

Computational Design + Fabrication

Jonathan Bachrach

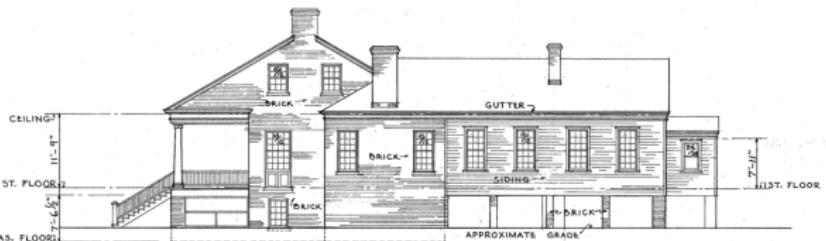
EECS UC Berkeley

August 27, 2015

- introduction
- thing compiler
- demos
- course info

Traditional Architectural Design

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RIGHT SIDE ELEVATION
SCALE $\frac{1}{8} = 1'-0"$



REAR ELEVATION
SCALE $\frac{1}{8} = 1'-0"$

J.L. GATLING JR. DEL.

WORKS PROGRESS ADMINISTRATION
OFFICIAL PROJECT NO. 245-4707
UNDER DIRECTION OF UNITED STATES DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE BUREAU OF PLATE ASSISTANCE

"UMBRIA" — THE GOV. SAMUEL PICKENS' HOME
NAME OF STRUCTURE
NEAR SAWYERVILLE, HALE COUNTY, ALABAMA

SCALE $\frac{1}{8}$ INCHES TO 1 FT.
IN 10 M 5 10 15 20 FT.
DM 10 0 1 2 3 4 5 6 METERS

METRIC SCALE

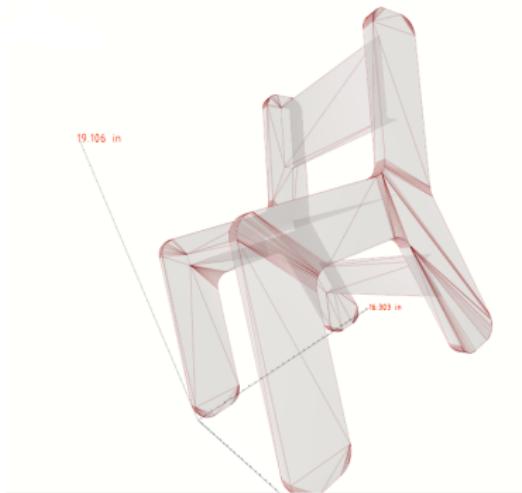
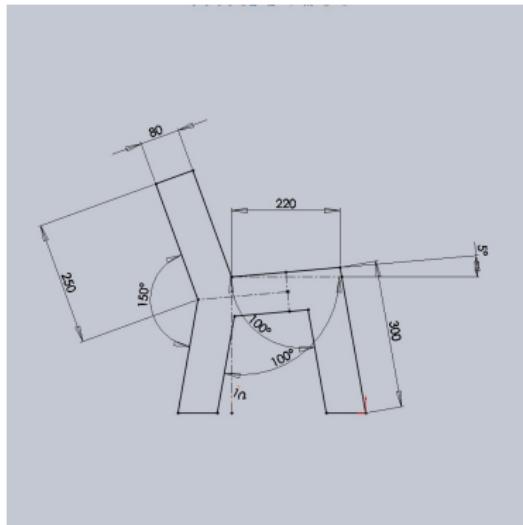
SURVEY NO.
ALA
236

HISTORIC AMERICAN
BUILDINGS SURVEY
SHEET 5 OF 8 SHEETS

1

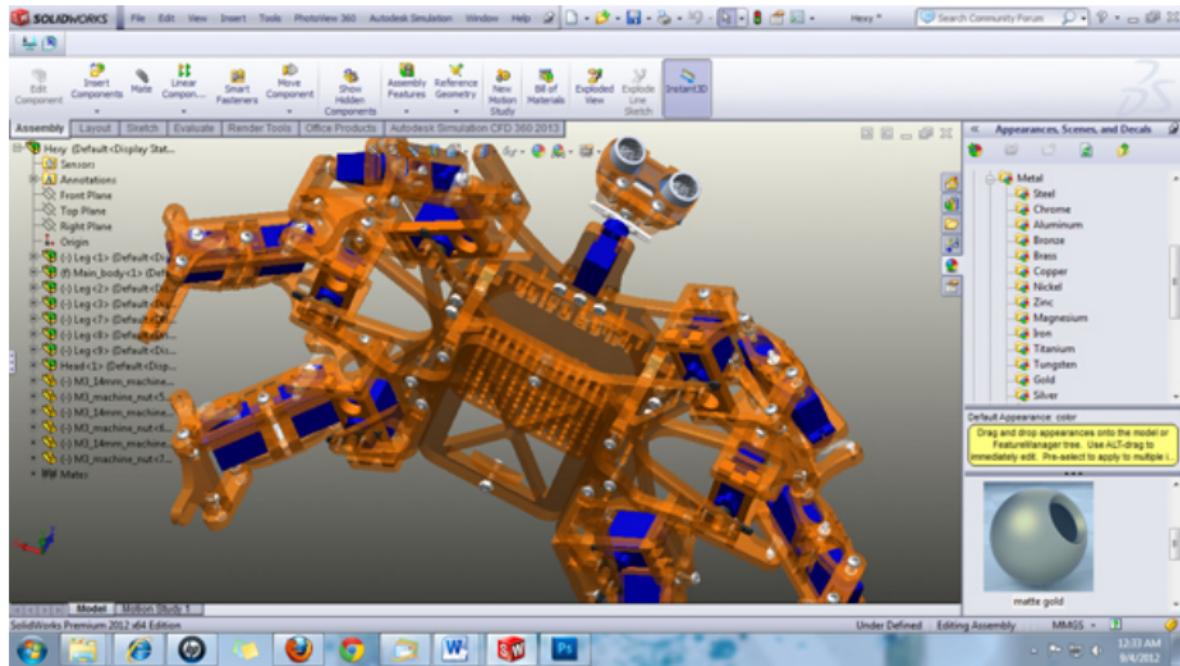
Parametric Design

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- parameters
- constraints

Traditional Robot Design



- manually intensive
- hard to keep in sync
- difficult to learn
- brittle – hard to parameterize
- disconnected from fabrication

