Introduction to Biological Imaging

Homework 1

Deadline: 21.11.2018, 23:59 CET

Submit your work to: ivan.olefir@tum.de

Email title: MAT{your matrikelnummer #} HW{homework #} 201819 {your name}

Example: MAT12345678 HW1 20189 Ivan Olefir

Acceptable formats: .pdf, .doc, .docx

Report guidelines:

- Do not be too elaborate in your answers unless you are asked to. 1-2 sentences are usually enough to answer the questions.
- Every figure should have a number and a title. In the text refer to figures by their number. Every plot should have titled axes. If the figure consists of several subplots, each one should have a self-explanatory title.
- Include the commented code as shown below either at the beginning or at the end of the document

Code Example:

```
 %% Assignment 1==========================================================
%===========================================================================

% 1)    Create a phantom for simulating XCT measurements. The phantom
should
% contain ellipses and polygons of varying intensity (use radon() and
augment
% the resulting image). Show an image of your phantom.

solution = pressxtowin(1); % create phantom by pressing X to win

% 2)    Compute the views (projections) with spacing of 1, 5 and 10
degrees.
% Show the projections at 0°, 30°, 45° and 90° (in one axes).
% Show the sinogram with the most angles.

solution = pressxtowin(2); % compute projections by pressing X twice

% 3)    Implement the backprojection algorithm (i.e. inverse radon
transform)
% according to slide 16 of the Tutorial slides. You are not allowed to use
iradon().

...

%% Assignment 2 ===========================================================
%===========================================================================
```

Assignment 1

1) Create a phantom for simulating XCT measurements. The phantom should contain ellipses and polygons of varying intensity (use *phantom()* and augment the resulting image). Show an image of your phantom.
2) Compute the views (projections) for the range of angles from 0° to 179° with spacing of 1°, 5° and 10°. Show the projections at 0°, 30°, 45° and 90° (in one axes). Show the sinogram with the most angles/projections.
3) Implement the backprojection algorithm (i.e. inverse radon transform) according to slide 16 of the Tutorial slides. You are not allowed to use *iradon()*.
4) Reconstruct the **phantom data** with the specified angular spacings using your backprojection algorithm **without filtering**. Show the obtained reconstructions.
5) Incorporate **filtering** in your backprojection. Implement 3 filters (ramp, cosine and hamming) and test their influence on the reconstruction using your phantom data (pick a single angle spacing). Show the reconstruction results
6) Reconstruct the **provided datasets** (*CT_2018.mat*) with **your** backprojection algorithm without filtering and with each of the implemented filters, respectively. Show the reconstructed images.
7) Shortly interpret **your** results.
    a. What is the effect of different angular spacings on the reconstruction?
    b. How do the different filters change the reconstruction results?
    c. Which filter performs best? Why? Under which circumstances?

Useful commands:

- *radon(), fft(), fftshift(), ifft(), ifftshift()*
- *hamming(), cos()*
- *repmat(), imrotate(), linspace()*

Assignment 2

Assume the 2x2 discretization of the spatial distribution of absorption coefficient shown in Fig. 1 and 2 point detectors with spacing L.

1) Design a model matrix $\mathbf{A}$ that relates X-ray measurements $\mathbf{p} = (\mathrm{P}_1, \mathrm{P}_2, \mathrm{P}_3, \mathrm{P}_4, \mathrm{P}_5, \mathrm{P}_6)^{\mathrm{T}}$ at 3 shown angles to the (unknown) absorption $\boldsymbol{\mu} = (\mu_1, \mu_2, \mu_3, \mu_4)^{\mathrm{T}}$ as in: $\mathbf{A}\boldsymbol{\mu} = \mathbf{p}$. Show $\mathbf{A}$.
2) Assume a specific distribution (values) of $\boldsymbol{\mu}_{\mathrm{test}}$ and a specific value of L. Simulate the corresponding measurements $\mathbf{p}_{\mathrm{test}}$ for this distribution using the model matrix $\mathbf{A}$. Show $\mathbf{p}_{\mathrm{test}}$.
3) Using the simulated measurements $\mathbf{p}_{\mathrm{test}}$, reconstruct absorption $\boldsymbol{\mu}_{\mathrm{rec}}$, i.e. solve $\mathbf{A}\boldsymbol{\mu}_{\mathrm{rec}} = \mathbf{p}_{\mathrm{test}}$. Show both the assumed ($\boldsymbol{\mu}_{\mathrm{test}}$) and the reconstructed ($\boldsymbol{\mu}_{\mathrm{rec}}$) absorption distributions.
4) Shortly interpret your result:
    a. Does the reconstruction $\boldsymbol{\mu}_{\mathrm{rec}}$ correspond to the assumed distribution $\boldsymbol{\mu}_{\mathrm{test}}$ of the absorption coefficient?
    b. Did you use *inv()* for inverting the model? Why?

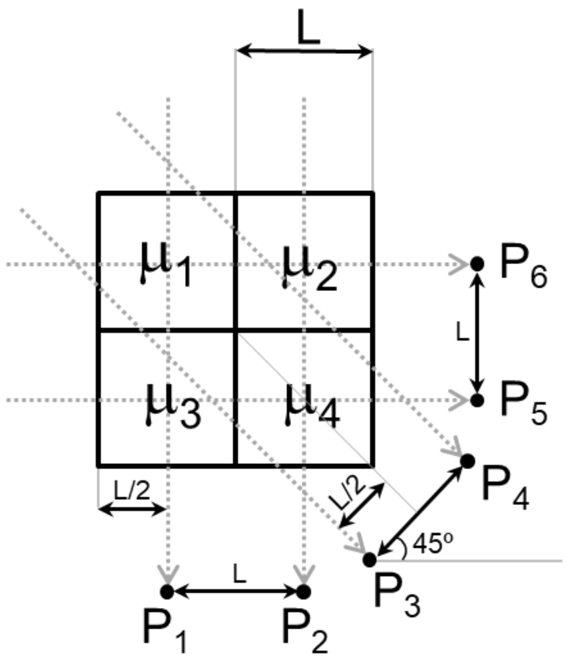

Fig. 1: Discretization and measurement schematic for Assignment 2.