BE280A, Principles of Biomedical Imaging 11/6/07
Fall Quarter 2007

BE280A Midterm Project Assignment

Due Date: Completed project (hard copy) is due at the start of class on Thursday, November 15, 2007. In addition to the hard copy, please submit a PDF version of the report via e-mail by 12 p.m. on that day. For full credit, the subject line of your e-mail should read **BE280A07 Midterm Project**. The report filename should follow the following format ct_{initials of partner 1}_{initials of partner 2}.pdf – e.g. ct_lk_pb.pdf.

Guidelines:
1) Select a partner to work with (there are 30 registered students, so that there will be 15 groups).
2) Discussion of **general ideas** is encouraged between groups, however, each report submitted should reflect each group's own understanding of the material. Significant discussions with other groups should be given appropriate credit.
3) An electronic copy of the MATLAB code should be submitted with the PDF of the report. The code file should be named in a similar fashion to the *.pdf file, except with a *.m extension.
4) Use a word-processing program to write the report, including all equations (no handwritten reports! Use an equation editor.). Neatness and clarity of exposition will play a **significant** role in the grading of the report. Other grading criteria include technical correctness and originality.
5) You may use external references (print or electronic). If you do so, please cite them at the end of your report.
6) Title and label the axes on all plots and images.
7) In addition to answering the questions below, please provide additional details and original insights as appropriate. If you noticed something interesting or learned something new in doing this project, please comment on that.

Description of Problem
Consider an object composed of the following two overlapping circles:
a) A circle of radius 50mm centered at (0,0)
b) A circle of radius 20mm centered at (15mm,15mm).

The attenuation coefficient of the object is 1 mm^{-1} everywhere within the larger circle, except for the area of overlap, where the attenuation coefficient is 2 mm^{-1}.

The object is imaged with a 1st generation CT scanner with a beamwidth of 2mm. The desired FOV is 128 mm.

1. (5 pts.) Determine the appropriate detector size Δr and the number of radial samples needed to span the FOV. Assume that the middle two samples are acquired at coordinates of $-\Delta r/2$ and $\Delta r/2$

2. (5 pts.) Determine the number of angular samples required. For the simulations, round this up to the nearest multiple of 4.

3. (30 pts.) Use MATLAB to generate a sinogram of the object. The sinogram should be based on analytical formulas that take into account the finite beam width (integral formulas, such as those at http://www.sosmath.com/tables/integral/integ13/integ13.html may be useful). Describe in detail how you derived and applied the analytical formulas. Note that the sinogram should cover the angles from 0 to $(N-1)\pi/N$ where N is the number of angular samples. Comment on the features of the sinogram – i.e. why does it look the way it does? **Hint:** Decompose the object into the two circles and compute the sinogram for each circle.

4. (20 pts.) Use MATLAB to generate the backprojection of the object. An easy way to do this is to backproject at a projection angle of 0 degrees and then use the MATLAB function imrotate to rotate each backprojection. Use the bilinear and crop options in imrotate. Comment on the features of the backprojected image.

5. (20 pts.) Filter the projections using both (i) a Ram-Lak filter and (ii) a Hanning windowed filter. Plot and compare the filters and the filtered projections at a projection angle of 0 degrees. Describe the design and the practical implementation of the filters. You will want to use the MATLAB functions conv.m or filter.m.

6. (10 pts.) Now backproject the filtered projections. Comment on features of the filtered backprojection images and on the effect of the choice of filter. Compare to the backprojected images. Discuss the normalization of the images that is required to get correct estimates of the attenuation coefficients.

7. (20 pts.) Experiment with acquiring fewer samples in the radial and angular dimensions (e.g. take every 2^{nd} sample; take every 4^{th} sample). Comment on what you see. Does changing the bandwidth of the filters help at all? Explain your answer.

8. (5 pts.) Follow the instructions for naming of e-mail and all submitted files.