Computer Vision for Closed Loop Control of 3D Printing

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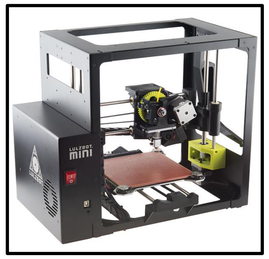
Abstract

Process control in 3D printing (known as Additive Manufacturing) has largely been absent in production systems. Simultaneously, computer vision has become more accessible with open source libraries. Relatively high performance computation can be realized with a Linux board costing less than $40 USD and a USB camera costing $30 USD. 3D printing is particularly well suited to be enhanced by computer vision as the fabrication is layer wise and predictable, assuming correct operation. Structures are created with Computer Aided Design (CAD) that were at risk of structural failure and potential delamination. Profiling of the structure in fabrication can easily identify occurrences of delamination of the structure. Information from detected delamination is then used to modify design and temperature of extrusion material to prevent future errors.

Overview of Lulzbot Mini 3D Printer

The Lulzbot Mini desktop 3D printer is meant for home users or those seeking easy operation. The printer can operate with easy to install software and costs $1,250 USD. The filaments used are made of either plastic, wood, or metal fibers.

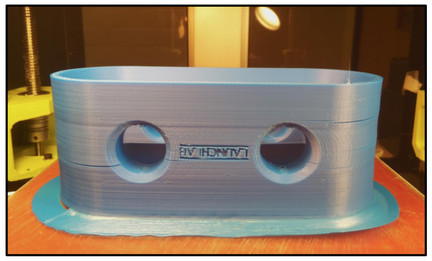


Motivation

- Traditional 3D printing uses open loop control – BLIND
- Press “print” and hope for the best.
- Open Source Computer Vision
  - just drove a car across California autonomously
  - Powerful and inexpensive
- Open Source Hardware
  - $30 for Linux computer Raspberry Pi.
  - $30 for camera
  - Linux computer can run 3D printer as well as perform CV

Choose Ohio First

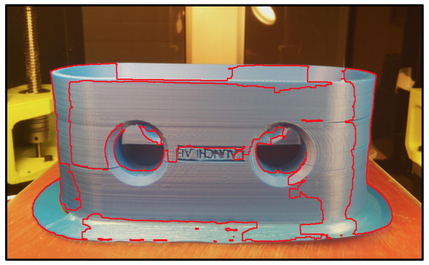
Detection of Delamination



An image such as the one shown is taken between each layer that is printed, and then run through Open CV using the following functions.

Detection of blue in the image is shown. The shade of blue detected can be edited manually based on lighting and other variables.

A grayscale version of the image is used to show areas of variation of the color previously detected, or the derivative of the previous image.



Using Canny, red lines are displayed to show any detection of possible delamination. Parameters could be added to show a more accurate display of delamination.

Purpose

The detection of delamination would prevent structural failures in 3D printed parts and would also prevent any possible damage to the printer if an error were to occur. By using Open CV to detect delamination, adjustments could be made to the temperature of material extruded and the rate at which that material is extruded to prevent more instances of separation between layers. A small part on a home printer can take up to 4 hours to print and use quite a bit of material, which means a structural failure would not only waste time but it would also waste valuable material. By detecting delamination, time and material waste can be prevented.

Conclusion

By using Open CV, we were able to detect two instances of delamination on the part shown. However, we would like to further our research by adding parameters to the image that is captured, so that way edges of the object are not shown as delaminated like they are on our final image. This would also allow for the exclusion of support material to be mistakenly detected.

Acknowledgements

America Makes

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