Steganography in G-Code Extruder Commands, Part II

In Part One I replaced only the two least significant digits of the decimal places of the extruder commands and the result was that the byte-correspondence histograms for the modified g-code file and the original g-code file were identical. The cubes printed with the modified g-code file were indistinguishable from the cubes printed with the original file. The conclusion was that hiding a message in g-code extruder commands is a viable form of steganography. For further experimentation, in Part Two, I replaced the three least significant decimal digits and all five decimal digits. In Part One, only 63% of the extruder commands were modified, so an additional change for Part Two was to modify 99% of the extruder commands.

The results of these changes show how sensitive the byte-correspondence histograms are to changes within the g-code file. Previously, I had modified the ASCII values of the message characters to clamp them between 0 and 97, and used 99 as an end-of-message sentinel, because I only had two decimal places to work with. In Part 2, I did have this limitation and therefore did not have to modify the ASCII values. However, this limited the third decimal place to 0 or 1 (when replacing the three least significant digits) and the first decimal place to 0 or 1 (when replacing all five decimal places). These changes to the file, as well as the tacking-on of extra zeros (when replacing all five decimal places) are apparent in the byte-correspondence histograms.

In Part Two, the cubes printed with the g-code file in which the three least significant digits had been modified were indistinguishable from the cubes printed with the original file. However, the cubes printed with the file in which all of the decimal digits had been replaced showed artifacts of the modifications in the file.

To see what this would look like in a larger print, I modified the g-code for a soap dish in the same manner and printed the files. The first one was the unmodified g-code, and the second one, printed with the three least significant digits replaced, was identical to it. However, the third soap dish, printed with all decimal digits replaced, had a blobby textured surface, the result of changing the extruder commands too much.

In comparing Part One to Part Two, it appears that Part One is the better method of steganography, since the byte-correspondence histograms were identical for Part One, but Part Two shows slight differences in the byte-correspondence histograms.