Optimization of car body structural crash design using reduced order models

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The size of crash models keeps increasing due to accuracy requirements and the necessary modeling of details in battery and cables for electric vehicles. High-Fidelity crash models currently exceed 10 million nodes and are computed overnight on hundreds of processor cores. Such a size of model limits the possibilities of parametric space exploration and optimization studies.

Reduced order models allow to perform these studies without significant increase in computing resources. As opposed to classical optimization methods where a response surface is built for a few quantities of interest, a reduced-order model is built using large parts of the space and time high-fidelity model results, for example displacements for all nodes over time. Renault and ESI Group have been collaborating for the past decade on the development of reduced order modeling technique.

The present work focuses on iteratively building accurate, yet affordable models, using dedicated quality assessment methods, to serve innovative structural optimization concepts. Two classes of methods have been developed: the PGD 'Proper Generalized Decomposition' builds an approximation of the solution with separation of interpolation functions for space, time and parameters. The ReCUR method builds a regression using machine learning techniques, currently random forest, which can deal with very large number of parameters. To assess model quality, several graphical tools are developed, to present correlations between predicted and high-fidelity results: classical scatter plots, objective rating metric for curve responses, and visualization of model differences as contours and with histograms.

The reinforcement method is an optimization approach proposed by Renault to guide structural design engineers in their choices of areas to be reinforced or weakened for the vehicle to reach safety targets. Components are split in zones, each zone having its own thickness variation. The large combination of possible solutions is explored using a reduced order model built on a dozen of training cases.