EE4603 Assignment

Semester II, AY2020/21

This assignment is to be done with Matlab. You may use built-in Matlab functions or write your own Matlab scripts. The code must be compatible with Matlab R2018.

Question 1 (5, 10, 10 marks)

1.1 Obtain the Radon transform of image *ellipse.bmp* (Figure 1) and show the sinogram with 720 projections (*sino1.bmp*). Explain in detail the features of the sinogram and how they relate to the image.

1.2 The ellipse is rotated by an angle θ_0. The resulting sinogram with 720 projections is *sino2.bmp*.
   (a) Explain in detail the features of the sinogram and how they relate to the image.
   (b) Determine as accurately as you can the rotation angle θ_0 from the sinogram. Your method can be graphical or computational. Methods that are more accurate will be given more credit.

1.3 The ellipse is translated by (x_0, y_0). The resulting sinogram with 720 projections is *sino3.bmp*.
   (a) Explain in detail the features of the sinogram and how they relate to the image.
   (b) Determine (x_0, y_0) as accurately as you can. Your method can be graphical or computational. Methods that are more accurate will be given more credit.

The values of θ_0 and (x_0, y_0) must be given with reference to the coordinate axes in Figure 1,

Question 2 (15 marks)

The test image is *phantom.bmp*.

2.1 Obtain the reconstructed images with 45, 90, 180, 360 and 720 projections using the Ram-Lak filter.
   (a) Examine each reconstructed image and describe how the results change with the number of projections. Pay particular attention to the fine details of the image.
   (b) For each reconstructed image, measure the SNR with reference to the original image phantom.bmp. Plot the SNR against the number of projections. Comment on your results.
   (c) Discuss the suitability (pros and cons) of the SNR as a measure of the quality of the reconstructed image.

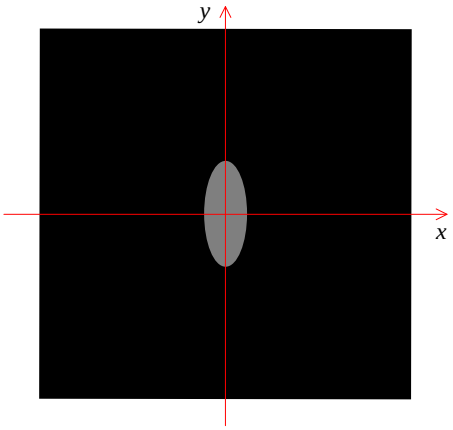

Figure 1

Note:

1. To examine the images in more detail, you can zoom in and/or use improfile.

2. The SNR is a quantitative measure of how closely the reconstructed image $\hat{f}(x, y)$ resembles the original image $f(x, y)$. It is defined here as:

$$\text{SNR (dB)} = 10 \log_{10} \left[\frac{\sum_{N_x} \sum_{N_y} [f(x, y)]^2}{\sum_{N_x} \sum_{N_y} [\hat{f}(x, y) - f(x, y)]^2} \right].$$

The larger the value, the "more accurate" is the reconstructed image.

Submission of Report

- The focus of the report should be on discussing and explaining your observations, and answering the questions. Relevant images should be included.
- If you use any Matlab code apart from the ones given below, include the code in the appendix.
- The GA for the assignment is Pan Jiachun (pan.jiachun@u.nus.edu). You may consult her if you need help with Matlab or clarification with the assignment.
- You are required to submit a softcopy of the report (pdf file) to the "Assignment Reports" folder in the EE4603 Luminus module website, by 4 pm, 31 March.
- The file is to be named as follows:
  matric number_full name.zip (e.g., A010134J_Tan_Shu_King.zip).
- ***The results and report must be your own work. Plagiarism is a serious offence.***

Matlab Help

Matlab primer

- https://engineering.purdue.edu/AeroAssist/wp-content/uploads/2013/08/Introduction-to-Matlab1.pdf
- http://www.math.ucsd.edu/~bdriver/21d-s99/matlab-primer.html
- https://web.stanford.edu/class/ee241/Handouts/matlab_primer3.pdf

Matlab primer for image processing

- http://www.cs.otago.ac.nz/cosc451/Resources/matlab_ipt_tutorial.pdf

Sample Matlab Scripts/Functions

```
clear all % removes all variables, etc
clc % clear command window

% Loading an image
I=imread('filename');

% Plotting data along a row
plot(I(100,130:175)) % row 100, columns 130 to 175)
plot(I(100,:)) % plot the entire row

% generating the Radon transform; num=number of projections, rota=rotation
angle
rota=180/num;
theta=0:rota:180-rota;
[R,xp]=radon(I,theta);

% displaying the sinogram
RR=flipud(R');
imshow(RR,[]);

% computing the reconstructed image with linear interpolation, Ram-Lak filter,
frequency_scaling = 1, size = 512
Q=iradon(R,theta,'linear','Ram-Lak',1,512);

% saving the reconstructed image (Q)
imwrite(uint8(Q),'filename.bmp')

% calculate SNR with reference to the test image
QQ=uint8(Q);
SNR=10*log10(sum(I(:).^2)/sum((I(:)-QQ(:)).^2));

% displaying an image
imshow(I,[]) % show loaded image
imshow(Q,[]) % show reconstructed image

% improfile
imshow(I,[]);
improfile
```

"improfile" can be used to view the intensity profile along a straight line (see example below).