A Generative Design Optimization Approach for Additive Manufacturing

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In this paper, we present a generative design optimization (GDO) approach for additive manufacturing (AM) by using topology optimization, support vector machines, cellular lattice structures (CLS) and metamodel-based design optimization. By starting from appropriate design domains with anisotropic properties in unilateral contact, a trade-off curve of design concepts is generated by SIMP-based topology optimization (TO) using the potential energy as objective function. The unilateral contact between the design domains with non-matching meshes are treated by the mortar approach most efficiently. Then, a smooth implicit representation of the TO-solution is established by classifying the discrete density values using soft non-linear support vector machines (SVM). Instead of using the standard soft non-linear SVM of Cortez and Vapnik, we classify the TO solutions by using the 1-norm SVM of Mangasarian. In such manner, the classification is obtained by linear programming instead of quadratic programming by using sequential minimal optimization. The implicit SVM-model is further modified by incorporating cellular lattice structures, such as e.g. Gyroid lattice structures, by applying boolean operators. Design of experiments using finite element analysis are then set up by morphing the CLS-modified SVM models for different volume fractions. Finally, metamodel-based design optimization is performed by using optimal ensembles of polynomial regression models, Kriging, radial basis function networks, polynomial chaos expansion and support vector regression. The steps presented above constitute our proposed generative design optimization approach for additive manufacturing. In the paper, the approach is demonstrated by studying several problems in 3D. For instance, a cutting tool, an automotive rocker arm and an engine bracket are studied using the proposed GDO approach for AM.

Keywords: Topology Optimization, Support Vector Machines, Lattice Structures, Metamodels

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