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Master student traineeship proposal

Title: *Joint non-rigid motion estimation and correction in transmission tomography.*

Context. With fourth generation synchrotron X-ray source, scientist push always further the limits of the experimental acquisition conditions: higher temperature, higher dose, mechanical constraints, higher resolution… Under such hard conditions, the investigated sample may suffer non-rigid deformation, while the (standard) tomographic reconstruction procedure expects a perfectly still object.

In the medical field, procedure exist to compensate for the patient respiratory motion during the scan time. And in recent advances, pure data-driven methods allow joint estimation and correction [1,2]. The aim of the project is to implement these methods and evaluate them on some pathological experimental datasets acquired on ESRF beamlines.

Problem. The joint estimation and compensation of motion in CT is a severely ill-posed, high-dimensional joint estimation problem: the number of unknowns (one DVF per projection/time-point, defined over the whole volume) vastly exceeds the information content of each 2D projection.

Objective. Develop and validate an alternating optimization scheme that iterates between (i) estimating a deformation vector field (DVF) from projection data given a current reconstruction, and (ii) updating the motion-compensated reconstruction given the current DVF estimate, until convergence.

The candidate will build upon a pre-existing implementation of the motion-corrected algorithm. He will focus on the estimation of the motion and the optimization algorithm to solve the joint problem.

Evaluation. The method will be first evaluated/validated on synthetic (analytic and Monte-Carlo) data and extended to experimental data from the BM05 beamline (e.g. batteries under thermal stress).

Deliverables. Prototype pipeline in Python (ideally integrated in the facility's tomographic software Nabu), quantitative evaluation on simulated (analytic and Monte-Carlo) and real experimental datasets, comparison against static reconstructions.

Skills involved. Inverse problems, non-rigid registration, iterative CT reconstruction, spline-based parametric modeling, numerical optimization.

References:

[1] Huang Y et al., *Phys Med Biol*. 2024. doi:10.1088/1361-6560/ad1546
[2] McClelland JR et al..,*Phys Med Biol*. 2017 doi:10.1088/1361-6560/aa6070

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Scientist in charge: Jérôme Lesaint (ADA)

Beamline(s)/Host Group: ADA and BM05

Traineeship supervisor(s): Jérôme Lesaint (ADA, Elodie Boller (BM05)

Access to Instruments/labs/computing/software: mainly access to compute resources and ESRF software ecosystem. Possible commissioning beamtime (BM05) if time and progress permit.

Starting date and Duration: Can start immediately. 6 months duration.

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