Assignment 1 Report (COSC 4372)

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Introduction

- In assignment 1 for COSC4372, for the Shepp-Logan phantom the preferred programming language is MATLAB used for generating and modifying. All code implementations, including the creation of customized phantoms, are written and executed in MATLAB to ensure accurate and efficient image processing. We explore the generation and modification of the Shepp-Logan phantom, a widely used digital phantom in medical imaging. The Shepp-Logan phantom serves as a testbed for various imaging techniques, including MRI and CT, allowing us to study reconstruction algorithms and system performance. By implementing customized functions, we will modify the phantom's parameters to simulate different imaging scenarios and analyze their impact.

Q1.1

- I started with the original source code provided by MATLAB to generate a Shepp-Logan phantom, which is widely used for testing reconstruction algorithms in medical imaging. The original `phantom` function takes predefined ellipses and generates a digital representation of a brain section. I modified this source

code by implementing a custom function that allows for dynamic input parameters such as the number of ellipses, their positions, sizes, and signal intensities. This flexibility enabled me to generate different phantoms based on specific input values, and the resulting image, as shown, contains adjusted structures that differ from the standard Shepp-Logan phantom.

Q1.2

- In the generated phantom, the signal of the background is zero. The reason for this is that the background does not belong to any ellipses, and thus, no intensity is added to those pixels. The phantom image only assigns intensity to the ellipses, while the rest of the matrix remains zero.

Q1.3

- In reality, the signal intensity of the background would depend on the imaging modality used. Generally, the surround outside the object of interest is anticipated to have a low or zero signal intensity, which is empty space/air. The imaging process may slightly vary this intensity due to factors like noise or interference.

Q2.1

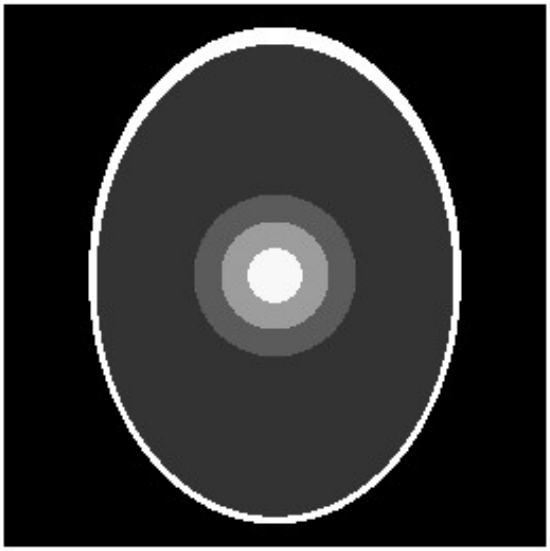
- For this question, I modified the Shepp-Logan phantom by changing the position and size of the ellipses so that there were no overlap structures. The main ellipse was made smaller and two other ellipses were shifted down and slightly rotated to prevent any intersections. Also, the intensity of the smaller ellipses

was increased to make them more visible in the final image. As a result, the modified phantom now clearly distinguishes distinctive ellipses, each occupies their own space, without any overlaps or mixing between structures. This modification instrumentation both the components visibility and separation as well as the layout of the original phantom structure.

Q2.2

- For this question, I added two full circles outside the Shepp-Logan modified phantom that I modified earlier. These two circles were symmetrically put on the left and right sides, outside the brain boundary, and were given a high signal intensity to clearly stand out. The main structure of the phantom remains the same as it was in Q2.1, with all the ellipses being distinct and non-overlapping. The incorporation of these circular external structures illustrates how the phantom can be further personalized to include features beyond its center region, thus simulating other anatomical or imaging elements. This enhancement results in an image that is more intricate while still keeping the components apart and easily recognizable.

Q2.3



- For this question, I modified the Shepp-Logan phantom by adding three concentric circles and two of the original ellipses. The circles were produced progressively increasing the outer circle with the highest brightness and reducing the signal intensities for the inner circles. The circle parameters were set using semi-major and semi-minor axes of 0.1, 0.2, and 0.3, and their intensities were 0.357, 0.257, and 0.157, respectively. The phantom1 function in the code was responsible for generating five ellipses: the original two ellipses and the three concentric circles all centered at the origin with no rotation. The outermost circle was assigned white intensity to clearly distinguish it, while the inner circles had progressively lower intensities creating a smooth gradient. The resulting phantom image clearly shows the three concentric circles in the center which indicates the control over the size and intensity within the phantom.

Conclusion:

- As a result, this report successfully illustrates the generation and modification of the Shepp-Logan phantom using MATLAB. Each task provided insights into how the parameters of ellipses can be adjusted to create customized images. While the majority of the tasks were fairly easy, Q2.3 proved to be more complicated because of the careful alignment and intensity adjustment of the concentric circles. It was important to calculate correctly to ensure that the circles were evenly spaced and properly centered. Overall, this assignment highlighted the flexibility and power of using MATLAB for medical image simulation and manipulation.