

BI-LEVEL OPTIMIZATION OF STRUCTURAL TOPOLOGY AND ACTUATION LAYOUT USING MULTIDISCIPLINARY DESIGN OPTIMIZATION

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Keywords: Multidisciplinary Design Optimization, Topology Optimization, Actuator Layout, Bi-level Optimization

Abstract

Multidisciplinary Design Optimization (MDO) has developed largely within the aeronautical domain, where strongly coupled design problems are common. However, many high-performance mechatronic systems in the semiconductor industry also exhibit strong interactions between structural dynamics, actuation, and control subsystems. In current industrial practice, design decisions across these domains are often made sequentially, which can limit achievable system performance. Applying MDO principles to such systems therefore offers the potential to better exploit cross-disciplinary couplings and improve overall system performance.

Previous research has demonstrated that concurrent optimization of structural topology and controller parameters through control co-design, can significantly improve closed-loop performance [1]. In addition to controller-structure interactions, other disciplinary design choices, such as layout and dimensions of actuation within the structural design, also strongly affect the performance of the controlled mechatronic system.

This contribution, therefore, focuses on the simultaneous optimization of actuator layout and structural topology. To model actuator size and position within the topology optimization domain, feature mapping methods are used to represent actuated magnetic material. While such approaches have been used to integrate actuator layout optimization into structural topology optimization [2], combining feature-mapping parameters with topology design variables in a single monolithic optimization can lead to scaling and conditioning challenges.

The main contribution of this work is the formulation of actuator layout and structural topology design as a bi-level MDO problem. Actuation design variables are controlled by a system optimizer, while structural topology optimization is solved as a nested disciplinary optimization. By decoupling the high-dimensional topology variables from the low-dimensional actuator design variables, the proposed formulation improves optimization conditioning while preserving strong cross-

disciplinary coupling between actuation and structure. The proposed approach is demonstrated on a representative mechatronic design problem

References

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