An Algorithm For Automatic Painterly Rendering Based On Local Source Image Approximation

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Overview

- Problem Description
- Related Work
- The Algorithm
- Results
  - Class project results
- Conclusions

Jason Waltman class project

Problem Description

- Convert a 2D image to a painterly style
- Use a variety of brush sizes to show different levels of detail

Related Work

- Previous methods use intensity gradient to determine stroke orientation
- Gradient measured at a pixel
- Stroke width is not based on image analysis

Contributions

- Stroke orientation based on image content over an area
- Chromaticity used in addition to intensity
- Brush width calculated for each stroke

The Painting Process

- Preparation
  - Stroke Distribution
  - Stroke Attributes
  - Painting Order
- Composition

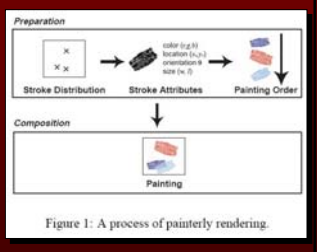


Figure 1: A process of painterly rendering.

Brush Stroke Parameters

- Color
- Location
- Orientation
- Length and Width
- Brush texture used by Meier

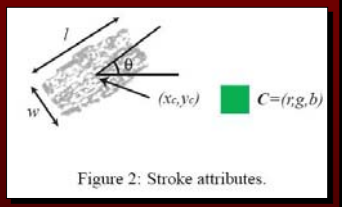


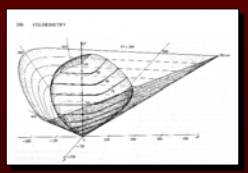
Figure 2: Stroke attributes.

Painting a Single Stroke

- Generate a Difference Image
- Calculate Image Moments
- Find Stroke that best approximates region

Color Spaces

- Perceptually uniform space – Euclidean distance equals perceptual distance
- RGB is not perceptually uniform
- CIE-L*u*v is perceptually uniform

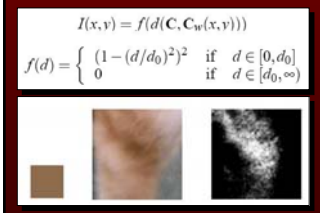


Generate a Difference Image

- Calculate ***Color*** Difference for each pixel in local image

$$I(x,y) = f(d(\mathbf{C}, \mathbf{C}_w(x,y)))$$

$$f(d) = \begin{cases} (1-(d/d_0)^2)^2 & \text{if } d \in [0, d_0] \\ 0 & \text{if } d \in [d_0, \infty) \end{cases}$$



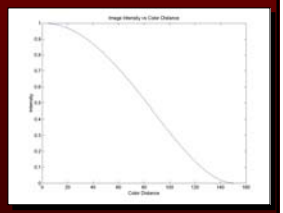
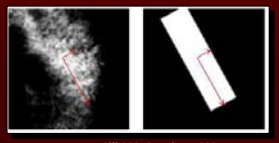


Image Moment Concept

Given difference image:

- Calculate 1st order moments in x and y to find center of stroke
- 2nd order moments in x and y give "spread" of stroke



Brush Parameters

- Find rectangle with same 0th, 1st and 2nd moments as difference image

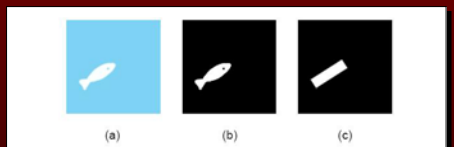


Figure 4: The approximation based on image moments: (a) A local source image. (b) A color difference image. (c) A binary image of the equivalent rectangle.

