Rapid Delivery

Design and Construction of Homes

Prof. Larry Sass
Department of Architecture, MIT

Motivation

Design & Build

Bassett Virginia 1960

How to generate geometry for fabrication?

CNC MIT
1949

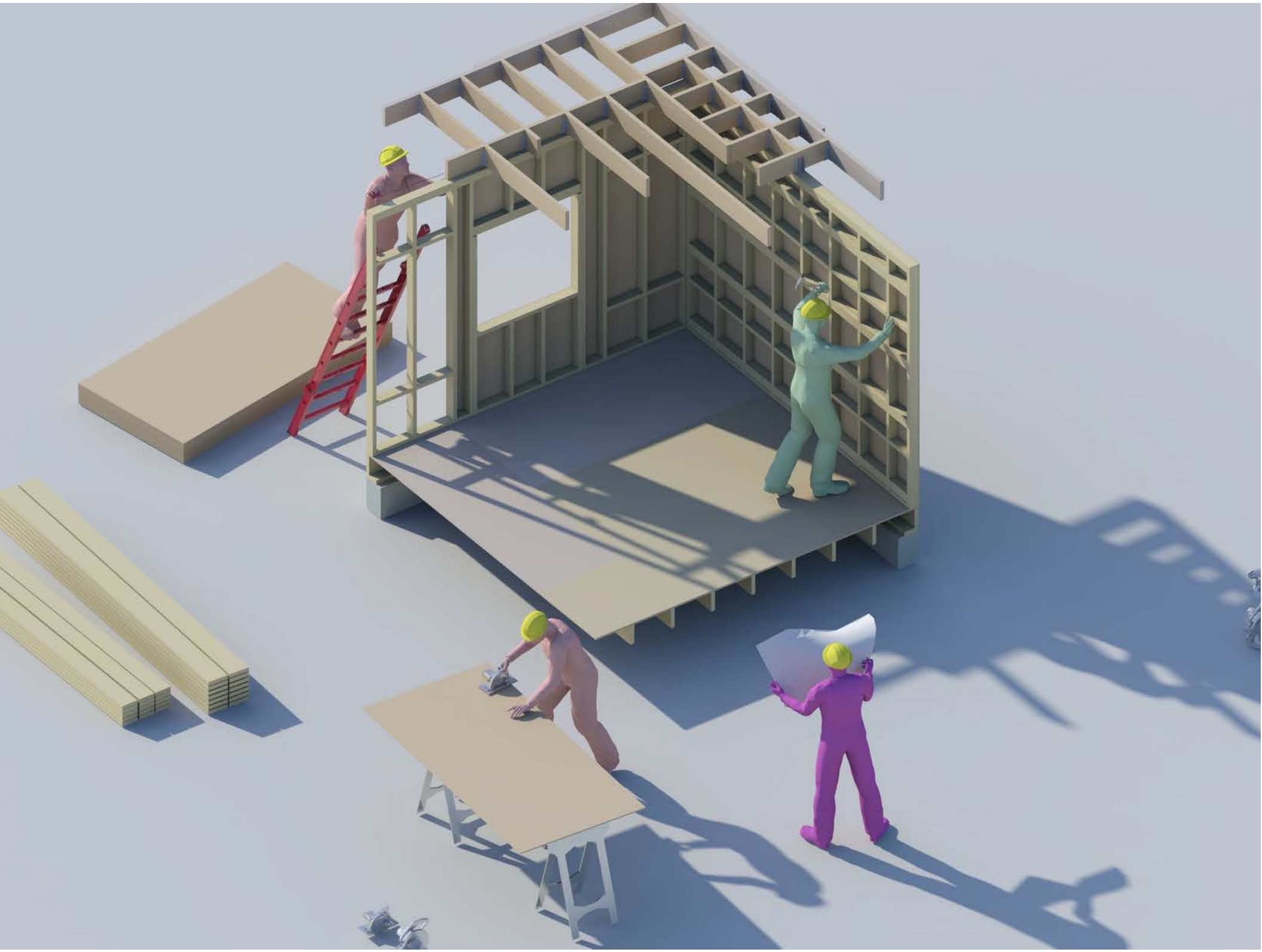
CAD Sutherland
1963

MIT 2020

Alison Ramsey
Architects
Beaufort South Carolina

Why is Rapid Delivery Important?

Housing Shortage & Destruction



Conventional construction is impossible to measure

(cost & time)

Design Interpreter

Calculating . Manufacturing Assembly

There is no Delivery Technology in Prefab

Epoch Homes (2012)

Acorn Deckhouse (1950s)

- Not Scalable
- Driven by Manual Production
- Invented by Sears & Roebuck in 1920s
- Finished product must be rectangular
- Requires an indoor environment to build a large products

Need for Design Variation

Actions are manage by the exchange of information

NOT software

Digital Building Systems

(North American & Europe)

2005

Digital Delivery

Design models are computable

Mitchell, William, and George Stiny. "The Palladian grammar." Environment and Planning B 5.1078 (1978): 189-198.

Design for assemblies

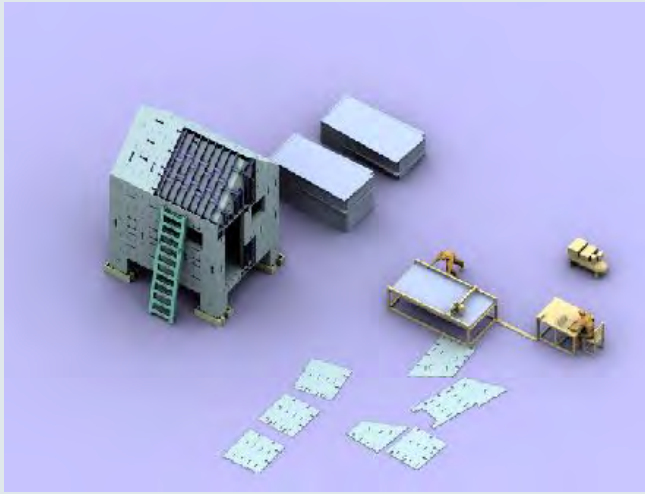
Boothroyd, Geoffrey, and W. Knight. "Design for assembly." IEEE Spectrum 30.9 (1993): 53-55.

Computing & Fab

Gershenfeld, Neil. Fab: the coming revolution on your desktop--from personal computers to personal fabrication. Basic Books, 2008.