Traditional Fabrication

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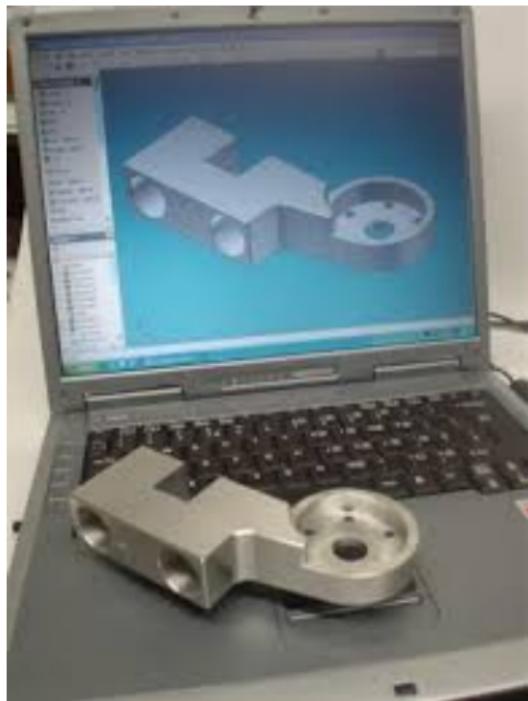


- is manually intensive
- is difficult/dangerous/slow to tools
- has a distribution bottleneck



What is Computational Design + Fabrication?

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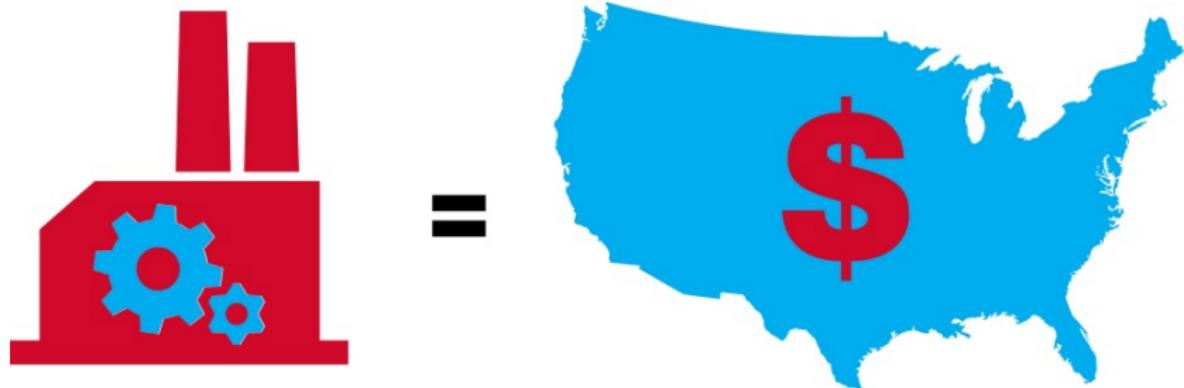


- make hardware more like software?
- automating design + fabrication
- new computer based fabrication machines
- using software techniques

Why is it so important?

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- 1/4 economy based on manufacturing of physical goods
- many people do repetitive / dull jobs
- tremendous latent creativity



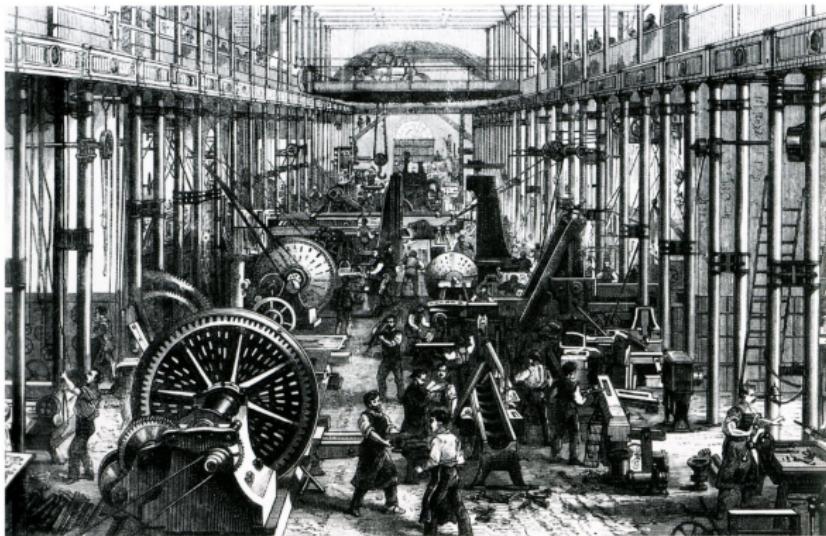
- set of technologies that vastly amplify productivity of people
- fewer people in society needed for bare essentials:
 - food, clothing, shelter
- more time spent on
 - ideas, invention, learning, politics, the arts, and creativity



