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Virtual CT Scanner Reconstruction

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Worked on implementing GUI and functions. Made tweaks to an existing Shepp-Logan phantom algorithm to suit the needs of the virtual CT Scanner. Within the Shepp-Logan algorithm you can set the number of detectors and the type of detector.

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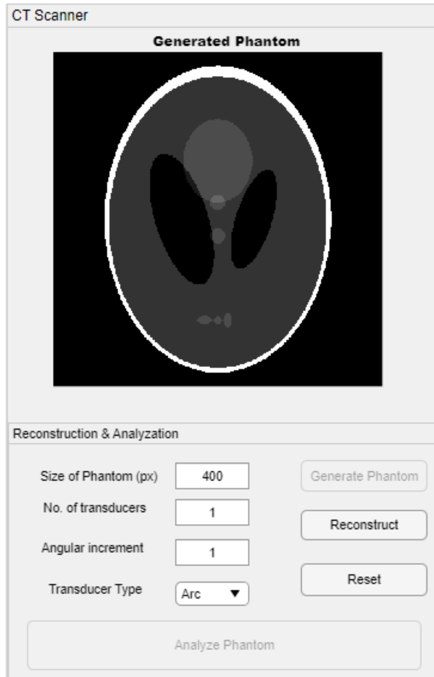
Worked on implementing GUI, callbacks, and functions. Coded all callback functions and designed the user interface using MATLAB's App Designer. Made a few tweaks to our plot functions in analyzing the phantoms so they could be sent to our GUI seamlessly.

Introduction

We implemented a Virtual CT-Scanner and studied how different parameters can impact the quality of an image through image reconstruction and analysis of that image. To do this we used MATLAB and used built-in functions to help with this task. For image reconstruction we can create a phantom using the phantom() function that MATLAB provides with user inputted parameters. We then can analyze the reconstructed phantom using different types of image analysis like image difference and signal intensity.

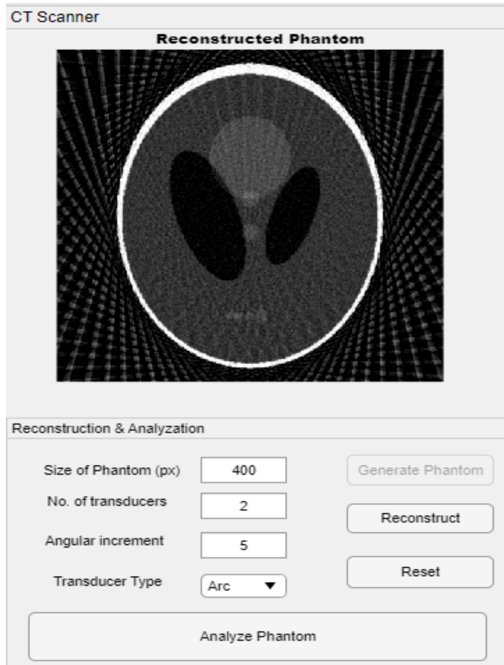
Graphical User Interface (GUI)

Image Reconstruction (Scanner)



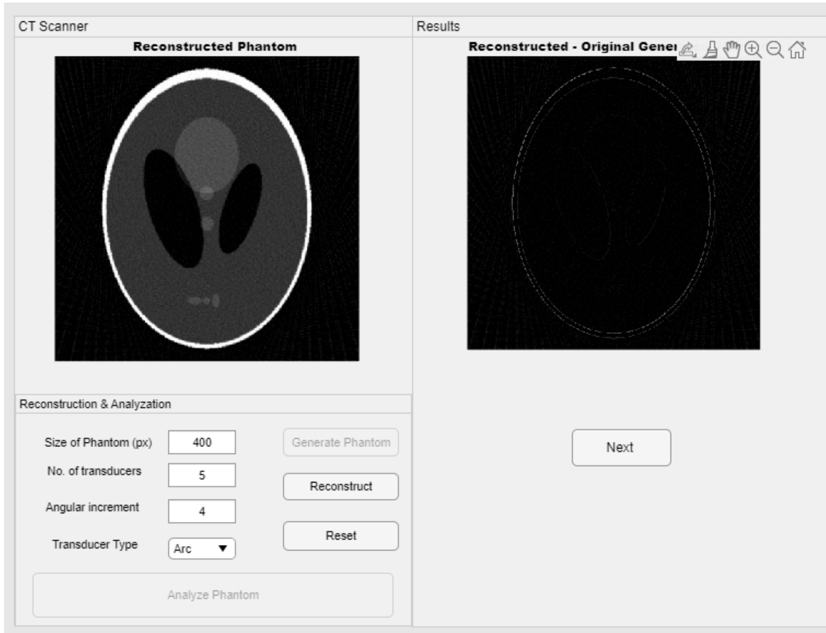
Shown above is the GUI we made. Within the **Reconstruction & Analyzation** panel you can enter different parameters to reconstruct the phantom generated from the Generate Phantom button. You can change the size of the phantom, number of sensors, angular increment of the sensors, and change the sensors to either linear or arc. Once all parameters are entered, you can hit the Reconstruct button to perform the image reconstruction on the generated phantom using the Shepp-Logan function that was created.

Image Analysis (GUI)



Once the generated phantom has been reconstructed using the user inputted parameters, the generated phantom will replace the old phantom, as shown above. We can now begin analysis on the reconstructed phantom. To perform analysis click the Analyze Phantom button which will call the analyze function. The analyze function will perform two different image analyses. The first being image difference and the second signal intensity based on direction.