Sass L., (2005) A wood frame grammar: a generative system for digital fabrication, International Journal of Architectural Computing, Issue 01, Number 04, pp 51-67

Sass, Lawrence. "Synthesis of design production with integrated digital fabrication." Automation in Construction 16.3 (2007): 298-310.



2008

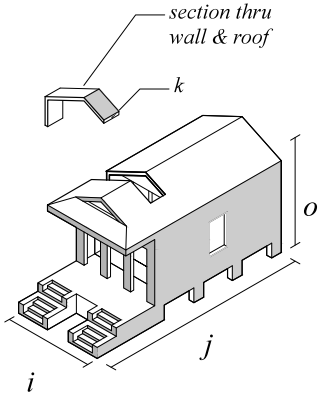
Digitally Fabricated House for New Orleans

Design

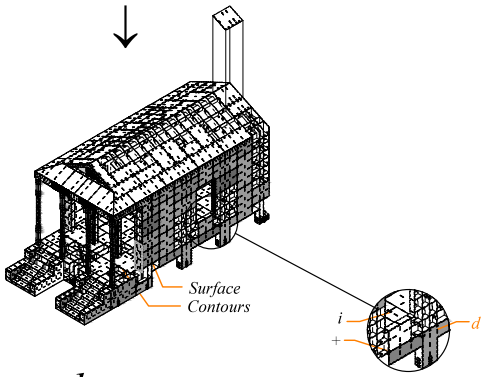
3D Modeling

Error detection modeling

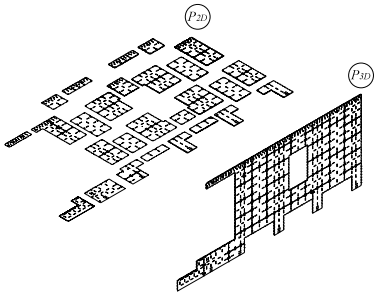
Prototyping



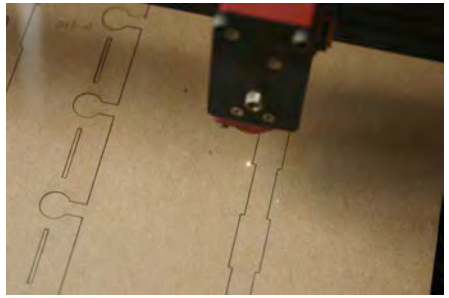
a) design



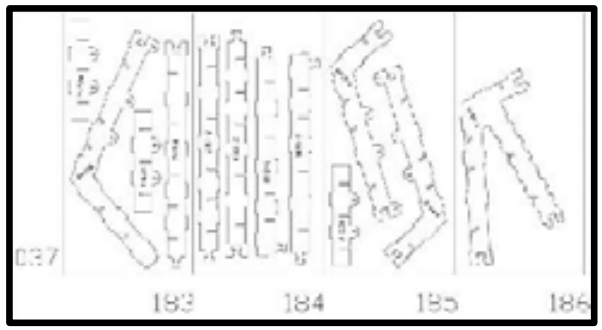
b) product

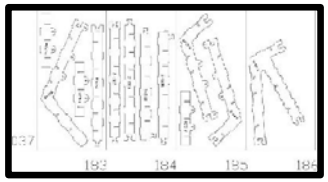


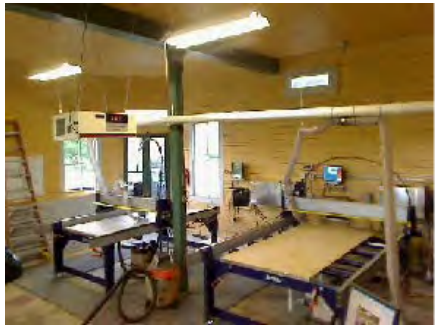
c) manufacturing



Fabrication



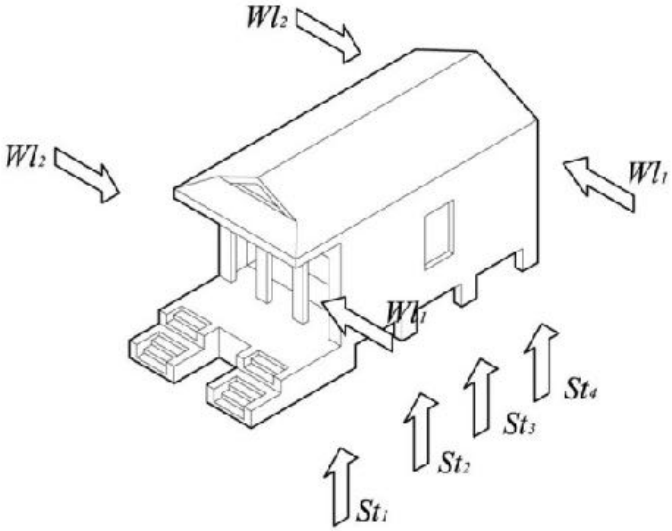


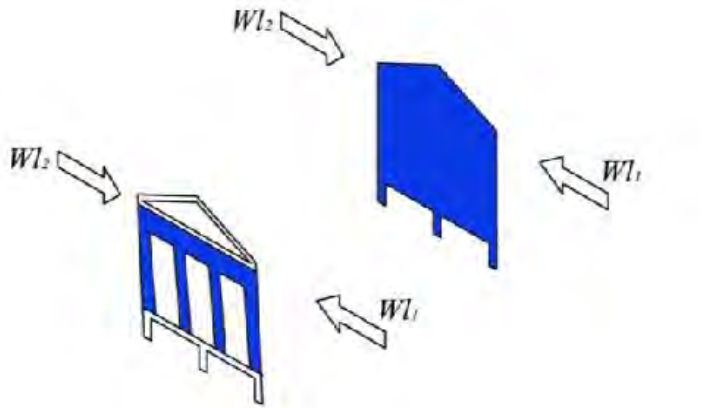


Laser Cutter

CNC (computer numerically controlled)