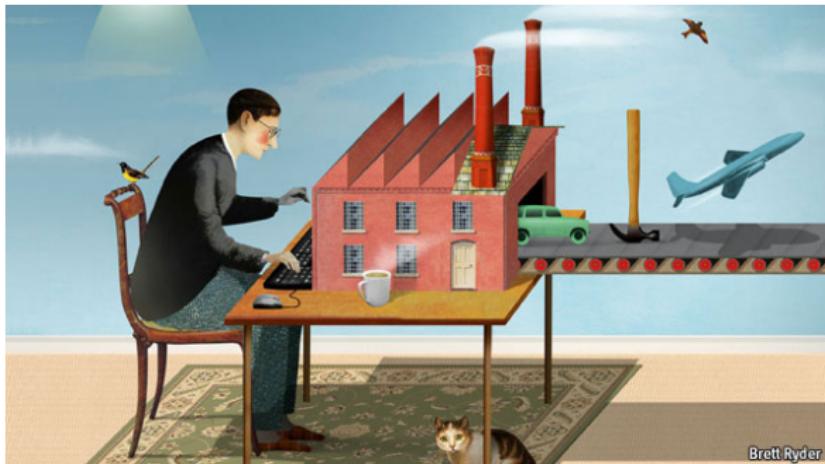
Previous Industrial Revolutions

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- 1 1700s – textiles – invention of invention
- 2 1850s – steel + transportation + assembly line



- hardware as software
- just in time manufacturing



The Economist

- affordable JIT manufacturing
- rise of the artisan
- increases entrepreneurship
- mass customization



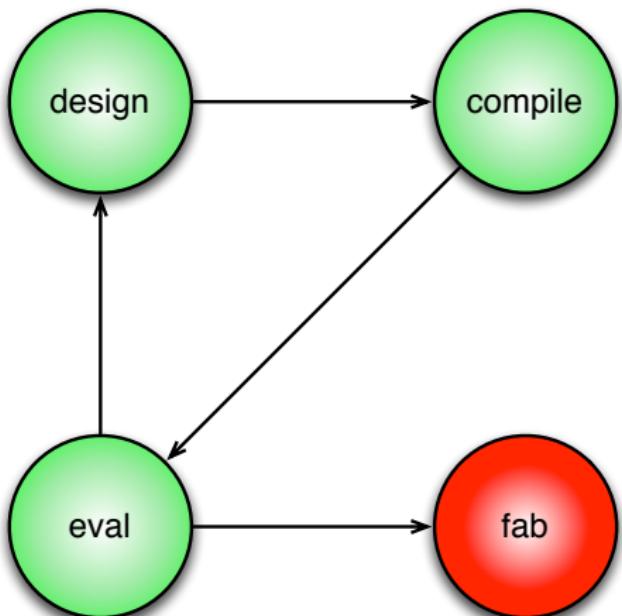
- designs as information – file formats
- network effect – sharing
- remix culture – rip, mod, fab
- manufacture local or global

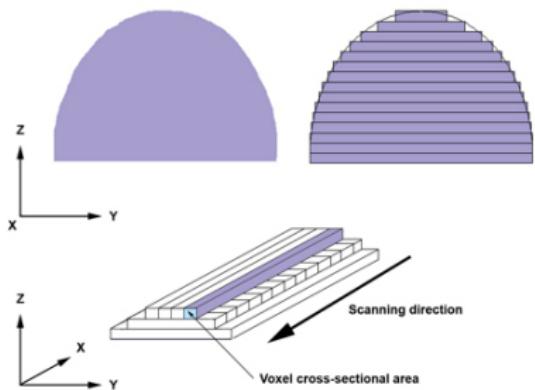


Design + Fabrication Loop

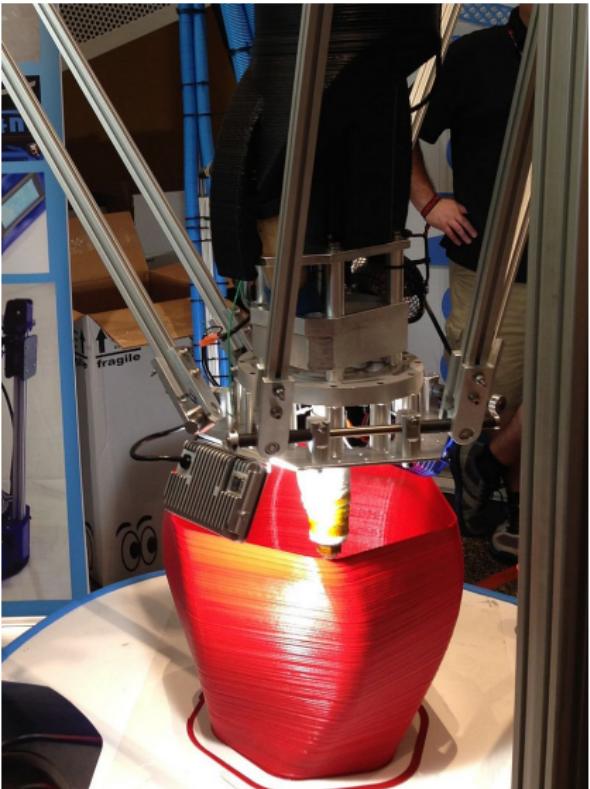
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- design
- compilation
- evaluation
- fabrication





additive manufacturing



many diffent kinds

- 1 complexity is free
- 2 variety is free
- 3 no assembly required
- 4 zero lead time
- 5 unlimited design space
- 6 zero skill manufacturing
- 7 compact, portable manufacturing
- 8 less waste by-product
- 9 infinite shades of materials
- 10 precise physical replication

What are 3DP challenges?

