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


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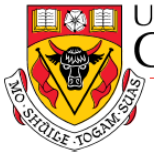

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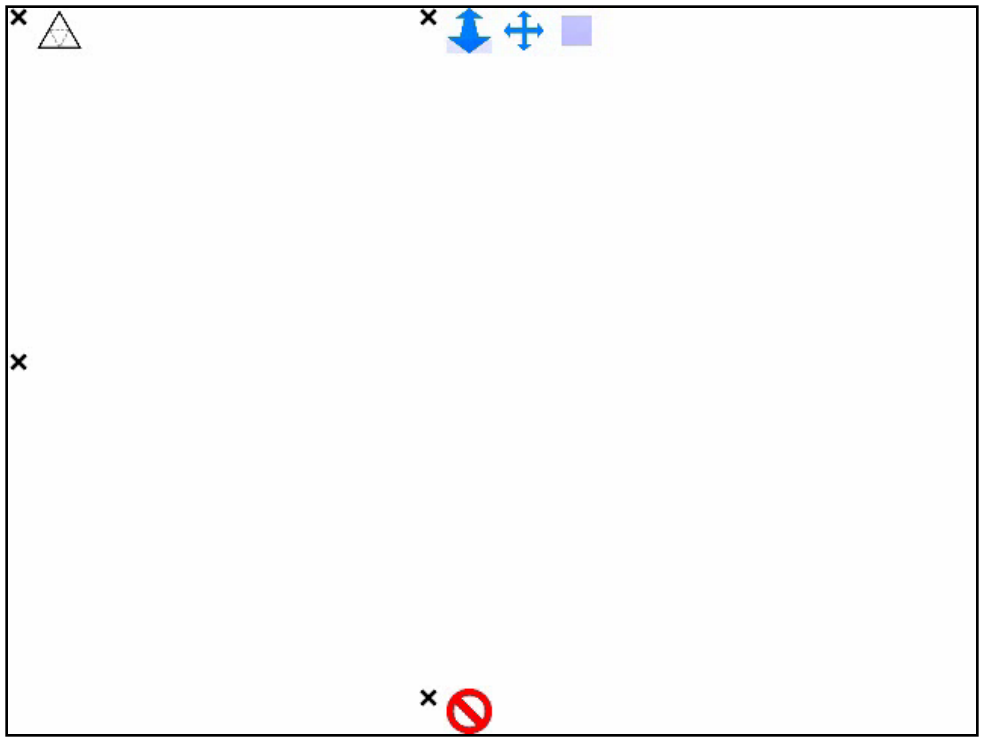
# 10,000-Foot View

