Finite Element Convergence and Speed-Up Studies Using COMSOL Multiphysics and LiveLink™ for MATLAB® with Large Assembly Models

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Introduction: COMSOL Multiphysics along with its LiveLink™ for MATLAB® is used to investigate the needed number of elements and the required order of Lagrangian p element for a number of different simulation models. For this task, convergence study, speed up testing and interactive meshing is performed on large assembly models. These models are imported using the LiveLink™ for SolidWorks. As a test bench, the famous Flyer Model was developed and speed ups for different solvers are studied for the evaluation of the parallel computation performance.

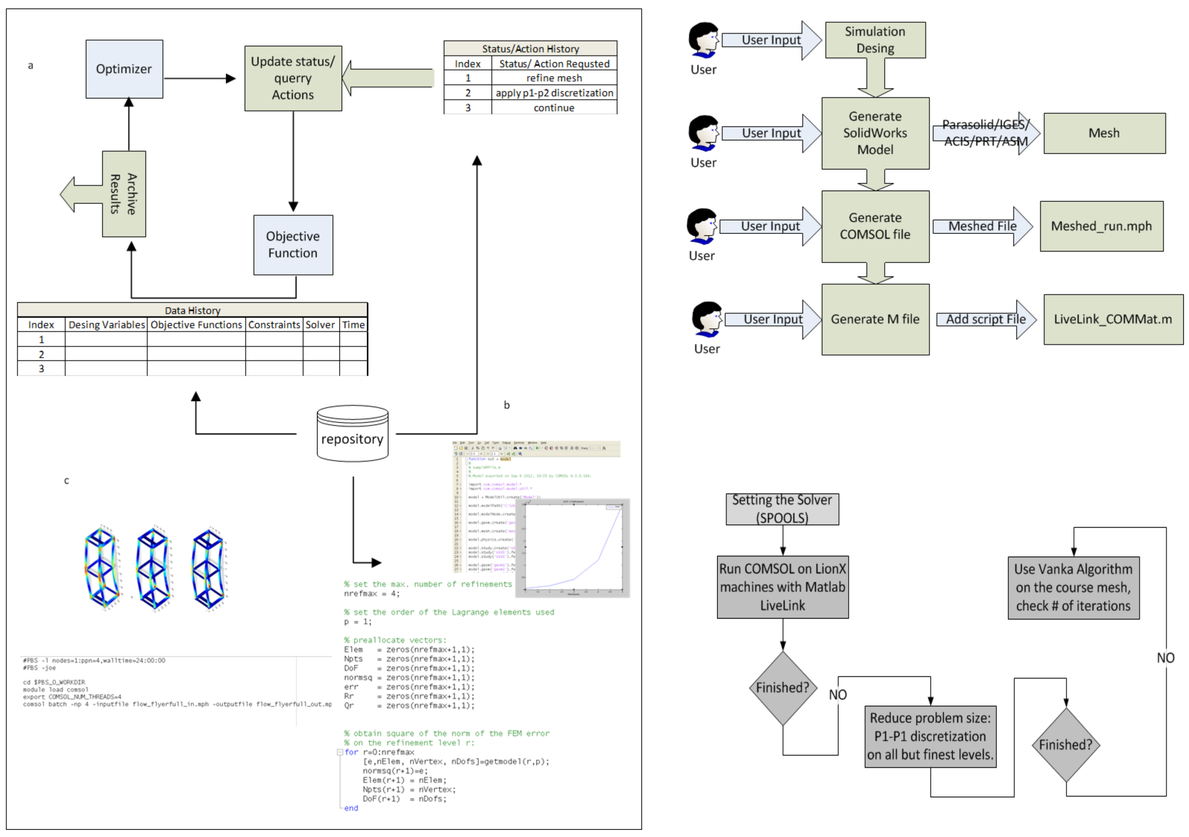


Figure 1. From Left clockwise: Illustration of convergence monitoring and mesh steering; data flow; Process flow diagram for the SPOOLS Solver.