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- 3d design
- limited materials, scale
- multi-material
- big data
- simulation + evaluation
- inadmissible inputs



- cutters
 - laser
 - vinyl
 - water jet
- mills
 - 3 axis
 - 5 axis
- miscellaneous
 - wire bender

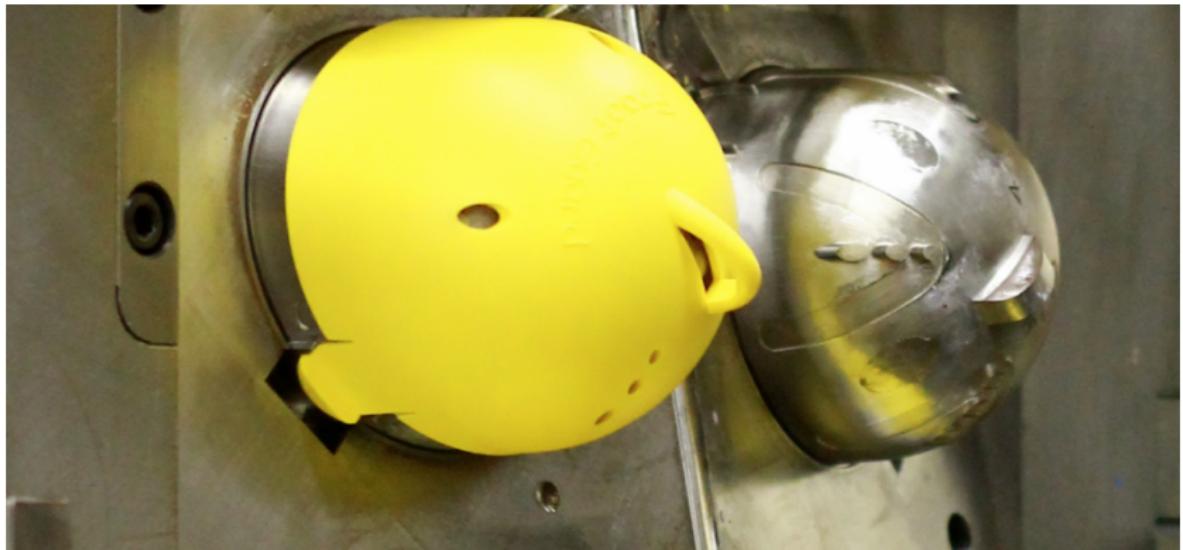


What are CNC challenges?

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- software
 - clunky
 - ambiguous input
 - sometimes manual
 - not WYSIWYG
 - no nesting
- assembly
 - still manual





- design twice
- labor intensive

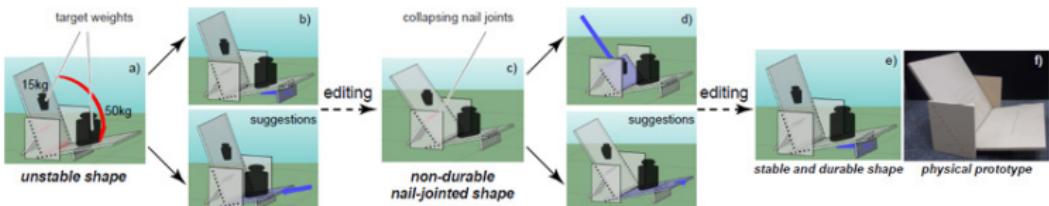
- design once
 - all design manufacturable
 - all problems shown up front in design
- human out of the loop

