MRI Acquisition Simulator

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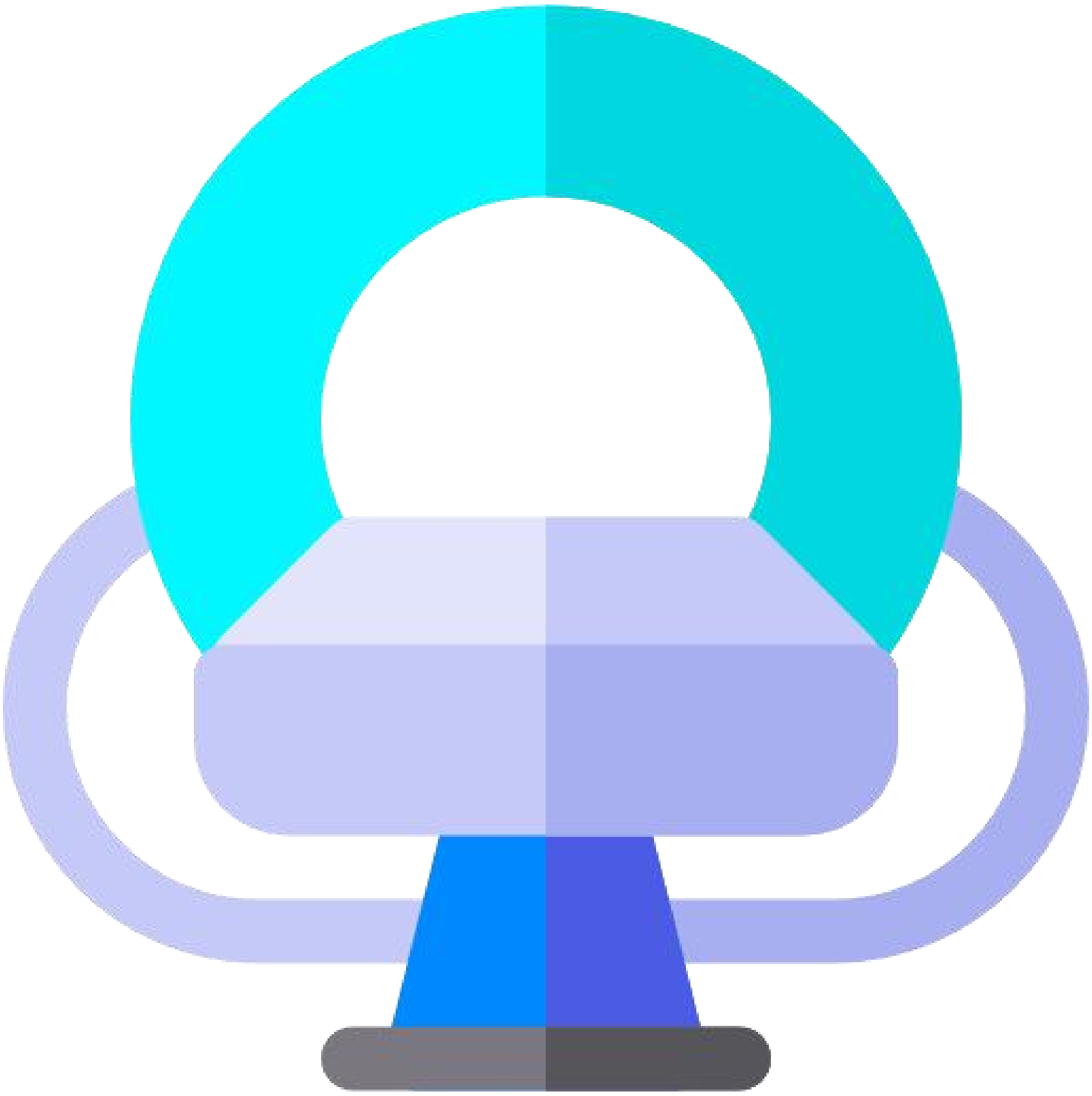
COSC 4372 Medical Imaging



Introduction

This project focuses on the implementation of a Magnetic Resonance Imaging (MRI) Acquisition Simulator. The algorithms and Graphical User Interface (GUI) were designed from the utilization of the program MATLAB. The algorithms were used to generate the phantoms and their corresponding k-space, using sample data with a specific trajectory. Results of the raw image and the MRI image are outputted and analyzed for results.

