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%% Assignment A
% The aim of this assignment is to get familiar with the properties of
% MRI k-space and parallel imaging
%
% Your task is to investigate different properties of k-space and their
% influence on image space by using only parts of k-space
%
% it makes use of the available matlab package pMRI by Santiago Aja-Fernandez, LPI
% www.lpi.tel.uva.es/~santi
%
% you can use the provided MRI brain slice (mri.png)
% and create an object yourself by using P = phantom('Modified Shepp-Logan',256);

%%
% Prior to starting the assignment, you will need to:
% - get access to MATLAB.
% - download the pMRI package (on blackboard or via Matlab central)
% - start to learn the basics of MATLAB in viewing and working with images (use the
% ?imshow? or 'imagesc' command to view images).
% - for the last part (parallel imaging) read the 2012 paper by Deshmane et al.
https://onlinelibrary.wiley.com/doi/abs/10.1002/jmri.23639
% which outlines the different methods for parallel imaging including SENSE (pages 60-
62)

%% create k-space for imaging slice
% using function [Mn, params, M0, Kn, K0]=phantom_parallel(I,coils,Sigma,rho,parallel,rate)
% I: Input image. If I=0, mri.png; or use P as above (Recommended Size 256x256)
% coils: Number of acquisition coils
% Sigma: Coils covariance matrix
% rho: correlation coefficient (cc) between coils [0-1]
% parallel: Acquisition type:
% 0: Multiple coils, no parallel acceleration
% 1: SENSE (ONLY 2x acceleration works properly)
% 2: GRAPPA
% rate: Subsampling rate (only for SENSE and GRAPPA)
% more info on parameters in phantom_parallel.m

% example k-space (mri.png, 2 coils, sigma=100, cc=0.1, no acceleration)
[Mn, params, M0, Kn, K0]=phantom_parallel(0,2,100,0.1,0);

% relevant OUTPUT
% Kn: Original k space (noisy)

%% What you need to do (20 marks in total):

%% Task 1) [1 mark]
% display k-space of coil 1

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imagesc(abs(squeeze(K0(:,:,1))));  
% display k-space of coil 2  
imagesc(abs(squeeze(K0(:,:,2))));
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% display of image from k-space of coil 1  
coil1=abs(k2x(squeeze(Kn(:,:,1)),1));  
imagesc(coil1);  
% display of image from k-space of coil 2  
coil2=abs(k2x(squeeze(Kn(:,:,2)),1));  
imagesc(coil2);
```

% Include the following in your assignment report: (.) the resulting images and (.) describe the results

%% Task 2) [4 marks]

% construct a composite image as using the sum of squares (SoS) method

%

% Include the following in your assignment report: (.) the resulting images and (.) describe the results

% What is different compared to the images from Task 1)

%% Task 3) [5 marks]

% remove half of k-space:

% - a) by replacing the most central half with zeros

% - b) by removing the outermost half of k-space

% reconstruct image space by using Fourier transform

%

% Include the following in your assignment report: (.) the resulting images and (.) describe the results

%% Task 4) [5 marks]

% remove half of k-space:

% - a) by removing the upper or lower half completely

% - b) by removing every second line in x-direction

% - c) by removing every second line in y-direction

% reconstruct image space by using Fourier transform

%

% Include the following in your assignment report: (.) the resulting images and (.) describe the results

%% TASK 5) [5 marks]

% reconstruct the half k-space from TASK 4c) – undersampling in phase encode

% direction by using the SENSE method

% get familiar with the SENSE method using the paper above

% you can use the implementation of SENSE as in mySENSE.m or write your own code

%

% Include the following in your assignment report: (.) the resulting images and (.) describe the results

%% some hints:

% the x2k.m contains a function for a fast Fourier transform (fft) of image space to k-space

% the k2x.m contains a function for the inverse fast Fourier transform (ifft) of k-space to image space

%% Material to be submitted (2 files):

% (1) Report: You should only submit what has been identified as "Include the following in your assignment report:" above

% Please submit a single file (.doc or .pdf) including the ASSIGNMENT COVERSHEET with all points labelled above as "Include the following in your assignment report:"

% Each question should be labelled clearly, and figures should be identified using appropriate titles

% (2) Code: Please also submit your MatLab code (.m file) that you used to create the results alongside your report