IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	**Acquisition of Discrete Projection data and Reconstruction of Digital Images**	
Project Number	**IMURA0390**	
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Research Academy 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

The research problem

Define the problem

Tomographic reconstruction of images from projections is relatively well-behaved, except for the most interesting cases where data is collected at asymmetric angles or for sparse projection data. Often statistical iterative techniques are applied, but these methods are slow to compute, have poor spatial resolution and uncertain convergence properties. The addition of noise to the collected projected intensities makes problems harder still. The Mojette transform [1] is an exact, digital projection method that copes well with asymmetric or sparse sets of data. It also has strong predictive constraints on the reconstructed image values (i.e. the depth of greyscale reconstruction or number of distinct densities or materials of which an object is composed). It can be mapped neatly onto the finite Radon scheme [2], which has the advantages of an exact inversion algorithm and strong symmetry properties [3]. The project will build on recent advances [4-5] and work at Monash [6] and investigate a novel idea of Andrew Kingston at ANU to

sample objects and reconstruct images in a 2D discrete form using real x-ray projection data. This project may involve undertaking some experimental work at ANU or an equivalent laboratory doing x-ray tomography. Reconstructions of 3D data from 2D images may also need to be investigated.

References

[1] The Mojette Transform, Theory and Applications, JP. Guédon (Ed.), ISTE, Wiley, 2009.

[2] Image representation via a finite Radon transform, Matus, F. and Flusser, J., IEEE Trans. Pattern Anal. Machine Intell. 15(10), 996-1006, 1993.

[3] Projective transforms on periodic discrete image arrays, A. Kingston and I. Svalbe, Advances in Imaging and Electron Physics, 139, pp 75-177, 2006.

[4] Applying Mojette discrete Radon transforms to classical tomographic data, H.Fayad, JP. Guédon, I. Svalbe, Y. Bizais, N. Normand, SPIE Medical Imaging, San Diego, 16-12 February, 2008.

[5] Interpolation method for the mojette transform, M. Servières, N. Normand and JP. Guédon, SPIE Medical Imaging 2006: Image Processing, San Diego, CA, USA, 2006 vol. 6142.

[6] Direct inversion of mojette projections, I. Svalbe, A. Kingston, JP. Guédon, N. Normand and S. Chandra, ICIP 2013, Sept. 15-18, Melbourne, Australia.

Project aims

Define the aims of the project

1. To re-map real x-ray projection data into a form that most closely mimics discrete (Mojette) projections of data from a digital PxQ pixel grid at discrete projection angles p:q.
2. To compare images reconstructed from Mojette-adapted projection data using Finite Radon Transform, direct back-projections and iterative reconstruction methods.
3. To examine the robustness of the reconstructed images to tailored levels of noise added to real and simulated projection data.

Expected outcomes

Highlight the expected outcomes of the project

1. Graphical evidence of reconstructed image quality (e.g. PSN) for a variety of discrete projection and reconstruction methods for a defined range of noise levels and noise distributions.
2. Evaluation of methods to tune and improve the image reconstruction quality by applying regularisation methods to the inversion filters for direct back-projection approach.

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

Describe how the project will address the goals of one or more of the 6 Themes listed above.

Image reconstruction is a key tool in medical imaging, non-destructive testing in industry and for the encryption and transmission of data on digital networks (where packet loss in data has the same effect as noise on projections).

Capabilities and Degrees Required

List the ideal set of capabilities that a student should have for this project. Feel free to be as specific or as general as you like. These capabilities will be input into the online application form and students who opt for this project will be required to show that they can demonstrate these capabilities.

Strong programming and signal processing skills, good graphic and image visualisation capability. Some exposure to medical imaging physics.