Computational MR imaging
Laboratory 5: Image space parallel imaging

Report is due on Wednesday the week after the lab session at 23:59. Send your report by email to Bruno Riemenschneider (bruno.riemenschneider@fau.de) and Florian Knoll (florian.knoll@fau.de).

Learning objectives

- Combine multicoil images
- Reconstruct undersampled multicoil data using SENSE algorithm
- Compute g-factor and SNR

Before the lab: Get familiar with the functions inv (matrix inverse) and pinv (matrix pseudo-inverse), and the operators ‘ (conjugate transpose) and * (matrix multiplication).

1. **Multicoil combination:** Load the file data_brain_8coils.mat. The variable d is the fully-sampled k-space data (256×256×8), the dimensions of the data are [PE,FE,channels], c is the coil sensitivity maps (256×256×8) and n is the noise-only scan (256×8). Combine the multicoil images using sum-of-squares and matched-filter (least-squares) algorithms. You might want to create a function for each combination, so that you can use it again. Comment of the effect of using the noise correlation matrix.

   ```
   function [mc] = sos_comb(m)
   % Input:
   % m: multicoil images [nPE,nFE,nCh]
   % Output:
   % mc: combined image [nPE,nFE]

   function [mc] = ls_comb(m,c,Psi)
   % Input:
   % m: multicoil images [nPE,nFE,nCh]
   % c: coil sensitivity maps [nPE,nFE,nCh]
   % Psi: noise correlation matrix [nCh, nCh]
   % Output:
   % mc: combined image [nPE,nFE]
   ```

2. **Cartesian SENSE reconstruction and g-factor:** Write a function that reconstructs regularly undersampled data along the phase-encoding dimension using the SENSE method and computes the corresponding g-factor. The function will unfold multicoil aliased images using coil sensitivity maps in the image domain.

   ```
   function [ir,g] = sense1d(ia,c,Psi,R)
   % Input:
   % ia: multicoil aliased images [Nx,Ny/R,Nc]
   % c: coil sensitivity maps [Nx,Ny,Nc]
   ```

% Psi: noise correlation matrix [Nc,Nc]
% R: acceleration factor
% Output:
% ir: unaliased image [Nx,Ny]
% g: g-factor map [Nx,Ny]

Simulate acceleration factors of R=[2,3,4] along the phase-encoding dimension for the provided 8-coil data set. Assume that the phase encoding direction is the row dimension (anterior-posterior). Reconstruct each undersampled data set using your SENSE implementation; compute the average g-factor and SNR loss (make sure to exclude the pixels outside the brain). Compute the RMSE with respect to the matched-filter combination of the fully-sampled data in exercise 1. Plot the reconstructed image, reconstruction error and g-factor map for each R.