COS426

Non-photorealistic Rendering

Lee Markosian

Q: What is computer graphics about?

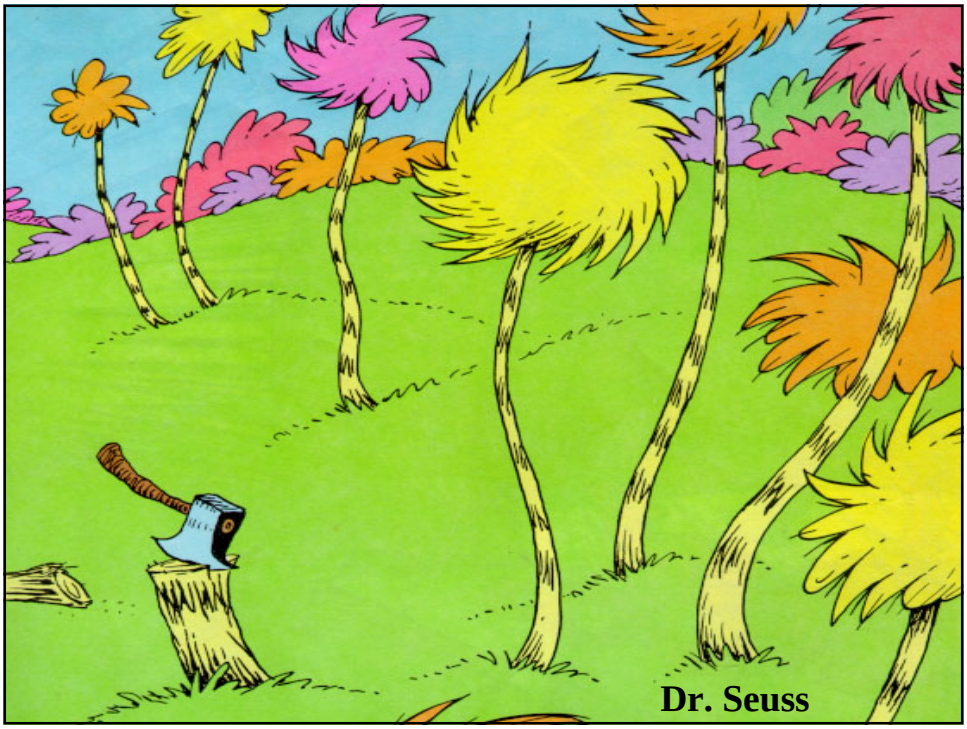
A: Providing tools to help human designers produce images that communicate visual information for some purpose.

Whether to use photorealism depends on the purpose of the image:

- Documentation
- Illustration
- Story-telling
- Expression

Qualities of hand-drawn images

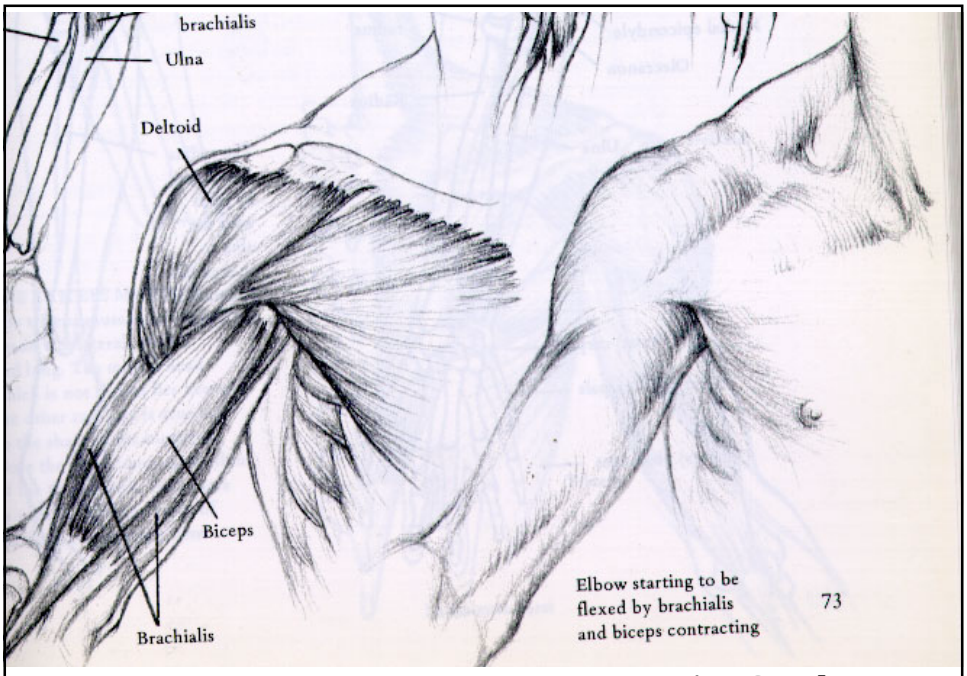
- Many details left out
- Some details emphasized
- Stylization / abstraction
  - used to evoke complex things
- Recognizable individual style



