Subtractive 3D Printing with Machine Tools using HPC

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Direct digital manufacturing (DDM) is the practice of creating a physical part directly from a computer-aided design (CAD) model with minimal process planning. DDM is typically applied in additive manufacturing (AM) processes, which offer rapid implementation and the ability to produce complex geometry. However, the treatment of subtractive manufacturing (SM) in the context of DDM is still lacking. SM is a decades- old process that is responsible for the production of many parts in the world today. SM and AM have distinct advantages and disadvantages. An advantage of AM that has recently made it more popular in DDM is that it often requires minimal understanding of process planning to implement successfully. The main issues to consider in AM are the configuration of support structures and the selection of build orientation, for which there is increasing software support. Most new machines, even table top 3D printers, can automatically place support structures on a given CAD model. The high amount of automation in AM has allowed for the ability to fabricate consolidated parts and mechanisms during a single build process; this reduces manufacturing time and cost by removing fasteners and assembly steps. This research tackles the fabrication of such consolidated assemblies using subtractive manufacturing. SM has advantages over AM in that it can process a wider range of materials without compromising strength due to anisotropic material properties. However, many process planning challenges are present in the subtractive manufacturing of consolidated assemblies; most importantly, the creation of the toolpath that the cutter must follow to machine the assembly. Resolving the issues for machining consolidated mechanisms can give an edge to SM processes in direct digital manufacturing. Advances in HPC and accessing GPU make new possibilities that can be exploited with a new modeling paradigm: voxel-based representation of solid geometric models.
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