3D Printing for Biomedical Research, Education, and Discovery

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National Library of Medicine / National Institutes of Health
U.S. Department of Health and Human Services

ROBOTS!

Heavy Metal making guitars for Heavy Metal

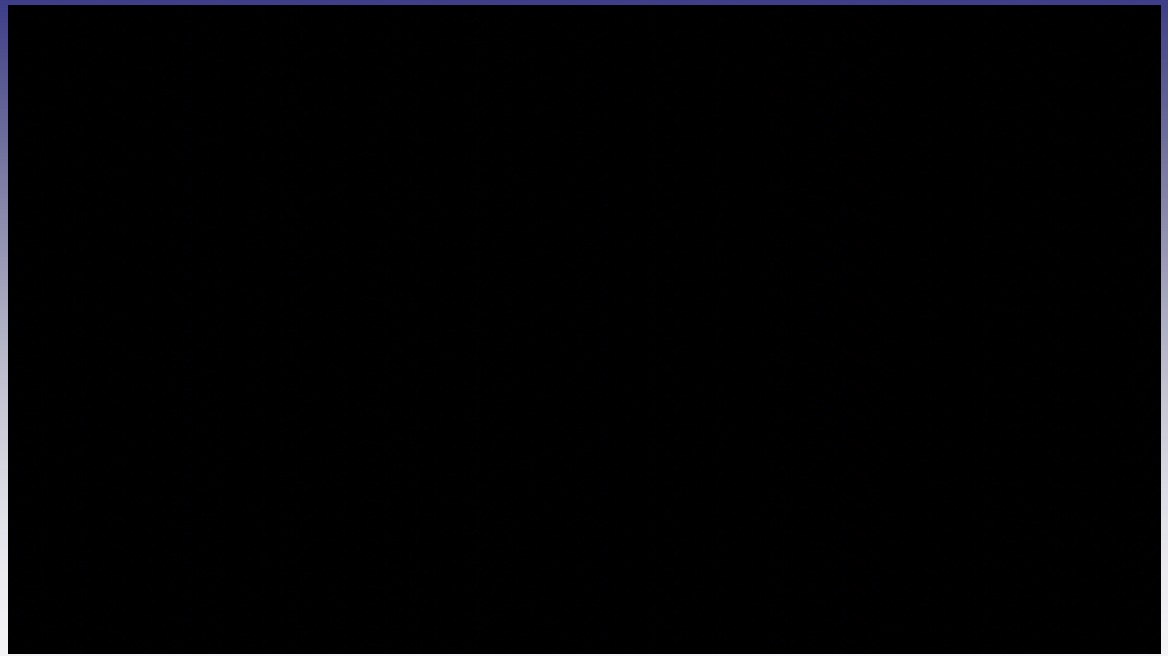
a Robotic Luthier –a Fadal at Paul Reed Smith Guitars, Fall 2013

CNC Machining

- Computer Numerically Controlled Machining
- Lathe, milling, etc.
- Subtractive
- Any material will do.

Computer Controlled Lasers

An example of Stereo Lithography (SLA), creating free-form parts from hardened epoxy resin.



Computer Controlled Lasers

An example of an EOS M 290 Selective Laser Sintering (SLS) system, creating a injection mold from maraging steel.

What does one of these SLS manufacturing printers cost?

$700,000

June 2014, reported price in Engineering.com Library

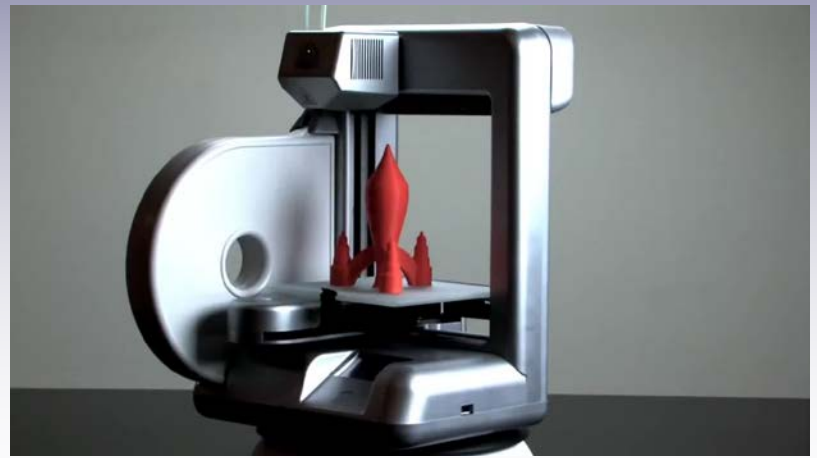
Fused Deposition Modeling (a.k.a. 3D Printing)

