Data-Driven Material Identification in Neutron Tomography Using Machine Learning

ETI–Consortium for Enabling Technologies and Innovation 2.0
Christopher Cogliano (Student) and Zeyun Wu (Faculty Advisor); coglianoc@vcu.edu
Department of Mechanical and Nuclear Engineering, Virginia Commonwealth University, Richmond VA 23284-3015

E8

Introduction

Neutron tomography (NT) is a powerful non-destructive technique used to infer the internal material structure of a target object, especially if it contains elements with lighter nuclei [1]. With advances in computational simulation tools and the rapid development of artificial intelligence, significant new opportunities exist to further enhance NT material identification techniques [1].

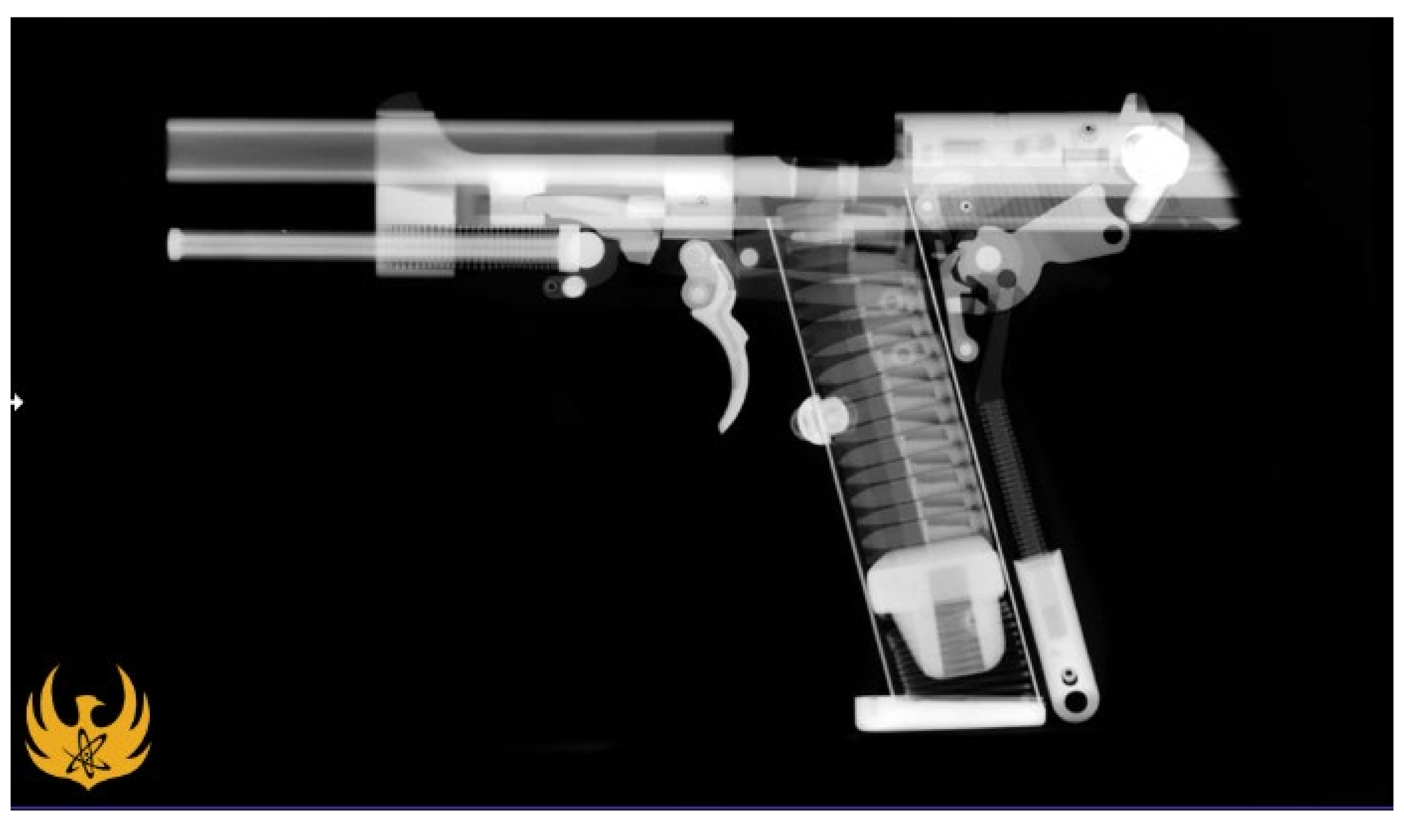

Figure 1. Neutron image of a Beretta 92FS firearm [2].

Objective:

We aim to use Monte Carlo code to simulate a realistic neutron radiography (NR) model of an unknown object and then use machine learning – specifically artificial neural networks (ANN) - to identify material composition. This will help improve detection of hidden or shielded materials and benefit the mission of nuclear safeguards and security.

