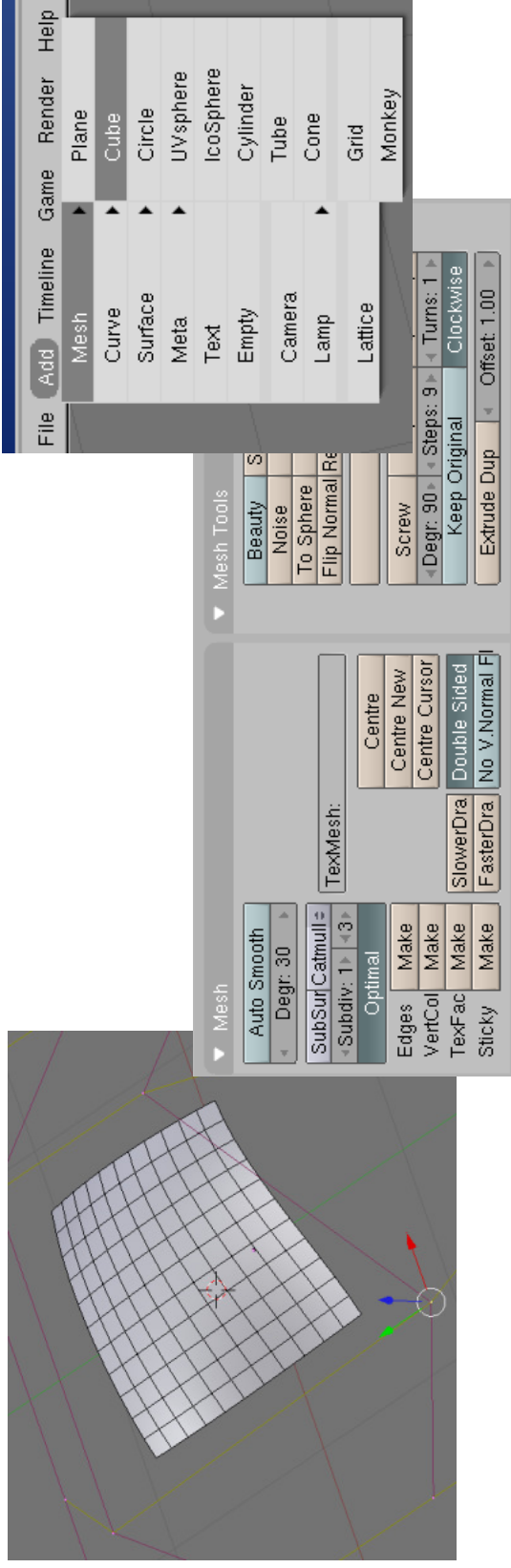# ShapeShop: Sketch-Based Solid Modeling with BlobTrees

Ryan Schmidt, Brian Wyvill, Mario Costa Sousa
University of Calgary, Canada

Joaquim A Jorge
TU Lisbon, Portugal

Motivation

- Current 3D modeling interfaces are not suitable in early design stages
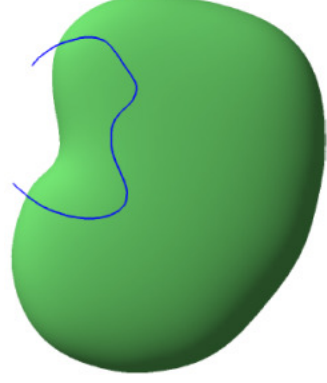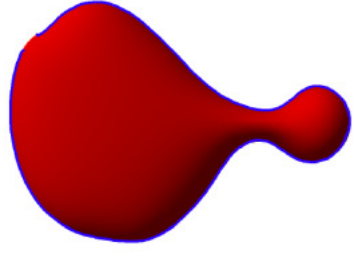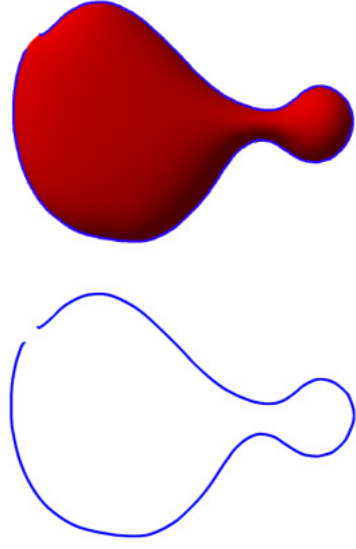 - Very time-consuming compared to a pencil

Motivation

- Simplify modeling interface by leveraging designers existing drawing skills

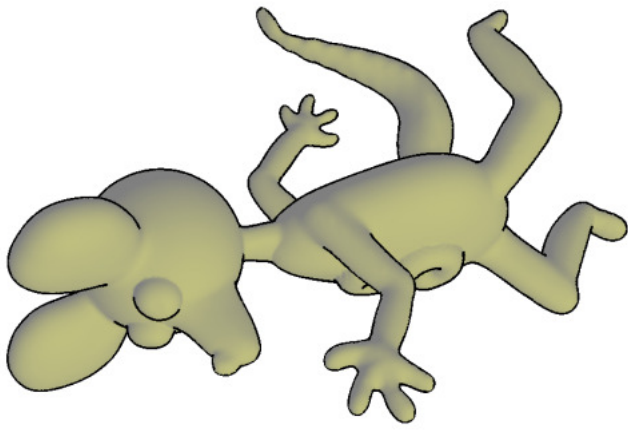 – Create 3D shapes using 2D sketches
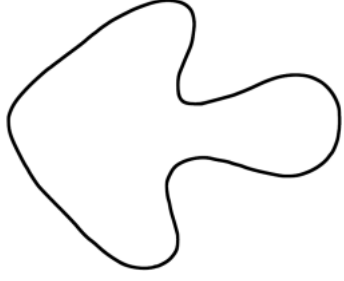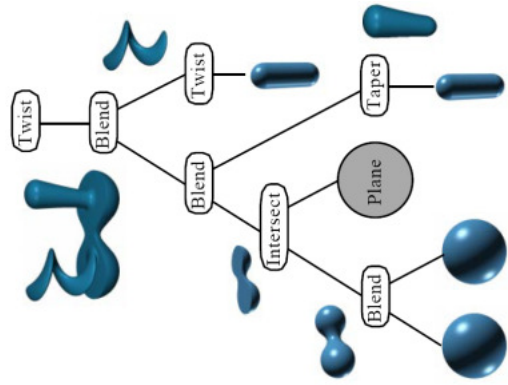
  – Edit models using 2D sketches

ShapeShop

- Build on ideas from SKETCH *[Zeleznik et al 96]*, Teddy *[Igarashi et al 99]*, GiDES++ *[Jorge et al 03]*

- Use Hierarchical Implicit Volume Modeling (BlobTrees *[Wyvill et al 99]*) as underlying shape representation
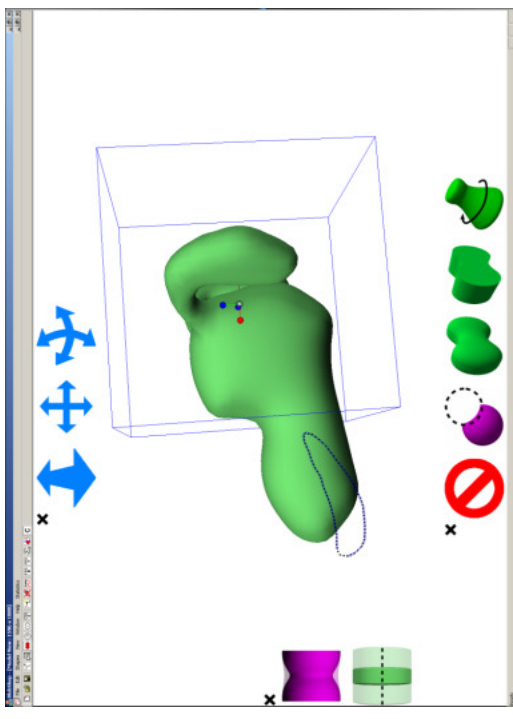
ShapeShop

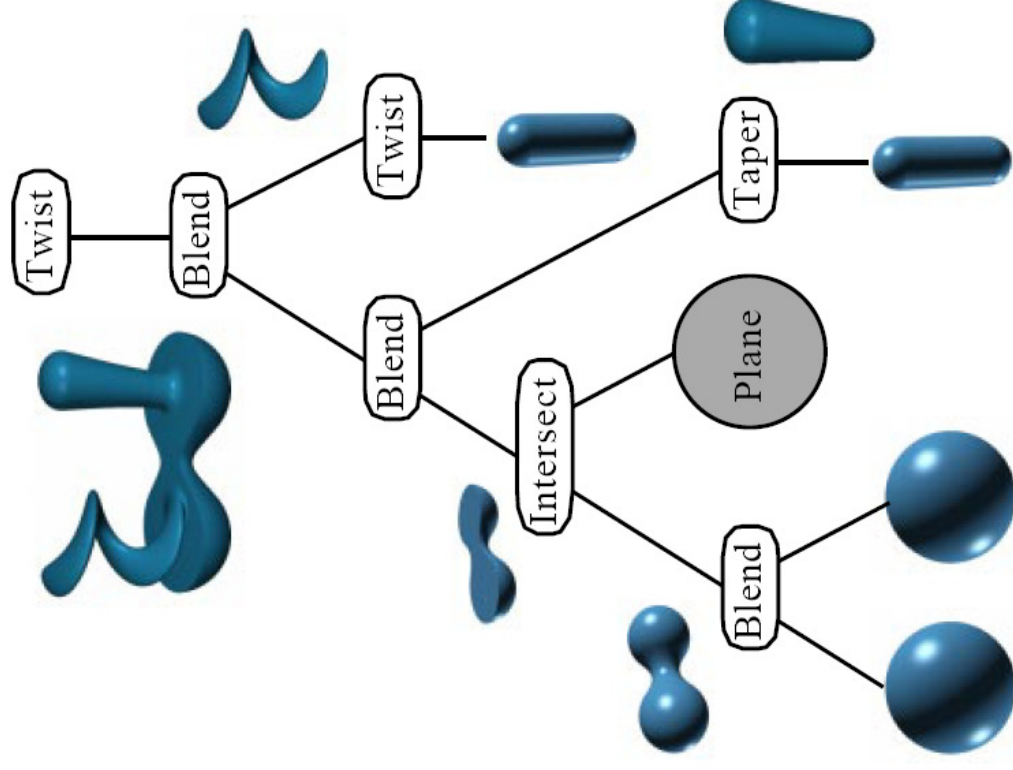- ShapeShop is a tool for creating BlobTree models using sketches

BlobTree + Sketching = ShapeShop

What is a BlobTree?

