Overview

The purpose of this *individual* project is to gain some practice with MATLAB (or Python) and generate forward projections of an object for subsequent reconstruction. You are expected to work individually on this project and to submit a final report (in electronic format) that includes appropriate images and textual information.

The Assignment

Part I: The Data

Two sets of high-resolution images are provided on the course website for use in generation of several sets of projection data that will be used in Project 2, in which you will explore different forms of image reconstruction. All images are provided at a size of 512 x 512 pixels, with a known isotropic resolution of 1mm. Note that the provided images comprise integer values at each location, where said values are to be interpreted as the (average) Hounsfield unit of absorption expected within the corresponding “voxel”. Due to the *unsigned* nature of TIFF images, you will need to subtract 1000 from all images to obtain sensible Hounsfield units!

Part II: 1G (Linear) Projection

Assuming the traditional model of linear projection from a single source point, you should write code to take as input a *volume* of slices (representing a three-dimensional object) and generate a set of projections having a given “pitch” (thickness) over 180 projection angles, separated by 1 degree, with each projection spanning an input number of translations along the $r$ axis. Your output should be a *sinogram* for each of the output “slices” (i.e., pitch locations).

**Report Content:**

1. For each of the given 24-slice datasets, generate and provide nine (9) representative sinograms of selected “slices” obtained using a pitch of 1.5mm having 128, 512 and 1024 translation locations. Note why you may have selected these nine sinograms.

2. Provide your code for generating 180 (linear) projections at an arbitrary pitch, given an input volume. Summarize your approach with regard to generating a projection, accounting for mismatches in requested resolution (in-plane) and pitch (thickness).

Part II: 2G/3G (Fan-Beam) Projection

Using fan beam geometry (i.e., point source for the x-rays along the diameter of the object, curved planar detector array centered diametrically opposite the source), write code to
generate fan beam projections (arbitrary numbers of pixels) over 180 projection angles, separated by 1 degree.

Your code should accept as input (a) the distance from the source to the center of the object (assumed to be the same as the distance from the center of the object to the center of the receiving array), (b) the angular extent of the receiving array, and (c) the number of receive elements in the array. As in Part II, your code should accept a “pitch” for the desired projections.

Report Content:

1. For each of the given 24-slice datasets, generate and provide nine (9) representative sinograms for using fan-beam projections, collected at a radial distance of 30cm with a pitch of 1.25mm and each of 128, 512, and 1024 receive array locations. Note why you may have selected these nine sinograms.

2. Provide your code for generating the fan-beam projections of an arbitrary volume at an arbitrary pitch and arbitrary distance from the center of the object. Summarize your approach with regard to generating a projection.

Part III: 4G/5G (Cone-Beam) Projection

Using a basic cone beam geometry (i.e., point source for the x-rays along the diameter of the object, curved-but-planar two-dimensional detector array centered diametrically opposite the source), write code to generate cone beam projections—assuming 16 “slices” (i.e., detector rows)—over 180 projection angles, separated by 1 degree.

Your code should accept as input (a) the distance from the source to the center of the object (assumed to be the same as the distance from the center of the object to the center of the receiving array), (b) the angular extent of the receiving array, (c) the pitch of the receiving grid, and (d) the number of receive elements in the array.

Report Content:

1. For each of the given 24-slice datasets, generate and provide images of sinograms for nine “slices” obtained using cone-beam projections collected at a radial distance of 30cm with a receive array pitch of 0.75mm (i.e., 12cm vertical FOV, given 16 “slices”) and each of 128, 512, and 1024 receive array locations. Include how you are defining a sinogram from these data!

2. If possible, compare sinograms for several slices as generated in Parts I, II and III. Does the sinogram change as the approach to projection generation is altered? If so, discuss any differences you observe.

3. Provide your code for generating the cone-beam projections of an arbitrary volume at an arbitrary pitch and arbitrary distance from the center of the object. Summarize your approach with regard to generating projections.
What You Submit

Written Report: You must provide a PDF report describing what you did that includes figures, graphs, images, and references. Since this course involves images, you are strongly advised to put images in your report. Submission will be by Dropbox. Information will be provided!

Paper Formatting: The report should be limited to 15 pages or less, so please be prudent in your selection of included images. You must use 12 point type with 1.5 spaces between lines. In addition to the textual and image content, please indicate (in the captions or in an Appendix) the particular electronic file (see below) that corresponds to each included image.

Submission Media: Please submit your PDF report and a TAR or GZIP file of a well-structured directory tree containing (a) your programs and (b) all final images you have generated for this project. Please store all images in the TIF format! If there are intermediate images of particular interest (or that have been incorporated into your report), you may include them.

Supplementary Comments

• Please start this project (and all others in this course) early. All of the projects take time, and no extensions will be granted.

• If you do not have access to computers that have large amounts of memory or substantial processing speed, please contact me as soon as possible. This project requires significant processing resources and access may be granted to you to use the computers in the Video and Image Systems Engineering (VISE) Laboratory for this purpose. If so, please be considerate of others using this laboratory.