

EECS 487

# Non-photorealistic Rendering

continued



Lee Markosian

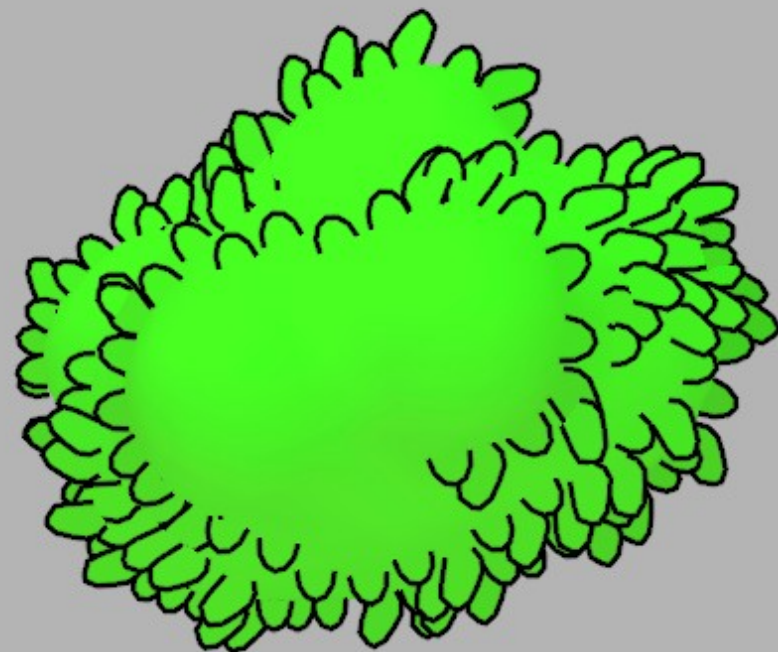
April 11, 2007

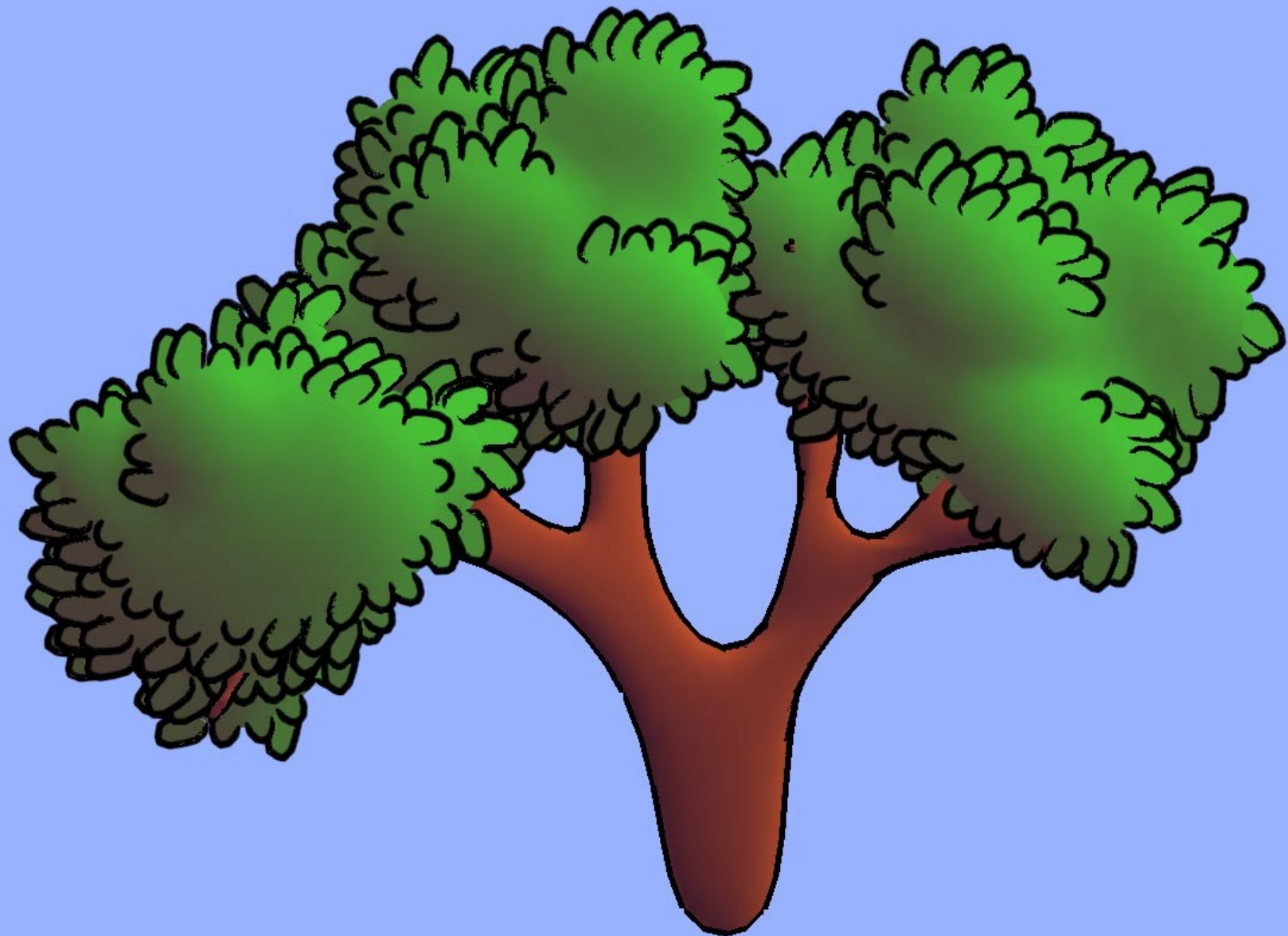
# talk overview

- graftals cont'd
- stroke-based rendering
- tonal art maps
- suggestive contours
- dynamic 2D patterns

# graftals

- 1<sup>st</sup> method:
  - generate graftals dynamically
  - use “desire image” to control density
- problem:
  - not very temporally coherent









Art-based Rendering w/ Continuous Levels of Detail.

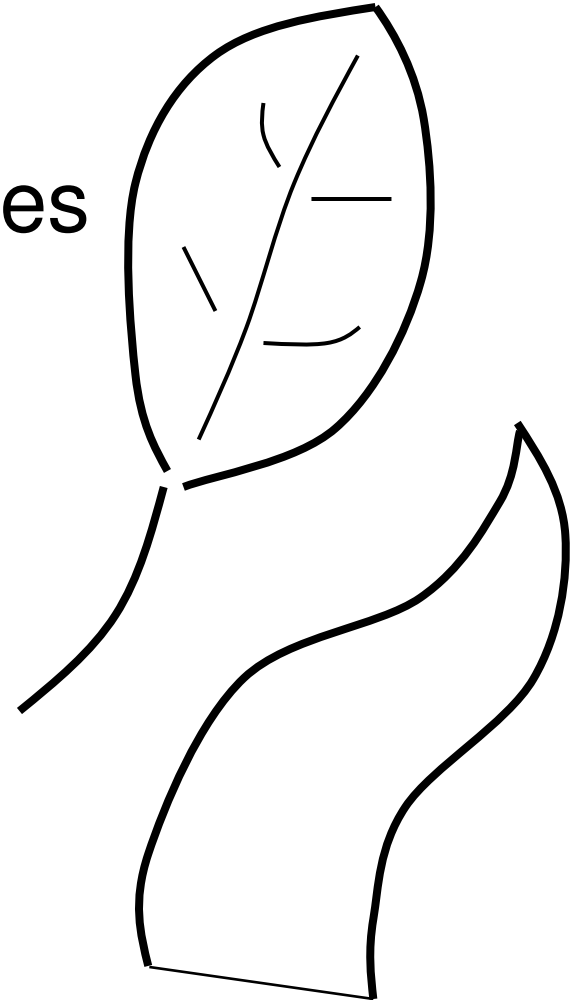
Markosian, Meier, Kowalski, Holden, Northrup, & Hughes.  
NPAR 2000.

# main difference

- graftals not generated dynamically
  - they always exist, but may not be expressed
- new idea: LOD
  - single graftal may appear as 1 tuft,  
or a whole collection
- fade in and out
- much better coherence!

