Crash failure detection

Nicolas Rosenblatt

Contexte de la thèse :

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Ecole Centrale de Lyon : Equipe Dynamique des Structures et des Systèmes (D2S), Laboratoire de Tribologie et Dynamique des Systèmes (LTDS)
Renault : Groupe « Optimisation et méthodes numériques », Direction de la Recherche, des Etudes Avancées et des Matériaux (DREAM)
Ecole doctorale MEGA (Mécanique, Energétique, Génie civil, Acoustique) de Lyon.
Encadrants ECL : Louis Jezequel (directeur de thèse), Olivier Dessombz
Encadrants Renault : Yves Tourbier, Marie-Maud Chatillon

Abstract :

The automotive manufacturers now have to comply with constraining environmental standards, while providing customers with innovative and efficient vehicles. Furthermore, the design stage has to be as quick as possible in order to be competitive. These constraints have lead Renault to use optimization in the design stage, in order to meet the specifications, mass and cost goals. Focus will here be placed on crashworthiness specifications.

The design and optimization stage lead to a solution meeting the specifications for nominal values of its design parameters. However, we need to take into account the scatter of these design parameters to check the solution robustness [1]. For instance, the thickness of a part will be included in a tolerance interval around its nominal value. Crashworthiness is very sensitive to this scatter, since the performance of a solution can drop dramatically for a small variation in the parameters. This change of performance is what we call a failure [2] [3].

In order to avoid the use of costly physical prototypes during the design stage, we are looking for these crashworthiness failures on a numerical model of the vehicle, here a finite element model. Crashworthiness performance of the vehicle is assessed through a group of outputs (passenger cell distortion, passenger deceleration, efforts, …). We usually use around fifty outputs to evaluate the crashworthiness of a solution. A failure appears when one or several outputs have a different value from the reference solution.

We present here a method used to identify the likely crashworthiness failures in the scattered design space. The problem is posed as an optimization problem: we are looking for crashworthiness performance different from the reference, in a likely-to-appear configuration of the scatter. This means that the configuration where all the parameters are set to the maximum of the tolerance interval is not interesting, since its probability to appear is very low. Since the model is costly to evaluate, we use the following approach:

- Design of experiments in the scattered design space in order to evaluate the influence of the design parameters scatter.
- Metamodeling of the outputs functions of the design parameters scatter [4].
- Solving the optimization problem using a genetic algorithm (NSGA II) and an aggregated criterion of the outputs [5].

The use of an aggregated criterion is necessary to solve the optimization problem, because of the dimension of the output space [6].

We will focus on the aggregated criterion construction: by changing the weights of the outputs in the criterion, we will be able to explore the crashworthiness failure space. We can take into account the crashworthiness expert opinion, who lists possible failures. If we increase the weight of a group of outputs in the criterion, the optimization solutions will change; different types of failure can then appear. We also observed that the solutions of an optimization iteration often belong to the same failure type. It can be interesting to constrain a group of outputs, so that we do not observe a failure already seen in a past iteration.

This method will be illustrated on an industrial problem: the method has been applied on a vehicle at the design stage, in order to identify and correct likely crashworthiness failures.

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