Painterly Rendering

Types of Computer Painting

Physical simulation
- User applies strokes
- Computer simulates media (e.g. watercolor on paper)

Automatic painting
- User provides input image or 3D model and painting parameters
- Computer generates all strokes
Two Painterly Rendering Systems

“Painterly Rendering for Animation”
• Meier, SIGGRAPH 96

“Painterly Rendering with Curved Brush Strokes of Multiple Sizes”
• Hertzmann, SIGGRAPH 98

Painterly Rendering Pipeline

from Meier, “Painterly Rendering for Animation, Proceedings of SIGGRAPH 96, page 480."
Basic Approach

Algorithm
- Surface particles placed in world space
- Reference images rendered
- Each particle becomes a screen-space stroke

Features
- Greater temporal coherence than purely screen-space approaches
- More natural style than purely geometry (texture-mapped) approaches

Particle Generation

Compute area of surface primitives

Randomly particles on primitives
- number proportional to area
Reference Images

Used to determine stroke attributes
  • color
  • orientation
  • size
  • many others possible

Rendered with programmable shaders

Stroke Rendering

Particle transformed to screen-space

Stroke parameters from reference images
  • perturbed according to user-specified variation

Brush image rendered according to stroke parameters
  • oblong brush shapes work best
  • grayscale brushes typically sufficient
    —color brush textures may be used to modify particle colors
Example - Haystacks

Haystacks without random parameter perturbation

Similar view with random parameter perturbation

from Meier, “Painterly Rendering for Animation, Proceedings of SIGGRAPH 96, pages 481 and 478.

Example - fruit

Figure 5: Four styles of painterly rendered fruit. By choosing different brush images and painting parameters, we have created four different looks from the same set of reference pictures. The upper left image has the soft, blended edges of a paint painting. The pointy brush setting, in the upper right, samples the original saturations and values from the color reference picture to a new range. A splayed brush image and increased blur simulation were used to create marker style strokes in the lower left image. The brush used to create the lower right contained some opaque black that helps create a woodcut print style.

from Meier, “Painterly Rendering for Animation, Proceedings of SIGGRAPH 96, page 481.
Layered Approach

Similar objects rendered together

Dissimilar objects often rendered as separate layers and composited later
  • Large strokes intrude less onto nearby objects

Video (or .mov movie files)

Meier, “Painterly Rendering for Animation”, Proceedings of SIGGRAPH 96.
## Hertzmann’s Approach

Apply to color images with no 3D model information

Allow longer, curved brush strokes
  - makes different styles possible

Multiple rendering passes
  - larger strokes first
  - add detail with smaller strokes

## Stroke Description

Constant color per stroke

B-spline path

Constant radius circle (or other shape)
  
  swept along path

Applied in layers, with opacity control
Building Up Layers

- Start with large strokes
- Each pass reduces stroke size
- New strokes placed according to error metric of current painting

Painting a Layer

- Select stroke size for layer
- Blur input image
- Start strokes within uniform grid cells
- Start each stroke at point of maximum error within grid cell
- Walk perpendicular to image gradient to place control points
- Render strokes in random order as circles along cubic B-spline path
**Style Parameters**

- Approximation threshold
- Brush sizes
- Curvature filter
- Blur Factor
- Min/Max stroke lengths
- Opacity
- Grid size
- Color jitter

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**Example Styles**

- “Impressionist”
- “Expressionist”
  - long strokes, color value jitter
- “Colorist Wash”
  - transparency, RGB color jitter
- “Pointillist”
  - densely placed circles, random hue and saturation
Example - adding passes

![Image 1]

Figure 2: Painting with three brushes. (a) A source image. (b) The first layer of a painting, after painting with a circular brush of radius 8. (c) The image after painting with a brush of radius 4. (d) The final image, after painting with a brush of size 2. Note that brush strokes from earlier layers are still visible in the painting.


Example - styles

Three styles: impressionist, expressionist, colorist wash

![Image 2]

from Herzmann, "Painterly Rendering with Curved Brush Strokes of Multiple Sizes, Proceedings of SIGGRAPH 98, page 460."
Hertzmann, “Painterly Rendering with Curved Brush Strokes of Multiple Sizes”, *Proceedings of SIGGRAPH 98*. 

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