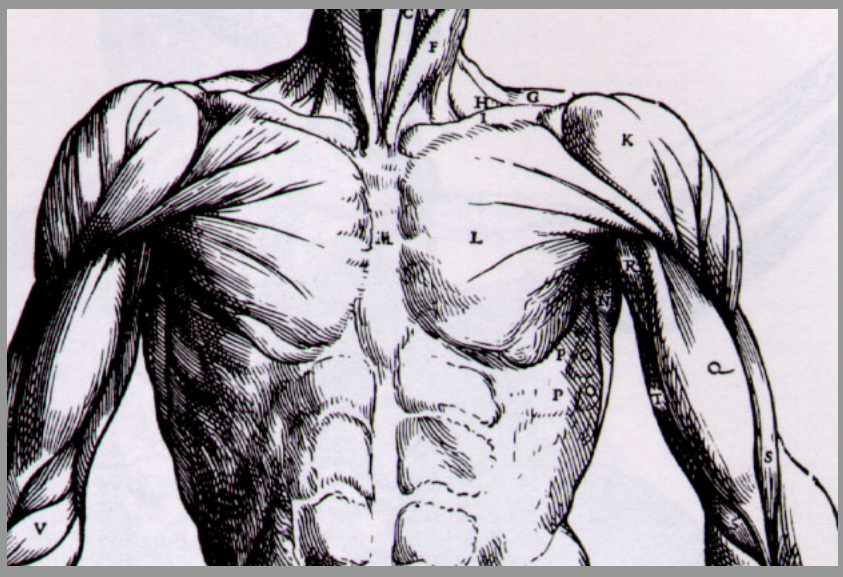
Monet

Uri Shulevitz

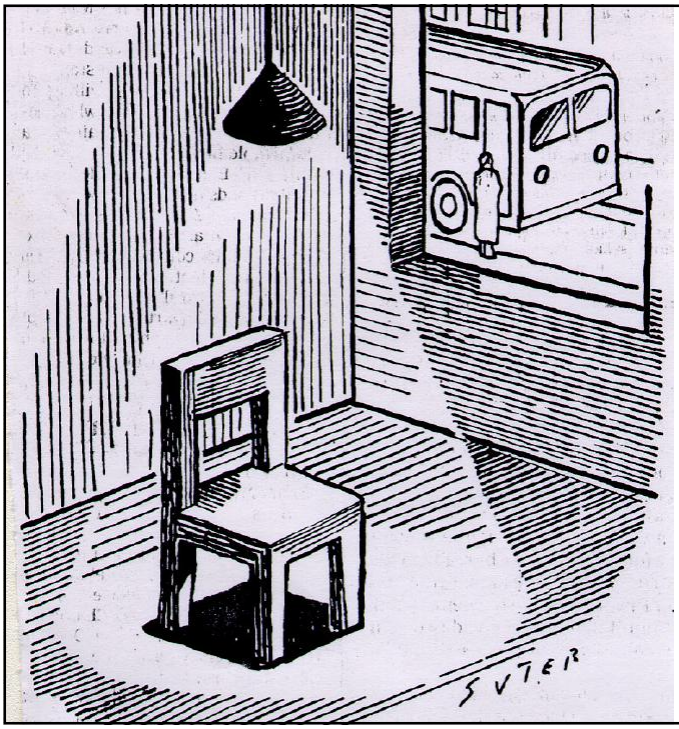
Charles Burns



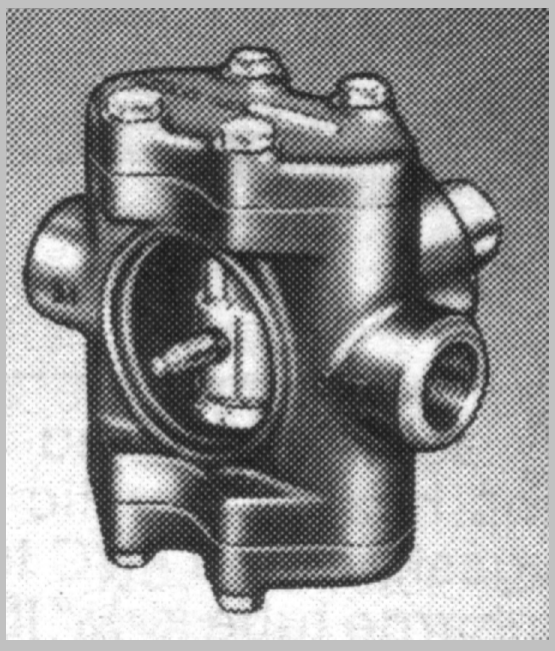
Louise Gordon



Vesalius



David Suter

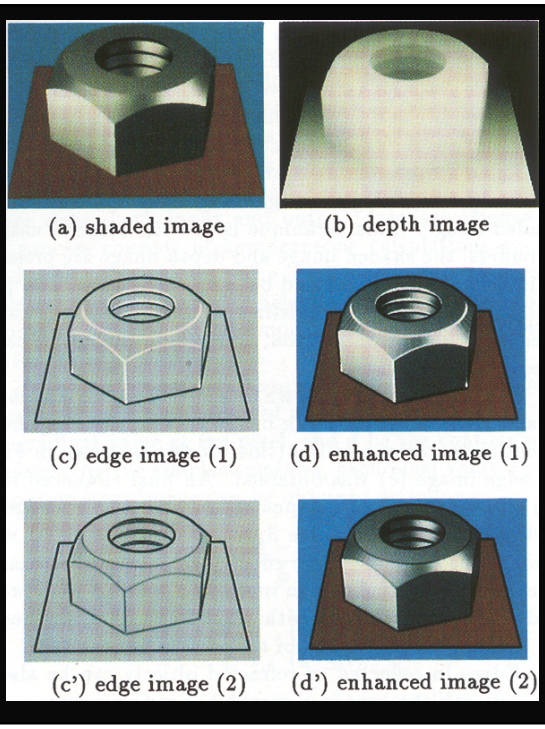


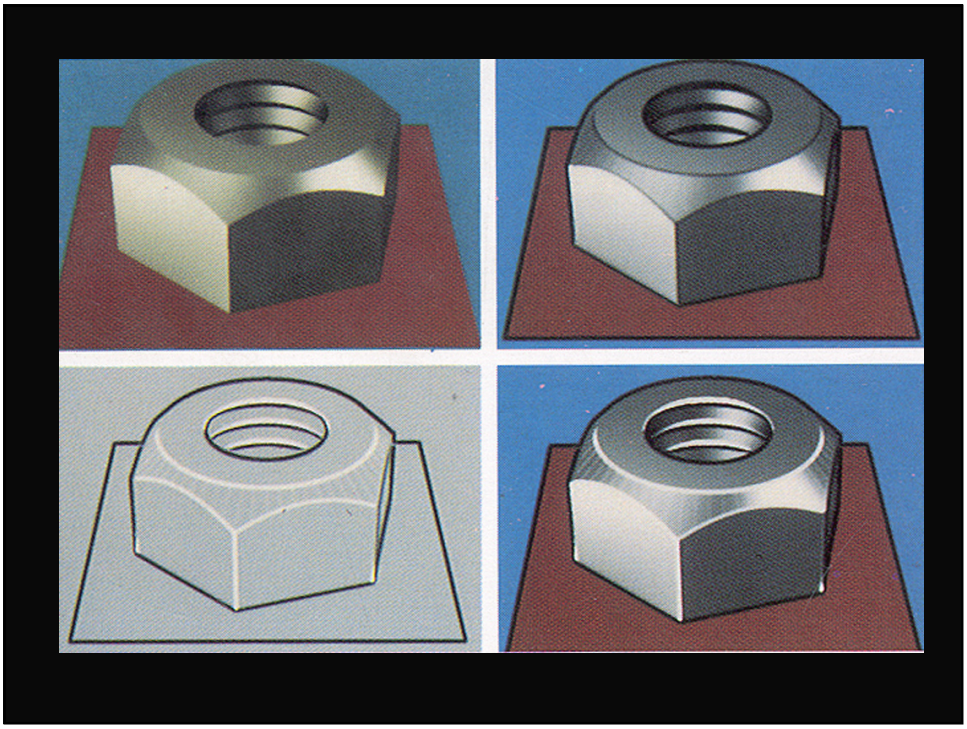
Outline

- Technical illustration
- Pen & Ink
- Painterly rendering for animation
- Cartoonish rendering

Technical illustration

- Saito and Takahashi, Siggraph 90
- Purpose: render 3D models in styles that are more “comprehensible”
- Method:
  - Render various intermediate images
  - Do image-processing operations on them
  - Combine the results


(a) shaded image
(b) depth image
(c) edge image (1)
(d) enhanced image (1)
(c') edge image (2)
(d') enhanced image (2)



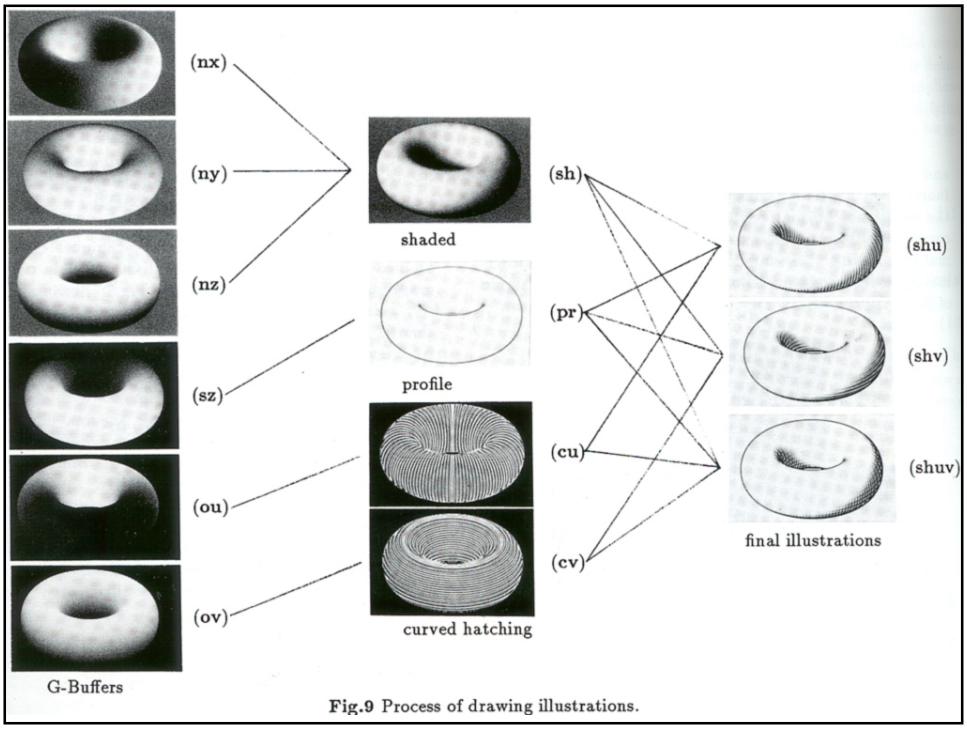
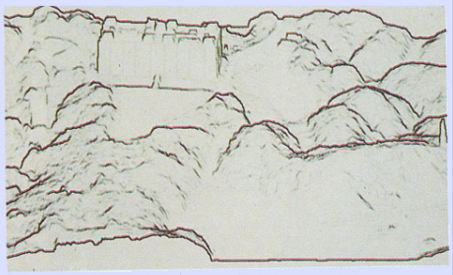
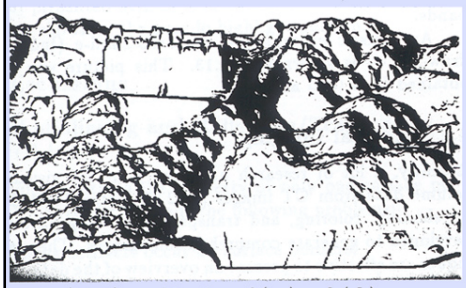


