Sketching, Scaffolding, and Inking: A Visual History for Interactive 3D Modeling

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10,000-Foot View

- How can we better support the design process in 3D modeling software?

- Sketch-Based Modeling

- Improve 3D model understanding
Visual Representations

Production sketch

Design sketch
Production sketch

Design sketch
Goals

- Figure out how to simulate design sketching
- Integrate with production sketch rendering
- Implement in an interactive 3D surface modeler
Design Sketches

Comic Art Pipeline

Sketching / Penciling

Inking

Coloring

Images © Jerry Holkins, taken from http://pennyarcade.blogspot.com
Sketching / Penciling

- Iterative refinement
- High-throughput
- Consistency
Visual Scaffolding

- Temporary artist-created design aids
  - “Construction lines/shapes”, “trace lines”, “guide lines”, etc...

Image © Jerry Holkins
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Geometric Massing

- Architectural Massing Models
- Helps with form, perspective
- Well-suited for SBM (model-by-part)
Geometric Massing

- Coarse geometric shapes
- Partial “shape axes”
- Varying occlusion
- Lots of overdraw
Algorithm

- Fit bounding box
- Contours from plane intersections
- Random perturbation
- Fade in/out based on viewing angle
Erasing vs Deleting

- Deleted parts “disappear”
  - Can’t learn from them

- No “mistakes” in design sketching !!!
  - Exploring alternatives

- Not an artifact of paper
“Real-World” Application

- Have design sketch “look”
  - Geometric Massing
  - Eraser Marks

- Composite w/ production sketch techniques
  - Pen & Ink

- Now to integrate renderer into an interactive modeling system...
Integration
Practical Limitations

- Free-form modeling
  - NURBS, SubD, Implicit

- Interactivity is critical
  - Meshes are low-res
  - Ugly contours

- Mesh is dynamic
  - Can’t precompute!
Silhouettes

Sub-Poly Contours on Base Mesh

Project

Refine
Caveats

- Need functional surface normals
- Base mesh needs to capture topology of surface
Hidden Line Removal & Stippling

- Surfel approach ("tiny canvasses")
  - Cover base mesh w/ surfels
  - Project to surface

- Hierarchical culling, lazy generation
  - base mesh as spatial data structure
Surfel Distribution

- “As-uniform-as-possible”
- Take surface curvature into account
Wins

- Visual Scaffolding
  - Geometric Massing, Eraser Marks

- Real-Time Pen & Ink on dynamic surfaces
  - Implicit, NURBS, SubDs
  - Fully object-space
  - Supports incremental refinement
  - Frame-coherent as long as base mesh triangles do not change

- Smoother-looking surface at equivalent interactive framerate!
The Future

- Other visual scaffolding types
- Interactive Scaffolding
- “Conjecturing” scaffolding?

- www.shapeshop3d.com
(Under “Downloads” -> “Extras”)
Surfel Rasterization

(a) Diagram with vectors $n_1$, $n_2$, and $S$. The angle $\theta$ and the points $x_1$, $x_m$, and $x_h$ are also shown.

(b) Another diagram with vectors and points.

(c) Grid pattern with diagonal lines.

(d) Complex grid pattern with irregular lines.
Surfel Distribution

- “As-uniform-as-possible”
- Take surface curvature into account
- View-dependent density
Sketching Videos

- **Eyes**: [http://www.youtube.com/watch?v=GAi7cHiaf-U](http://www.youtube.com/watch?v=GAi7cHiaf-U)
- **Superman**: [http://www.youtube.com/watch?v=EZZtXKUHUyU](http://www.youtube.com/watch?v=EZZtXKUHUyU)
- **Jim Lee**: [http://www.youtube.com/watch?v=Ys5UmSx9rfA](http://www.youtube.com/watch?v=Ys5UmSx9rfA)
- **Great quick sketches**: [http://www.youtube.com/watch?v=kygMLl60Bt4](http://www.youtube.com/watch?v=kygMLl60Bt4)
- **Wolverine!**: [http://www.youtube.com/watch?v=v_kB6GzzCkU](http://www.youtube.com/watch?v=v_kB6GzzCkU)
- **Stewie**: [http://www.youtube.com/watch?v=-AH4Zrw7MwM](http://www.youtube.com/watch?v=-AH4Zrw7MwM)
- **Drawing a head**: [http://www.youtube.com/watch?v=erKzKISJxxk](http://www.youtube.com/watch?v=erKzKISJxxk)
- **Hand**: [http://www.youtube.com/watch?v=p2-aheNqhRM](http://www.youtube.com/watch?v=p2-aheNqhRM)
- **Geometric Massing**: [http://www.youtube.com/watch?v=rRj5CaMjTNs](http://www.youtube.com/watch?v=rRj5CaMjTNs)
- **Spongebob Squarepants**: [http://www.youtube.com/watch?v=m6MfGYwsy80](http://www.youtube.com/watch?v=m6MfGYwsy80)
- **Adam Hughes**
  - [http://www.youtube.com/watch?v=UvaG1EZ9shM](http://www.youtube.com/watch?v=UvaG1EZ9shM)
  - [http://www.youtube.com/watch?v=mAO3sUyg-Bw](http://www.youtube.com/watch?v=mAO3sUyg-Bw) (talks about construction lines!)