Machine Learning Techniques for Sequential Learning Engineering Optimisation

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When designing a fusion reactor, many first-of-a-kind components are required. This presents a large potential design space across as many dimensions as the component's parameters. In addition, multiphysics, multiscale, high-fidelity simulations are required to reliably capture a component's performance under given boundary conditions. Even with HPC resources, it is not possible to fully explore a component's design space. Thus, effective extrapolation between data points via machine learning techniques (ML) is essential.

With sequential learning engineering optimisation, ML techniques inform the selection of simulation parameters which give the highest Expected Improvement (EI) for the model: balancing exploitation of the current best design with exploration of uncertain areas in the design space. Different ML techniques have different advantages. For example, Neural Networks (NN) excel at capturing non-linear patterns in the design space, while Gaussian Processors (GP) have reliable uncertainty quantification and thus reliable EI calculations.

In this talk, the application of a ML-driven Design of Experiment (DoE) procedure for the sequential learning engineering optimisation of a fusion component will be discussed. A parameterised fusion component is taken as a typical example of a component requiring HPC simulation to model. The component’s design is optimised using a number of ML techniques, with each technique then evaluated in its performance at minimising the number of function evaluations (i.e. HPC simulations) to achieve the optimal design.