Guided Exploration of Physically Valid Shapes for Furniture Design

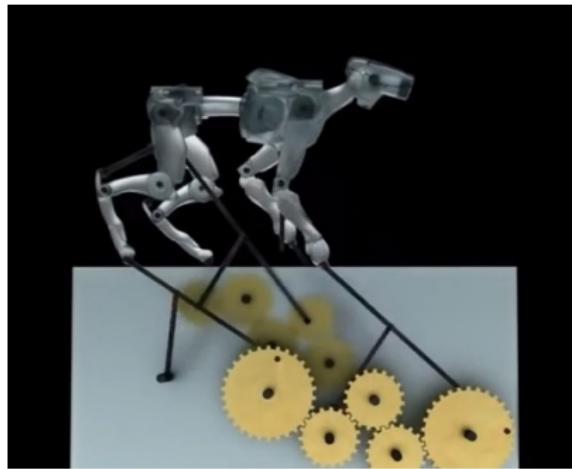
ACM SIGGRAPH 2012

Nobuyuki Umetani Takeo Igarashi Niloy J. Mitra

The University of Tokyo JST ERATO University College London

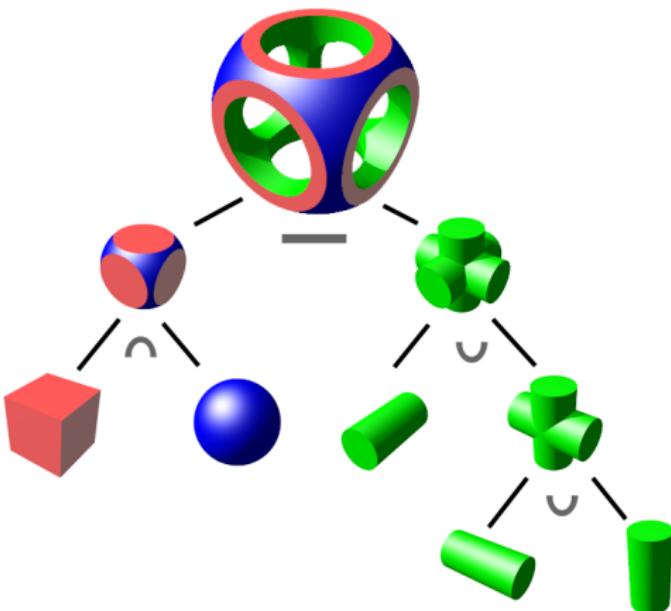


- what not how
- goals + constraints
- optimization

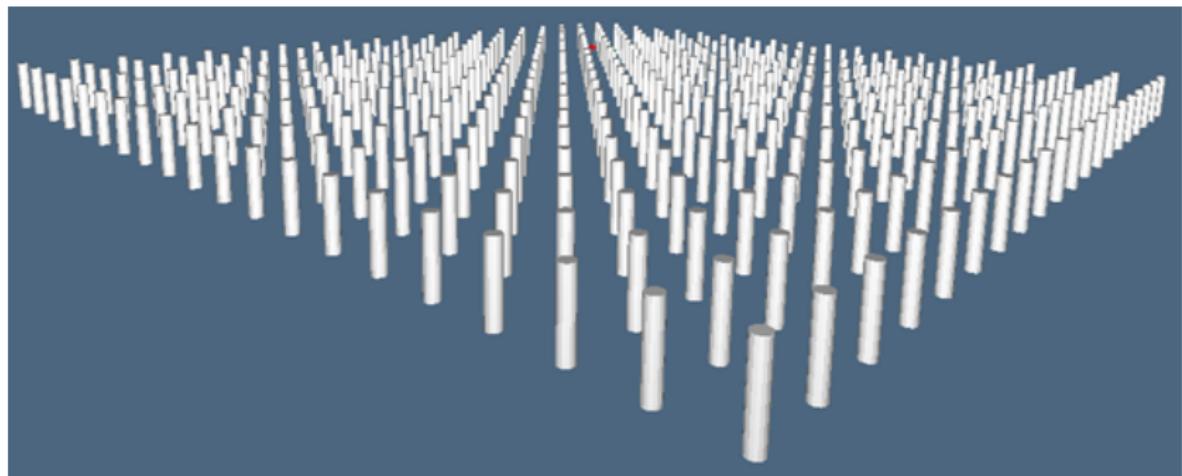


Computational Design of Mechanical Characters – Disney Research

- primitives + operations + transformations



- abstraction -> reuse
- replication etc



- thing functions
- parameters sweep space
- what are parameters?



=>



Example Shape Generator

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Community Developed Shape Generators

Built using the Autodesk Creative Platform



Limpet
by Dr Who Joh...



D 2
by Dr Who Joh...



Broken Heart
by Dr Who Joh...



Butterfly
by Marrisa



Cute Heart
by Dr Who Joh...



eyes
by Dr Who Joh...



Telstar
by Dr Who Joh...



Pin
by Dr Who Joh...



Icosa-diamond
by Dr Who Joh...



puzzle 2
by Dr Who Joh...



crystal
by Dr Who Joh...



Half Paraboloid
by Dr Who Joh...



d
by Dr Who Joh...



Roller Cylinder
by Anthony



Semi Butress T...
by Anthony Gra...



Voronoi
by Tinkercad



Angular Ring
by Henrik W Ni...



