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A parametric and non-intrusive reduced order model of car crash simulation

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Abstract

Industrials have an intensive use of numerical simulations in order to avoid physical testing and to speed up the design stages of their products. The numerical testing is indeed quicker to set-up, less expensive, and supplies a lot of information about the system under study. Moreover, it can be much closer to the physical tests as the computation power increases. Despite the rise of this power, time consuming simulations remain challenging to be used in design process, especially in an optimization study. Crash simulations belong to this category. These rapid dynamic computations are used by RENAULT during the sizing of the vehicle structure in order to ensure that it meets specifications set up to reach safety criteria in case of accidents. They are completed using finite element software such as VPS (Virtual Performance Solver) developed by ESI group that will be used in this study. For car manufacturers, the goal of the optimization study is to minimize the mass of the vehicle (and thus its consumption) by modifying the thicknesses of some parts (from 20 to 100 variables). Industrials such as RENAULT currently perform optimization studies based on numerical design of experiments. The number of computations required by this technique is from 3 to 10 times the number of variables. This is too much in order to be intensively used in a design process.

In order to decrease the time-to-market and to explore alternative technical solutions, we explore the potential of using a parametrized reduced order model in the optimization studies. The parametrized reduced order model gives an estimation of the high-fidelity result for a new set of parameters without using the solver, by analysing the existing results of previous computations with various sets of parameters. The developed reduced order model is called ReCUR. It is partly based on a CUR approach embedded in a regression analysis. The regression statistical model uses the data of a few calculations made with the solver. Other tools such as clustering and linear programming are used to get the regression analysis more efficient.