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

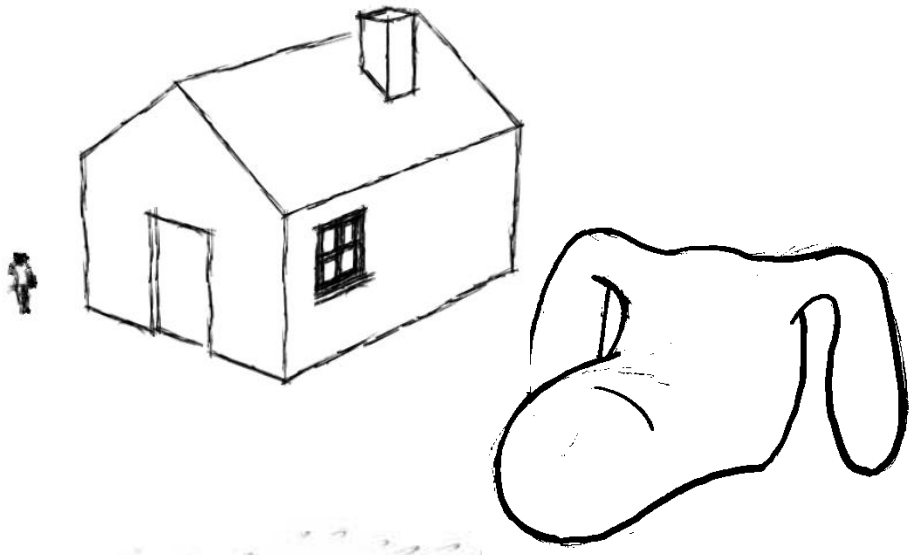
- Sketch-Based Modeling

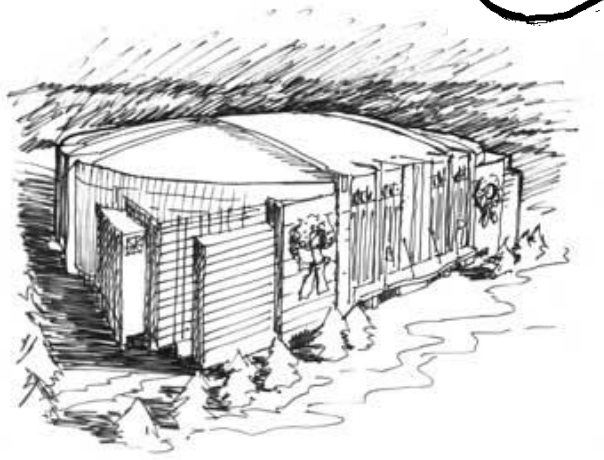
- Improve 3D model understanding



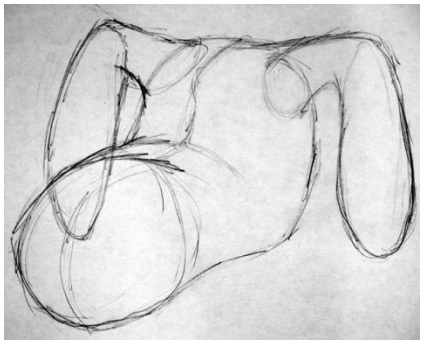
# Visual Representations

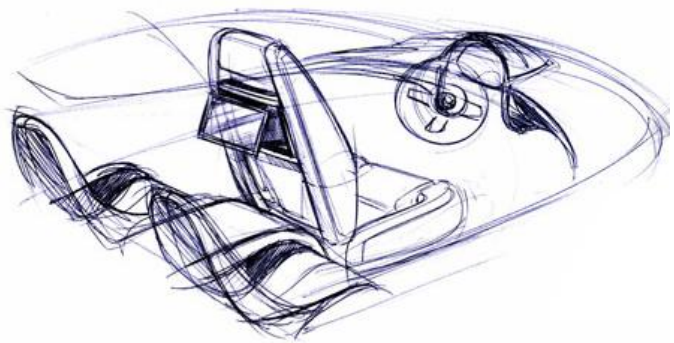
## **Production** sketch

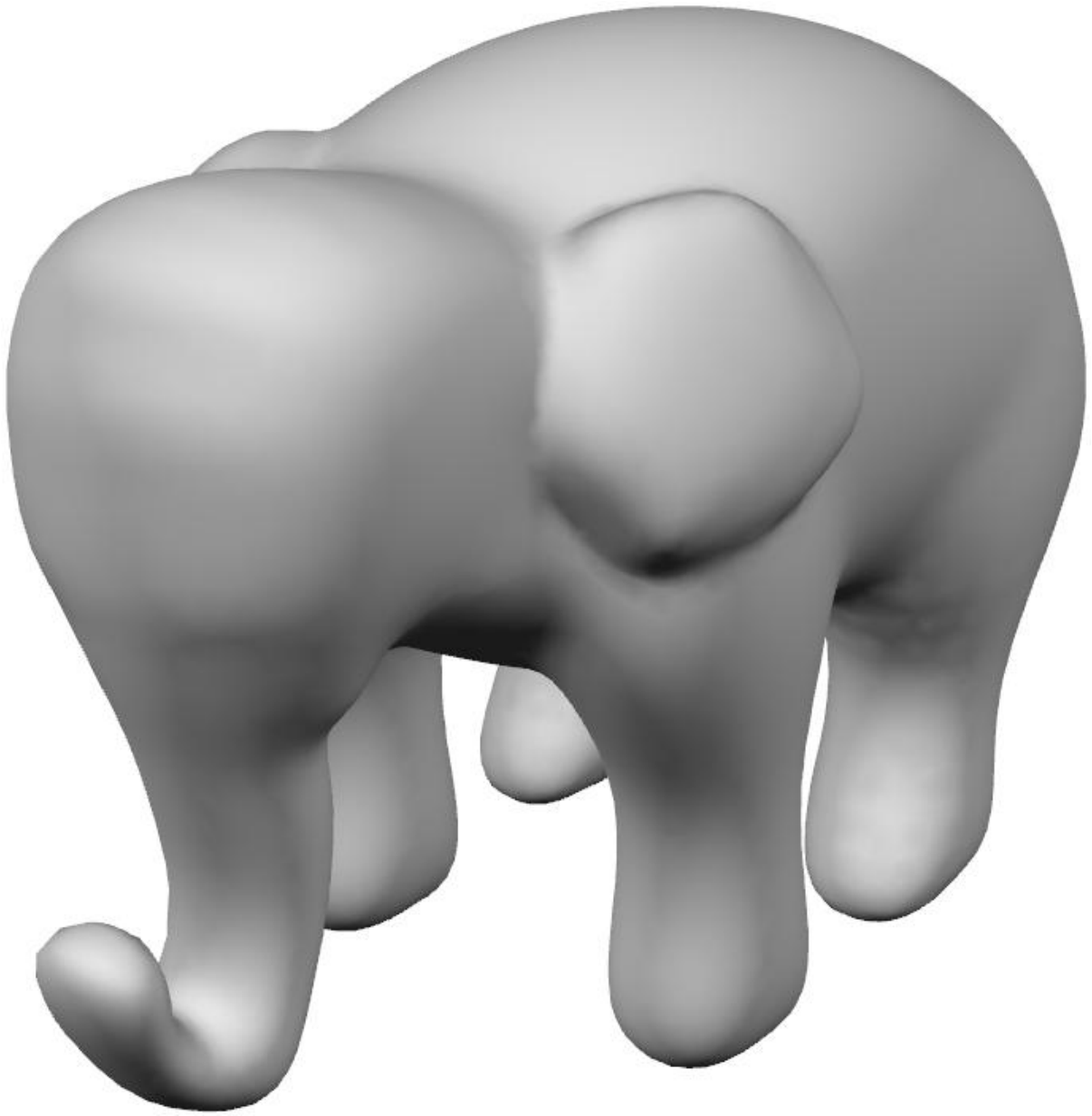




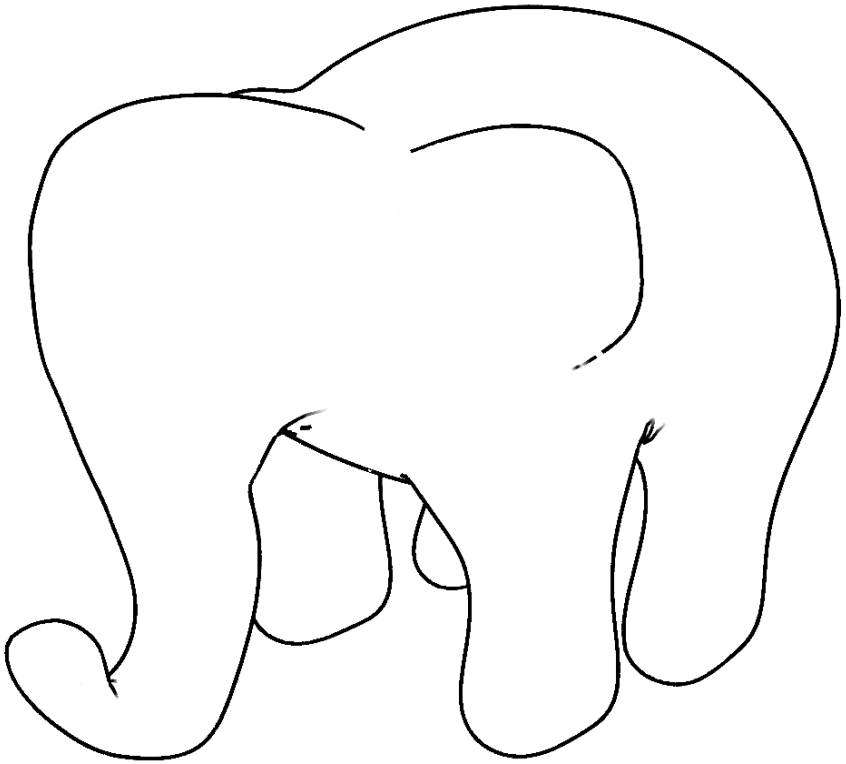
## **Design** sketch



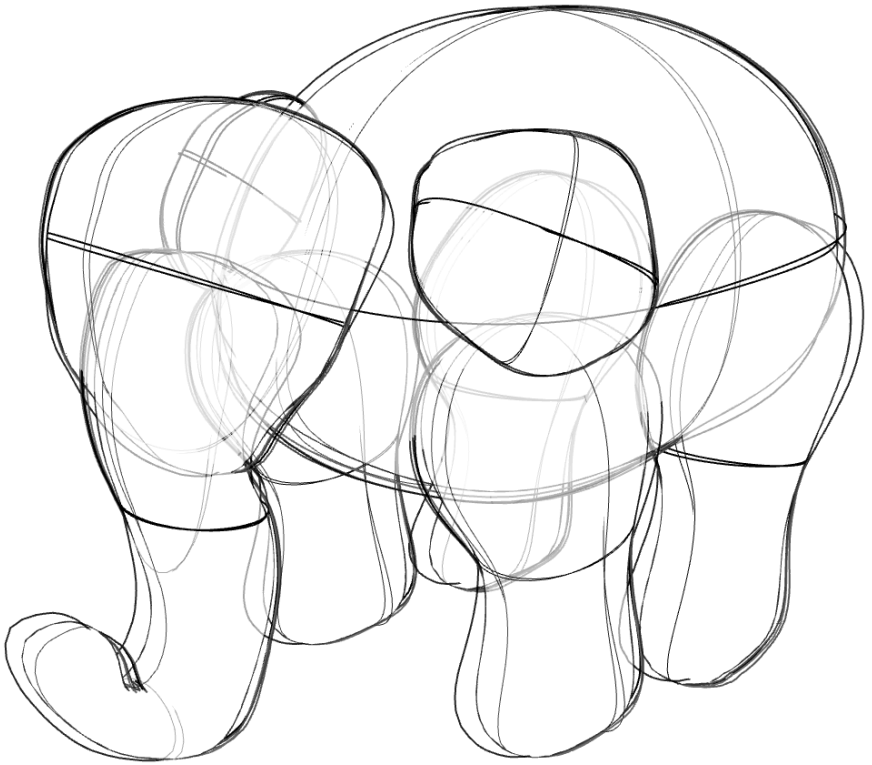


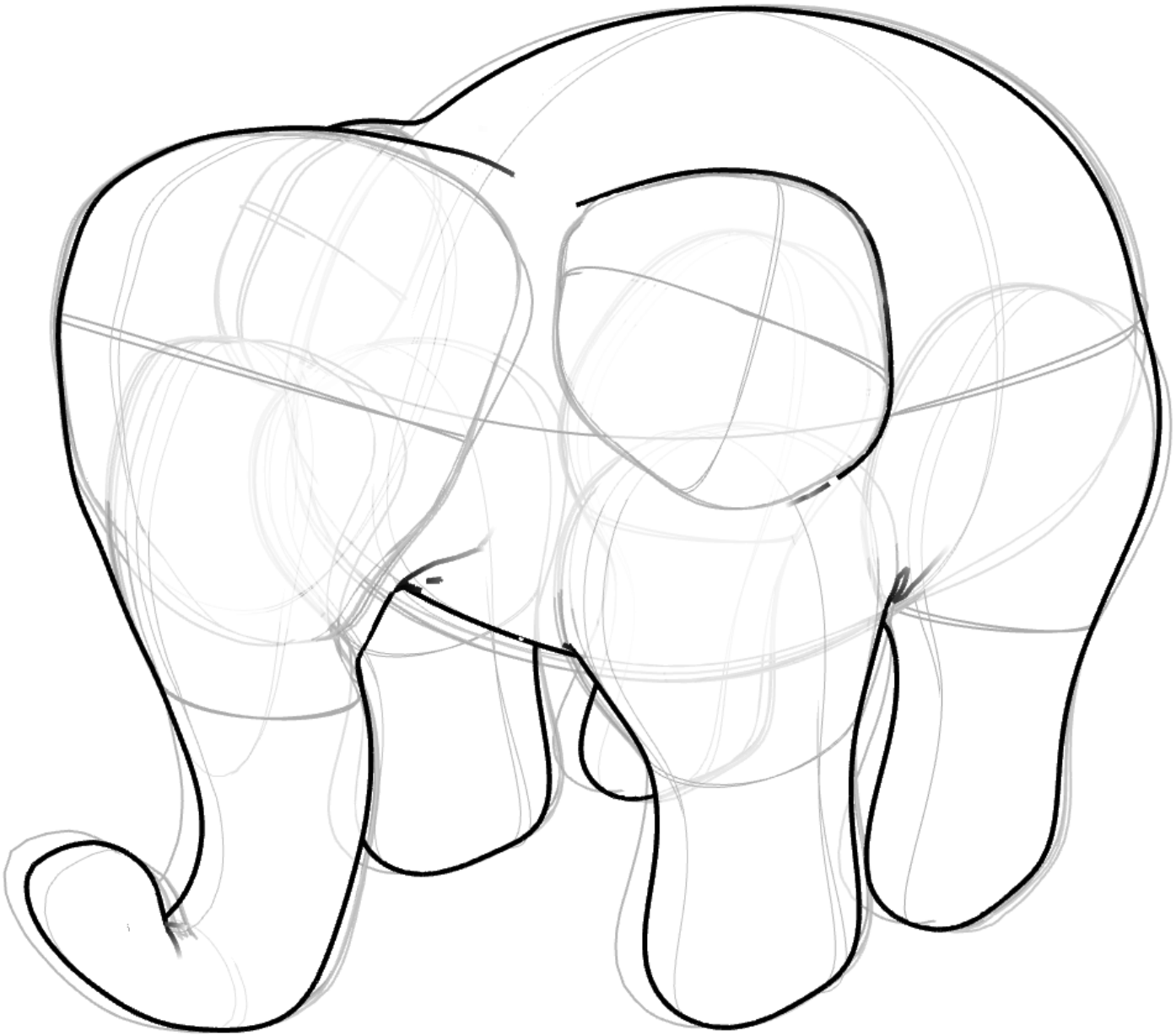


**Production** sketch



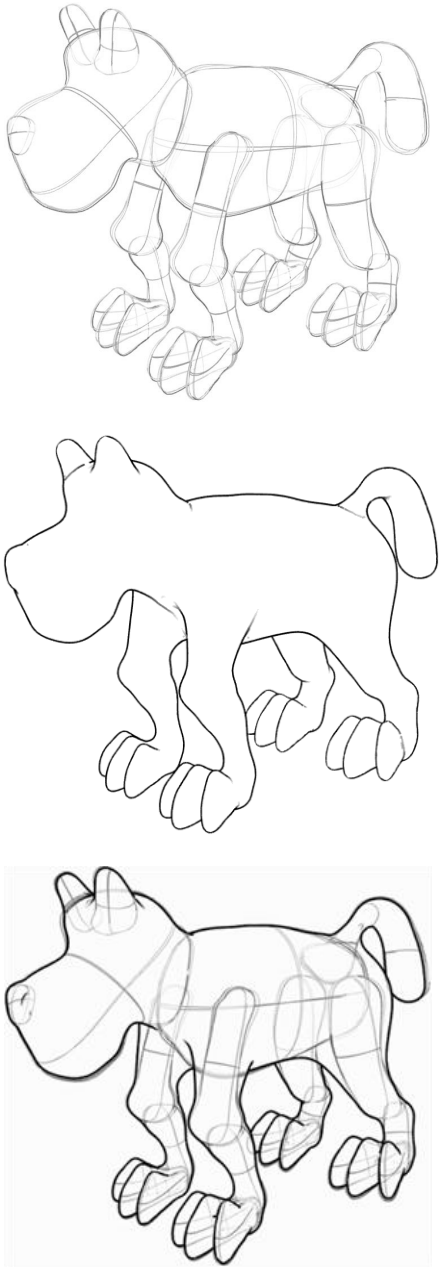
**Design** sketch



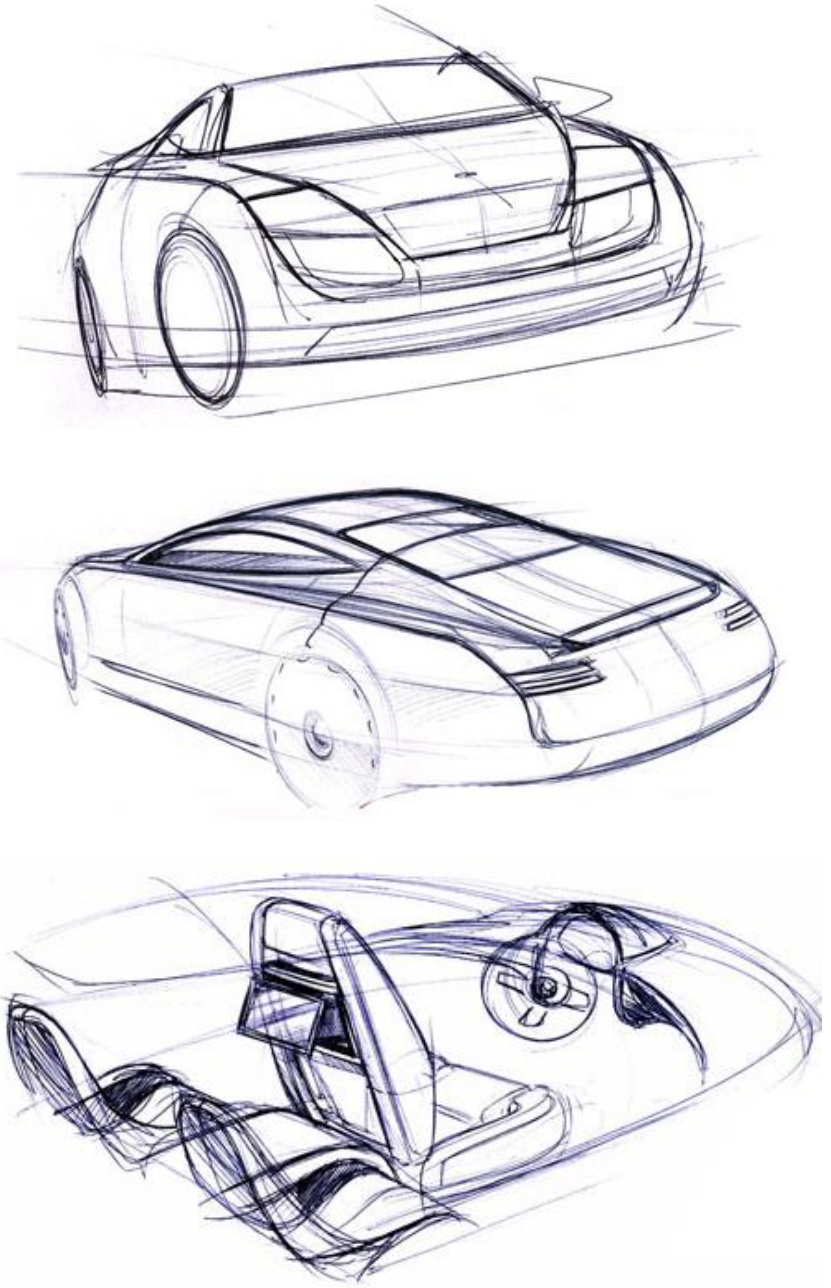


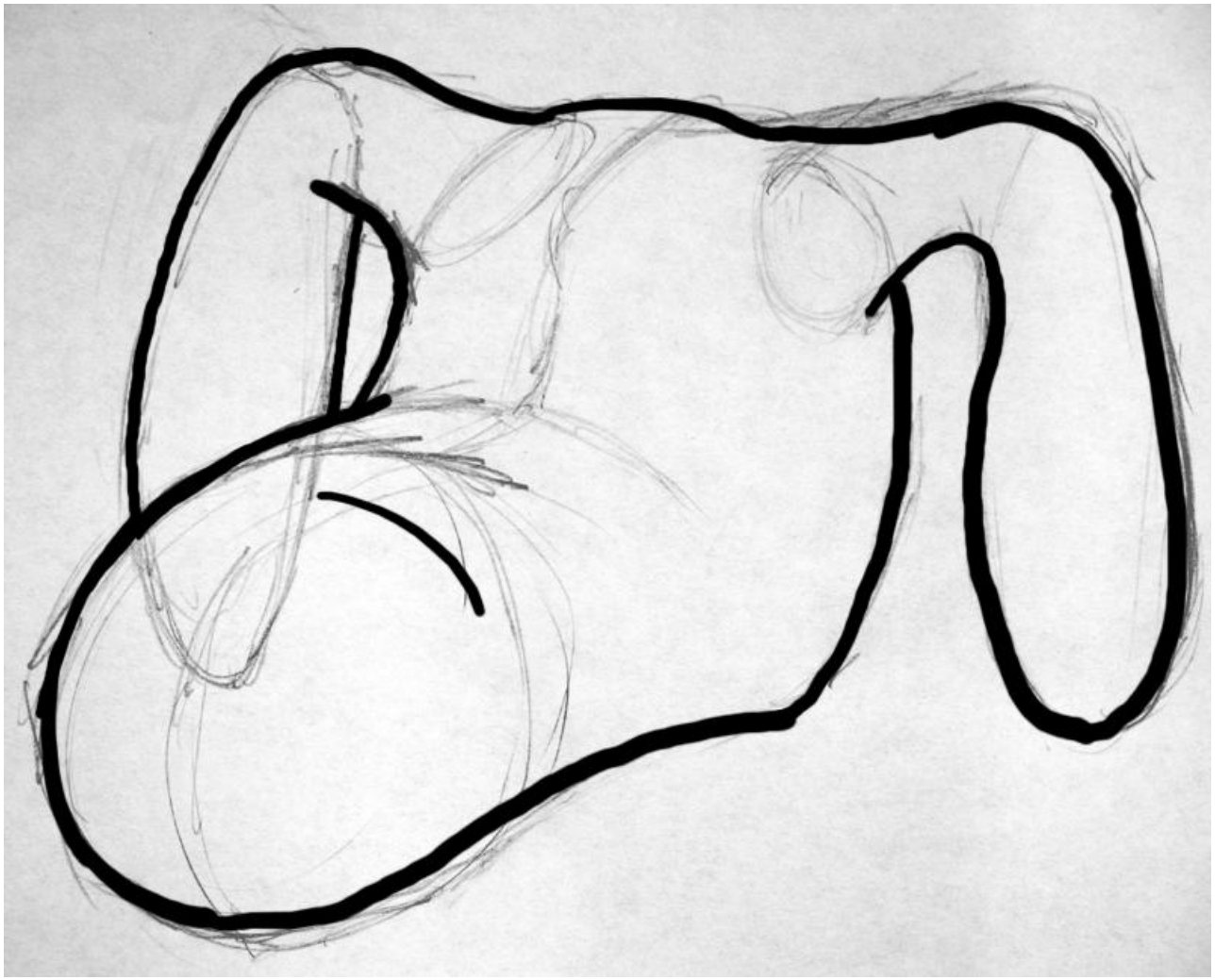
# Goals

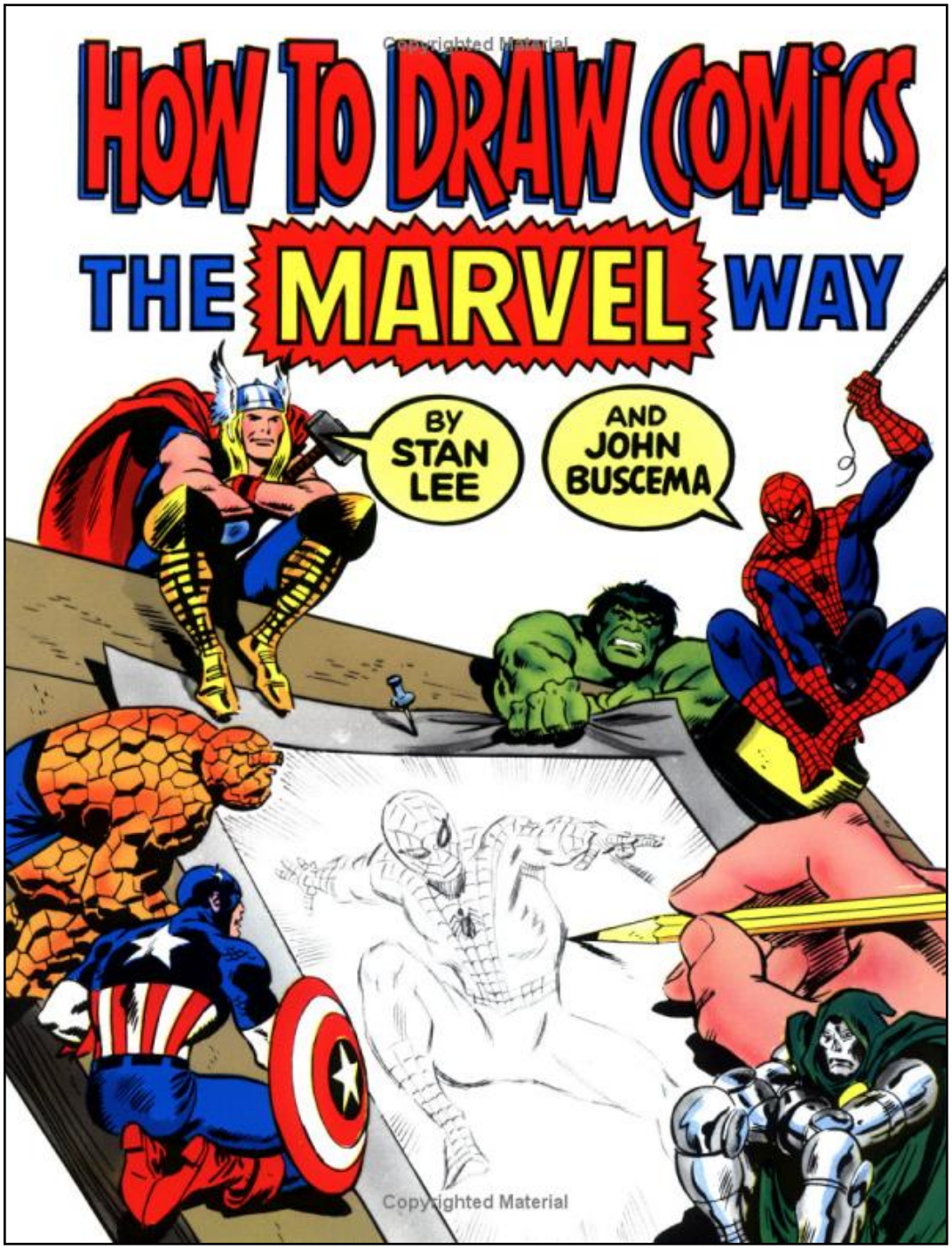
- Figure out how to simulate design sketching
- Integrate w/ production sketch rendering
- Implement in an interactive 3D surface modeler



