Computational MR imaging
Laboratory 3: Partial Fourier imaging

Report is due on Wednesday before the next lab session at 23:50. Please upload your report on StudOn.

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. Load kdata_phase_error_severe.mat. This dataset has been acquired with a PF=9/16. Compute and plot the zero-filled Fourier reconstruction and the theoretical half-Fourier reconstruction (Hermitian symmetry only, no phase-correction). Discuss artifacts for each case.

2. Write a function to estimate the phase of an image from a symmetric region at the center of k-space. Hint: use the method shown in class, which includes zero-padding and filtering. (see format below. Note: The format below is an example format. You can change it as you wish.)

```
def estim_phs(kspace, N):
    '''
        Phase estimation

        Param:
            kspace: asymmetric k-space data
            N: target size of the reconstructed PF dimension
        Return:
            estimated_phase: estimated phase of the input "kspace"
    '''
```

3. Write a function that reconstruct partial Fourier MRI data using the Margosian method (see format below. Note: The format below is an example format. You can change it as you wish.)

```
def pf_margosian(kdata, N, ftype):
    '''
        Margosian reconstruction for partial Fourier (PF) MRI

        Param:
            kdata: asymmetric k-space data
            N: target size of the reconstructed PF dimension
            ftype: k-space filter ('ramp' or 'hamming')
        Return:
            I: reconstructed magnitude image
    '''
```

4. Write a function that reconstruct partial Fourier MRI data using the POCS method (see format below. Note: The format below is an example format. You can change it as you wish.)

```
def pf_pocs(kdata, N, Nite):
    '''
        POCS reconstruction for partial Fourier (PF) MRI

        Param:
            kdata: asymmetric k-space data
            N: size of the reconstructed PF dimension
            Nite: number of iterations
        Return:
            I: reconstructed magnitude image
    '''
```

5. Perform Margosian reconstruction using ramp and Hamming filters on kdata.

6. Perform POCS reconstruction with number of iterations = 2, 4, 6, 8 and 10 on kdata. Choose the minimum number of iterations where the algorithm has converged based on the change in the solution for each iteration and explain your choice. Plot the change in the solution with respect to the number of iterations.

7. For each partial Fourier data set, plot the zero-filled FFT, Margosian and POCS reconstructions. In addition, load kdata1.mat 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.