Optimizing Application-Dependent Energy Group Structures for Multigroup Neutron Transport Models using Machine Learning

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ABSTRACT:

We will develop Generative Adversarial Networks (GANs) to predict optimized application-dependent energy group structures for multigroup neutron transport models. These methods will dramatically reduce both the computational run-time and manual effort needed to find multigroup energy structures that accurately capture the underlying physics of neutron reactions while allowing multigroup simulations to run quickly without overwhelming available memory. Training data for the machine learning models will be generated using multigroup simulations of various application problems, including thermal, fast, and mixed spectrum reactors. Discriminator neural networks will be trained to predict the deviation in key quantities that are introduced by the choice of group structures in a multigroup code. These quantities include k-eigenvalues and condensed few-group neutron spectra, and cross sections. The discriminator networks will be coupled to generator networks in order to predict ideal energy group structures with a single execution of the model. We will use high-fidelity continuous energy Monte Carlo simulations for establishing baselines against which multigroup simulations run using tuned group structures will be validated. The development and deployment of advanced reactors depends critically on the accuracy and performance of modeling and simulation tools. The proposed work directly addresses these critical aspects of simulation through innovations that significantly accelerate reactor simulation and modeling.

In the proposed work, the project team at the Colorado School of Mines and Los Alamos National Laboratory will develop and deliver: Machine learning codes for characterizing nuclear assemblies in terms of their neutronic properties; Machine learning codes for identifying deficiencies, approximations and assumptions in multigroup neutron transport models; Trained neural networks for generating group structures tailored to specific multigroup codes and nuclear applications; Group structures for gas cooled, fast and pressurized water reactors, optimized for applicability over their entire burnup and temperature operational envelopes; Optimized group structures gas cooled, fast and pressurized water reactors under specific burnup, control rod position and temperature states.