Introduction to Non-Photorealistic Rendering (NPR)

Pen-and-Ink Illustration
Painterly Rendering

11/20/01

Traditional CG

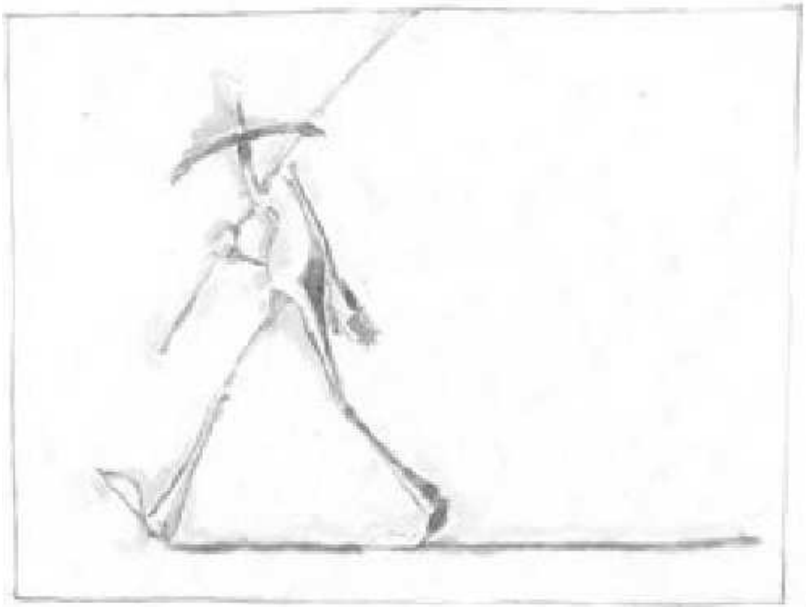
- Photorealistic is often the most important thing!
- But it is not the only possible goal…

http://www.autodesk.com/us/lightscape/examples/index.html

Beyond Photorealism

- Photorealism is good, but…
  sometimes people want more control!

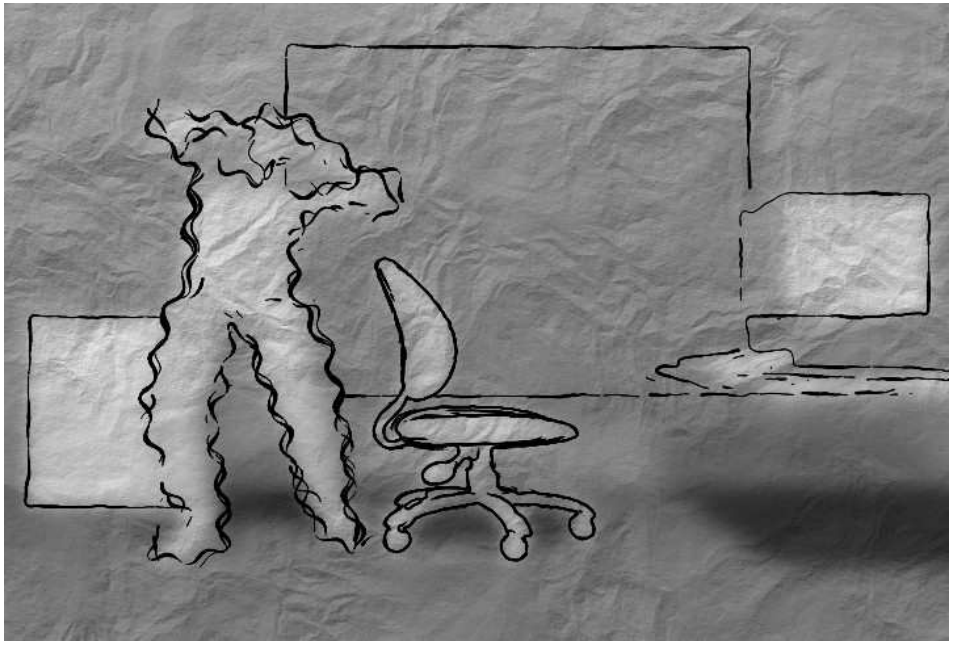
Narodni Galerie, Prague



reference image by David Gainey for *fishing*

What is NPR?

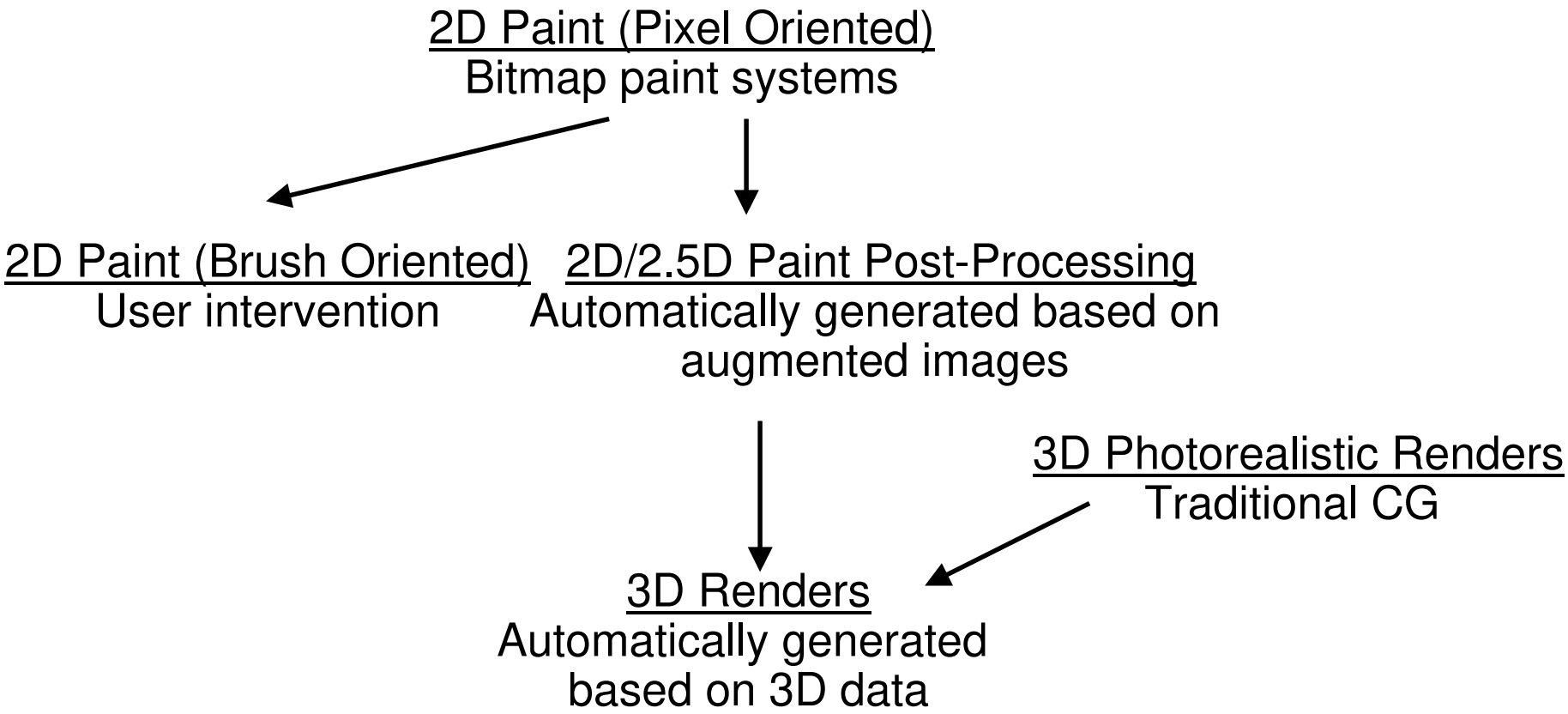
"A means of creating imagery that does not aspire to realism" – Stuart Green