Methods

Our approach:

- Use Monte Carlo N-Particle Transport (MCNP) code to simulate neutron transmission through different materials
- Collect simulation data from a variety of materials and organize it into a data library
- Use the data library to train and validate the ANN model so it learns how neutron feedback corresponds to different materials and locations
- Assess the ANN's material identification abilities

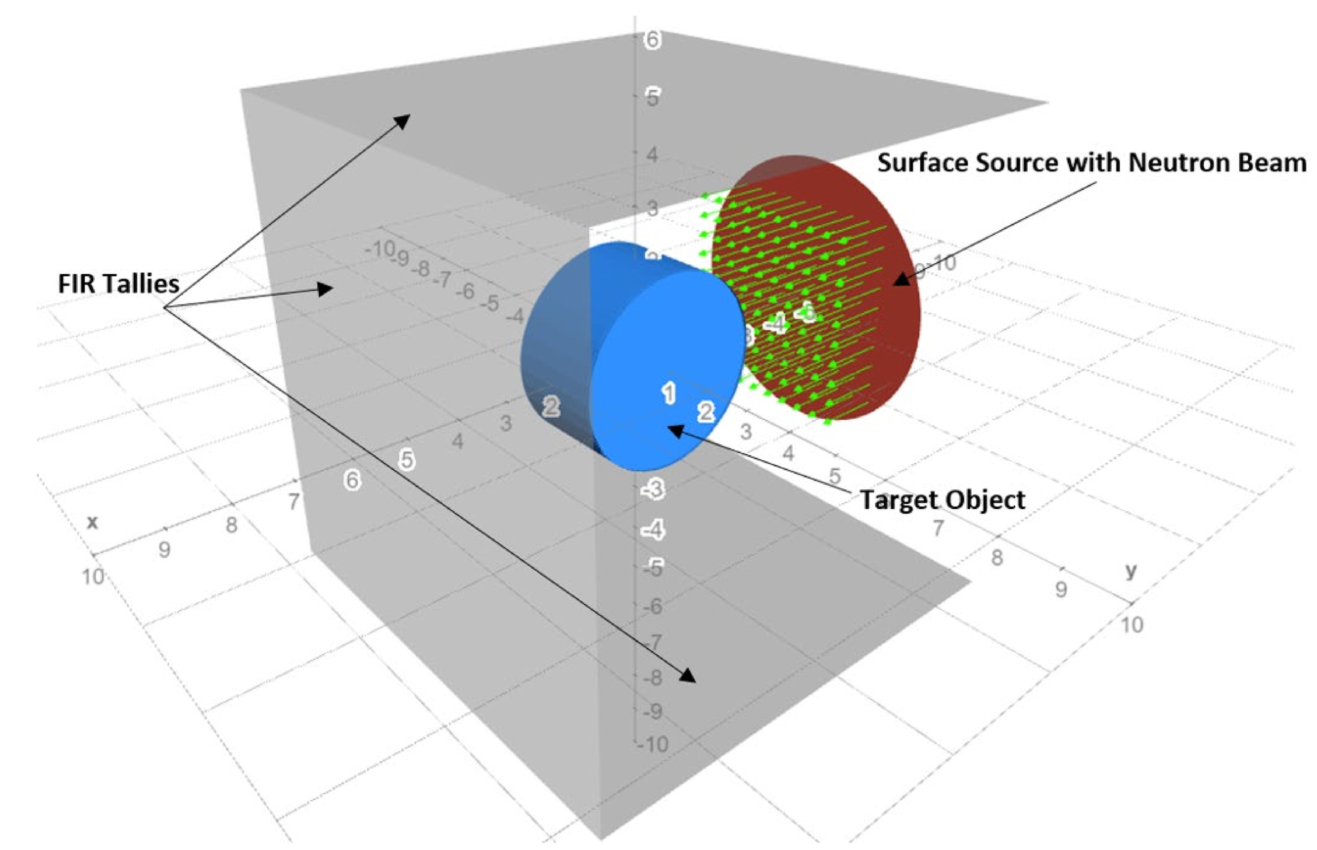

Figure 2. MCNP configuration with Flux Image Radiograph (FIR) detector tallies simulating NR.