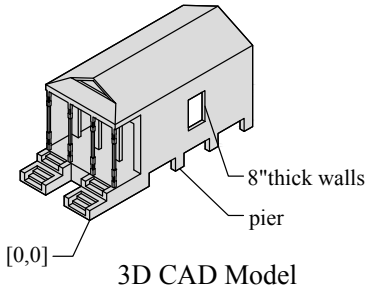
Hand-Guided Assembly





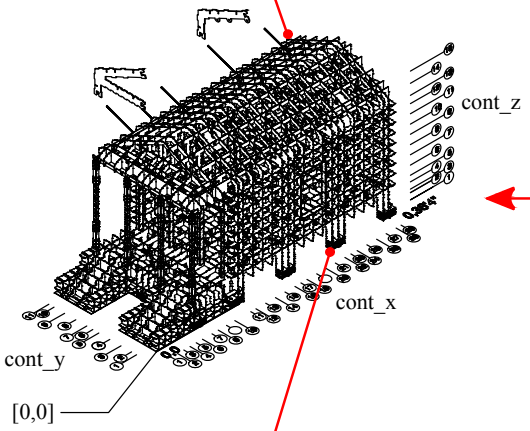
- Certified for a 75mph
- Can withstand a 140mph

Daniel Bonardi PE, Cambridge , MA

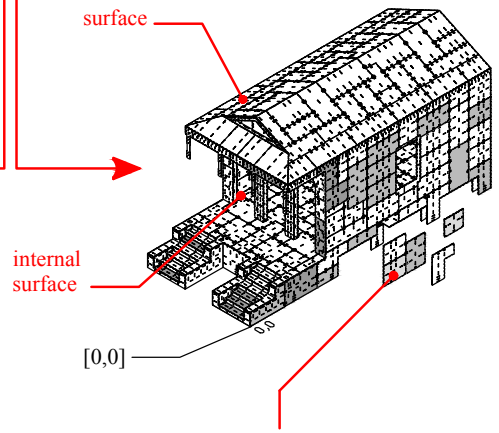


3D CAD Model

Bi-Directional Contouring



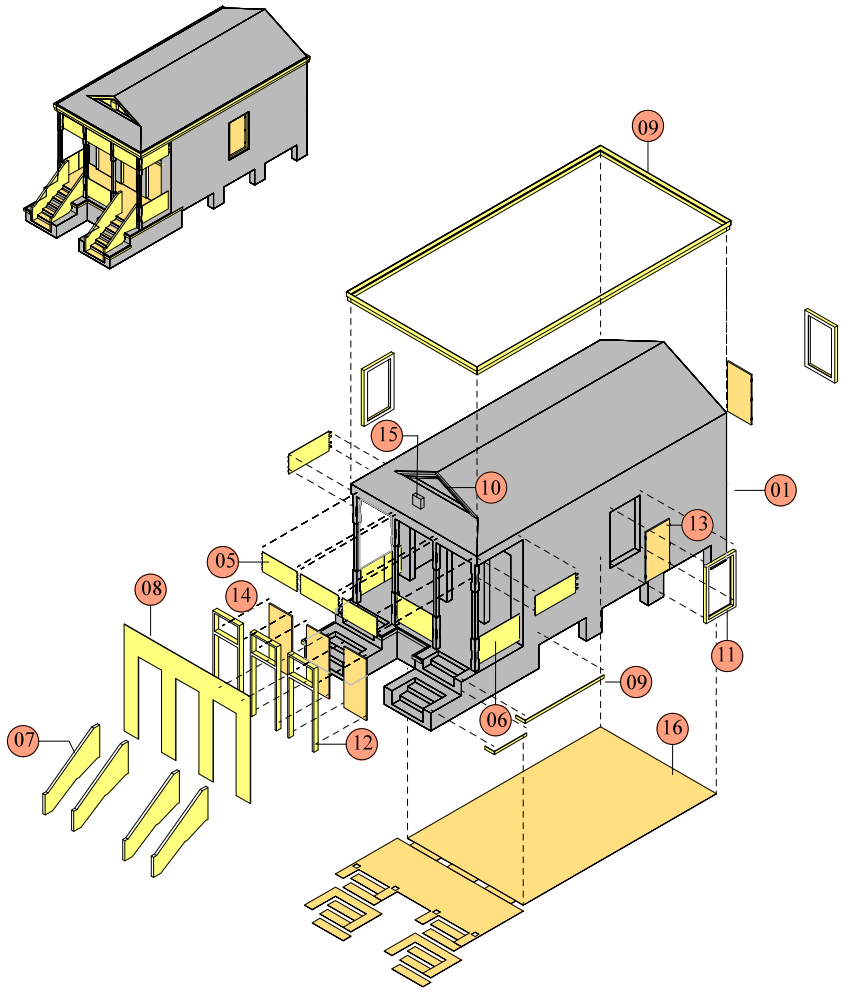
Contouring



Plates

Sets

01-Shape (exterior)
02-Reference Grid
03-Contours (interior)
04-Panels
05-Frieze
06-Rail
07-Stair
08-Ornament
09-Trim
10-Medallion
11-Window Frame
12-Door Frame
13-Window
14-Door
15-Crescent
16-Floor



Results
(2008)

1. 375 Square foot building (35 sq meters)

