Increasing 3D Printing Accessibility Through a Low-Cost, Automated Workstation

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Background

Rapid prototyping technology is currently staged to revolutionize manufacturing by allowing on-demand, one-off production of parts without the extensive setup required by traditional manufacturing methods. 3D printers, for instance, can automatically fuse or deposit a material (e.g. plastic, metal, paper) to form complete products based on computer assisted drawing (CAD) models.

Over the past decade, 3D printers have become increasingly versatile, available, and cost effective. Start-up companies have begun to sell 3D printer kits that are affordable to enthusiasts. With minimal training, individuals can now assemble desktop-sized machines, download or create CAD models, and print plastic parts (anything from kitchenware to replacement cell phone parts) at home. To effectively reach the consumer market, however, 3D printers must become more accessible, user-friendly, and automated.

Purpose

The 3D Printing Creative Inquiry group at Clemson University is developing a low-cost rapid prototyping system easily accessible to students on campus for personal and academic projects. The goals have been twofold: the evaluation and construction of several 3D printer designs and the creation of a printing station which can operate with minimal outside intervention. The end objective is a rapid prototyping "vending machine" to automatically print and distribute uploaded designs from users.

Design/Method

A multidisciplinary team of engineering and science students evaluated existing 3D printing technology and identified a niche of budget devices which create parts by heating and extruding polymer filaments in layers. Two contrasting designs, available for purchase as unassembled kits, were selected to meet desktop size constraints and affordability targets. In both designs, stepper motors move an extrusion nozzle to create solid parts within a $200mm^3$ print window. The pyramidal RepRap Prusa Mendel printer has open-source plans and software, can reproduce most of its own components, and deposits layers on a heated platform. The cube-shaped Bits from Bytes RapMan is a proprietary design, optimized for easy assembly and capable of printing directly from a flash drive. Components were acquired and assembled throughout 2012.

Simultaneously, the "vending machine" concept was developed to pair and automate the two printers once assembled. 8-bit chips control the 3D printers, and a similar IO board (Arduino) was used to interface vending machine hardware to central server. C and Matlab programs were developed to combine user interface elements, printer microcontrollers, sensor hardware, vending machine actuators, and web server controls.

Results

Printer hardware assembly was completed in Fall 2012, revealing design tradeoffs between the open-source (Mendel Prusa) and proprietary (RapMan) 3D printers. The Mendel provided greater customization options and a large community of enthusiasts, yet components, manufactured using other 3D printers, presented compatibility, tolerance, and calibration challenges. The RapMan was a more complete package—straightforward to assemble, yet more difficult to modify or interface with the non-proprietary vending machine system.

Vending machine infrastructure was created to receive remote commands, provide online monitoring, verify user identities, and control hardware. Users can remotely email commands to the printer system, receive status notifications. At the central console, a radio frequency identification (RFID) reader allows students to scan their ID cards, uniquely associating them with their print job and activating linear actuators which grant access to the machinery.

Conclusions

Just as conventional paper printing has become universal in homes and offices, 3D printing is poised to become similarly universal and user-friendly with the development of systems like the rapid prototyping "vending machine." In this project, a team of undergraduates with no prior experience were able to construct two cost-effective 3D printers. Simultaneously, the team developed and demonstrated an automation system intended as a step to transform rapid prototyping from a laboratory phenomenon to a publically accessible convenience. In the future, the team will complete system development and testing in order to install a complete "vending machine" printer workstation on the university's campus.