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Multi-Objective Topology Optimization of Composite Structures Considering Resin Filling Time

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Abstract

This paper presents multi-objective topology optimization of composite structures manufactured by resin transfer molding. The problem is formulated as minimizing both structural compliance and resin filling time. The empirical model of resin filling process is constructed by mining the results of numerical process simulations of massively sampled structural topologies within a fixed bounding box, using Random Forest statistical learning. Thanks to the abstract topology features inspired by underlying physics of the filling process, the resulting process model is far more generalizable than the traditional surrogate models based on, e.g., bitmap and local feature representation, with no penalty in computation time. In particular, the model can reasonably be applied to the situations with the different inlet gate locations and initial bounding boxes from the training samples, while the traditional surrogate models completely fail in such situations.

Three case studies for composite structure topology optimization are discussed with different inlet gate locations and initial bounding boxes in order to demonstrate the robustness of the developed process model. The multi-objective topology optimization problem is solved by the Kriging-interpolated level-set approach and multi-objective genetic algorithm (MOGA). The resulting Pareto frontiers offer opportunities to select the designs with little sacrifice in structure performance, yet dramatically reduced resin filling time as compared to the structurally optimized design.

Keywords: Topology Optimization, Manufacturing Constraint, Composite Structure, Resin Transfer Molding (RTM), Resin Filling Time.