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OPTIMAL DESIGN SOLUTION AMONG PARETO ALTERNATIVES FOR VEHICLE NONLINEAR SUSPENSION SYSTEM

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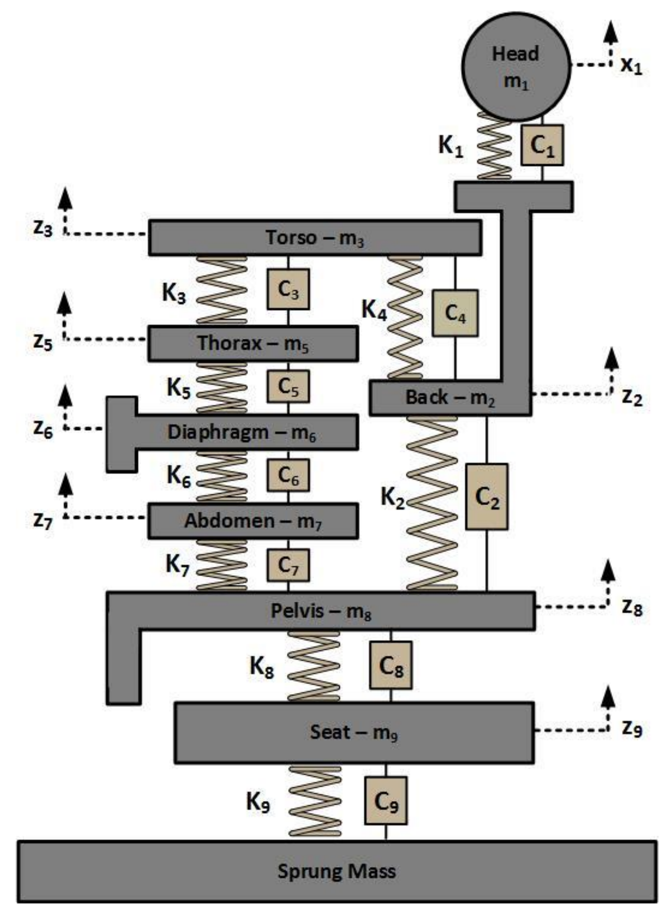
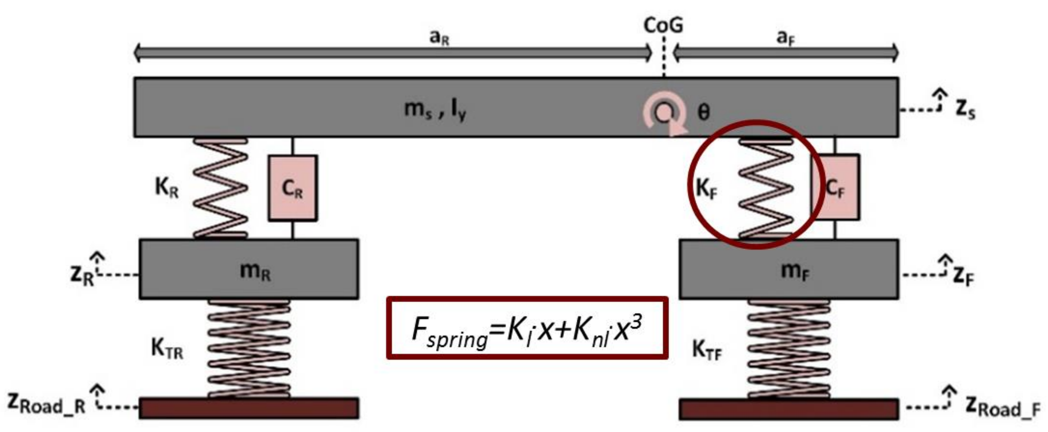
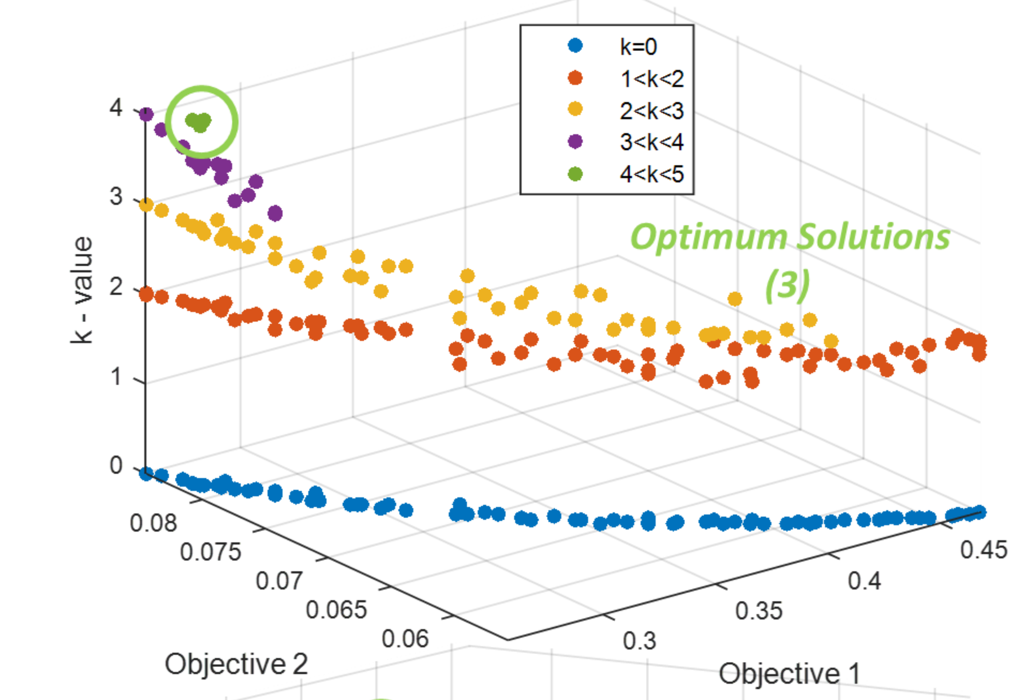
Abstract In this paper the optimization problem of selecting the optimum design parameters of a nonlinear vehicle suspension system is investigated. A Half – Car model is used in order to simulate the behavior of a heavy vehicle under two different road excitations and subsequently optimize it in respect of its characteristics. A multi – objective Pareto approach was adopted and several different targets regarding the dynamic behavior of the vehicle were used in the optimization process. In the end, with the use of appropriate methods, the extraction of one optimum solution from the Pareto set is investigated and comments regarding the dynamic behavior of the optimized model are presented.

