EE369C: Projects

Initial Idea Due Nov 17

During the next week you should start thinking about topics for a project. Send me a paragraph about what you are thinking by next week, Thursday, Nov 17th.

You can choose any project that is related to the subject of the class. This can be something related to your Ph.D. work, some problem you found interesting, or one of the problems listed below. The scope of the problem should be something beyond what you have done in the homework. However, it should also be restricted in scope, to fit the limited time available. One good choice is the implementation of one of the algorithms that we have discussed, that haven't appeared in the homework.

You have two options for presenting your project

- A 10 minute oral presentation, with slides and an abstract. This would be on the last day of class, Thursday December 6.
- A 10-15 page written report of your project. The project reports are due Thursday Dec 13th at 10 PM, the end of the time scheduled for the final.

Time for oral presentations is limited, so let me know as soon as possible if you want to reserve a time slot on Dec. 6.

The projects will be assessed based on the difficulty and importance of the problem, and on how well you do with your problem. You can do well either by doing a thorough job on a well understood problem, or by making progress on a difficult or new problem.

Send me your current thoughts about a topic. This isn't binding, so don't be too concerned. If you are at all unsure, have questions, or just want to talk, make an appointment to come by my office. I will be in my office Tuesday Nov 13 from 9-12 and Wednesday Nov 14th from 1-4. Please email me a specific time when you would like to come by.

Possible Project Topics

1. ***Parallel Imaging Algorithms***
   There are a large number alternative parallel imaging algorithms that have been presented. Implement one or more of these and compare these to SENSE. Possibilities include SMASH, GRAPPA, or one of the many other variations. Plot the performance as a function of acceleration.

   We have an 8-channel head coil data set, with calculated sensitivities for you to use for this project.

2. ***Parallel Imaging and Partial k-Space Reconstruction***
   Several abstracts have proposed methods to combine parallel imaging and partial k-space reconstruction. The degree of acceleration R and the k-space fraction interact, limiting the total acceleration. It appears there is a smooth, continuous tradeoff between these two. Implement one of the parallel image reconstruction algorithms, and map out this trade off. GRAPPA is one natural algorithm to use here, since it can be applied to fill in the missing k-space lines on the acquired data first, before the partial k-space reconstruction. SENSE is also a possibility, since it inherently rephases the independent channels, and should produce a real image.

3. ***Non-Cartesian Parallel Image Reconstruction***
So far, all the parallel image reconstruction algorithms have been 2DFT. This simplifies things, because only a few pixels contribute to each aliased pixels. The reconstruction consists of lots of small problems. The situation is much different for non-Cartesian trajectories, such as spiral or PR. Here the aliasing from one pixel can contribute to a large fraction of the image, and the reconstruction must be handled as one large problem.

Several algorithms have been proposed for this problem. The first was due to Pruessmann, *et al.* (Advances in sensitivity encoding with arbitrary k-space trajectories, MRM 46(4):638-51, 2001). This is an iterative solution to the full SENSE encoding problem. Since then there have been several others, including GRAPPA derivatives. It is still an open questions as to which is the best approach.

Possible projects include:

(a) Implement and test the non-Cartesian SENSE algorithm. This is well described in the Pruessmann paper.

(b) Implement and test one of the other approaches, such as one of the GRAPPA deriviatives, or the k-space implementation of the SENSE algorithm. or invent your own.

4. ***Off-Resonance Correction***
There are several open questions with the off-resonance correction methods we studied in class. These could make good projects.

(a) For the autofocus algorithm we talked about in class we rephased the data set, and used a function of the imaginary channel as a focus metric. Another alternative is to start with a magnitude reconstruction, and then use the highpass filtered image as a focus metric. This is closer to how cameras work, and has many potential advantages. We would be searching for a maximum, which might be more robust, and it wouldn't require rephasing the data. Can you get this to work? What should you use as the filter, and the focus metric?

(b) For the autofocus algorithm the integration window was chosen as a small nxn window. How should we choose the window size? Are there benefits from choosing a smoother window?

(c) The focus metric has an exponent. What effect does this have? What should we choose for the exponent?

You can use the data from the homework for this.

5. ***Fan Beam CT***
Next week we will be talking about backprojection and CT. In practice, almost all CT data is acquired using a fan beam. We have some fan beam data from a current commercial whole-body CT system. For this project, you will reconstruct the actual fan beam data. There are several alternative fan beam reconstruction algorithms. The filtered backprojection case over a 360 degrees of rotation will be covered in the homework. One project option is to modify the fan beam filtered backprojection to use only 180 degrees plus the fan angle. This is known as "halfscan" reconstruction, and is covered in the Kak and Slaney book. Another option is to implement the rebinning algorithm, which we won't do in the homework.

6. ***Partial k-Space Spiral Reconstruction***

Spiral acquisitions can also use partial k-space acquisitions. An iterative POCS type acquisition can be used to fill in the missing data (J.H. Lee et al, ISMRM 2003, p 475).

One issue that has not been considered is the effect of off-resonance on the partial k-space reconstruction.

(a) The multifrequency reconstruction should allow the image to be completely rephased into the real channel. With this, can a non-iterative reconstruction work? Can the multifrequency reconstruction help the POCS reconstruction?

(b) Typically partial k-space spirals are acquired by taking alternate interleaves. This produces aliasing at distance of half the FOV. Another alternative is to collect the first half of the interleaves (plus one or two). Does this behave better with off-resonance?

You can do this project with the full off-resonance spiral data from the homework, by taking subsets of the full data set.