Objectives

- MRI Acquisition: MRI data collection based on samples of the frequency domain or the k-space.
- Image Reconstruction: Perform reconstruction of raw image into MRI image.
- Phantoms: Will test the two acquisition trajectories to sample the k-space of our phantoms. One being Cartesian, which is reconstructed with parameters of number/density of horizontal lines, density of points within a line, swapping the horizontal and vertical lines, and the width of the acquisition matrix. The other being Radial, which is reconstructed with the parameters of the number of radial lines, and the points along each line.
- Graphical User Interface: The graphical user interface combines those pieces of code and performs different tasks.

Algorithms

Input

- Phantom Images
- Number of Lines To Sample
- Number of Points Per Line
- Trajectory Algorithms (Cartesian or Radial)

Cartesian/Radial Sampling Algorithm

- Both Cartesian and Radial Sampling algorithms proceed with the same concept of obtaining the data from input and then outputting that data based on what we have chosen in our graphical user interface. The general idea is that, first, we would pre-process and obtain the phantom k-space by computing the ratio of phantom size to the points-per-line number and create a new image with the size multiplied by the ratio with a factor of 9. Next, we would sample the

The k-space by generating the grids based on input and interpolating the image K at each grid point. Afterwards, there will be two different pathways for Cartesian and Radial Algorithms. For the Cartesian algorithm, we would first prepare the sampling for reconstruction and then we would reconstruct the acquired image and do post-processing. This is based on acquiring inverse of 2D FFT of K. For Radial algorithm, we would instead obtain the acquired projects and then reconstruct from said projects and post-process.

Graphical User Interface

The Graphical User Interface consists of 2 modules, in which the user is allowed to sample the data with a specific trajectory with lines and points, as well as having functions to generate for phantoms and masks. The images that correlate with the inputs (or raw image) and the MRI image are displayed.

- Module
  - In our project, we have simulator options located on the right side of the GUI. Here we can change the trajectory, whether it be through Cartesian or Radial trajectory sampling. There is also options provided for the user to modify the parameters to digitize the data, through number of slices and number of points. Finally, there is a mask percentage slider and simulation “runner” button to perform the acquisition and output the data.

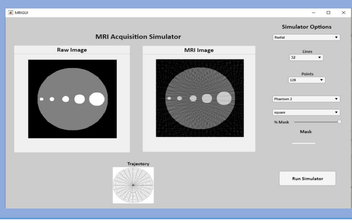
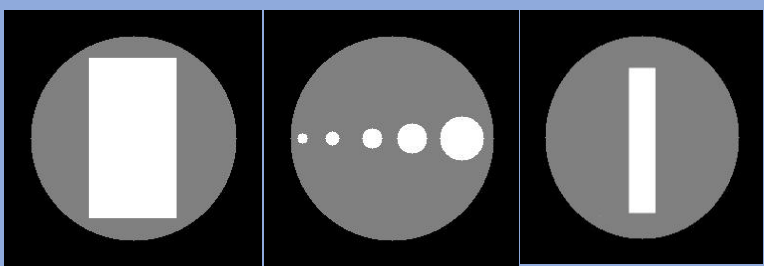


Image Analysis

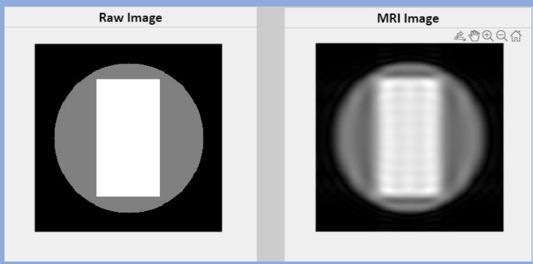
To perform our Magnetic Resonance Imaging Simulator, we acquire our reconstructions from 3 phantoms: Phantom 1 being a rectangular like structure, Phantom 2 being circular structures, and Phantom 3 being a thin, vertical line as shown below.

