Principles of Magnetic Resonance Imaging. Final assignment

December 2012

Write a report about the following two exercises. The report should include a short introduction, a theoretical part, discussions and a summary/conclusion. Try to answer (and/or discuss) as many questions as you can. Send the report in a digital version to my gmail account, please: a.sbrizzi at gmail.com. The deadline for the submission is on the 15th of January, 2013 at 9.00 am. Good luck!

Exercise 1: Circular $k$-space trajectory

Suppose you want to scan an object, which measures $L \times L$, with a given spatial resolution $\Delta_x = \Delta_y$. The $k$-space trajectory you choose is the concentric circular trajectory, starting from the center, as shown in Figure 1. How many circles do you need to be sure the image you get will not exhibit aliasing? What is the distance between the circles, along the radial direction? Write an analytical formula for the circular parts of the trajectory. Hint: use the complex exponential notation. Derive the gradients $G_x$ and $G_y$ needed to acquire the data in this way.

The $k$-space samples are taken along the trajectory with a distance in time equal to $\Delta_t$, i.e. the $k$-space is discretized in a circular fashion. Modify the above derived formula for the trajectory in such a way that the distance between the samples fulfills the Nyquist criterion, that is $\Delta_k \leq 1/L$.

In practice, the gradients are subject to the constraint $|G_x| \leq G_{\text{max}}$ and $|G_y| \leq G_{\text{max}}$ with $G_{\text{max}}$ a given positive real number. Modify your trajectory in a way that it fulfills also to this requirement.

Can you write an algorithm (or a matlab-code) which, given $L$, $\Delta_x$, $\Delta_t$, $\gamma$ and $G_{\text{max}}$, returns the gradients for this trajectory? Suppose you wish to apply SENSE reconstruction and undersample the $k$-space by a factor $R = 2$. How can you do it efficiently with this trajectory? How can you reconstruct the image? Write

Figure 1: Circular $k$-space trajectory
an expression for the 2D SENSE reconstruction matrix $D_{\text{full}}$. Can you implement the matrix in matlab? How large will the matrix be?

In practice, the spin magnetization is subject to relaxation. This means that the signal decays during the scan. As a consequence, the effect of noise will be more relevant at the end of the acquisition. Can you explain what is the advantage of scanning the $k$-space along this trajectory?

**Exercise 2: Cartesian SENSE**

Work out exercise 3 from the 3rd matlab session (lesson of December 18th).