Mantid Imaging: A Graphical Interface for Neutron Imaging and Tomography

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Science and Technology Facilities Council

ISIS Neutron and Muon Source

mantidproject.github.io/mantidimaging

What is Mantid Imaging

Mantid Imaging is an open source, user orientated and intuitive graphical software tool for neutron tomography and time of flight (ToF) data. Mantid Imaging [1,3] provides a dedicated software solution for neutron imaging instruments such as users of at ISIS in the UK, who require pre-processing tools for projection data and a variety of reconstruction methods such as filtered back projection and iterative methods to produce 3D volumes. Although Mantid Imaging focuses development for neutron imaging, we are open to collaborations to enable other forms of imaging within our software.

Mantid Imaging has 6 main windows:

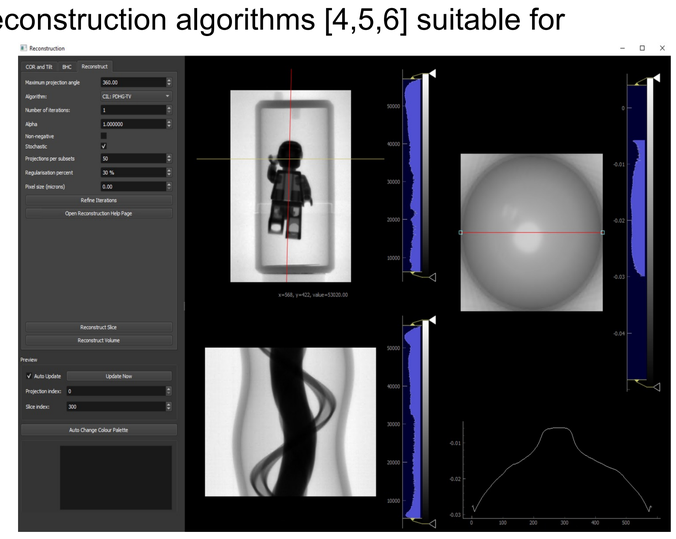
- The Main Window
- The Operations Window
- Compare Image Stacks
- Reconstruction Window
- Spectrum Viewer
- Live Viewer

Mantid Imaging GUI: Main Window

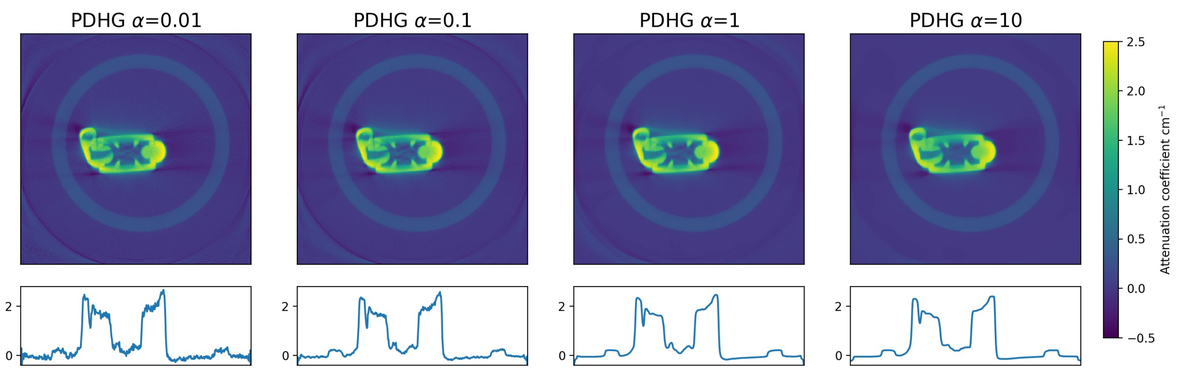
Advanced Reconstruction

Mantid Imaging offers many different reconstruction algorithms [4,5,6] suitable for parallel beam geometry:

- Filtered Back-projection and Simultaneous Iterative Reconstruction Technique (SIRT) from ASTRA toolbox [4].
- Grid Reconstruction (gridrec) from Tomopy [5], to support non-GPU systems.
- Total Variation Primal Dual Hybrid Gradient (TV-PDHG), from CIL [6], provides control of the regularisation parameter to control effect of noise in the source data.