Method:

Repeatedly refine the mesh that was used to compute the FEM solution, re-compute the solution and its error norm and keep the snapshot of one parameter for qualitative evaluation.

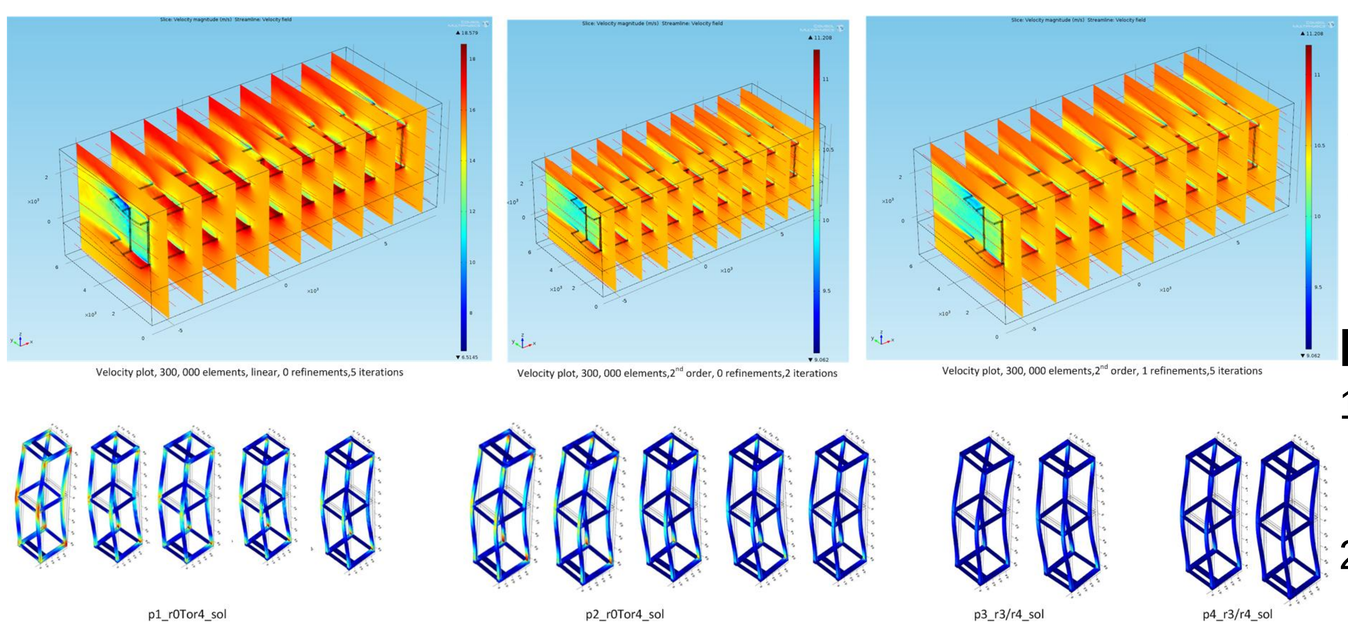


Figure 2. Qualitative convergence studies: element types and refinement-order are changing.

Results: The driver script driver_model.m computed the solution for different models while using the PARDISO linear solver and the SPOOLS solver. P= 1,…,4 and for several meshes each obtained by refining a course initial mesh r (r = 0 to 4) times regularly.