Cassidy Curtis, "Loose and Sketchy Animation," Technical Sketch , SIGGRAPH 98

Emergence of NPR

Daniel Teece, “3D Interactive NPR”



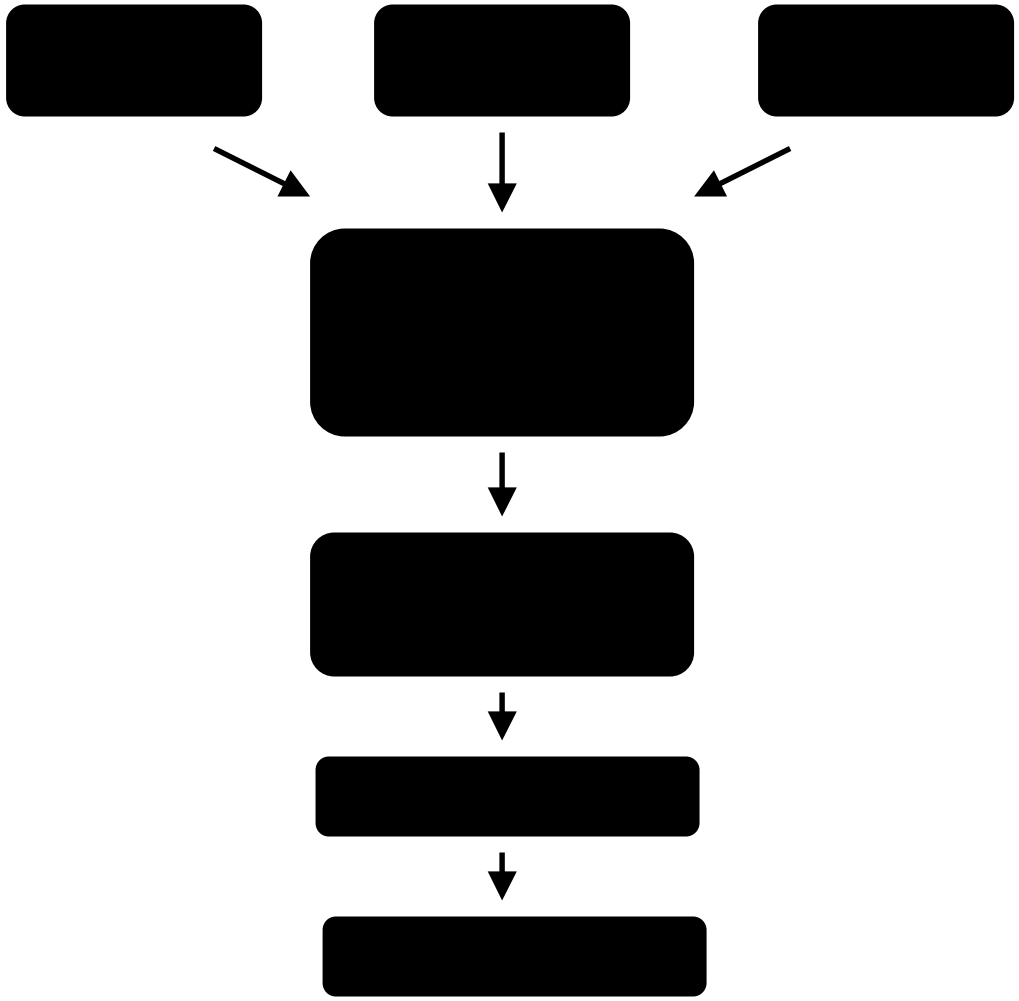
NPR Examples

- Pen-and-Ink illustrations
- Painterly rendering
- Others
  - cartoons
  - technical illustration
  - scientific visualization
- Driven from human data

Pen-and-Ink Illustrations

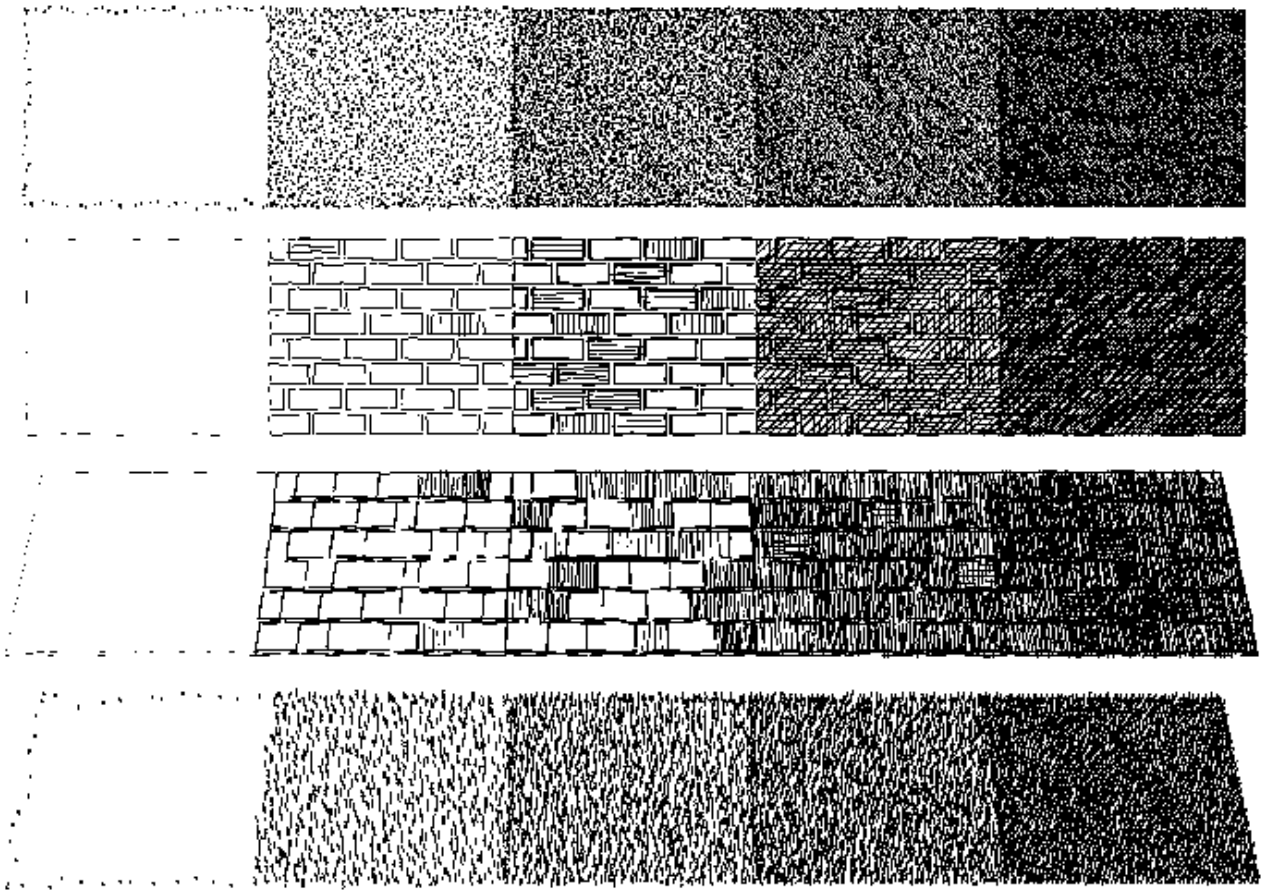
- Strokes
  - Curved lines of varying thickness and density of placement
- Texture
  - Character conveyed by collection of strokes
- Tone
  - Perceived gray level across the image
- Outline
  - Boundary lines which disambiguate structure information

