CNC Titanium Anodization with a Modified Consumer Desktop FFF 3D Printer

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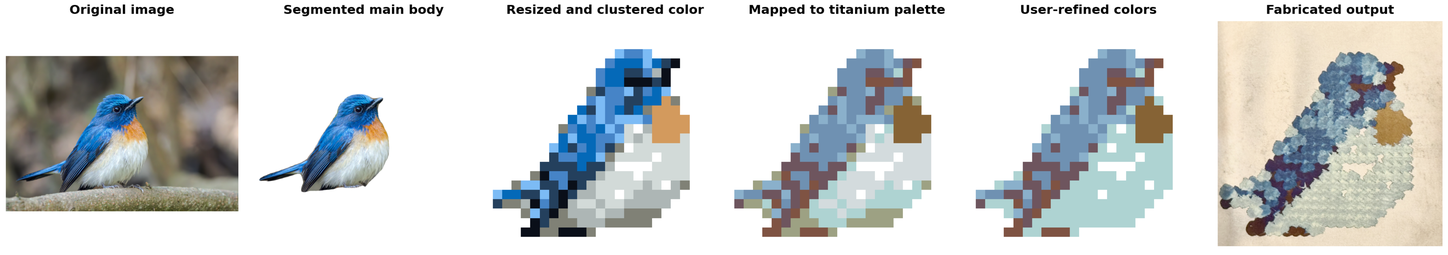


Abstract

We present a low-cost system that transforms user images into anodized titanium prints using a modified desktop FFF 3D printer. The pipeline integrates image processing, perceptual color mapping, and pixel-based anodization to reproduce multicolored images directly on titanium surfaces. In contrast to prior hobbyist methods that depend on manual and unsafe techniques, our approach automates the workflow from color mapping to G-code generation, providing a safer and more reliable process that can be easily replicated on other setups. This work shows how accessible digital fabrication tools can be adapted to broaden creative expression in metals and lower the barrier to advanced finishing techniques.

Contributions

- First accessible automated pipeline for titanium anodization.
- Safe and replicable using a standard consumer 3D printer.
- Demonstrates creative applications and re-purposing of accessible digital fabrication tools for makers and artists.

Hardware Setup

A Bambu Lab A1 mini was modified with a soft-tipped conductive pen toolhead and connected to a manual DC power supply (0-110V). The electrolyte is a baking soda solution, ensuring conductivity and safety.

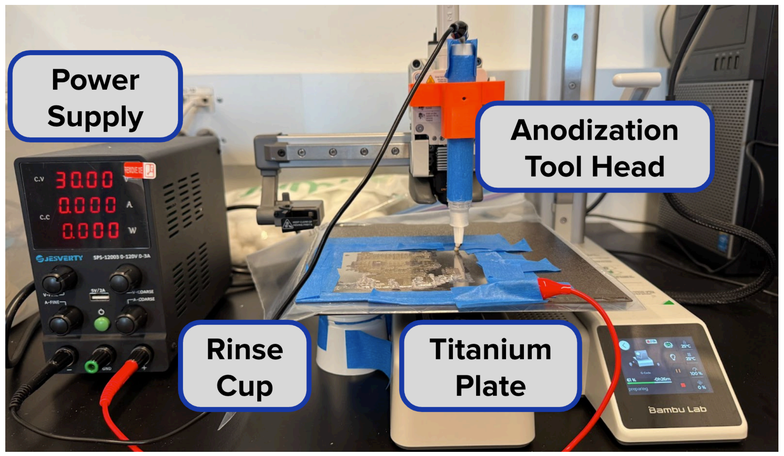


Figure 1. Image for a 3D printer modification and anodization toolhead setup.

Color Calibration

Voltages from 15V to 65V yield distinct, stable colors. Low voltages are faint; high voltages could create electric sparks and are too dangerous.

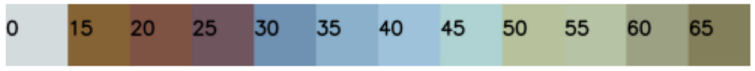


Figure 2. Experimentally derived titanium color palette.

Software Pipeline

1. Resize input image to 32 by 32 pixels
2. Cluster into 10 colors using k-means
3. Map to the titanium palette in CIE Lab space using the CIEDE2000 metric
4. Generate G-code sorted by voltage levels, pause is inserted for manual voltage change between colors

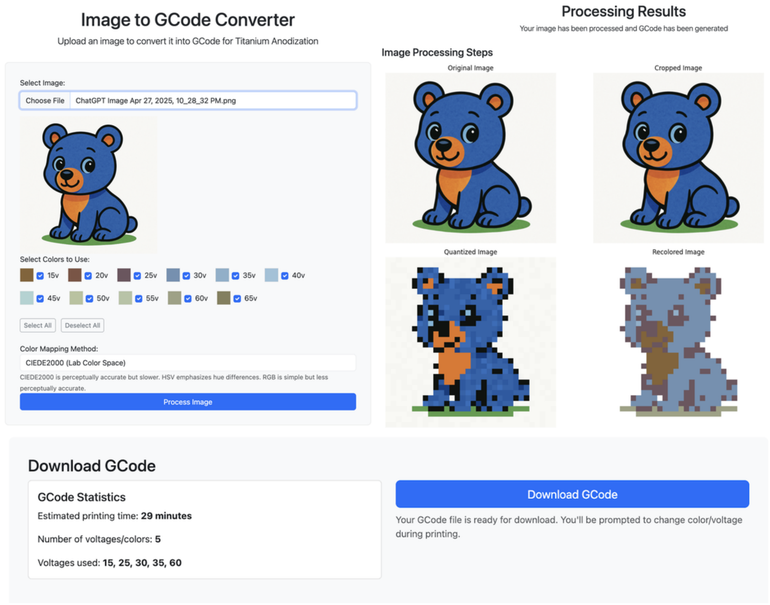
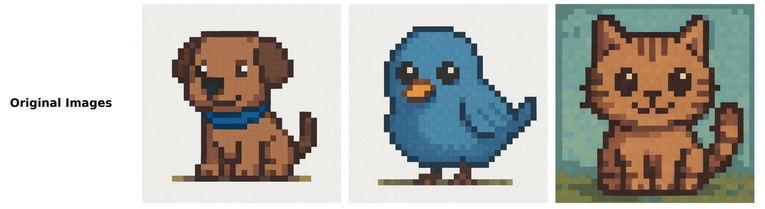


Figure 3. Web user Interface. Top left: Input image and select which color to use. Top right: Image processing results. Bottom: color used, time estimation, and G-code download.

Fabrication Results and Conclusion

Each 32 by 32 image produces 700 to 1000 dots on a 100 mm titanium plate. Prints took 40 to 100 minutes, depending on pixel count and voltage variation.



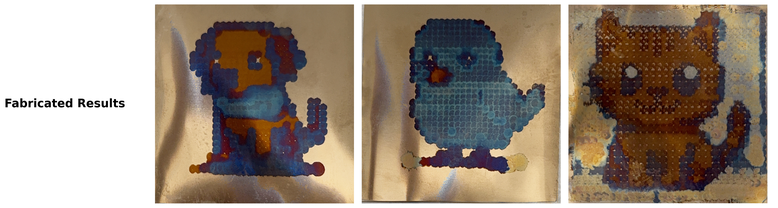


Figure 4. Fabrication results of 3 different input images.

Our system enables safe, low-cost titanium anodization using a modified consumer 3D printer, automating the image-to-anodization pipeline. We demonstrated creative ways of re-purposing existing digital fabrication tools to expand artistic expression on metal surfaces finishing.

Acknowledgments

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