

CSCI 420 Computer Graphics  
Lecture 24

## Non-Photorealistic Rendering


Pen-and-ink Illustrations  
Painterly Rendering  
Cartoon Shading  
Technical Illustrations

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## Goals of Computer Graphics

- Traditional: Photorealism
- Sometimes, we want more
  - Cartoons
  - Artistic expression in paint, pen-and-ink
  - Technical illustrations
  - Scientific visualization [Lecture next week]




cartoon shading

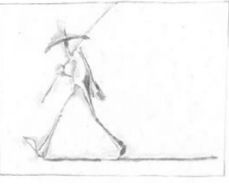
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## Non-Photorealistic Rendering

*“A means of creating imagery that does not aspire to realism” - Stuart Green*



Cassidy Curtis 1998




David Gainey

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## Non-photorealistic Rendering

Also called:

- Expressive graphics
- Artistic rendering
- Non-realistic graphics
- Art-based rendering
- Psychographics



Source: ATI

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## Some NPR Categories

- Pen-and-Ink illustration
  - Techniques: cross-hatching, outlines, line art, etc.
- Painterly rendering
  - Styles: impressionist, expressionist, pointilist, etc.
- Cartoons
  - Effects: cartoon shading, distortion, etc.
- Technical illustrations
  - Characteristics: Matte shading, edge lines, etc.
- Scientific visualization
  - Methods: splatting, hedgehogs, etc.

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## Outline

- Pen-and-Ink Illustrations
- Painterly Rendering
- Cartoon Shading
- Technical Illustrations

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### Hue

- Perception of “distinct” colors by humans
- Red                      • Green
- Blue                      • Yellow

0    60    120    180    240    300    360

Hue Scale Source: Wikipedia

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### Tone

- Perception of “brightness” of a color by humans
- Also called lightness
- Important in NPR

lighter                      darker

9  
8  
7  
6  
5  
4  
3  
2  
1  
0

Source: Wikipedia

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### Pen-and-Ink Illustrations

Winkenbach and Salesin 1994

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### Pen-and-Ink Illustrations

- Strokes
  - Curved lines of varying thickness and density
- Texture
  - Conveyed by collection of strokes
- Tone
  - Perceived gray level across image or segment
- Outline
  - Boundary lines that disambiguate structure

Winkenbach and Salesin 1994

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### Rendering Pipeline: Polygonal Surfaces with NPR