Rendering Polygonal Surfaces



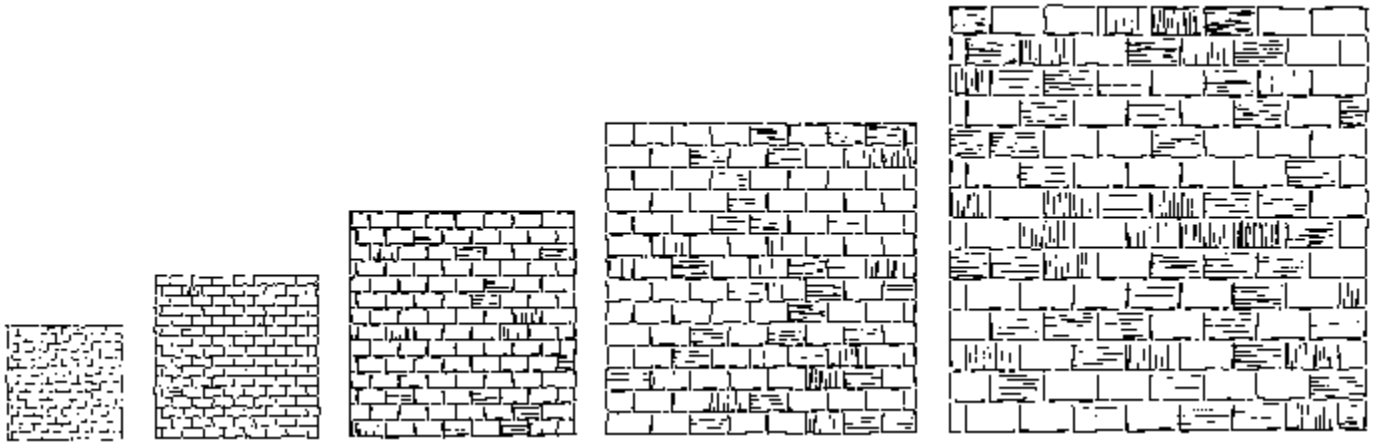
Texture and tone generation

Prioritized stroke texture

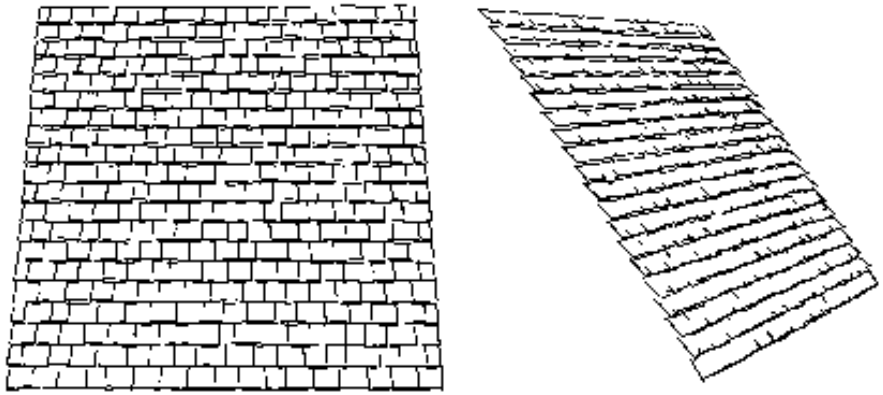


Winkenbach & Salesin, "Computer-Generated Pen-and-Ink Illustration," SIGGRAPH 94

Scaling

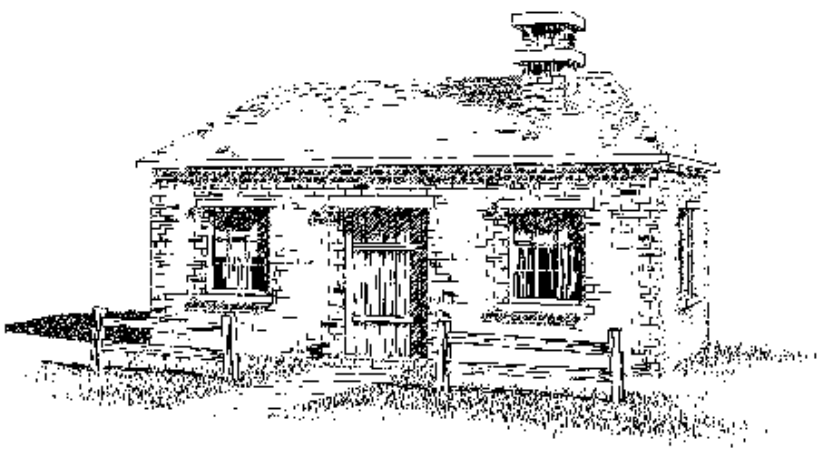


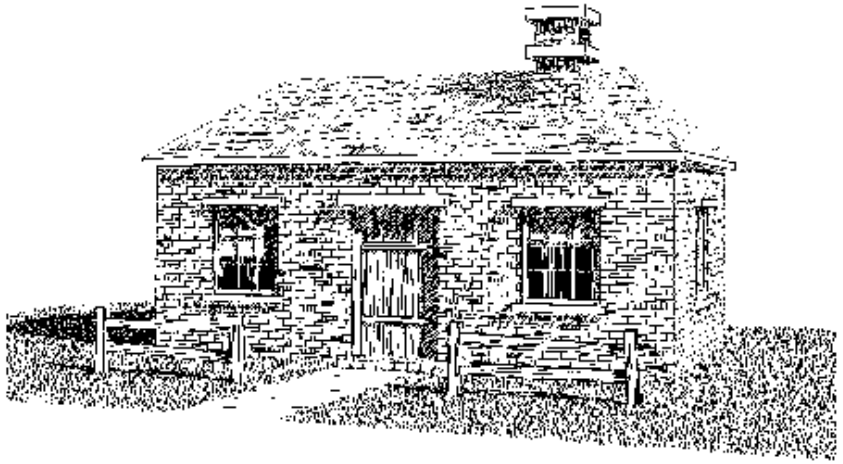
Viewing direction



Winkenbach & Salesin, "Computer-Generated Pen-and-Ink Illustration," SIGGRAPH 94

