LAB-1 Computing Tomography - Reconstructing an Image from Projection Data

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This is Lab-1 for EEE 491, Biomedical Engineering. Lab Due date is Sunday, April 06, 2014. Follow the instruction and submit the figures and answer the questions as described.

Introduction

This example shows how to use `radon`, and `iradon` to form projections from a sample image and then reconstruct the image from the projections. Here `radon` and `iradon` use a parallel-beam geometry for the projections.

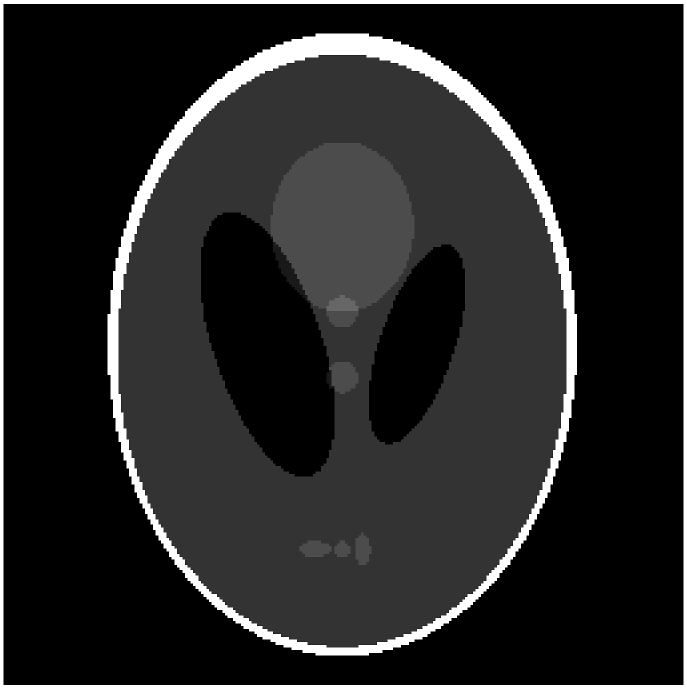
A real-world application that requires image reconstruction is X-ray absorption tomography, i.e., CT scan where projections are formed by measuring the attenuation of radiation that passes through a physical specimen at different angles. The original image can be thought of as a cross section through the specimen in which intensity values represent the density of the specimen. Projections are collected by special medical imaging devices and then an internal image of the specimen is reconstructed using `iradon`.

The function `iradon` reconstructs an image from parallel-beam projections. In parallel-beam geometry, each projection is formed by combining a set of line integrals through an image at a specific angle.

Create Head Phantom

The test image is the **Shepp-Logan head phantom** which can be generated using the function `phantom`. The phantom image illustrates many qualities that are found in real-world tomographic imaging of human heads. The bright elliptical shell along the exterior is analogous to a skull and the many ellipses inside are analogous to brain features or tumors.

```
clear all
close all
P = phantom(256);
imshow(P)
```



Submssion

- 1. Include the phantom figure as **Figure-1** in your report.
- 2. What does phontom image represent?

Parallel Beam - Calculate Synthetic Projections

Calculate synthetic projections using parallel-beam geometry and vary the number of projection angles. For each of these calls to `radon`, the output is a matrix in which each column is the Radon transform for one of the angles in the corresponding `theta`.

```
theta1 = 0:10:170;
[R1,xp] = radon(P,theta1);
num_angles_R1 = size(R1,2)
```

