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OVER-RESOLUTION INDEX OF A 3D DIGITAL MODEL FOR 3D PRINTING

HP INC

Over-resolution index of a 3D digital model for 3D printing

Abstract

Most 3D models printed haven't been created to be specifically printed in a specific 3DP technology. These models, that mostly come from CAD and 3D Scan applications, are usually generated trying to have as much resolution as possible to have a high-resolution 3D surface (see figure 1). However, all 3DP technologies have a certain digital resolution (voxel size), so an over-resolution model won't have a better final part quality but will have a negative impact on printing pipeline performance (time, resources). Here we introduce an index (Over resolution Index, ORI) to quantify the degree of over-resolution of the model for each specific technology. This allows the user to precisely known the degree of over-resolution of the mesh.

Problems Solved

Most 3D models have been created without taking in consideration the 3DP technology that will produce the part. Thus, some digital models have higher resolution than the digital printer resolution (see Figure 1). This fact constrains the performance of 3D printer data preparation pipelines. For instance, the compliance checks done in the mesh (inverted normal, mesh closed…) just after job submission or over the slicing process whether it happens in the preprint application or the printer.

Our index provides a way to detect over-resoluted digital models. Thus, enabling users to adjust their models' resolutions accordingly to optimize data processing performance while obtaining the same final part quality.

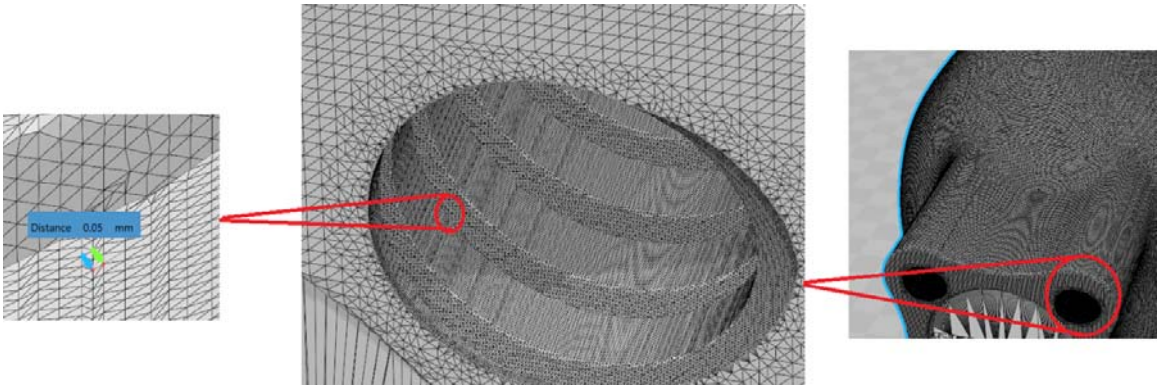

Figure 1. *3D Mesh with a too high resolution. In this case, the mesh got 200k triangles over the printer voxel resolution (0.08 mm).*

Prior Solutions

There is not any step where users can check if their models' resolution is too high regarding printing voxel size.

Description

Over resolution Index

Given a digital model specified as a triangular mesh we define the *Over-resolution index of a 3D digital model for 3D printing* as the percentage of triangles which contains triangles that have, at least, one of their sides larger than the *printing voxel resolution*. The general formula for the *Over Resolution Index* (ORI) is:

$$ORI(\%) = \frac{\#over\_resolution\_triangles}{\#total\_triangles} x100$$

Given a layer printing thickness and a layer rendering resolution (600 dpi and 1200 dpi or 42 and 21 microns respectively) the printing voxel resolution is computed as the minimum of the three dimensions. Thus being 21 or 42 microns.

Also, an extra step can be taken, once ORI is computed we can select a percentage threshold and if the model value is higher we can ask to the user to do a remeshing of the model, in order to decrease the resolution of the model, or confirm he wants to proceed with the current model.

Database Results for sample 3D printer Technology

We analyzed about 6000 models (see figure 1) and for all these models we calculated the ORI. See Figure 2 for results. Note that about 91% of the models have ORI>0, which indicates that over resolution is a problem that affects to current customer digital models. If we breakdown ORI>0 results we see that there is a considerable number of models (about 43%) with ORI >10%. It is also remarkable that 8.5% of the models have ORI>50%.