Fig.9 Process of drawing illustrations.

(cn) contour image



(pr) profile image



(mx2) combination of (pr) and (sh)

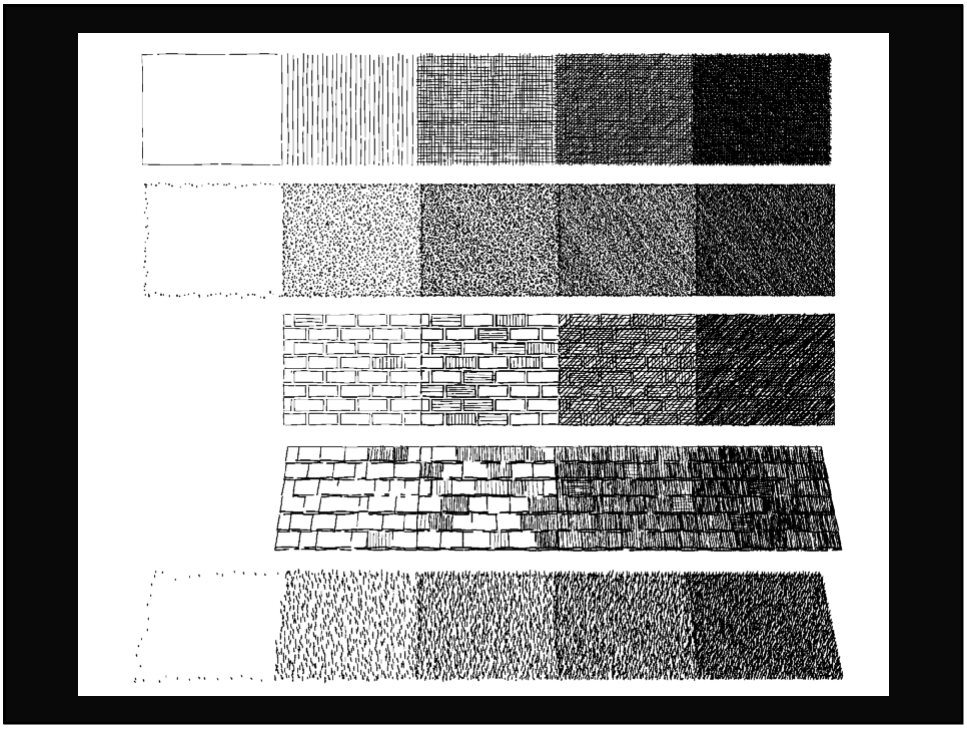
(mx4) combination of four enhanced images

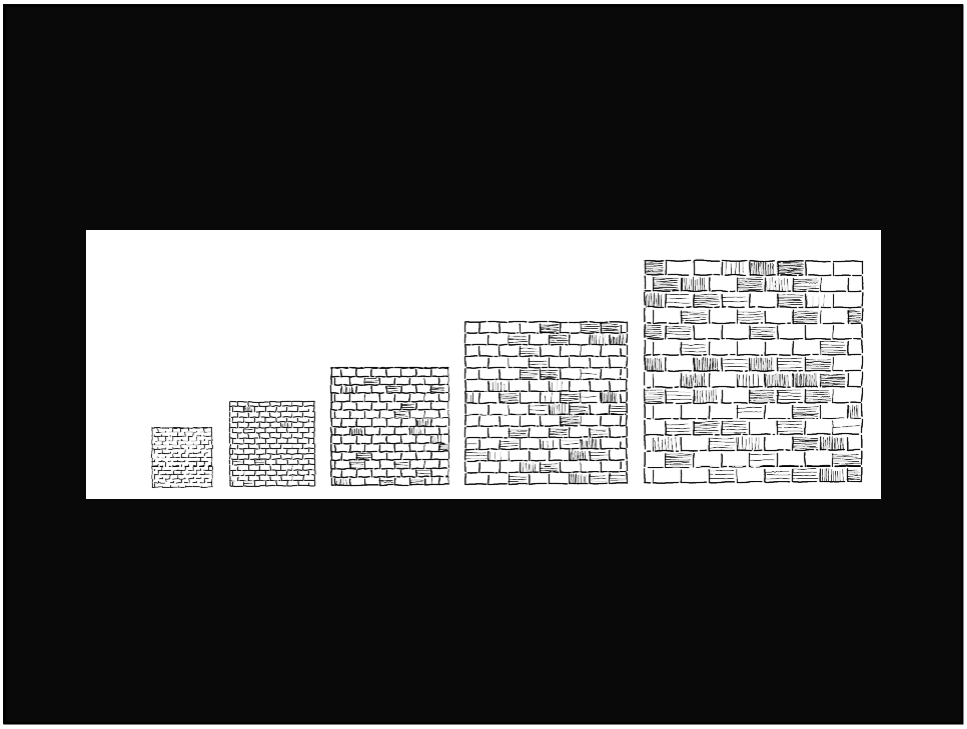
Problem

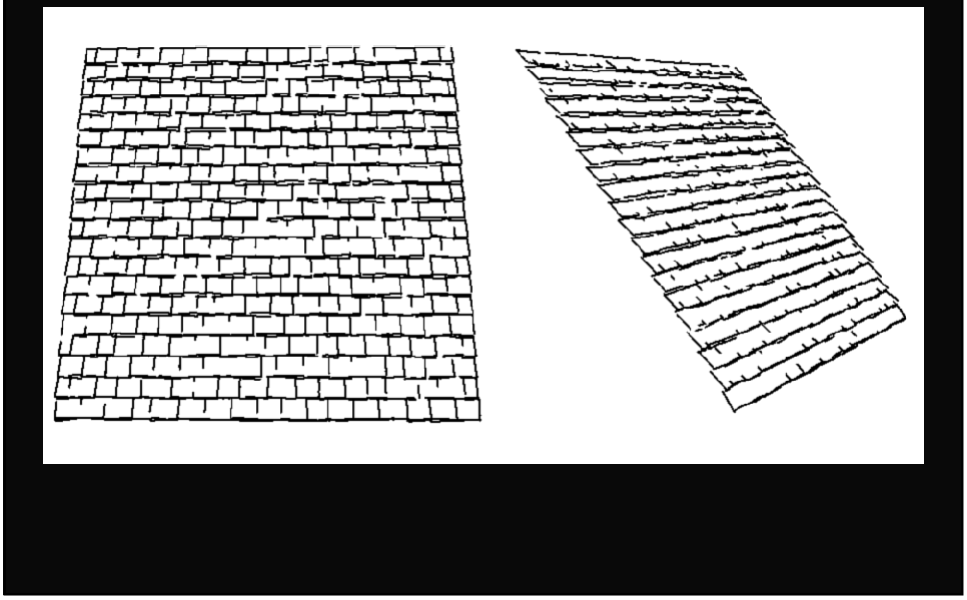
- Parameters need careful tuning for good results