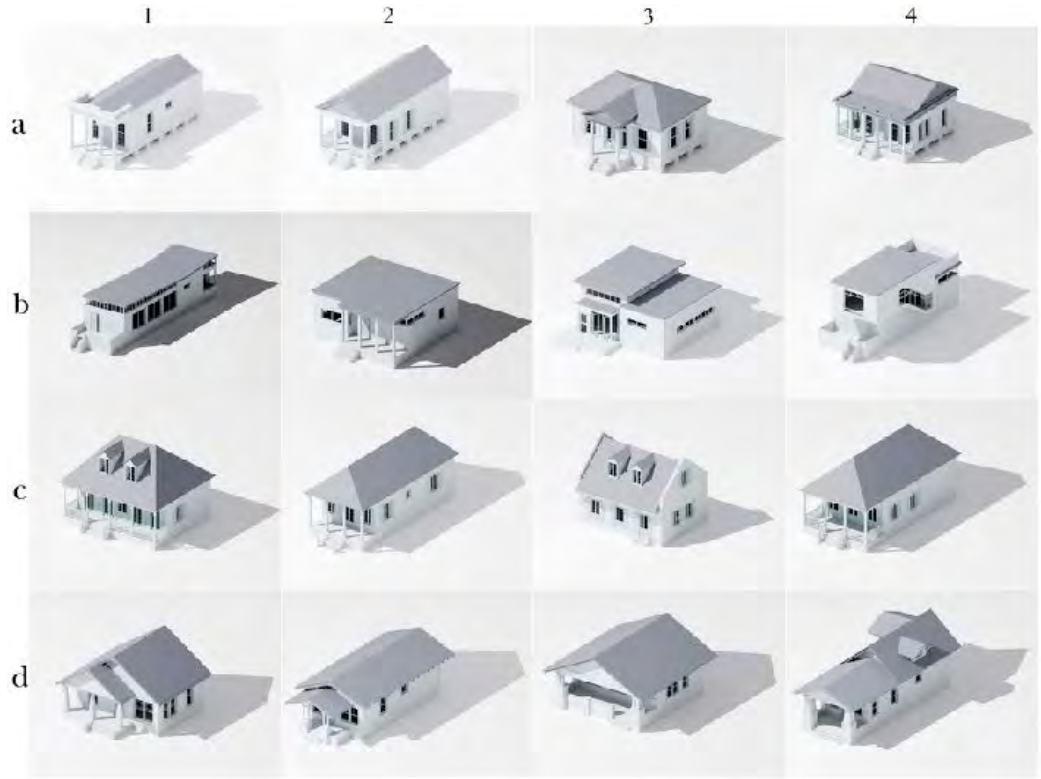
2. Assembly sustained by friction only

3. Model (Error detect & correct) 5000 components – 20 days to assemble

4. Building 5000 components – 22 days to assemble

5. Structure – Approved for 75mph winds – Max tested winds – 140mph

6. Materials:
   - Plywood (BC & AC Grade)
   - Polyethylene
   - Concrete Base



Advantages

Fast

Accurate

Flexible

Scalable

Productive

Disadvantages

Keyboard driven

Unclear system

3D Printing was on the rise

Design Fabrication, MIT 2005
Larry Sass

Materializing Design

Facit Homes, UK 2007
Andrew Goodeve

D-Process

Wiki House, UK 2012
Aliastar Parvin

Blackbird


Housing Prototypes, Timber Tectonic Culture and the Digital Age

Sofia, C., & Blair, G. (2019).
Housing Prototypes, Timber Tectonic Culture and the Digital Age. In Digital Wood Design (pp. 911-935). Springer, Cham.

Embodied Cognition
Physical Design
2012

Embodied Cognition

Wilson, M. (2002). Six views of embodied cognition. *Psychonomic bulletin & review*, *9*(4), 625-636.

Factors in learning through the body and mind

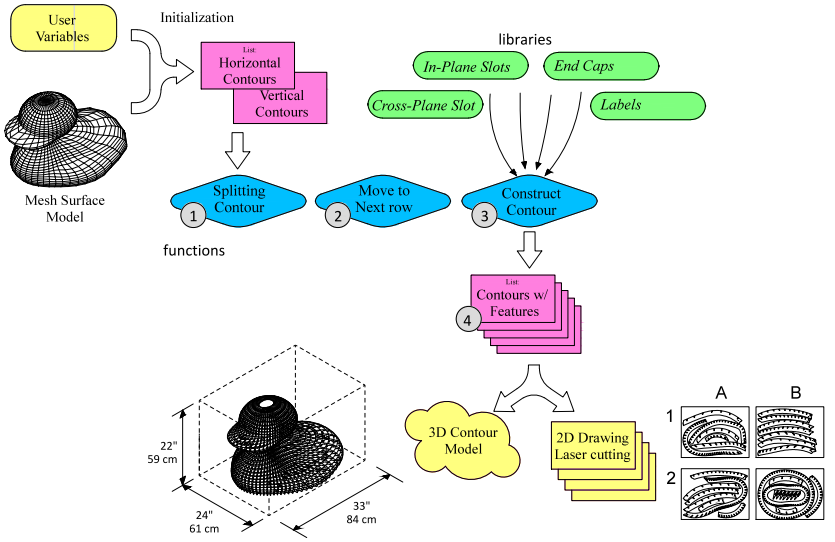
1. The Situation (New Problem)
2. Time Pressure
3. Off-loading cognitive work onto the environment
4. The environment is part of the cognitive system
5. Cognition is for action
6. Offline cognition is body based

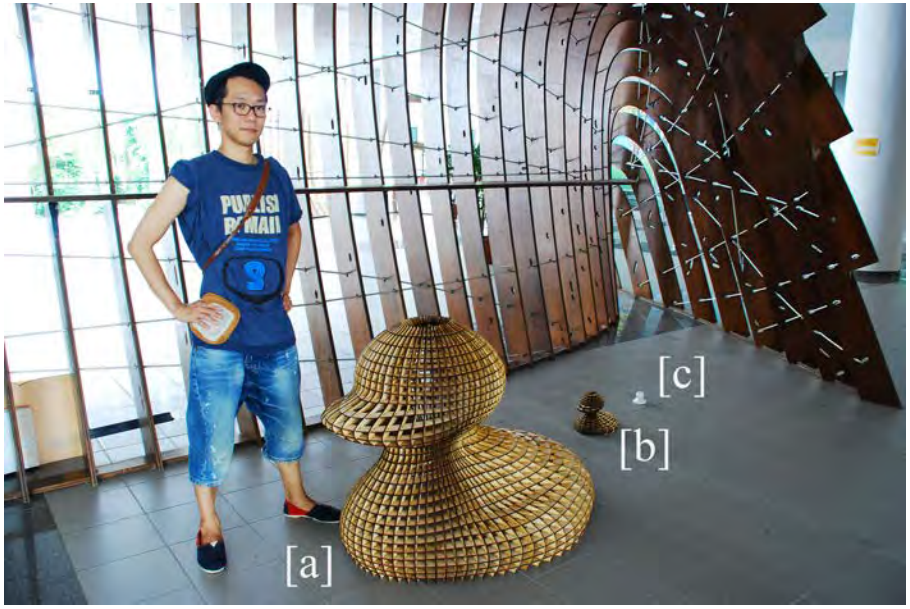
Sass, Lawrence, Lujie Chen, and Woong Ki Sung. "Embodied prototyping: exploration of a design-fabrication framework for large-scale model manufacturing." *Computer-Aided Design and Applications* 13.1 (2016): 124-137

