COMSOL Multiphysics® Automated Installation Verification via LiveLink™ *for* MATLAB®

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Introduction: Verifying that a local software installation performs as the developer intended is a potentially time consuming but necessary step for safety related codes. Automating this process not only saves time, but can increase reliability and scope of verification compared to 'hand' comparisons. While COMSOL does not include automatic installation verification as many commercial codes do, it does provide tools such as LiveLink™ *for* MATLAB® and the COMSOL API for use with Java® through which the user can automate the process.

Computational Methods: Using models with included solutions from the model database, we re-solve the models locally and compare the relative differences over the full model domain for all dependent or 'solution' variables:

$$d_r^{u_i} = \max\left(\frac{\left|\bar{u}_i^{local} - \bar{u}_i^{included}\right|}{\max\left(\left|\bar{u}_i^{included}\right|\right)}\right), \quad d_r^m = \max_i\left(d_r^{u_i}\right),$$

where $u_i/\bar{u}_i$ is the ith dependent variable/vector over all nodes and cases. If the model maximum relative difference, d_r^m, is sufficiently small, the local COMSOL installation is considered verified for the physics involved in the model.

	Task	Automation Level
1	Identify models with included results	Full
2	Identify physics exercised by said models	Full
3	Select relevant physics	None
4	Down-select models with relevant physics	Partial
5	Rerun selected models locally	Full
6	Compare included and local results	Full

Table 1. Verification process tasks and level of automation via LiveLink™ *for* MATLAB®.

Verification Example: Local COMSOL 5.0 installation for ORNL High Flux Isotope Reactor safety calculations:

Physics:	Fluid Flow				Heat Transfer				Mathematics				Struct. Mech.	
Models:	Fluid-Structure Interaction	Turbulent Flow, SST	Turbulent Flow, k-ε	Turbulent Flow, k-ω	Heat Transfer	Heat Transfer in Fluids	Heat Transfer in Solids	Heat Transfer in Thin Shells	Boundary ODEs and DAEs	Curvilinear Coordinates	Deformed Geometry	Global ODEs and DAEs	Shell	Solid Mechanics
oscillating fsi	X													
naca0012 airfoil		X												
ahmed body			X											
displacement ventilation				X		X								
heat sink surface radiation					X									
disk stack heat sink							X	X						
cohesive zone debonding									X					X
arterial wall mechanics										X				X
electrochemical polishing											X			
diffuse double layer												X		
bracket shell													X	X

