MRI Contrast Simulator

Note: this group arrange to meet with me ASAP for additional material

OVERVIEW: The goal of this project is to implement a virtual MRI scanner and simulate the image contrast for different “acquisition sequences” for tissue with different type of MR properties. Specifically, this code will

- The pulse sequences will be: spin echo (SE), gradient recalled echo (GRE) with complete dephasing of the transverse magnetization and fast imaging with steady precession (FISP).
- Input parameters for the “pulse sequences” will be: repetition time (TR), echo time (TE), excitation angle (alfa), size of the acquisition matrix
- Tissue MR parameters will be: the longitudinal relaxation time (T1), the transverse relaxation time (T2) and T2* (T2 star)

You will use two phantoms. The majority of your work will be performed on “test/validation” phantom shown in the figure. This is a simple phantom that is a circular compartment with another circular and a rectangular structure inside. You will use those phantoms to study and analyze the effect of different acquisition parameters on image quality. The second phantom will be based on the phantom() function of Matlab. You must modify it so it can work with MRI (remember that the phantom Matlab function is specifically made for x-rays). Use this one as a final demonstration that your scanner works properly!

SPECIFICS:

1. Develop the different functions/code to perform all necessary calculations for:
   - Generate the phantoms
   - operation of the scanner by selecting different acquisition schemes
   - image generation
   - image analysis
2. Implement a GUI that combines those pieces of code and performs the different tasks.
3. Test/validation phantoms: Assign different T1, T2, T2* values to each compartment and systematically study your code.
4. Head-phantom: Modify the phantom() function by Matlab.
5. Image Analysis: Implement code for three types of image analysis:
   - Signal Intensity (SI) and Contrast (relative signal intensity differences between two regions). These quantities should be reported as numbers and you will use them to investigate whether your calculations are correct (how? e.g. is the beam attenuation correctly calculated?)
   - Image Difference: This will be used to compare your image generated by your scanner and the original input which is your phantom. You will use this type of analysis to identify artifacts or other problems with image reconstruction.
- Signal Intensity (SI) profiles: Generate graphs of the signal intensity vs. position along a specific direction. You will use those graphs to investigate for potential artifacts. You must be able to compare the profile of both your original object (phantom) and your image (the output of your virtual scanner). So, you can arrange to view two or more profiles in the same figure-graph.

6. The scanner part of the GUI should allow you to select the different pulse sequences SE, GRE, FISP, as well change the different parameters of data acquisition: TR, TE, alfa, acquisition matrix,. Add a run button to activate the acquisition. In the output do not forget to add appropriate comments that list the parameters you used (Matlab gives you some good options for this)

7. Your analysis should be based on the following: graphs that show the signal intensity versus a particular parameter, such as TR, TE, and alfa. Single intensity versus the MR parameters of tour compartments such as T1, T2, T2* 

8. Based on your results, generate the images for the different selected values.