ESRF | The European Synchrotron

Master student traineeship proposal

Title: Residual classifier learning for X-ray tomography: unraveling noise, artifacts, and true structures.

Abstract:

Before analysing a tomogram acquired at a synchrotron, scientists must correct it for noise, detector ring artefacts, and artefacts introduced by reconstruction due to issues with the centre of rotation and other problems. Generally, these corrections are combined, but noise (stochastic)[1] and ring artefacts (predictable patterns) are different, and merging them can cover important details such as fine cracks and nanopores. This project aims to develop a transparent correction pipeline that separates detector rings from noise. The approach consists of (i) **identifying random noise** by splitting the projection data into separate angles, which will help show a noise field without objects, and (ii) **determining the detector's fingerprint** by comparing scans taken while stationary with those during random motion [2], which will help distinguish the ring pattern from the sample and (iii) *training a classifier,* using the separated signals, we will train a classifier or neural network to label each voxel, indicating whether it contains ring noise or real structure, resulting in a confidence map for each voxel and the corrected volume[3]. **Benefits for the student**: The student will gain hands-on experience with synchrotron tomography and develop skills in tomographic reconstruction, image processing, and machine learning. He will also contribute to a publication and tool development for the beamline user community under the supervision of Clarisse Uwizeye and co-supervisors Claire Seydoux and Benoît Cordonnier at the ESRF in Grenoble.

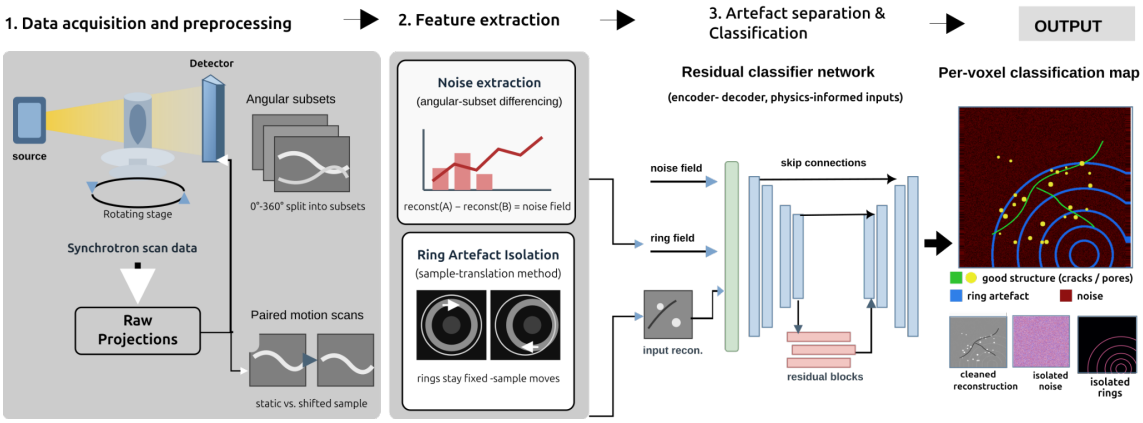

Figure: Physical informed neural network for artefact separation in x-ray tomography

What we are looking for: We are seeking a M2 student in engineering, particularly in image processing, computer science, applied mathematics, or physics. Candidates should have strong Python programming skills. Familiarity with PyTorch, machine learning frameworks, or 3D image analysis is an advantage, prior experience in tomography is not required. We value curiosity about physical imaging and a scientific scepticism toward black-box machine learning predictions. If you are interested send a CV and cover letter to clarisse.uwizeye@esrf.fr

References:

[1] Pelt et al. (2018). Ring artifact reduction in synchrotron x-ray tomography through helical acquisition. *Measurement Science and Technology*, *29*(3), 034002.

[2] Hendriksen, A. A., Pelt, D. M., & Batenburg, K. J. (2020). Noise2inverse: Self-supervised deep convolutional denoising for tomography. *IEEE Transactions on Computational Imaging*, *6*, 1320-1335.

[3] Bhadra, S., Kelkar, V. A., Brooks, F. J., & Anastasio, M. A. (2021). On hallucinations in tomographic image reconstruction. *IEEE transactions on medical imaging*, *40*(11), 3249-3260.

Scientist in charge: **Clarisse Uwizeye**

Beamline(s)/Host Group: **ADA Group**

Traineeship supervisor(s): **Clarisse Uwizeye , Claire Seydoux , Benoit Cordonnier**

Access to Instruments/labs/computing/software: **Experiments will be conducted at BM05 and ID16A, with the ADA group providing the computing cluster and related pipeline.**

Starting date and Duration: **6 months, flexible depend on the master program**

Contact : clarisse.uwizeye@esrf.fr