- 3D Implicit model
  - $F(\mathbf{p}) = v_{iso}$

- Like a CSG Tree with Blending, Warping, and many other operators

- Procedural definition
- Scene graph

BlobTree Modeling

- Benefits Include:

  —Solid (Volume) Modeling

  —Shape composition is easy and robust

  —BlobTree is a **full construction history** and can be animated

ShapeShop

- "Free-Form" Sketch-Based Modeling
  - Largely in the style of Teddy
  - Integrated with CAD-style BlobTree modeler

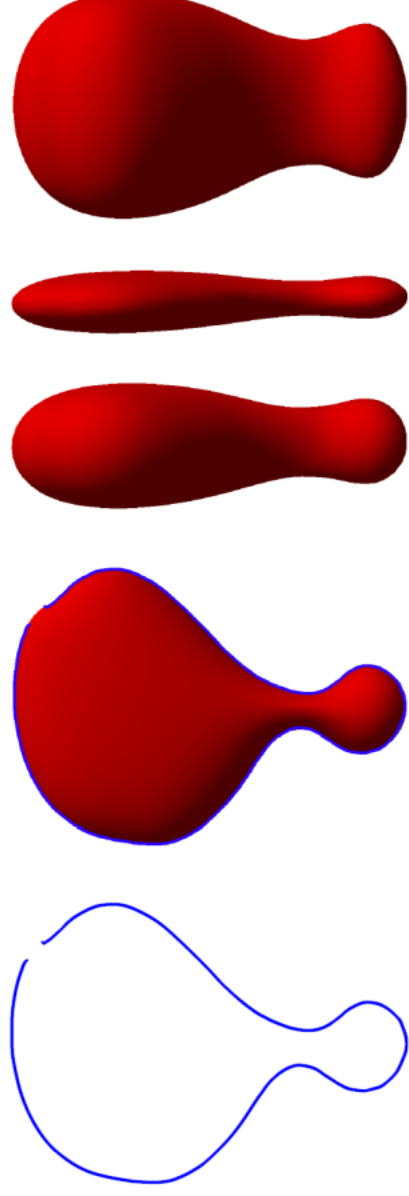- Non-modal sketching interface
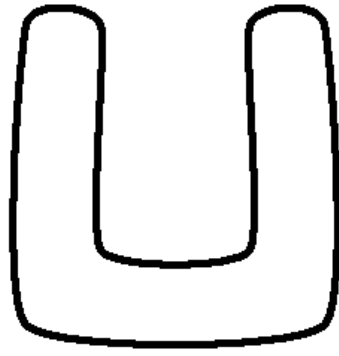 - No mouse buttons ("Clickless")

"Blobby" Inflation

- Mimic inflation technique of Teddy
  - Based on smooth distance field approximation
- Width variation generated by falloff function

Distance Field Approximation

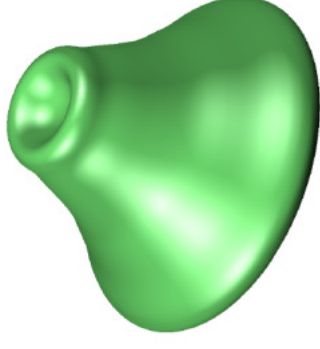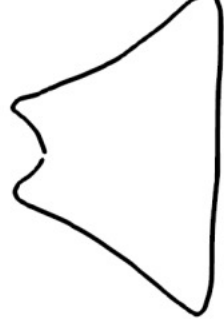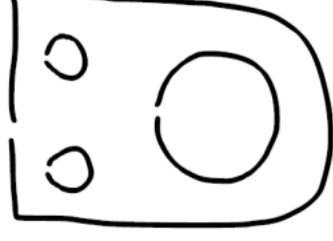Initial Curve

Exact Distance Field (C¹ Discontinuities)

C² Smooth Distance Field Approximation

Sweep Surfaces

- Linear Sweeps
  - Flat endcaps
  - Rounded or sharp edge
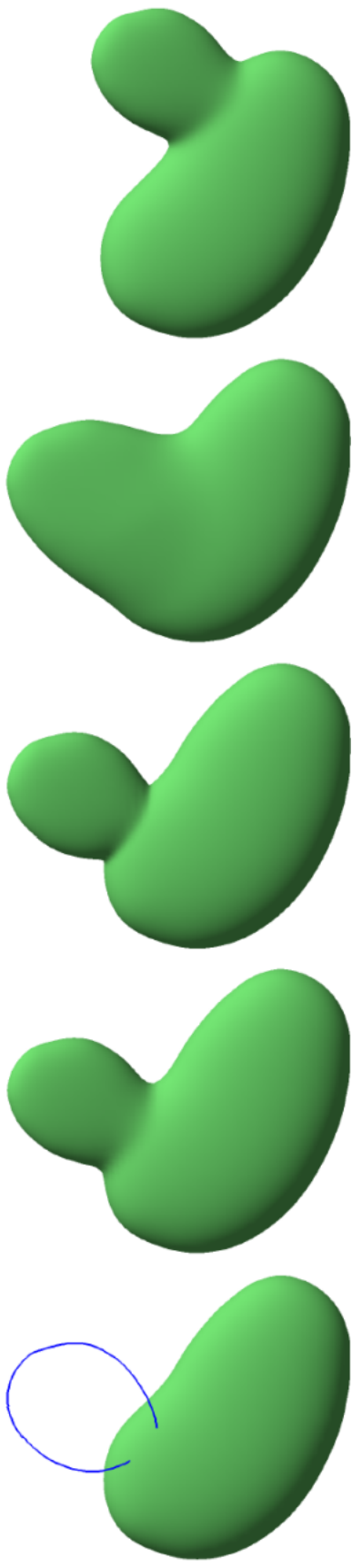- Surfaces of Revolution
  - Toroidal or Spherical
  - Interior Holes

Blending

- Parameterized Blending Operator
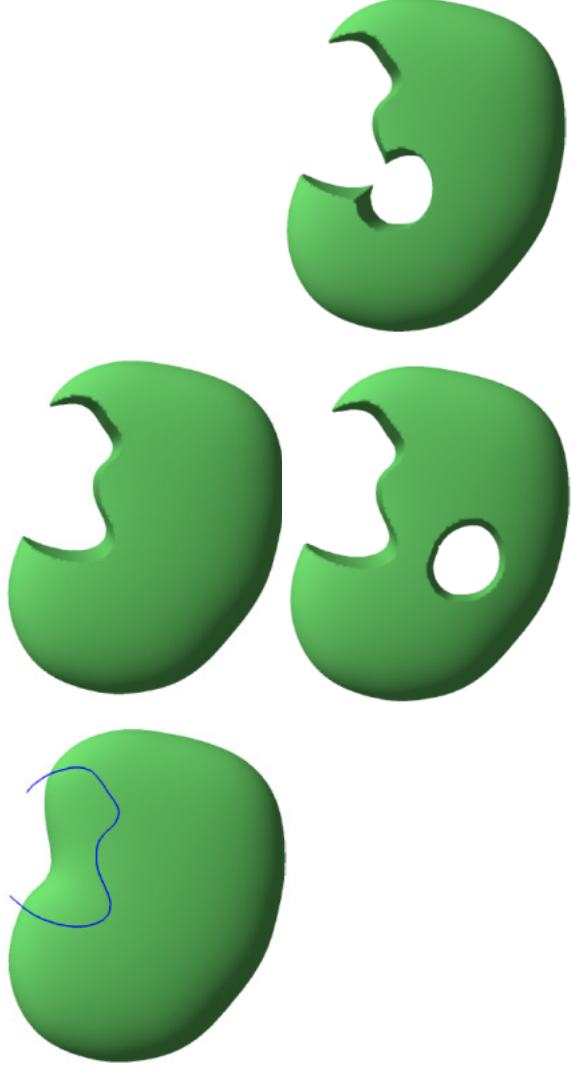- Blend surface is recomputed interactively

