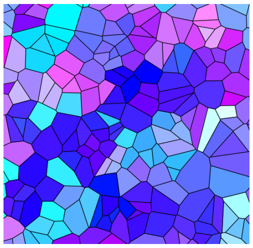

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Thermal-Pack: A packing engine tailored to drive HP MJF production yield up

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PLÁTICA

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1 Introduction

HP MJF is an additive manufacturing (AM) powder-based technology (3D printer) that allows to build multiple objects in parallel. The cumulative building of powder layers come up with several advantages like flexible design objects and quick fabrication time. Besides AM advantages, HP MJF technology allows to build a part at any location inside of the predefined build volume without part supports, then reducing material (powder) waste.

To drive up MJF's adoption for end-part manufacturing, the packing solution needs to optimize for two vectors simultaneously: first, it is necessary to optimize the parts packing tailored to MJF thermal physics such that the parts placed into the build volume for production has acceptable yield; second, it is necessary to maximize packing density (total parts volume sum) so that production throughput is drive up while reducing manufacturing costs.

It is well known that packing problems are high computational complex since from low dimensions (1D,2D) they become NP-Complete even when squared-shaped objects are packed [1]. As might be expected, when arbitrary 3D-shaped objects are required to be packed the problem becomes even more challenging, since multiple factors like ideal rotation angles and continuous placement locations are come into play [3, 2].

2 Approach

In this talk, we present the HP Thermal-Pack multi-objective optimization engine for part packing based on a Genetic Algorithm framework. Thermal-Pack takes a set of 3D mesh files and creates build buckets ready to be 3D printed (See figure 1). Objectives implemented include packing density and solution z-height, in addition to thermal-aware features to maximize mechanical properties at end printed parts.

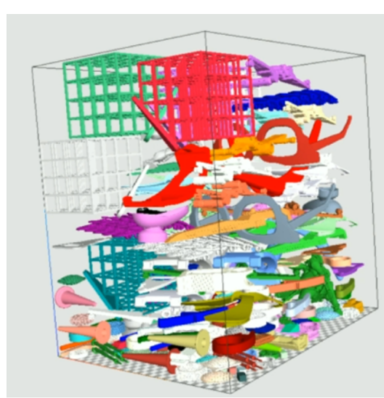

Figura 1. Thermal-pack packing solution

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Thermal-pack main building blocks to tackle down the challenging arbitrary-shape packing problem are describe down below.

Implementing rapid geometric object manipulation is a key point for solution screening inside the huge combinatorial search space. One way to accelerate object manipulation is by reducing geometrical accuracy, which means to wrap up an object with complex geometry into a low-resolution volumetric representation. The voxelization module applies a geometric transformation to diverse geometrical shapes into a unified data representation, so-called voxels (See figure 2).

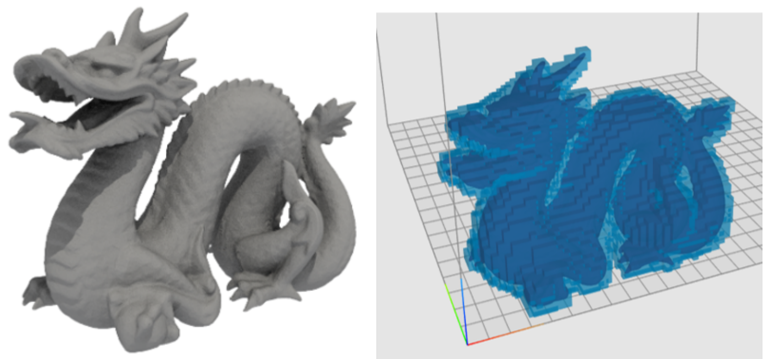

Figura 2. Left) Input 3D mesh. Right) Geometric transformation to voxel representation.

Before proceeding to pack with low resolution objects, Thermal-pack runs a object classification procedure to group parts based on geometric properties like shape, size, density or business rules like printing priority, shipping deadline etc. The packing algorithm treats priority groups differently to commit printing rules.

The Genetic Algorithm framework enables effective-composable optimization among different objectives. The entire genetic algorithm process consists of continuously optimize a set of chromosomes (potential solutions), such that after several generations it comes up with a chromosome (solution) with high fitness value.

The part placement algorithm takes the sequence defined in a chromosome and enters each part one after another in the given order. The placement heuristic suggests entering parts with diverse placing rules in order densely populate the building space.

While placing the parts, the collision detection module assures there are not two voxels occupying the same space, It takes advantage of voxelization objects and based on the bounding volume hierarchy technique, allows to efficiently detect part collisions.

Aside from geometric modules to efficiently process and optimize packing solutions, we have implemented a number of thermal aware features that allow to ”codify fusing science” right in the build preparation stage. Thermal awareness gives the ability to predict and avoid printing defects while packing, preventing to committing them in real life.

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