# Design Sketches



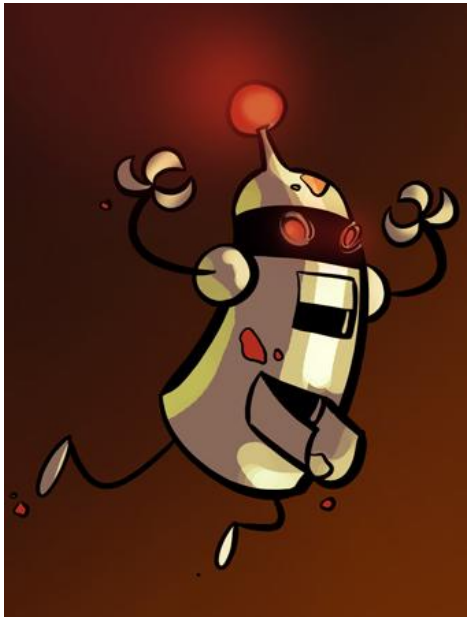




# Comic Art Pipeline

Sketching / Penciling

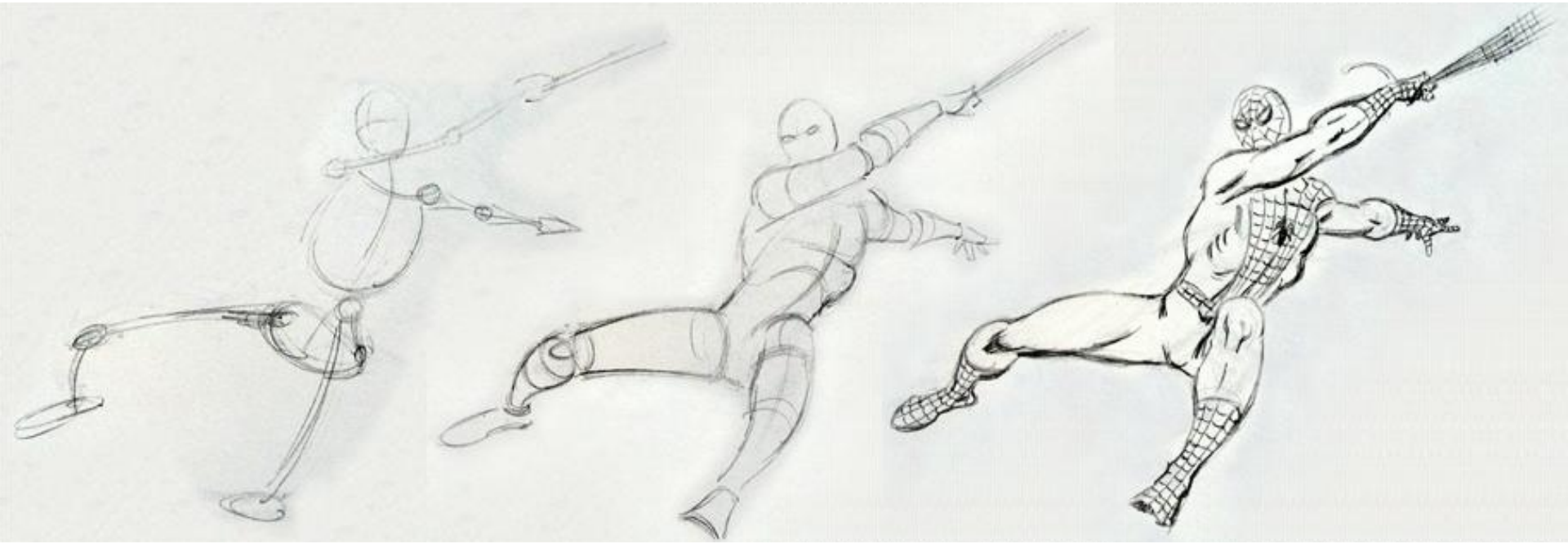
Inking



Coloring

# Sketching / Penciling

- Iterative refinement
- High-throughput
- Consistency



# Visual Scaffolding

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

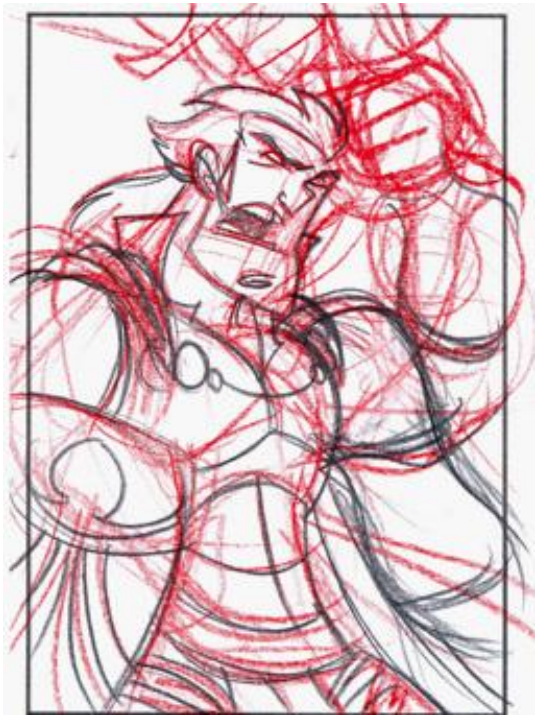
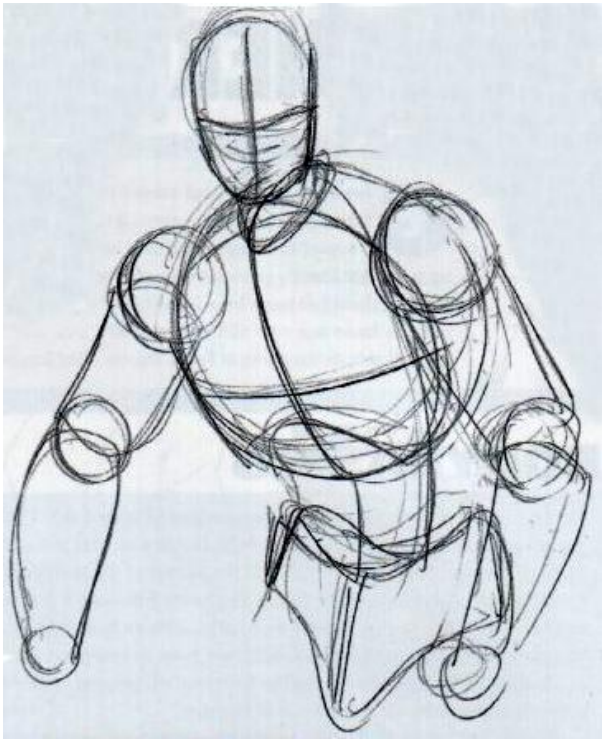
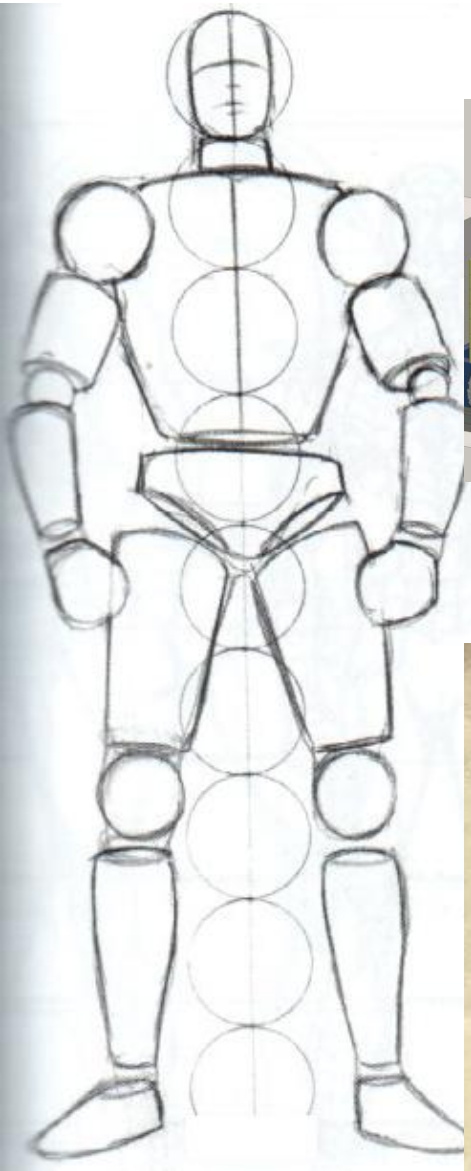
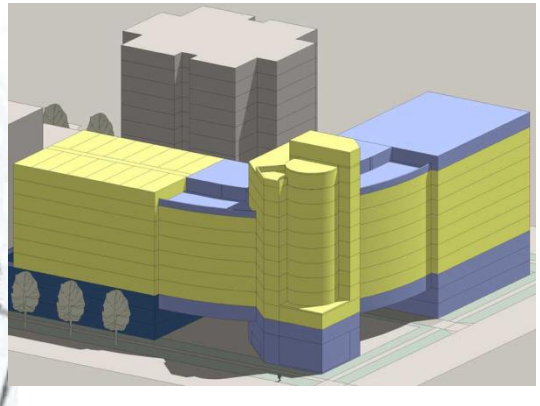


Image © Jerry Holkins

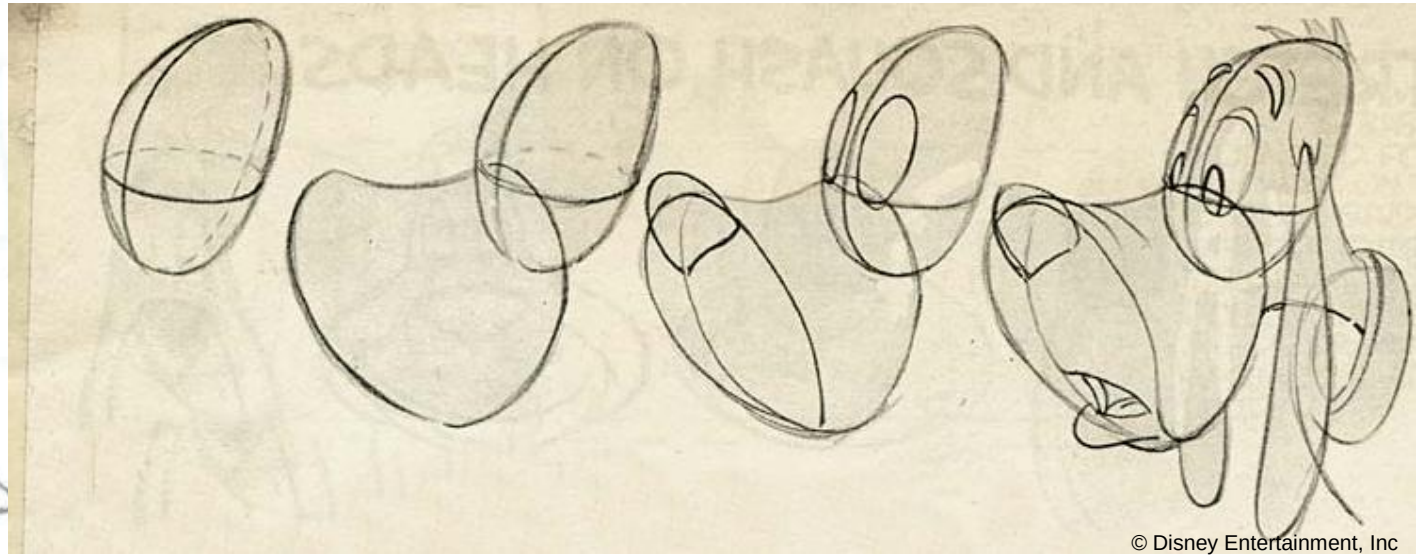


# Geometric Massing



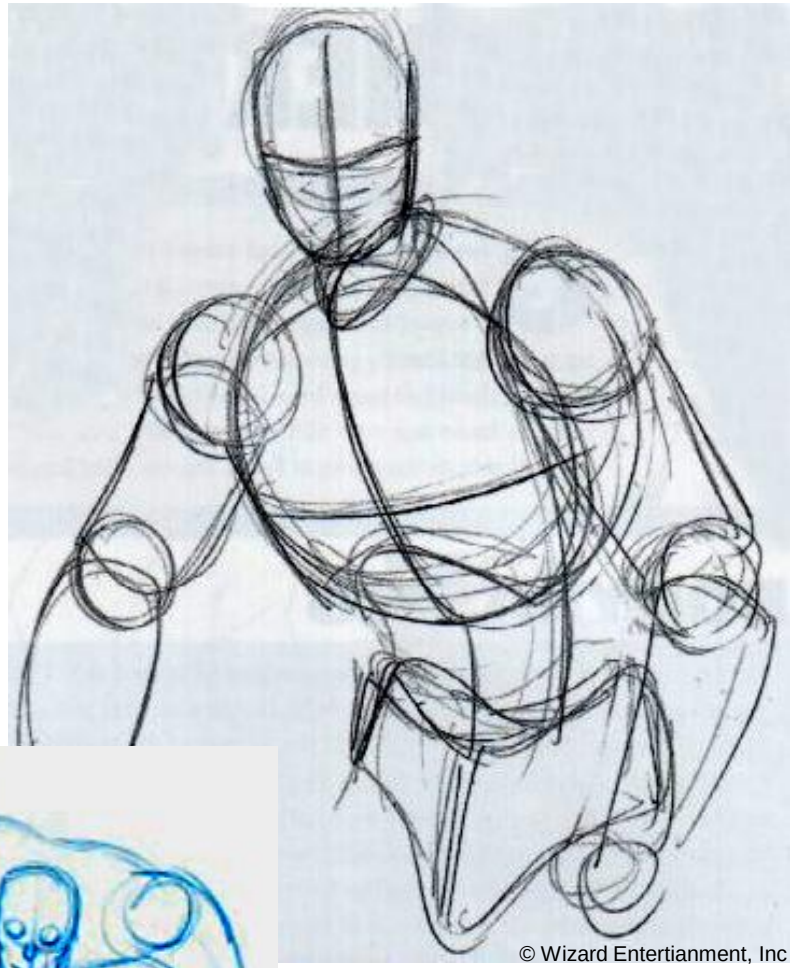


- Architectural *Massing Models*
- Helps with form, perspective
- Well-suited for SBM (model-by-part)

