EE225E/BIOE265 Spring 2012 Miki Lustig
Principles of MRI

Optional Assignment 11

Due before the end of semester

1. Consider the Hadamard encoding of two slices as shown in Fig. 8.2 in Nishimura. What is the relative SNR of the two slices compared to imaging two slices sequentially?

2. Consider the EPI and spiral trajectories in fig. 8.12 in Nishimura.

   a) Assume T ms readout gradients and that the gradients start 1ms from the peak of the RF excitation. What is the echo-time for EPI and what is the echo time for the spiral trajectory?

   b) What is the k-space weighting due to T_2^* decay in EPI and spiral for a gradient echo sequence. (Assume decay happens only in the slow direction.)

   c) How would your answer change if the sequence is a spin-echo. What's the problem for spiral spin-echo imaging?

3. **Some Matlab programming**. The following problems will be concerned with a simple 2DFT SENSE reconstruction. The SENSE data is a simulated resolution phantom, so that the sensitivities are known exactly. Download the data file sense_2dft.mat from the class website. This simulates a 24 cm FOV acquisition, with 24 cm circular diameter coils directly above and below the object. The acquisitions is an axial slice, so the coils are aligned with the y axis.

   g-Factor. The most important characteristic of a SENSE acquisition is the geometry factor g. This tells you how well conditioned the reconstruction problem will be. The two sensitivity maps are stored in S1 and S2. Assume that the noise covariance matrix is $\sigma^2 I$, meaning that the noise is uncorrelated between coils, and is of equal intensity. Refer to Pruessmann's paper for reference.

   a) Make an image of the g-factor if the phase encode is along the y axis. Show the image with the range of g-factors limited to 1 (the minimum possible) to 4. Plot a cross section along the y axis. Where is the largest g-factor? What is it?

   b) Repeat the calculation for phase encoding along the x axis. Show the image, and plot a cross section along the x axis. Again, limit the g-factor image to a range of 1 to 4.

   c) For the second case, the g-factor is large in specific places. What is it about the coil sensitivities there that cause this to happen?

4. **2DFT SENSE Reconstruction**.Two acceleration factor 2 aliased images are in the matlab variables im1a and im2a. Write an mfile that performs the SENSE decomposition. Show the resulting image. comment on the appearance of the noise.

5. **SENSE and Averaging**. One of the tradeoffs with SENSE is that it reduces SNR in exchange for speed. Occasionally, the SNR will be too low, and the operator will decide to average multiple SENSE acquisitions to get the SNR back.

   a) Assume that the acquisitions has been accelerated by a factor R, and then averaged R times. In this amount of time, we could have simply acquired a fully encoded data set. Find an expression for the ratio of the SNRs of the two alternatives.

   b) When would acceleration and averaging be a reasonable thing to do?