ShapeShop: Sketch-Based Solid Modeling with BlobTrees

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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
  \[ F(p) = v_{iso} \]
- 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
(C\(^1\) Discontinuities)

C\(^2\) 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

- Parameter Bar
- View Controls
- Expectation List
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
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
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
Outline

• Interactive BlobTree Modeling

• ShapeShop Operations
  – Creating Shapes from Sketches
  – Sketch-Based Shape Manipulation

• Sketching Interface

• Results
Distance Field Approximation

Exact Distance Field
($C^1$ Discontinuities)

$C^2$ Smooth Distance Field Approximation
Hierarchical Spatial Caching

Standard BlobTree

BlobTree with Cache

Union

Blend

Cache

Blended

Approximated

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Caching Evaluation

Polygonization Time in Seconds

Timestep

Order of Magnitude Speedup

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

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