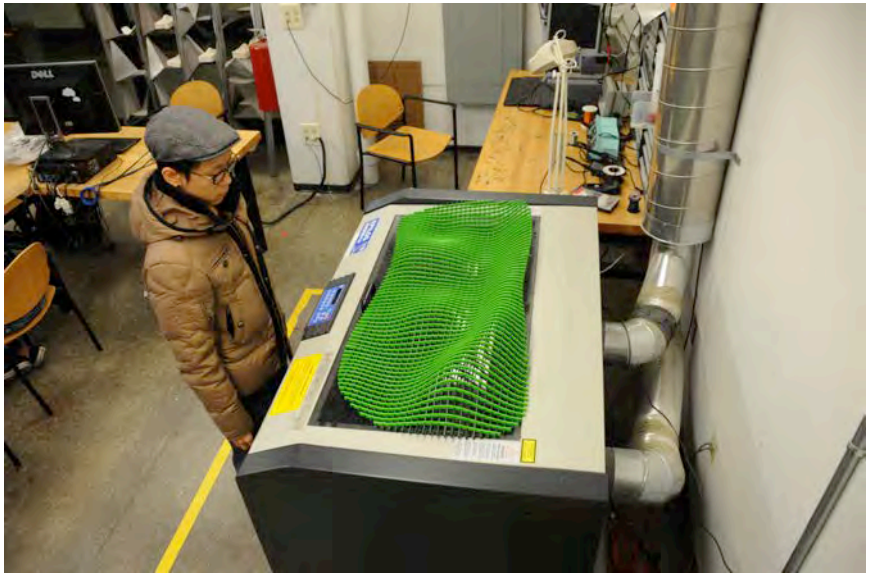
Smithwick, D., & Sass, L. Embodied Design Cognition: Action-Based Formalizations in Architectural Design. *International Journal of Architectural Computing*, *12*(4) pp. 399-418, 2014

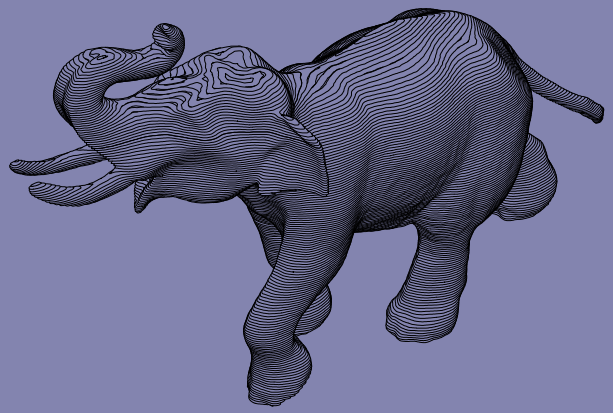
Planar Modeling Research

2012-14



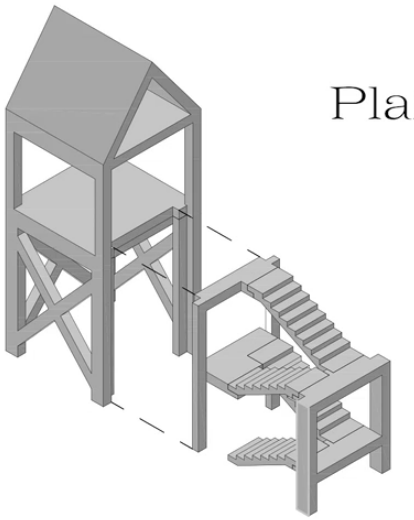






Lu Ban

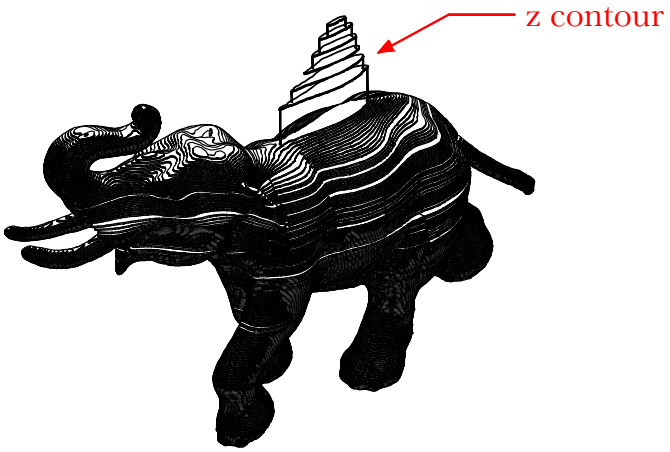
Design Fabrication Software



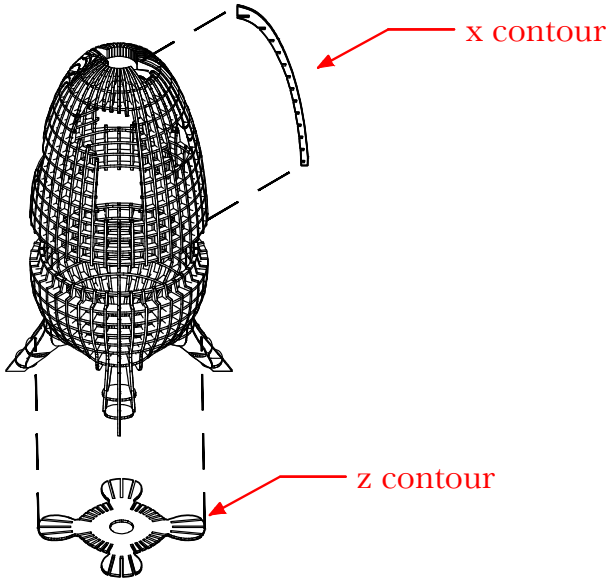
Lu Ban

Planar Modeling Software

MIT
Department of Architecture
Prof. Larry Sass & Dr. Lujie Chen



Contouring



Bi-Directional Contouring

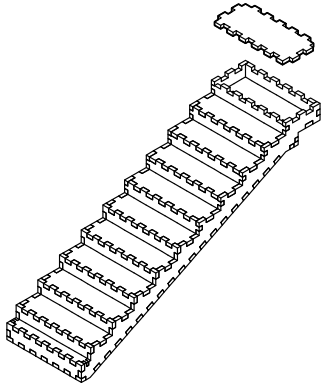
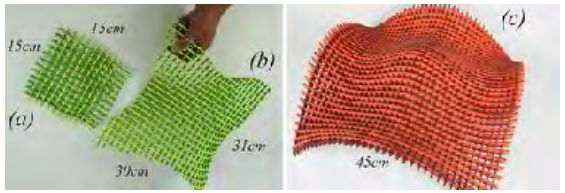
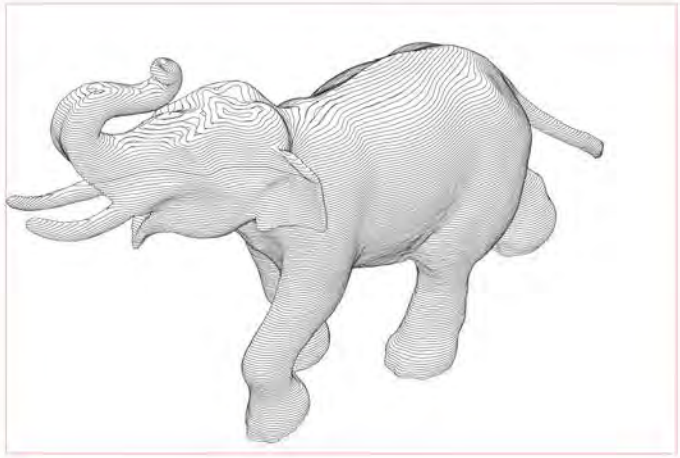


