Getting State-Space Models From FEM Simulations

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Abstract

Finite element based modeling is one of the most powerful computational tools currently available. Amongst others a possible drawback could be the computation duration time, that can be expected at transient nonlinear problems, or at more simple problems with a large time span. One of the possible solutions is trying simplify the FEM model into a lower order system without losing its characteristic behavior. In this paper we study the possibilities of state-space models as candidate lower order systems of FEM models using three different approaches: (1) Using the state-space model export function of COMSOL Multiphysics® itself; (2) Using a system identification tool to retrieve a black box state-space model; (3) using inverse modeling to get a grey box state-space model.
Our methodology was to start with a simple benchmark in COMSOL Multiphysics®, compare the three above mentioned approaches and proceed by adding more complexity into the next benchmark. Thus obtaining results for different benchmarks
We conclude that all three approaches are capable of reducing the system order and are able to reduce computation duration time. Comparing the three approaches from a physical point of view, the grey-box model is preferable because its parameters (state-space matrices) have a physical meaning and therefore parameters studies can be done without the necessity to simulate the FEM model over and over again. Finally, the reader should notice that no general conclusions can be obtained from this rather limited study.

Schijndel, A.W.M. van & Kramer, R.P. (2013). The benefits of FEM-SS-BES (Finite Element Method, State-Space, Building Energy Simulation) modeling exchange for building physics. Proceedings of the 2nd central European conference on building physics, 9-11 September 2013, Vienna, Austria. (pp. 253-260). Vienna: Vienna University of Technology.

Figures used in the abstract

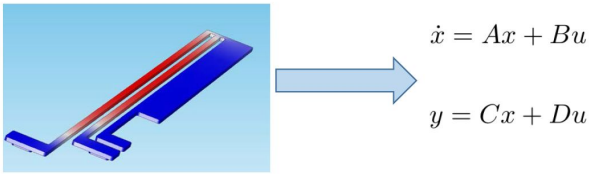

Figure 1: The approach of getting State-Space models from FEM Simulations