3D printing mathematical surfaces

Alba Málaga

November 28, 2022
What is 3D printing?

▶ A new technology
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⇒ cheaper and cheaper
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  ⇒ public domain
  ⇒ cheaper and cheaper
  (other 3D printing technologies remain expensive)
How expensive is FDM 3D-printing?

A “turnkey” Ultimaker: \( \sim 2000 \text{ EUR} \)
How expensive is FDM 3D-printing?

A Reprap-like 3D-printer in kit: ~ 200 EUR

Example: The $\mu$Delta from eMotion Tech
How expensive is FDM 3D-printing?

**Supplies:** PLA (corn plastic) spools cost ~ 30 €/kg
How does 3D printing work?

Focus here: FDM technology (ask me about “powder” printers)
How does 3D printing work?

Plastic wire pulled by tiny motor,
How does 3D printing work?

Plastic wire pulled by tiny motor, “print head” = “nozzle” heats it,
How does 3D printing work?

Plastic wire pulled by tiny motor, “print head” = “nozzle” heats it, wire gets deposited along 2D designs, layer by layer
How does 3D printing work?

Together the layers make the 3D object: 10 wraps/mm
Thus, how do we get a 3D surface out of its equations?

What software? What filetypes?
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1. **Mesh**  Compute mesh from equation using SageMath, MathMod or similar; save result typically into .obj, .ply or .stl file.

2. **Solid** If surface not "watertight", i.e. does not enclose volume, thicken it using Blender. Export result as .stl file.

3. **Slice** To tell the nozzle what path to follow, which is the only thing that the 3D-printer understands directly, use a slicer like Cura (install it) or IceSL (online), giving a .gcode file.

These are the three basic steps when everything goes fine.
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Do you wanna dive in?
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Get inspired: a tour of contemporary mathematical creation
Mathematical galleries
by silviana amethyst

mixed media

Interactive Barth Sextic
A 3d printed electronic Arduino-powered interactive art piece. Much of my current work is in this vein.

plastic

Hauser's algebraic surfaces
a reproduction in plastic of Herwig Hauser's gallery
Children of the Magic Tangle
with
Triples of Two-Bridge Fillings

Family $A_{m,n}$ - "Whitehead's Nieces"
Ken Brakke – facstaff.susqu.edu/brakke

Susquehanna University

Ken Brakke
Mathematics Department

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Phone: 570-312-4466
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Email: brakke@susqu.edu

Office Hours (Spring 2016):
- MATH 110: Introduction to Statistics, 3:00-4:00 PM, Fisher 308.
- MATH 211: Linear Algebra, 10:00-11:50 AM, Fisher 217.
- MATH 221: Multivariate Calculus, 8:45-9:50 AM, Fisher 104.

Class schedule, Spring 2016:

The Surface Evolver
Version 2.78, August 29, 2013

My Surface Evolver is an interactive program for the modeling of liquid surfaces shaped by various forces and constraints. The program is available free of charge.

Book on Microdroplets, using Surface Evolver
Jean Bethier and I have collaborated on a book about the behavior of liquid in microfluidic circumstances. Over a hundred Evolver models, available for download from the book's website (if you buy the book).

Plateau's book translated into English
The result of my amateur attempt to translate Joseph Plateau's famous 1873 book on soap films and surface tension.

Random Fractals
Arnaud Chéritat

A model of Boy’s surface in Constructive Solid Geometry

What is it about?

Take the following pieces

All pieces are obtained from the following primitive shapes: torus, cylinder, planes, and a sphere, and elementary operations: intersection, difference, union, ... (that’s constructive solid geometry). Now glue them together as follows:

Selection:

Direction de recherches (CNRS) à l’Institut de mathématiques de Toulouse

Parens, CV

Publications, prépublications.

Gestion du TMM ABC

Dégazettage

Travaux, documents et réalisations accessibles sur cette page web :

Les manuscrits de Herman, tapés en français et en anglais.

