MEASURING MESH DISTANCES IN THE CONTEXT OF ADDITIVE MANUFACTURING

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ABSTRACT

For this project, we develop an objective way to measure the differences between two meshes, as quality control for the SPEE3D cold-spray additive manufacturing process. Our tool effectively measures the three elements crucial in additive manufacturing: overbuilding, underbuilding and surface deviation. The core of our tool relies on the cloud to mesh (c2m) distances computed by the open-source mesh processing software CloudCompare. We then apply statistical measures to the c2m distances to estimate the above factors. Our tool also provides visualisation of distances for manually checking the meshes. As a test case, we apply our tool to a range of different meshes and find our statistical measures give better results compared to manual inspection.

BACKGROUND

In the context of additive manufacturing, the following three criteria are used to gauge the quality of the printed object compared to the original CAD model:

- **Overbuilding**: when the print is larger than the model. A small level of overbuilding is necessary as the printed object often needs to be machined to remove the uneven, raw printed surfaces.
- **Underbuilding**: opposite of overbuilding, when the print is smaller than the model. Underbuilding is a critical issue since material can be easily subtracted from the printed object in case of overbuilding, but cannot be easily added back on when the object is underbuilt.
- Amount of **surface deviation** between the model and the print.

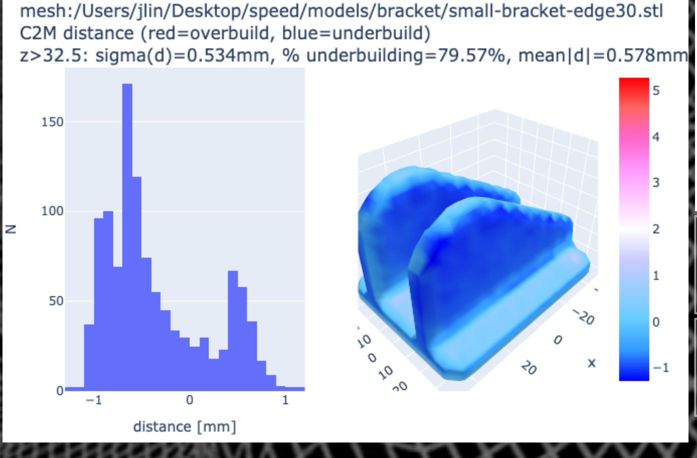
The goal of this project is to devise a tool to objectively measuring these three criteria as quality control for the SPEE3D cold-spray additive manufacturing process.

RESULTS

Using the c2m distance distributions, we quantify the amount of **over/underbuilding** as the portion of the distance distribution above/below zero (top right panel, Figure 1). The amount of **surface deviation** is quantified as the standard deviation of the distance distribution (middle right panel, Figure 1). The overall bulk distance measurement is the absolute mean distance (bottom middle right panel, Figure 1).

For our test simulations, we find the edge30, splat0.2, edge10 and splat0.125 simulations are not adequate due to underbuilding and/or large surface deviation, whereas the standard and fine simulations are least affected by these issues.

Our tool produces both summary statistic plot for all simulations (Figure 1) as well as interactive plots for each simulation (Figure 2).



METHOD

We use the open-source mesh processing software CloudCompare (CC, www.cloudcompare.org) to compute **cloud-to-mesh** (c2m) distances.

CC computes the nearest orthogonal distance from the reference point cloud (all points) to the target mesh. In c2m, the orthogonal distance can fall on a vertex or an edge or a plane of the target mesh. CC returns the distribution of c2m distances.

To test this method, we generate a simple bracket model (the model) and an array of eight print simulations using SPEE3D's proprietary simulation software TwinSPEE3D (the simulation).

We apply a uniform resampling to the model to ensure it is on the same resolution as TwinSPEE3D simulations. We then calculate c2m distances using the model as the sampled cloud and the simulation as the target mesh.

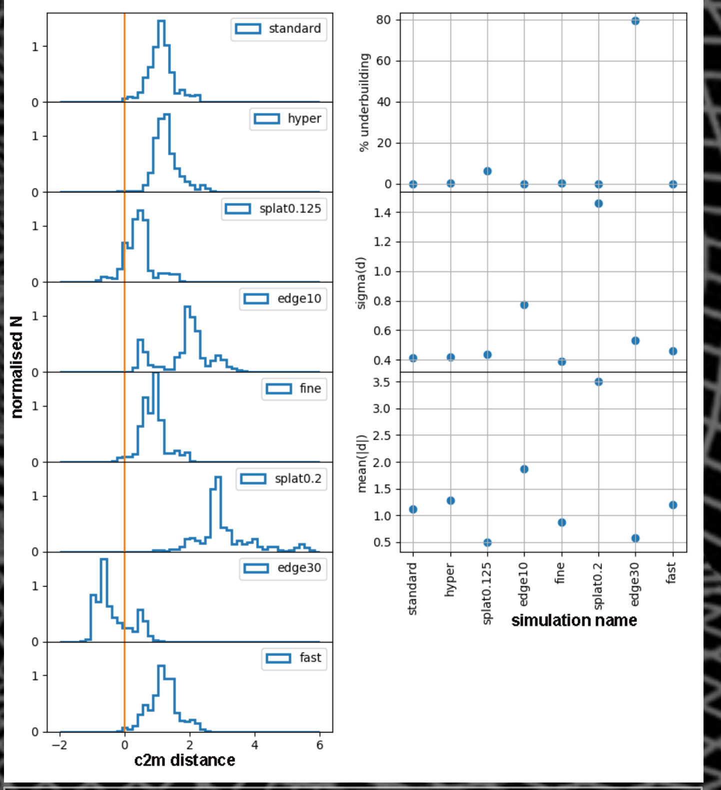


Figure 1: Left panels: normalised histograms of distance distribution of 8 different simulations of a bracket model. Right panels: summary statistics for the simulations.

Figure 2: Left panel: histograms of c3m distance. Right panel: c2m distances mapped on the ref. model. The colour scale diverges at d=2 mm, as it is the minimum allowed overbuilding for the printer.