
Brick-Printing Technologies for *in-situ* Smart Structure Fabrication

Jeffrey I Lipton

Cornell Computational Synthesis
Laboratory
Sibley School of Mechanical and
Aerospace Engineering
Cornell University
Ithaca, NY 14853 USA
jil26@cornell.edu

Hod Lipson

Cornell Computational Synthesis
Laboratory
Sibley School of Mechanical and
Aerospace Engineering
Computing and Information
Science
Cornell University
Ithaca, NY 14853 USA
hod.lipson@cornell.edu

Abstract

Multi-material, three dimensional printing (3D printing) allows for the seamless integration of sensors, systems and structure. It is a scalable interchangeable platform which will allow for intelligent buildings and use a developed hardware platform. The platform will enable teaching and learning about the subject. The printing of interlocking bricks, with embedded systems, allows for the creation of structures of great size and high detail. The basic research into materials and techniques for the three dimensional printing of dynamical systems and architectural elements has already been completed. The combination of different printing materials and techniques can produce novel architectural elements and systems which provide unique geometries and uses.

Keywords

Three Dimensional Printing, Fab@Home, Architectural Robotics, Solid Freeform Fabrication

ACM Classification Keywords

H.1.2 User/Machine Systems, H.5.3. Group and Organization Interfaces, I.2.9 Robotics

3D printing, or Solid Freeform Fabrication (SFF), is the layered creation of objects by adding material into a desired shape. This is done without the need for forms or specialized tooling. Often these layers are fused together through a variety of means (laser heating, conventional heating, adhesive, etc.). Traditionally, SFF processes are used to create small objects that are limited in size by the printer. Several large scale printers exist to make structures. [2]

Using the Fab@Home printer, bricks have been made of conventional ceramic bricks and gypsum cement. Bricks allow for a structure to be larger than the printer. The Fab@Home printer allows for the creation of multi-material objects. This allows a printed object to be functional rather than static. Fluidic and electrical conduits have been printed, enabling the creation of structural bricks that contain an edifice's plumbing and wiring pre-installed [5].

Strain gauges, thermocouples, actuators, batteries and transistors have been printed [1][3][4]. The sensors can provide a wealth of information throughout the structure. Distributed logic could give the buildings 'reflexes' which react instantly to catastrophic failures (pipe bursts, power outages, fires). Actuators can give buildings a new level of life by allowing them to move. Printed Morphing structures could automatically change a room's shape to meet its functional need and modify acoustics.

The Fab@Home system would be an excellent platform for teaching and learning about architectural robots. It will allow students to scale down a building's elements and print them out using the actual building materials

to see how the overall structure will look feel and function.

Conclusions

3D printed smart bricks provides a versatile and exciting platform for implementing architectural robotics. It offers the ability to create new dynamical systems that seamlessly combine technologies from vastly different fields. The Fab@Home platform presents a means of educating students and providing the infrastructure needed to realize all the possibilities printing has to offer architecture.

References

- [1] Mallon, Evan. *Dissertation: Freeform Fabrication of Complete Electromechanical Devices*. Ithaca NY : Cornell University, 2008.
- [2] Khoshnevis, Behrokh. Automated Construction by Contour Crafting. *Journal of Automation in Construction*. 2004, Vol. 13, 1.
- [3] L. Sun, K.J. Jakubenas, J.E. Crocker, S. Harrison, L.L. Shaw, and H.L. Marcus. *Fabrication of In-Situ SiC/C Thermocouples by Selective Area Laser Deposition*. Proc. Solid Freeform Fabrication Symposium, 1997.
- [4] Mallon, Evan. *Fab@Home*. <http://fabathome.org>.
- [5] Lipton JI, Cohen DL, Lipson, H. *Brick Printing: Freeform Fabrication of Modular Architectural Elements with Embedded Systems*. Proc. Solid Freeform Fabrication Symposium, 2009