Mantid Imaging GUI: Reconstruction Window

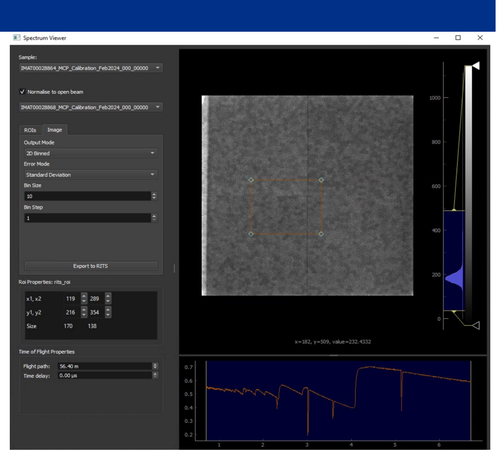


Reconstruction and line profile demonstrating fine control of TV-PDHG with a range of iterations and regularisation (α) values compared

Recent Work and Future Plans

The releases of Mantid Imaging 2.7 and 2.8 have added improvements to the Spectrum Viewer window, including shutter count correction when normalising transmission data, and the introduction of the Live Viewer window. It is now possible to work with ToF data to do normalisation, data selection and binning. We are currently working towards providing tools to perform Bragg-edge fitting [8].

The newly added Live Viewer provides faster feedback to users during an experiment.

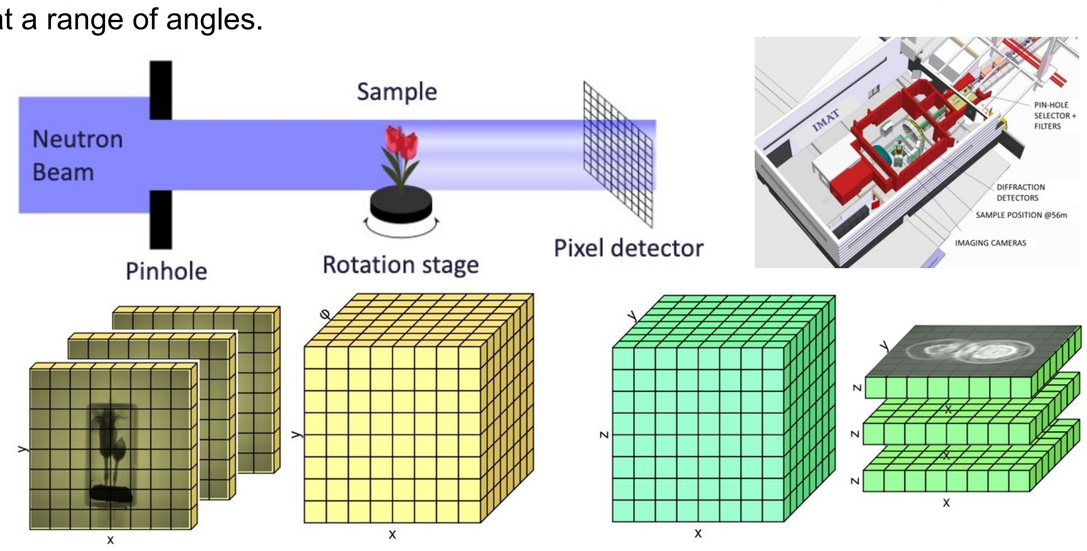


Mantid Imaging GUI: RITS [9] Format Spectrum Export

Neutron Imaging

Neutrons are a powerful probe for imaging internal structures and materials of objects non-destructively.

The attenuation through a sample using neutron imaging not only depends on the sample's density, the neutron scattering and absorption cross-sections, but also on the material properties of the sample such as its crystal structure and texture. Tomography allows for 3D reconstruction of the object from a set of projections taken at a range of angles.

