Homework #5

Due: Sunday, Nov 11th, 2018

to be submitted via course webpage

Matlab General Guidelines

Please follow the instructions below. Please provide a document that contains your images and answers / comments on the tasks described below. When you are asked to discuss or provide reasoning for how something looks, please type out your response. Also provide the Matlab code you used to generate the images and answers.

Additional Files

Matlab files and all data files for this work can be found on the course website.

Introduction

In this MATLAB exercise we will investigate the phase of images acquired in a phantom and in vivo in respect to the echo time in a spoiled gradient echo sequence (aka SPGR aka FLASH). We will generate frequency maps and images that separate water and fat based on Dixon reconstruction techniques. The lecture slides on this topic should provide a solid basis for the analysis at hand. In addition, a write-up from Dr. John Pauly at Stanford University is provided.

Please label all images properly: provide colorbars and a title. Also provide labels for x and y when you see it necessary. Make sure that the images are properly displayed in terms of their aspect ratio (hint: use *truesize* with imshow or *axis image*)

Problem 1 – Phantom data

Read the phantom data set into Matlab. In this experiment, I placed 1 vial of fat on top of 2 vials of water. Those are single slice data that were acquired with a gradient echo sequence on a Siemens Sonata scanner. The TR was kept constant at 40 ms while the echo time TE was shifted from 4.0 ms (Series 01) to 6.0 ms (Series 02) and 8.0 ms (Series 03) corresponding to in and out of phase images or water and fat.

Note the difference in raw data format from the GE datasets that were provided in Homework #2. For each Series, there is a data file (meas.out) and a text file (meas.asc). The text file contains details on the scan parameters (e.g. field of view, bandwidth, etc).

a) Find the parameters for field of view and slice thickness in in the scan parameter file for Series 1 and report the values (sSliceArray.asSlice[0].dThickness, sSliceArray.asSlice[0].dPhaseFOV, sSliceArray.asSlice[0].dReadoutFOV = 300 – all stored in mm) . Tip: If you change the extension of meas.asc to meas.txt, your computer will associate the appropriate text editor with opening this file.
b) Read the raw k-space data into Matlab and generate the corresponding images for each echo time. I prepared a routine read_raw_form_n4.m to read the data and I also posted a mini script script_read_phantom.m to show you how to use it. Provide the resulting images (magnitude and phase) for all 3 echoes.
c) Draw regions of interest in each of the 3 vials and create plots of signal vs echo time and phase vs echo time. Remember that phase wraps may occur and try to compensate for those. Describe the results.

d) Implement a 2-point Dixon reconstruction. Provide the water only and a fat only image of the phantom.
e) Implement a modified 2-point Dixon reconstruction. Provide the water only and a fat only image of the phantom.
f) Implement a 3-point Dixon reconstruction. Provide the water only and a fat only image and the field map of the phantom.
g) Field Map Estimation: The phase estimate ϕ (in radians) can be converted to a frequency estimate (in Hz) by dividing ϕ by $2\pi\ \Delta TE$, where ΔTE is the time between the first and second images. Generate and provide the field map.
h) Compare the results from d, e, and f.

Problem 2 - In vivo data

The in vivo data set was provided by Dr. John Pauly from Stanford University. It is saved in matlab format in the file *dixon_images.mat*. There are three matlab variables, image 1, image 2, and image 3, which contain the three Dixon images. The images are from a gradient recalled sequence, with echo times of 12.8 ms, 19.2 ms, and 25.6 ms. These correspond to 2π, 3π and 4π phase shifts of the fat/water difference frequency, which is 72 Hz for 0.5T where these images were acquired. Before starting, take a look at the three images to get a sense of the different information they contain. The first and third have water and fat in phase, while water and fat have opposing phase in the second image. This is particularly noticeable behind the eye in the contrast between the optic nerve (water) and the retro-orbital fat.

a) Run the 3 reconstructions developed in problem 1 (2-point Dixon, 2-point modified Dixon and 3-point Dixon) and compare the results.