A hierarchical projection based-reduced order model applied to neutron transport

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1 Abstract

Reduced order modelling (ROM) is a method of approximating a discretised model (the high fidelity model) by a model with fewer degrees of freedom (reduced model) than the original one. Such reduced models have been proven to reduce the computational cost by several orders of magnitude in the field of nuclear modelling [1, 2]. A typical ROM framework consists of two stages: a computationally expensive offline stage and a rapid online stage. In the offline stage, many solutions of the high fidelity model are computed. The information in these so-called snapshots is compressed often by using Singular Value Decomposition (SVD), however autoencoders [3] are an alternative.

The resulting basis functions can either be used to project the discretised governing equations onto the reduced space, (projection-based ROM [4]) or they can be used to project the snapshots onto the reduced space, and these variables can train a neural network to approximate the discretised governing equations (a non-intrusive ROM). In the online stage, the reduced order model is solved for previously unseen parameter values. Within the nuclear field these reduced order models have typically been applied to the whole system. However, due to the complexity of reactors and the need for a high resolution in certain dimensions, the amount of data required to describe the system is extremely large which makes constructing a reduced order model intractable. Instead, one method of reducing the amount of data is to split the spatial domain into a number of sub-domains. A reduced order model is then created for each subdomain and the resulting models can then be combined to solve for the whole system. One such example of this is the so-called reduced-basis element method [5]. The offline stage for this process will typically be less time consuming because the ROMs for each sub-domain can be trained simultaneously.

This poster demonstrates the effectiveness of the hierarchical reduced order modelling approach for a problem of interest to nuclear engineers.

2 Pen Profile

During an MEng in Mechanical Engineering at the University of Nottingham Toby developed a strong interest in energy production. Subsequently, this led to him joining Imperial College's ESPRC Centre for Doctoral Training in Nuclear Energy where he completed an MRes and is now studying for a PhD. Within Imperial, he is a member of the Applied Modelling and Computation Group where his work focuses on reduced order modelling and machine learning applied to nuclear engineering under the supervision of Professor Christopher Pain, Dr Claire Heaney and Professor Paul Smith.

References

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