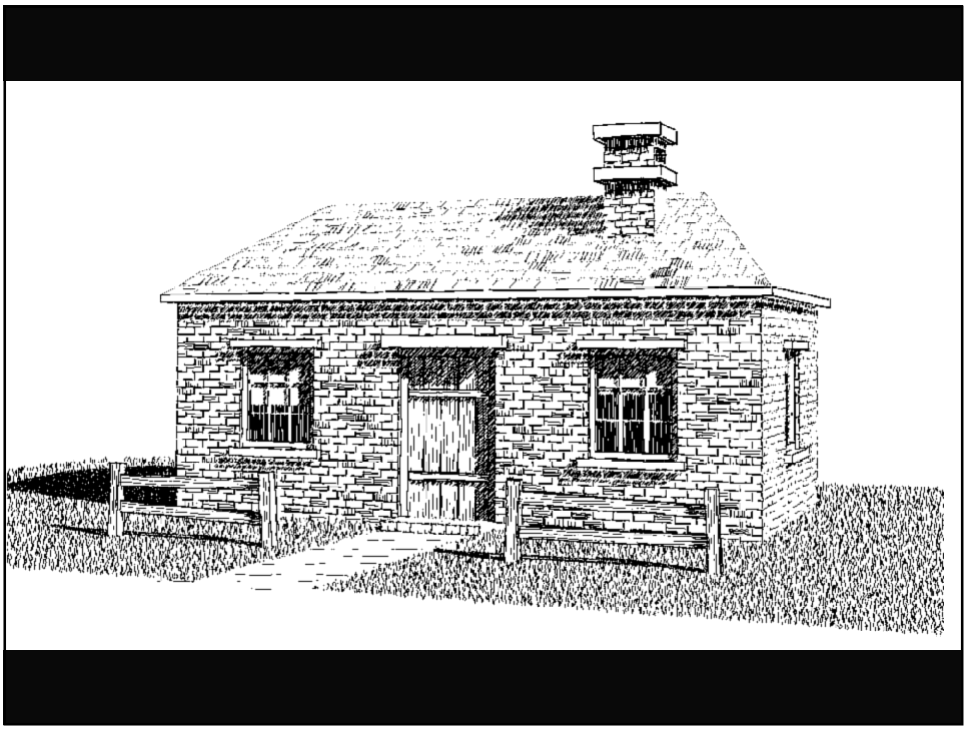
Pen and Ink

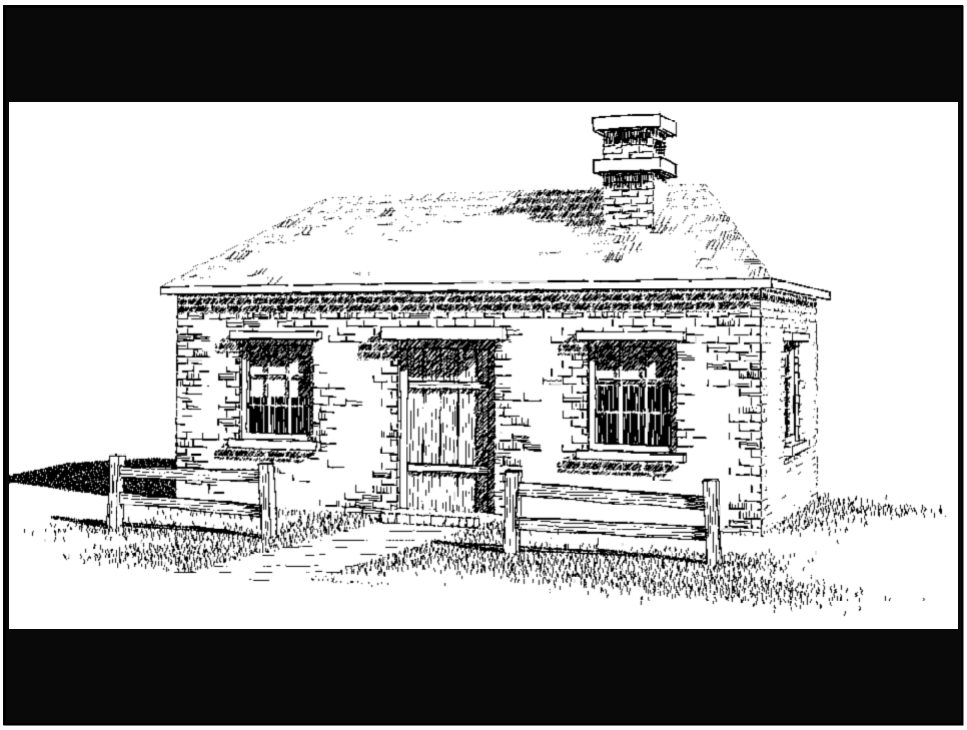
- Winkenbach and Salesin, Siggraph 94
- Purpose: render 3D models as pen & ink drawings
- Method:
  - annotate model with procedural “textures”
  - Render tonal “reference image”
  - Use it to guide pen and ink textures





