstruction when compared to the triangular kernel.

(b) However, the toolbox does a better job at suppressing the streaking artifacts at the edges of the image outside of the anatomical ROI.

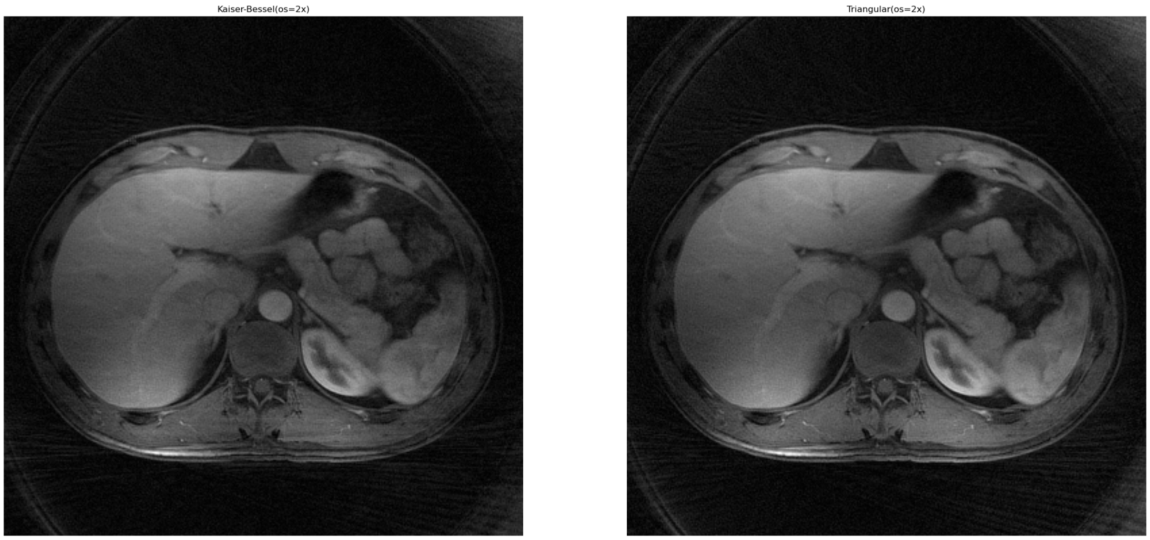

Figure 9: Kaiser-Bessel vs Triangular (os=2x).

6.3 (a) However, the same comparison for an over sampling rate of 2, both kernels appear to produce similar reconstruction results when examined at the anatomical ROI.

(b) However, the Kaiser Bessel kernel again performs much better at reducing streak artifacts compared the Triangular kernel.