MULTI-FIDELITY DIMENSION-ADAPTIVE POLYNOMIAL CHAOS EXPANSION FOR PLASMA MICRO-INSTABILITY ANALYSIS

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Forward uncertainty quantification of predictive simulations provides insightful information about the properties of a system. But accurate prediction of uncertainty poses multiple challenges due to large number of stochastic parameters and high computational cost of the simulation. In real world applications, we often have computationally cheap but relatively inaccurate low-fidelity models in addition to accurate high-fidelity models. We propose an efficient algorithm to build multi-fidelity polynomial chaos expansion by combining the high-fidelity and the low-fidelity models. We combine the different fidelities by introducing a correction term in between different fidelities [1]. We use sparse grid combination technique [2] along with adaptivity [3, 4] to efficiently select the evaluation points. This not only decreases the number of simulations but also counters the curse of dimensionality. In this work, we show considerable saving of computational resources as compared to the single fidelity adaptive algorithm.

The real-world application case considered is the simulation of the microturbulance in magnetized fusion plasma. The behaviour of plasma depends upon various parameters making it crucial to study the effect of input parameter uncertainty. In this work, we employ GENE [5] to solve linear gyrokinetic eigenvalue problems to evaluate the growth rate for the dominant mode. For a low-fidelity model, we built a gaussian process surrogate. Then, we combined both models using our proposed algorithm to perform forward uncertainty quantification. The polynomial chaos expansion provided us the statistical moments of the output and the sensitivity index of each parameter. This information is highly useful to the plasma physics community for constructing reduced order models.

References

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