AI-based Program for Nuclear Design and Safety Evaluation - TopMC

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To provide intelligent design and analysis in the fields of radiation shielding, material activation, and dose calculation, TopMC (multi-functional program for neutronics calculation, nuclear design and safety evaluation) has been developed. As an updated and extended version of SuperMC, TopMC focus on full-function and high-efficiency neutronics calculation, CAD/image-based accurate modeling for complex irregular geometry, data analysis based on multi-dimensional / multi-style visualization, and especially support intelligent dose calculation and safety evaluation based on Artificial Intelligence (AI). The integrated AI prediction, multi-objective optimization and particle transport model modification modules are included.

The AI prediction module provides various surrogate models based on artificial neural network and mathematical statistics. After training by suitable data, they can replace or couple with the traditional Monte Carlo particle transport programs to perform flux or dose calculations (predictions) in the process of optimization, which accelerate the overall design and optimization work. The multi-objective optimization module automatically sample the different parameters according to the design constraints of the Monte Carlo transport model set up by users through the graphical user interface (GUI). After analyzing the results from AI predictions or transport simulations, this module will provide an optimization scheme for the next batch of models to be calculated, which include geometry dimensions, materials, etc. The particle transport model modification module will locate and modify the parameters in Monte Carlo transport model automatically according to the optimization results without human interference. After verification, a complete new model will be constructed for the next optimization. This modification module can be applied for transport models of different fields according to the parameters ranges specified by users through the GUI. The data managing module will ensure users to perform the whole design and optimization process, and managing their special model and data, which liberate users from coding, manual analysis of simulation results and manual modification of transport models.

The nuclear design and safety evaluation based on AI has been applied in the neutronics analysis for an HCPB DEMO has been accomplished, in which the nuclear performance including neutron wall loading, tritium breeding ratio, nuclear heating and radiation loads was calculated. Results demonstrated its enhanced efficiency in nuclear design and safety evaluation.

Type of contribution:	Poster session	☐
	Oral Contribution	☒