Technion-Israel Institute of Technology

Computer Science Department

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CGGC Seminar – PhD Talk

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Advanced Geometric Methods in Machining and Additive Manufacturing

In this thesis, we show how geometry, and specifically parametric freeform geometry, can be used to solve manufacturing related problems. This thesis deals with both additive manufacturing (specifically 3D printing) and the more traditional (subtractive manufacturing) machining process.

The first topic handled is the representation and manufacturing of functionally graded material (FGM) objects in 3D printing. Specifically, this thesis presents the use of parametric (trimmed) volumes to manufacture FGM objects. Using the underlying parametrization offered by parametric volumes enables the succinct specification of material composition in the printer's native resolution, without resorting to discrete volumetric representations (voxels) and their associated problems. The related chapter also presents several FGM objects (which would require billions of voxels to represent) fabricated using our methods.

The second topic related to additive manufacturing is the use of non-planar print-paths or layers. In traditional 3D printing, objects are decomposed into a set of thin, essentially 2D, planar layers. These layers are manufactured one after the other, which greatly simplifies the planning of the 3D printing process. However, by using non-planar layouts, objects with better material properties can be manufactured. This thesis shows how non-planar covering print-paths can be generated, and how they can be 3D printed to fabricate objects. This work fully supports general objects, not limited to some very specific class of geometries, that can be fabricated using non-planar print-paths, and presents several examples of such fabricated objects. The methods presented here can also be applied to scenarios involving non-planar fiber layouts, toward composites, in 3D printing and to hybrid manufacturing.

With regard to machining, this thesis presents algorithms that enable the generation of collision free 5-axis tool-paths for convex machining tools. Unlike previous efforts, the methods presented here rely on bounding sufficiently small surface patches rather than sampling of the machined geometry, with all the deficiencies that sampling can entail. By bounding the position, normal, and normal curvature properties of freeform surface patches not only is the tool-path assured to be globally collision free, it can remain so even after it is optimized using continuous optimization methods. The introduced patch subdivision and bounding procedures also enable the use of configuration space methods to help navigate between the surface patches.

The lecture will be held on Sunday, 03.03.2019, at 13:30, Taub 337

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