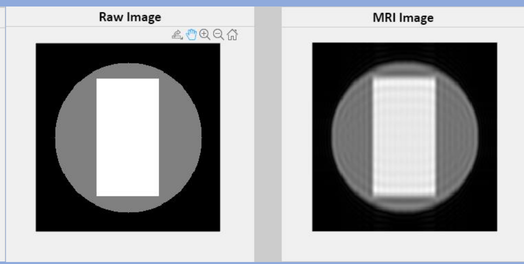


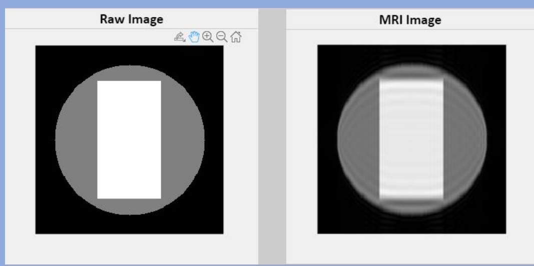
Phantom 1	Phantom 2	Phantom 3

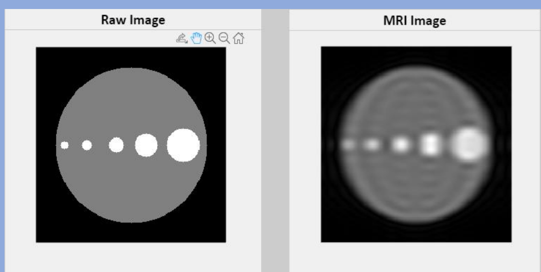
In the following pictures, we acquire the MRI Image through phantom reconstruction using a Cartesian sampling algorithm. The first section is the number of fixed scan lines of 32 for Phantoms 1 and 2. We would modify the number of scan points with the values 16, 64, and 128 respectively. The second section is the number of fixed scan points of 32 for Phantoms 1 and 2. We would modify the number of scan lines with the values of 16, 64, and 128 respectively.