Indication

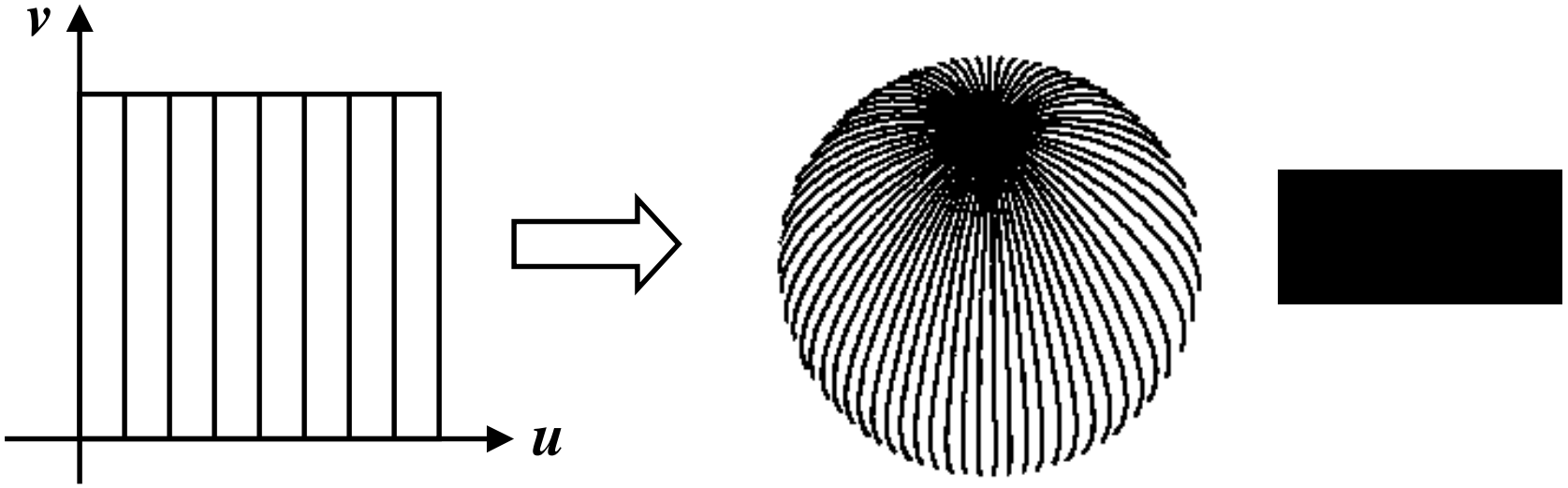




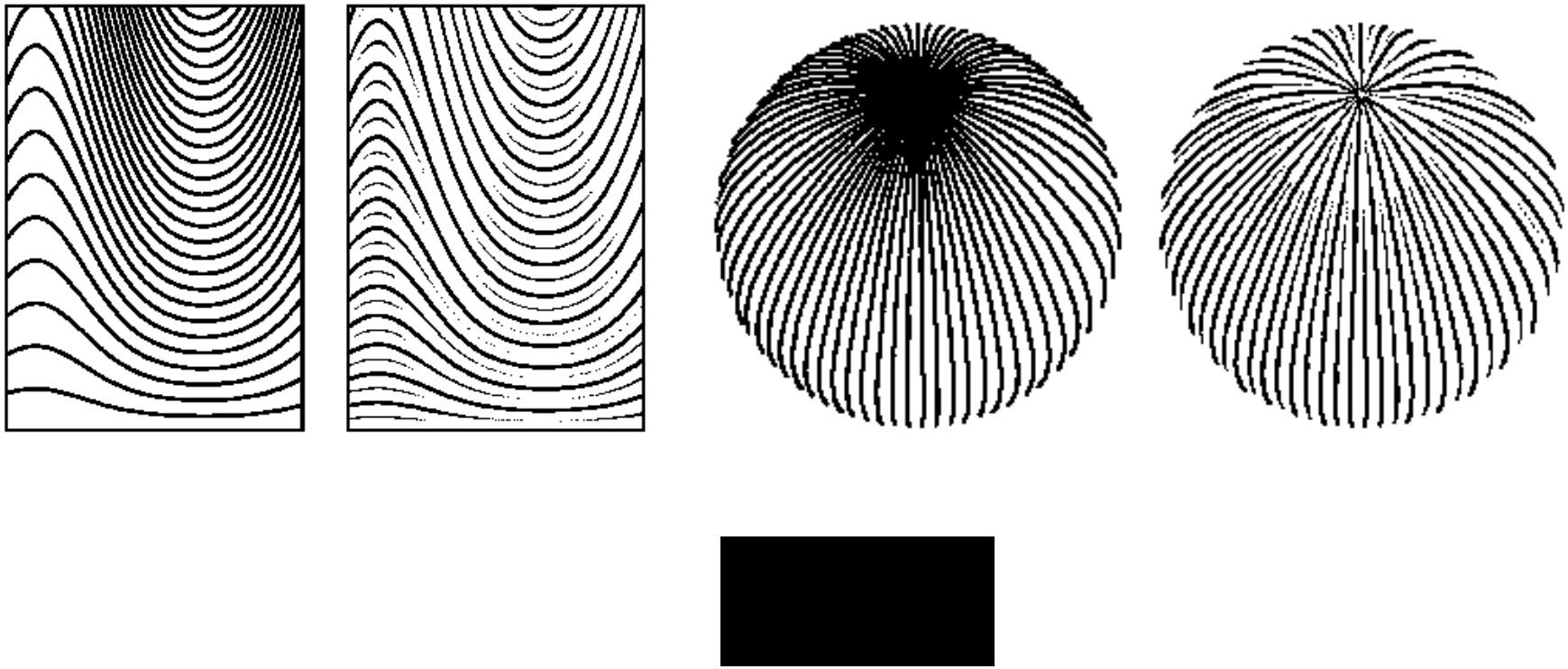
Winkenbach & Salesin, "Computer-Generated Pen-and-Ink Illustration," SIGGRAPH 94

Rendering Parametric Surfaces

- Stroke placement – orientation and density
  - place strokes along isoparameter lines of parameterized surface
  - choose density according to maximum gray level and maximum allowable stroke width