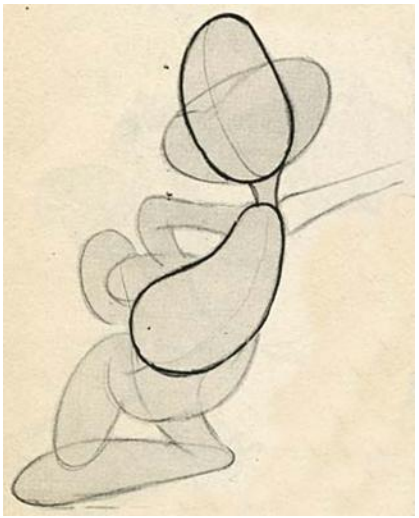


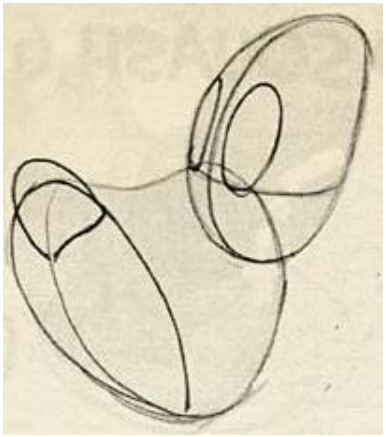
# Geometric Massing

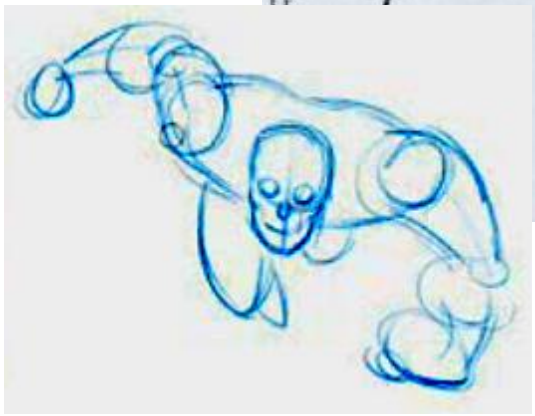
- Coarse geometric shapes
- Partial “shape axes”
- Varying occlusion
- Lots of overdraw





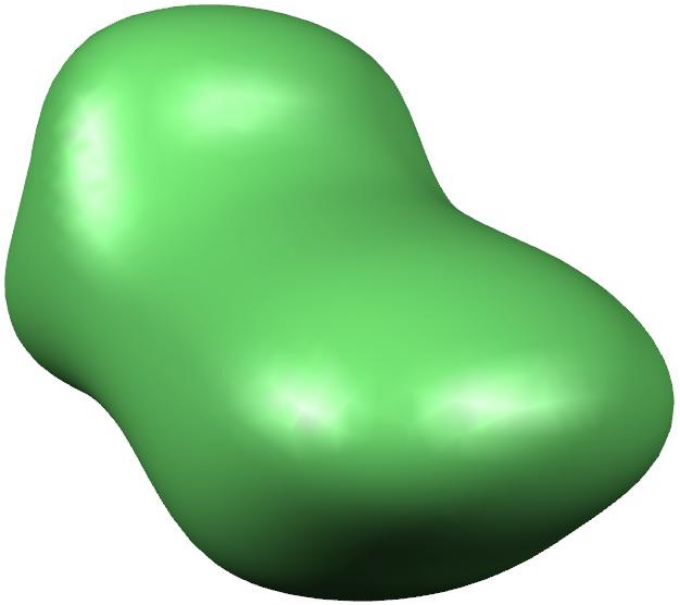


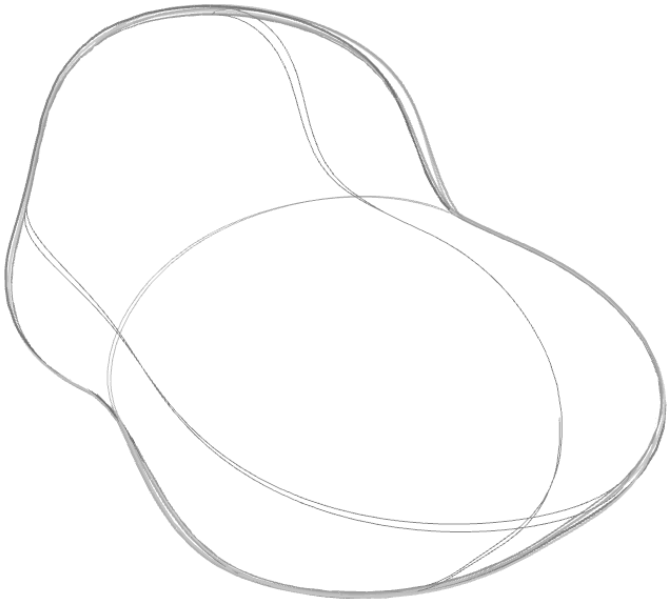


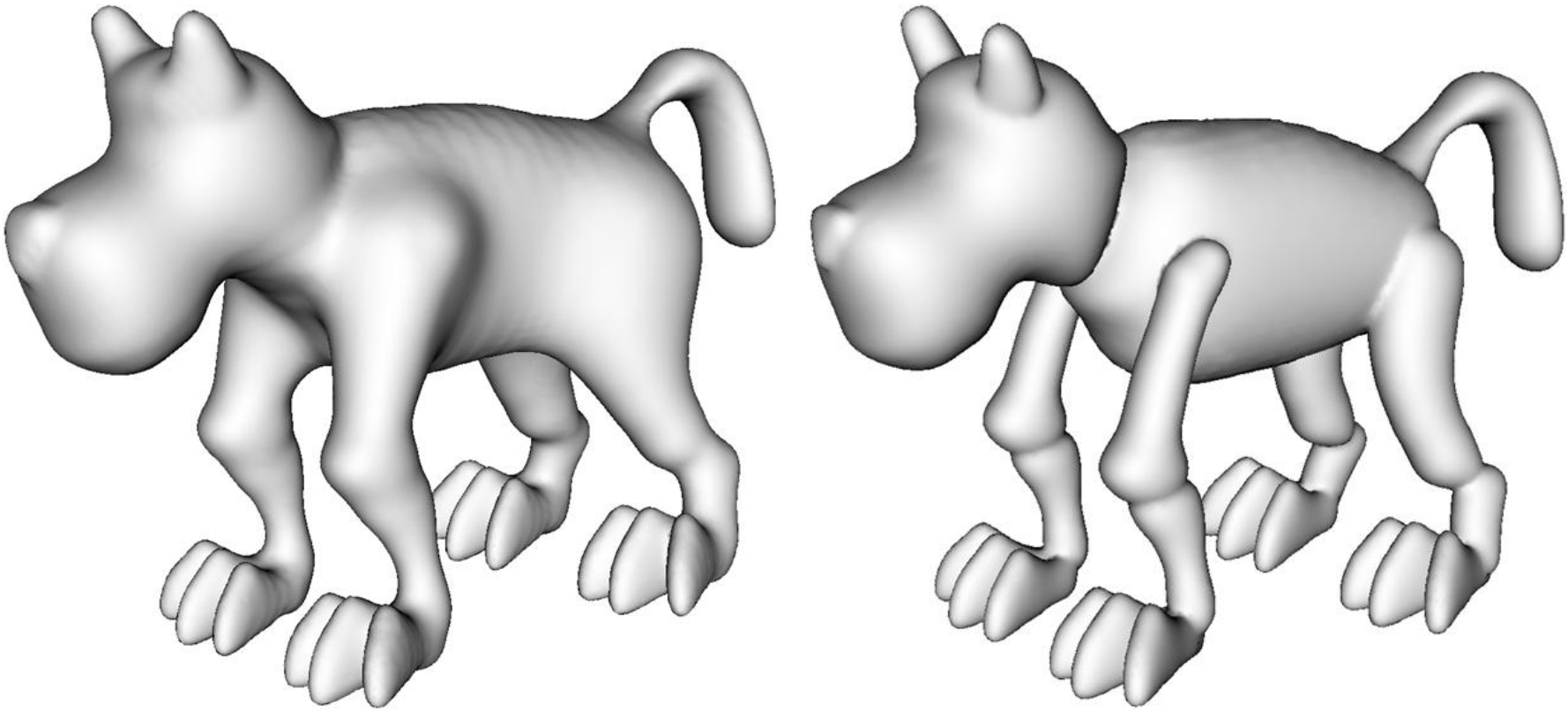


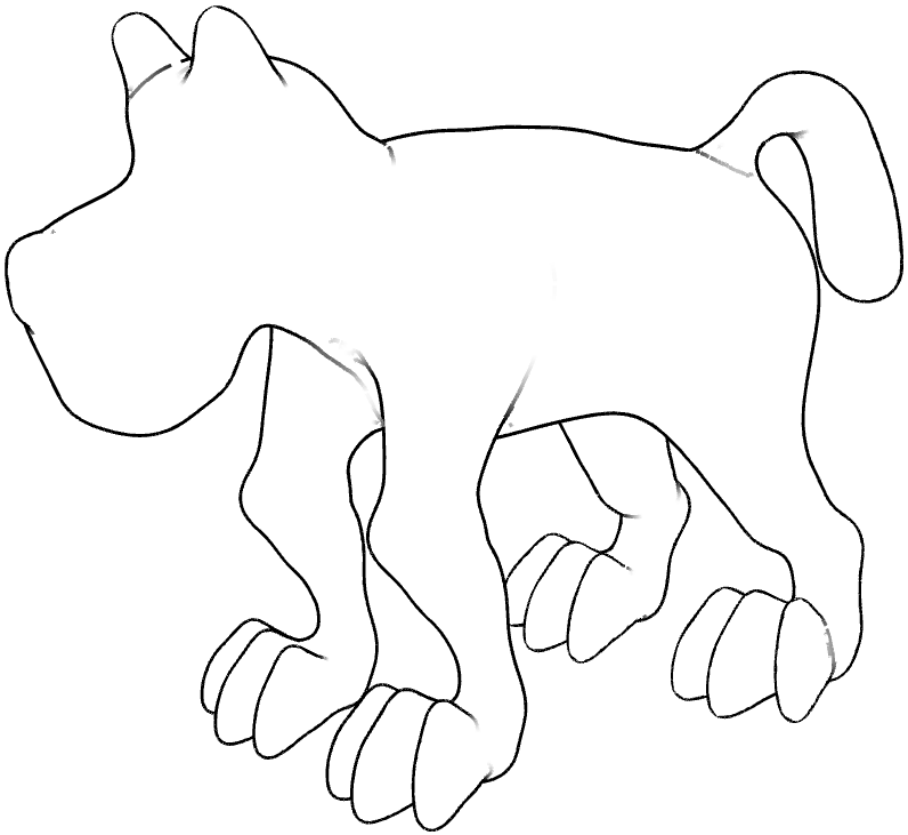
# Algorithm

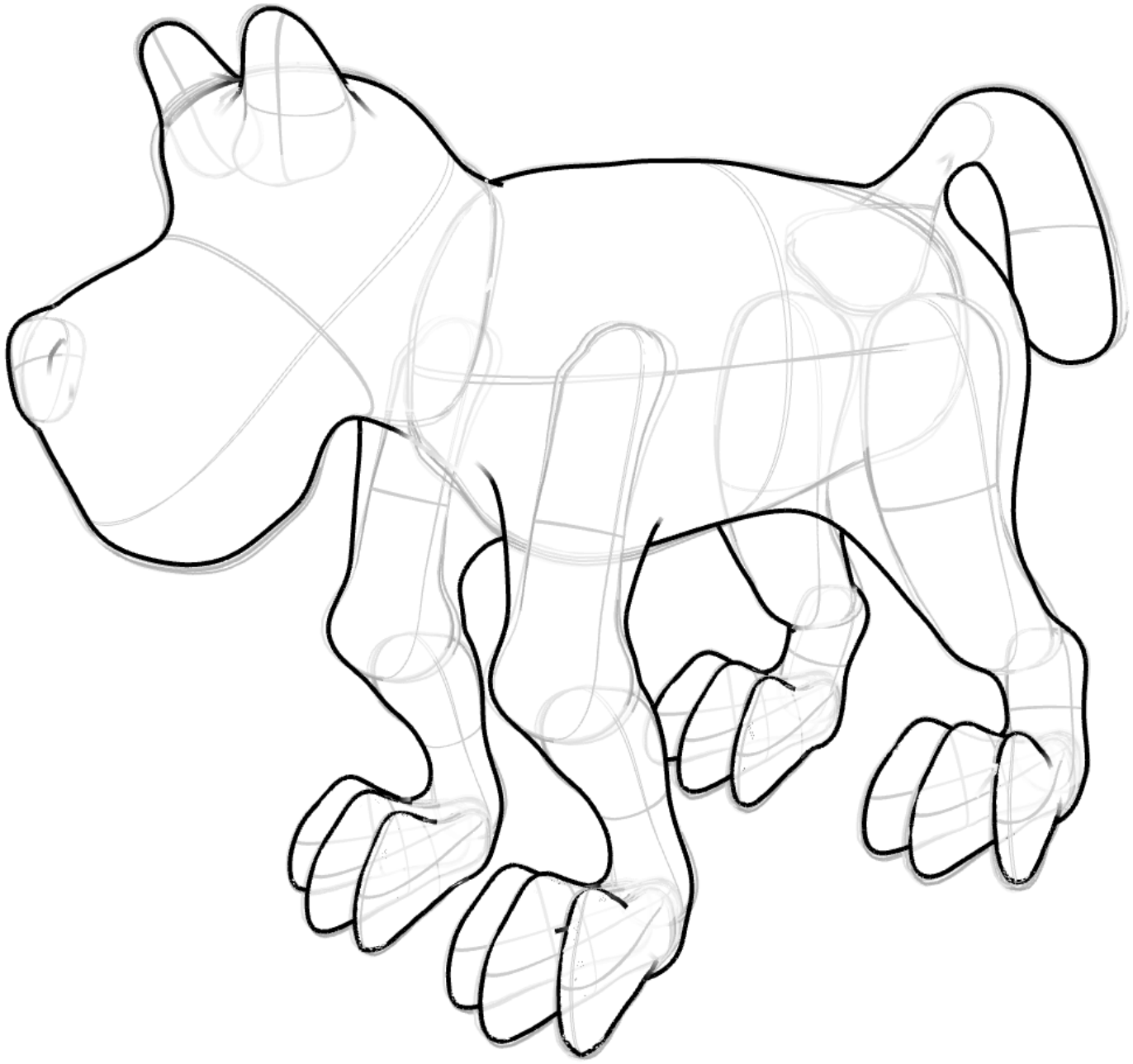
- Fit bounding box
- Contours from plane intersections
- Random perturbation
- Fade in/out based on viewing angle

