Deep Learning for Reconstruction and Segmentation of Neutron Tomographic Data

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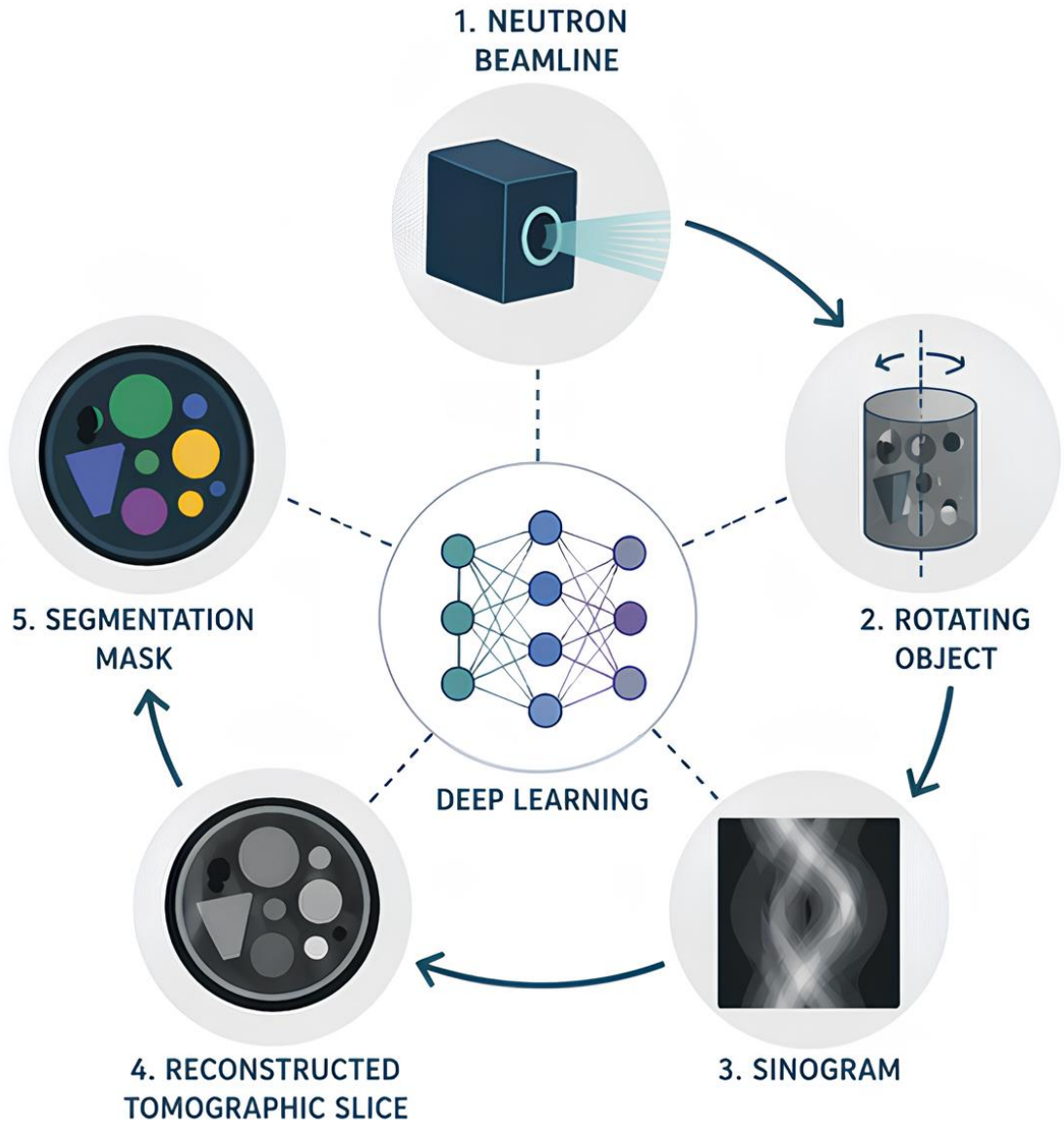

Project overview

Computed tomography is widely used in materials science, geology, archaeology, and related fields. Neutron tomography is especially valuable because it provides contrast that is complementary to X-ray imaging and is well suited for studying porous structures, corrosion products, hydrogen-containing materials, and complex multi-component objects. At the same time, neutron tomography remains technically demanding because experiments are often limited by long acquisition times, incomplete projection data, noise, and the need for efficient post-processing. These limitations motivate the development of new data-processing algorithms based on deep learning.

This project focuses on the application of convolutional neural networks to neutron tomographic data. The student may choose one of two directions:

- **Reconstruction track:** development of CNN-based methods for improving tomographic reconstruction from sparse-view or incomplete projection data.
- **Segmentation track:** development of CNN-based methods for automatic segmentation of neutron tomographic images or reconstructed volumes.

The project is intended for students interested in the intersection of physics, image processing, and artificial intelligence.

Project work

Depending on the chosen track, the student will work on either reconstruction or segmentation of neutron tomographic data. In both cases, the work will include preprocessing of neutron datasets, implementation and training of a selected neural network architecture, quantitative evaluation of results, and preparation of a final presentation or report.

For the reconstruction track, the main goal is to improve tomographic reconstruction quality when only sparse or incomplete projection data are available. This direction is directly motivated by recent work on neutron tomography from incomplete data and by broader developments in deep-learning-based reconstruction methods.

For the segmentation track, the main goal is to identify and separate relevant structures in tomographic images, such as pores, inclusions, cracks, or object boundaries. This direction is relevant to current research on CNN-based segmentation of complex tomographic microstructures, especially in situations where annotated data are limited.

Expected outcome

By the end of the project, the student should obtain a working and reproducible pipeline for either reconstruction or segmentation of neutron tomographic data, together with quantitative evaluation of model performance and visual examples of the results.

Required skills

- Basic Python programming skills
- General understanding of mathematics, data analysis, and image-based data processing
- Ability to work independently with scientific software and computational workflows

Preferred background

- Physics, materials science, computer science, or a related field
- Basic familiarity with image processing, tomography, or machine learning
- Interest in applying neural networks to scientific and experimental data

Recommended literature

1. **Bakirov, B., Kichanov, S.E., Kozlenko, D.P.** *Convolutional neural networks for reconstruction of neutron tomography from incomplete data*. Nuclear Instruments and Methods in Physics Research A, 2025.
2. **Daugherty, M.C., et al.** *Assessment of Dose-Reduction Strategies in Wavelength-Selective Neutron Tomography.* SN Computer Science, 2023.
3. **Tsamos, A., et al.** *Synthetic Data Generation for Automatic Segmentation of X-ray Computed Tomography Reconstructions of Complex Microstructures.* Journal of Imaging, 2023.

Number of project participants: up to 6

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