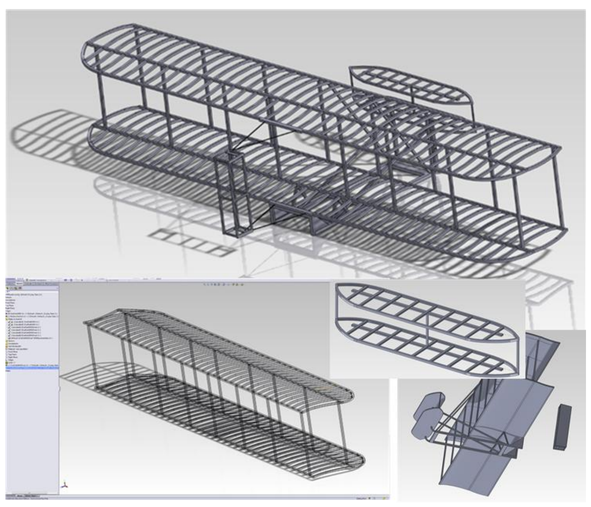


Figure 3. SolidWorks CAD models.

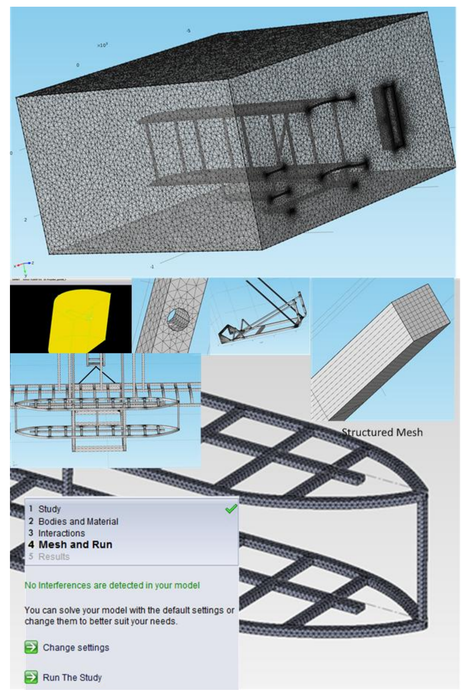
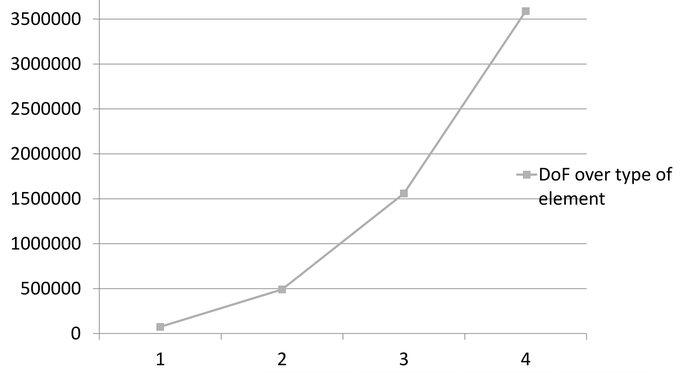


Figure 4. Meshed volumes.

r	N_e	N_v	DoF
0	1128	579	24054
1	3719	1515	69915
2	11052	3625	189150
3	33402	9123	530835
4	103115	24775	1559424

r	N_e	N_v	DoF
0	1128	579	8637
1	3719	1515	24141
2	11052	3625	62883
3	33402	9123	170922
4	103115	24775	491028

r	N_e	N_v	DoF
0	1128	579	1737
1	3719	1515	4545
2	11052	3625	10875
3	33402	9123	27369
4	103115	24775	74325



r	N_e	N_v	DoF
0	1128	579	51372
1	3719	1515	153024
2	11052	3625	422832
3	33402	9123	1207314
4	103115	24775	3588858

Table 1. convergence study.

Conclusions: A procedure for estimating the convergence order of the FEM solution is outlined. Also, it was observed that the parallel computing performance in large assemblies is more sensitive to the solver settings, the meshing technique and the element type used; comparing to smaller models.

References:

1. David W. Trott and Matthias K. Gobbert, Conducting Finite Element Convergence Studies using COMSOL 4.0, Boston COMSOL Proceedings, 2010
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3. Andy J Kean, Prasanth Nair, Computational Approaches for Aerospace Design, 2005