

# Real-Time Hatching

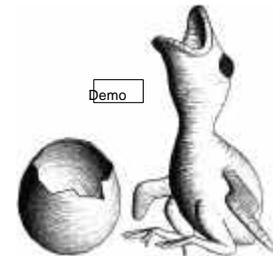
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Hugues Hoppe   Microsoft Research  
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## Goal

Stroke-based rendering of 3D models

Strokes convey:

- tone
- material
- shape

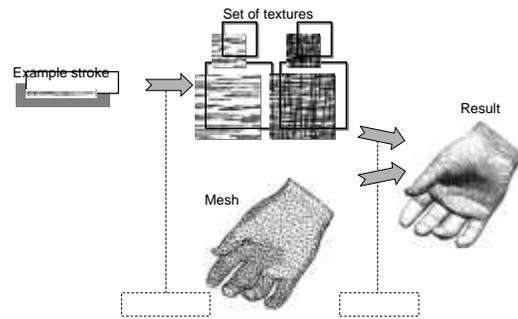


## Challenges

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



## Approach



## Previous Work

Off-line  
Real-Time Hatching



[Winkenbach *et al.* '94, '96]



[Hertzmann *et al.* 2000]



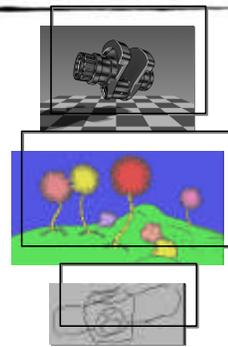
[Sousa *et al.* '99]

& many others ...

## Previous Work

NPR  
Real-Time Hatching

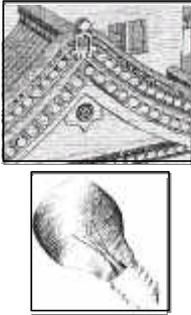
- Technical Illustration [Gooch *et al.* '99]
- Graftals [Kowalski *et al.* '99, ...]
- Silhouette rendering [Markosian *et al.* '97] [Hertzmann *et al.* 2000] [Sander *et al.* 2000]



### Previous Work

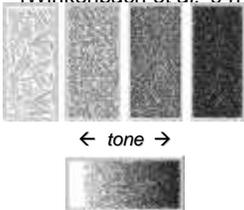
**Real-Time Hatching**

- Screen-space "filter" [Lake *et al.* 2000]
- Fixed density strokes [Elber '99]

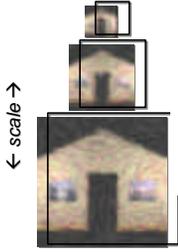


### Previous Work – Stroke Collections

**Prioritized Stroke Textures** [Salisbury *et al.* '94] [Winkenbach *et al.* '94]

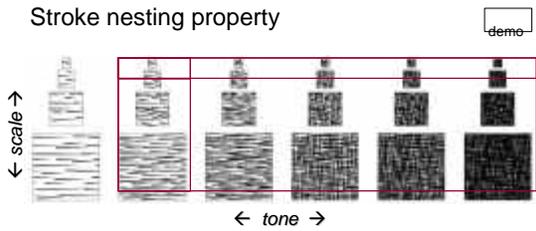


**Art Maps** [Klein *et al.* 2000]

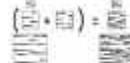


### Tonal Art Maps

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



### Stroke Nesting Property



### Stroke Nesting Property

Strokes persist in finer & darker images



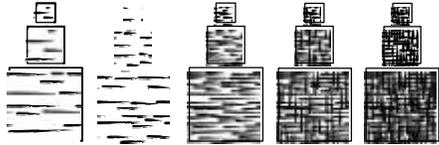
### Approach

## Generating Tonal Art Maps

Draw or import bitmap for one stroke

Automatically fill TAM with strokes

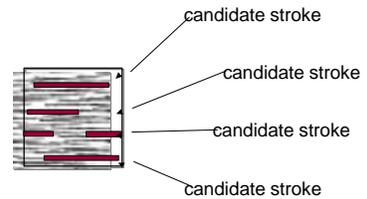
- When placing stroke in an image, add it to all finer & darker images
- Fill table column by column, coarse to fine
- Space strokes evenly



## Even Spacing of Strokes

Choose best stroke from large candidate pool

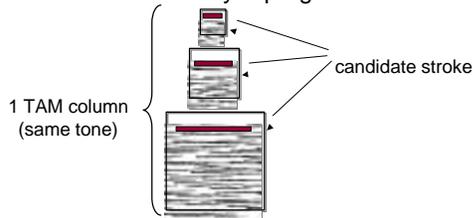
Fitness = uniformity & progress towards tone



## Even Spacing of Strokes

Choose best stroke from large candidate pool

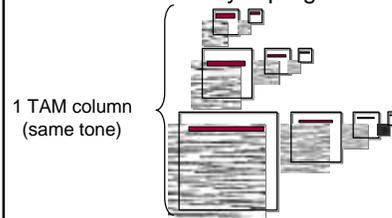
Fitness = uniformity & progress towards tone