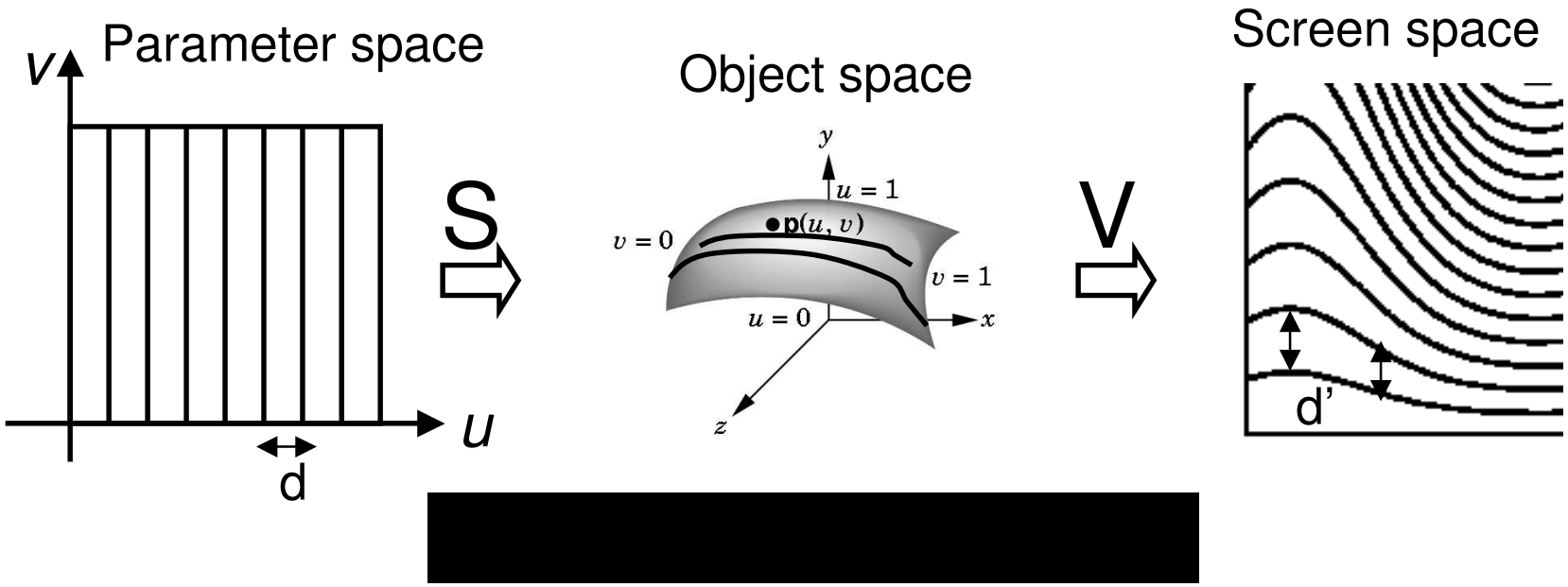


- **Stroke width**
  - adjust width to account for divergence and desired tone along each stroke



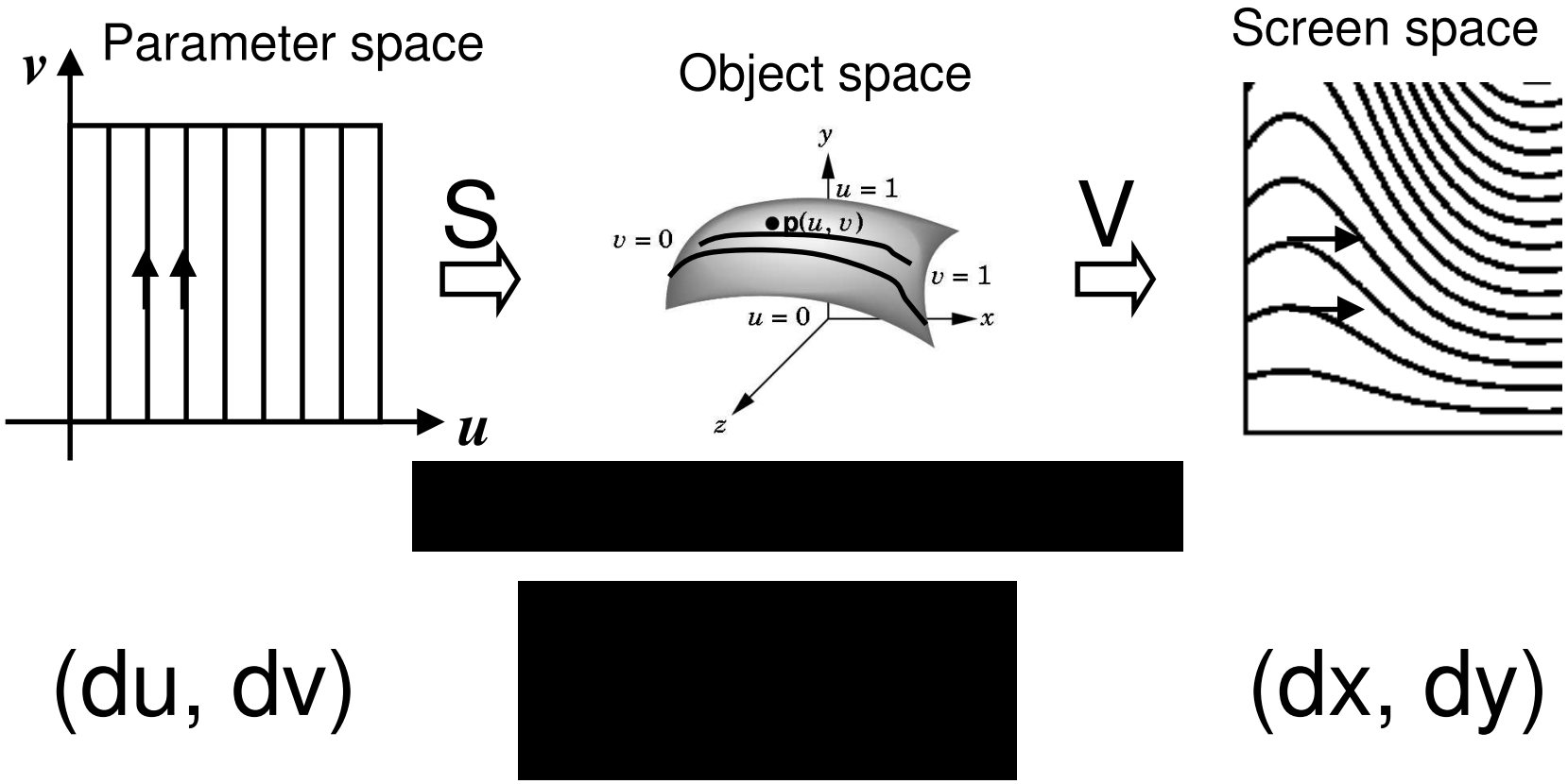
How to do this?

