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A Programmatic Metamodel-Driven Modeling Paradigm for MCNP

MCNP is a widely used and well validated Monte Carlo radiation transport code applicable for a plethora of reactor physics problems. Despite being a powerful simulation tool, MCNP provides no programmatic interface through which to automate execution, transform models, or support user-defined logic and abstractions. To address this need, we have developed an intuitive yet full-featured MCNP Application Program Interface (API) in Python, named mcnpy. Moreover, to guarantee our reading, writing, and modeling capabilities remain self-consistent (and to render the huge scope of the MCNP API manageable) we have adopted a strategy of model-driven software development described in previous work. As mcnpy is primarily a Python wrapper around a codebase automatically generated through this strategy, this ensures mcnpy too remains remains consistent with our MCNP (meta)model and maintainable. With mcnpy, users can freely read, write, and modify any syntactically valid MCNP input file regardless of its origin. These capabilities allow users to automate complicated tasks like nonlinear optimization and model translation. As examples, this work demonstrates the use of mcnpy to find the critical radius of a plutonium sphere and to translate a 9,000+ line MCNP input file into a corresponding OpenMC model.