One example:

Cube 3D Printer

- From 3DSystems
- Prints in plastic
- $999 from Amazon.com

(24-September-2014)



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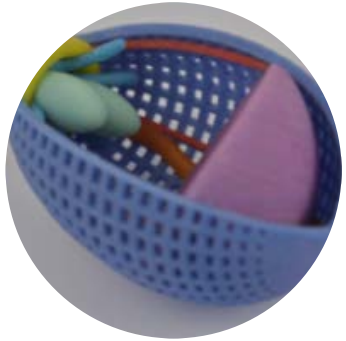
A community-driven portal to accurate, high-quality bioscientific models

MEDICAL & ANATOMICAL

CUSTOM LABWARE

PROTEINS, MACROMOLECULES, & VIRUSES

BACTERIA, ORGANELLES, CELLS, & MORE



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Volunteers use 3D printers to create inexpensive prosthetics

Thu, Sep 25 2014

By Daniel Gaitan

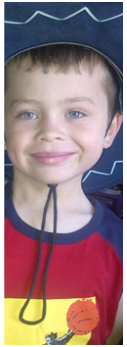
NEW YORK (Reuters Health) - An online organization of more than 1,500 volunteers is using 3D printers to produce prosthetic hands or fingers for people around the world who need them.

This Sunday, the group, called e-NABLE, will come together at the Johns Hopkins Hospital in Baltimore to further their goals of designing, printing and distributing their inexpensive plastic prostheses, in advance of an upcoming U.S. Food and Drug Administration public forum on 3D printing of medical devices.

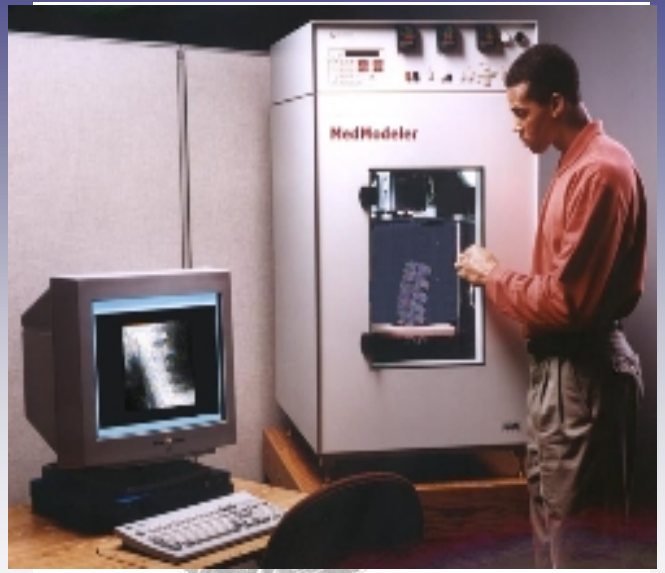
e-NABLE founder Jon Schull, a research scientist at New York's Rochester Institute of Technology's Center for MAGIC (Media, Arts, Games, Innovation and Creativity), said the group's prostheses are made of tough plastics and cost little to make or repair.

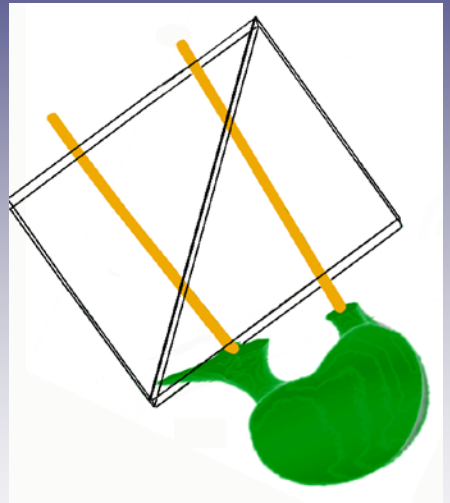
"Traditional prosthetics can cost more than $40,000, and our hands have been favorably compared to them," Schull told Reuters Health. "We live in a world where the standard offerings are extraordinarily expensive. In contrast, we are harnessing the power of thousands of volunteers and giving them away."

