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A Nash Equilibrium-Genetic Algorithm optimization code for structural problems
Test case: an aluminum plate subjected to low velocity impact events

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Abstract

Low velocity impact events can be expected on any kind of structure and throughout its entire life [1]. They may in fact occur during both manufacturing, service, and maintenance operations. New and more calibrated design tools are continuously needed in order to realize increasingly specialized but at the same time robust devices. This in order to make them possible to face the widest range as possible of random events that, unfortunately, could occur. In this work we present the numerical solution for a structural optimization problem comparing the Nash Equilibrium (NE) concept (Game Theory) with a typical Pareto front. An explicit FEM code (LS-Dyna) was used for simulations [2].

The advantages of the NE as a design solution is clear if compared to the Pareto front since it provides an unique solution which is the most balanced inside the variable space, even if it's not an optimum.

The NE point was hunted through the use of a Genetic Algorithm suited for multiplayer competitions, central core of the game theory [3]. After having introduced randomly generated initial populations of individuals (possible problem solutions) the competition started. The best ones, sorted according with a payoff function, are put in the mating pool for coupling, exactly as in nature happens. An operation of mutation on the individuals was performed too. The test case is a very simple structural scheme but capable of showing the potential of the Nash-Genetic algorithm. It consists of an aluminum plate subject to a low velocity impact event. The variables controlled by the "players of the game" are (1) the velocity of the impactor, and (2) the thickness of the plate. The aluminum plate is square shaped with fixed side dimension and simply supported on the edges. The objectives are to minimize the plate thickness but maximizing, at the same time, the impactor velocity. This in order to carry out the lightest plate as possible able to withstand impacts involving increasing impact energy values.

References

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