Twisted polygon
by Eliza Byrne



Rounded Cube
by Tony



Delta
by Peter Qian



Custom Gear
by Android78



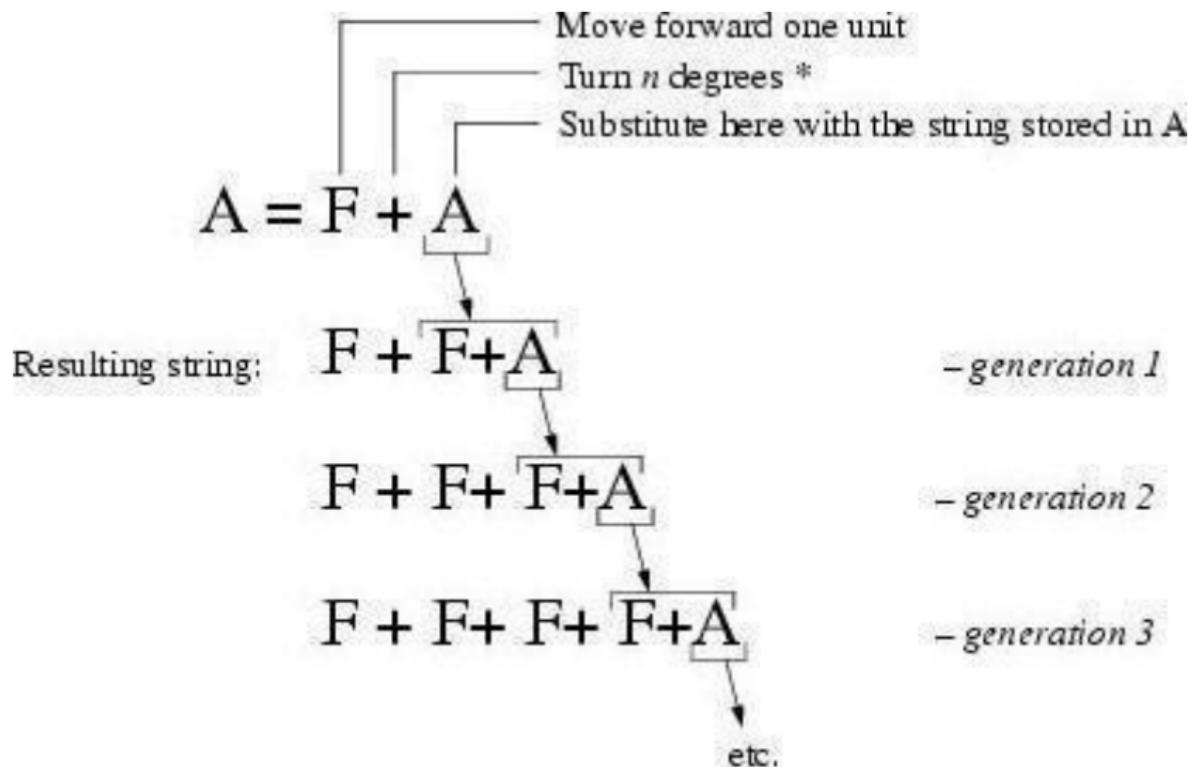
QR Code
by bogood



SoftBox
by john sadler



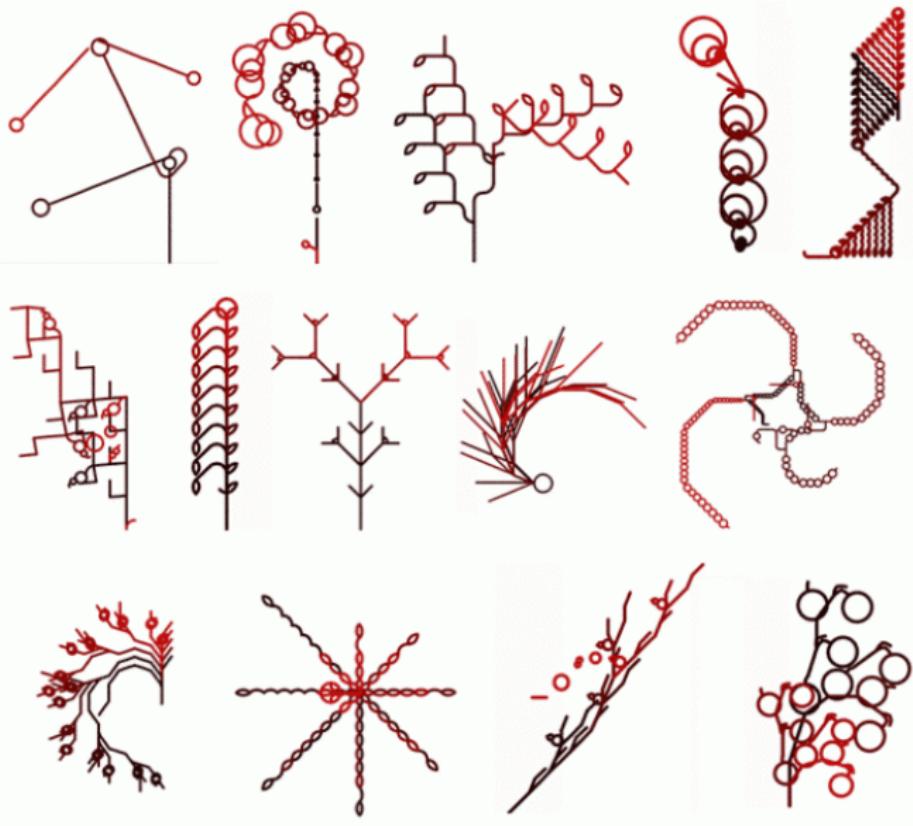
Hi-Res Sphere II
by klaas



* The value of n can be set via the L-system SOP's Value/Angle parameter.

Example L-system Uses

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Bending and Folding Structures 1

Arch 259 – Prof. Simon Schleicher

UC
BERKELEY
ENVIRONMENTAL
DESIGN



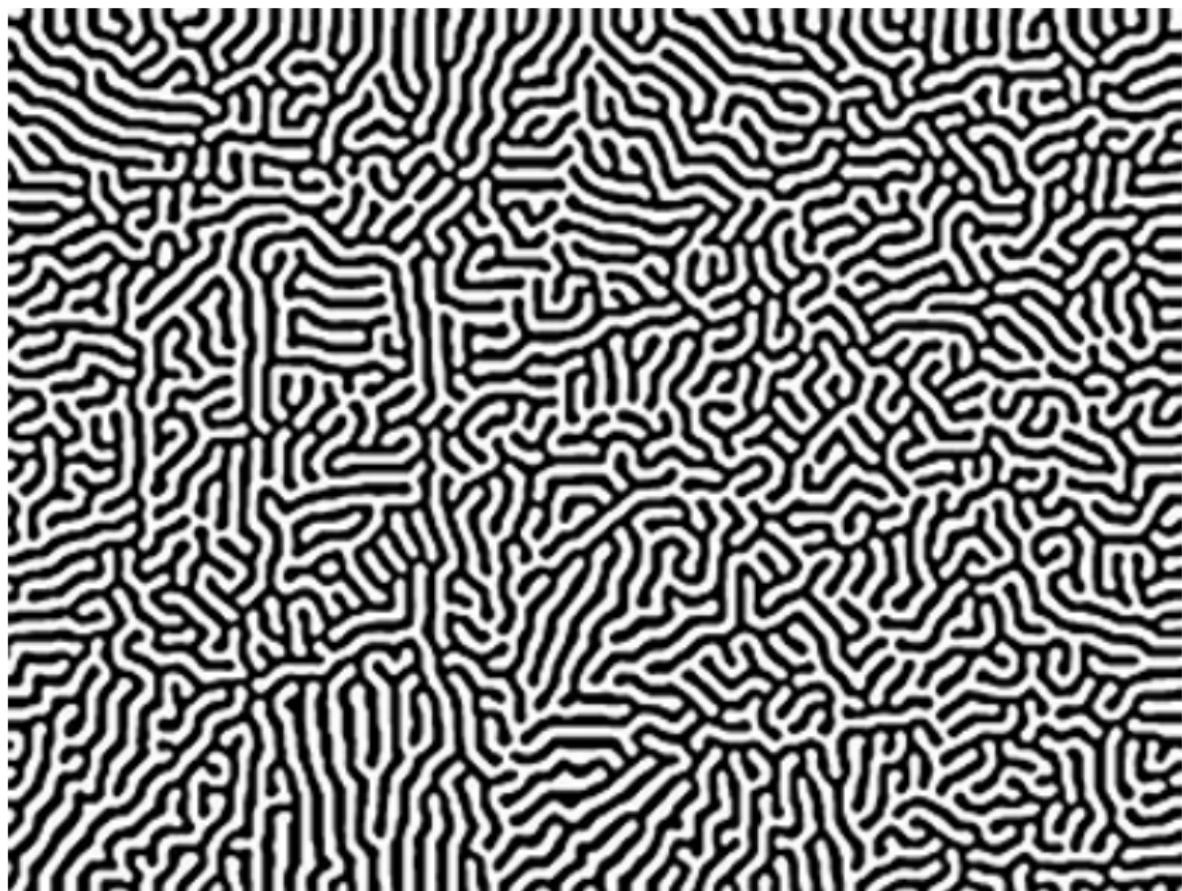
photo: Nicola Haberbosch and Andreas Schönbrunner