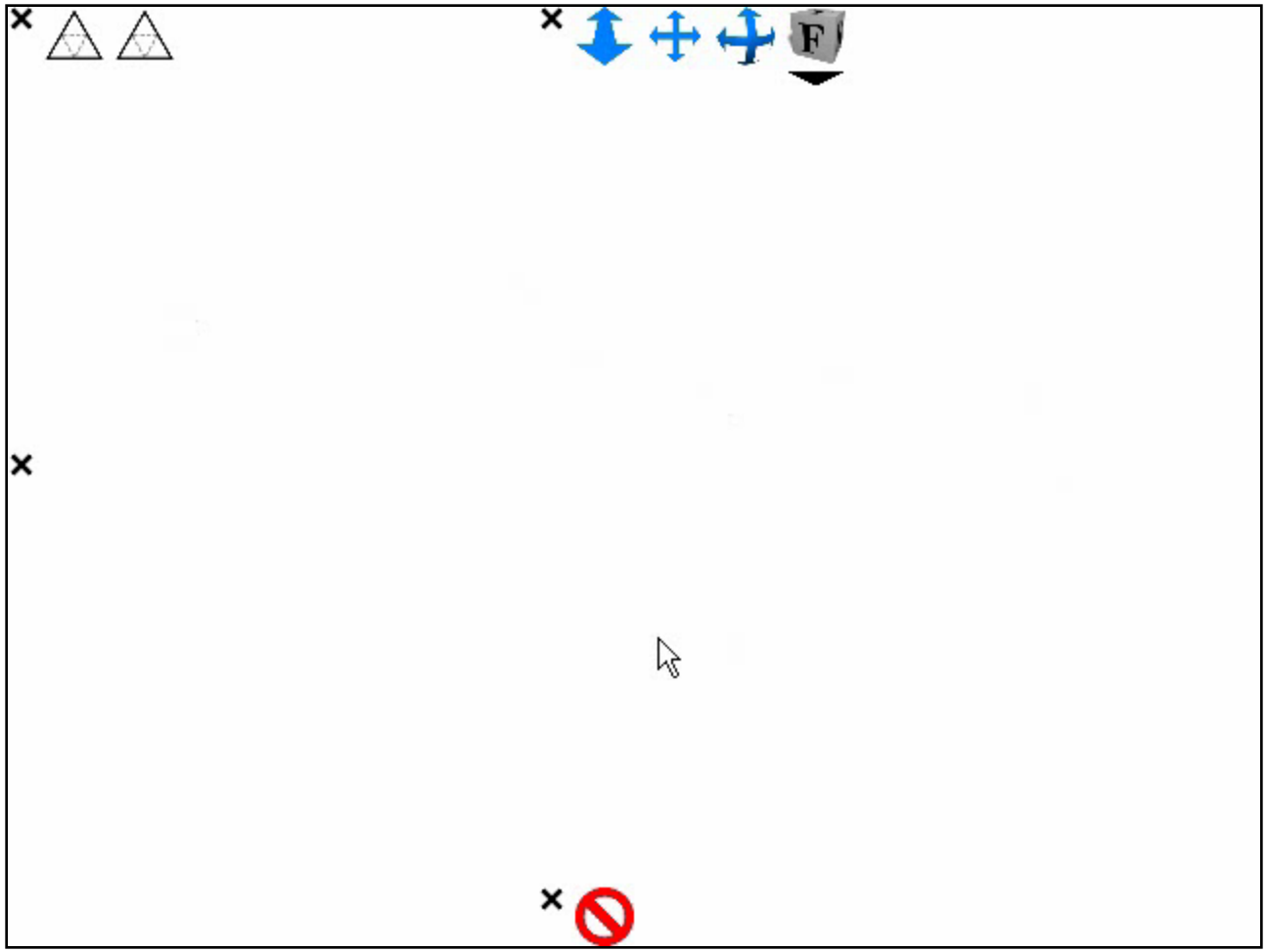






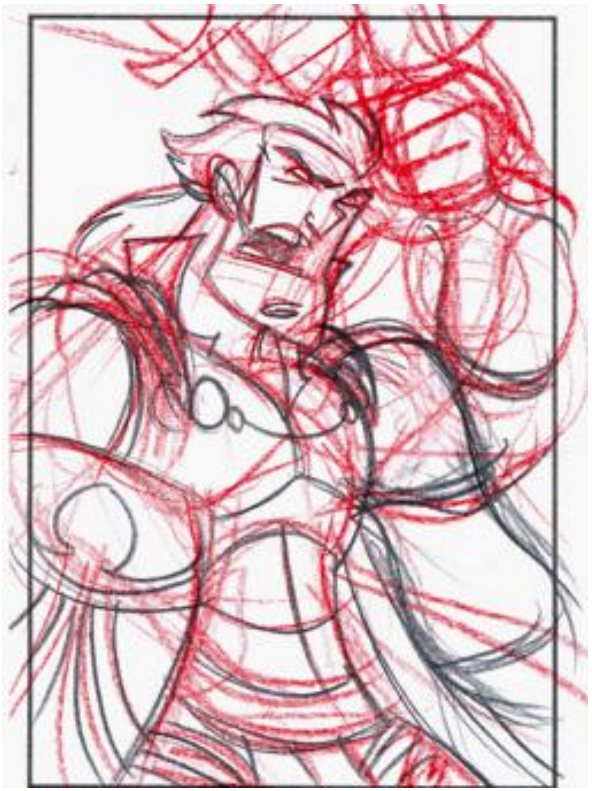






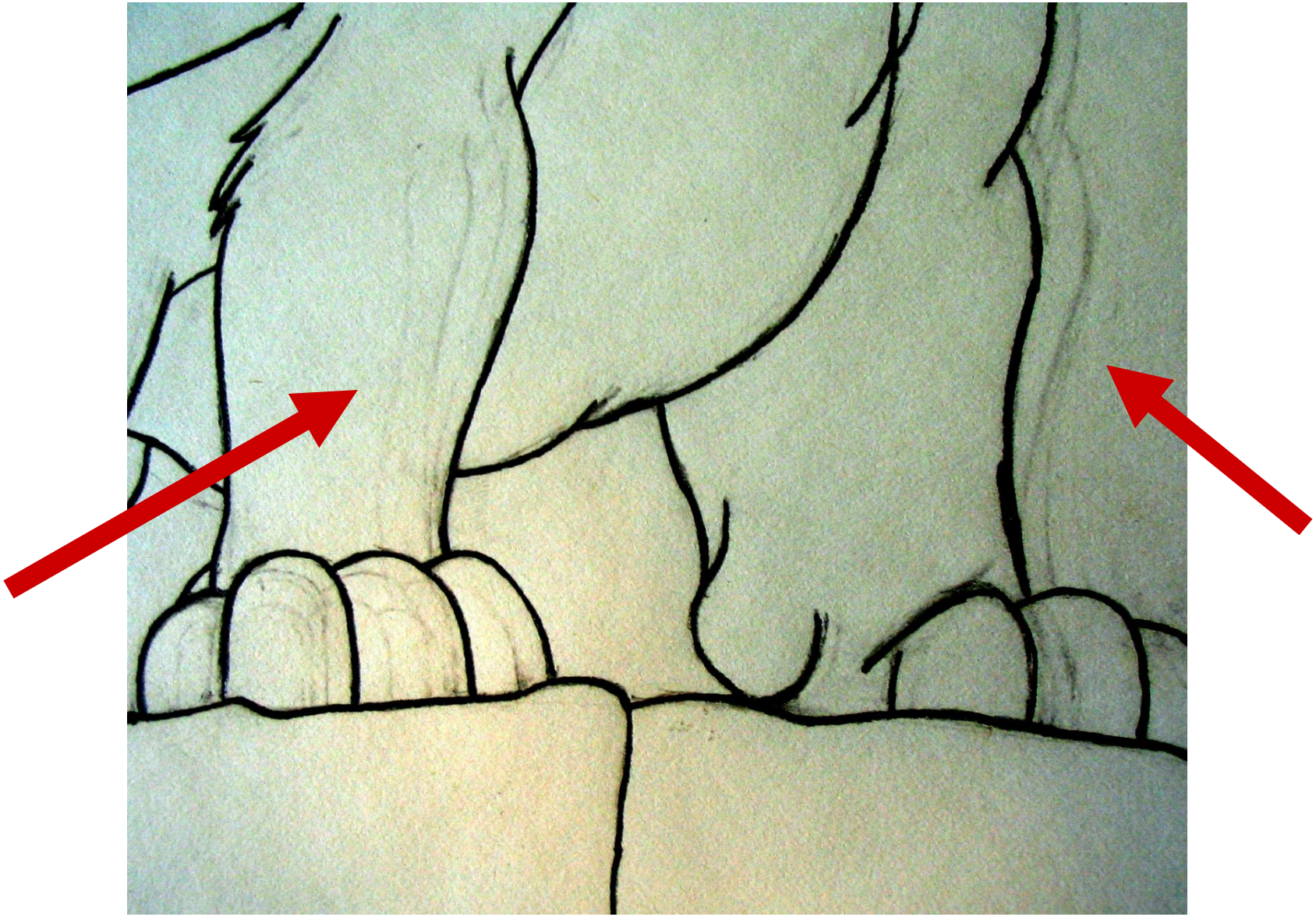
# Erasing vs Deleting

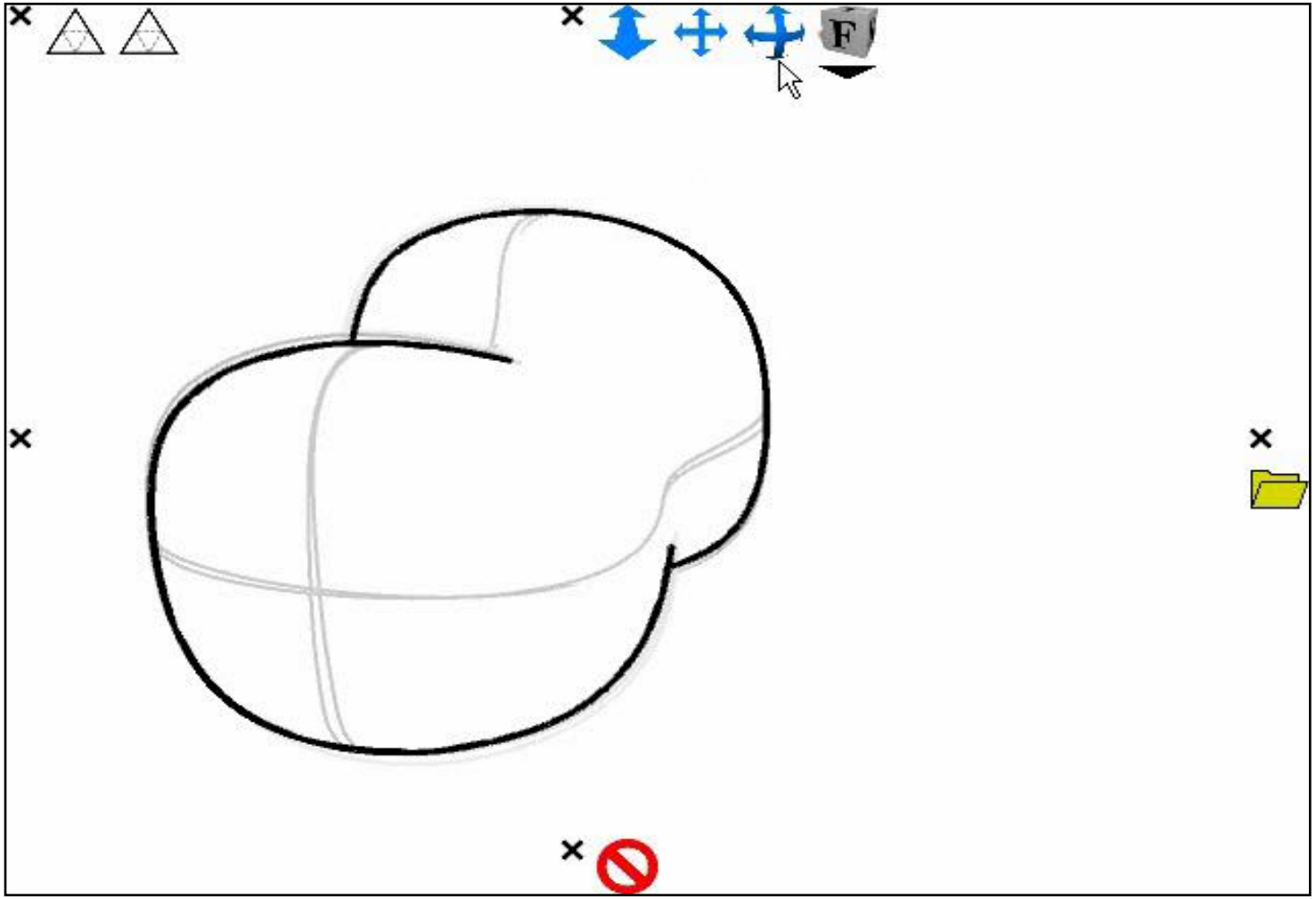
- Deleted parts “disappear”
  - Can’t learn from them
- No “mistakes” in design sketching !!!
  - Exploring alternatives
- Not an artifact of paper




AH!

# Eraser Marks

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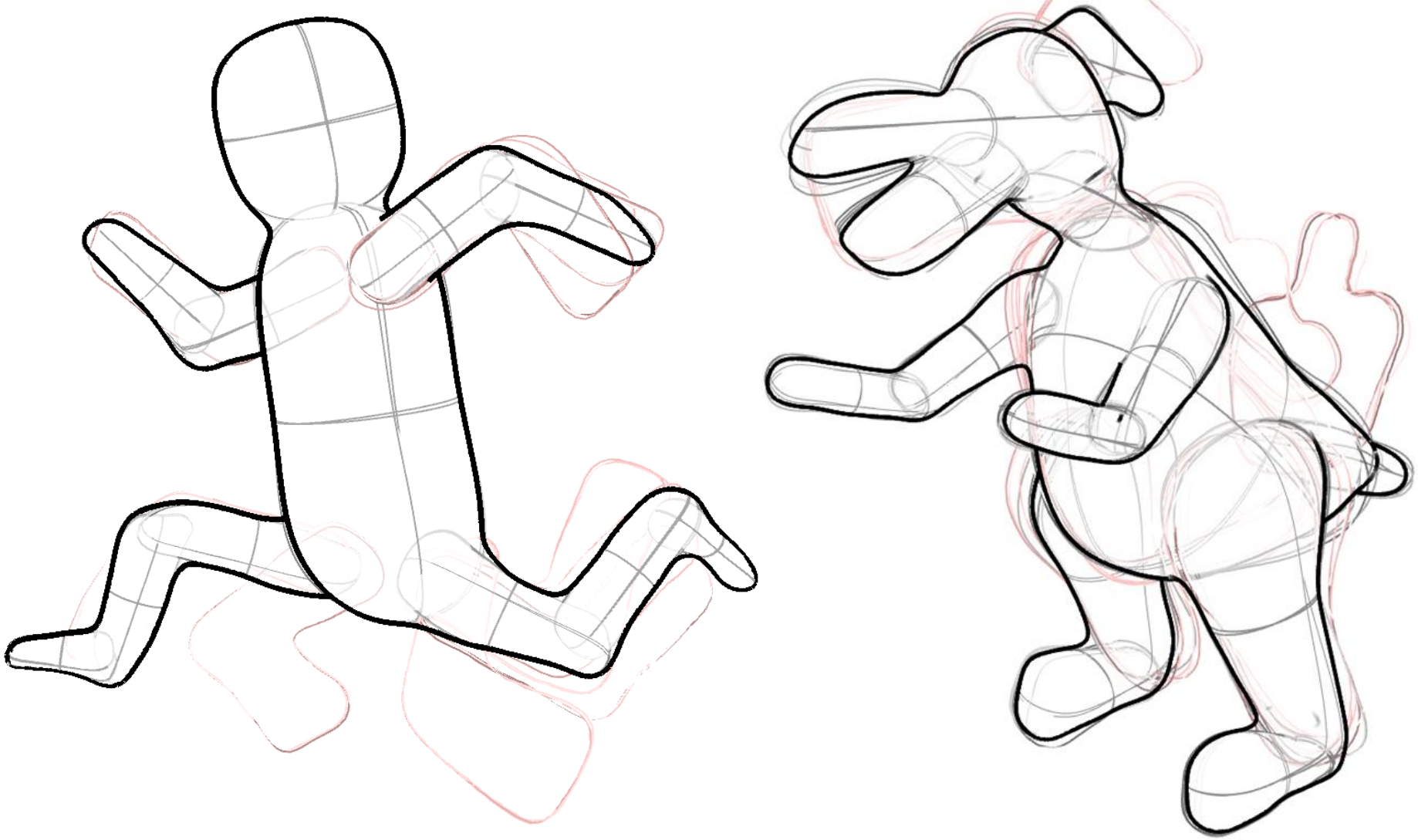
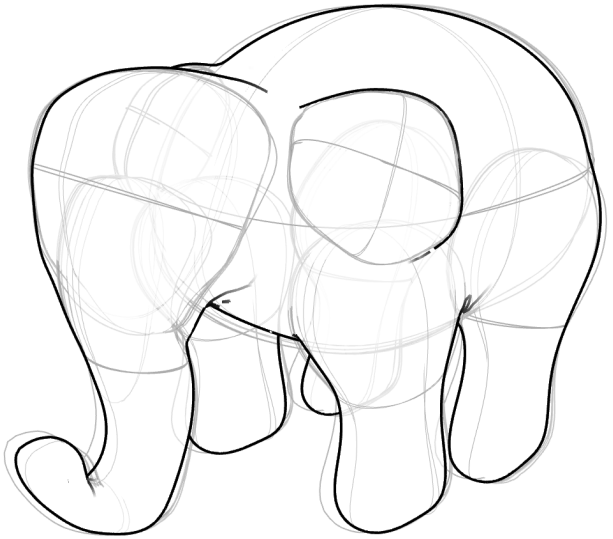


