Bioengineering 278: Magnetic Resonance Imaging Laboratory
Winter 2009
Lab 1- Week of 1/5

1. **Reconstruct an image from raw (k-space) data.** Place the BIRN phantom in the single channel head coil and insert into the scanner. Collect a localizer scan. Prescribe a single slice 2D gradient echo scan, using a field of view that is larger than the phantom. Set the Control Variable (CV): rhexecctrl=rhexecctrl+2 (it's a bitmask) to make the scanner save raw (K-space) data. Scan. Obtain the raw data file (the most recently written file with the name P?????.7 in /usr/g/mrraw). The data file consists of a header, followed by raw data in the time order in which it was collected. Complex data is stored in 16 bit signed integers, with the real part followed by the imaginary part for each data point.

   a. **Construct an image of the k-space data.** Why is the k-space data peaked at the center? Is it possible for the data not to have it's largest value at the center? Why or why not? (2 points)

   b. **FT the data in the frequency encode direction and display the result as an image**. Label the corners of this image with absolute units. What does each row of the resultant image represent? What does each column represent? (2 points)

   c. **FT the result of part b in the phase encode direction to reconstruct the final image.** Display both magnitude and phase images. What information is contained in the phase image? (2 points)

2. **Calculate a B_1 map from 2D gradient echo image data.** Using the same phantom, collect 2D gradient echo images at nominal flip angles of {30°,60°,90°,120°,150°}. The true flip angles will be linearly related to the nominal flip angles. Use the minimum TE and a TR of 1s. If the TR is long compared to the T_1 of the phantom, then the signal at each location will be proportional to $\sin(\alpha)$, where α is the local flip angle. From the images:

   a. **C**alculate a map of the true flip angles in the nominal 90° image. You may assume that the slice profile is a perfect rectangle, and neglect T_1 relaxation for this calculation. (8 points)

3. **Generate and analyze a quadrature artifact.** Place something with structure in the same coil. Acquire a single slice gradient echo image with a 30° flip angle as in Part 2 above. Reconstruct the image. Multiply the imaginary channel by 0.9 and re-reconstruct the image. This simulates a severe imbalance between the real and imaginary channels in the receive chain of the scanner. The resultant image can be thought of as a superposition of a true image and a ghost image.

   a. How does the geometry of the ghost image relate to that of the true image? More specifically, for a point (x,y) in the true image, at what coordinates does the corresponding point in the ghost image appear? (3 points)

   b. Measure the relative signal intensities of the true and ghost images. Write a mathematical expression for these intensities in terms of the factor A (0.9 in this case) that multiplies the imaginary channel data relative to the real channel data. (3 points)