in collaboration with

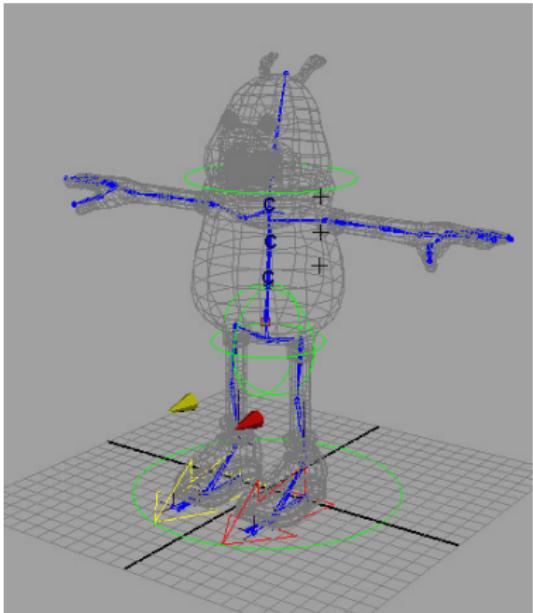
 **SOFiSTiK**

Pattern Formation

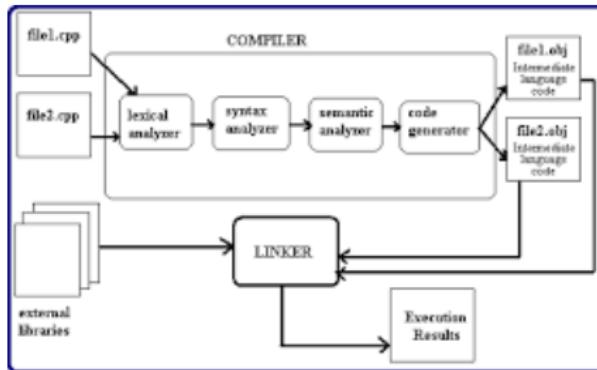
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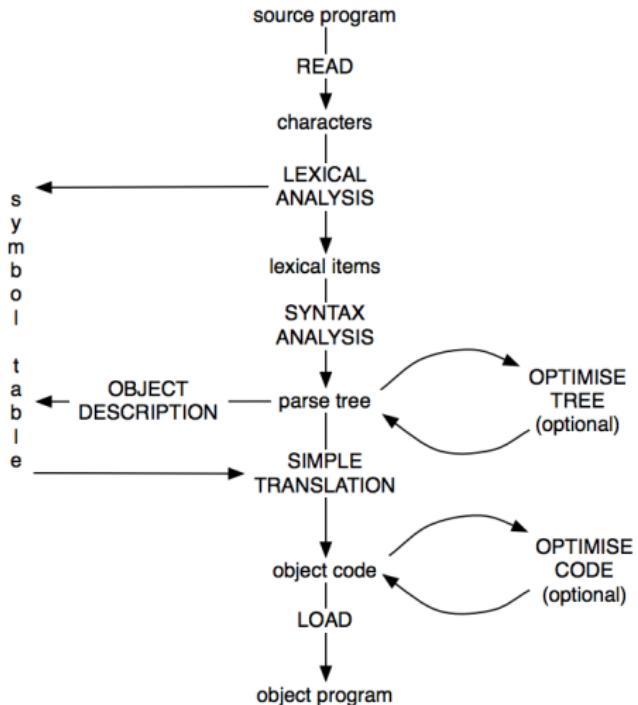


- specification
- transformation
- example skeleton + skinning

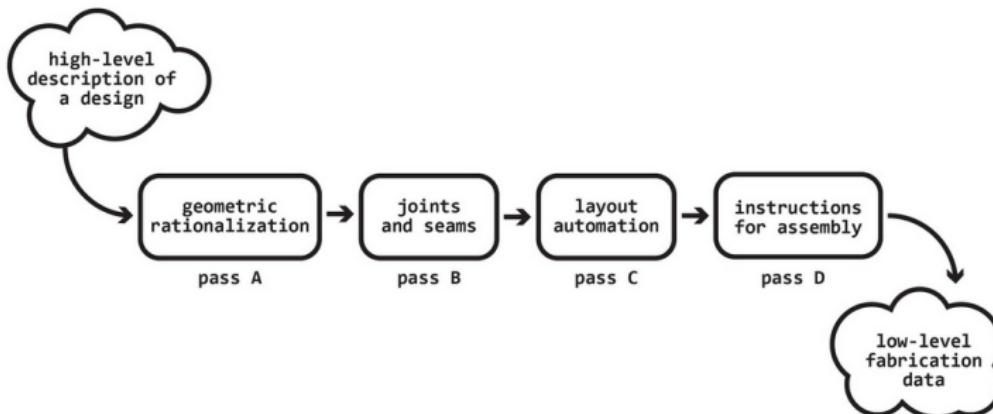


- human-readable source into machine-executable object code
- intermediate representation + passes
- front-end, optimizer, back-end