# Basic graftals

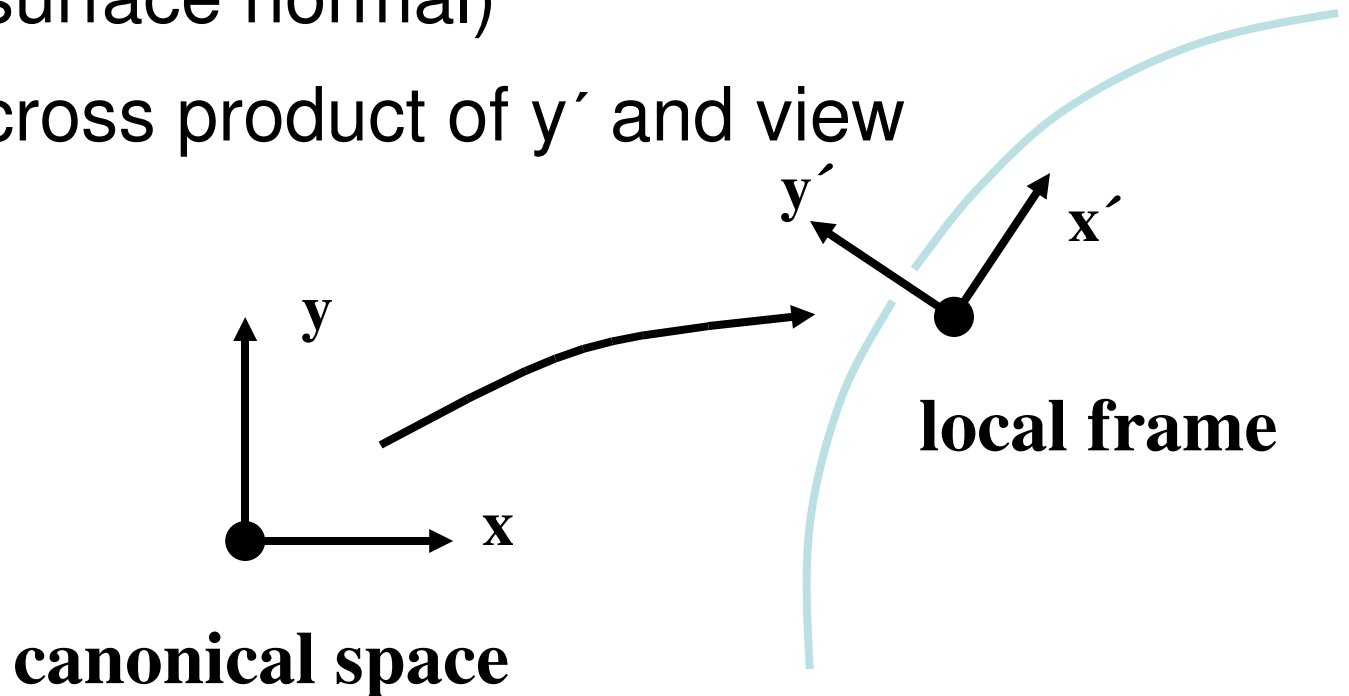
- Collection of drawing primitives
  - triangle strips / fans
  - plus strokes
- Shared vertices
- Local coordinate frame
- Tuft: hierarchy of graftals