Quelques illustrations mathématiques

Caléris I: Fractals.

Caléris II: Dynamique holomorphe et analyse complexe.

Caléris III: Géométrie.

Animations mathématiques

Applets java: liens vers mon travail de programmation en Java.

Logiciel: traçant ensembles de Julia et Mandelbrot, Windows 98 (32K0), ©1999 Arnaud Chéritat

Logiciel (work in progress: Snapshot (80K0)) didactique pour explorer la dynamique du z^2 + c, Windows XP.


Page web de la conférence en honneur des 70 ans d’Adrien Douady (du 9 au 11 mai 2006).

Troussou.
22. Mathematical models

clebsch surface model with spheres

some images of the clebsch surface model with spheres file available on shapeways

Nov 16, 2014 | Have your say »

clebsch surface model with pentahedron

some images of the clebsch surface model with pentahedron file available on shapeways

Nov 16, 2014 | Have your say »

clebsch surface model with 3 horizontal planes and spheres and pentahedron

some images of the clebsch surface model with 3 horizontal planes and spheres and pentahedron file available on shapeways

Nov 16, 2014 | Have your say »

clebsch surface model with 3 horizontal planes

some images of the clebsch surface model with 3 horizontal planes file available on shapeways

Nov 16, 2014 | Have your say »

clebsch 23 rods + 31 spheres

some images of the clebsch 23 rods + 31 spheres file available on shapeways

Nov 16, 2014 | Have your say »

numbered clebsch diagonal surface images

some images of the numbered clebsch file available on shapeways

Nov 16, 2014 | Have your say »

classical mathematical model recreation in rapid prototyping

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we were quite pleased to recently have our ongoing mathematical model work featured in joshua baton’s article in wired magazine. [...] Aug 31, 2014 | Have your say »

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mathematical models for sale on SHAPEWAYS

our decades long project to recreate portions of a classical mathematical model collection as rapid prototyping models which were originally [...]
Francesco de Comité
pro.univ-lille.fr/francesco-de-comite/

3D Printing

March 2014: 3D printed hats, based on the Cardioidal Variations, by Milliner Gabriela Ligenza (photos Josh Shiner)

Shortlisted at 3D Print Show Fashion Artist of the Year, Paris, October 2014.

Music

Marillion's "Sounds that can't be made" album cover
Welcome! I'm a designer for 3D printing, mostly in steel. Here you'll find sculpture, pendants, cephalopods, and laser etched glass.

**Laser Glass**
Scientific data laser etched in full 3D, inside cubes of clear glass. This begins where 3D printing leaves off. It handles intractable, unstructurable information with precision and grace.

**Crystal Proteins**
Got your own intractable data? At CrystalProtein I can put it in glass for you. Keychains to large awards, quantities one to hundreds. Proteins and small molecules are a specialty, but it's always interesting to see something different.
I am a research professor in the engineering school at Stony Brook University and a freelance mathematical sculptor/designer. I am always looking for interesting sculpture, lecture, and workshop opportunities. **Invite me!** I spent much of the past four years helping to create and design the [Museum of Mathematics](https://www.momath.org) in NY. Yes, I am related to (my daughter) V. Hart. An enormous amount of my work is freely available on my web pages. There are no ads. If you would like to support my mission of showing the world that math is cool, please feel free to make a donation.

This is a top-level table of contents into my hundreds of web pages:

- **Geometric sculpture** (I am a sculptor. Take a look and enjoy my work.)
- **My YouTube Videos** (showing math is cool)
- **Mathematical Impressions** – Video essays I am making for the [Simons Foundation](https://www.simonsfoundation.org) web site. ([activities](https://www.simonsfoundation.org/main-site/activities/mathematical-impressions/))
- **Puzzles** (I also design geometric assembly puzzles)
- **Making Math Visible** (classroom activities)
- Some Trip and Workshop Photos:
  - Lafayette College [Easton, PA, June, 2014]
  - Phillips Academy [Andover, MA, April, 2014]
  - Brown University [Providence, RI, March, 2014]
  - Gathering for Gardner Conference [Atlanta, GA, March, 2014]
  - TED talk at Wellesley [MA, Feb, 2014]
  - Sculpture Bann Raising at JMM Conference [San Antonio, TX, Jan, 2014]
  - Cardboard Construction at Goucher College [Baltimore, MD, Oct, 2013]
  - Cardboard Construction at St. Paul's School [Concord, NH, November, 2012]
  - Princeton University [October, 2013]
  - [MathCamp 2013](https://www.mathcamp.org) [Wabun, Maine, July, 2013]
  - [Alta University](https://www.altauni.edu) [Hilgard, CA, April, 2013]
  - Teacher's Workshop at Math for America [NYC, Feb, 2013]
  - Running for Office — Twenty Twelve [Alaska, HA, November 2012]
  - Cardboard Conjugation at SCSU [New Haven, CT, October 2012]
  - Cardboard Construction at the Bridges Conference [Princeton, NJ, July 2012]
  - Math for America [Hoboken, NJ, January 2012]
  - [Mathematical Impressions](https://www.mathematicalimpressions.com) [June 2012]
Geoffrey Irving

Ph.D. Computer Science, Stanford
B.S. Mathematics and Computer Science, Caltech
https://naml.us/blog
irving@naml.us

Research

My research interests include computational physics, computer graphics, compilers and languages, and games.

- Solving peritago on a supercomputer with online exploration of the results.

- Robust computational geometry using infinite series of deterministic pseudorandom perturbations (with Forrest Green).

- Fractal curves visualized as surfaces using the third spatial dimension to represent complexity (with Henry Segerman).
artistic practice

London Tsai

to the ends of the world, 2010, stainless steel, 28 x 14 x 14 in
T. Reepleks – thingiverse.com/treepleks
Saul Schleimer – homepages.warwick.ac.uk/~masgar

Saul Schleimer

Office: B2.14 Zeeman
Phone Number: 024 7652 3560
Email address: s.schleimer at warwick dot ac dot uk

Teaching: I am not teaching in term two. Past courses and students.
Office hours: (Term II, 2015-2016) Friday 1:00pm - 2:00pm and by appointment.
Seminars: The geometry and topology seminar. Past seminars.
Conferences: A meta-list of conferences.
Research: My research page, papers at the arXiv and at the Front, and reviews at MathSciNet (subscription only).
Exhibit and talks: Slides, videos, and/or other links for my art exhibit and various talks.
Junk: Various random links.
Warwick: Math department webpage.

Last touched: Tuesday, 7 April 2015 15:20:10 BST.

Quintessence

The goal of this family of burr puzzles, collectively called Quintessence, is to assemble collections of ribs into self-supporting structures. The ribs are shown immediately to the right.

The ribs are divided into three sets: Meteor, Pulsar, and Inflation. These are shown below right, in order and are also described in the table at the bottom of this page. The sets may be purchased from Shapeways.

http://shopw.me/sr6G
http://shopw.me/sr6Q
http://shopw.me/sr6F

Each rib is made from four, five, or six dodecahedral cells (1) in the cell-centered projection (c) of the spherical 120 cell to three-space. A puzzle receives the designation DcN where N counts the number of cells. Twelve of the many possible burr puzzles are pictured on the following pages.

In every case, assembling the puzzle relies on the ribs being slightly flexible. For some puzzles a very small amount of pressure may be needed to place the final rib. The ribs can be assembled into various interesting structures. The files for these puzzles are available here.
mathgrrl Designs
3D models and other geeky stuff

Perko Morph
Designed with KnotPlot, MeshLab, TopMod, and Meshmixer; 3D printed in full color powder with binder.

Giant Spiky Perko Knot
Designed with KnotPlot, TopMod, and Cura; 3D printed with FDM in Polylactic Acid with custom supports.
Recall: from equation to 3D printed surface

The 3 basic steps

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