3D Model    Lighting    Camera

Visible Polygons

Procedural Stroke Texture

Stroke Clipping

Outline Drawing

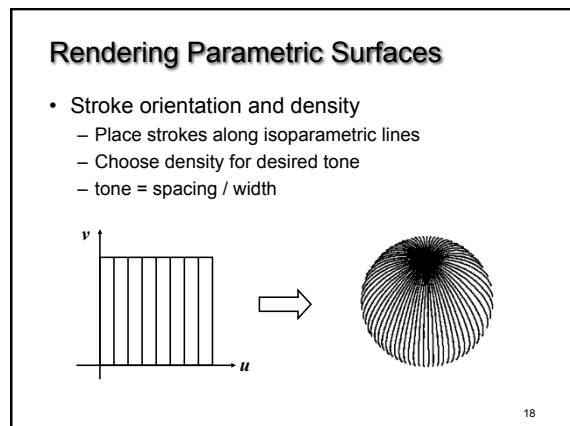
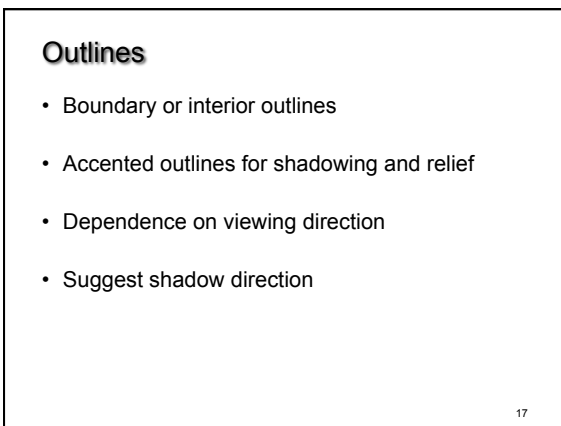
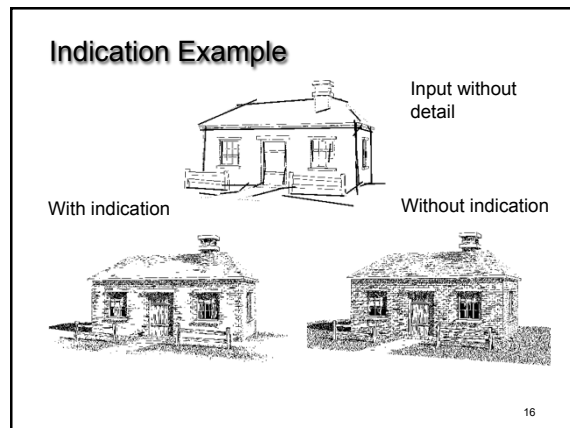
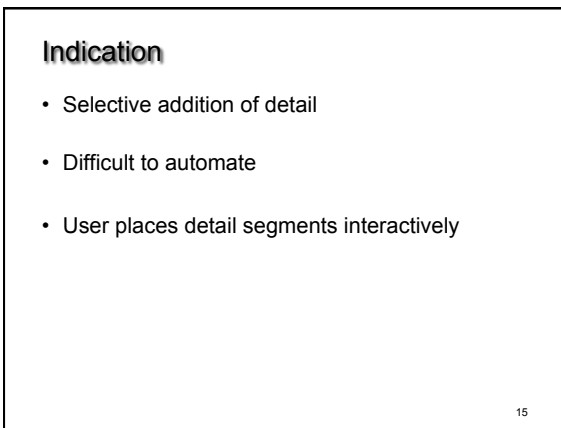
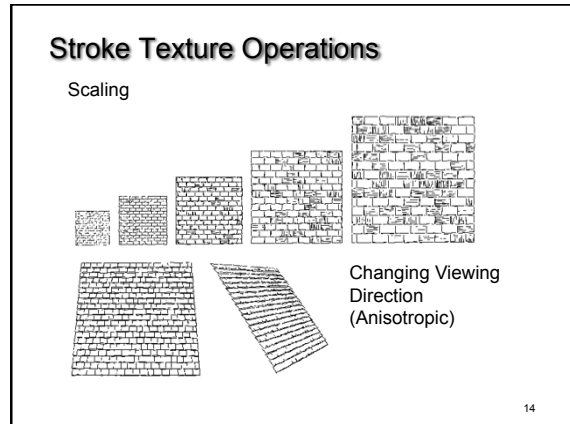
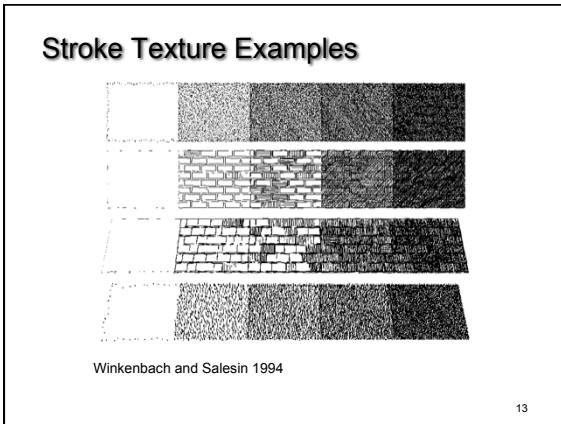
How much 3D information do we preserve?

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### Strokes and Stroke Textures

- Stroke generated by moving along straight path
- Stroke perturbed by
  - Waviness function (straightness)
  - Pressure function (thickness)
- Collected in stroke textures
  - Tone dependent
  - Resolution dependent
  - Orientation dependent
- How automatic are stroke textures?

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### Parametric Surface Example



Winkenbach and Salesin 1996

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### Hatching + standard rendering



Constant-density hatching      Longer smoother strokes for glass      Varying reflection coefficient

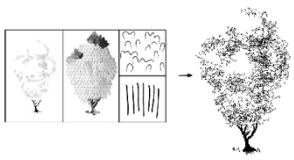
Smooth shading with single light      Environment mapping

Standard rendering techniques are still important!

