IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	**Blind Trajectory Calibration in MRI**	
Project Number	**IMURA0768**	
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Research Clusters:

Highlight which of the Academy's CLUSTERS this project will address? *(Please nominate JUST **one.** For more information, see www.iitbmonash.org)*	
1	*Material Science/Engineering (including Nano, Metallurgy)*
2	*Energy, Green Chem, Chemistry, Catalysis, Reaction Eng*
3	*Math, CFD, Modelling, Manufacturing*
4	***CSE, IT, Optimisation, Data, Sensors, Systems, Signal Processing, Control***
5	*Earth Sciences and Civil Engineering (Geo, Water, Climate)*
6	*Bio, Stem Cells, Bio Chem, Pharma, Food*
7	*Semi-Conductors, Optics, Photonics, Networks, Telecomm, Power Eng*
8	*HSS, Design, Management*

Research Themes:

Highlight which of the Academy's Theme(s) this project will address? *(Feel free to nominate more than one. For more information, see www.iitbmonash.org)*	
1	***Advanced computational engineering, simulation and manufacture***
2	*Infrastructure Engineering*
3	*Clean Energy*
4	*Water*
5	*Nanotechnology*
6	*Biotechnology and Stem Cell Research*
7	*Humanities and social sciences*
8	Design

The research problem

MRI is a very popular modality for medical imaging. As per the underlying physics of the MR machine, it measures the Fourier transform of the diffusivity values of the underlying object at a set of user-specified frequencies where the *i*th frequency is denoted as u*i*. However due to hardware errors, the machine ends up measuring the Fourier transform at slightly different frequencies, where the *i*th perturbed frequency is given by u*i* + d*i*, where d*i* is the unknown perturbation value. The reasons for these perturbations are gradient delays, main magnetic field distortion, resonating frequency drifts, and the difference between the specified and actual start time of the MR sequences.

Compressed sensing techniques have recently produced great success in reducing MRI acquisition time, because they allow for high fidelity signal reconstruction even from substantially undersampled measurements. These techniques primarily exploit the sparsity or compressibility of the underlying signals in their estimation. However these techniques require accurate specification of the sensing matrix, which in the case of MRI, consists of the Fourier matrix at the specified set of frequencies. The aforementioned frequency perturbations can cause serious degradation in reconstruction performance if ignored.

The aim of this project is to perform blind calibration, i.e. estimate both the underlying signal as well as the frequency perturbations in an alternating framework. More specifically, the project will seek to build upon the framework in [1] for MR reconstruction assuming a variety of different acquisition protocols and sampling schemes such as random Cartesian, radial, spiral, etc and compare it to methods from [2,3,4] which do not adopt a compressed sensing framework.

References

1. E. Malhotra, H. Pandotra, A. Rajwade and K. Gurumoorthy, Signal recovery in perturbed Fourier compressed sensing, https://arxiv.org/pdf/1708.01398.pdf
2. A. Deshmane, M. Blaimer, F. Breuer, P. Jakob, J. Duerk, N. Seiberlich, and M. Griswold, “Self-calibrated trajectory estimation and signal correction method for robust radial imaging using GRAPPA operator gridding,” Magnetic Resonance in Medicine, vol. 75, no. 2, pp. 883–896, 2016
3. A. Moussavi, M. Untenberger, M. Uecker, and J. Frahm, “Correction of gradient-induced phase errors in radial MRI,” Magnetic Resonance in Medicine, vol. 71, no. 1, 2014.
4. J. D. Ianni and W. A. Grissom, “Trajectory auto-corrected image reconstruction,” Magnetic Resonance in Medicine, vol. 76, no. 3, pp. 757–768, 2016.

Project aims

There are two main aims:

- Modelling of sources of trajectory error in MRI
- Development of algorithms for correction of trajectory errors along with underlying signal estimation in a compressive sensing framework

Expected outcomes

Models for expressing trajectory errors in MRI and algforithms to correct them along with estimation of the signal.
These tasks have implications for future development of low cost MR scanners.

How will the project address the Goals of the above Themes?

The project aims to further the state of the art in magnetic resonance imaging, a very important medical imaging modality.

Capabilities and Degrees Required

The student should have familiarity with and good understanding of basic techniques in image processing, signal processing and machine learning. The student must have the ability to program numerical algorithms using tools such as MATLAB, NUmpy or C++ and possess mathematical maturity. An interest in signal processing and sparse representations is a plus. Knowledge of magnetic resonance imaging or MRI image processing is a plus but not essential.

Potential Collaborators

Please visit the IITB website www.iitb.ac.in OR Monash Website www.monash.edu to highlight some potential collaborators that would be best suited for the area of research you are intending to float.

Select up to **(4)** keywords from the Academy's approved keyword list **(available at http://www.iitbmonash.org/becoming-a-research-supervisor/)** relating to this project to make it easier for the students to apply.

Compressed sensing, magnetic resonance imaging, trajectory correction