Cutting

- CSG Subtraction with a linear sweep
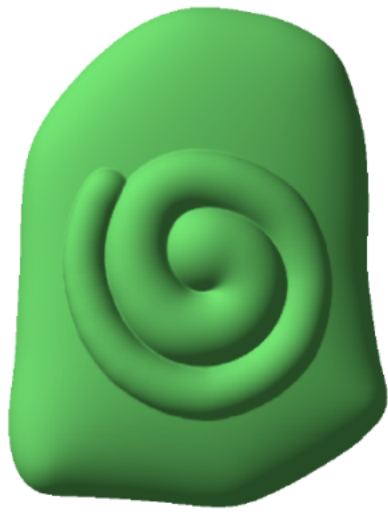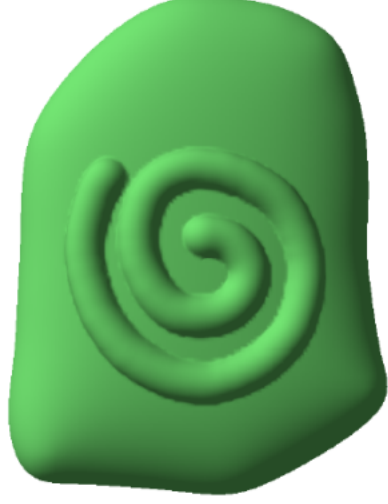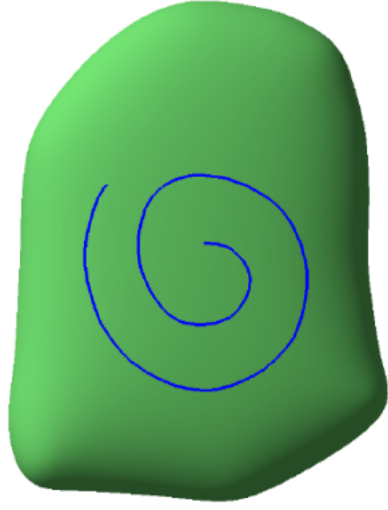
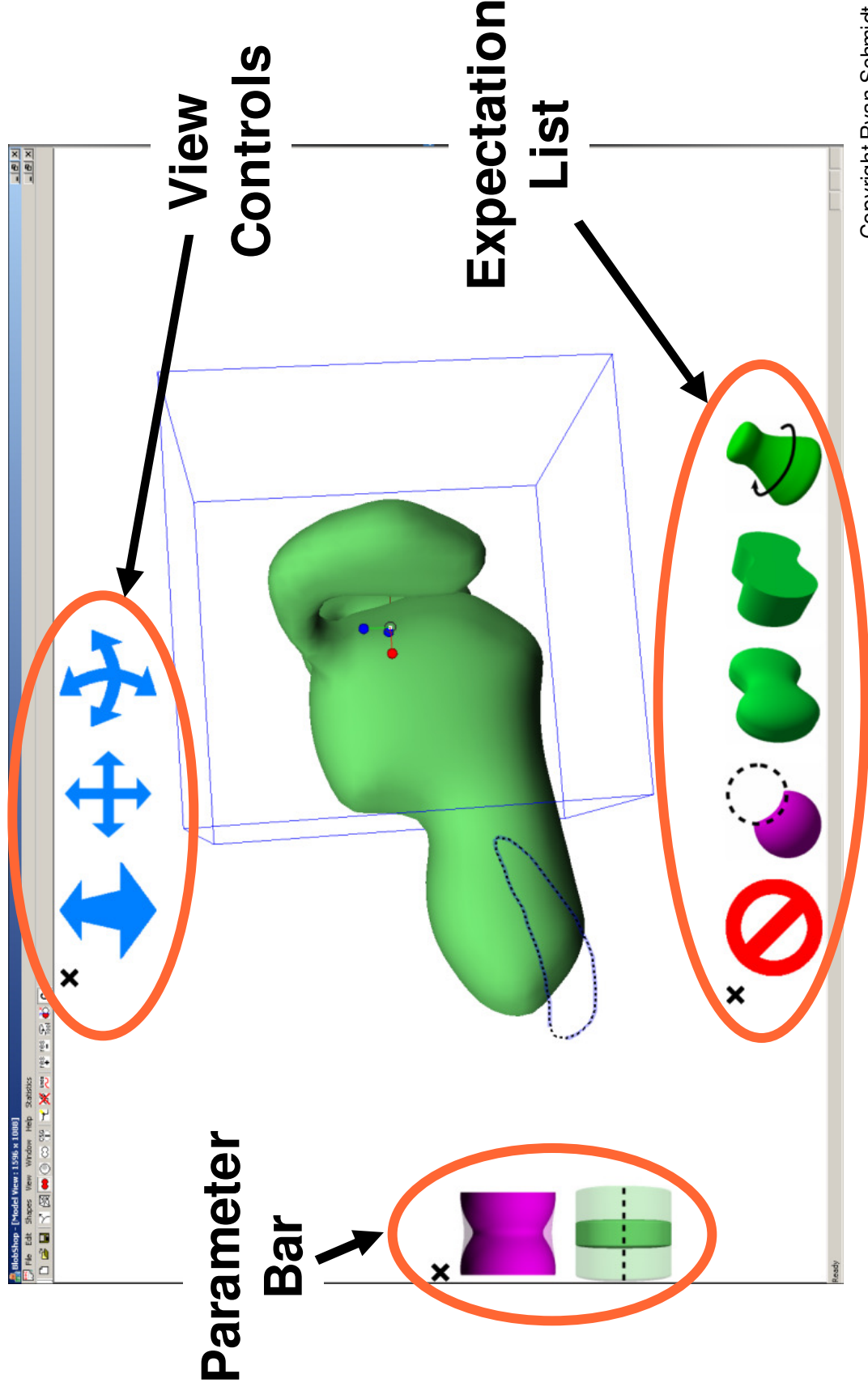- Interactively manipulate hole by manipulating sweep

Surface Drawing

- Find polyline on surface with ray intersection
- Add new primitives
- Entire stroke can be removed at any time

Sketching Interface

View Controls

Expectation List

Parameter Bar

Variational Sketching

- Treat mouse input as samples (not polyline)

- Fit interpolating variational curve
  - Automatically fills gaps
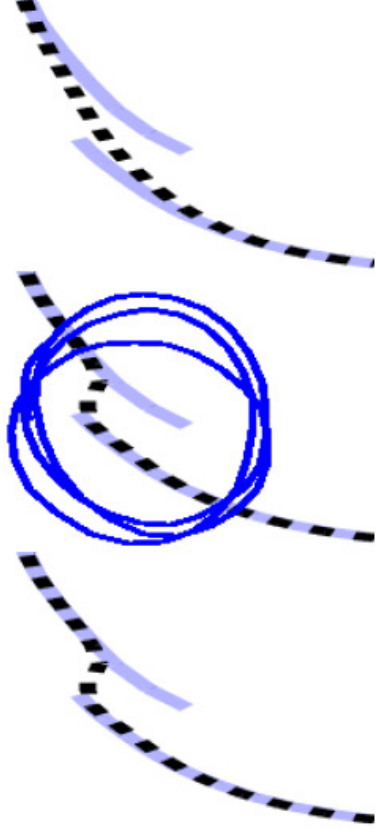 - Handles self-intersections
  - Supports erasing, smoothing

2D Sketch Editing Gestures

- Erase
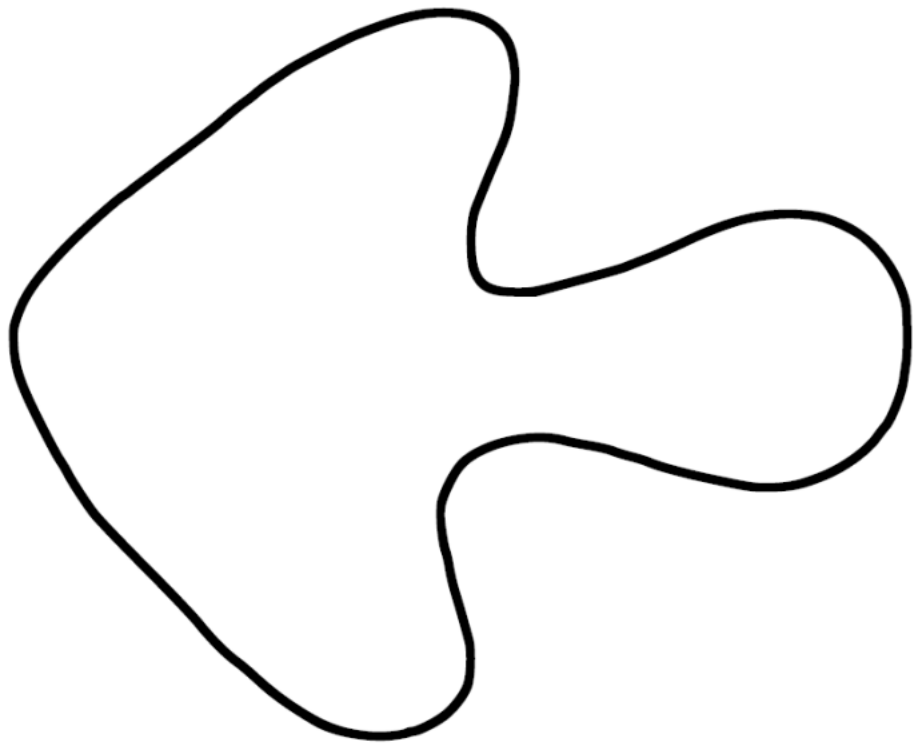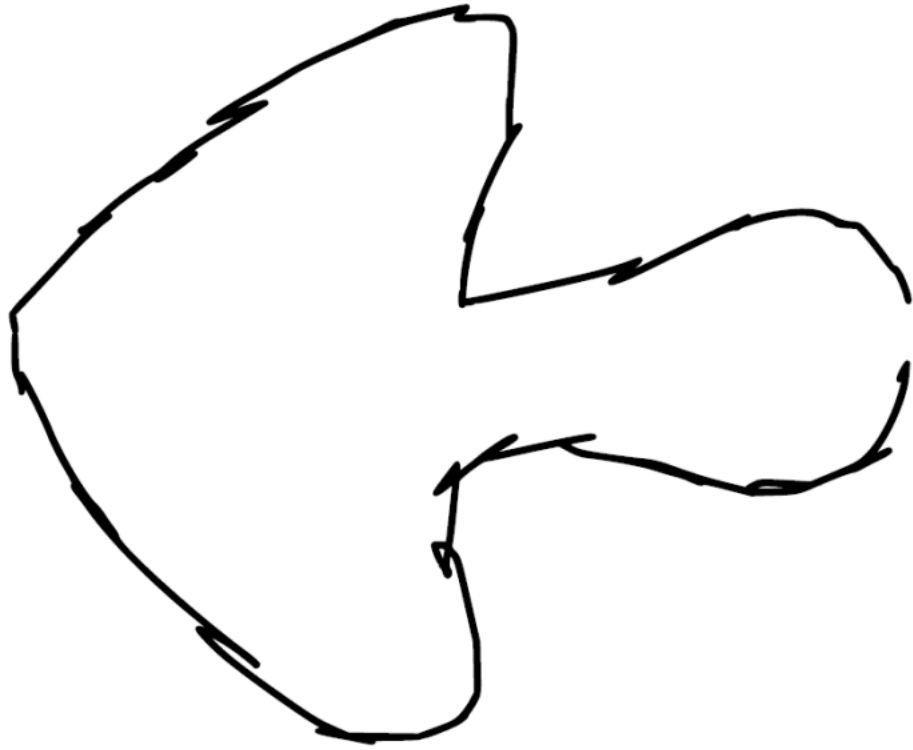
- Smooth