Plate Forming



Contouring

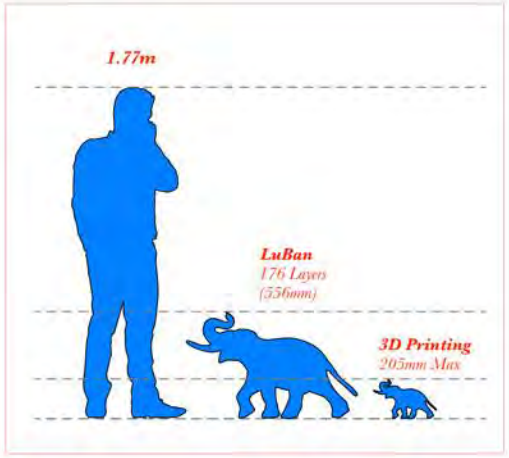


a.

Model Notes:

Method: Stack
Unit: mm
Model size X: 900
Model size Y: 286.999
Model size Z: 566.493
Dowel size: 5
Ring width: 15
Parts: 436
Machine time: 10 h
Assembly time: 37 h
Total time: 48 h
Nesting: ordered

b.



c.

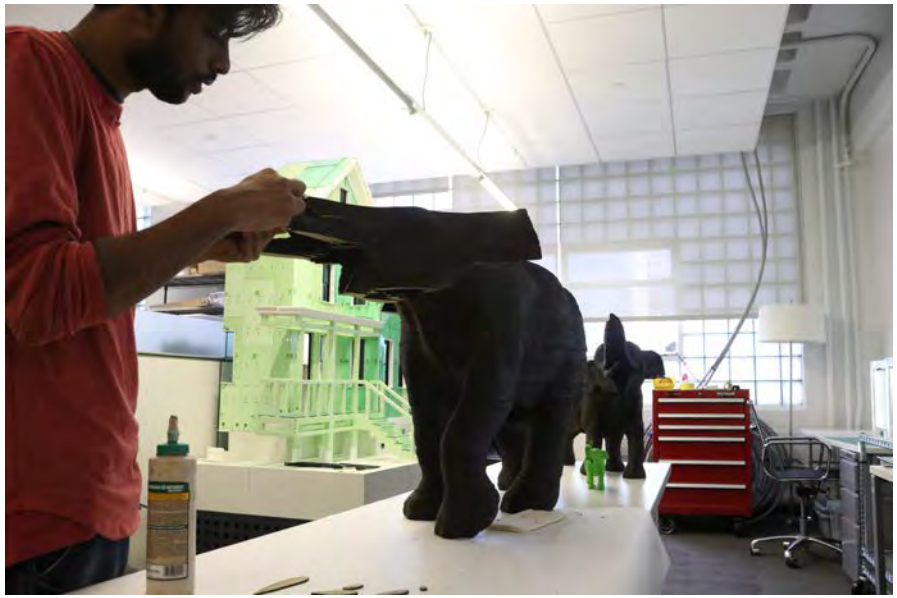
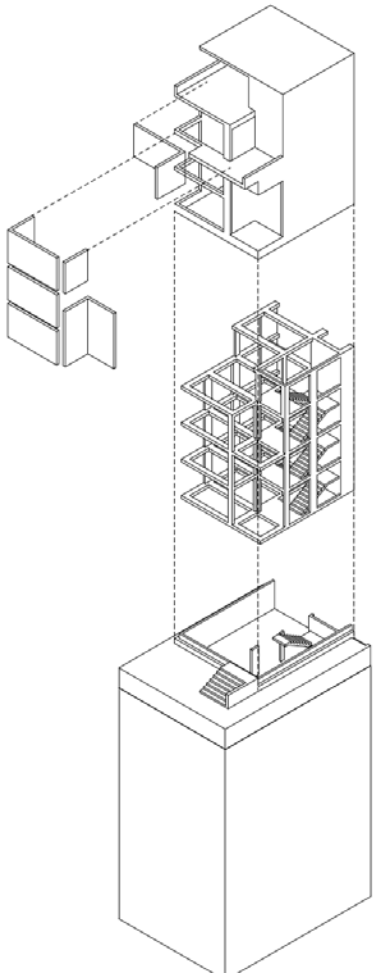
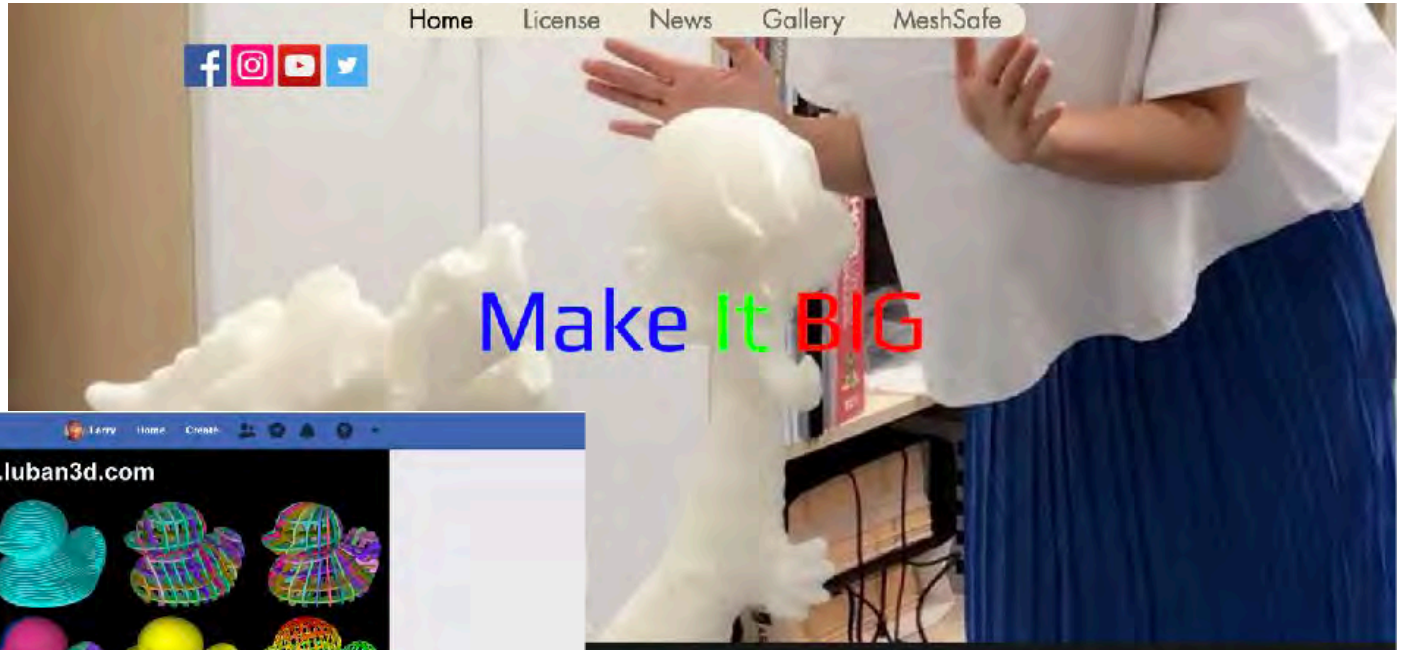