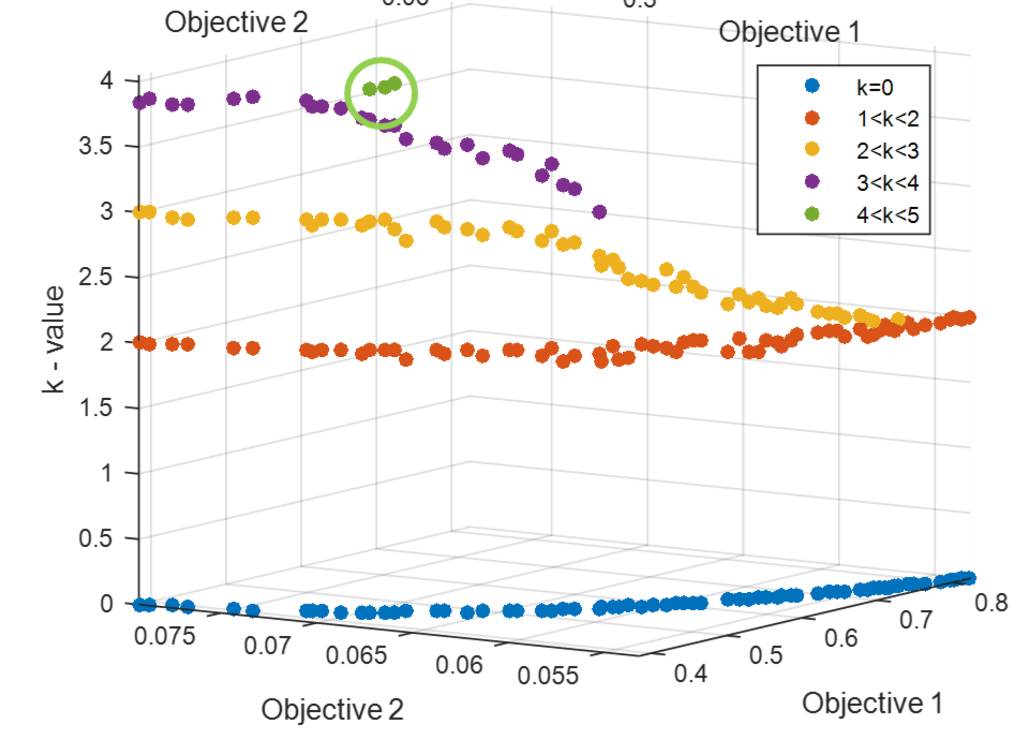
Introduction

In the literature, the simulation and consequently the optimization of different types of suspension systems have been discussed extensively [1-4]. In recent research studies, subsystems for driver's seat and the passenger's body were added to the vehicle models so as to investigate, in depth, the ride comfort of the passengers and evaluate more accurately the vibrations induced to the human body by the road [5, 6]. Multi – objective approach is commonly used in order to receive indicative results concerning the many conflicting targets involved. The most common methods entail the Pareto Front approach where the different targets of the optimization are separated throughout the optimization process [7, 8]. The aforementioned separation of the optimization targets results in a set of optimal solutions, equally optimal. Depending on the complexity of the problem, the size of the optimal set of solutions can be quite large. Thus, many methods have been developed in order to assess the vetting process and consequently the reduction of the optimal set of solutions.









Materials & Methods

The simulation models consist of a nonlinear suspension system in a half car model which provided 3 targets (Variance of sprung mass' acceleration, Mean of the variances of both suspension travels Mean of the variances of both tire deflections) and a seat – driver model with 3 extra targets (Head's Vibration Dose Value, Head's Crest Factor, Variance of the pitch angle).

The optimization process contained:

(a) the initial formulation of the optimization problem,
(b) optimization of the half Car model for 3 objectives (Genetic Algorithms – Pareto front) ,
(c) simulation of the driver model for all the solutions of the Pareto Front,
(d) expansion of the problem for 3 extra objectives and
(e) selection of the Optimum Solution for the six Objectives (k-ε Optimality method).

Results & Discussion

The optimization was implemented in the vehicle model for 3 targets, whereas 3 extra targets were added from the passenger model for the identification of the optimum solution. Additionally 2 different road excitations where tested:

- Road bump the optimal set of solutions is located in the closer to the middle of the initial Pareto front.
- C Road profile, the set of solutions is acquired from the edge values of the Pareto front, indicating that the algorithm encountered difficulties in the vetting process.

Conclusions

- The k – ε optimality method behaved differently in every case.
- The value of the threshold was proven crucial, so as the algorithm to be tuned properly, in order to obtain a proper set of optimal solutions not only as far as the number of the solution but also as their "position" in the Pareto front.
- Finally, it is important to mention the success of the algorithm in delivering reliable results, with the 3 of the 6 targets added after having already obtained the Pareto front.

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