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Forensic Engineering 3D Printed Parts
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The overarching goal of this research was to search for characteristics in 3D generated model parts produced by different 3D printers that would enable tracing the printed parts back to their source printers and software. In all, eight different 3D printers were used in this study, each producing four printed parts that could be used for analysis of distinguishing characteristics. This research is significant as there are many applications for this, including the forensic applications for tracking a 3D generated printed part back to its source [1].

The model part chosen is shown in Figure 1. The model part was designed to allow for testing for infill pattern, for dimensional accuracy of overall and embossed features, for breakaway support patterns, and any unexpected physical characteristics generated.

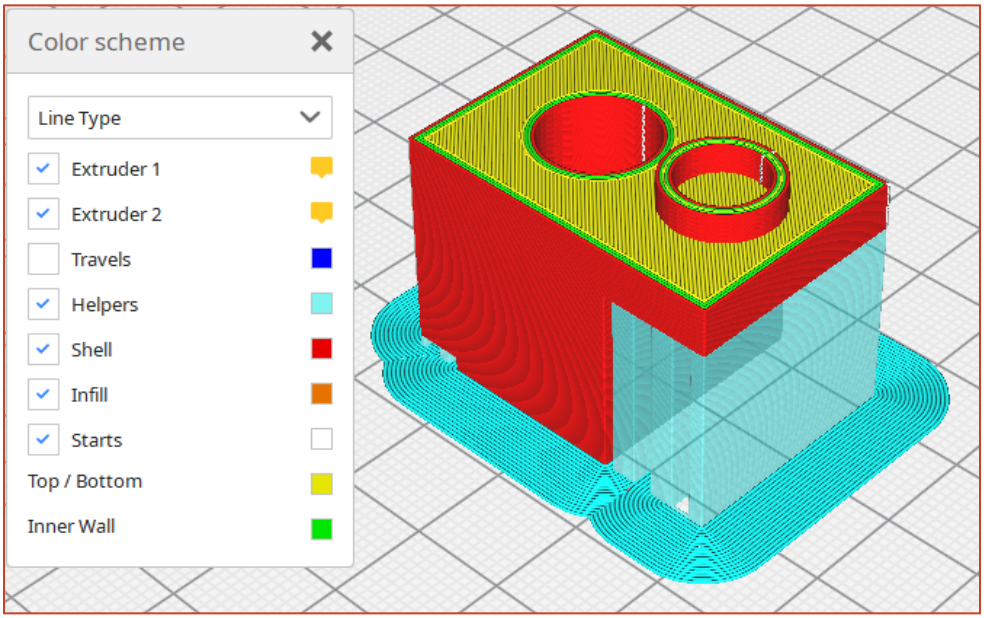

Figure 1: Chosen model part for 3D printing analysis

Infill refers to the honeycomb-like structure used to fill the part to save on material without sacrificing strength. The pattern can vary depending on what slicing software was used on the model making infill a less distinctive trait.

The dimensional analysis involved comparing the part's physical measurements with the computer-generated model to find the accuracy of the print. The exterior measurements along with the added features of the extruded ring and the hole cut in the center were analyzed.

The breakaway supports, shown in Figure 1 in blue, which are similar to scaffolding during a building's construction, help create overhangs and are removed upon completion. Different

software uses different patterns for these supports and they are not modifiable, making them a particularly identifiable characteristic in tracing the 3D model back to its source.

The last group of characteristics that were analyzed were physical features that appear on the printed part that were not on the computer-generated model. Such features are known in the 3D printing community as “stringing”, as shown in Figure 2. Stringing is generated by leftover filament on the printer’s extruder that is dragged along as the 3D model is printed.

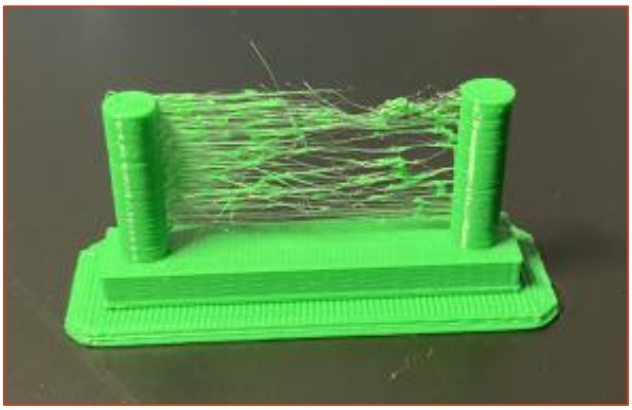

Figure 2: Stringing Example

The results thus far are inconclusive. Eight 3D printers along with seven different slicing software programs were used in generating and testing the 3D models. Four printed parts were printed per printer, yielding a total of 32 parts included in the analysis. Given the small sample size, the data are not definitive in terms of source, based on the characteristics tested. The summary of the results can be seen in Table 1.

Table 1: Summary Results Summer 2021 Data

#	Printer	Software	Material	Stringing	Dimensions (mm)					
					Avg X	StDev	Avg Y	StDev	Avg Z	StDev
0	N/A	SolidWorks	N/A	N/A	37.00	0.00	25.00	0.00	25.00	0.00
1	Makerbot Replicator #4	Makerbot Print	PLA	Y	36.99	0.12	24.94	0.07	25.13	0.03
2	Ultimaker S5 #1	Cura	PLA	N	37.05	0.01	25.17	0.03	24.91	0.01
3	Stratasys F170 #1	GrabCad	ABS		37.18	0.02	25.20	0.05	25.46	0.09
4	Prusa i3 MK3 #1	Prusa Slicer	PLA	Y	36.94	0.01	24.97	0.02	24.96	0.01
5	Prusa i3 MK3 #2	Prusa Slicer	PLA		37.00	0.01	24.99	0.02	25.25	0.02
6	FormLabs 3B #1	FormLabs Slicer	Tough 1500 Resin		37.29	0.05	25.15	0.09	25.00	0.01
7	Markforged Onix #1	Eiger	Onyx	N	36.93	0.01	25.00	0.06	25.00	0.05
8	Monoprice Maker Select V2	Cura IIIP Edition	PLA	Y	37.03	0.06	25.00	0.09	25.35	0.08

Future work with a larger sample is needed to study how the tested characteristics would provide sufficient information to trace the printed part back to its printer of origin. In addition, image processing of the infill patterns to help with accelerated analysis and further crowdsourcing would help in bringing more definitive patterns to light.

References

Chase, Ruby J., Laporte, Gerald "The Next Generation of Crime Tools and Challenges: 3D Printing." *National Institute of Justice*, pp. 6-8. https://www.ncjrs.gov/pdffiles1/nij/250697.pdf. Accessed 17 Mar. 2021.