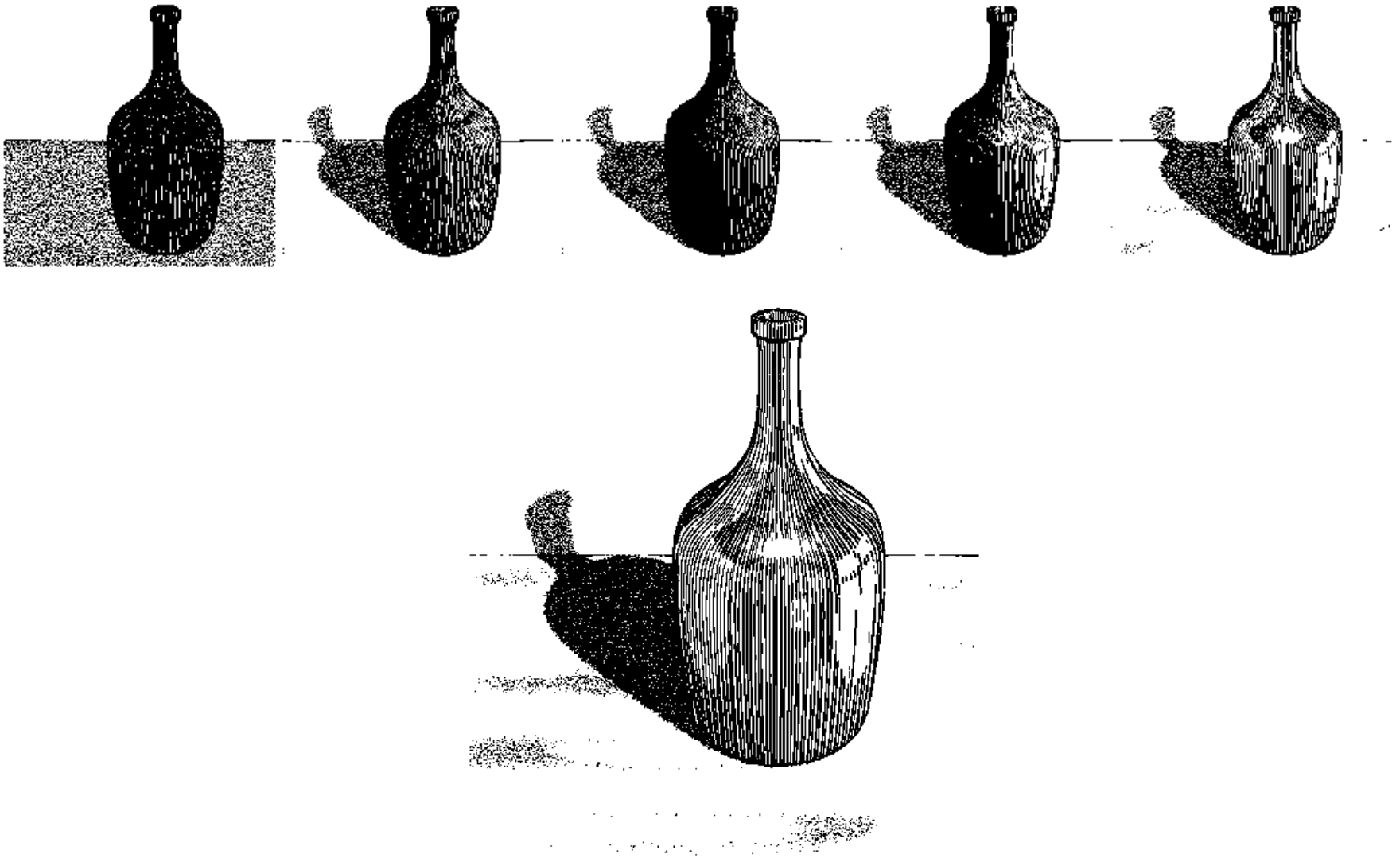
- Stoke placement and width are affected by curve spacing!
- Key problem:
  - Given line spacing d in parameter space, what's curve spacing d' in screen space?



Linearize the mapping

- Approximate M by its Jocobian
- The transformation is linearized in a small area

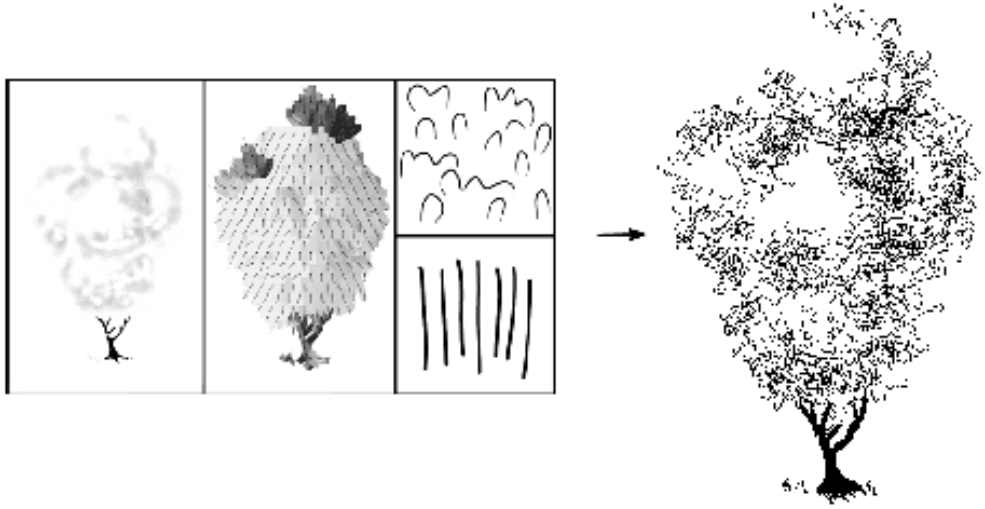


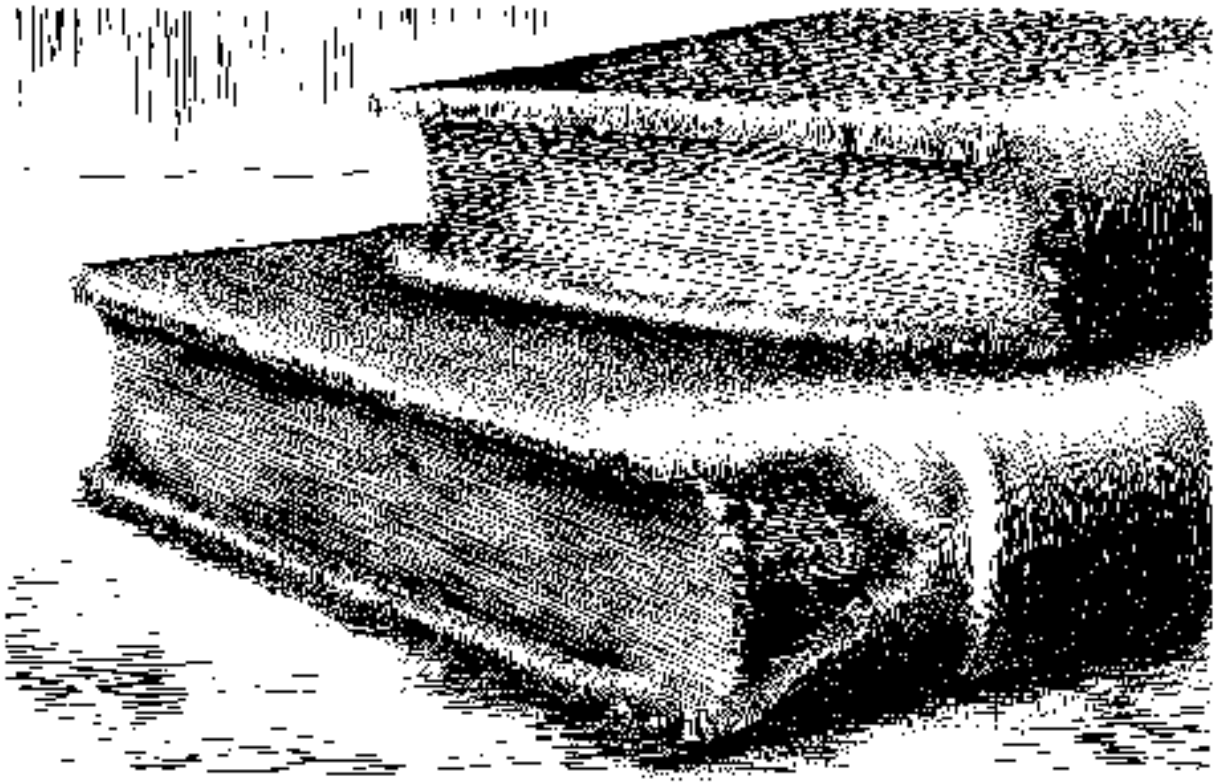


Winkenbach & Salesin, "Rendering Parametric Surfaces in Pen and Ink," SIGGRAPH 96