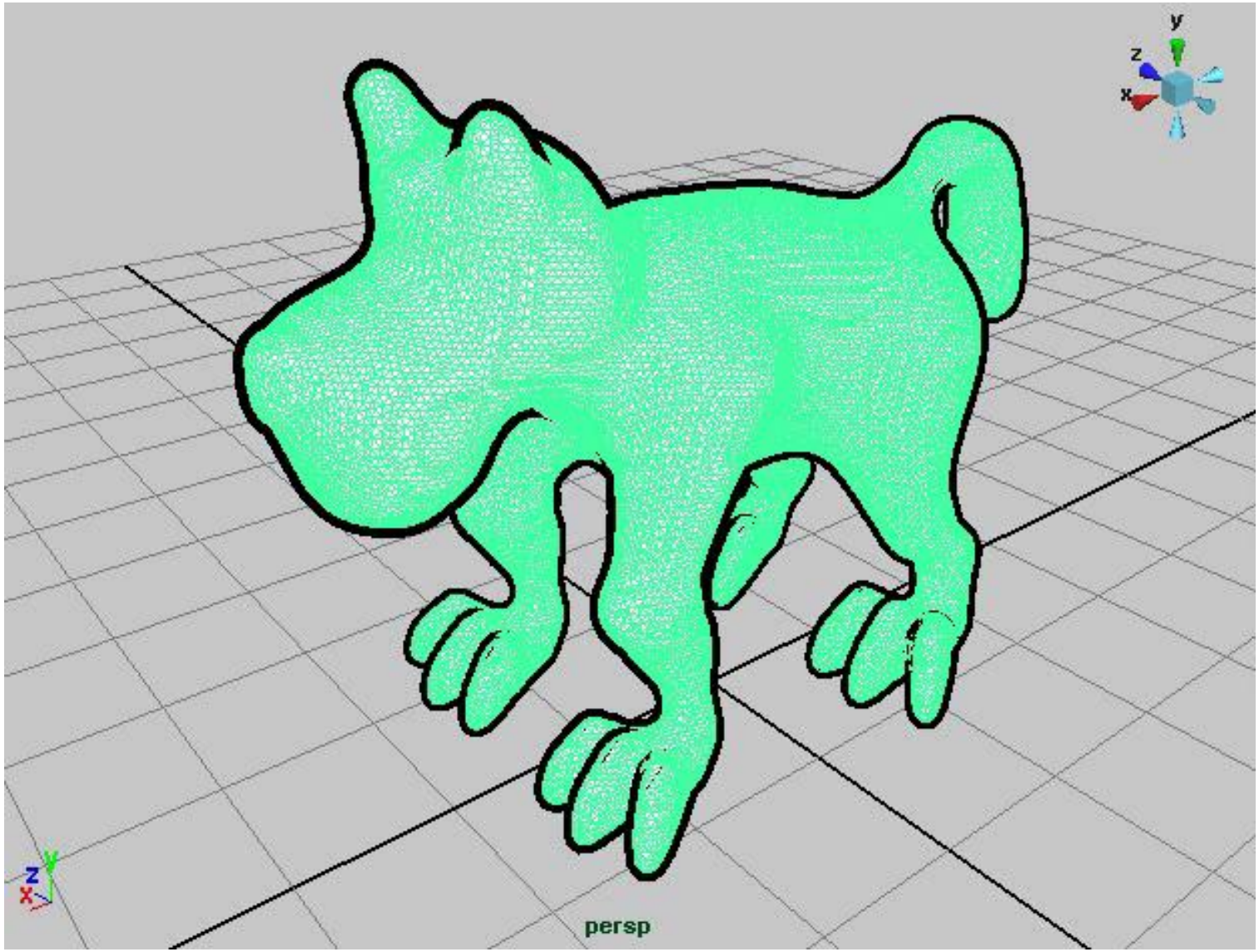
# “Real-World” Application

- Have design sketch “look”
  - Geometric Massing
  - Eraser Marks
- Composite w/ production sketch techniques
  - Pen & Ink



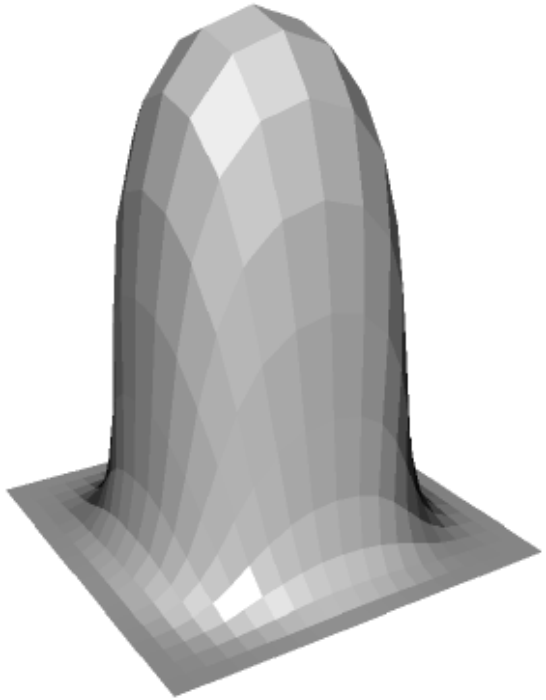
- Now to integrate renderer into an interactive modeling system…