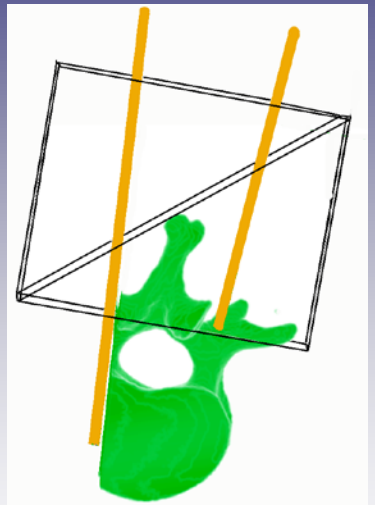
e-NABLE's printed hands cost less than $50 to produce for volunteers with access to 3D printers, but they are not as elaborate as traditional prostheses. They are based on open-source, non-proprietary designs, some of which were first developed in 2012. (Hand, finger and arm design files are available from the group here: bit.ly/1CcwpWd.)

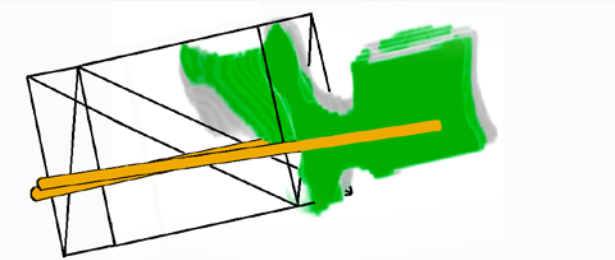


Trajectory Planning and Accuracy









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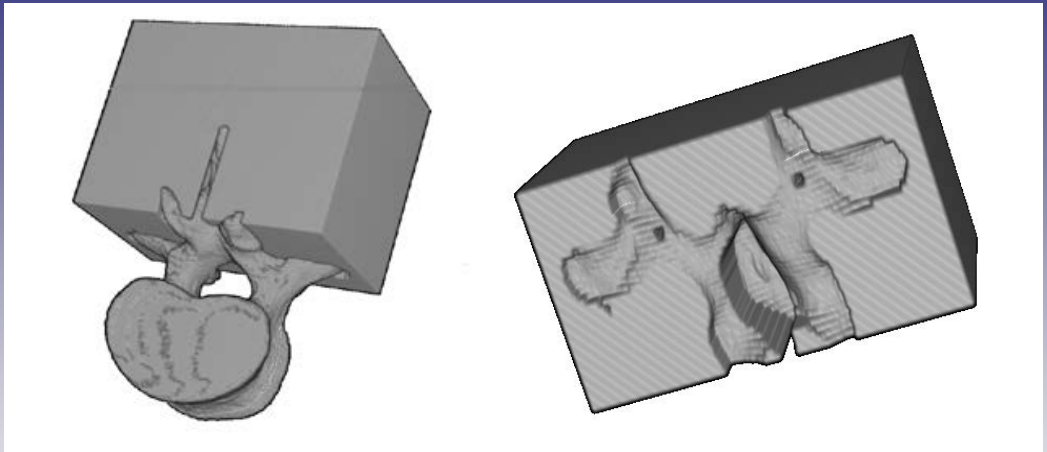
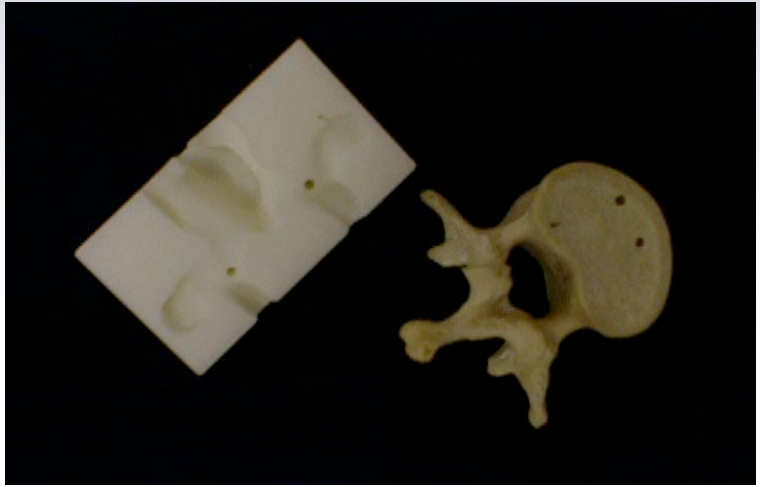
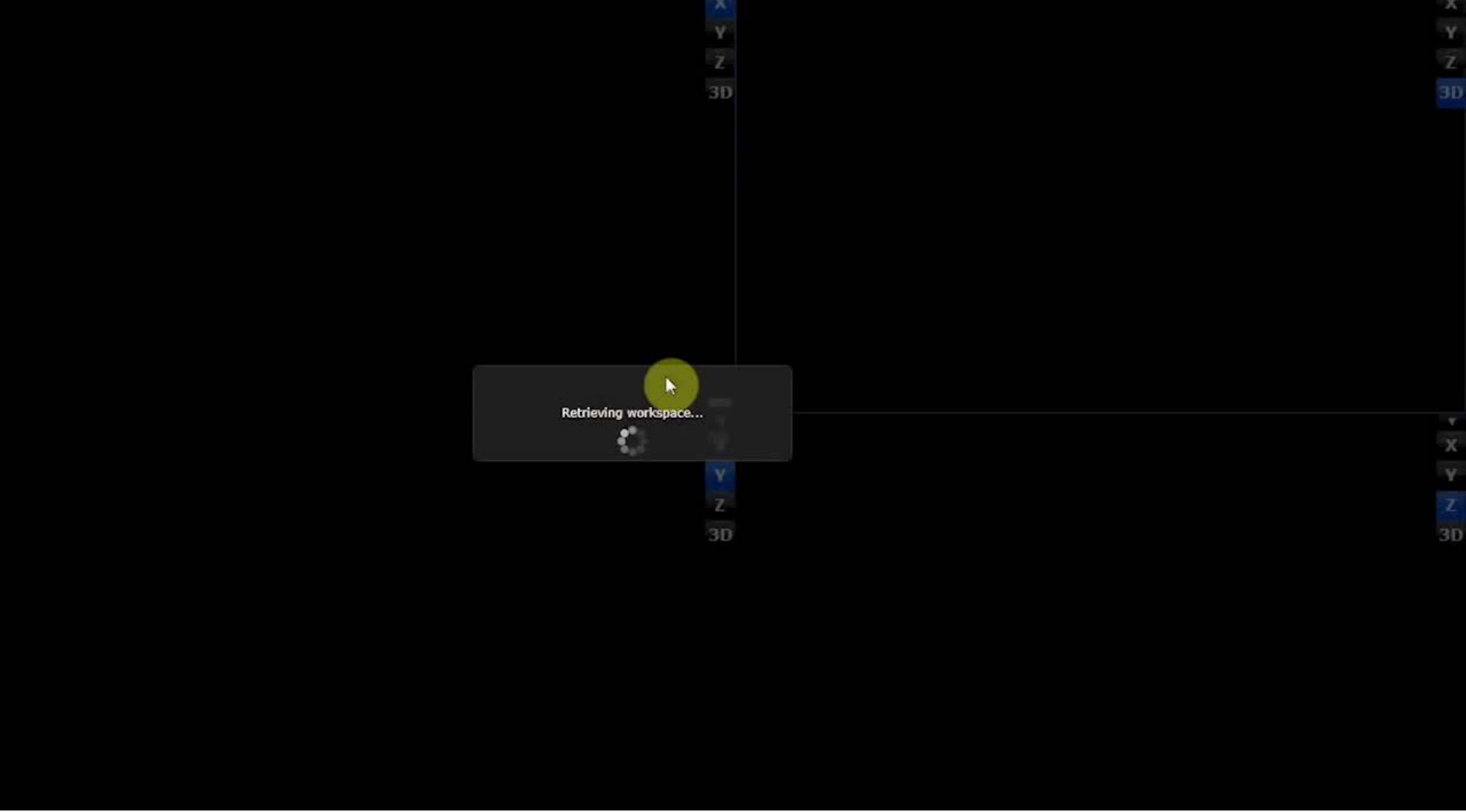
Results





