Modern Model Order Reduction (MOR) for ANSYS

Model reduction is not new for engineers and the mode superposition method and Guyan reduction method have enjoyed widespread use for long time.

Yet, in parallel a topic of model reduction has been actively researched by mathematicians. They see model reduction as a formal theory of approximating large-scale dynamic systems [1] and this makes all the difference.

Fig. 1.
Model reduction is an efficient means to enable system-level simulation.

MOR for ANSYS is open-source software developed at IMTEK to employ modern model reduction directly for ANSYS models. It reads binary ANSYS FULL and EMAT files in order to extract the system matrices and then runs a model reduction algorithm. MOR for ANSYS uses implicit moment matching based on the block Arnoldi algorithm, as it is the most efficient computational method. Time to perform model reduction in this case is comparable with that for a static solution provided there is a plenty of memory. In our experience, 4 Gb of RAM is enough to treat many finite element models up to 500 000 degrees of freedom.

The dimension of a reduced model depends on a particular problem and required accuracy. In our practice, 10 to 100 generalized variables are enough for most applications. The reduced model is written as small matrices and one can use any simulator to work with it.

Implicit moment matching is applicable to linear dynamic system with both symmetric and unsymmetric matrices. During our research we have identified different scenarios for different physical domains when it can be successfully used in practice. In the Eurosime short course (see link in More Information), one can find results for

• Electro-thermal MEMS,
• Structural mechanics,
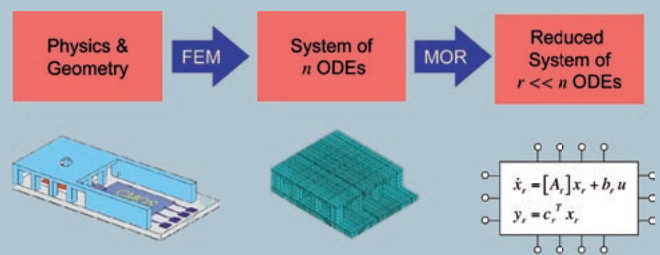• Piezoelectric actuators for control,

• Pre-stressed small-signal analysis for RF-MEMS,
• Thermomechanical models,
• Acoustics including fluid-structure interactions.

More details are in the research papers available at the MOR for ANSYS site.

Finally, we would like to direct your attention to new results on parametric model reduction. It happens that one can formally preserve several parameters within system matrices in the symbolic form during a modified model reduction procedure. This feature has not been implemented in MOR for ANSYS yet but the research phase has almost been completed.
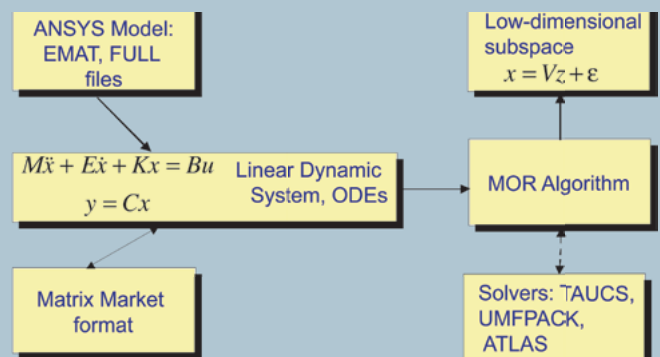

Fig. 2.
MOR for ANSYS structure.

Authors
Evgenii B. Rudnyi, Jan G. Korvink,
Lab of Simulation, Department of Microsystem Engineering,
University of Freiburg – IMTEK,
rudnyi@imtek.uni-freiburg.de, korvink@imtek.uni-freiburg.de

References
[1] Athanasios C. Antoulas, Approximation of Large-Scale Dynamical Systems.
Society for Industrial and Applied Mathematic, 2005, ISBN: 0898715296. Book at SIAM http://www.ec-securehost.com/SIAM/DC06.html

Further information

• **MOR for ANSYS site:**
  www.imtek.uni-freiburg.de/simulation/mor4ansys/

• **Eurosime course:**
  www.imtek.uni-freiburg.de/simulation/mor4ansys/morEurosime/

• **Introduction to Model Reduction:**
  http://ModelReduction.com

Software