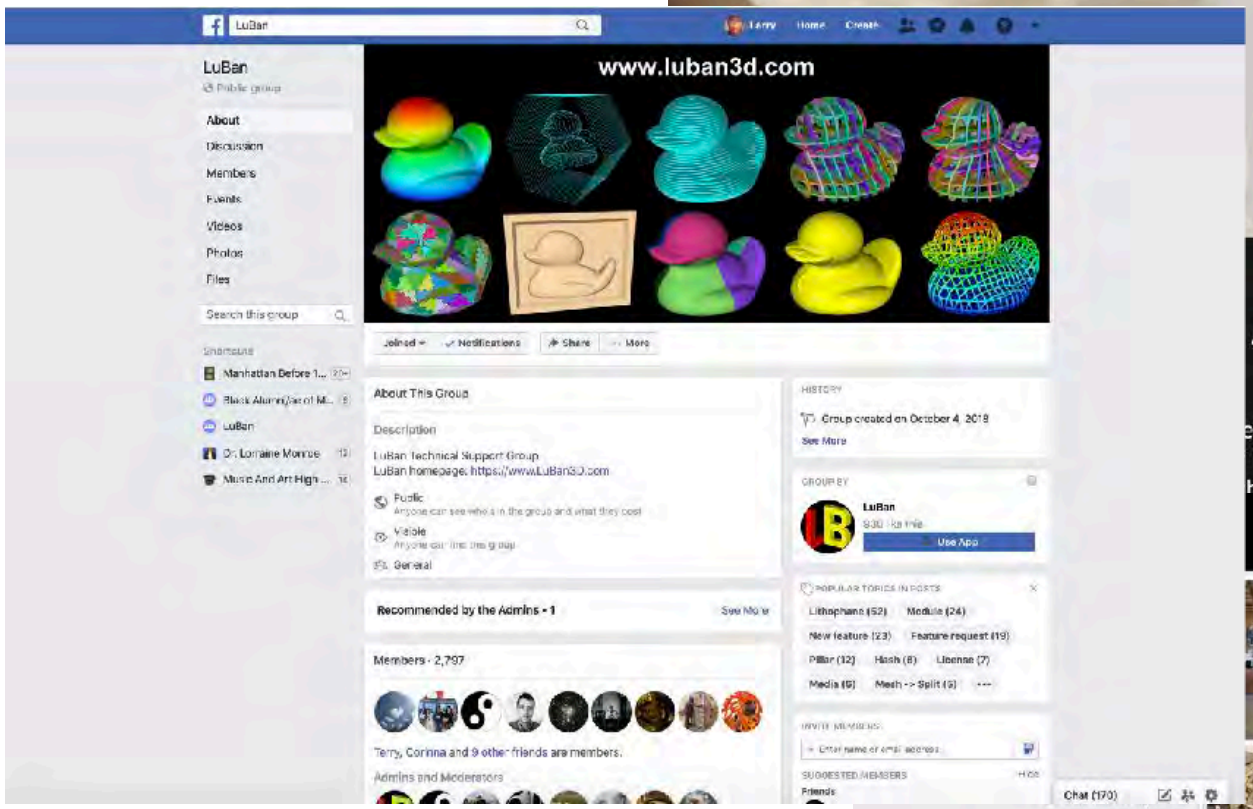
Plate Forming

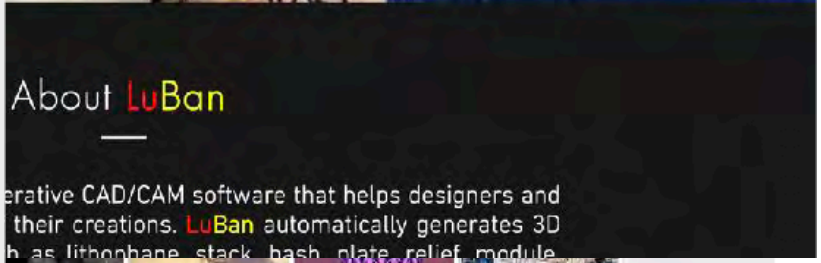


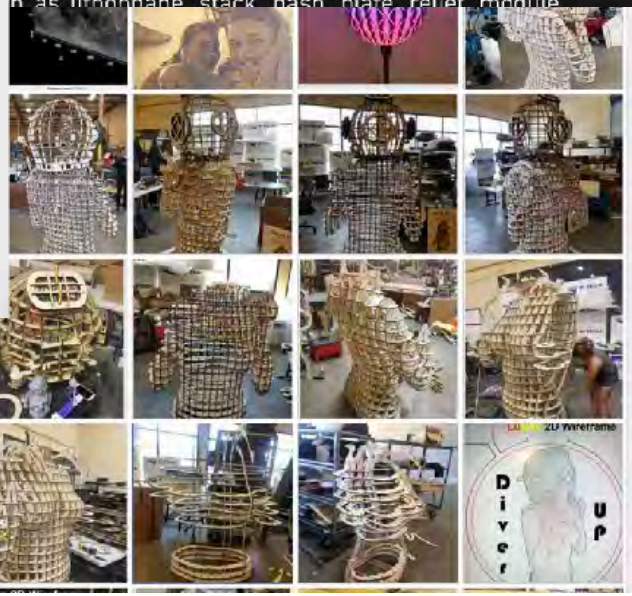
Future of LuBan

2020


Home
License
News
Gallery
MeshSafe
Make It BIG


LuBan
www.luban3d.com
About
Discussion
Members
Events
Videos
Photos
Files
About This Group
Description
Recommended by the Admins • 1
Members · 2,797