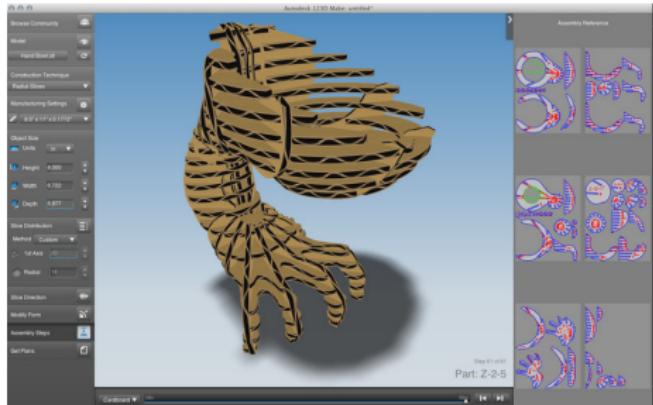




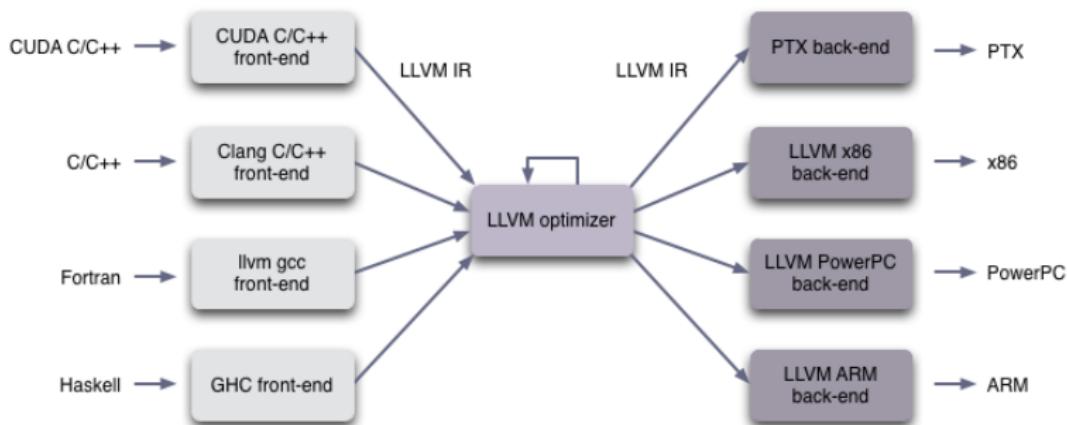
- high-level conceptual design text input
- fabrication machine code output
- towards an architecture compiler



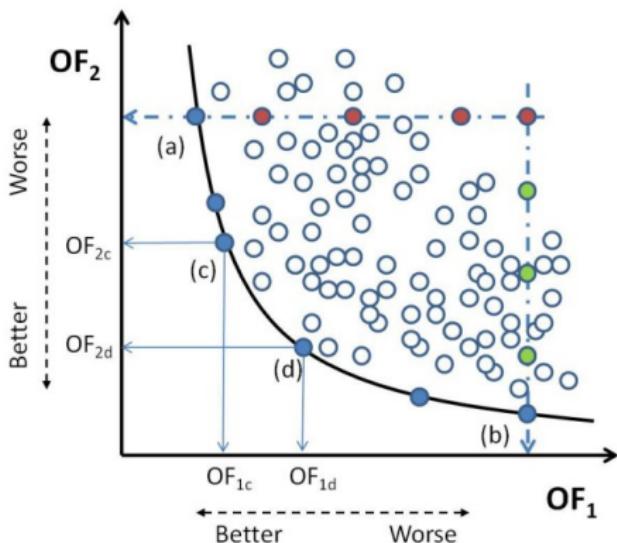
- 3d mesh into slices
- slots
- labels
- layout
- instructions



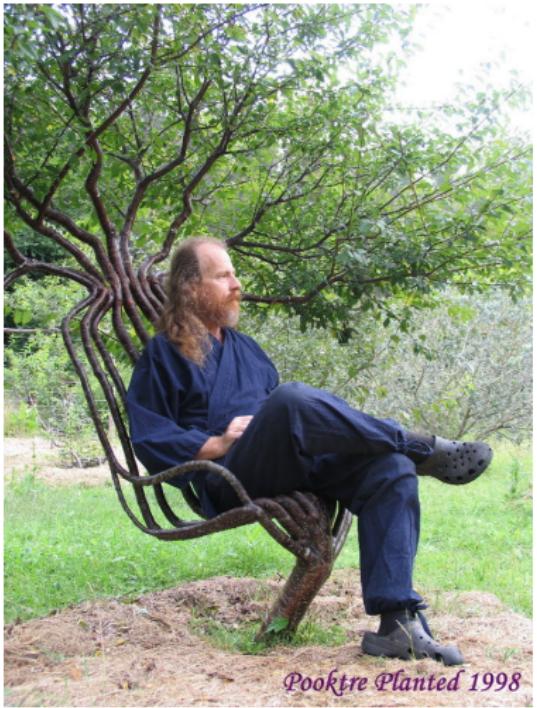
- modularize compiler into library
- compiler is set of passes
- can write new passes
- explosion in languages and backends



- combination of DSE + compilers
- optimization technique
- visualization



- healing
- growing
- programmable shapes



Pooktre Planted 1998

- robotic construction
- feedback loop with materials



ETH University + Gramazio Kohler Research

- Fabricated: The New World of 3D Printing, by Hod Lipson, Melba Kurman
- Makers: The New Industrial Revolution, by Chris Anderson
- Makers, by Cory Doctorow
- The Third Industrial Revolution, The Economist