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AN ORIENTATION-FIELD BASED ALGORITHM FOR FREE-FORM FILAMENT DEPOSITION

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Fused Filament Fabrication (FFF) is a widely adopted Additive Manufacturing (AM) process belonging to the material extrusion family of technologies. FFF working principle involves a thermoplastic filament that is heated and extruded along a predetermined path and then stacked in a layer wise manner to build a part. Like any other AM technology, FFF offers an unprecedented design freedom, making it suitable to produce extremely complex designs that the traditional methods cannot manufacture. Although trends from the past decade have shown tremendous improvements for this technology in terms of available materials, software and hardware, some limitations in the exploitation of FFF technology still exist: among others, one of the most limiting is that the deposition paths used to fill the geometry to be printed can only follow certain predefined patterns like rectilinear, honeycomb, concentric etc., implemented in the current slicing software, thus preventing an enhanced deposition strategy of the material. The inherent anisotropic nature of the 3D-printed parts along with such predefined patterns may not attribute the structural performance in most applications. A load-oriented designing of the fibres has shown improved structural performance and is well established in the field of composites, but very few works have used load-oriented slicing for 3D printing [1, 2]. A recent work by Khan et al. [1], demonstrated the improvement in the mechanical strength of a 3D printed open-hole plate when its filaments are oriented to the load paths. However, only an analytical approach was used in which the curvilinear filament paths were found from the analogy of fluid-flow equations around a cylinder. The present work makes a step forward developing a robust, generally valid filament deposition algorithm that produces curvilinear filaments paths taking as input arbitrary point-wise orientation fields is presented. Like slicing software, it can control a variety of process parameters, including extrusion width, layer height, filament spacing, number of layers, printing and travel speeds, and produces G-Code instructions. Capabilities of the algorithm are presented by producing parts with both partial and maximum infill and parts with a multi-oriented layer stacking sequence. The proposed filament deposition algorithm is primarily intended for, but is not limited to, structural applications.

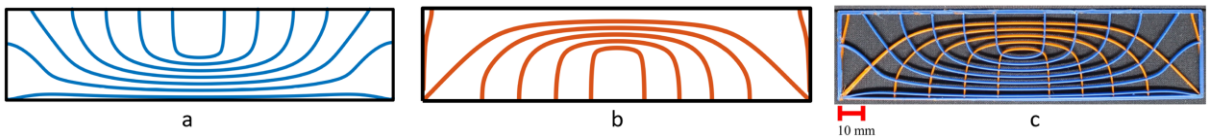

Figure 1. *Bending problem with multi-oriented stacking sequence. Material orientation is computed according to first (a) and second (b) principal stress directions. In (c) the resulting FFF 3D printed part.*

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