HW01 Report: Digital Shepp-Logan Phantom Generation

Name: Mustafa Sahin

PeopleSoft ID: 2032759

Course: COSC 4372/6370 - Medical Imaging

Assignment: HW01 - Shepp-Logan Phantom Generation for MRI Simulation

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Introduction

In this project, the goal was to learn how to modify digital phantoms and visualize the result. This phantom helps test imaging systems and reconstruction algorithms.

Q1: Phantom Generation and Modification

1. **Q1.1: Function Implementation**

   The `generate_phantom()` function takes the following parameters to create a phantom:

   - **Phantom Matrix Size (N)**: Defines the resolution of the phantom.
   - **Ellipses**: A list of ellipses defined by:
     - **Center Position (X, Y)**: The position of the center of each ellipse.
     - **Rotation Angle**: The rotation applied to the ellipse.
     - **Width and Height (semi-major and semi-minor axis)**: Defines the size of the ellipse.
     - **Signal Intensity**: The brightness level of the ellipse.

   The function adds each ellipse onto the phantom matrix, which allows us to create complex structures similar to a head shape used in medical imaging.

2. **Q1.2: Signal Intensity of the Background**

The background signal intensity in the generated phantoms was **0**, which means the background is black and represents empty space.

3. **Q1.3: Real-World Background Intensity**

   In real-world medical imaging, the background signal intensity is typically close to zero or very low. This is because areas outside the object being imaged (like the human body) don't return significant signals in techniques like MRI.

Q2: Testing the Code

1. **Q2.1: Phantom with No Overlapping Structures**

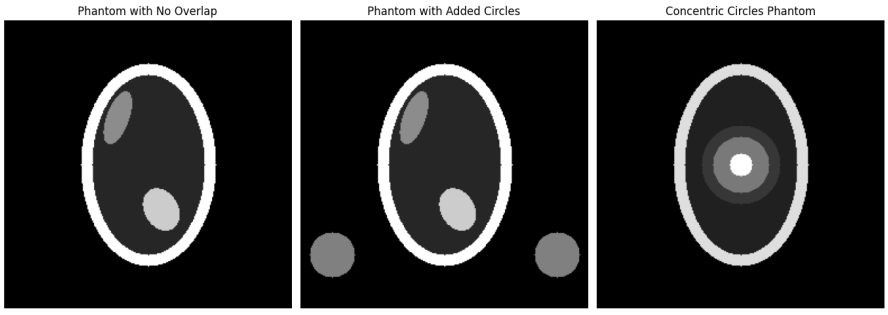
   The first phantom was generated with three ellipses arranged so that they do not overlap. Each ellipse has a different size, position, and signal intensity, which simulates different structures in a medical image. These ellipses are centered on the main shape but positioned to avoid overlaps.

2. **Q2.2: Phantom with Added Circular Structures**

   In this step, two additional circular structures were added outside the main shape. These circles were positioned at the right and left sides of the main structure. This modification simulates adding external structures to the image, which is a common use case in medical imaging testing.

3. **Q2.3: Phantom with Concentric Circles**

   The final phantom is composed of concentric circles. Here, we generated three circles, each with a different size and signal intensity. This design looks like a target or rings and helps simulate layered structures in a medical image.



Conclusion

In this project, I successfully implemented and modified the Shepp-Logan phantom. I learned how to create digital phantoms by using ellipses and how different parameters (like size, intensity, and position) affect the resulting image. The project provided a better understanding of how medical images can be simulated and tested using simple shapes, which can be useful in testing algorithms for MRI or CT scans.

Additional Information

- **Code**: The Python code is included in the `Code` folder and can be run to generate the phantoms.
- **Dependencies**: The required libraries are listed in `requirements.txt`.