Table 2. Desired physics and selected models

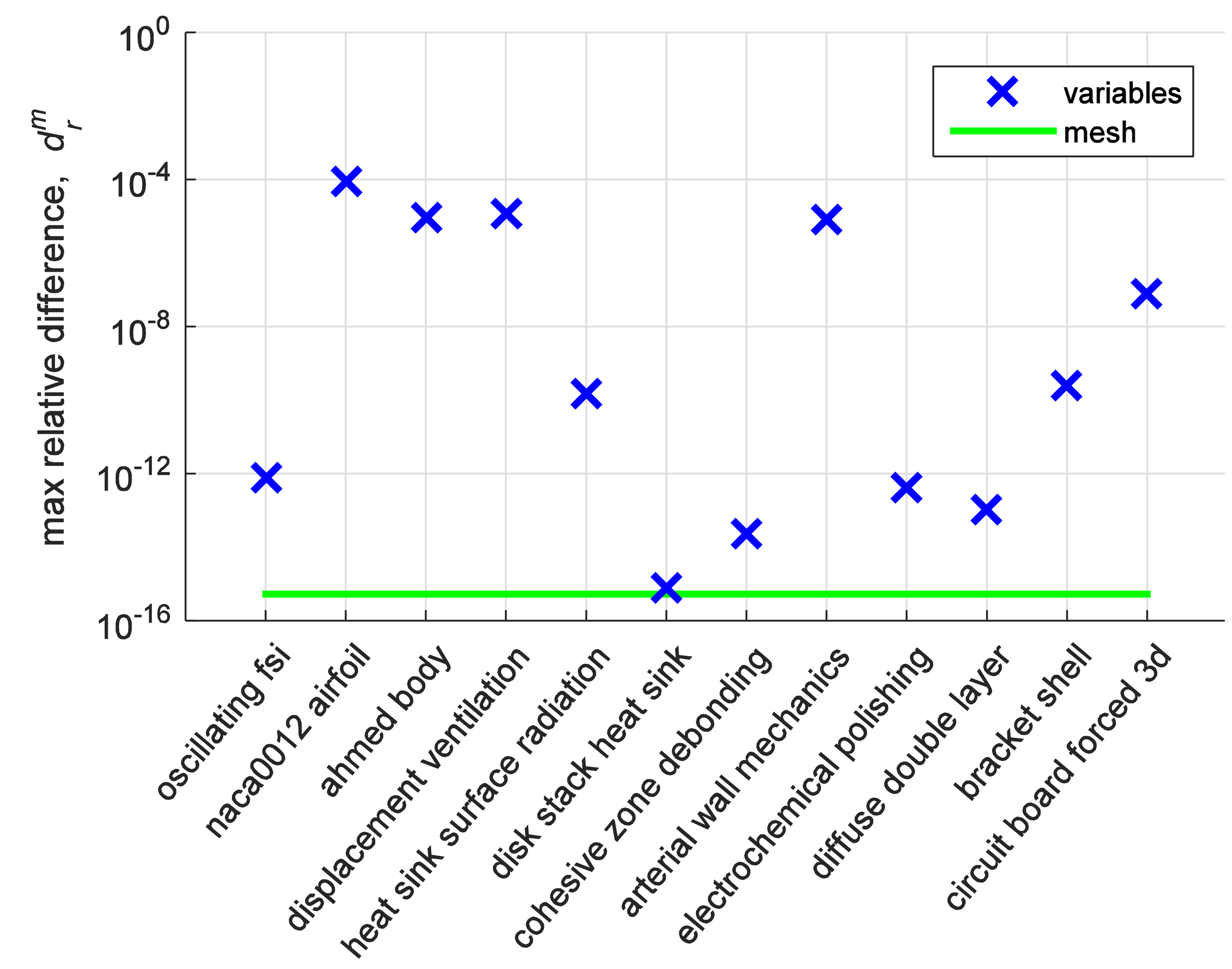

Figure 1. Relative differences for selected models

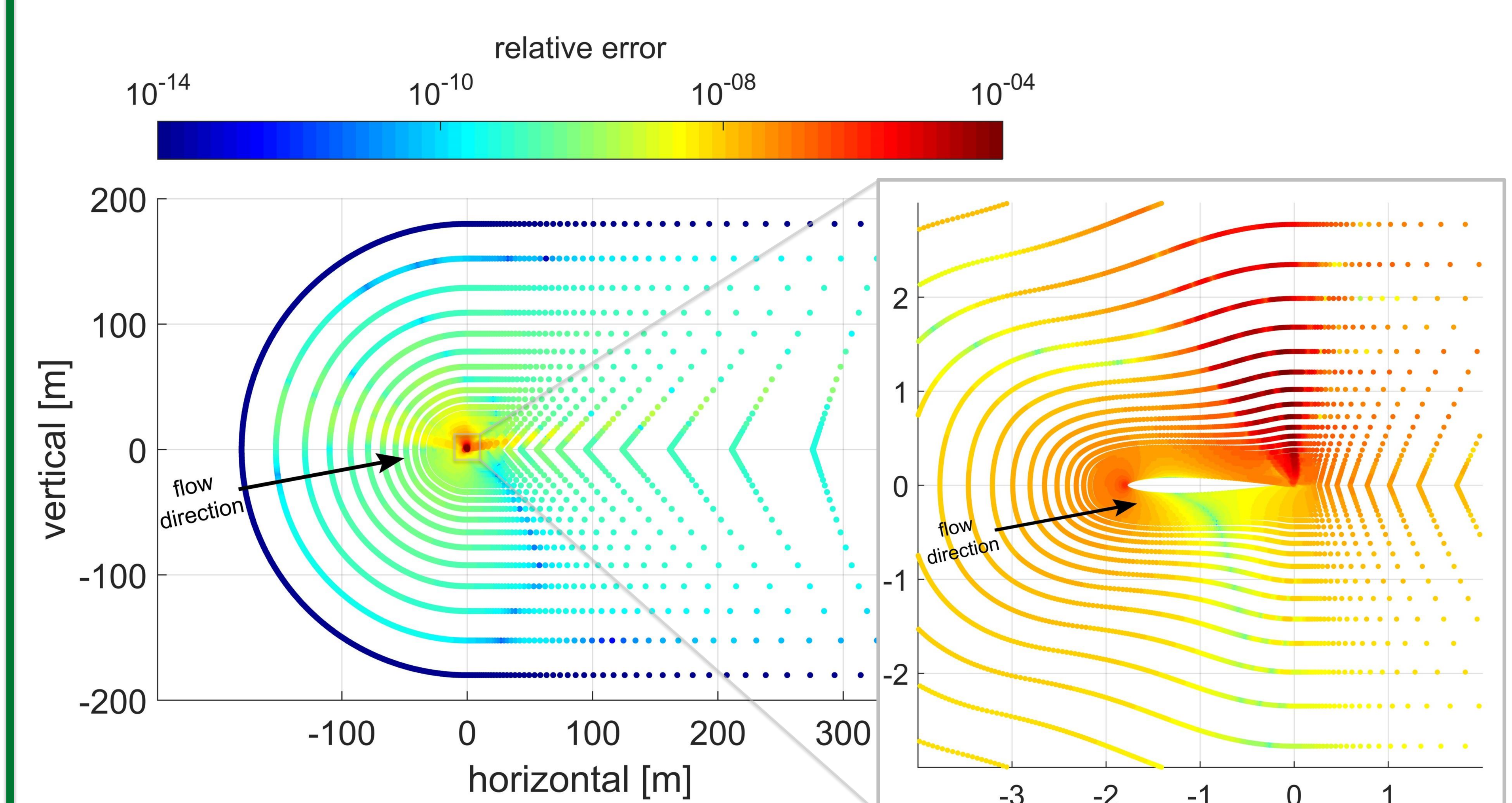

Figure 2. Worst case: vertical flow velocity relative differences for naca0012 airfoil model

Results: With a solver relative tolerance setting of 10^{-3} (default), all models had maximum relative errors $<10^{-4}$, which is acceptable. The models with the most relative error also had the high degrees of nonlinearity, while models with little to no nonlinearity had relative errors approaching 10^{-16}, which is approximately double-precision machine epsilon.

Conclusions: Automated installation verification represents a major improvement over the hand method.

- *All* model outputs are considered.
- Time required for installation verification is essentially limited to model computation time.
- COMSOL updates can be quickly verified on many local computers with minimal staff time.

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