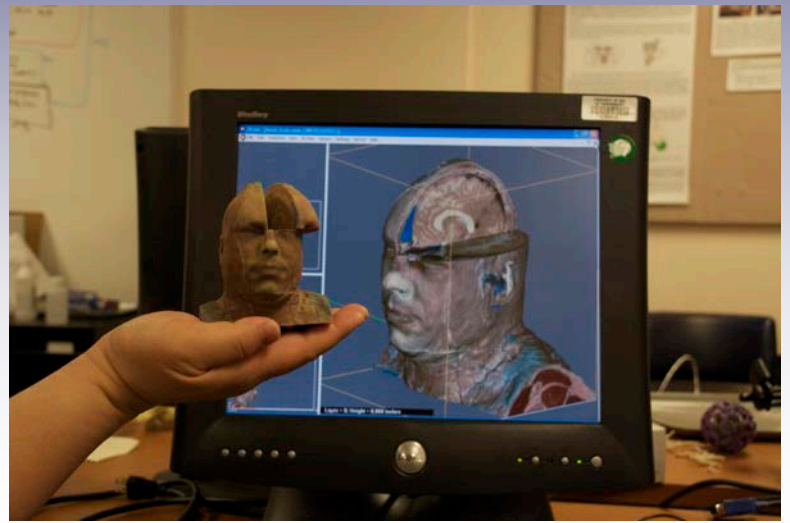
Results

HiSpeed CT/i SYS#CT03
Ex: 38294
Se: 2
IC S21.5
Im: 24
DFOV 13.0cm
BONE
A 33
C.C.N.I.H. BETHESDA, MD_C
lumbar 1
p000000000
May 15 01
512
R
6
5
L
6
5
kV 120
mA 60
Large %
1.0 mm/1.0:1
Tilt : 0.0
0.8 s/HE 07:04:39 AM/18.40
W:3110 L:-129
P 97


X
Y
Z
3D
Retrieving workspace...
Y
Z
3D
X
Y
Z
3D

3D Printing:

The “Ultimate” Rendering Technique for Three-D Informatics



Driving Problem: (Cancer) - Not so Solid Modeling?

Before Treatment

3 Months

1. How do these pictures differ?

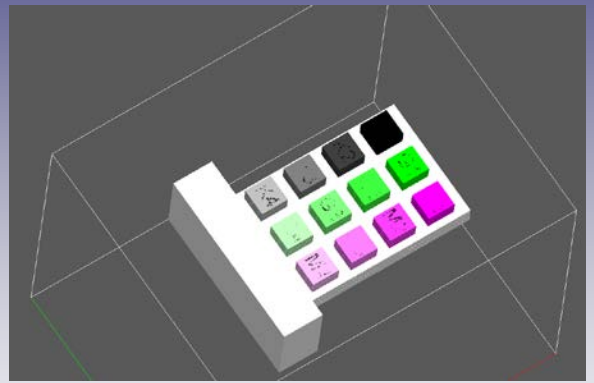
- Tracking cancer treatment
  - What modeling primitives do you use?
  - How good is your measurement?
  - How certain are you? How do you portray that?

