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Reliability-based design optimization of vehicle front-end structure for pedestrian lower extremity protection

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Abstract

Injuries to the lower extremities are one of the major issues in vehicle to pedestrian collisions. To minimize injury risks of pedestrian lower extremity, this paper presents the design optimization of a typical vehicle front-end structure subjected to two different impact cases of TRL-PLI and Flex-PLI. Several approaches involving sampling techniques, surrogate model, multiobjective optimization algorithm and reliability analysis are introduced and applied. In order to take into account the effect of design variables uncertainty, the reliability-based design optimization (RBDO) is conducted, and a Monte Carlo Simulation (MCS) is adopted to generate random distributions of the constraint functions for each design. The differences of the different Pareto fronts of the deterministic optimization and RBDO are compared and analyzed in this study. Finally, the reliability-based optimum design result is verified by using test validation. It is shown that the pedestrian lower extremity injury can be substantially improved for meeting product development requirements through the proposed approach.

Keywords: Reliability optimization; Vehicle front-end structure; Pedestrian protection; Multiple impact cases