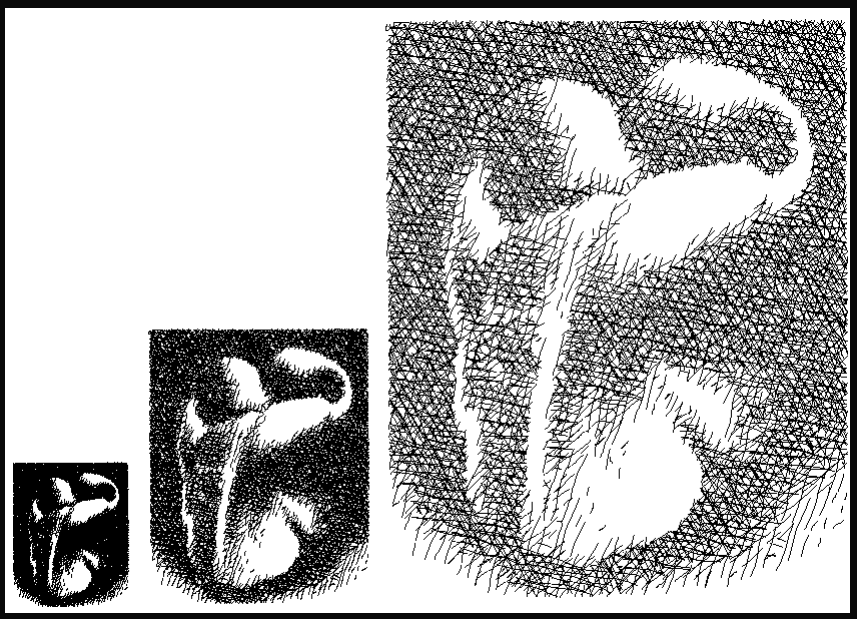


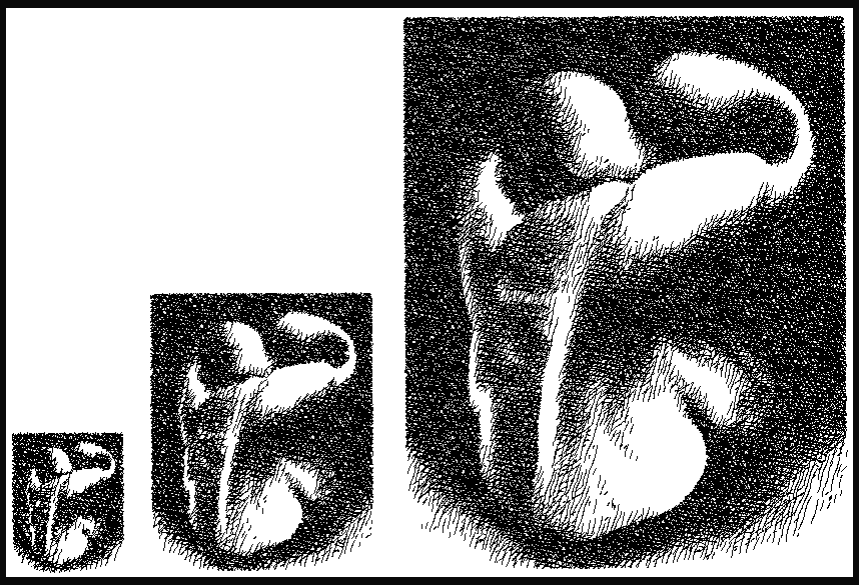




Pen and Ink

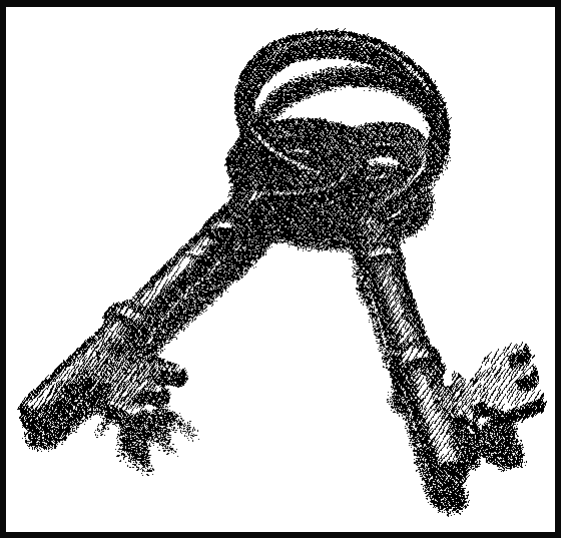
- Salisbury, Anderson, Lischinski and Salesin, Siggraph 96
- Purpose: define a scale-independent representation for pen & ink images

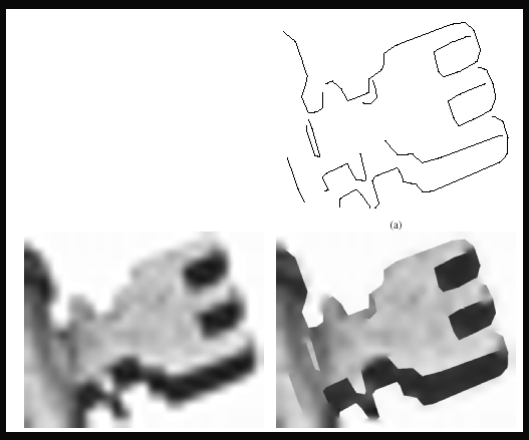


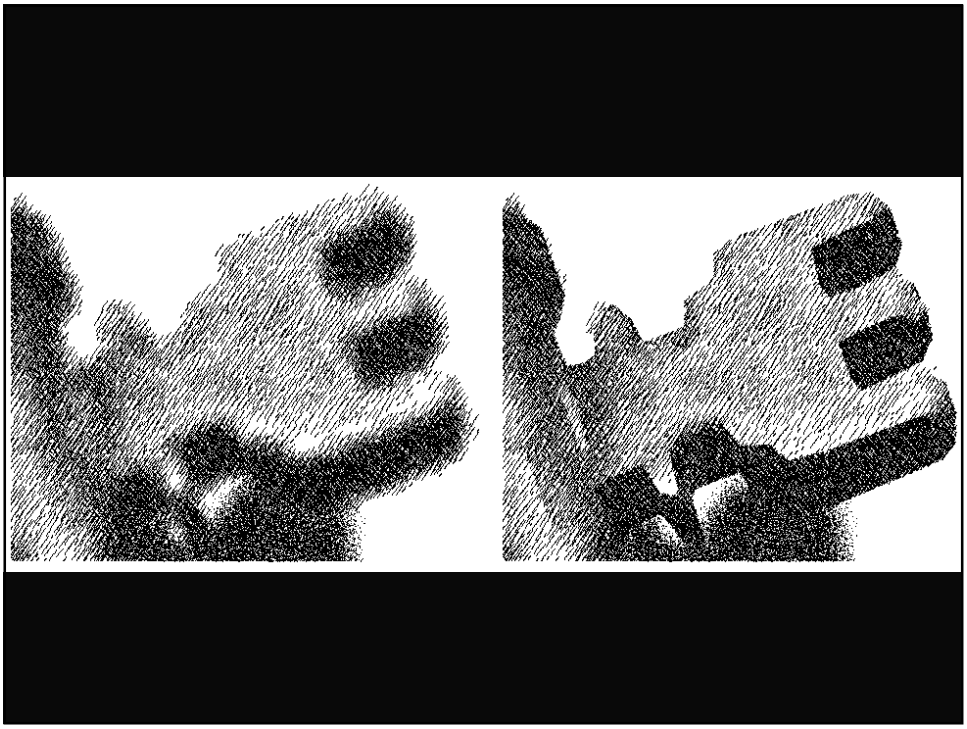


Salisbury et al., cont’d

- Method:
  - Store lo-res greyscale image annotated with discontinuities
  - filter greyscale image to desired size, run stroke generation algorithm on it




(a)

