

Direct Interval Multi-Objective Optimization Method for Uncertain Structures

Guiping Liu* and Sheng Liu

State Key Laboratory of Advanced Design and Manufacturing for Vehicle Body, College of Mechanical and Vehicle Engineering, Hunan University, Changsha, 410082, China.

*Corresponding Author: Guiping Liu. Email: liuguiping@hnu.edu.cn.

Abstract: In engineering multi-objective optimization of structures, the parameters involved in the problems are usually given deterministic values. However, due to the presence of manufacturing and measurement errors, uncertainty inevitably exists in the geometrical properties of the structure, the material properties, the boundary conditions, etc. For uncertain problems, the interval optimization methods are widely used. They describe the uncertainty by intervals which only need to find the upper and lower bounds of the uncertain parameters instead of constructing the exact probability distribution function. However, in multi-objective optimization problems, if considered all the upper and lower bounds of the objective functions as optimization objectives, the amount will double. Therefore, most of interval multi-objective optimization methods took the midpoint or radius of each objective function's interval, or the combination of those two, as approximations of the optimization objectives. Obviously, it will lose some accuracy. In this paper, a direct method for uncertain multi-objective structural optimization is presented. In the framework of the multi-objective genetic algorithm, the upper and lower boundaries of the objective and constraint functions are found by the Monte Carlo simulations; and then an interval non-dominated sorting are performed for the evolutionary population evaluations, which includes two steps. Firstly, the interval individuals are sorted by using the interval sorting method and their non-dominated ranks are obtained; secondly, a general crowding distance is calculated for each individual to maintain the diversity of the evolutionary population. Finally, the efficiency and accuracy of the proposed method is demonstrated by a numerical example, the multi-objective structural optimization of the ten-bar truss, and the multi-objective structural optimization of a vehicle body for crashworthiness.