Grant Roberts

MP 710: Advanced MRI

11/12/2018

## Project Proposal: **Compressed Sensing Applied to MR Elastography**

Compressed sensing (CS) has recently become an important aspect of magnetic resonance (MR) imaging (and more generally the field of signal processing as whole), as it allows one to exploit sparsity of a signal (in some domain) to undersample. This, in turn, greatly reduces the amount of time needed to acquire an MR image while still preserving important imaging characteristics, such as the signal-to-noise ratio (SNR). MR elastography (MRE) is a relatively new application in MR, in which tissue stiffness can be quantitatively measured.

The primary goal of this project is to determine the feasibility of CS by simulating various under-sampling schemes on the k-space data. The feasibility of CS will be evaluated by comparing SNR efficiencies [] between the two acquisition techniques. Both images and stiffness maps will be compared. Two identical k-space datasets of the brain (human subject) will be acquired using a customized head driver operating at 60 Hz. Two additional sets of images will be undersampled in several well-known sparse domains (spatial finite-differences, discrete cosine transform, wavelet transform, etc.) with pseudo-random sampling schemes. SNR­diff will be used to calculate SNR for the original and undersampled reconstructed stiffness maps. Stiffness maps will be generated by using an already implemented reconstruction code provided by Wally Bloch. Note, the time of scan for the CS dataset can be inferred from the degree of undersampling which will allow for a SNR efficiency calculation. Images will hopefully be acquired here at the UW, which has been discussed with Wally Bloch. Matlab and Python will be the primary software tools to undersample the raw k-space data. There are several Matlab algorithms available for download, in which one can under-sample in image in different domains. After an in-depth literature search, it seems that only few studies have been published on applying CS applied to MRE.

## References

2017 Master’s Thesis by Christopher Ebersole: Compressed Sensing (BEAM) applied to MRE

<https://etd.ohiolink.edu/!etd.send_file?accession=osu1494340605419894&disposition=inline>

Miki Lustig – Compressed Sensing

<https://onlinelibrary.wiley.com/doi/pdf/10.1002/mrm.21391>

Meenu Rani - Review of Applications in Compressed Sensing

<https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8260873>

Irene Orovic - Compressed Sensing Algorithms and Transform Domains

<https://www.hindawi.com/journals/mpe/2016/7616393/>

Cara Morin - Comparing CS, Breath-Hold, & Free-Breathing in Liver MRE

<https://www.ajronline.org/doi/abs/10.2214/AJR.18.19761>

Yogesh Mariappan – Review of MRE

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3066083/pdf/nihms278057.pdf>

MRI Questions – MRE

<http://mriquestions.com/mr-elastography.html>

Compressed Sensing MRI Phantom Algorith (David Smith) – Matlab File Exchange

<https://www.mathworks.com/matlabcentral/fileexchange/29364-compressed-sensing-mri-phantom-v1-1>

Feedback by Oliver

Grant, this is an interesting proposal and combines 2 topics that are likely new to you: MR Elastography and Compressed Sensing. I like the topic and it is good to see that you already thought about how to get access to MR data. I will work on getting you the data.

In terms of a research plan, there are some details missing:

1. If you have MRE raw data, you still need to reconstruct the data. There are several steps: (1) create images from the k-space data and (2) generate a stiffness map from the MR images. Will that be your code or will you use some MRE recon provided by Mayo or others?
2. I assume your compressed sensing code will be implemented for step described above?
3. Your research plan is lacking some metrics of success / performance. I assume you will run some simulations of undersampling the fully sampled MRE data and see how much you can undersample with CS and still get decent stiffness estimates. How will you measure the similarity or assess errors?

Your project is approved but I encourage you to think about my comments.