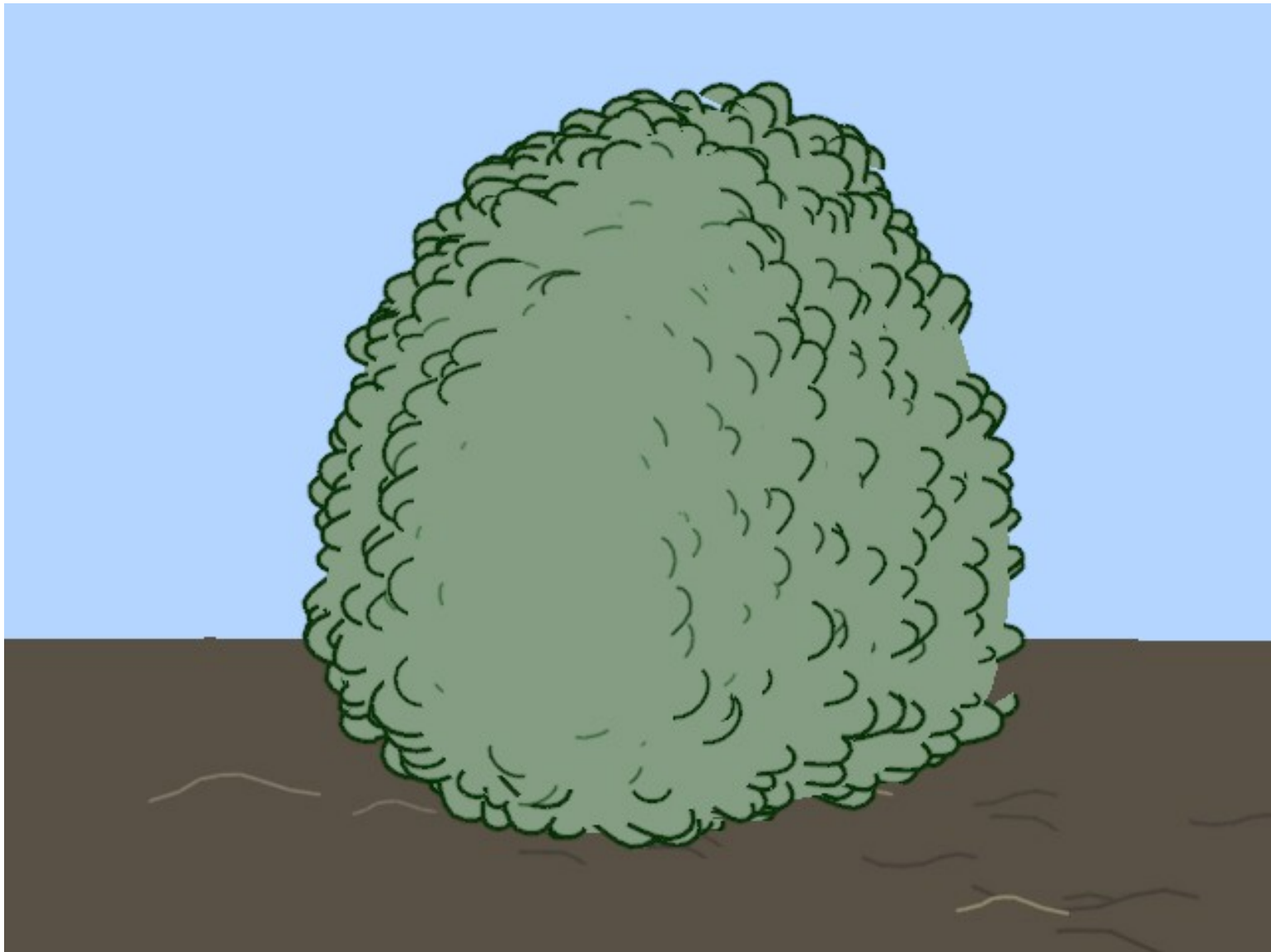
# The local frame

- Base position (e.g. on surface)
- $y'$  (e.g. surface normal)
- $x'$  (e.g. cross product of  $y'$  and view vector)