Smoothing Rough Sketches
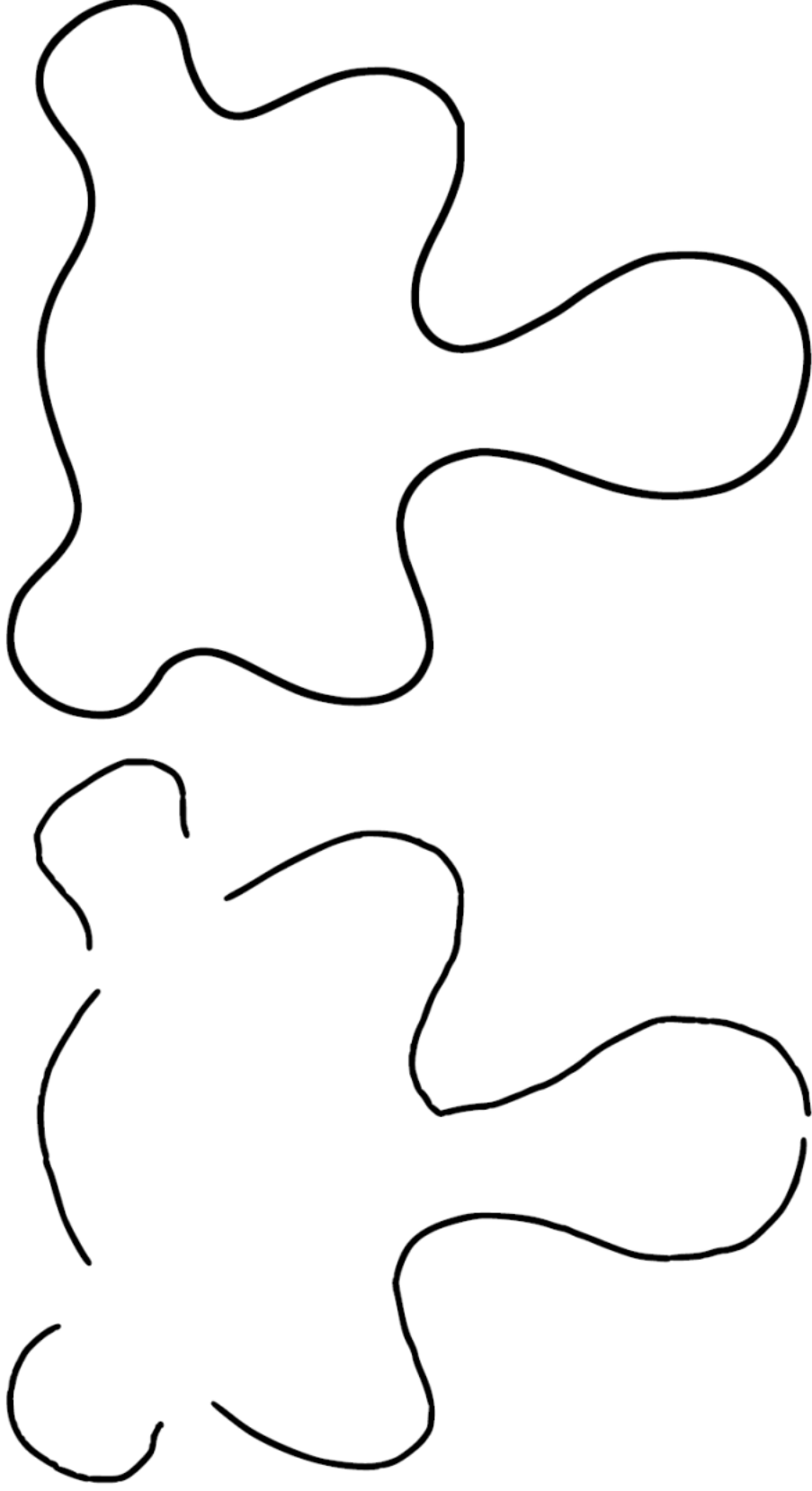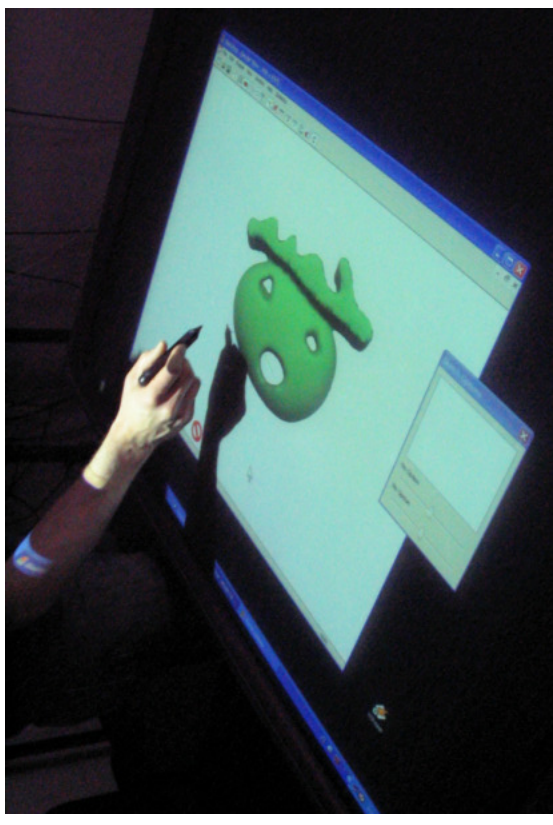
Gap Filling

Interaction Design

- Sketching interface is Non-Modal
  - No Mouse Buttons or Keyboards
- Pencils have no buttons
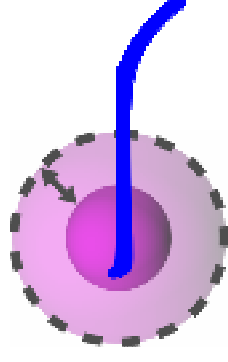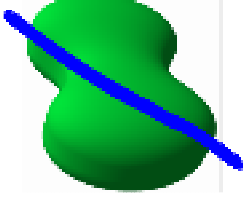- Large display input systems are often non-modal (SmartBoard, etc)

Non-Modal Widgets

- Pure gesture interface is challenging
  - Complex gestures, sketch/gesture collision
- Adapt ideas from CrossY *[Apitz et al, UIST 04]*
- Crossing for button selection
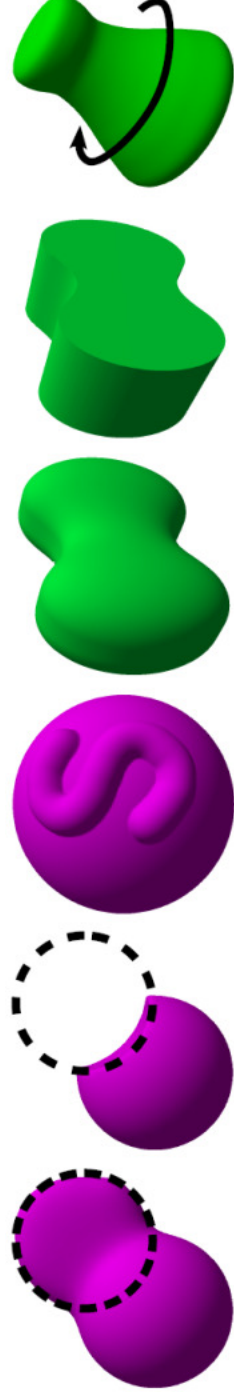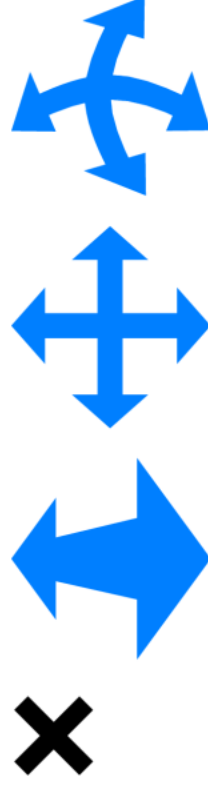- Capture-Drag for changing continuous values

