Model Order Reduction using Proper Generalized Decomposition (PGD) applied to validation of airbag and restraint systems

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This presentation introduces Model Order Reduction (MOR) applications for occupant safety with PGD (Proper Generalized Decomposition). Validation studies for improving occupant safety are very time consuming using high fidelity simulation models, despite all recent progress made on high performance computing and software performance. As of today, the time spent for calibration and validation loops using high fidelity finite element simulations may be incompatible with the time constraints associated with car projects. Furthermore, design optimization involves lots of parameters, and are therefore out of reach using standard optimization techniques due to the number of simulations that would be required.

The capabilities of simulation for occupant safety have improved a lot in the past years, becoming more accurate, more detailed, in particular for airbag deployment predictions. Advanced techniques using Fluid Structure Interaction (FSI) approaches, such as FPM (Finite Point Method) are now widely used for the development of airbag restraint systems, namely prediction of the kinematics and the dummy response. Nevertheless, the precise modeling of the airbag deployment requires to validate precisely the outflow conditions of the airbag: seam leakage, fabric permeability, heat transfer. Robustness studies related to the test set up are also necessary due to uncertainties: ambient temperature, positioning of support plates, sensors, tank test data.

Only a fraction of these parameters may be measured easily in a laboratory test and therefore high fidelity runs for calibration purposes are required. Case studies using Model Order Reduction (MOR) related to the validation of airbag deployment cases and comparison with experimental measurements are presented. The Sparse Proper Generalized Decomposition (SPGD) is applied to the calibration of the airbag outflow and boundary conditions to provide a real time parametric model. The efficiency and accuracy of the method is demonstrated for a large number of parameters. The number of training runs required to reach a good accuracy of the SPGD parametric model is documented.

The predictions of the real time parametric model are compared with high fidelity airbag deployment simulation results, namely standard airbag validation tests such as pendulum or head form impacts. For example, the pendulum acceleration time history in the case of an impactor case is compared with a validated finite element simulation. Additional industrial usage of Reduced Order Modeleing for other safety related studies are introduced.