Real-Time Hatching

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Goal
Stroke-based rendering of 3D models
Strokes convey:
- tone
- material
- shape

Challenges
Interactive camera and lighting control
Temporal (frame to frame) coherence
Spatial continuity
Artistic freedom

Approach
Set of textures
Result

Previous Work
Off-line
Real-Time Hatching
- Technical Illustration [Gooch et al. '99]
- Graftals [Kowalski et al. '99, …]
- Silhouette rendering [Markosian et al. '97]
- NPR [Hertzmann et al. 2000, Sander et al. 2000]

Previous Work

Real-Time Hatching
- Screen-space “filter” [Lake et al. 2000]
- Fixed density strokes [Elber ’99]

Previous Work – Stroke Collections

Prioritized Stroke Textures [Salisbury et al. ’94]
[Winkenbach et al. ’94]
Art Maps: Same Size Strokes [Klein et al. 2000]

Tonal Art Maps

Collection of stroke images
Will blend design with high coherence
Stroke nesting property

Stroke Nesting Property

Strokes persist in finer & darker images
**Approach**

Tonal Art Map

Preprocess

Real-Time

Example stroke

Result

Mesh

**Generating Tonal Art Maps**

Draw or import bitmap for one stroke

Automatically fill TAM with strokes
- When placing stroke in an image, add it to all finer & darker images
- Fill table column by column, coarse to fine
- Space strokes evenly

**Even Spacing of Strokes**

Choose best stroke from large candidate pool
Fitness = uniformity & progress towards tone

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Keep Gaussian pyramid for all TAM images
Continuity

Stroke size continuity $\rightarrow$ mipmapping
Tone continuity $\rightarrow$ blend multiple textures
- Spatial continuity: same contribution for a texture on both sides of an edge
- Temporal continuity: no "popping"

Texture Blending

Pack grayscale tones in R,G,B channels $\rightarrow$ 6 tones in 2 textures
Use multitexture engine $\rightarrow$ single-pass 6-way blend
Vertex programs compute blend weights $\rightarrow$ static vertex data

Texture Blending

Approach

Example stroke $\rightarrow$ Tonal Art Map
Mesh $\rightarrow$ Lapped texture
Result

Texturing Arbitrary Surfaces

Lapped Textures
[Praun et al. 2000]

Direction Field

Based on surface principal curvatures
Optimized to be smooth
- [Hertzmann & Zorin 2000]
- Symmetry: $180^\circ$ instead of $90^\circ$
- Sample on faces
Real-time hatching for NPR
Strokes rendered as textures
High coherence TAMs prevent blend artifacts
6-way blend very fast on modern graphics
Future Work

More general TAMs
View-dependent stroke direction
Automatic indication

Future Work (Actual)

- "Fine Tone Control in Hardware Hatching" NPAR 02
- Described two new real-time hatching schemes that provide enhanced control of tone
  - Volume Scheme
  - Color
  - Threshold Scheme
    - Per-pixel lighting operations

Approach

Set of textures
Mesh
Result

Announcements

- Reminder: final projects due Wednesday, April 13th, 5pm.
- No exceptions
  - Prof is leaving town shortly thereafter
  - Need to have enough time to grade

Questions?