The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5-9 June 2022, Oslo, Norway

Model Order Reduction for Large-Scale Coupled Problems with Application to Thermo-Mechanical Reliability Analysis

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Keywords: *Model Order Reduction, Coupled Systems, Thermo-Mechanical Systems*

Many modern engineering systems are highly complex and composed of interconnected modules. Involved design processes frequently simulate such systems with computational models. With growing model complexity, reduction techniques are required to obtain acceptable simulation times.

A model reduction technique that is suitable for the reduction of large-scale computational models is moment matching [1], though choosing expansion points to obtain accurate reduced models is non-trivial. An expansion point selection algorithm based on $\mathcal{H}_2$ optimality criteria, Iterative Rational Krylov Algorithm (IRKA), was introduced in [3], and in extension Near-Optimal Frequency-Weighted Interpolation (NOWI) [2] for controller reduction.

With these methods in mind, this work proposes a further extension of the optimal moment matching framework to general interconnected systems. The proposed methodology allows designers of complex systems to reduce computational models while preserving interconnection structures. The method and its advantages are illustrated on a comprehensive numerical engineering example: analyzing the thermo-mechanical reliability of a Printed Circuit Board (PCB). It is shown that preserving the interconnection structure allows re-use of the reduced model for local changes (such as updates to material properties of individual packages), while the reduced model is sufficiently accurate for reliability analysis.

Acknowledgement. This work has been funded in part by ITEA under the COMPAS project (ITEA project 19037).

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