Calculate Image Moments

- Moments are sums across an image region
- Less sensitive to noise than a single pixel
- Can be used to calculate brush parameters

$$M_{lm} = \sum_x \sum_y x^l y^m I(x,y)$$

$$x_c = \frac{M_{10}}{M_{00}} \quad y_c = \frac{M_{01}}{M_{00}}$$

$$M_{00} = \sum_x \sum_y I(x,y)$$

$$M_{10} = \sum_x \sum_y xI(x,y)$$

$$M_{01} = \sum_x \sum_y yI(x,y)$$

Brush Parameters

- Find rectangle with same 0th, 1st and 2nd moments as difference image

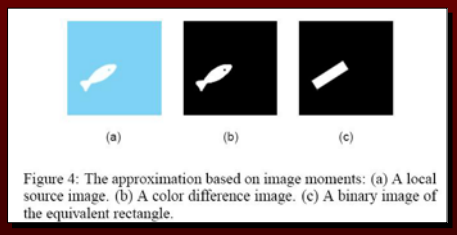
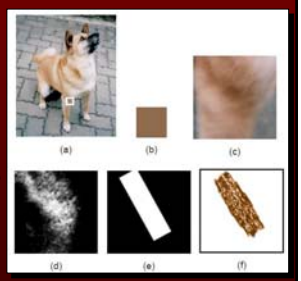


Figure 4: The approximation based on image moments: (a) A local source image. (b) A color difference image. (c) A binary image of the equivalent rectangle.

Single Stroke Review

- a) Full Image
- b) Brush Color
- c) Local Image
- d) Difference Image
- e) Best fit Rectangle
- f) Painted Stroke

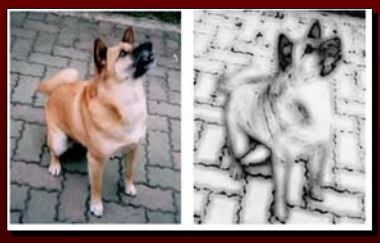


Painting Multiple Strokes

- Find distribution of strokes across image
- At each point, calculate/draw stroke using method described previously
- The size of the local area can be chosen by the user

Stroke Distribution

- Stroke Area Estimation: Calculate 0th moment at each pixel



Stroke Distribution

- Sampling Points Generation: Sample more frequently in regions with low stroke area

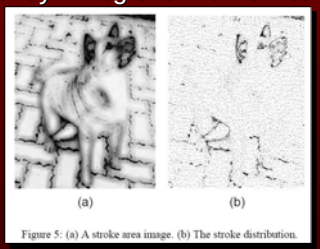


Figure 5: (a) A stroke area image. (b) The stroke distribution.

Stroke Ordering

- Sort on area & paint smallest strokes last
- Preserves fine detail in image

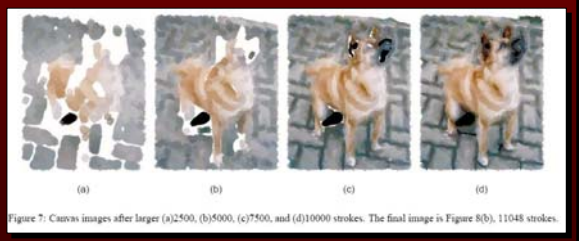


Figure 7: Canvas images after larger (a)2500, (b)5000, (c)7500, and (d)10000 strokes. The final image is Figure 8(b), 11048 strokes.

Effects of Varying Stroke Size

- Local area size constrains maximum stroke size

Figure 8: Influence of the parameter z. (a) A source image. (b) $z = 25$, 11048 strokes. (c) $z = 15$, 9073 strokes.

Implementation and Analysis

- Algorithm implemented as a class project by Jason Waltman
- Exact method of generating sampling points not fully specified

Original Image: Downtown Seattle at Night
Brush Size = 40; Sample Size = 50%
Apx. 103,200 Strokes

Jason Waltman, 2001

Results

- Required a large number of strokes to fill canvas

Original Image: The Parthenon
Brush Size = 16; Sample Size = 50%
Apx. 117,500 Strokes

Same source image from above.
Brush Size = 50; Sample Size = 65%
Apx. 62,000 Strokes

Jason Waltman, 2001

Future Work

- Find a better method for choosing the local image size
- Analytically determine the minimum number of strokes to cover the canvas

Conclusions

- Stroke attributes determined by examining an area instead of a point
- Stroke size varies to match the level of detail in the image
- Chromaticity used in addition to illumination