Trajectory Planning for Additive Manufacturing Based on Mechanical Performance

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Additive manufacturing (AM), also known as 3D printing, is a technique to construct physical objects, including their internal structure, by [adding] layer over layer of material. AM empowers a fast, flexible, and even cost efficient production of elements directly from a digital file. This file, usually in Standard Tessellation Language (STL) format, is generated by a Computer-Aided Design (CAD) software and then digitally sliced and converted into a series of commands that control the tool trajectory in the AM process. In the case of fused filament fabrication (FFF), the direction in which the filament is deposited plays an extremely important role in the final quality of the part; however, the tool trajectories are automatically generated without any regard for the mechanical performance of the object. The objective of this investigation is to establish a methodology to generate tool trajectories considering the principal stresses within the object. To this end, our approach makes use of finite element analysis (thermal and mechanical) to predict and optimize the mechanical performance based on the direction of the layered filaments in FFF. The results are demonstrated in a Steam Engine 3D printed (3D Parts Manufacturing, LLC, Indianapolis, Indiana) but are extensible to any FFF 3D printer.

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