



Improving Material Identification Capabilities in Neutron Tomography via Machine Learning

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Abstract:

Neutron tomography is a powerful non-destructive technique that is used to infer the internal material structure using exiting neutron radiations such as many radiographic projections taken from different angles. This technique is uniquely able to accurately distinguish materials containing elements with lighter atomic nuclei, such as hydrogenous materials, even if they are shielded by materials with heavier nuclei, such as lead. With the assistance of advanced computational simulation technology and the continual growth of artificial intelligence, there can be significant development to this image reconstruction technique.

The objective of this project is to first use Monte Carlo simulations (e.g. MCNP) to develop a realistic neutron radiography imaging platform for a target object, where significant amounts of measurement data are collected for multiple trials that vary with material composition. The second step is to develop an artificial neural network capable of identifying the material makeup of an unknown object based on its imaging information, in which the training, validating and testing data are collected from the MCNP results. The developments of this project carry potential for applications of nuclear safeguards and security, automotive and aerospace component analysis, and medical imaging.

To date, a generalized MCNP model for collecting the necessary radiation data has been finalized, simulating a collimated beam of neutrons directed at a disk of homogeneous material makeup with neutron image radiograph tallies (detectors) surrounding it. One specific simulation case was completed and validated through comparison with a reference model. The results agree well with those from the reference study within a relative error within 0.2%. Furthermore, a materials library encompassing a broad range of applications and elemental nuclear sizes has been curated and is ready for large-scale data collection.