Printing Phantoms in 3D with Contrast

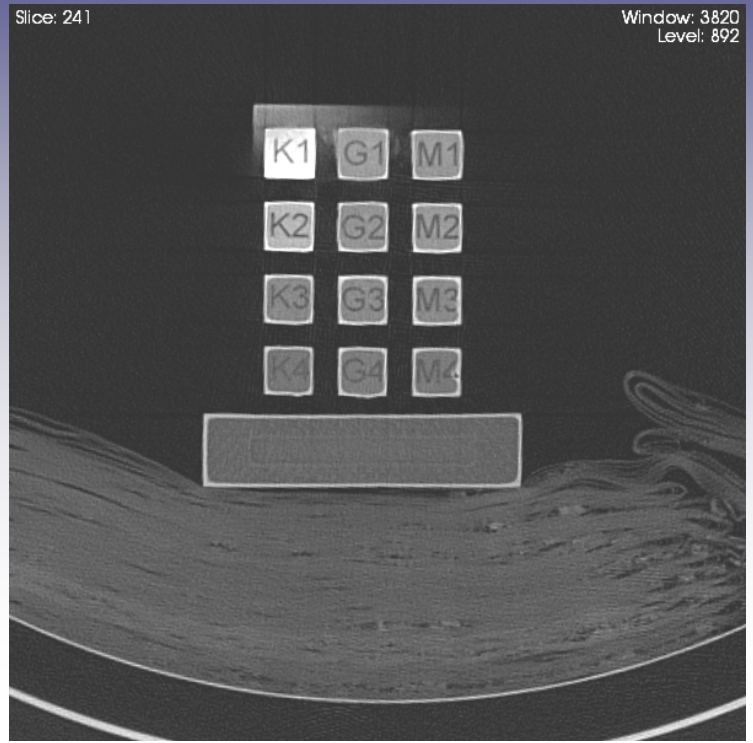
Can we create X-ray attenuation coefficients with 3D printing that mimic biological tissue?

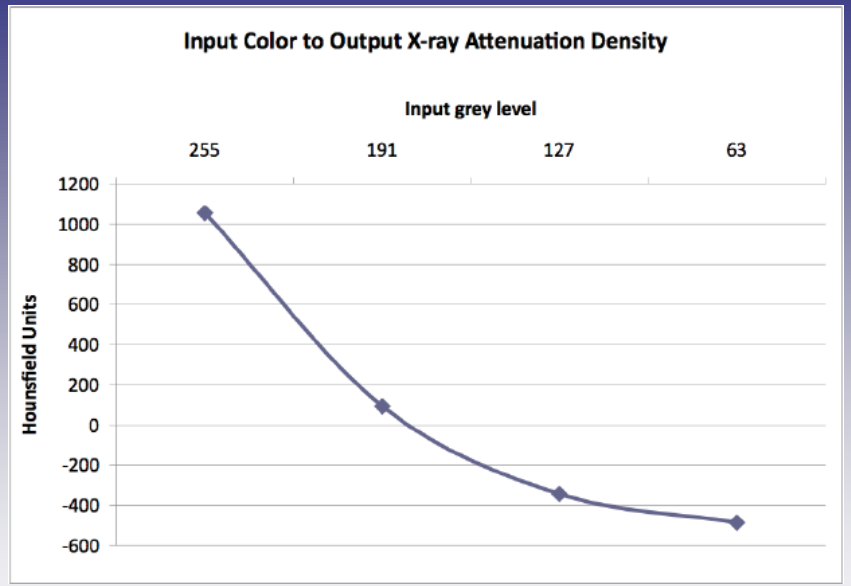
- Amending the standard binder with NaI
  - High Concentrations (1 g / ml)
- Employing zp15e powder
  - Primarily cornstarch and cellulose

- A test model to plot the intensity scale
- The “C plaque”
- The “E plaque”



