A Bio-Inspired Mathematical Approach to Design for Additive Manufacturing

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Abstract. It is well acknowledged that DfAM requires a comprehensive understanding of materials, processes and parameters, and the associated geometric opportunities and limitations. The holistic knowledge required for efficient DfAM poses a major challenge to the progression of industrial applications of additive manufacturing (AM). Whilst AM offers enhanced geometric freedom during the design process, the psychological inertia of long-standing subtractive approaches is retained in the design thinking of the engineering community and inherent in computer aided design (CAD).

To create an axisymmetric form about a curved axis defined in 3D-space, the traditional method enabled by CAD is to define a centreline and/or a series of cross-sections. However, this process is constrained by the planar nature of the sketch function and can be highly time-consuming. This paper proposes a novel approach, using a mathematical framework that has proved useful in the modelling of living tissue, to enable the parametric design of axisymmetric forms. The mathematical methodologies will be presented as follows: a length-polar-projection description of the centreline and specification of the axisymmetric cross-sections.

This transdisciplinary approach was developed between the disciplines of mathematics, biology and engineering. As such, it offers a completely novel, more efficient and insightful process than current commercial approaches. The results of this study offer two contributions to research knowledge: time-efficient, parametric generation of complex axisymmetric geometries defined in 3D and a process by which to upskill knowledge of the design engineer.

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