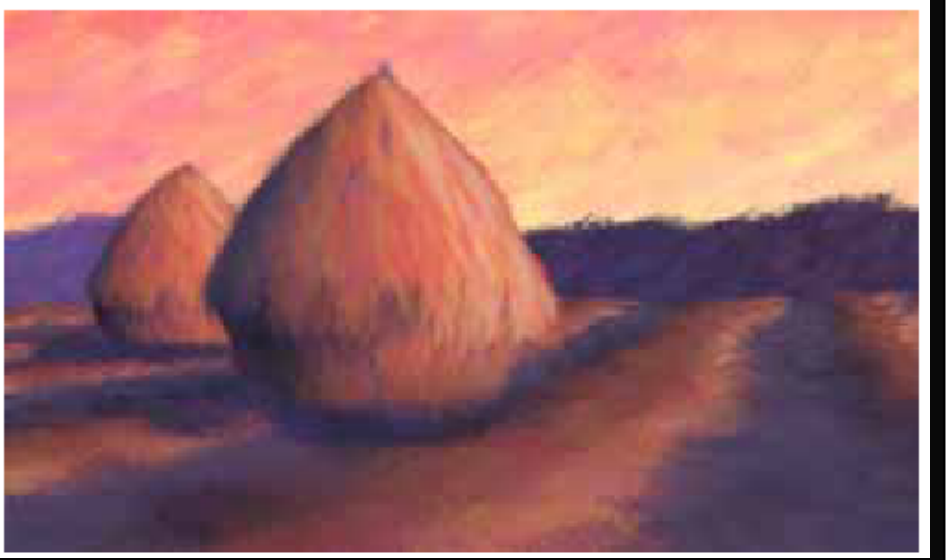


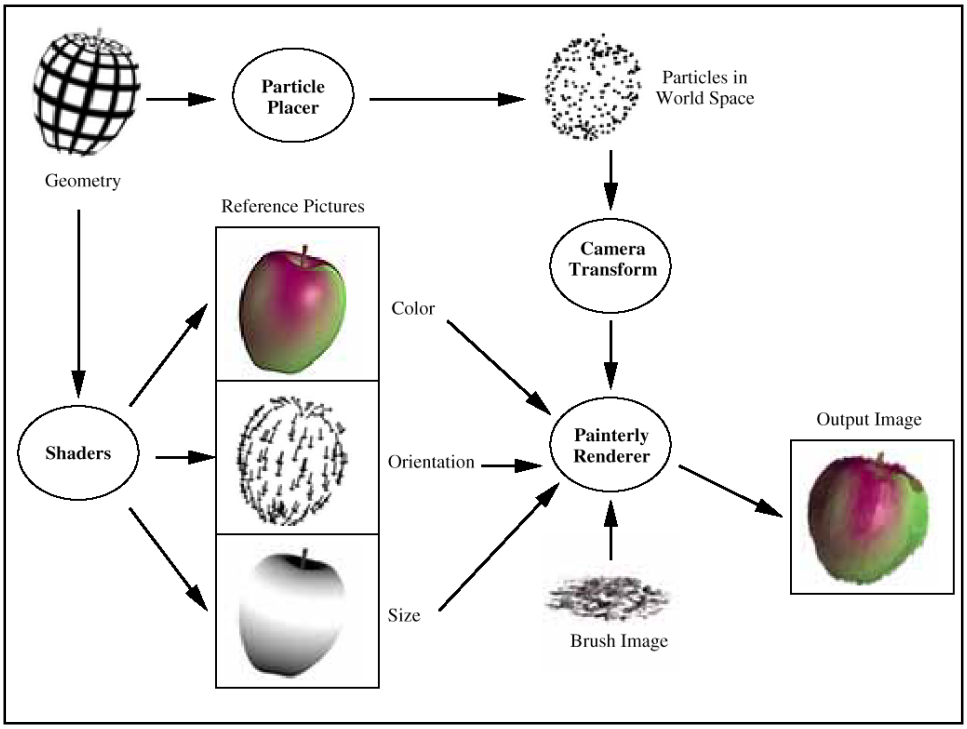
Problems

- Only produces still images
  - Would not provide temporal coherence
- What's the application?

Painterly rendering

- Meier, Siggraph 96
- Problem: produce animations in a "painterly" style with temporal coherence of strokes
- Method:
  - Populate surfaces with stroke "particles"
  - Render with the help of reference images




Particle Placer
Particles in World Space
Geometry
Reference Pictures
Camera Transform
Color
Shaders
Orientation
Painterly Renderer
Output Image
Size
Brush Image

video

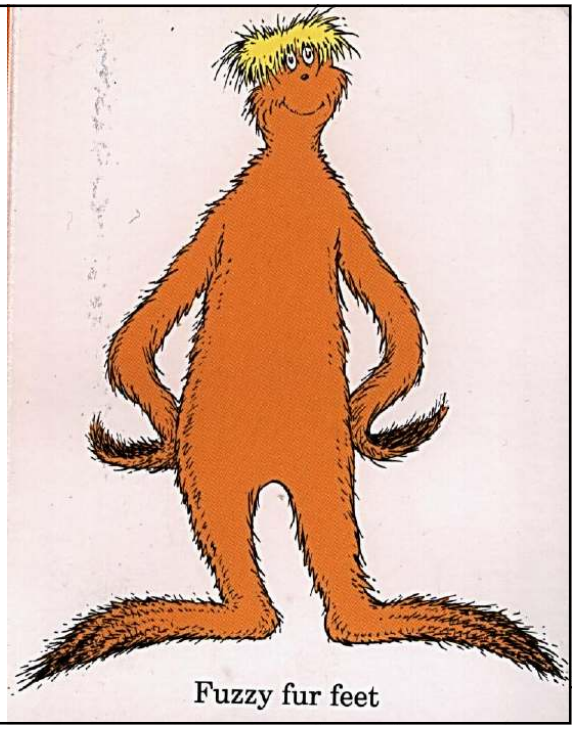
Problem

- Particles have fixed distribution
  - Need prescribed camera path

Cartoonish rendering

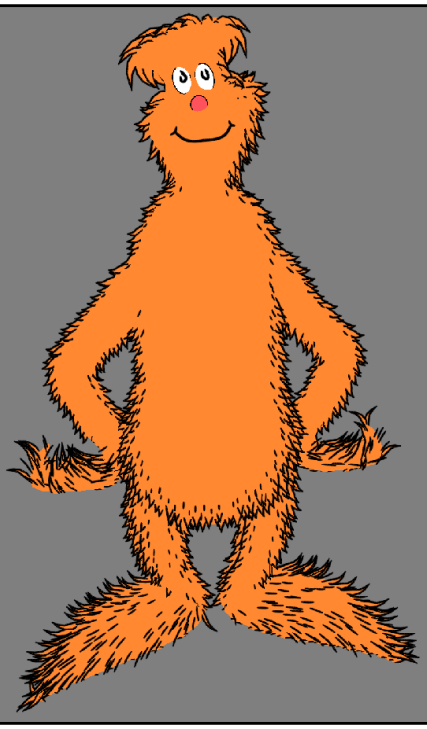
- Kowalski, Markosian, Northrup, Holden, Bourdev, Hughes, Siggraph 99
- Problem: render scenes like those truffula trees I showed you earlier
- Method:
  - Populate scene with detail elements “graftals”
  - Render with the help of reference images