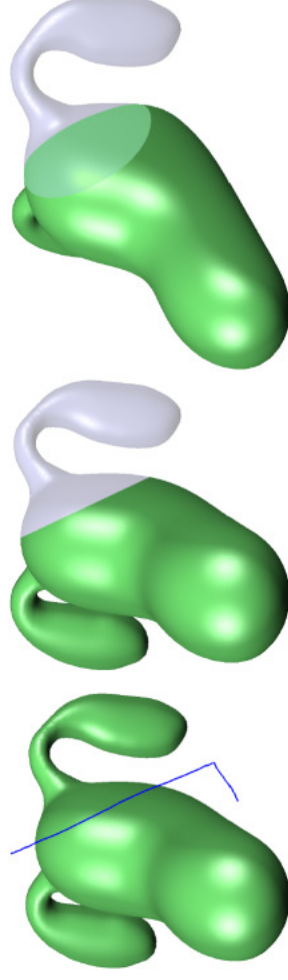# Model Interaction

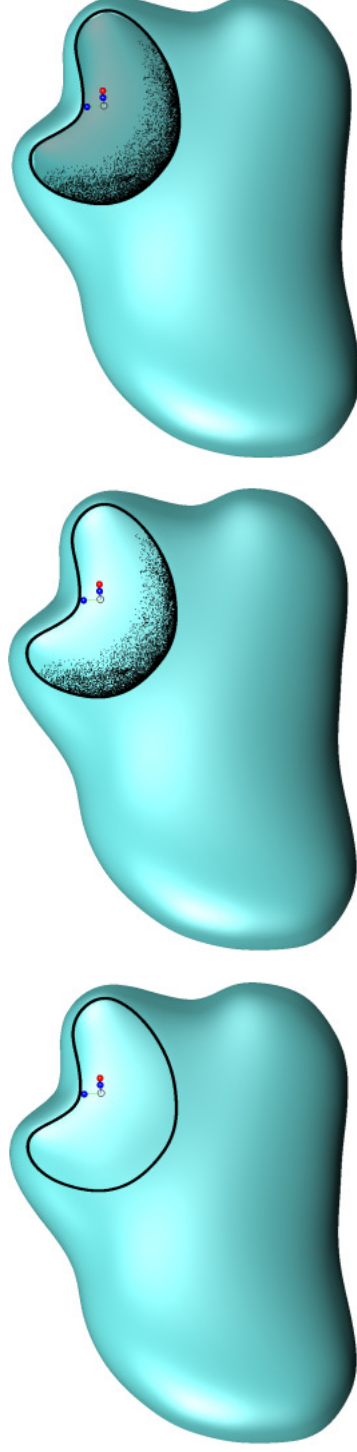- Expectation List

- View Control Toolbar

Visualization Assistance

- Dynamic Clipping
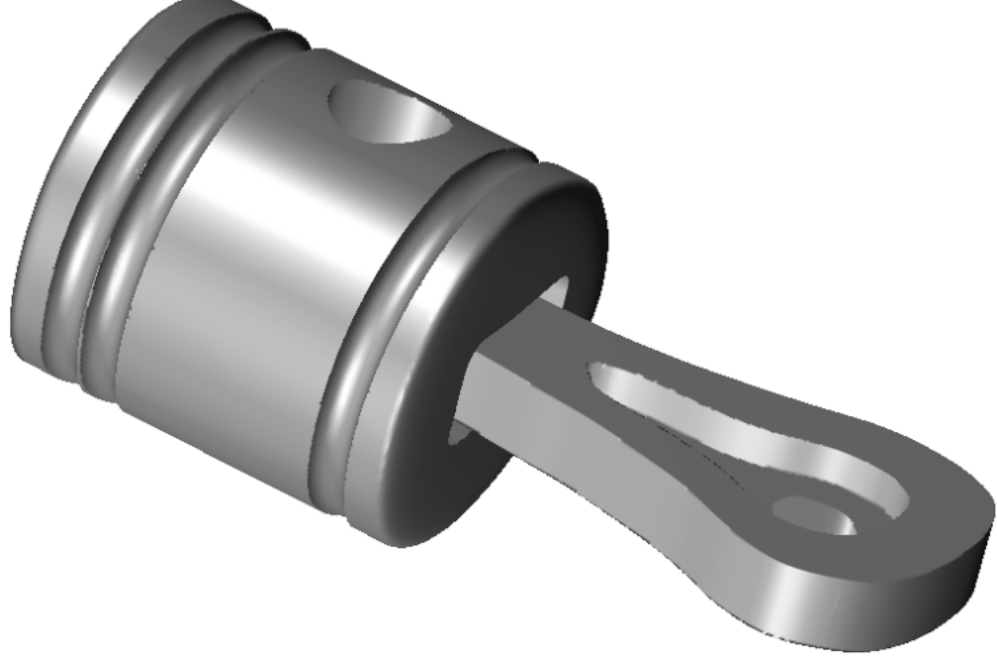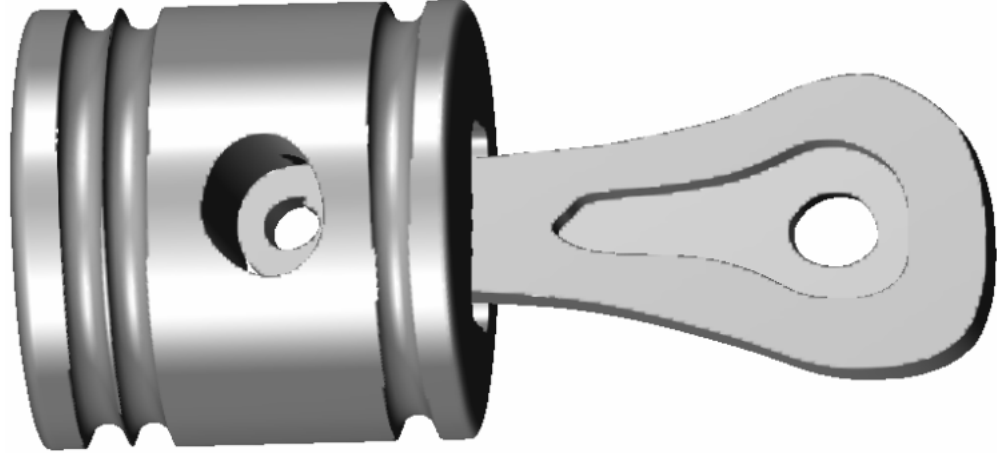
- Internal Volume Visualization