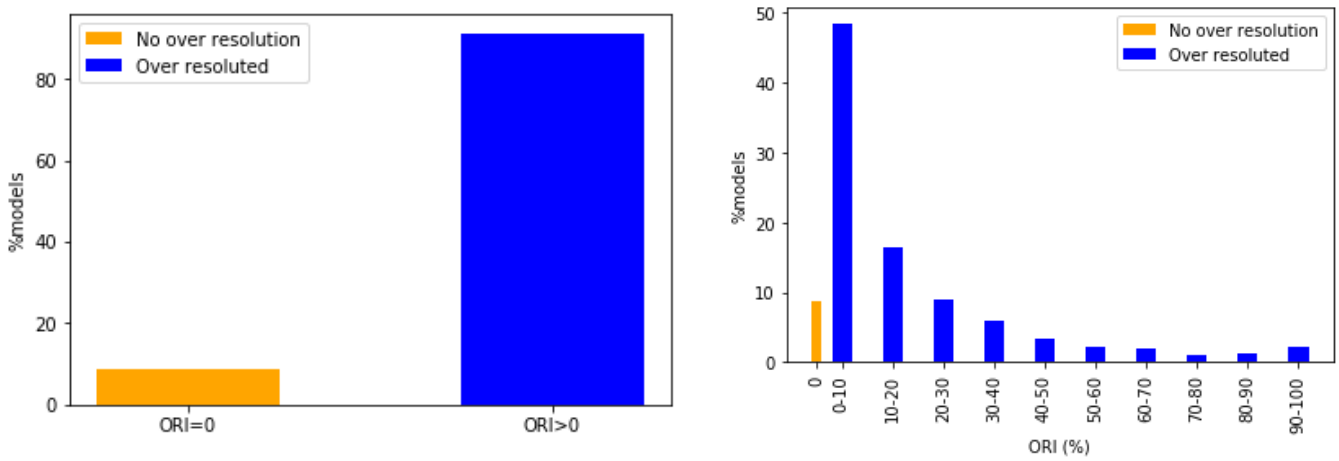

Figure 2: ORI of 6000 models using sample 3D printer (600 dpi, 80 micron layer).

Histogram in Figure 3 shows the number of models with triangles with higher printing resolution.

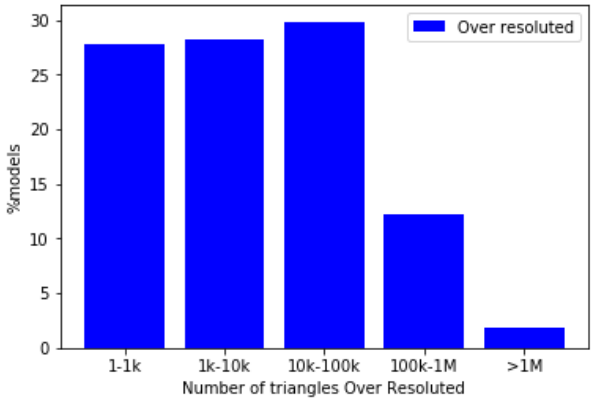

Figure 3: It shows the number of triangles smaller than printing voxel size (600 dpi, 80 micron layer). 6000 models from sample 3D printer.

Improvement of the ORI

The ORI can be improved by a simplifying of the mesh, with its consequents improvements of the data pipeline performance and saving a lot of time and space. We used the implementation of the library 'pymesh', which collapses the non-sufficiently large edges. The command

`pymesh.collapse_short_edges(mesh, minim_length_resolution)`

simplifies the mesh complexity without loss of effective resolution.

Advantages

Main advantages:

- **Data pipeline impact:** Before printing a 3D part, the digital model must pass through a processing and slicing process. If the mesh has an excessive resolution this step will be long and will require excessive processing resources and time.. For instance, the time to do some of the processing operations scale as n^2 (for the case of triangle intersection) being n the number of triangles or some operations involved in the slicing/octree generation scale in time as n*log(n), so the number of triangles has a big impact on the whole performance.

- **Processing errors:** Reducing the number of triangles in the mesh could eventually lead to avoiding some processing errors of the digital model.

- **Prevention**. Detection of a mesh with high ORI values allows users to do a previous remeshing before printing the model. This new mesh will result into the same produced part, i.e., won't affect to the final printed part quality.

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