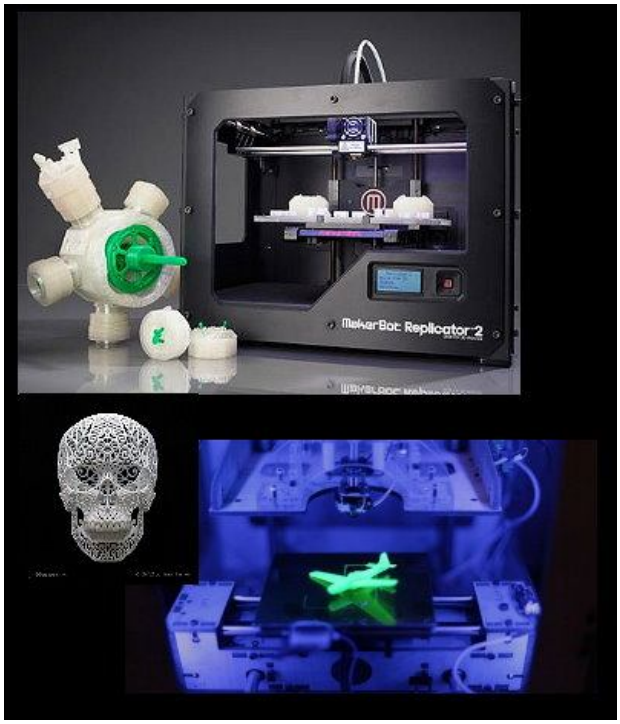
3-D Printing Made Plain

by Des Nnochiri (reprinted 26 March 2014)



3D printing, or **additive manufacturing** is the process of making three dimensional solid objects from a digital model.
It is achieved using **additive processes**, where an object is created by laying down successive layers of material.

3D printing is considered distinct from traditional machining techniques which mostly rely on the removal of material by methods such as cutting and drilling - and are known as **subtractive processes**.

You've seen the movie, "Iron Man"?

The scenes where Tony Stark (Robert Downey, Jr.) draws up bits of his superhero armor on a snazzy 3-dimensional computer display, before the Artificial Intelligence called Jarvis puts the pieces into production?

The design process is like that.

3D printing is usually performed by a **materials printer** using digital technology.

The technology is used in jewelry, footwear, industrial design, architecture, engineering and construction (AEC), automotive, aerospace, dental and medical industries, education, geographic information systems, civil engineering, and many other fields.

The fabrication of the finished pieces is usually achieved by the **extrusion** of a pliable material.

Basically, you take a gloopy substance (like molten plastic), or a granular material (like cement dust) that can be put down in layers.

You squeeze or blow it out through a tube (that's the extrusion bit), along the contours of a design drawing.

And you build up a model. In layers.

Them's the basics.

Now, let's look at some of the science.

Some History, First

The term "3D printing" was coined at MIT in 1995 when then graduate students Jim Bredt and Tim Anderson modified an inkjet printer to extrude a binding solution onto a bed of powder, rather than ink onto paper.

The resulting patent led to the creation of modern 3D printing companies Z Corporation (founded by Bredt and Anderson, and now owned by 3D Systems) and ExOne.

Additive versus Subtractive Manufacturing

In manufacturing, and machining in particular, subtractive methods are typically known as traditional methods. The term subtractive manufacturing is itself a retronym developed in recent years to distinguish it from the newer additive manufacturing techniques.

Machining (generating exact shapes with high precision) has typically been subtractive - from filing and turning, to milling and grinding.

Fabrication has included methods that are essentially "additive" for centuries - such as joining plates, sheets, forgings, and rolled work via riveting, screwing, forge welding, or newer kinds of welding.

The information technology component of model-based definition is new.

Objects that are manufactured additively can be used anywhere throughout the product's life cycle, from pre-production (i.e. rapid prototyping) to full-scale production (i.e. rapid manufacturing), in addition to tooling applications and post-production customization.

3-D Fabrication

Personal manufacturing machines (or f**abricators**) are known as "fabbers" or "3D fabbers".

Construction of a model using traditional methods can take upwards of several hours to several days, depending on the method used, and the size and complexity of the model.

Additive systems can typically reduce this time to a few hours - although it varies widely, depending on the type of machine used and the size and number of models being produced simultaneously.

Traditional techniques like injection molding can be less expensive for manufacturing polymer products in high quantities, but additive manufacturing can be faster, more flexible and less expensive when producing relatively small quantities of parts.

3-D Design and Model Slicing

Additive manufacturing takes **virtual blueprints** from **computer aided design** (**CAD**) or animation modeling software and "slices" them into digital cross-sections for the machine to successively use as a guideline for printing.

Depending on the machine used, production material or a binding material is deposited on the **build bed** or **platform** until material / binder layering is complete, and the final 3D model has been "printed."

It is a **WYSIWYG** process (**What You See Is What You Get**), where the virtual model and the physical model are almost identical.

To perform a print, the machine reads the design and lays down successive layers of liquid, powder, or sheet material to build the model from a series of cross sections.

