Bioengineering 208: Magnetic Resonance Imaging Laboratory
Winter 2008
Lab 4- Week of 1/28

1. **EPI reconstruction.** In this exercise, you will observe and correct the effects of time shifts and resonance offset in EPI. Place a phantom in the birdcage head coil and insert into scanner. Use the UCSD generated pulse sequence called spep_product, which supports both EPI and spiral image acquisition. Prescribe a single axial slice with 64x64 resolution and set CV: gtype=1 (EPI). Record the value of the CVs: skip; pw_xcyc. Autoprescan and then scan. Record the name of the latest raw data files in /usr/g/mrraw as you scan. In manual prescan, misset the X shim by 10 units and rescan. Return the X shim to the original value, and scan with the Y shim misset by 10 units. In this pulse sequence, EPI data is collected using a single readout that covers all 64 echoes. The data appears in raw time order. In order to reconstruct the data, you will need to extract the individual echoes from the echo train, discarding the (skip) data points between echoes that are collected on the gradient ramps. Even numbered echoes should be reversed in time, and 2D FT performed. The resulting image will likely have significant Nyquist Ghosts that are dominated by time shifts between even and odd echoes.
    a. **Correction of Nyquist Ghosts.** The Fourier shift theorem states that a shift in K-space can be simulated (or corrected) by applying a phase ramp in image space (after row FT). Apply a linear phase ramp to the even echoes by multiplying your data after row FT by exp(j(A*x)) where x is the x location in pixels (centered at pixel 33), and apply the column transform. Adjust A until the Nyquist Ghost is minimized. Calculate from the optimal value of A what the time shift was, in units of the sampling period. (5 points)
    b. **Off resonance effects in EPI.** In addition to the time shift correction above, you will also need to correct the data for spatially dependent phase shifts when reconstructing the data with misset shims. Use the coefficients of the required corrections to estimate the gain of the shim system (gradient per unit shim offset) and compare with Part 2b of Lab 3. For this calculation, you will need to use pw_xcyc, which is the time in microseconds from echo to echo in the EPI train. (5 points)

c.

2. **T2* blurring in EPI.** In this exercise, you will be estimating the T2* of a point in your phantom using two different methods. In order for this to work, you must choose a point in a phantom that has a sharp edge, such as the high resolution GE phantom.
    a. **In the first method, you will be using the blurring of the edge to estimate T2*.** Measure the image profile across the nominally sharp edge. Convince yourself that the derivative of this profile is the local PSF. In principle, you could FT this PSF into a T2* decay curve, but this would require a very accurate measurement of the complex PSF and is not likely to work with our data, given the additional resonance offset related distortion. A simple but crude way is to simulate various T2* decay curves across the EPI readout, and FT them to find estimated PSFs. Adjust the T2* until the calculate PSF has the same width as the measured local PSF. The T2* that generates the best fit for the PSF is your estimate of T2*. (5 points)
    b. **In the second method, you will measure T2* more directly, using the magnitude data from images acquired at 2 different values of TE.** Experiment with different echo times until you generate a significant signal drop in the longer TE and can calculate T2*. You data for part 1b may or may not suffice for this. Calculate T2* in your region of interest, and compare with your estimate from part 2a. (5 points)