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### Orientable Textures

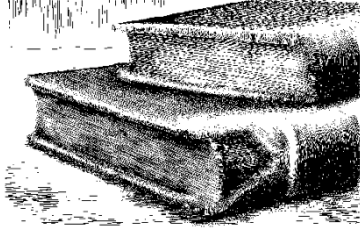
- Inputs
  - Grayscale image to specify desired tone
  - Direction field
  - Stroke character
- Output
  - Stroke shaded image



Salisbury et al. 1997

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### Orientable Stroke Texture Example



Salisbury et al. 1997

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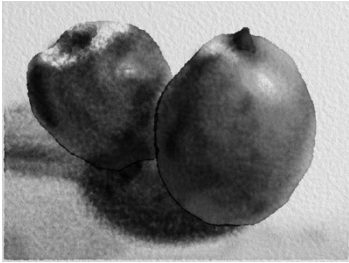
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### Painterly Rendering

- Physical simulation
  - User applies brushstrokes
  - Computer simulates media (paper + ink)
- Automatic painting
  - User provides input image or 3D model
  - User specifies painting parameters
  - Computer generates all strokes

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### Physical Simulation Example




Curtis et al. 1997, *Computer Generated Watercolor*

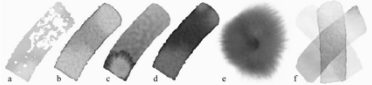
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### Computer-Generated Watercolor

- Complex physical phenomena for artistic effect
- Build simple approximations
- Paper generation as random height field



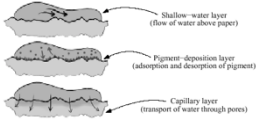
- Simulated effects



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### Fluid Dynamic Simulation

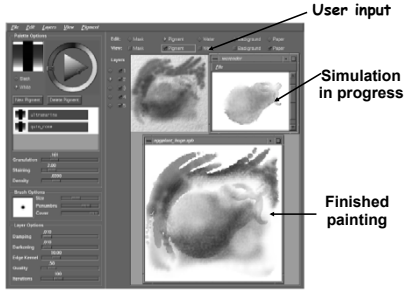
- Use water velocity, viscosity, drag, pressure, pigment concentration, paper gradient
- Paper saturation and capacity



- Discretize and use cellular automata


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### Interactive Painting



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### Automatic Painting Example



