Computational MR imaging
Laboratory 5: Image space parallel imaging

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

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 in scipy.linalg **inv** (matrix inverse) and **pinv** (matrix pseudo-inverse), and the numpy operators **.T**(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.

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

def ls_comb(m,c,Psi=None):
% 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.

```
def sense_recon(ia,c,Psi,R):
% Input:
% ia: multicoil aliased images [nPE/R,nFE,nCH]
% c: coil sensitivity maps [nPE,nFE,nCH]
```

% Psi: noise correlation matrix [nCH,nCH]
% R: acceleration factor
% Output:
% ir: unaliased image [nPE, nFE]
% g: g-factor map [nPE, nFE]

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 (make sure to exclude the pixels outside the brain) and compare SNR of accelerated image to that of non-accelerated image. 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.

don't calculate NR wrt backgroud v foreground.
Instead, analytically look at images wrt fully
sampled and also deduce results from equations
and relations