CSCI 480 Computer Graphics
Lecture 24

Non-Photorealistic Rendering

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]

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

Non-Photorealistic Rendering

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

Some NPR Categories

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

Outlook

• Pen-and-Ink Illustrations
• Painterly Rendering
• Cartoon Shading
• Technical Illustrations
**Hue**
- Perception of “distinct” colors by humans
- Red
- Green
- Blue
- Yellow

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

**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

**Rendering Pipeline:**
- 3D Model
- Lighting
- Visible Polygons
- Procedural Stroke Texture
- Stroke Clipping
- Outline Drawing
- Camera

**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?
Stroke Texture Examples

Stroke Texture Operations

Indication

- Selective addition of detail
- Difficult to automate
- User places detail segments interactively

Indication Example

Outlines

- Boundary or interior outlines
- Accented outlines for shadowing and relief
- Dependence on viewing direction
- Suggest shadow direction

Rendering Parametric Surfaces

- Stroke orientation and density
- Place strokes along isoparametric lines
- Choose density for desired tone
- $\text{tone} = \text{width} / \text{spacing}$
Parametric Surface Example

Winkenbach and Salesin 1996

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!

Orientable Textures

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

Salisbury et al. 1997

Orientable Stroke Texture Example

Salisbury et al. 1997

Outline

- Pen-and-Ink Illustrations
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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
Physical Simulation Example

Curtis et al. 1997, Computer Generated Watercolor

Computer-Generated Watercolor

• Complex physical phenomena for artistic effect
• Build simple approximations
• Paper generation as random height field
  • Simulated effects

Fluid Dynamic Simulation

• Use water velocity, viscosity, drag, pressure, pigment concentration, paper gradient
• Paper saturation and capacity
  • Discretize and use cellular automata

Interactive Painting

User input
Simulation in progress
Finished painting

Automatic Painting Example

Hertzmann 1997

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
Layered Painting

Adding detail with smaller strokes

Painting Styles

- Style determined by parameters
  - Approximation thresholds
  - Brush sizes
  - Curvature filter
  - Blur factor
  - Minimum and maximum stroke lengths
  - Opacity
  - Grid size
  - Color jitter

- Encapsulate parameter settings as style

Style Examples

Some Styles

- “Impressionist”
  - No random color, 4 ≤ stroke length ≤ 16
  - Brush sizes 8, 4, 2; approximation threshold 100

- “Expressionist”
  - Random factor 0.5, 10 ≤ stroke length ≤ 16
  - Brush sizes 8, 4, 2; approximation threshold 50

- “Pointillist”
  - Random factor ~0.75, 0 ≤ stroke length ≤ 0
  - Brush sizes 4, 2; approximation threshold 100

- Not completely convincing to artists (yet?)

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Cartoon Shading

- Shading model in 2D cartoon
  - Use material color and shadow color
  - Present lighting cues, shape, and context

- Stylistic
- Used in many animated movies
- Real-time techniques for games

Source: Alec Rivers
Cartoon Shading as Texture Map

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

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Technical Illustrations

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

Conventions in Technical Illustrations

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

Summary

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