Dr. Seuss



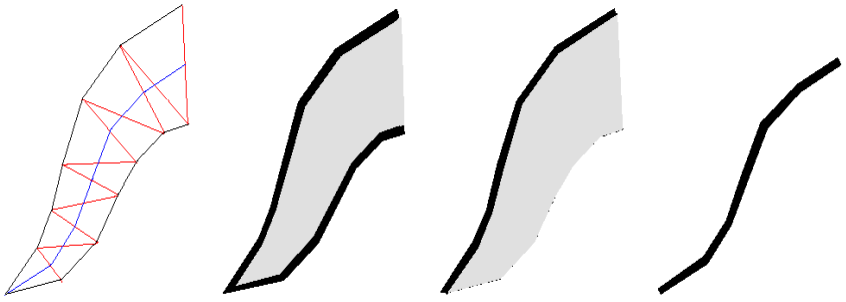
Graftal textures

Detail elements (graftals) generated as needed



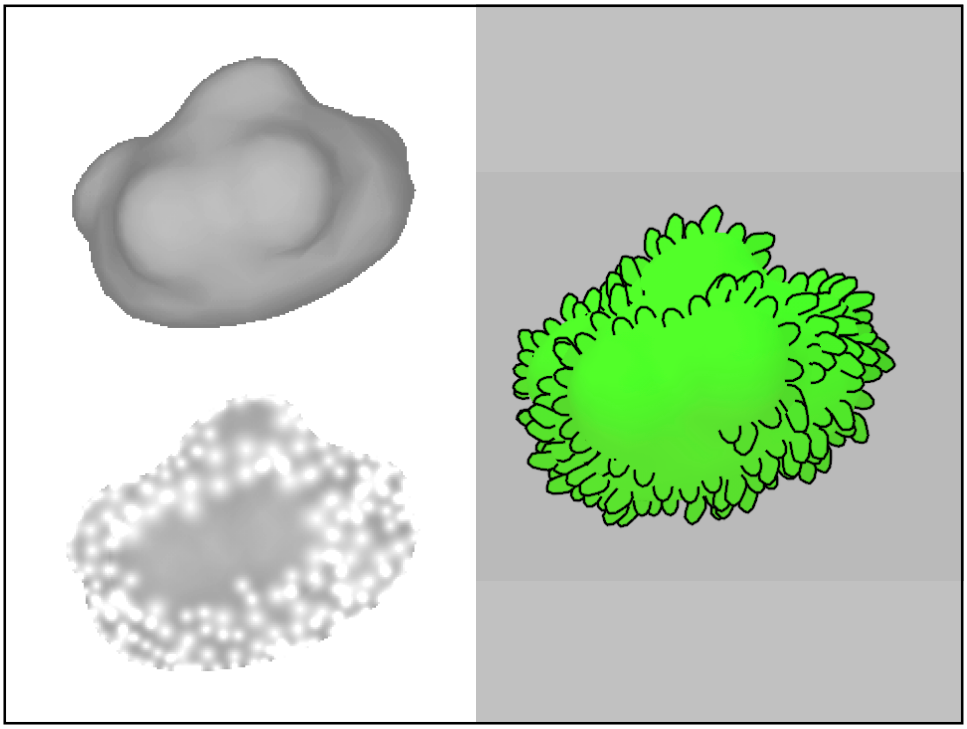
Graftals

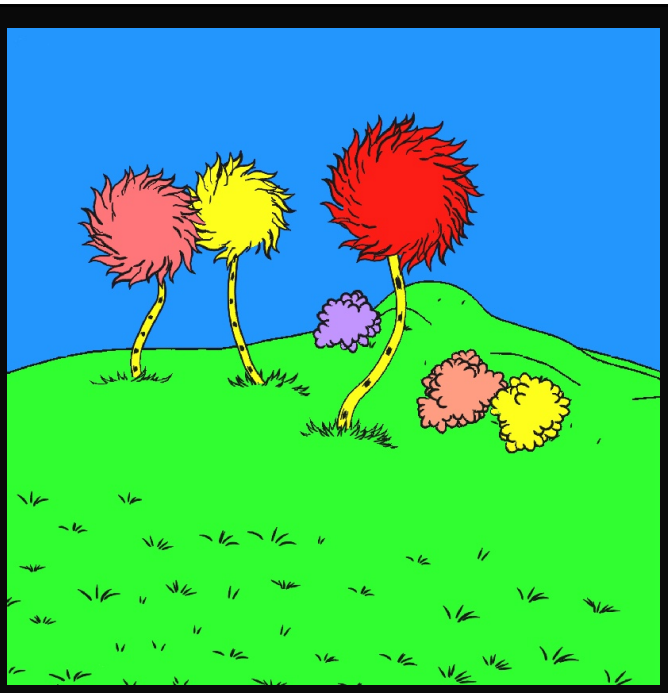
- Oriented in local frame
- Can choose level of detail



Needed for placement of graftals:

- Primarily at silhouettes (e.g.)
- Controlled *screen-space* density
- Placement on surfaces
- Persistence of graftals





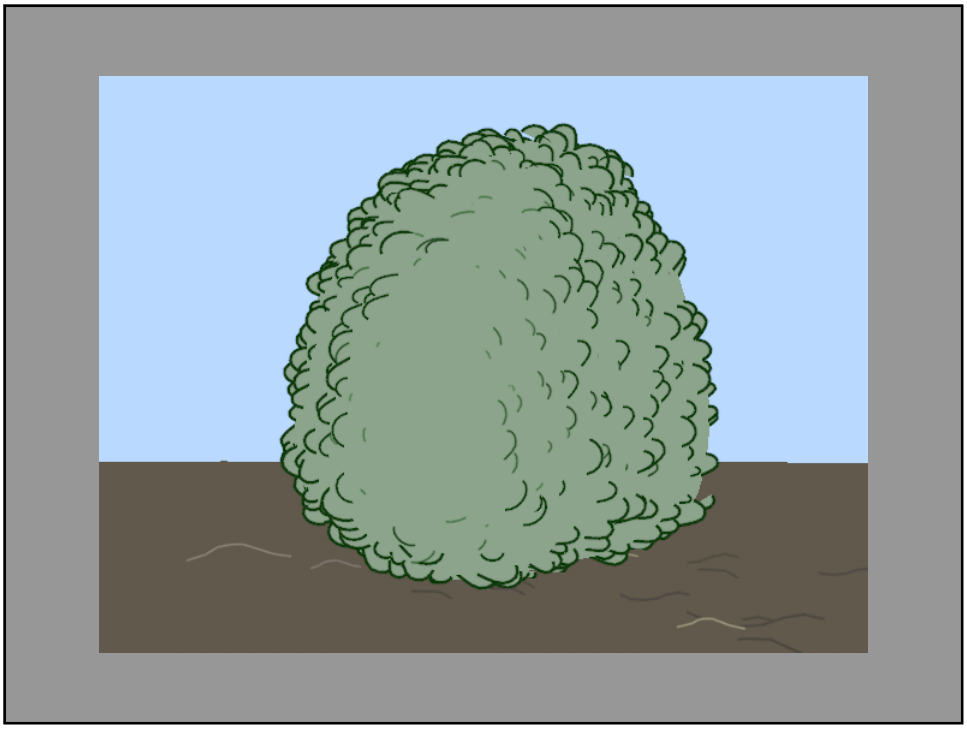
video

Problems

- Temporal incoherence
- Hard to author new scenes
  - You have to write C code

Static graftals

- Markosian, Kowalski, Meier, Northrup, Holden, Hughes, NPAR 00
- Problem: improve temporal coherence
- Method:
  - Graftals are fixed on surfaces
  - Draw with view-dependent LOD