Piston Model

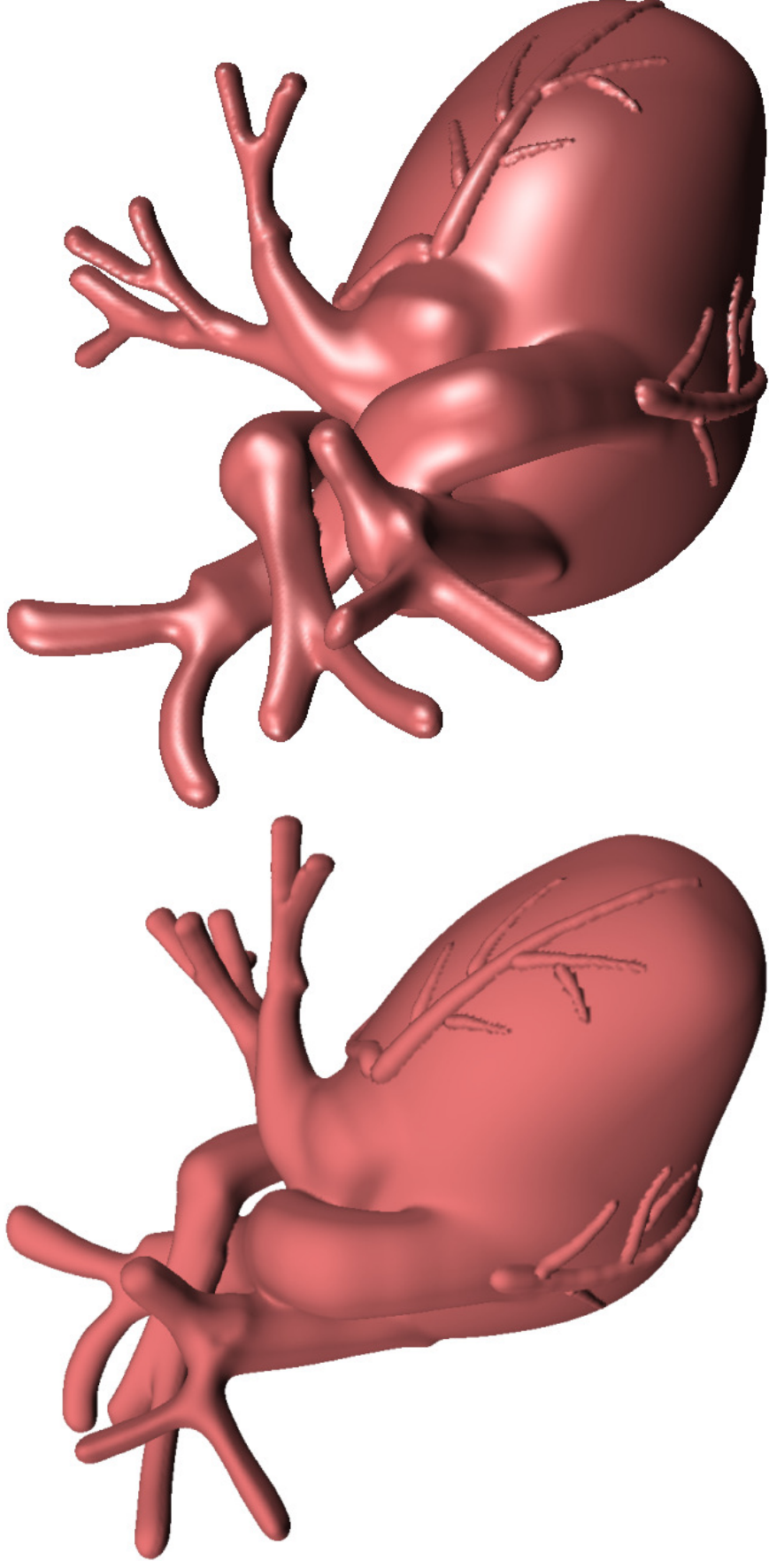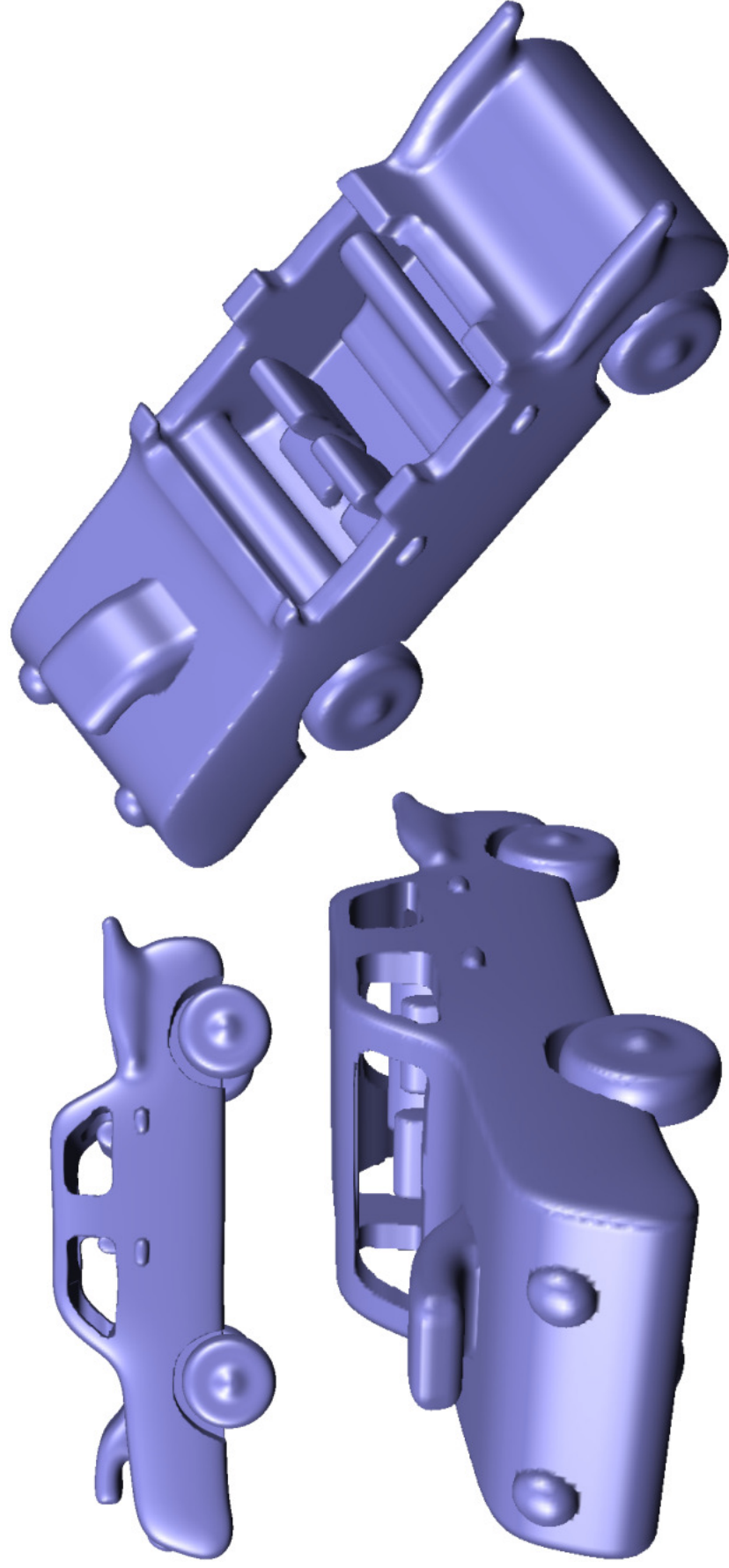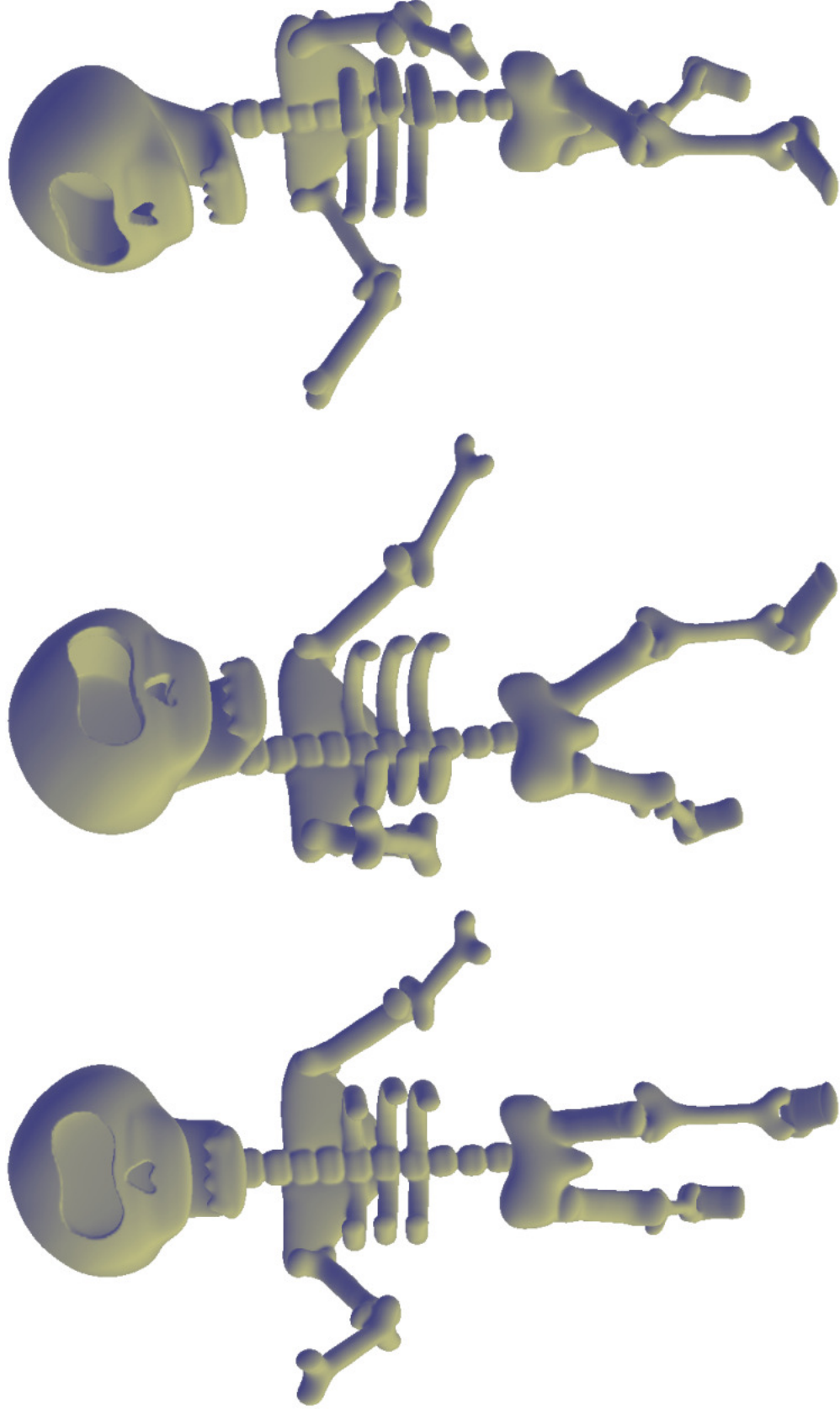# Heart Model