After the analyze function has run, the GUI will expand and show the different analyses. The first being image difference. The second being signal intensity based on rows and the last being signal intensity based on columns. You can cycle through these analyses using the next button. An example of the GUI is shown below.



Phantom Analysis

We use two different types of analysis on the generated phantom. The first being image difference and the second being signal intensity. Using these different analyses can be very helpful in seeing the areas of the image that have changed during the reconstruction of the phantom.

Image Differencing

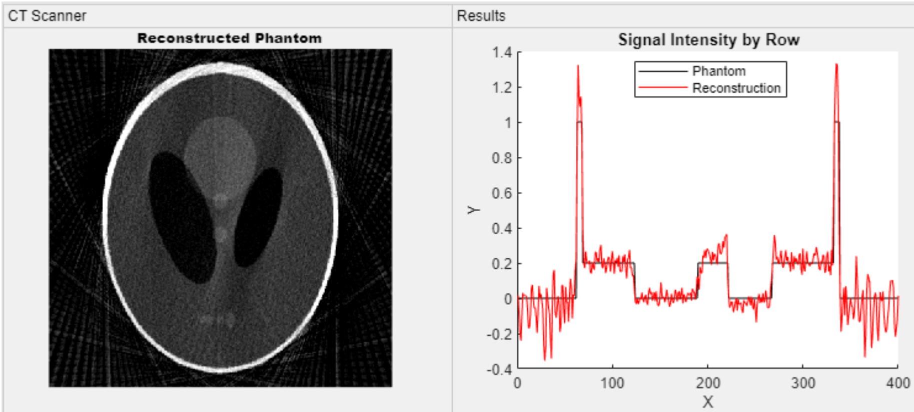
Image differencing is a good technique that helps determine the differences between two different images. This is done by finding the differences between each pixel in the different images. This process generates a new image where you can see where the places that the changes have occurred.

Below you can see image differencing take place between two phantoms. The first phantom being the original, the second being the reconstructed, and the last being the difference between the two. You can see increased contrast around the edges of the reconstructed phantom based on the image difference provided.

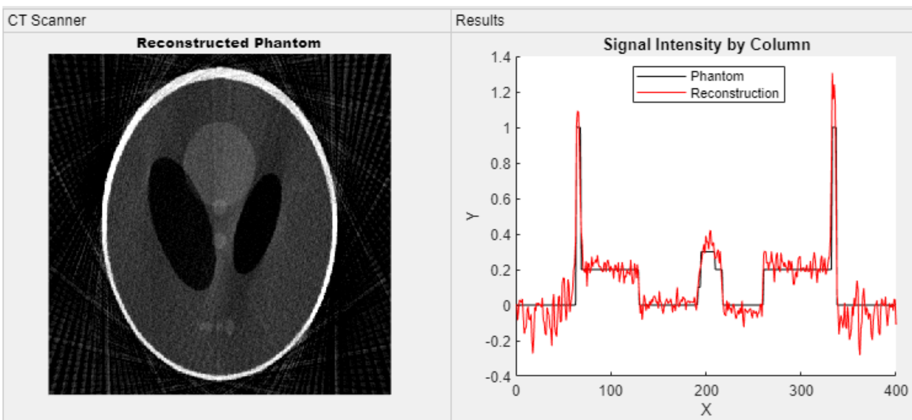
Signal Intensity

An image is formed from the signal received from a detector within an imaging device. In medical imaging brightness tends to correlate with the amount of tissue that gives off a particular signal. We can use signal intensity to see contrast within our image. Once the analysis of our reconstructed phantom is complete, you can view the signal intensity based on rows and columns. The x-axis being the pixel number of either the row or column of the phantom and the y-axis being the intensity of that location.

In the image below you can see a comparison between the original phantom and the reconstructed phantom’s signal intensity by rows.



In the image below you can see a comparison between the original phantom and the reconstructed phantom's signal intensity by columns.



Parameters

In our GUI, we can set different parameters for the generation and reconstruction of the phantom. We can set the size, number of sensors, angular increment of the sensors, and the type of sensor (linear or arc). Setting the number of sensors determines how clear the scanner will be. Obviously increasing the amount of sensors will make the reconstructed phantom more clear. Setting the angular increment changes the amount of noise and contrast within the image. Increasing the angular increment will require more sensors. Lastly you can change the type of sensor between linear or arc. When changing the sensor to arc, the image also becomes more clear and less rigid. If the image is linear, you will need a lot more sensors to make a clear image.

Conclusion

To conclude, imaging devices are important devices that are used in everyday life with copious amounts of applications. It is important for medical imaging devices to be clear, to have high signal intensity and contrast. Nevertheless, in regards to our Virtual CT Scanner, we found there to be a few correlations between the different input parameters. When the probe type, also known as the probe array, is arc and the angular increment is high, the contrast between the original and the reconstruction is prominent. These artifacts and general noise are offset with an increased number of transducers or detectors, resulting in a phantom closer to the original. This however, does not hold true with linear probe type as the phantom generates more noise, generally blur, proportional with the number of transducers. This in large has to do with the length of the probe and the angular increment, as it was with an arc probe type. However, this noise can be offset with a large amount of transducers that is not usually practical nor efficient.