Other variants of Pen and Ink

- Orientable Textures
  - grayscale image as input (describes tone)
  - user specifies direction field and stroke character
  - stroke shaded image output



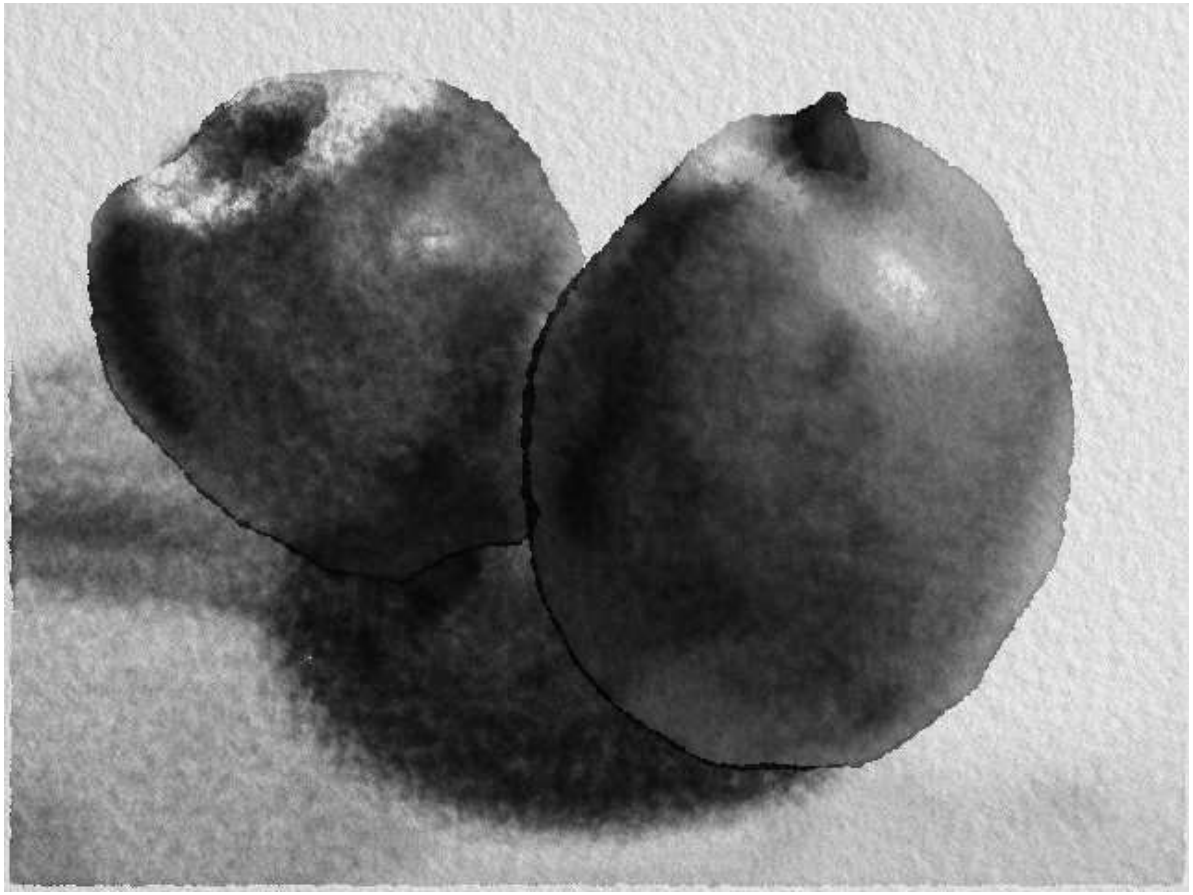


Salisbury, Wong, Hughes and Salesin, “Orientable Textures for Image-based Pen-and-Ink Illustration,” SIGGRAPH 97

Painterly Rendering

- Physical simulation
  - user applied strokes
  - computer simulated media (e.g. watercolor)
- Automatic painting
  - user provides input image or 3D model and painting parameters
  - computer generates all strokes

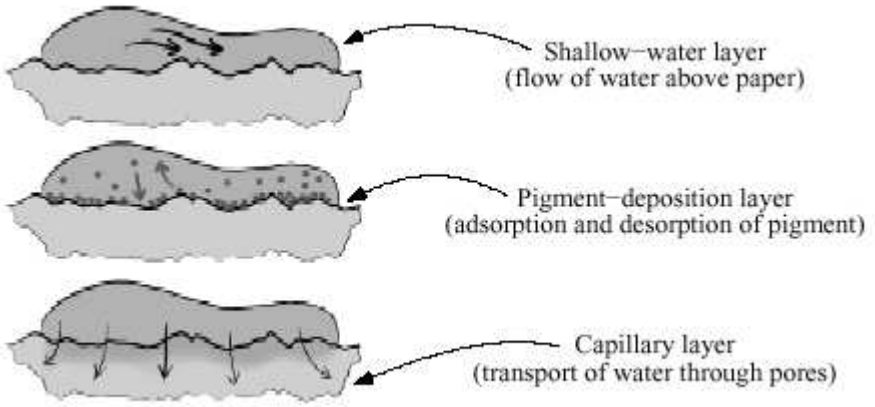
Example of physical simulation



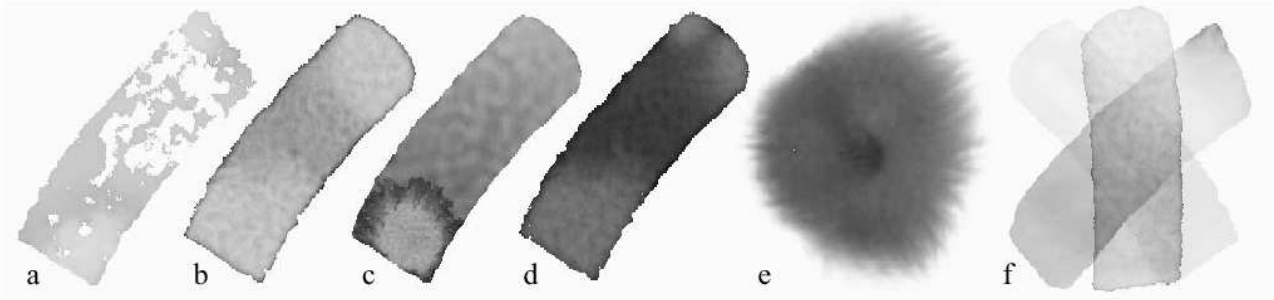
Curtis, Anderson, Seims, Fleischer and Salesin, "Computer Generated Watercolor," SIGGRAPH 97

