The Bleeding Edge of 3D Printing and Digital Fabrication

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1. Introduction

This presentation provides an overview of recent advances in 3D printing and digital fabrication. At the heart of these processes is the desire to translate three-dimensional objects designed in the virtual space of the computer into tangible objects. Additive and subtractive processes at a staggering array of scales are being used in a variety of disciplines to produce tangible prototypes and sculptures with increasingly varied functional and material properties—from electronic circuits at nanometer scales, to biological substrates, to high-density tooling, to architecturally-scaled structures and functional firearms.

2. Discussion

With respect to additive technologies, advances in the range of materials available for prototyping permit resolutions as fine as 6 microns (e.g., Solidscape's wax deposition process). At the other extreme, architecturally scaled elements have been successfully created using masonry extrusion devices developed at the University of Southern California (Khoshnevis, 2013). The market for low cost systems, below $1000 US, has exploded (Vance, 2011). High end systems such as the Objet Connex 3D Printer from Stratasys uses multiple materials in one printed prototype to create composites with distinct, predictable material properties (see http://www.stratasys.com/3d-printers/design-series/precision/objet-connex500). In material science labs, structures in the 50 nm range using a combination of Focused Ion Beams (FIB) and Scanning Electron Microscopy (SEM) have been realized (FEI, 2013).

Advances in subtractive processes include expanded material palettes, high speed cutting, and novel software applications. The work of Don Vance **(Figure 1)** utilizes a custom algorithm developed in Grasshopper (a Rhino3D plug-in) to automate the processes of 3D solid model analysis, facet intersection, and manufacturing. Refinements in digital stone carving yield unprecedented opportunities for sculptors and designers. High speed mills cut machine time by several orders of magnitude.

4. Future Research

Functional prototypes in materials ranging from hard steel to flexible rubbers to biological substrates are already possible. The new unit of choice for designers may be the "voxel"--a neologism that combines the words "pixel" and "volume." Design environments using voxel data sets will soon allow an operator to specify not only volumetric information, but material or physical property characteristics. Imagine a knife blade custom crafted to different specified levels of flexibility and density (Collins 1997, Oxman 2011).

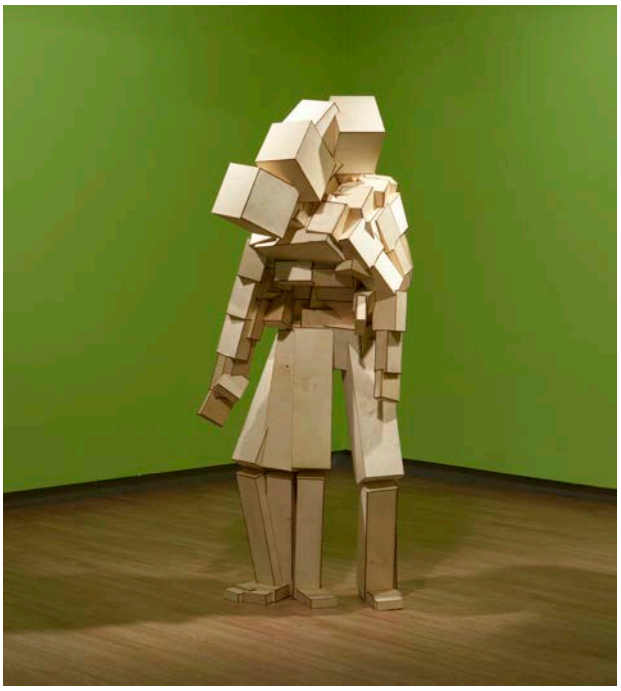

Figure 1. Don Vance. *Delivery.* Laser cut birch ply. Sculpture created using 3D Studio Max and custom Rhino/Grasshopper routine

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