Computational MR imaging
Laboratory 3: Partial Fourier imaging

Code submission is due by 12:00 before the next Thursday lab section. Please upload your code to StudOn in a described format. Late submissions will not be accepted.

Learning objectives

- Accelerate the acquisition of real-valued images using Hermitian symmetry in k-space
- Estimate the phase for partial Fourier reconstruction
- Apply the Margosian and POCS methods to reconstruct partial Fourier data

1. Zero-filled Fourier reconstruction and Hermitian symmetry reconstruction.
   1.1. Kdata is loaded by *load_kdata_pf*, which was acquired with a partial Fourier factor, PF=9/16.
   1.2. Define the half zero-filled kdata and the theoretical Hermitian symmetric kdata
      1.2.1. Define a method, *get_half_zf_kdata*, which returns a half zero-filled kdata.
      1.2.2. Define a method, *hermitian_symmetry*, which returns a theorical hermitian semmetric kdata of the half zero-filled kdata.
      1.2.3. Plot both kdata
   1.3. Compute and plot the half zero-filled Fourier reconstruction and the theoretical half-Fourier reconstruction (Hermitian symmetry only, no phase-correction).
   1.4. Discuss artifacts for each case.

2. Phase estimation function
   2.1. Write a method, *estim_phs* to estimate the phase of an image from a symmetric region at the center of k-space.
   2.2. Estimate the phase of the zero-filled kdata.
   2.3. Plot estimated phase

3. Margosian partial Fourier reconstruction
   3.1. Define a method, *get_window*, returning a window filter of type either Ramp or Hamming.
   3.2. Define a method, *pf_margosian*, for Margosian reconstruction.
   3.3. Reconstruct PF kdata using Margosian method with both Ramp and Hamming window filters.
   3.4. Discuss results between two filters in terms of SNR and potential artifacts.

   Hamming has better SNR as it suppresses higher frequency components, but it also blurs the image

4. POCS partial Fourier reconstruction
   4.1. Define a method, *pf_pocs*, for POCS reconstruction.
   4.2. Perform POCS reconstruction on the PF kdata with multiple iterations (2, 4, 6, 8, and 10)
   4.3. Choose the minimum number of iterations where the algorithm has converged by comparing reconstructed images to each other. Hint: when comparing reconstructed images, do not forget to normalize images in a range of 0-1. Plot the change in the solution with respect to the number of iterations.

5. Comparison of reconstructions
    5.1. Plot the zero-filled FFT, two Margosian reconstructions, and POCS reconstruction.
        5.1.1. Fill 0s to the *kdata* in the orignal shape for the zero-filled FFT.
    5.2. Load fully-sampled kdata by calling a method, *load_kdata_full*, from the exercise from the previous week and plot the difference of your reconstructions to the IFFT reconstruction of the fully sampled. Which method provides a better reconstruction? Explain in terms of SNR, spatial resolution, residual artifacts and ringing.