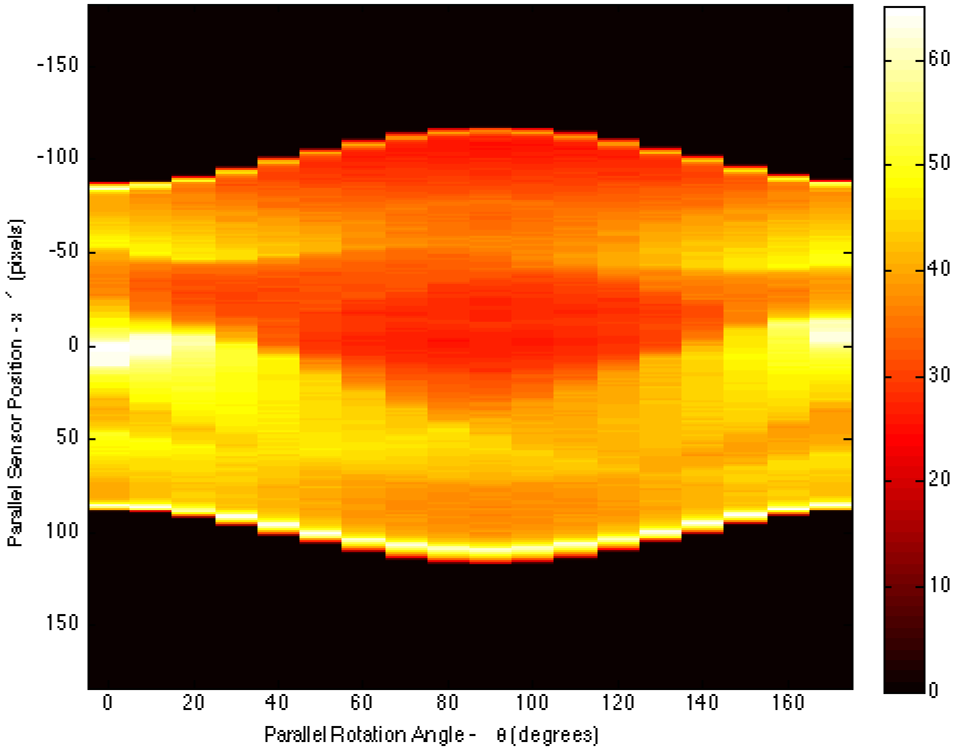
```
num_angles_R1 =

    18
```

Visualization of the projections

Display the projection data R1. Some of the features of the original phantom image are not visible in the image of R1. The first column of R1 corresponds to a projection at 0 degrees, which is integrating in the vertical direction. The centermost column corresponds to a projection at 90 degrees, which is integrating in the horizontal directions. The projection at 90 degrees has a wider profile than the projection at 0 degrees due to the large vertical semi-axis of the outermost ellipse of the phantom.

```
figure, imagesc(theta1,xp,R1)
colormap(hot)
colorbar
xlabel('Parallel Rotation Angle - \theta (degrees)');
ylabel('Parallel Sensor Position - x\prime (pixels)');
```



Submission

- 3. Include the projection image, i.e., Radon transformation $g(\theta, \rho)$ as **Figure-2** .
- 4. What does xp represent in the code?
- 5. Provide absorbtion variation at $\theta = 0$ degree and plot $g(0, \rho)$ as function of ρ and include the plot as **Figure-3** . Justify the obtained plot, i.e., projection.
- 6. Provide absorbtion or attenuation variation at $\theta = 90$ degree and plot $g(0, \rho)$ as function of ρ and include the plot as **Figure-4** . Justify the obtained plot, i.e., projection.

- 7. How is the size of R1 determined?

Parallel Beam - Reconstruct Head Phantom from Projection Data

```
% In realistic scenario, we would not have access to Phantom image |P|, rather, we
% need to get the Phantom image from the projection |R1|.

% Match the parallel rotation-increment, |dtheta|, in each reconstruction
% with that used above to create the corresponding synthetic projections. In
% a real-world case, you would know the geometry of your transmitters and
% sensors, but not the source image, |P|.
%

output_size = max(size(P));
dtheta1 = theta1(2) - theta1(1);
I1 = iradon(R1,dtheta1,output_size);
figure, imshow(I1)
```

Submission

- 8. Include the reconstructed image I1 in your report as **Figure-5**.
- 9. Comment on the quality of image I1 compared to the original image P.

- 10. What algorithm is used in `iradon` MATLAB function for the reconstruction?
- 11 Use the unfiltered back projection using `iradon` and include the reconstructed image as **Figure-6**.
- 12. Repeat the simulation with more measurements by reducing increament of theta, i.e., dtheta = 5 and dtheta = 2. Include the reconstructed image as **Figure-7** and **Figure-8** in your report.
- 13. Comment on the reconstructed images obtained in Submission-12.
- 14. If the Phantom image size of 128x128, what will be size of `xp`? Justify your answer.

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