

MULTI-OBJECTIVE OPTIMIZATION OF AEROSPACE MICRO-STRUCTURES USING A DIRECT-SEARCH METHOD IMPLEMENTED IN PYTHON

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Abstract

Multiobjective optimization problems are common in aerospace structural design, where improving one performance criterion may degrade another, such as increasing stiffness at the cost of additional mass. When these problems are evaluated through high-fidelity numerical simulations, the resulting objective functions are often expensive, noisy, and unavailable in analytical form. These characteristics motivate the use of derivative-free optimization methods.

The main objective of this work is to migrate the Direct Multisearch (DMS) algorithm to Python and verify its behaviour against the existing MATLAB reference implementation. The complete workflow was translated into Python while preserving the behaviour of the original implementation and its main mechanisms.

The Python implementation was then verified through MATLAB–Python equivalence tests, using different objective and constraint functions, as well as several algorithmic parameter configurations, to confirm that the translated code produces results consistent with the MATLAB implementation.

Finally, an aerospace-oriented case study was developed based on a parametrized auxetic unit cell. A computational pipeline was implemented to generate a finite-element discretization of each candidate geometry and compute its homogenized effective elastic properties. These properties were then used to define the objective functions evaluated by DMS, allowing the computation of trade-off solutions between stiffness-related performance and auxetic behaviour. Overall, the verification shows that the Python implementation is consistent with the MATLAB reference code and can be coupled to external simulation workflows for practical multiobjective optimization problems.