Car Model

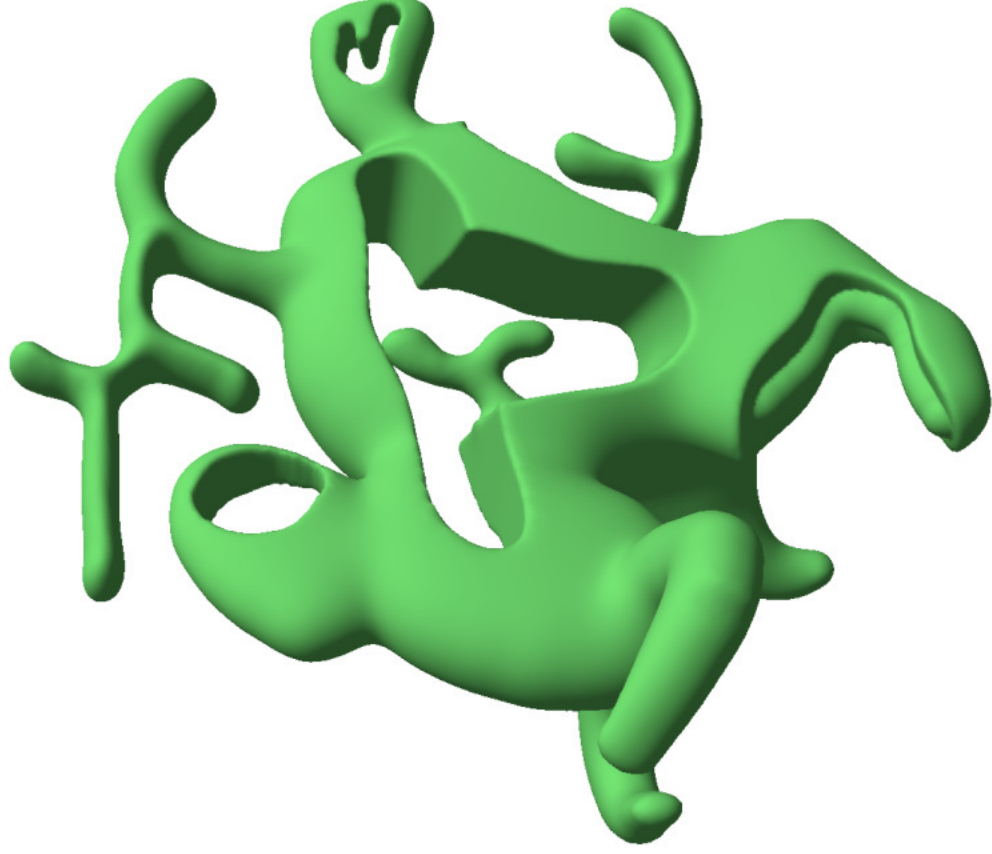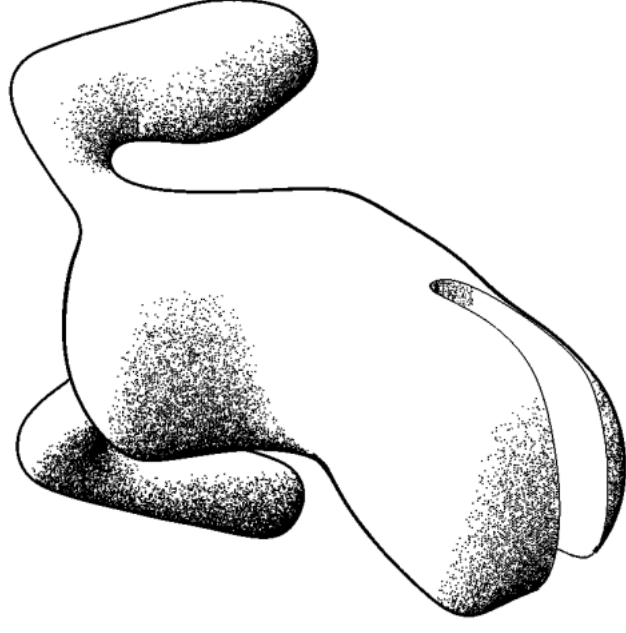# Skeleton Model

3D Doodle

Thank You

- Download ShapeShop:
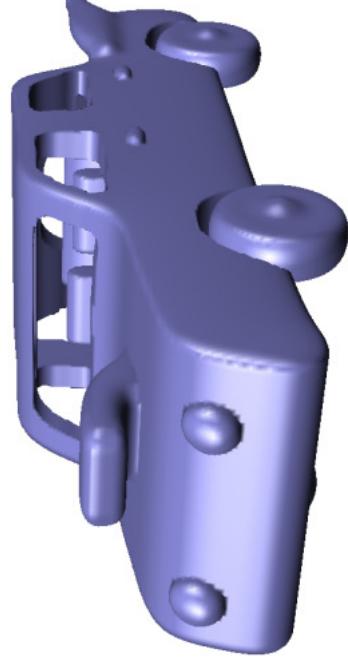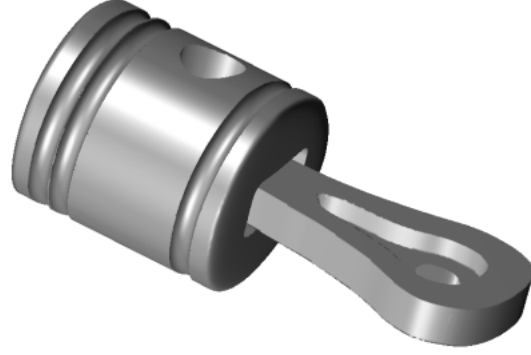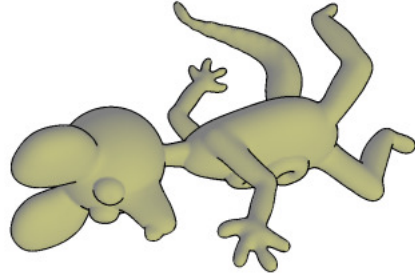 http://www.unknownroad.com/projects/shapeshop
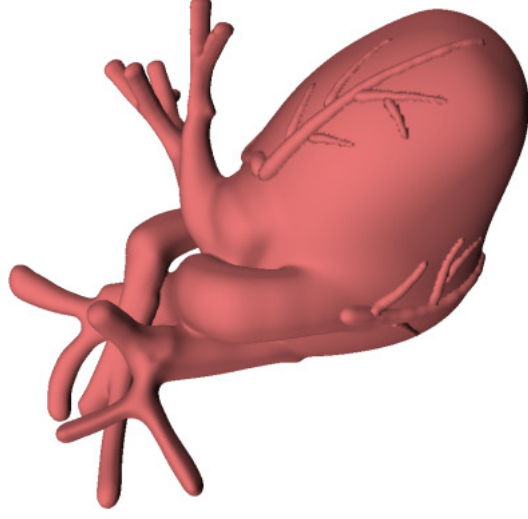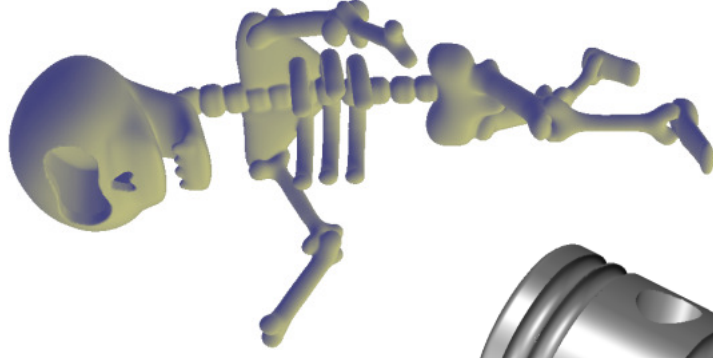
- Questions?

Questions?
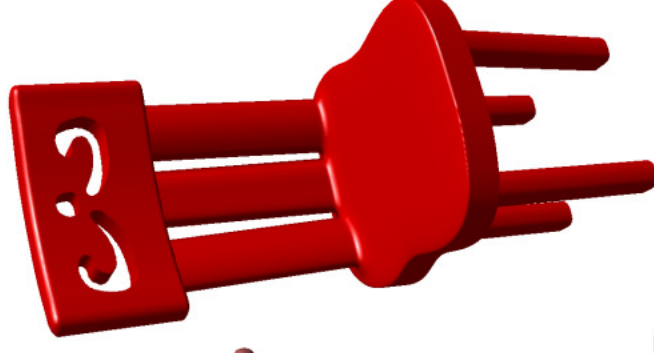
Evaluation

- How do we do it?
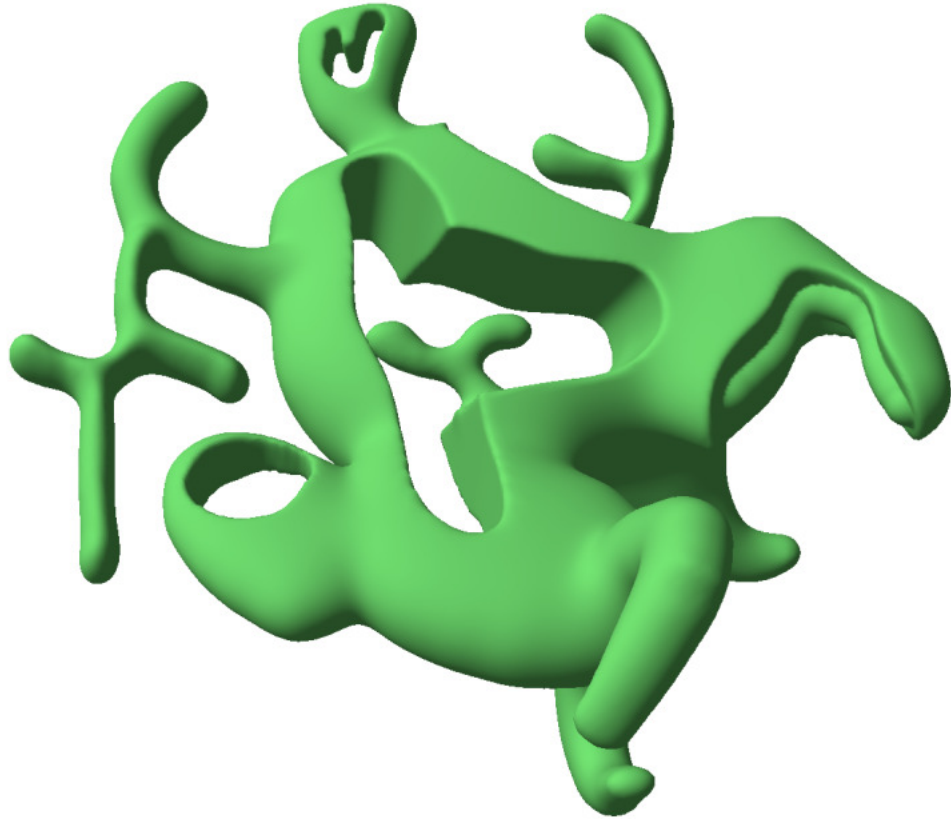
Hierarchical Spatial Caching