Results

Anticipated deliverables:

- A trained ANN that accurately identifies materials from neutron transmission data
- An extensive simulation based data library
- Performance evaluations of ANN
- A full technical report summarizing findings and recommendations

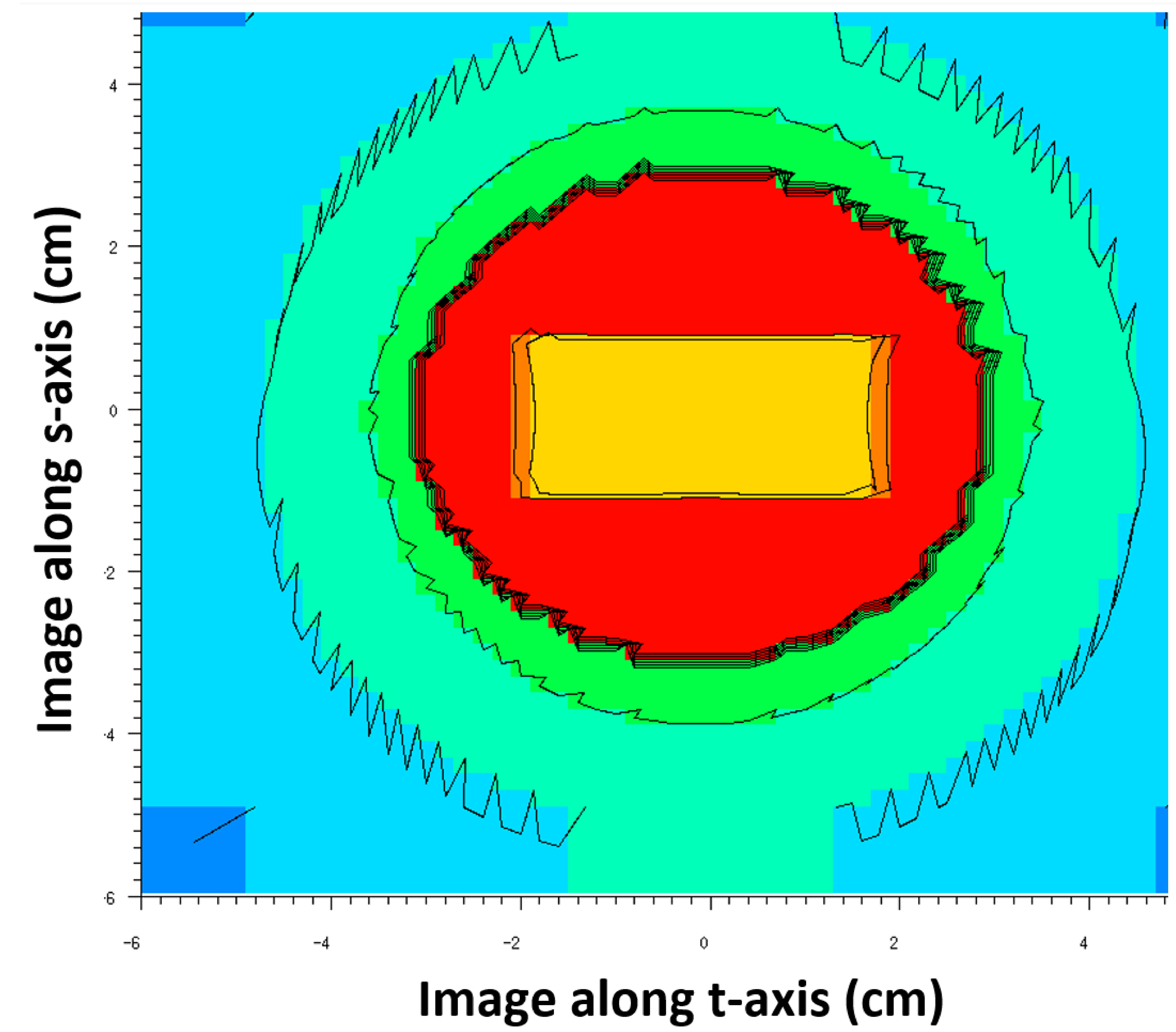

Figure 3. 2D image of light water cylinder produced by neutron FIR tally in MCNP.

Discussions and Relevance

Thus, this research would support the Office of Defense Nuclear Nonproliferation mission by:

- Improving methods for detecting and monitoring nuclear materials
- Enabling faster and more reliable inspections
- Developing of advanced technologies for nonproliferation and threat reduction

References

[1] J. Yang, C. Zhao, S. Qiao, T. Zhang, and X. Yao, *Deep learning methods for neutron image restoration*, 2023. doi:10.2139/ssrn.4336810

[2] "Neutron Image Gallery," Phoenix Neutron Imaging, https://www.phoenixneutronimaging.com/insights-and-updates/neutron-image-gallery (accessed Mar. 9, 2026).

This material is based upon work supported by the Department of Energy / National Nuclear Security Administration under Award Number(s) DE-NA0004196.

This material has been reviewed and released by the Department of Mechanical and Nuclear Engineering at Virginia Commonwealth University

Peace Through Atomic Strength

Unclassified

U.S. DEPARTMENT of ENERGY

NNSA National Nuclear Security Administration