Bioengineering 278: Magnetic Resonance Imaging Laboratory
Winter 2012
Lab 11: Compressed Sensing

Collect an image at high resolution (1024x1024). For this lab, please use image i5633321.MRDC.8. iFT the image to generate 'true' k-space data.

The general approach for CS reconstruction that we discussed is:
Step 1. Guess at an initial image (imhat).
Step 2. iFT into k-space and enforce data consistency. For an undersampling matrix U consisting of 0s and 1s, where 1 represents acquired data, this means
imhat=FT(U.*data+(1-U).*iFT(imhat))
Step 3. Transform imhat using a sparsifying transform and increase sparsity in that domain. Moving down the gradient of the L1 norm in this domain amounts to simply subtracting a constant value from the magnitude of each coefficient in the transform domain. The value of this constant can be adjusted across iterations, and the schedule for this adjustment is up to you. Transform back to image space.
Step 4. Loop back to Step 2.

1. Reconstruct the image using half of the data (acceleration factor R=2) using compressed sensing and the following 3 undersampling patterns:
    a. Every other line in k-space.
    b. Randomly sampled lines with a Gaussian probability density function.
    c. Randomly sampled points in 2D k-space with a Gaussian PDF

For 1b and 1c, the functions vdgrid and vdgrid2 (available at the class website) can be used to generate random sampling patterns for you. Both of these functions have an option to specify a patch at the center of k-space that is guaranteed to be sampled, and the size of that patch is another tweakable parameter.

Please provide the residual RMS error for 1a-c. In addition to this metric, it is instructive to make images of imhat-true_im before and after your iterations. For the reconstructions that worked well, I found that the RMS error went down slightly, but the residual errors were much less structured (more noiselike) after the CS iterations. Report any other metric you found useful for evaluating the quality of your reconstructions, but remember that for CS recon, you cannot use any metric that compares imhat to the true image as feedback for the recon, since you don't know the true image. (**10 points**) Why does 1a fail? (**4 points**)

2. For whichever sampling pattern performed best in part 1, increase the acceleration factor R to 3 and 4, and see if you can still achieve acceptable reconstructions. (**6 points**) Note that while the 2D random sampling probably gave you the best results, it is not obvious how one would achieve such sampling (in 2D imaging), although for 3D imaging, you could use the random 2D pattern to choose points in Ky-Kz space at which to acquire full Kx lines.