DRAMATIC: Developing Reconstruction Algorithms for Miniature-Area Timepix Imaging of Cancer

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Research Centre or Department: Department of Engineering and Mathematics

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Project summary

In gamma-ray imaging, a patient ingests a radioactive material, which is preferentially absorbed by cancerous cells. High-resolution imaging of the emitted gamma rays allows accurate spatial mapping of cancerous tumours, improving tumour diagnosis, characterisation, and management. Through so-called 'digital collimation', Compton cameras provide a way to ascertain the distribution of a radioactive isotope within patients in a way that permits a lower absorbed dose to the patient compared with traditional methods.

The Timepix3 pixelated detector technology can, in principle, be used as a miniature, portable single-layer Compton camera, measuring the energy and trajectory of a recoiling electron originating from the Compton scattering of a gamma-ray emitted from a patient. The resolution of an image of a patient is limited by uncertainties in the reconstructed directions of the electrons, which deviate significantly from a linear trajectory due to scattering processes. This project will test a Timepix3 detector and model its behaviour using radiation transport simulations. Using these simulations as training data, state-of-the-art Machine Learning (ML) methods for regression will be applied to optimising the data analysis for image reconstruction. These include Support Vector Machines, Artificial Neural Networks, Long Short-Term Memory Networks, and Random Forests for Surrogate modelling.

This is a standalone study that could feed into a larger project where a more comprehensive Timepix3 imaging system is constructed. An opportunity for this is via the upcoming NuSec-NNSA collaboration grants round. An intern will be provided with simulated data sets and use these to explore existing Python and Matlab ML methods for regression and image reconstruction. They will also conduct experimental tests in the SHU physics laboratory using our gamma- and beta-emitting sources to benchmark any analysis methods that are developed. An intern will gain valuable experience in applications of Machine Learning techniques and laboratory work, including assisting with writing risk assessments.

Specific skills and experience required for this project

Please also refer to the advert on our jobs pages for the person specification for these internships

The intern should be confident with computer programming in at least one language and have a willingness to learn Matlab or Python if/when required. They should have some experience in data manipulation and analysis.

Knowledge and experience in applying Machine Learning methodologies to data analysis would be advantageous, as would some experience in a physics or engineering laboratory setting.

Knowledge and understanding of the interactions of radiation (x-rays/gamma-rays and electrons) in materials would be advantageous but could be self-taught by somebody with a physics/engineering background during the internship.

Project location

City Campus

Home working may be available

Project delivery

This project should run full time over the first 6 weeks from the May/June 2024 start date, as the lead supervisor may be needed to conduct experiments overseas during parts of late July and August.