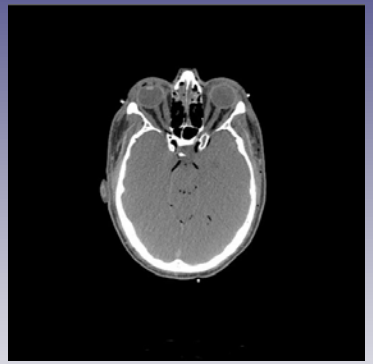
Results

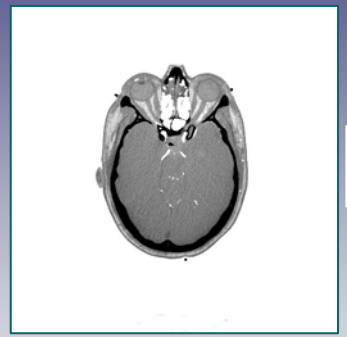


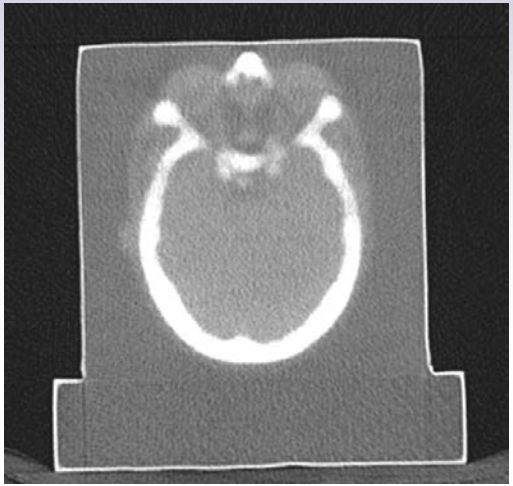


	Input CMY values	Average Density (Hounsfield Units)	StdDev
material only	(0,0,0)	-631.8199387	16.84
K1	(255,255,255)	1056.448564	36.02
K2	(191,191,191)	92.59012371	20.65
K3	(127,127,127)	-343.1649806	14.19
K4	(63,63,63)	-484.9999983	13.75

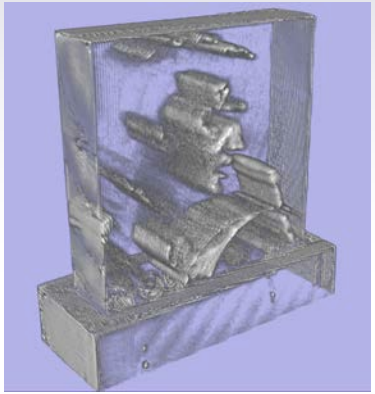
Demonstrations: C plaque







Demonstrations: E Plaque



What does a virus look like?

Using 3D printing for visualization to understand the life sciences.