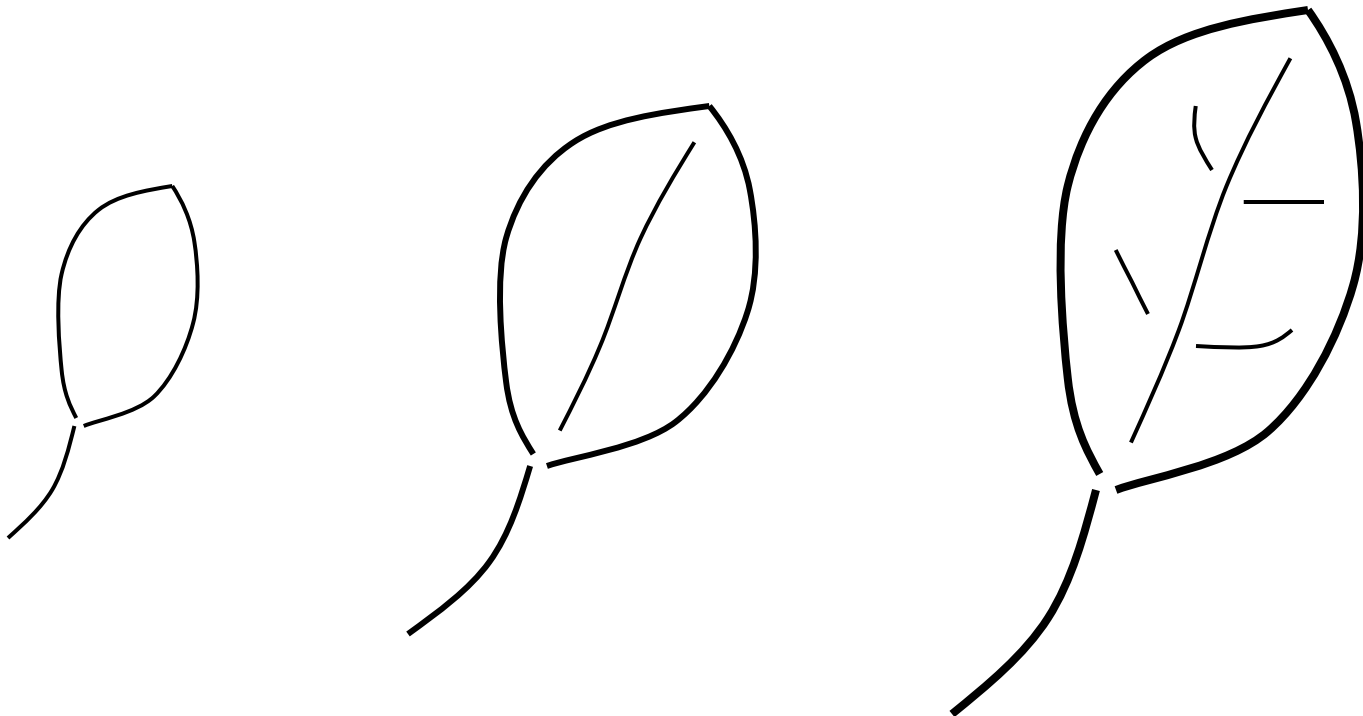
# Placement and duplication

- Designer creates a few “example graftals”
- Copies can be generated on surfaces
  - explicitly, or
  - procedurally
- Random variation can be used
  - copies are not exact
  - looks less mechanical



# Level of detail (LOD)

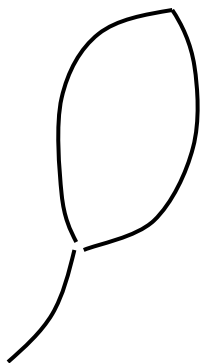
- Graftal computes current LOD
- Decides which primitives to draw



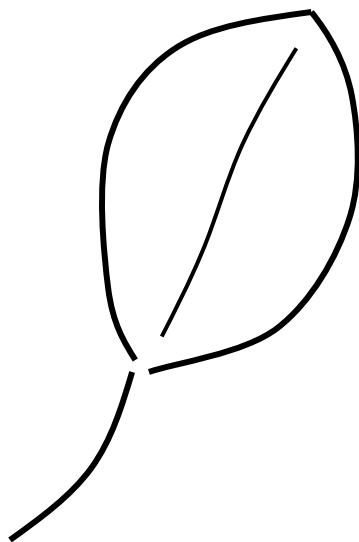
# Computing LOD

- LOD can be derived from:
  - apparent size
  - orientation
  - elapsed time

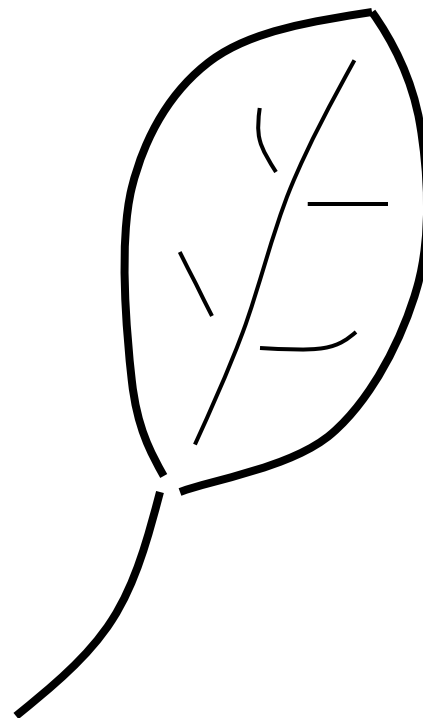
$\sigma$ : ratio of current size to “rest” size



