Title Project 1: Virtual X-rays
Title Project 2: Mammography

OVERVIEW: Implement a system to simulate the generation of plain film x-ray. These are two projects for one person! They are similar and they differ only on the design of the phantom.

Implement the software to simulate a conventional/standard film x-ray machine using a GUI to run it. Through this GUI change the parameters to control data acquisition, view the reconstructed images and perform simple analysis. You will use two phantoms. One is a simple “testing/validation” 2D phantom, and you will use it to test if your algorithms are working correctly and analyze the effect of different acquisition parameters. The second phantom will be a 3D phantom to simulate a leg or a breast for mammography.

SPECIFICS:
1. Develop the different functions/code to perform all necessary calculations to:
   - Generate the phantoms
   - Adjust the geometric and the acquisition parameters
   - Generate the 1D profile of the 2D phantom and the 2D image for the 3D phantom
2. Implement a GUI that combines those pieces of code and performs the different tasks.
3. The control of your x-ray machine will include: the energy of the beam, the x-ray angle, the distance of the film and the source from the phantom.
   Note: when you change the energy you should also change the \( \mu \) values of your phantom! One simple solution is to use a pull down menu to select ONLY a few energy values (so you have a small number of tissue \( \mu \) values to deal with)
4. Test/validation phantom: Generate the profile of the test phantom and verify that your algorithms work correctly when:
   - Change the distances between source, film and phantom
   - Change the \( \mu \) values of the two structures.
   - Change the angle of the x-ray; what is the effect?
5. Then work with the “human” phantoms.
6. First create the phantom in 3D as a 3D matrix:
- Leg project ONLY: The leg phantom will be a cylinder that simulates the leg and another cylinder that simulates the bone.
- The Breast project ONLY: will be a rounded edge 3d structure with a sphere at its center that simulates a cancerous lesion.

7. Expand your code to generate the 2D image of your 3D phantoms.
8. For the Leg project ONLY: After you validate that your algorithms works flawlessly, then modify your phantom to simulate a broken leg as shown the figure. Generate the film x-ray image. Test for a split that is orthogonal to the bone and one that is in angle!
   - What is contrast of the split?
   - If it is in an angle what is happening?
   - If you widen the gap of the angled split what do you observe in regard to contrast?

9. For the Breast project ONLY: After you validate that your algorithms works flawlessly, answer first the question:
   - What is the contrast of the cancerous lesion relative to the rest of the tissue?
   - Can you see clearly the cancer?
   - Now compress the breast by reducing the width of your phantom. What is the effect of this? Quantify the effect you may have.