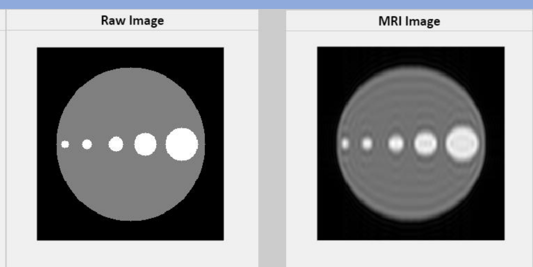
Section 1

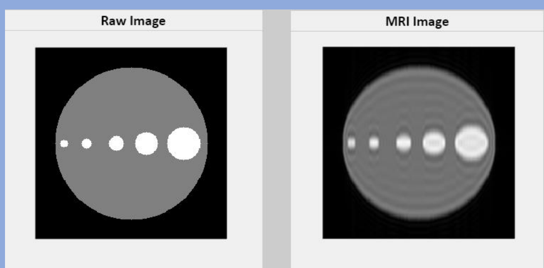




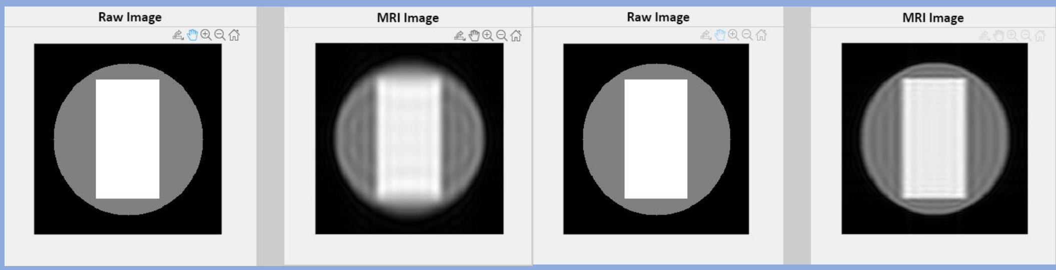


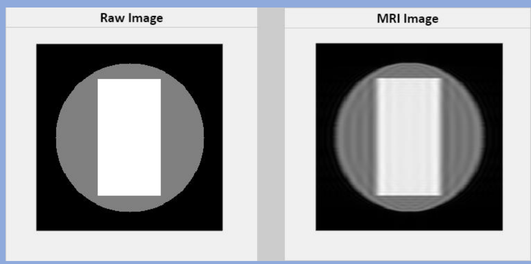


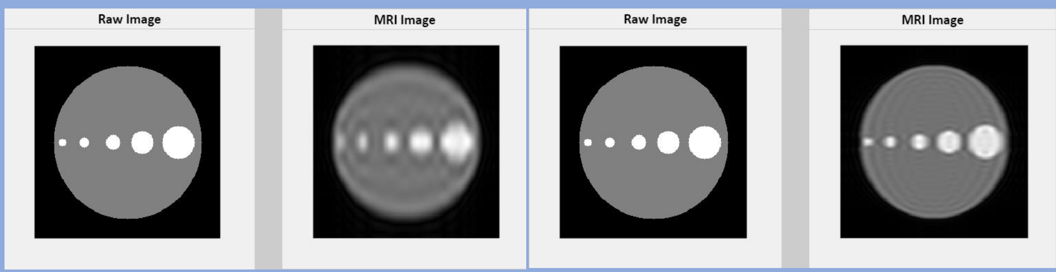


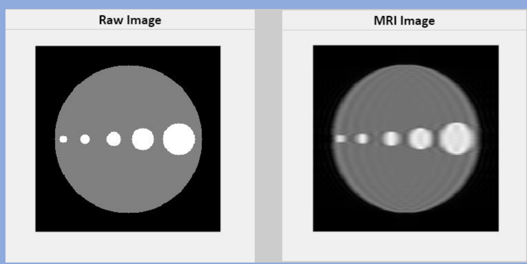


Section 2





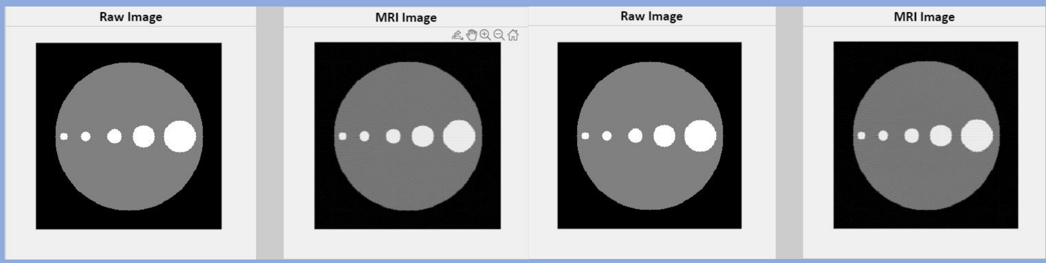


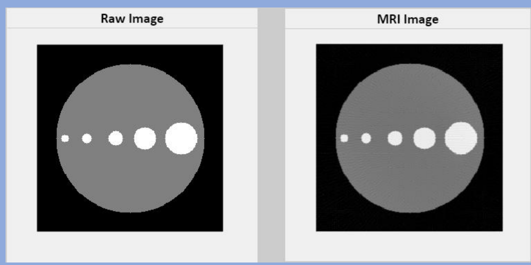


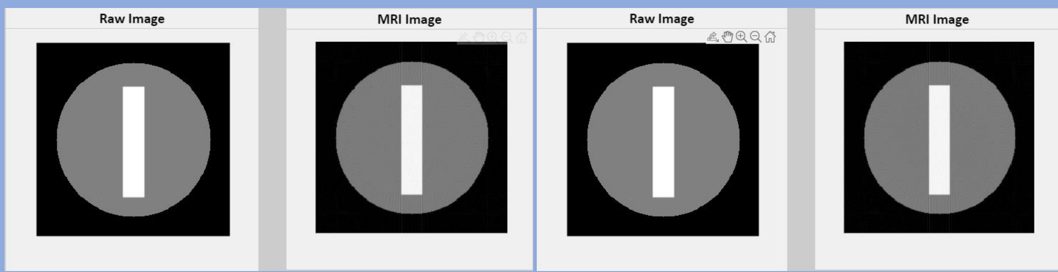
As we can see from our data results based on the Cartesian sampling algorithm, as we increase the number of scanned points, the quality of the image becomes progressively worse, while if we were to do the opposite and increase the number of scanned lines instead, the quality of the image becomes progressively better or closer to the original image.