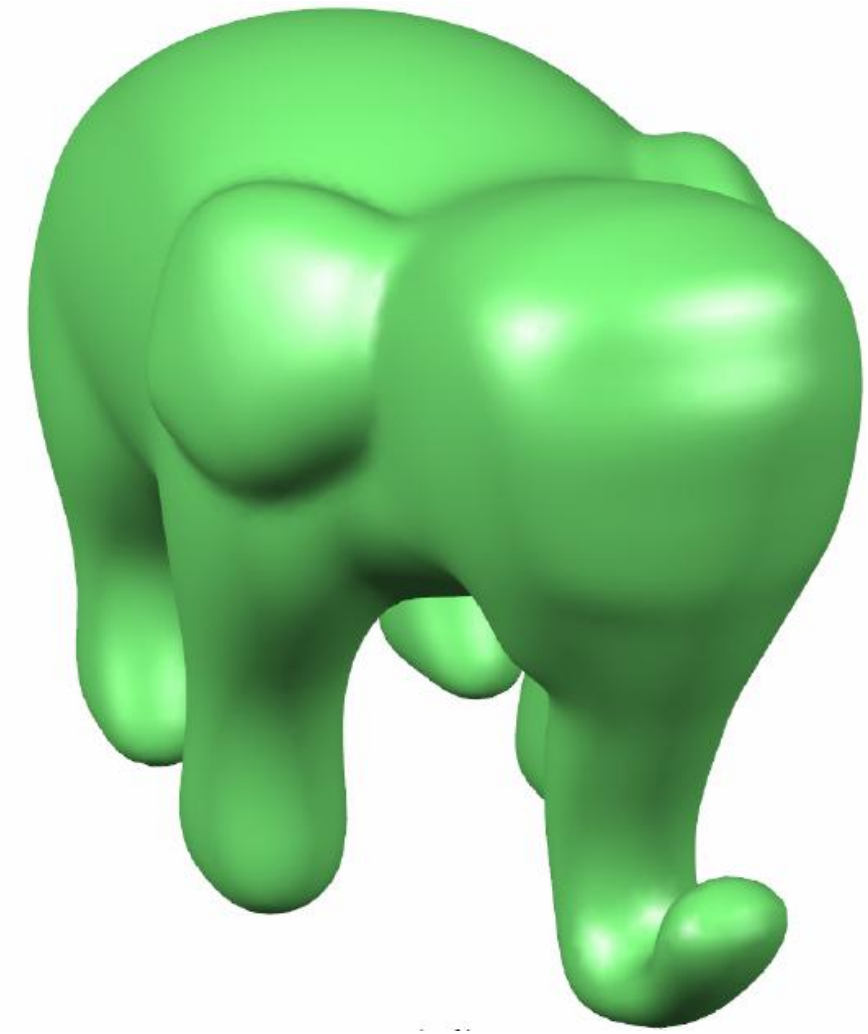
# Integration

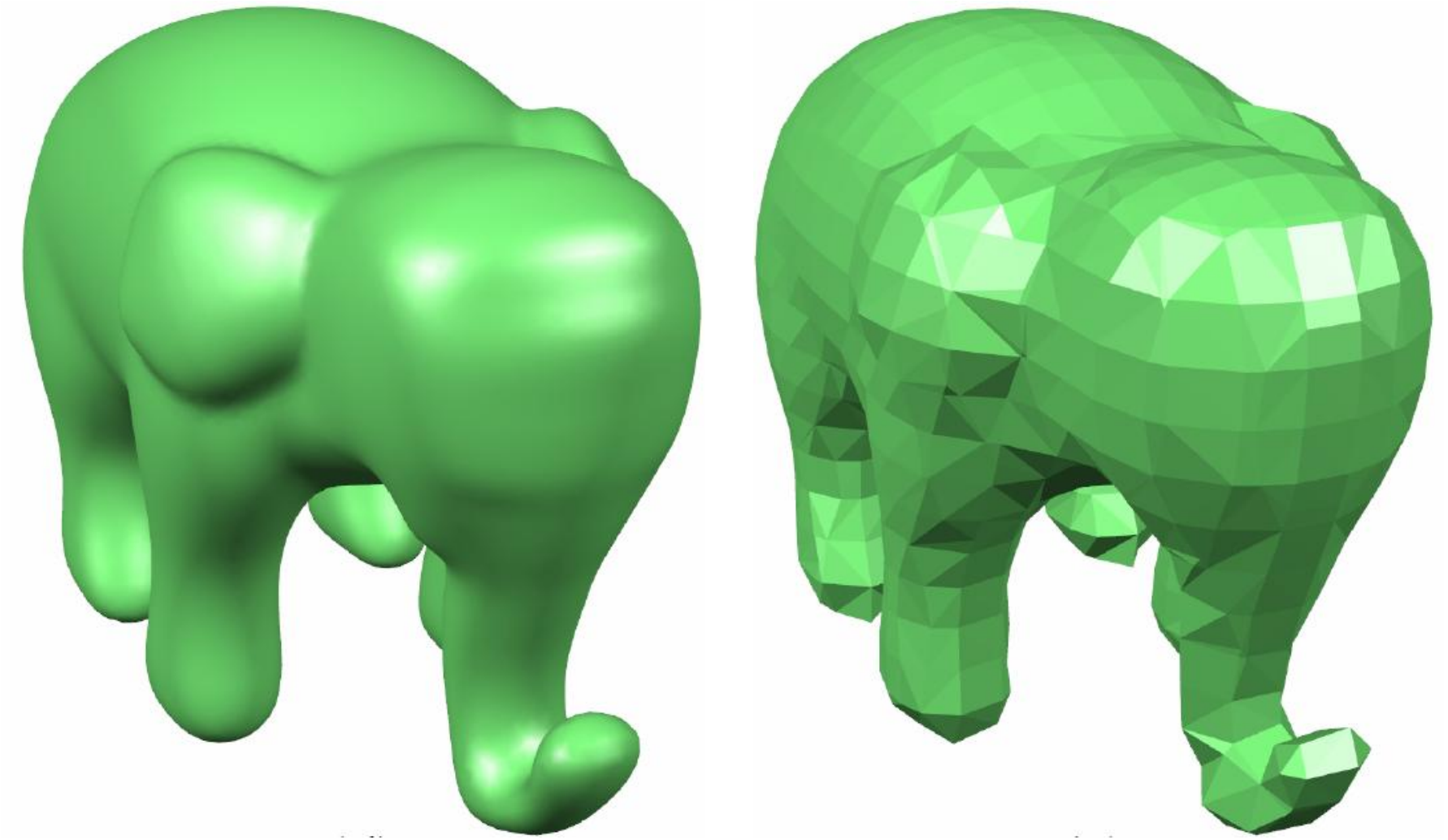


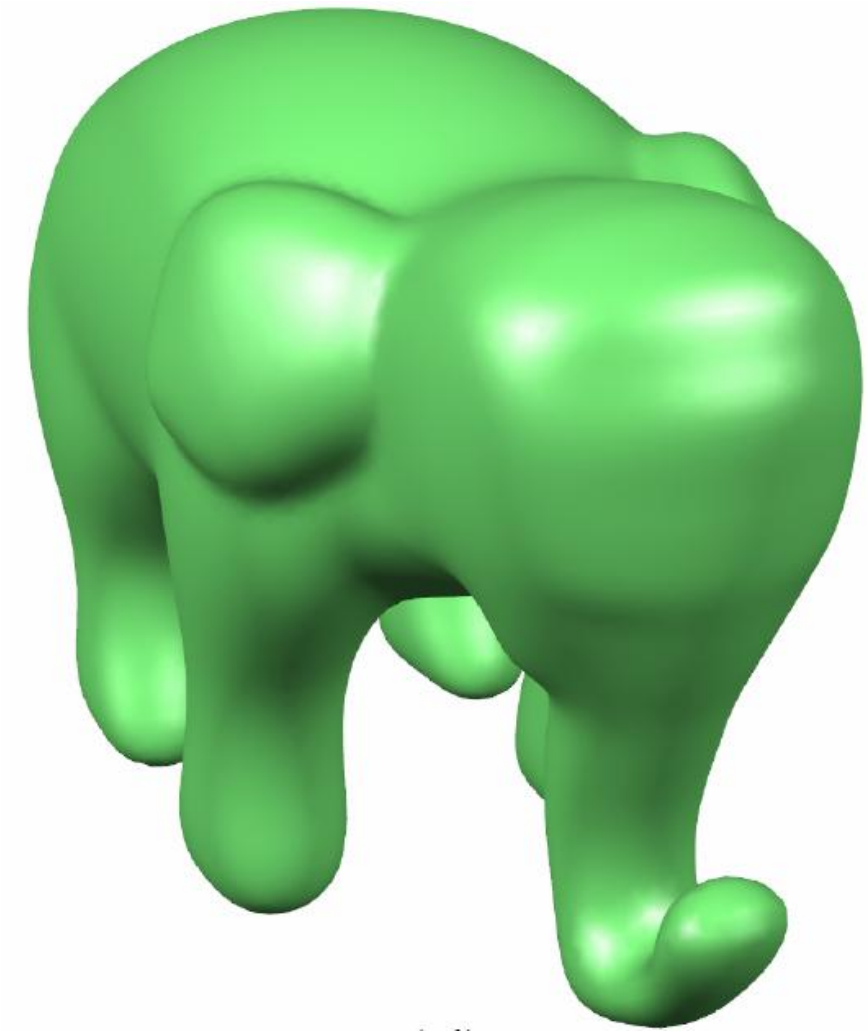
# Practical Limitations

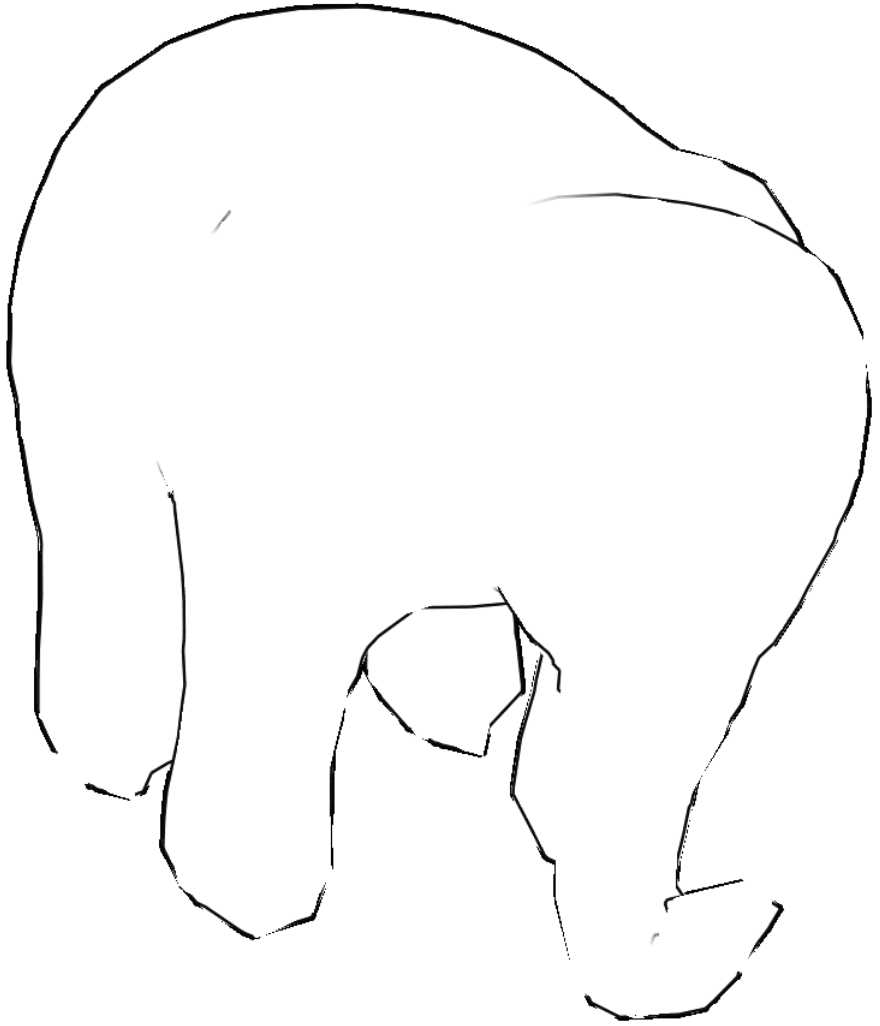
- Free-form modeling
  - NURBS, SubD, Implicit
- Interactivity is **critical**
  - Meshes are low-res
  - Ugly contours
- Mesh is dynamic
  - Can’t precompute!



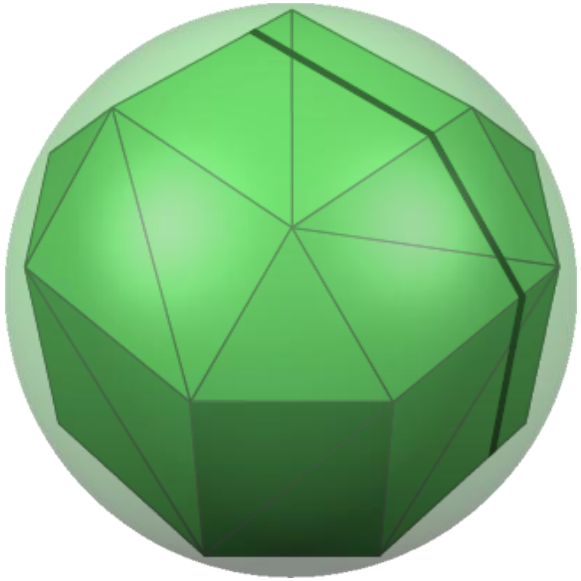








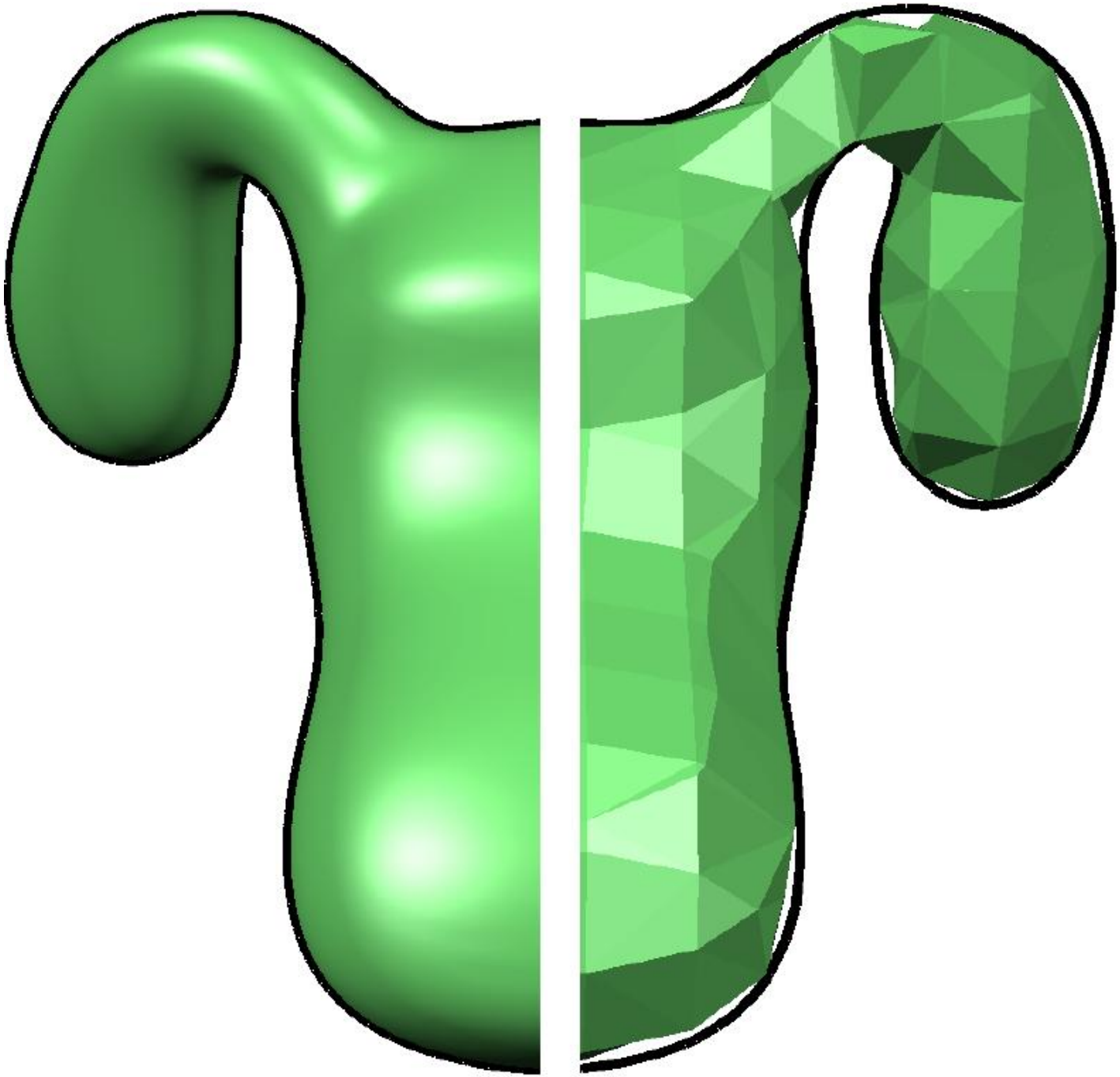
# Silhouettes

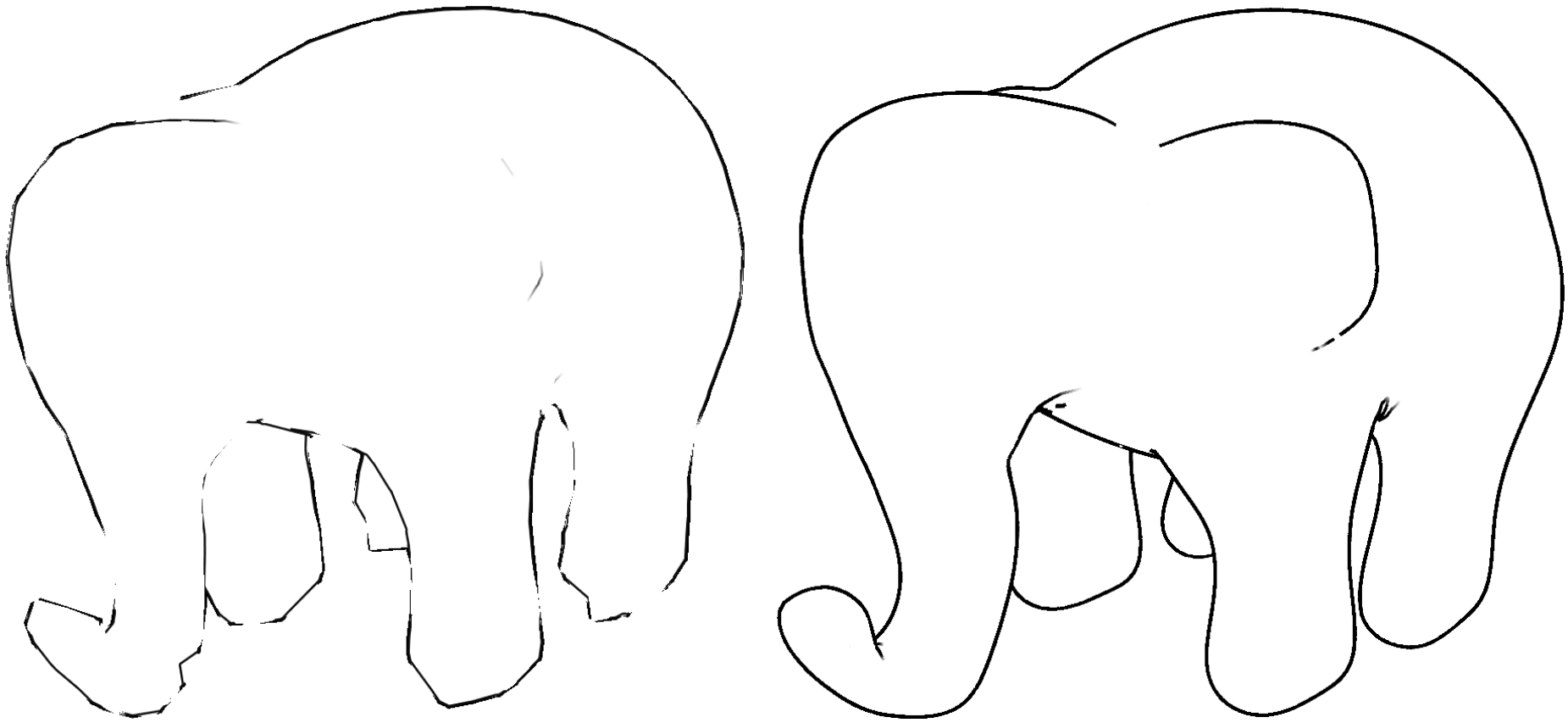


Sub-Poly Contours on Base Mesh

Project

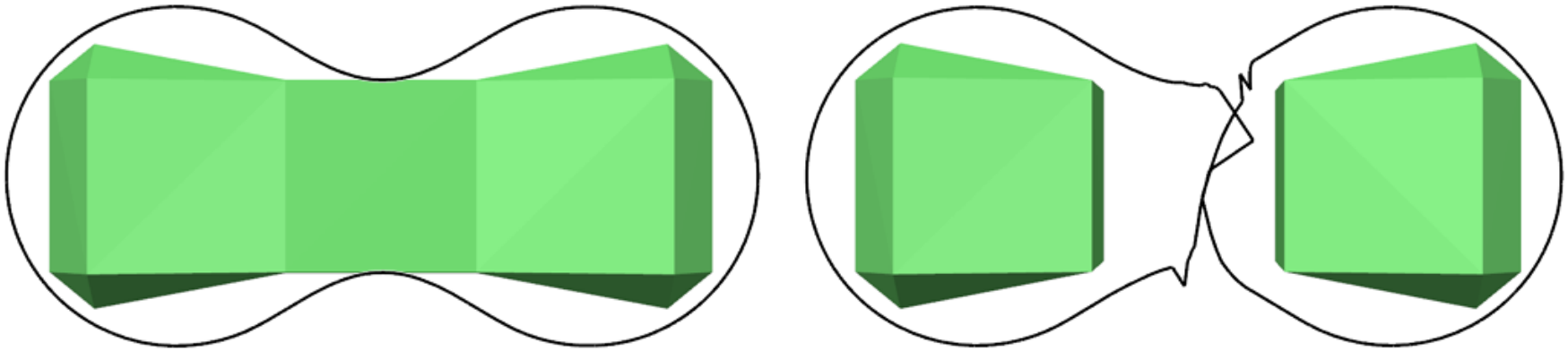
Refine





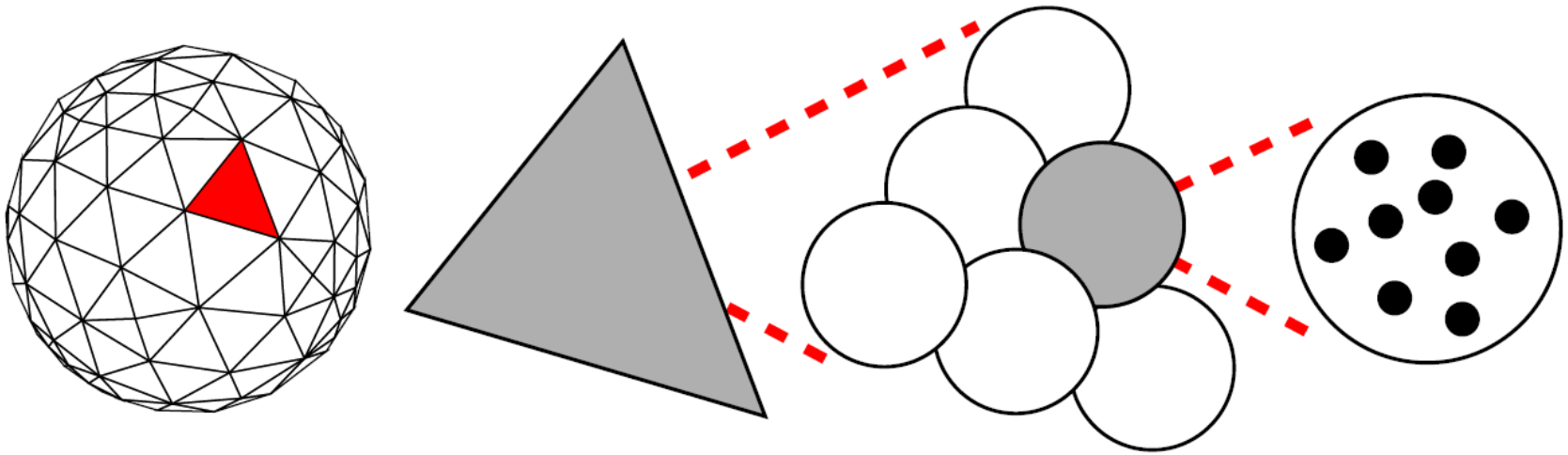
# Caveats

- Need functional surface normals
- Base mesh needs to capture topology of surface



