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HYBRID PHYSICS-BASED, DATA-DRIVEN SURROGATE MODELING FOR DIGITAL TWINS

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Physics-based computational models are desired to provide reliable simulations of sensitive, coupled systems in a digital twin setting. However, the high costs of computational models prevent real-time analysis and scalability for evaluating the trade-offs between different system designs. We propose a hybrid approach that improves the accuracy of a physics-based model, and constructs data-driven surrogates of Quantities of Interest (QoI). The physics-based model model is calibrated using Bayesian Inference through sequential model evaluations that are selected through the balance of exploiting accumulated knowledge and exploration of uncertain regions using high-dimensional Bayesian Optimization. The calibrated physics-based model is then used to drive the development of surrogate models over a range of design inputs with quantified uncertainty. Both of the above operations are underpinned by optimal experimental design to improve generalizability of the predictions. The framework is demonstrated on a nuclear reactor application. A Pebble-bed Fluoride-salt-cooled High-temperature reactor (PB-FHR) is modeled using the System Analysis Module (SAM) tool [1]. The core power density distribution indicates the current state of the fission reactions and whether the reactor is maintaining criticality. The core power density distribution is calibrated and a surrogate model is developed with goal of prediction at new operational configurations. The underlying algorithms are benchmarked with the DAKOTA software suite.

REFERENCES

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