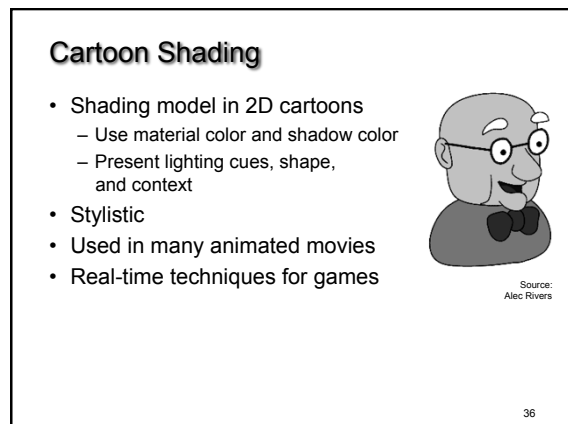
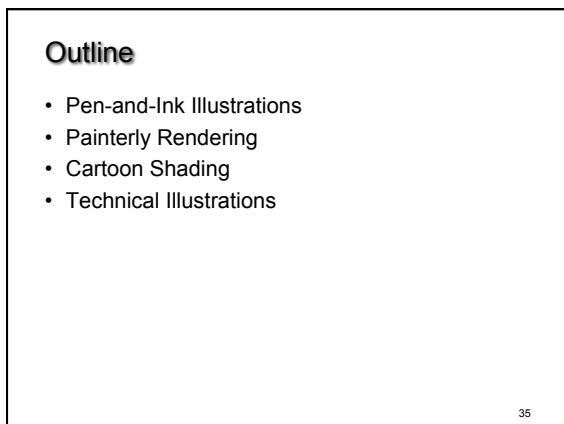
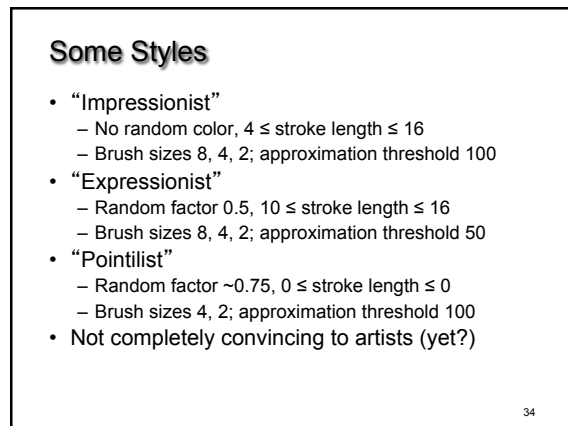
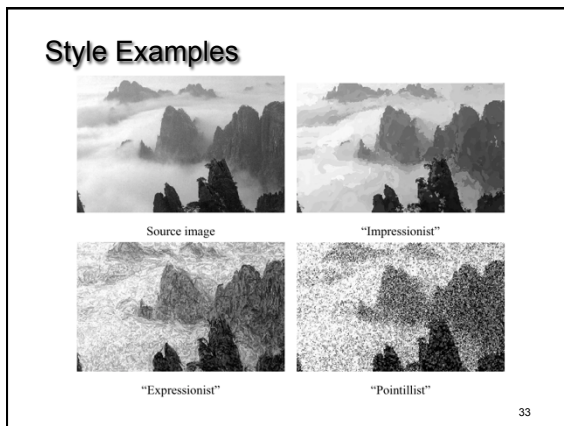
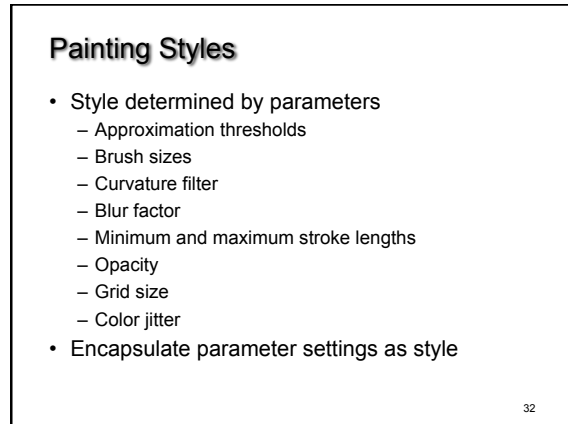
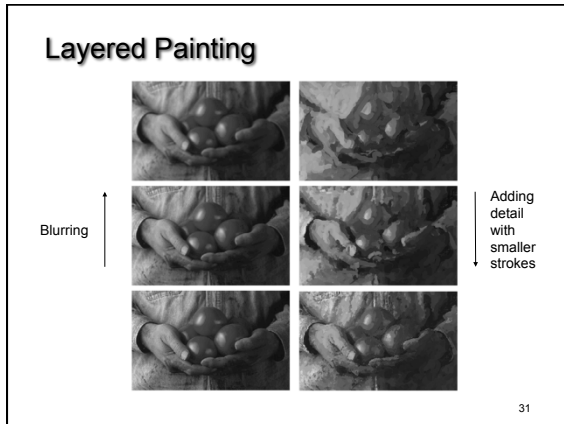
Hertzmann 1997

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### Automatic Painting from Images

- Start from color image: no 3D information
- Paint in resolution-based layers
  - Blur to current resolution
  - Select brush based on current resolution
  - Find area of largest error compared to real image
  - Place stroke
  - Increase resolution and repeat
- Layers are painted coarse-to-fine
- Styles controlled by parameters

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### Cartoon Shading as Texture Map

- Apply shading as 1D texture map

Carl Marshall 2000

- Two-pass technique:  
 Pass 1: standard shader  
 Pass 2: use result from 1 as texture coordinates

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### Shading Variations

Gouraud      1 texel      2 texels      8 texels

Flat shading      Shadow      Shadow + highlight

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### Technical Illustrations

- Level of abstraction
  - Accent important 3D properties
  - Dimish or eliminate extraneous details
- Do not represent reality

Photo      Ruppel 1995

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### Conventions in Technical Illustrations

- Black edge lines
- Cool to warm shading colors
- Single light source; shadows rarely used

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### Technical Illustration Example

Phong shading      Metal shading (anisotropic)      Edge lines      Gooch shading (cool to warm shift gives better depth perception)

Source: Bruce Gooch

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## The Future

- Smart graphics
  - Design from the user's perspective
  - HCI, AI, Perception
- Artistic graphics
  - More tools for the creative artist
  - New styles and ideas

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## Summary

- Beyond photorealism
  - Artistic appeal
  - Technical explanation and illustration
  - Scientific visualization
- Use all traditional computer graphics tools
- Employ them in novel ways
- Have fun!

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