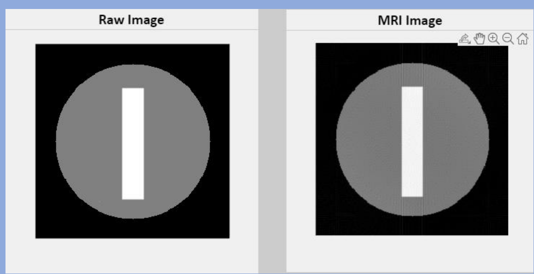
In the following pictures, we acquire the MRI Image through phantom reconstruction using a Radial sampling algorithm. The first section is the number of fixed scan lines of 128 for Phantoms 2 and 3. We would modify the number of scan points with the values 16, 64, and 128 respectively. The second section is the number of fixed scan points of 128 for Phantoms 2 and 3. We would modify the number of scan lines with the values of 16, 64, and 128 respectively.

Section 1

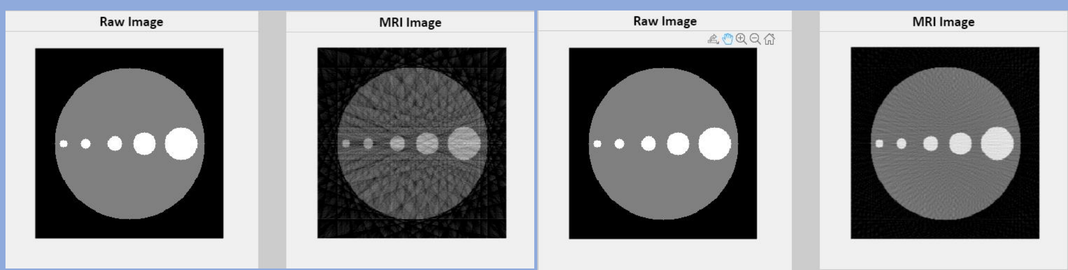


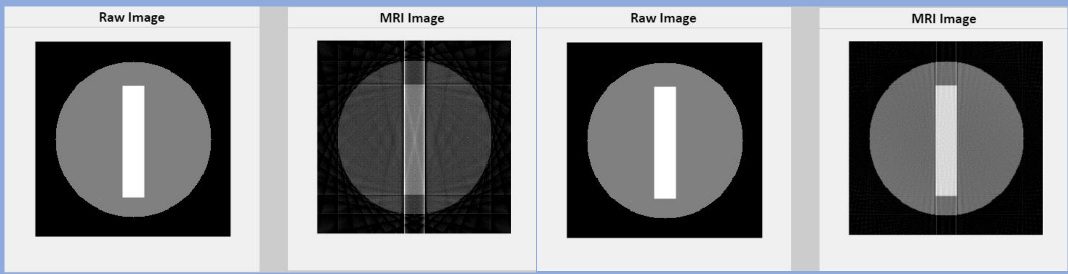


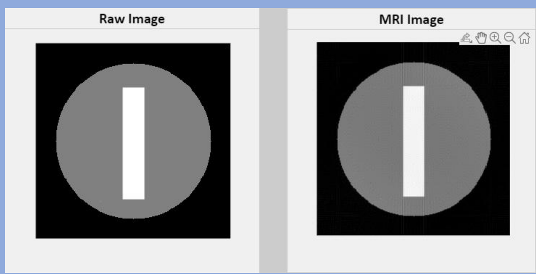




Section 2







As we can see from our data results based on the Radial sampling algorithm, as we increase the number of scanned points, the quality of the image seems to appear consistent and close to the original image. The same appears to go along if we were to do the opposite and increase the number of scanned lines instead, the quality of the image becomes progressively better or closer to the original image as well.

Conclusions

In this project, we have documented and implemented MATLAB software to create a Magnetic Resonance Image Acquisition Simulator. The data that has been collected is performed by two different algorithms for reconstruction: Cartesian and Radial. Image analysis above outputs the results of our input data.

Appendix A

The MATLAB code is provided as a link to a GITHUB as indicated:
https://github.com/RBranch47/medical-imaging-project