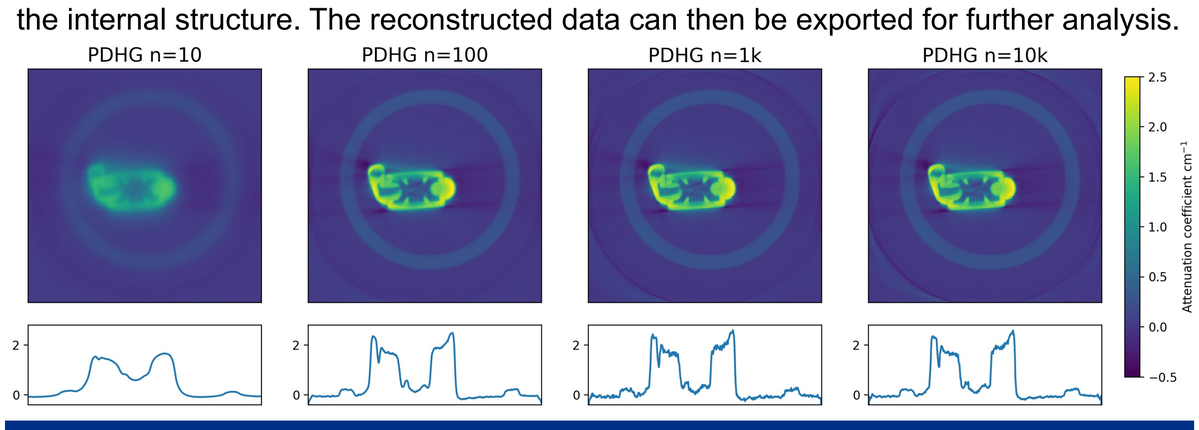


Mantid Imaging: Tomography and Reconstruction Slices

The IMAT instrument at ISIS [2] can record images with a spatial resolution of 50 microns over a 200x200mm area. IMAT also has time of flight capabilities using certain cameras to achieve energy resolved imaging. Samples from industry, earth sciences, palaeontology, cultural heritage, agriculture, and many more are studied on IMAT.

Experimental Workflow

A sample is placed between a pin-hole and a pixelated neutron detector. The detector records the intensity of the beam after being attenuated by the sample. The sample is rotated so that a projection is recorded for each angle. The stack of images can be viewed live during the experiment in Mantid Imaging or loaded in after where pre-processing can be applied, to normalise and remove artefacts. A tomography reconstruction calculates the neutron attenuation at each voxel in the sample revealing the internal structure. The reconstructed data can then be exported for further analysis.



Software Development

Mantid Imaging [1,3] is developed in Python using Qt as the front-end GUI toolkit and is compatible with Windows and Linux. The project is developed within the ISIS Scientific Software Group, licensed under GPL 3+ and is free to use. The project benefits from several open-source libraries such as ASTRA [4], Tomopy [5], Core Imaging Library [6], and Algotom [7], which help Mantid Imaging to provide pre-processing and reconstruction algorithms.

Find out more about The Mantid Imaging Project

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[1] Mantid Imaging https://mantidproject.github.io/mantidimaging, doi:10.5281/zenodo.4728059
[2] T. Minniti, K. Watanabe, G. Burca, D.E. Pooley, W. Kockelmann, Characterization of the new neutron imaging and materials science facility IMAT, NIMA, (2018). doi:10.1016/j.nima.2018.01.037
[3] S Tygier, D Akello-Egwel, J Allen, R Baust, J Bradley, G Burca, A Fedrigo, M Gigg, S Jones, W Kockelmann, D Nixon, D E Pooley and D Tasev, Accepted for Proc. 9th International Topical Meeting on Neutron Radiography, 2023
[4] W. van Aarle et. al, "Fast and Flexible X-ray Tomography Using the ASTRA Toolbox", Optics Express, (2016), doi:10.1364/OE.24.025129
[5] D. Gürsoy, F. De Carlo, X. Xiao, and C. Jacobsen. Tomopy: a framework for the analysis of synchrotron tomographic data. Journal of Synchrotron Radiation, (2014), doi: 10.1107/S1600577514013939
[6] JS. Jørgensen et al. Core Imaging Library Part I: a versatile python framework for tomographic imaging. Phil. Trans. R. Soc. (2021). doi:10.1098/rsta.2020.0192
[7] NT. Vo, RC. Atwood, M. Drakopoulos, and T. Connolley. Data processing methods and data acquisition for samples larger than the field of view in parallel-beam tomography. Opt. Express, (2021). doi:10.1364/OE.418448
[8] R. S. Ramadhan et. al. Characterization and application of Bragg-edge transmission imaging for strain measurement and crystallographic analysis on the IMAT beamline, J. Appl. Cryst. (2019) doi:10.1107/S1600576719001730
[9] Hirotaka Sato https://mlfinfo.jp/bl22/en/GUI-RITS.html