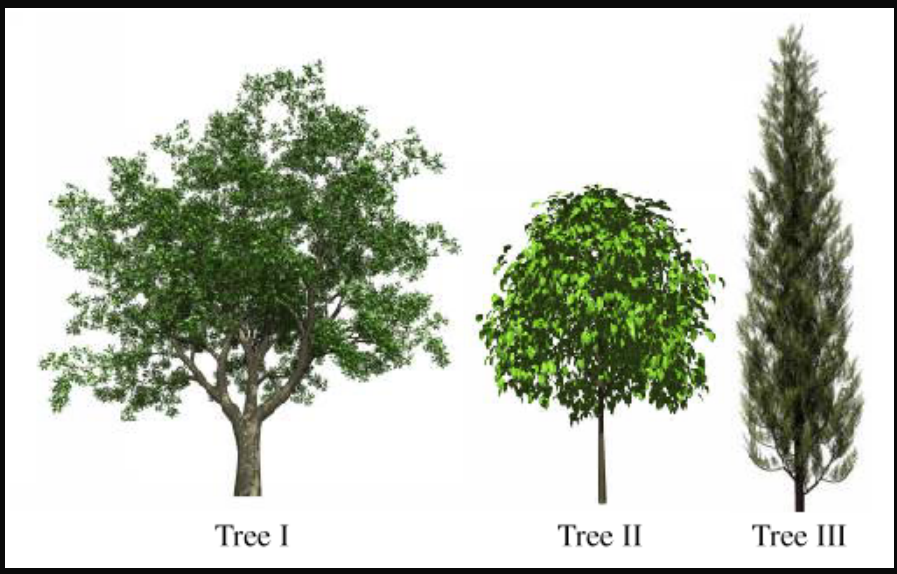
Demo: night scene

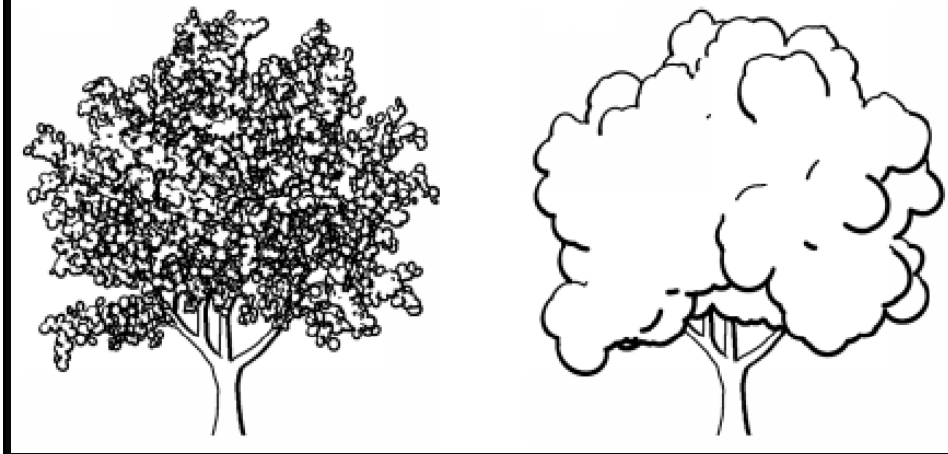
Problems

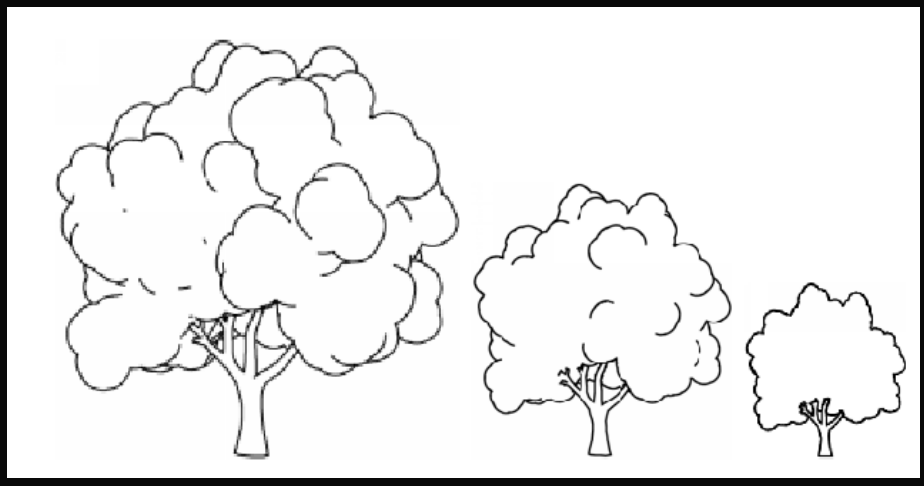
- Still hard to author scenes
  - You have to edit text files
- LOD handling too restrictive

Pen & Ink: trees

- Deussen and Strothotte, Siggraph 00
- Problem: temporally coherent pen and ink rendering of trees
- Method:
  - Draw leaf entities w/ controlled size/abstraction
  - Do image processing on depth buffer


Tree I
Tree II
Tree III

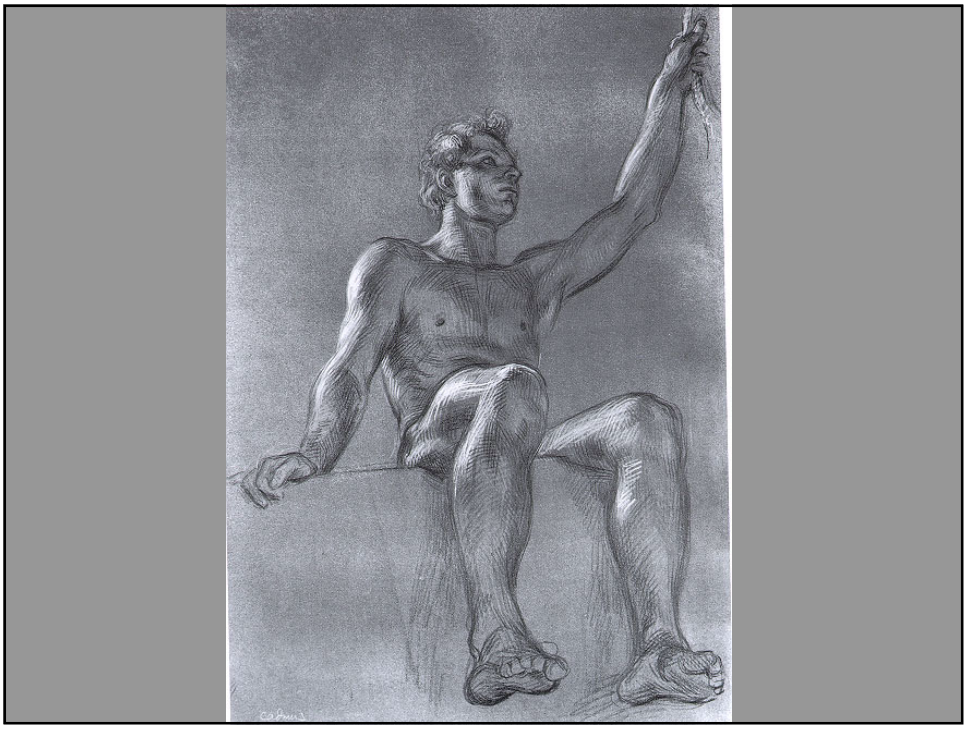


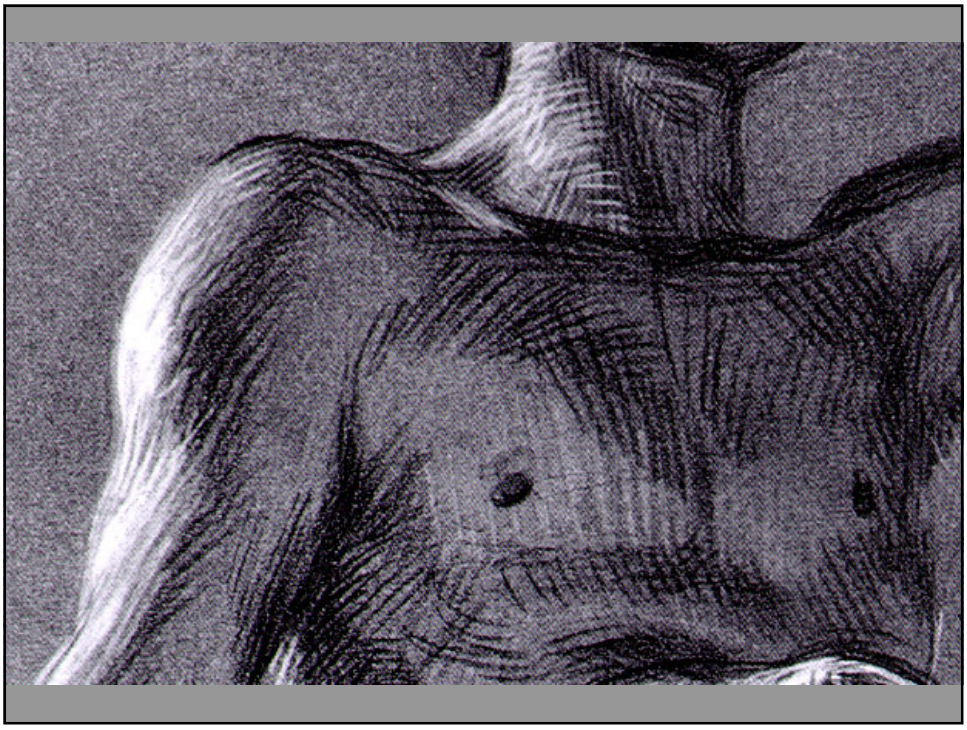


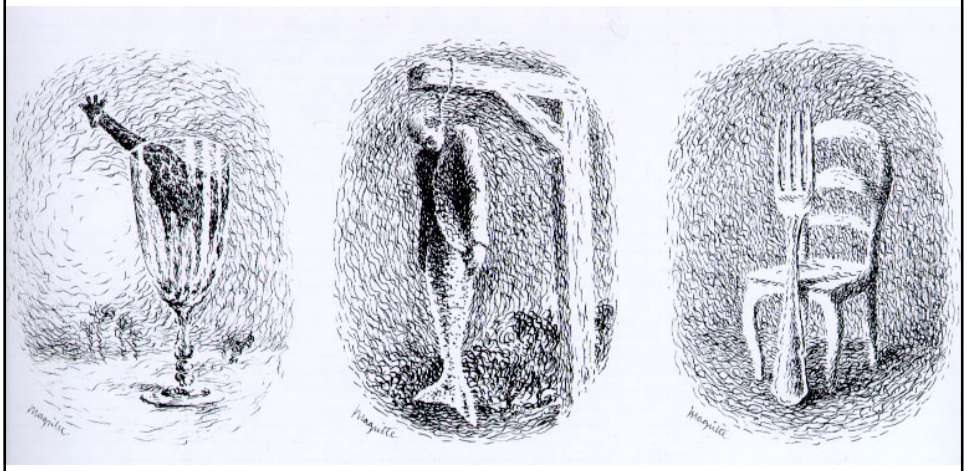
video

The future

- More rendering algorithms
- Better tools (UI)
  - NPR images need this especially
- Prediction: big advances in our ability to model stylized characters (people) are coming
- Reason: the content creators will demand it







Magritte

Millet