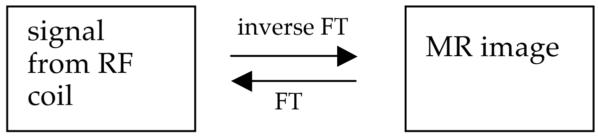
BIOEN 6330 Principles of Magnetic Resonance Imaging
Homework #1
Due Thursday, January 28, 2010

The signal received by the MRI radiofrequency (RF) coil consists of “spins” oscillating at frequencies proportional to their spatial position. Consequently, the detected signal is essentially the Fourier-domain representation of the associated MR image.



With this background in mind, the purposes of the following exercises are to review linear systems theory and MATLAB programming that will be useful for the course:

- For each exercise, your “solution” will include both the exact MATLAB commands issued and the recorded output.
- For displaying images, make sure the pixels have the right aspect ratio (i.e., square) and that the first dimension of the data corresponds to the horizontal axis. Also, according to image processing convention, the origin should be at the top left corner. For printing, make the images no bigger than 1/4 page (to save toner).
- To promote good Matlab programming, each problem that does not contain codes involving any built-in Matlab function (except FFT and display commands) and for-loop will receive 2 points extra credit.

1. Use binary I/O to read the file `hw1.raw` (144 x 192 complex, big-endian floating point matrix) into MATLAB, calling it `raw_signal`:
   a. Graph the central 64 x 64 portion of the *magnitude* of `raw_signal`, plotting the values as height along the z-axis using, for example, the MATLAB `mesh` or `surf` command.
   b. Display the same submatrix but represent the matrix values as black-and-white (i.e., grayscale) intensity levels using, for example, the MATLAB `pcolor` or `imagesc` command.
   c. Reconstruct the data to obtain the MR image. Perform magnitude computation and display the image in grayscale with low frequency component at the center.

2. The signal-to-noise ratio (SNR) is defined as the average intensity value over a region-of-interest (ROI) divided by the standard deviation of the noise field (e.g., the background). For the MR image obtained in Problem 1 part (c), determine the SNR in at least 3 areas of the brain white matter, and compute the average SNR.

3. Create a Fermi filter (i.e., a centrically located circular disk of unity intensity inside and zero outside) of 96-pixel diameter centered in the image matrix. Treating `raw_signal` from Problem 1 as the frequency spectrum of the MR image, use the Fermi filter (and its inverse

filter) to obtain low-pass and high-pass filtered images. Describe the results and explain using linear systems theory.

4. Create a rectangular (144 x 96) filter of unity gain, and a Fermi filter of equal area. Apply each filter to `raw_signal`, reconstruct, and repeat the SNR analysis in Problem 2 for the respective images. What are the general effects of low-pass filtering on the image SNR? What are the effects on the objects in the image?

5. Obtain sub-sampled versions of `raw_signal` by extracting (a) the center 72 x 96 elements, and (b) alternating rows and columns of the matrix. Reconstruct each case. Describe the results and explain using linear systems theory.