

Homework 2: DOC 2023, Biomedical Imaging

Due: May 25th, 2023. Version 1.0

Instructions

Please show work for all problems, and email solutions to *hall.er@northeastern.edu* as “*Homework_#_Group_#.pdf*”.

1 Project Brainstorming

The first portion of this homework will be brainstorming and researching for your final project. Some topic ideas are listed below. Start by looking for articles with interesting abstracts on Google Scholar and PubMed, and then use the Northeastern Library to access the full article (if not already available). We will help you with this if need be.

Each person should review at least one paper and write a summary of 1 page. Your summary should mimic the format of typical research papers, with discussion on:

- Background and Hypothesis
- Methods
- Results and Conclusions

Remember! The hypothesis and results may not align, but that does not mean the paper doesn't have value/show something of value. In addition, we would like you to share your own opinions on the paper, including:

- Strengths/Weaknesses of the paper
- What would you have done differently?
- How could this paper be useful for defining your project?

To submit: Combine each of your summaries, as well as references to each paper, and submit as one group. A link would be awesome as it will help us quickly get to the paper for us to review. Please state which student completed each summary.

Some examples of imaging modalities include (but are not limited to):

- X-Ray/CT Scan (Small Angle X-Ray Scattering, X-Ray Backscatter)
- MRI
- Ultrasound (Doppler Ultrasound, Elastography)
- Optical Coherence Tomography (OCT)
- Confocal Fluorescence/Reflectance Microscopy
- Super-Resolution Microscopy (this has several types!)
- Hyperspectral Imaging

- Endoscopy
- Other...

2 X-Ray/CT Scan/Radon Transforms

This assignment asks you to use MATLAB to simulate an X-Ray computed tomography scan. **Unlike the previous homework, you will be making this program from scratch.**

- 2.0a.) Begin by looking up the MATLAB functions *radon* and *iradon*. Briefly explain how they work.
- 2.0b.) In MATLAB, generate a $10 \times 10\text{cm}$ phantom *image* with $100\mu\text{m}$ resolution. Your phantom should include the following features, all in the same phantom. You can assume everything outside of these shapes is zero. Please do not overlap the shapes, and *please submit a photo of your original phantom*.
- Bone \rightarrow A circle of 1.5cm .
 - Brain Tissue \rightarrow A rectangle with a side lengths of 2cm .
 - Adipose Tissue \rightarrow An Equilateral Triangle with side lengths of 2cm .

Table 1: Testing

Tissue	Mass Attenuation [cm^2/g]	Density [g/cm^3]
Bone	28.52	2.90
Brain Tissue	5.41	0.99
Adipose Tissue	3.27	0.90

- 2.0c.) For 0° to 90° and a step size of 30° , perform a radon transform of your phantom image. Then, reconstruct the image using the *iradon* function. Would you say this is a sufficient reconstruction? (For submission attach a plot of both the radon transform and the reconstructed image of your phantom, and your logic of why or why not it is good enough for reading).
- 2.0d.) Repeat 2.0c with a step size of 1° . How does your reconstructed image look now?
- 2.0e.) Mess around with a few step sizes from 0° to 90° . At what value does your image begin to be readable? (This may be slightly different for each team, since everyone has a different sense as to what “readable” is. Try to justify your answer. As a hint, the shapes will be quite wonky looking, but you should be able to make out that they are all present.)
- 2.0f.) Let’s say your lab gets a fancy new CT Scan machine, which can now rotate 180° instead of 90° . At what angle step size do you achieve a readable image? Is it the same or different than the previous step? Also think about the number of measurements. For example, if you took 90 measurements with a max angle of 90° (1° step size), and 90 measurements with a max angle of 180° (2° step size), which reconstructed image looks better?.
- 2.0g.) With the 180° machine, decrease the number of measurements (increase the angle step size) until your image looks like the one created by the 90° machine with a 1° step size. Now, let’s say each measurement *per column of pixels* takes 10ms . How much time would you save with the 180° machine compared to the 90° machine?

Hints for Problem 2:

- When first creating your phantom image, think about using *uint8* as your datatype. This is because the *insertShape* function requires 0-255 values to assign color.
- Look for the *insertShape* MATLAB function. This will make inserting your shapes into your phantom much easier.
- The color of your shape should correspond to a constant acquired by using Table 1. However, these values don't quite fit well into the 0-255 scale. So, I would suggest scaling them by a factor to visualize them better. I found a factor of 3 works well.
- The *insertShape* only accepts RGB images, so you will need to initialize your phantom as a 3 dimension array, instead of a 2 dimensional one. Similarly, when you assign color values to your shapes, you need to use the format [your_value your_value your_value], instead of [your_value]. You can just convert the image back to grayscale after using *rgb2gray*.
- Finally, the *insertShape* function has a default opacity of 0.6 (I really don't know why). You should change this to 1.0.