- BlobTree visualization is expensive
  - Does not scale interactively
- Dynamically approximate portions of the model tree with volume datasets
  - Pro: interactive performance
  - Con: accuracy problems at sharp / thin parts

Schmidt, Wyvill, Galin – SMI 2005

Outline

- Interactive BlobTree Modeling
- ShapeShop Operations
  - Creating Shapes from Sketches
  - Sketch-Based Shape Manipulation
- Sketching Interface
- Results

Distance Field Approximation

C² Smooth Distance
Field Approximation
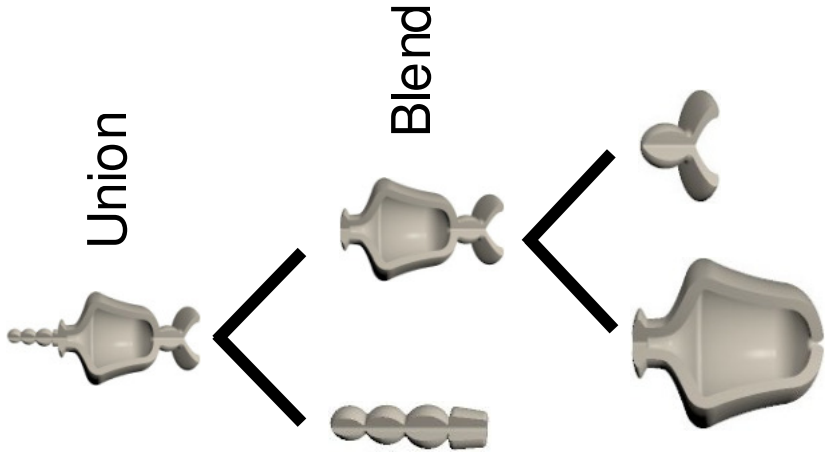
Exact Distance Field
(C¹ Discontinuities)

Hierarchical Spatial Caching

Standard BlobTree

Union

Blend

BlobTree with Cache

Union

Cache

Blend

Approximated
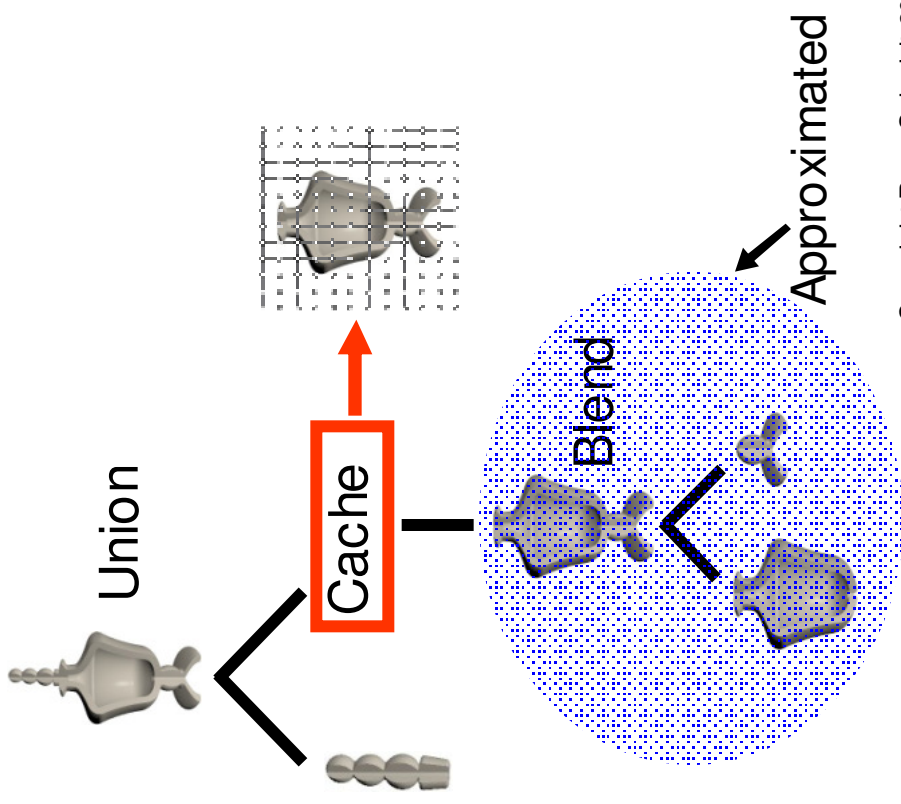
Caching Evaluation
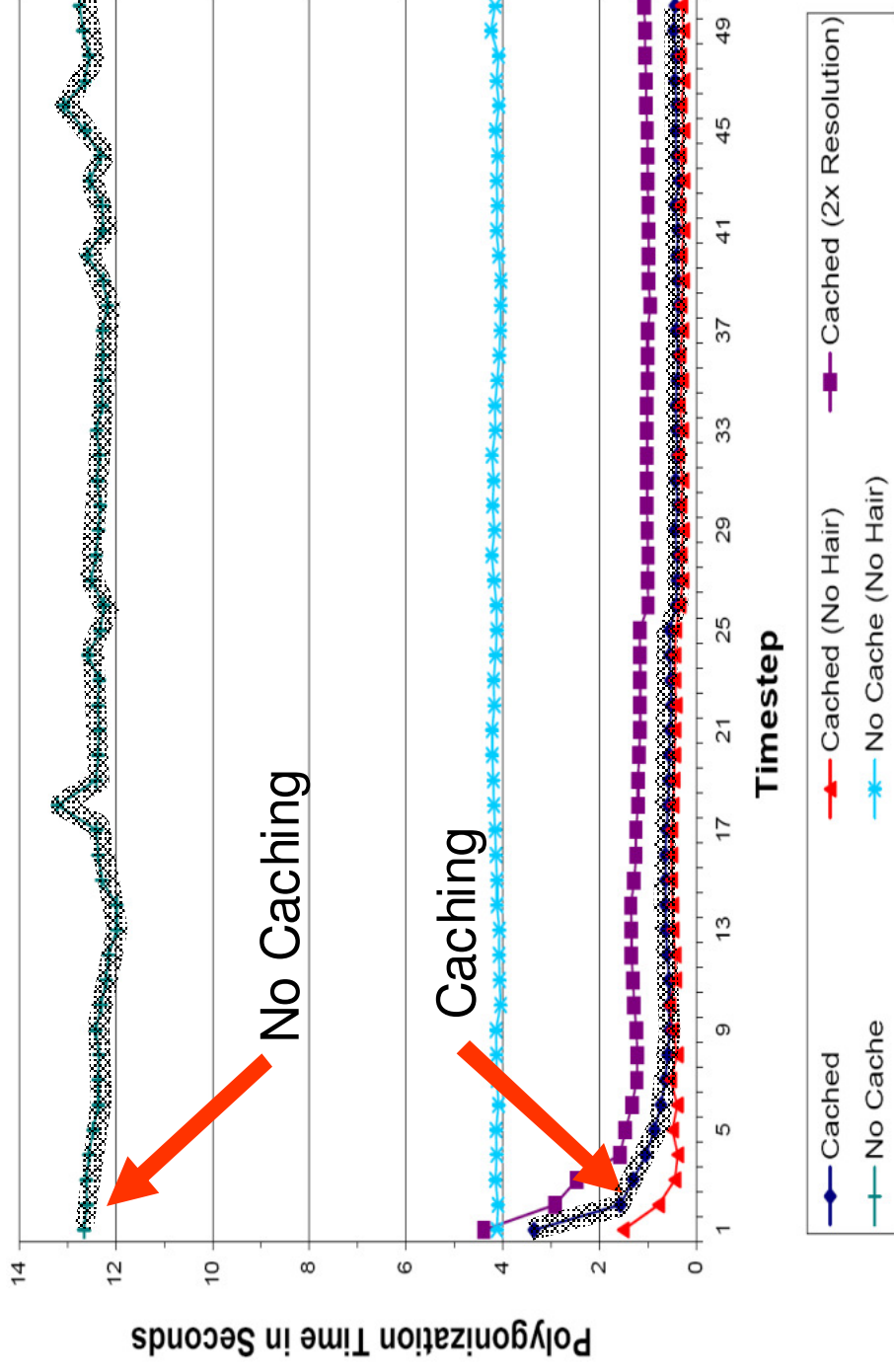
Order of Magnitude Speedup

No Caching

Caching

Polygonization Time in Seconds

14
12
10
8
6
4
2
0

1   5   9   13   17   21   25   29   33   37   41   45   49

Timestep

Cached — Cached (No Hair) — Cached (2x Resolution)
No Cache — No Cache (No Hair)

Schmidt, Wyvill, Galin – SMI 2005
Copyright Ryan Schmidt 2005