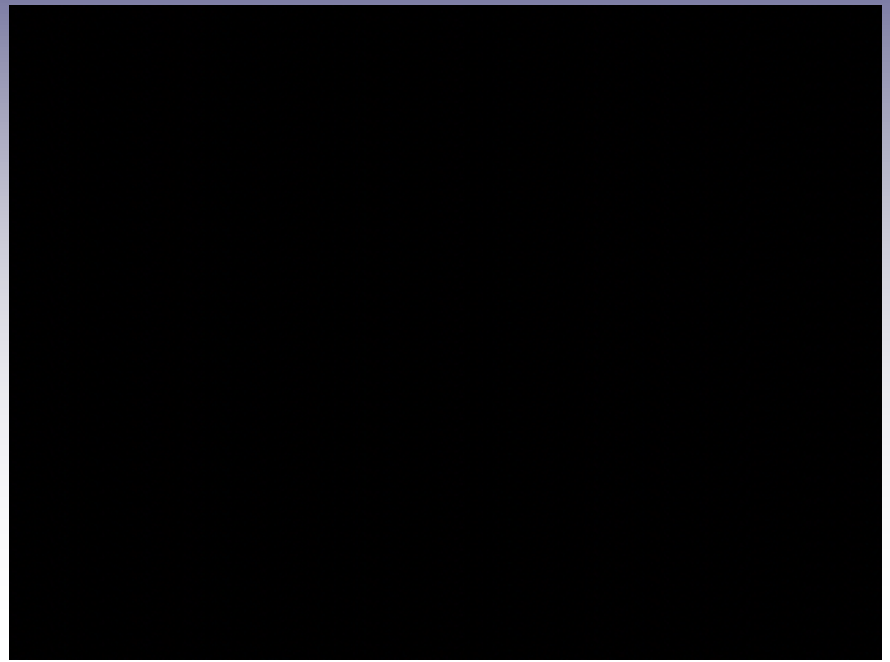
Volumetric Bodies Exhibit

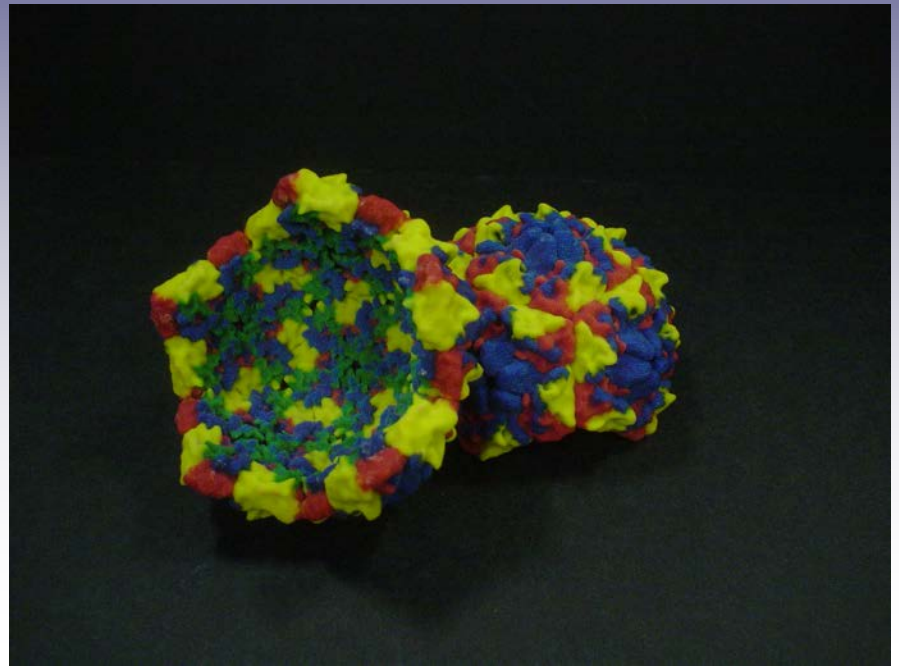
NLM, Rutgers U. – IEEE Visualization 2009

What does a virus look like?

Using 3D printing for visualization to understand the life sciences.

Example: Polio

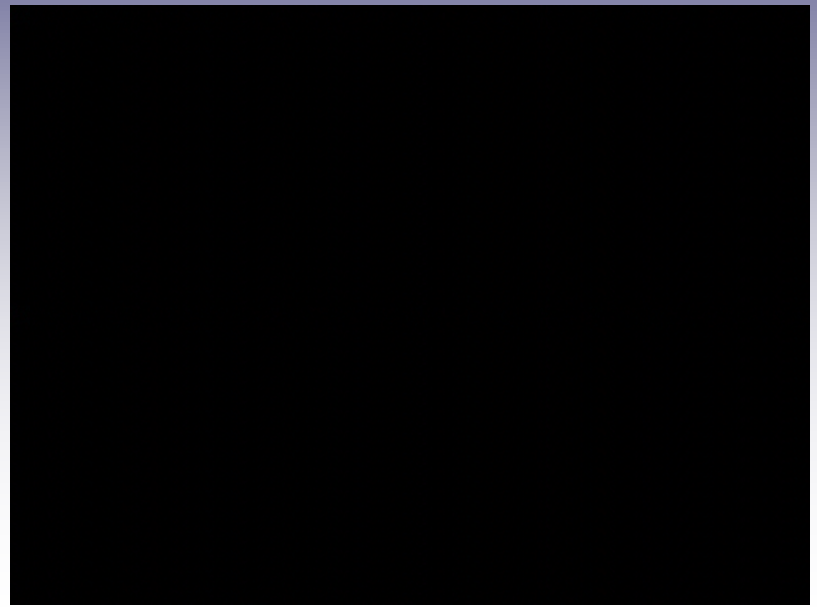




Self assembly –

an essential feature of nanotechnology

- Augmenting 3D printed models with magnets
- Simulating chemical bonds.
- Demonstration of self assembling molecular structures.



Chance favors the prepared mind.

- *Louis Pasteur*

Luck is when preparation meets opportunity.

- *Seneca (quoted by Roy Williams)*

What preparation do I need to play with robots?

- Math, Geometry
- Computer Science
- Physics
- Biology
- Material Science
- Mechanical/Industrial Engineering
- Art

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