

%% Part 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 Deslaurans 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)

```
% 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
```

```
imagesc(abs(squeeze(K0(:,1))))); % display k-space of coil 2
```

```
imagesc(abs(squeeze(K0(:,2)))));
```

```
% 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);
```

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

<https://powcoder.com>
%% Task 2) [4 marks]
% construct a composite image as using the sum of squares (SoS) method

```
%
```

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% 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

PART B

Through this assignment you will learn about susceptibility weighted imaging (SWI). You are provided with real data acquired on a 7T MRI scanner (single human brain slice, gradient recalled echo acquisition with an echo time of 16.81ms). Your job is to take a corresponding magnitude and phase image and create a susceptibility weighted image. You will investigate how susceptibility weighted images are created and how contrast in these images can be changed via the phase mask.

Prior to starting the assignment, you will need to:

- get access to MATLAB.
- download NIAK tools (<https://www.nitrc.org/projects/niak/>)
- download the data provided and open it in MATLAB using the NIAK tool to read .nii (NIFTI) files.

- start to learn the basics of MATLAB in viewing and working with images (use the 'imshow' command to view

images and play around with the scale).

- read the 2000 paper by Wang et al. which outlines the method of homodyne filtering (Eqs. 5-7).
- read the 2004 paper by Haacke et al. which describes SWI, and the process used to create a phase mask.

Once you have completed the above tasks you are ready to start to create susceptibility weighted images. Enjoy!

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

- 1) Show the magnitude and raw phase images in MATLAB. Use the data cursor tool and highlight values around the image, you will see that the raw phase image contains values in the $[-\pi, \pi]$ range. *Why is this the case?*

[1 mark]

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- 2) You will now work with the magnitude and raw phase image data. Your task is to implement homodyne filtering and produce an image of tissue phase.

You need to submit your homodyne filter script. Save the tissue phase image and plot it over a range $[-2, 2]$. What happened to the wraps present in the raw tissue phase?

[Note: as a first step, use a filter size of 1/4 of the matrix size, and consider using the 'hann' function in MATLAB for the creation of the 2D filter]

[5 marks]

- 3) Now you will create a phase mask. Create the phase mask from tissue phase using positive tissue phase values only.

Show the image over the range $[0.7, 1]$ and save it for submission.

[3 marks]

- 4) With the tissue phase mask in hand, now you will be able to investigate how raising the phase mask to a power (P) influences the result. Create a susceptibility weighted image when

○ $P=1$. Save the image and label it. ○ $P=2$. Save the image and label it. ○ $P=4$. Save the image and label it.

Discuss the influence of P on the susceptibility weighted result. How should P be chosen?

[4 marks]

5) Create a susceptibility weighted image using $P = 2$ and by emphasizing negative tissue phases only. *Describe the steps you used to create this image. Save your result and label it clearly. How does this image differ from*

when positive tissue phase values are used to create the phase mask?

[4 marks]

6) Instead of using $1/4$ of the matrix size in your homodyne filter setting, try different sizes such as $1/2$ and $1/8$.

Show the images and discuss how filter size affects tissue phase.

[3 marks]

You should only submit what has been identified as part of this assignment using blue italicized font. Please submit a single file including the ASSIGNMENT COVERSHEET. Each question should be labelled clearly, and figures should be identified using appropriate titles.

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