About LuBan
erative CAD/CAM software that helps designers and
their creations. LuBan automatically generates 3D


Diver
UP

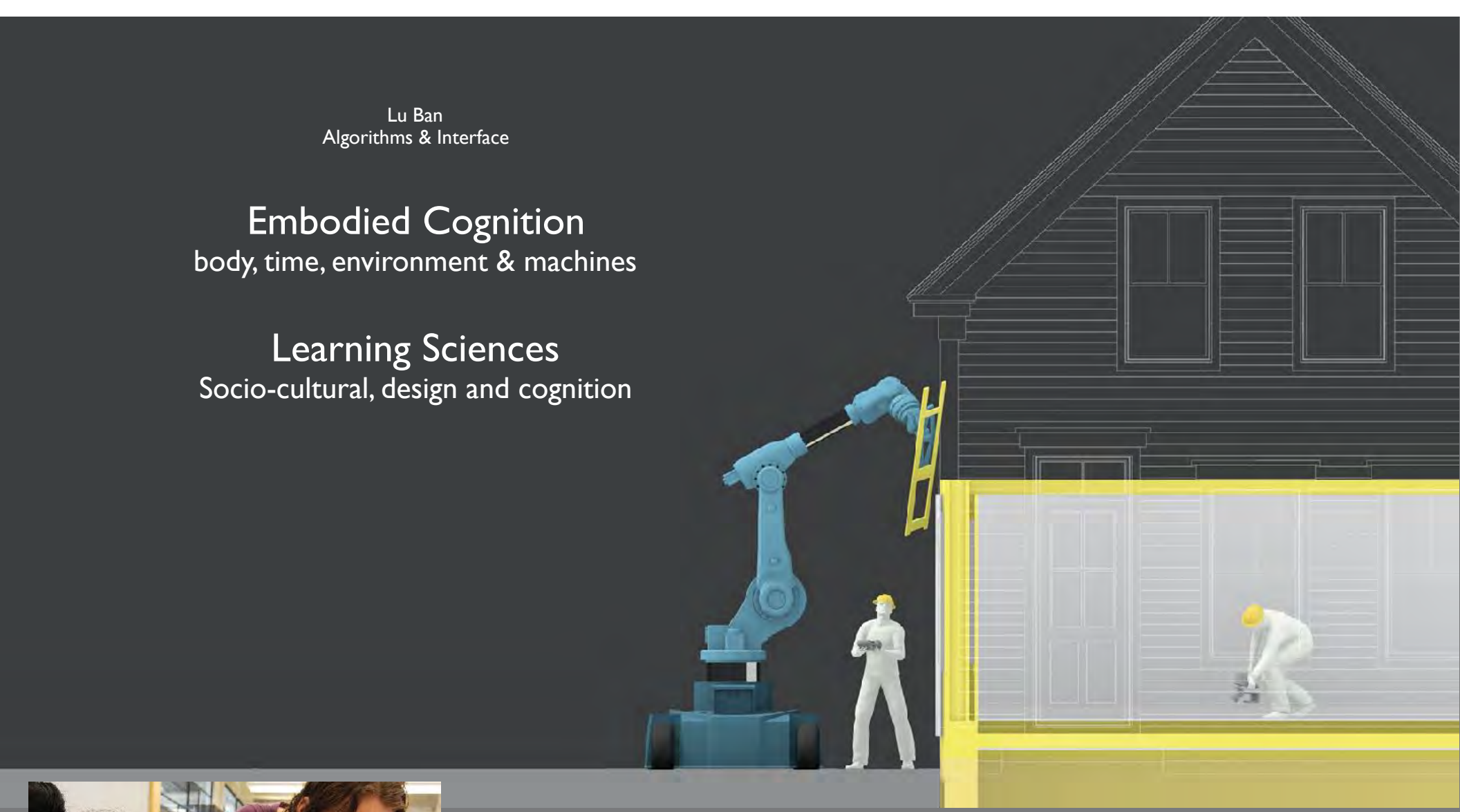
Lu Ban
Algorithms & Interface

Embodied Cognition

body, time, environment & machines

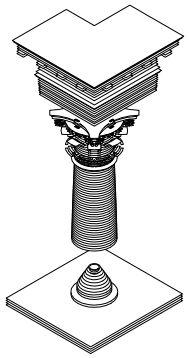
Learning Sciences

Socio-cultural, design and cognition

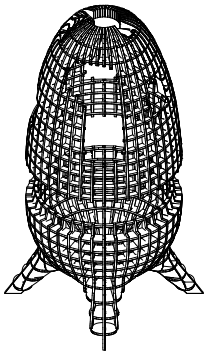


Rapid Delivery as a collaboration between people and machines (learning)

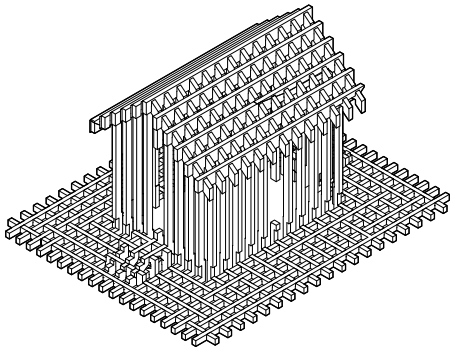


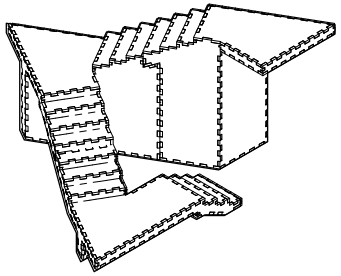
Contouring



Radial



Hash



Plates