NPR
Non-photorealistic rendering

Umesh A Bhat
{umesh@ut.ee}
The “Opposite” of making things look real...
Watercolors
Exploded view
Exploded view (complex)
Ink wash (Sumi-e)
NPR is also known as...

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

SRC: Yao et. al 2011
Why ?
“A means of creating imagery that does not aspire to realism” - Stuart Green
Hue
Perception of “distinct” colors by humans

Tones
Perception of brightness of a color by humans

Two fundamental cues

**Silhouette** – the visible edges of a surface

**Hatching** – the use of texture to indicate the local orientation (shading) of a surface

*SRC: Salisbury et al. 1997*
NPR can also be classified as

- **Model based NPR**
- **Image based NPR**

**SRC:** Doug DeCarlo and Anthony Santella 2002, Winkenbach and Salesin 1996
Model based NPR

Visible polygons
Illumination
Textures
Image based NPR

- Pen-and-ink drawings
- Water-color paintings
- Cartoon style
NPR – rendering polygonal surfaces

- 3D Model
- Lighting
- Camera

How much 3D information do we preserve?

Visible polygons

Procedural stroke texture

Stroke clipping

Outline drawing

We will collect a reference image here to indicate desired tone (lightness or darkness) at each pixel
NPR Categories

- Pen-and-ink illustration
- Painterly rendering
- Cartoons
- Technical illustrations
- Scientific visualization
Pen-and-ink illustrations

user input

reference image

rendered output

SRC: Winkenbach and Salesin 1994
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

SRC: Winkenbach and Salesin 1994
Strokes and Stroke Textures

Strokes are generated by moving along straight path

Strokes are perturbed by

- Waviness function (straightness)
- Pressure function (thickness)

Collected in stroke textures

- Tone dependent
- Resolution dependent
- Orientation dependent

SRC: Winkenbach and Salesin 1994
NPR – rendering parametric surfaces

- Uses parametric directions as stroke directions
- Maintain constant tone
- Varying tone based on lighting
- Can be combined with texture-mapping

SRC: Winkenbach and Salesin 1996
NPR – rendering general surfaces

- Placing strokes along a direction field
- The field is either computed automatically or designed by user

SRC: Hertzmann and Zorin 2000
Automatic painting

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

SRC: Hertzmann
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

Source image

“Impressionist”

“Expressionist”

“Pointillist”
Cartoon shading

- Silhouette edge detection
- Cartoon shading

The illumination is computed at discrete levels (often 2) between the fully lit illumination and shadow (ambient) color, determined by $\mathbf{n} \cdot \mathbf{L}$.

[src: 1]
Cartoon shading

Gouraud 1 texel 2 texels 8 texels

SRC: Lake et. al, NPAR 2000
Technical illustrations

Level of abstraction

- Accentuate important 3D properties
- Diminish or eliminate extraneous details

Does not represent reality

Black edge lines
Cool to warm shading colors
Single light source
Shadows rarely used
Technical illustrations

Phong shading  Metal shading  Edge lines  Gooch shading

SRC: Gooch et. al 96
Technical illustrations

Phong shading

Metal shading

Edge lines

Gooch shading

SRC: Gooch et. al 96
Cel shading

- The back faces are drawn with thick lines
- The object is drawn with a basic texture
- Shading
Cel shading

screen-sized color texture

depth and world-space surface normal

Sobel filter or similar edge-detection filter

Cel shading
Select references

Presentations


Papers


Book

Non-Photorealistic Rendering
Bruce Gooch and Amy Gooch.
Typos ? Corrections ? Left something out ?

Feel free to ping me at  {umesh@ut.ee}