The application of machine learning to the development of reduced order models in nuclear thermal hydraulics

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Sponsors: EPSRC Nuclear CDT and Imperial College

The study of thermal hydraulics in a nuclear reactor, in both primary and secondary circuits is vital in the assessment of the performance and safety of any reactor design. The flow of coolant is a challenging problem in which coolant flows through a complex arrangement of channels, ducts, valves and other components and is subject to wall heat transfer where a wide range of boiling regimes could occur, particularly in accident scenarios. Broadly speaking, two approaches to the problem are commonly used in practice: Computational Fluid Dynamics (CFD) and Systems Codes (SC). In simple terms, CFD involves a high fidelity 3D discretisation of the problem and SC is a simplification based on an averaging over the flow cross section resulting in a 1D discretisation. The advantage of the SC model is that whole plant simulations can be done rapidly which helps in design, safety analysis and uncertainty quantification. CFD, even with large computing resources is simply too expensive to model such whole plant systems in reasonable time. Conversely, the SC loses 3D effects (including turbulence), near wall flow detail such as wall friction and heat transfer, all of which are very important features of the flow. The SC incorporates such effects by the use of friction coefficients, simple correlations, flow-regime maps and the like. These correlations are, in principle, obtained from experiments and/or detailed CFD but are prone to inaccuracy. The objective of this project is to investigate more rigorous and reliable means by which reduced order models (ROMs) may be obtained that combine the efficiency of SC with the accuracy of CFD. The approach here is to use recent developments in machine learning and artificial intelligence.