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AXITOM: A Python package for reconstruction of axisymmetric tomograms acquired by a conical beam

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Software

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Summary

The ability to picture the internals of a body in a non-invasive way is vital for both diagnostics and research in a broad range of fields. Tomography is the imaging of body sections, typically acquired from projections of the body by using a penetrating wave, and then reconstructed by employing a reconstruction algorithm. Some cases allow for simplification of the tomographic problem, one of them being the presence of symmetries within the tomogram. Axi-symmetry reduces the tomographic reconstruction to the inversion of the Abel transform, which can be obtained from a single projection, having a fractional acquisition cost compared to typical datasets. In home-laboratory X-ray setups, X-rays are distributed in space as a conical beam rather than parallel rays, which has to be accounted for in the reconstruction of the tomogram.

`AXITOM` is a Python package that allows for the reconstruction of axi-symmetric tomograms when the projections have been obtained by a conical beam. Excellent Python packages such as TomoPy (D. Gürsoy, De Carlo, Xiao, & Jacobsen, 2014) and the Astra toolbox (Aarle et al., 2015, 2016; Pelt et al., 2016) are already available for tomographic reconstruction, but are general-purpose and do not exploit axi-symmetries. PyAbel (Hickstein, Yurchak, Das, Shih, & Gibson, 2016) is a Python project for inversion of the Abel transform but is focused on parallel beam geometries.

`AXITOM` contains a collection of high-level functions that can be used to load datasets, perform virtual experiments and perform the tomographic reconstruction. A Feldkamp David Kress algorithm (Feldkamp, Davis, & Kress, 1984) is used to reconstruct the tomograms, with modifications for reduced computational cost. The implementation relies on NumPy (T. E. Oliphant, 2015) and SciPy (Jones, Oliphant, Peterson, & Others, n.d.), as well as numerous packages for visualization and IO.

`AXITOM` was implemented for reconstructing axi-symmetric density fields measured by X-ray absorption radiography. This project is a part of the ongoing research within the SFI CASA research group at NTNU and has been a key component in the pursuit of *in-situ* investigation of cavitation of polymers during deformation.

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References

Aarle, W. van, Palenstijn, W. J., Beenhouwer, J. D., Altantzis, T., Bals, S., Batenburg, K. J., & Sijbers, J. (2015). The astra toolbox: A platform for advanced algorithm development in electron tomography. *Ultramicroscopy*, *157*, 35–47. doi:10.1016/j.ultramic.2015.05.002

Aarle, W. van, Palenstijn, W. J., Cant, J., Janssens, E., Bleichrodt, F., Dabravolski, A., Beenhouwer, J. D., et al. (2016). Fast and flexible x-ray tomography using the astra toolbox. *Opt. Express*, *24*(22), 25129–25147. doi:10.1364/OE.24.025129

Feldkamp, L. A., Davis, L. C., & Kress, J. W. (1984). Practical cone-beam algorithm. *J. Opt. Soc. Am. A*, *1*(6), 612–619. doi:10.1364/JOSAA.1.000612

Gürsoy, D., De Carlo, F., Xiao, X., & Jacobsen, C. (2014). TomoPy: A framework for the analysis of synchrotron tomographic data. *Journal of Synchrotron Radiation*, *21*(5), 1188–1193. doi:10.1107/S1600577514013939

Hickstein, D. D., Yurchak, R., Das, D., Shih, C.-Y., & Gibson, S. T. (2016). PyAbel (v0.7): A Python Package for Abel Transforms. doi:10.5281/ZENODO.47423

Jones, E., Oliphant, T., Peterson, P., & Others. (n.d.). SciPy: Open source scientific tools for Python. Retrieved from http://www.scipy.org/

Oliphant, T. E. (2015). *Guide to NumPy* (2nd ed.). USA: CreateSpace Independent Publishing Platform.

Pelt, D. M., Gürsoy, D., Palenstijn, W. J., Sijbers, J., De Carlo, F., & Batenburg, K. J. (2016). Integration of TomoPy and the ASTRA toolbox for advanced processing and reconstruction of tomographic synchrotron data. *Journal of Synchrotron Radiation*, *23*(3), 842–849. doi:10.1107/S1600577516005658