Paper generation:
height field +
fluid capacity field

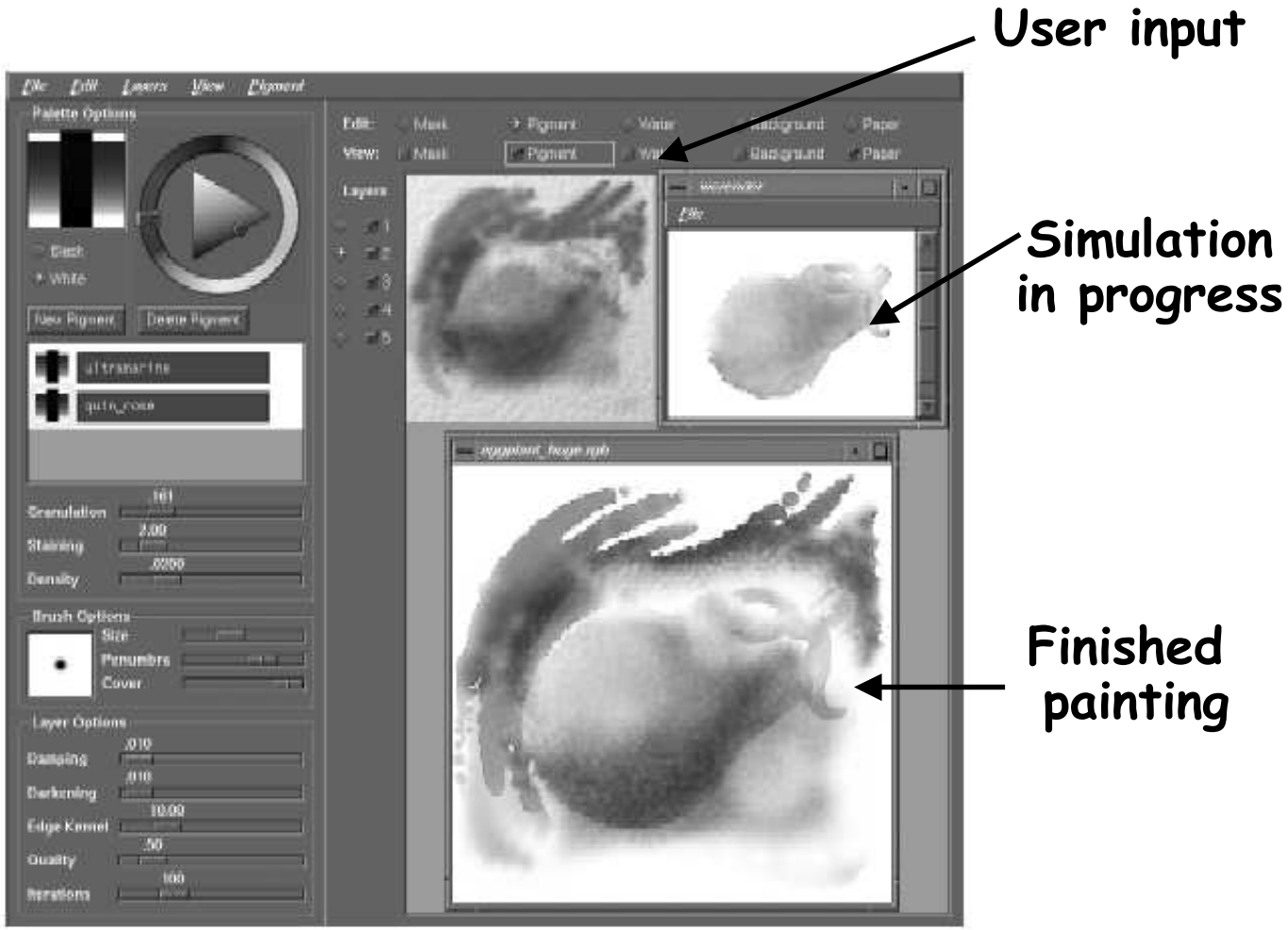
Fluid dynamics simulation



Simulated effects

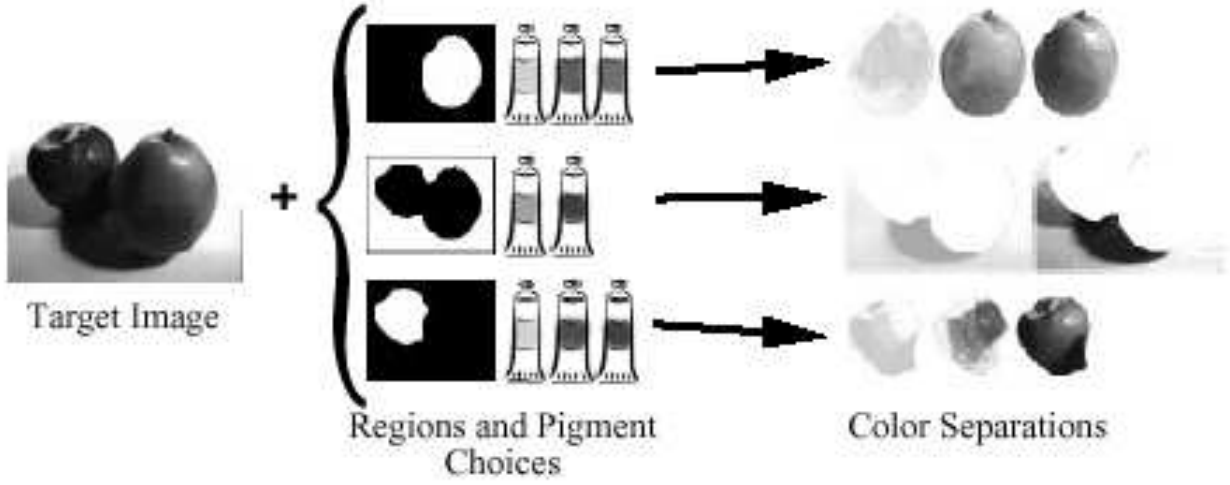


Interactive painting

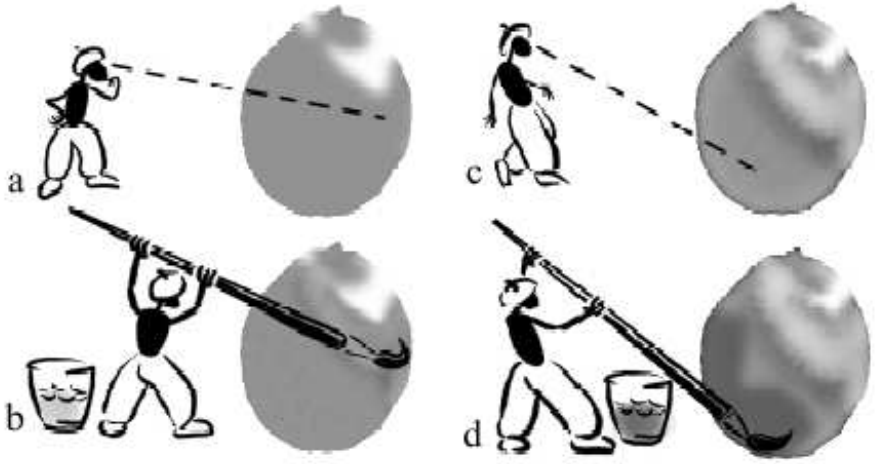


Watercolorization

Color Separation



Brushstroke planning



Example of Automatic Painting

Hertzmann, "Painterly Rendering with Curved Brush Strokes of Multiple Sizes," SIGGRAPH 97

Algorithm concepts

- Apply to color images with no 3D model information
- Layered painting
  - coarse-to-fine painting
  - place stroke at point of largest error (near grid point)
- Brush strokes
- Styles