## Even Spacing of Strokes

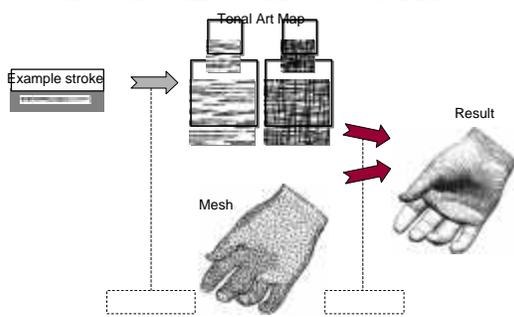
Choose best stroke from large candidate pool

Fitness = uniformity & progress towards tone



Keep Gaussian pyramid for all TAM images

## Approach

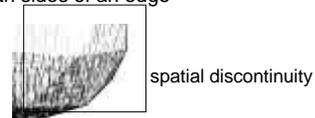


## Continuity

Stroke size continuity → mipmapping

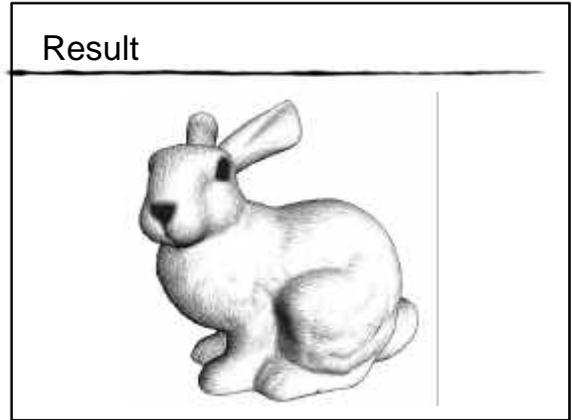
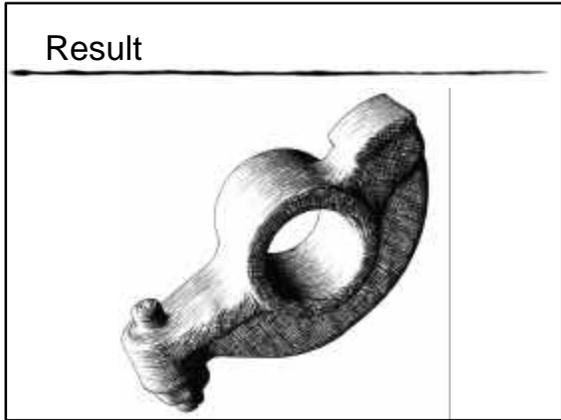
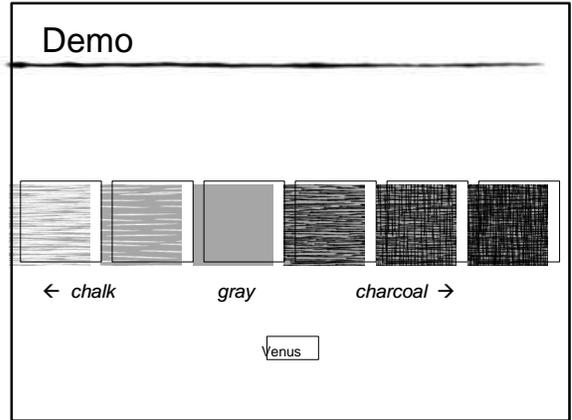
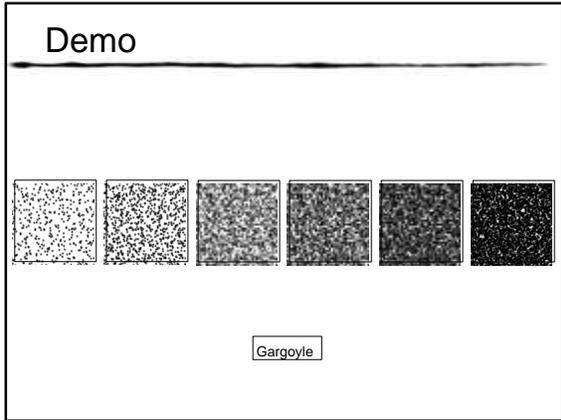
Tone continuity → blend multiple textures

- Spatial continuity: same contribution for a texture on both sides of an edge



- Temporal continuity: no "popping" demo





### Summary

- 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

A 2D rendered elephant drawing, showing a simple, stylized elephant with a trunk and a small horn-like protrusion on its head.

Bill Plympton

## Acknowledgements

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### Support

Microsoft Research, NSF

### Hardware

NVidia, Dell

### Models

Viewpoint, Cyberware, Stanford, MIT

### Thanks

Georges Winkenbach, Lee Markosian, Grady Klein

## NPAR 2002

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International Symposium on  
Non-Photorealistic Animation and Rendering

- Annecy, France
- Submissions: November 12, 2001
- Conference: June 3-5, 2002

<http://npar2002.cs.princeton.edu>