These layers (which correspond to the virtual cross sections from the CAD model) are joined together or automatically fused to create the final shape.

The primary advantage of this technique is its ability to create almost any shape or geometric feature.

The User Interface

The standard data interface between CAD software and the machines is the **STL file format**.

An STL file approximates the shape of a part or assembly using **triangular facets**. Smaller facets produce a higher quality surface.

PLY is a scanner generated input file format, and VRML (or WRL) files are often used as input for 3D printing technologies that are able to print in full color.

Printing

Printer resolution describes layer thickness and X-Y resolution in **dpi** (**dots per inch**), or **micrometers**.

Typical layer thickness is around 100 micrometers (0.1 mm), although some machines such as the Objet Connex series and 3D Systems' ProJet series can print layers as thin as 16 micrometers.

X-Y resolution is comparable to that of laser printers. The **particles** (3D dots) are around 50 to 100 micrometers (0.05 - 0.1 mm) in diameter.

3D printers give designers and concept development teams the ability to produce parts and concept models using a desktop size printer.

Technologies Used

A number of additive manufacturing technologies are available. They differ in the way layers are deposited to create parts, and in the materials that can be used.

Some methods melt or soften material to produce the layers, e.g. **selective laser sintering** (**SLS**) and **fused deposition modeling** (**FDM**).

Others cure liquid materials using different sophisticated technologies, e.g. **stereolithography** (**SLA**).

With **laminated object manufacturing** (**LOM**), thin layers are cut to shape and joined together (e.g. paper, polymer, or metal).

Some additive manufacturing techniques are capable of using multiple materials in the course of constructing parts.

Some also utilize supports when building. Supports are removable or dissolvable upon completion of the print, and are used to support overhanging features during construction.

Each method has its own advantages and drawbacks, and some companies offer a choice between powder and polymer for the material from which the object is built.

The main considerations in choosing a machine are generally speed, cost of the 3D printer, cost of the printed prototype, and cost and choice of materials and color capabilities.

For example, printers that work directly with metals are expensive. In some cases, less expensive printers can be used to make an injection mould, which is then used to make metal parts.

Printers for Domestic Use

There are several projects and companies making efforts to develop affordable 3D printers for the home desktop.

RepRap is a one of the longest running projects in the desktop category.

The RepRap project aims to produce a **free and open source software** (**FOSS**) 3D printer, whose full specifications are released under the GNU General Public License, and which can print many of its own parts (the printed parts) to create more machines.

As of November 2010, the RepRap can print plastic parts, and requires motors, electronics, and some metal support rods to be completed.

As of 2012, several companies and individuals are selling parts to build various RepRap designs, with prices starting at about €400 (US$500).

Many related projects have used the RepRap design for inspiration, creating an ecosystem of related or derivative 3D printers, most of which are also open source designs. The availability of these open source designs means that variants of 3D printers are easy to invent.

The open source Fab@Home project has developed printers for general use with anything that can be squirted through a nozzle - from chocolate, to silicon sealant, and chemical reactants. Printers following the project's designs have been available from suppliers in kits or in pre-assembled form since 2012 at prices in the US$2000 range.

The price of printer kits can vary from US$400 for the open source SeeMeCNC H-1 and US$500 for the Printrbot (both derived from the previous RepRap models), to over US $2000 for the Fab@Home 2.0 two-syringe system.

The Solidoodle 2 - a 6x6x6 inch printer - is available fully assembled for US$499.

Mass Customization

Companies such as MakieLab and Kodama Studios have created services where consumers can customize objects using simplified Web-based customization software, and order the resulting items as 3D printed unique objects.

Advocates of additive manufacturing predict that this arc of technological development will counter globalization, as end users will do much of their own manufacturing rather than engage in trade to buy products from other people and corporations.

As an example of possible future applications, an open source group emerged in the US in 2012 that was attempting to design a firearm that was downloadable and printable from the Internet. The weapon would still require bullets produced by traditional methods.

Calling itself Defense Distributed, the group wants to facilitate "a working plastic gun that could be downloaded and reproduced by anybody with a 3D printer".

What If I Don't Want A Plastic Gun?

Okay. How about a plastic house?

Or a personalized chocolate treat?

Or a cover, for your mobile phone?

We'll be looking at some projects that aim to bring each of these to fruition.

Next time.

Till then.

Peace.

Post Tags: 3-D Printing, Additive manufacturing, Additive processes, Subtractive processes, Materials printer, Extrusion, Jim Bredt, Tim Anderson, Z Corporation, 3D Systems, ExOne, Machining, Fabrication, Personal manufacturing machines, Fabbers, 3D fabbers, Virtual blueprints, Computer aided design, CAD, Build bed, Platform, WYSIWYG, What You See Is What You Get, STL, PLY, VRML, WRL, Dots per inch, dpi, Micrometers, Selective laser sintering, SLS, Fused deposition modeling, FDM, Stereolithography, Laminated object manufacturing, LOM, Free and open source software, FOSS, RepRap, Fab@Home, SeeMeCNC H-1, Printrbot, MakieLab, Kodama Studios, Defense Distributed

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