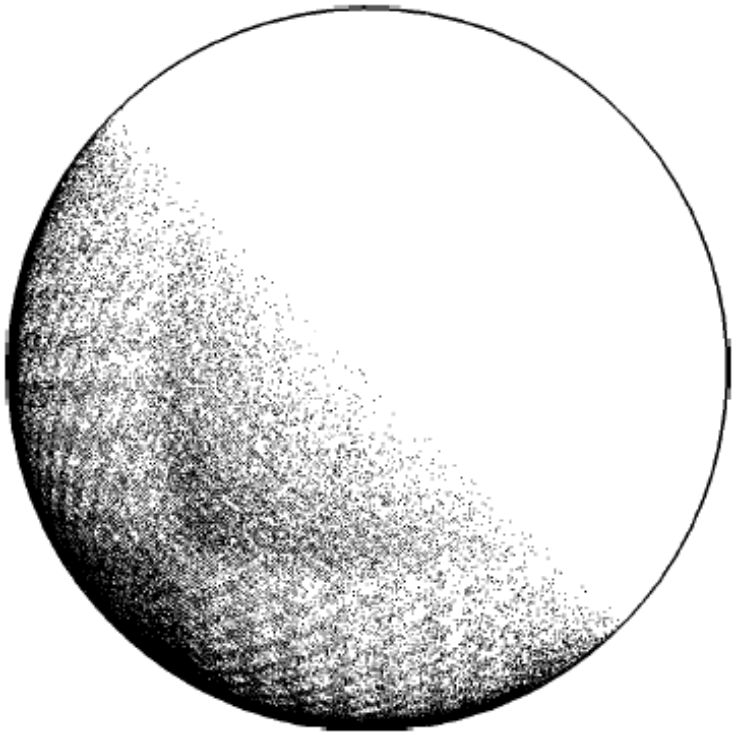
# Hidden Line Removal & Stippling

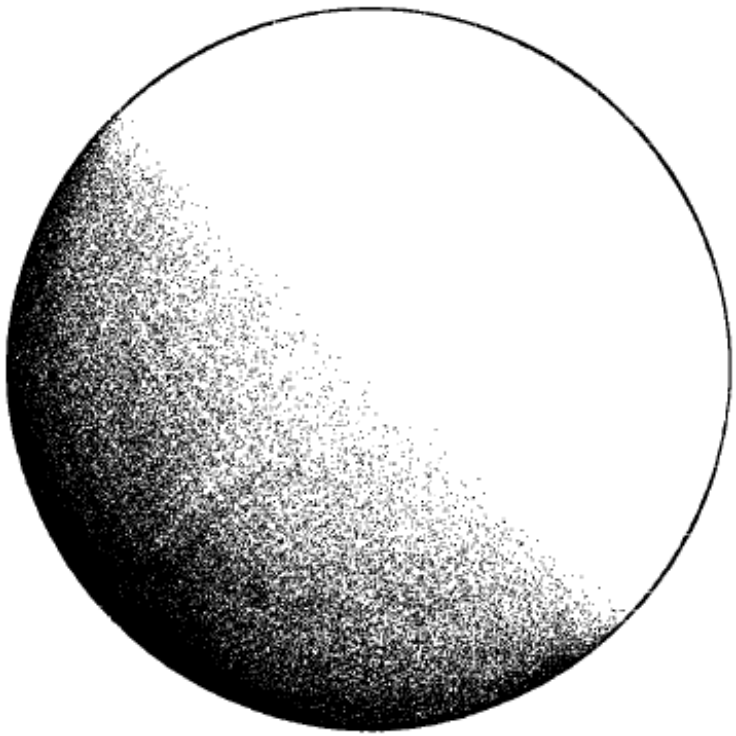
- Surfel approach ("tiny canvasses")
  - Cover base mesh w/ surfels
  - Project to surface
- Hierarchical culling, lazy generation
  - base mesh as spatial data structure



# Surfel Distribution

- "As-uniform-as-possible"
- Take surface curvature into account





# Wins

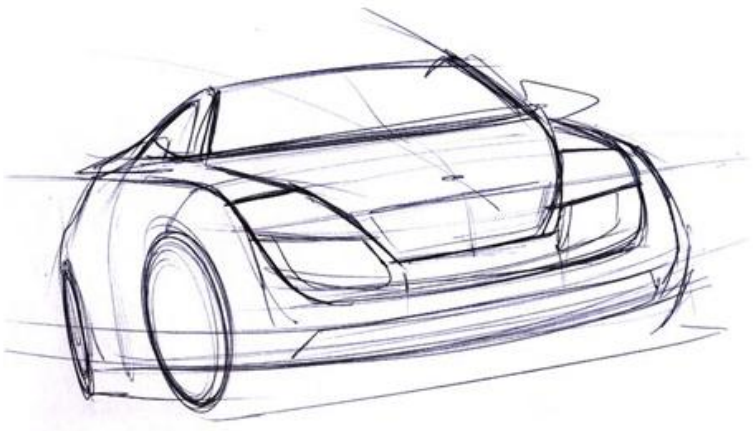
- Visual Scaffolding
  - Geometric Massing, Eraser Marks
- Real-Time Pen & Ink on dynamic surfaces
  - Implicit, NURBS, SubDs
  - Fully object-space
  - Supports incremental refinement
  - Frame-coherent as long as base mesh triangles do not change
- **Smoother-looking surface at equivalent interactive framerate!**

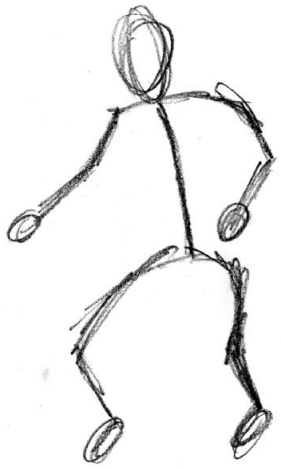
# The Future

- Other visual scaffolding types
- Interactive Scaffolding
- "Conjecturing" scaffolding?

- www.shapeshop3d.com

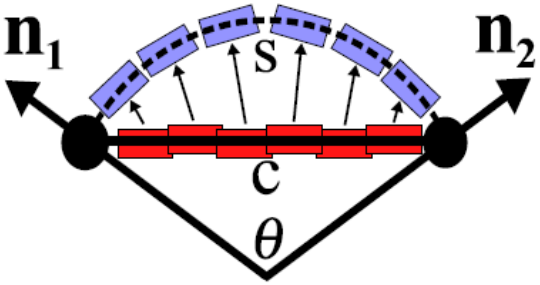
  *(Under "Downloads" -> "Extras")*



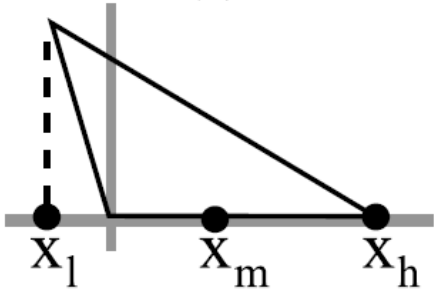


Enes Canay http://www.carbodydesign.com/archive/2006/08/10-audi-sportscoupe-concept/

# Surfel Rasterization




(a)

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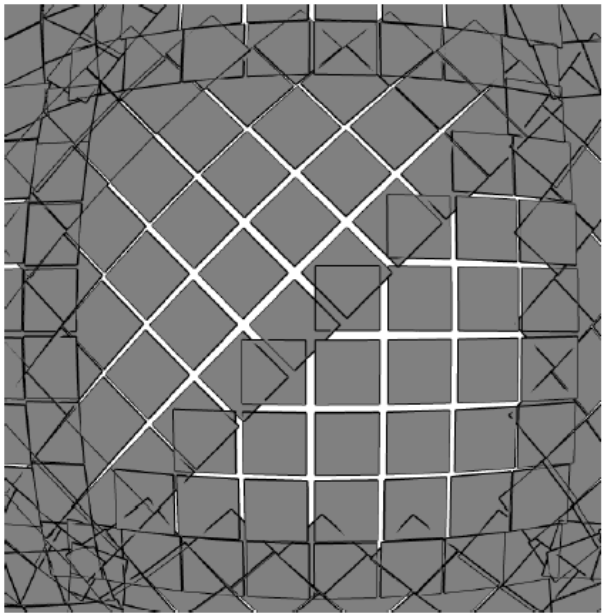

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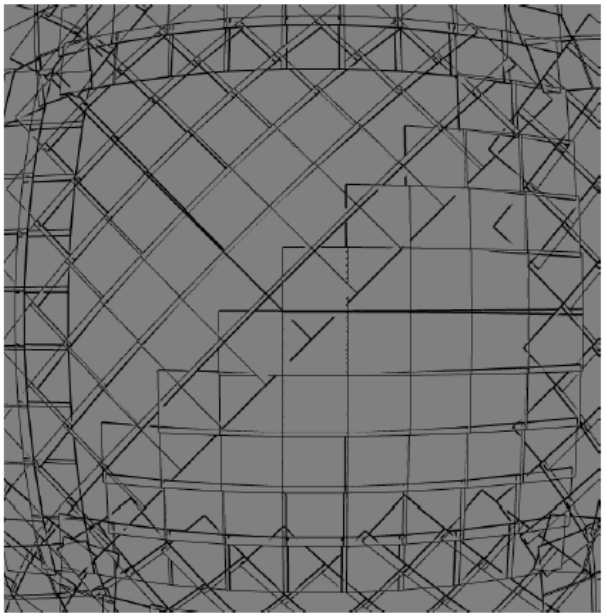
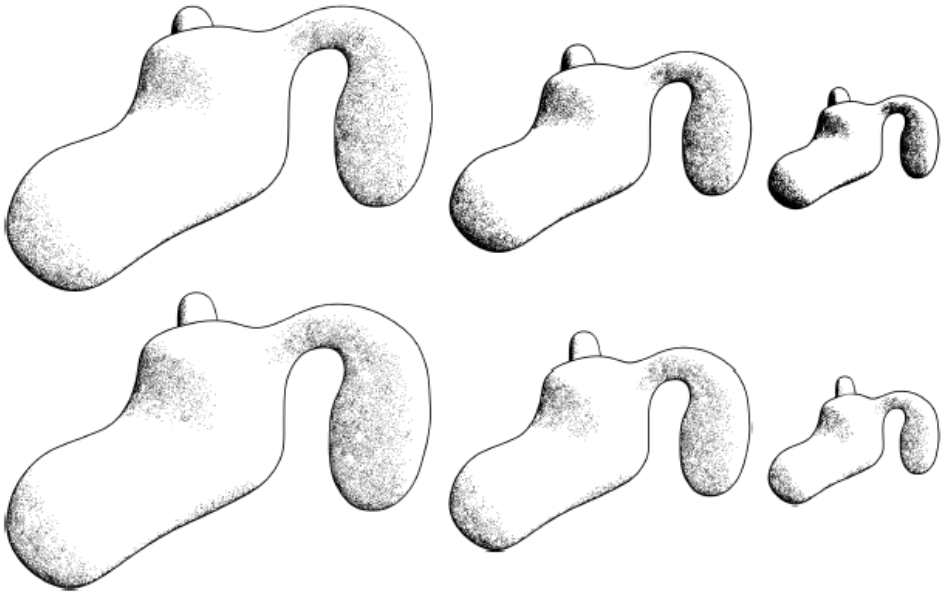
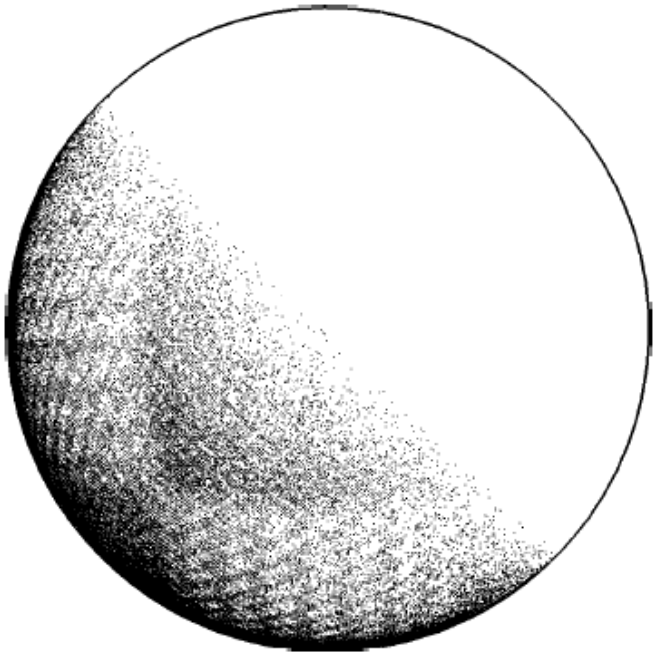


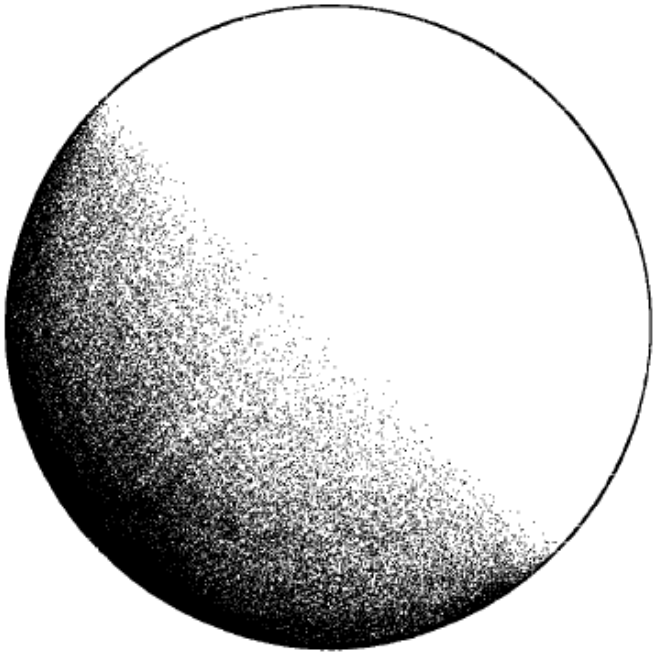
(d)

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