$\sigma = .7$



$\sigma = 1$

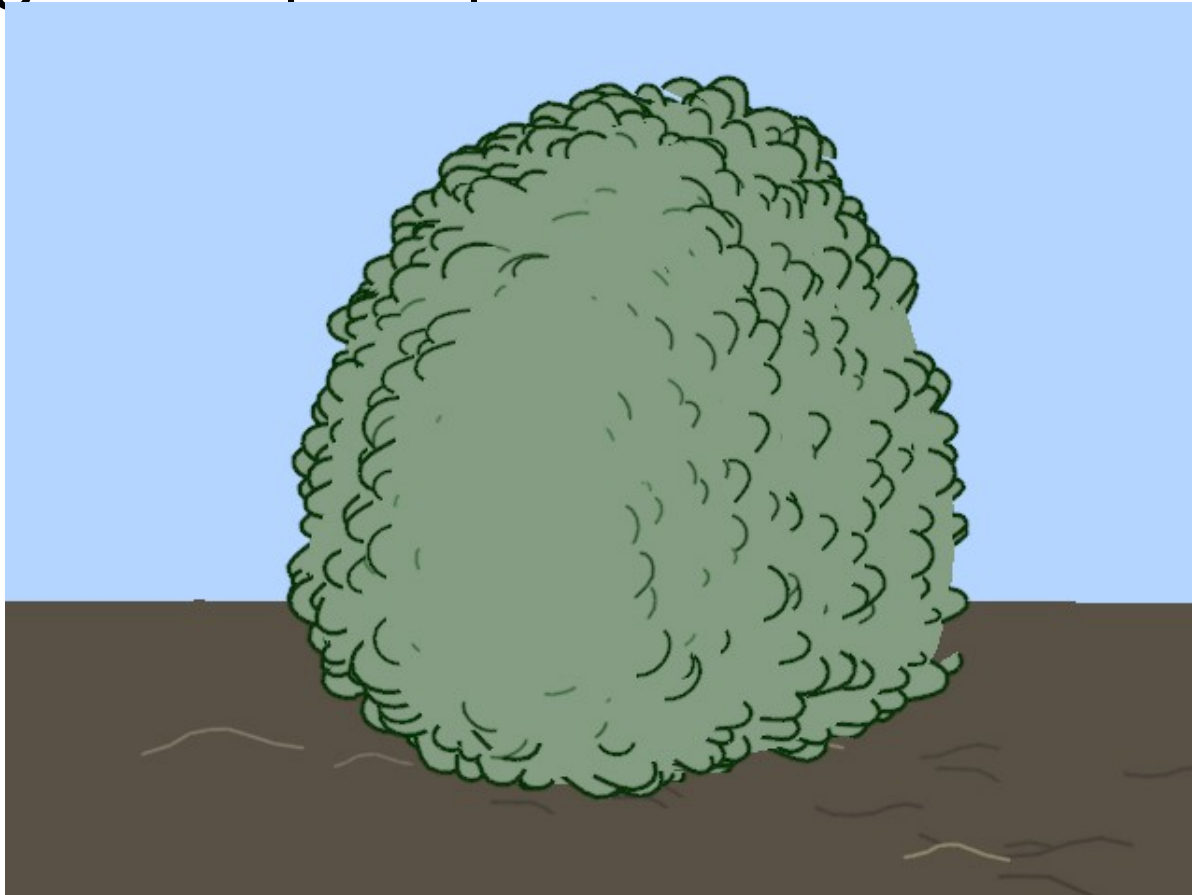


$\sigma = 1.4$

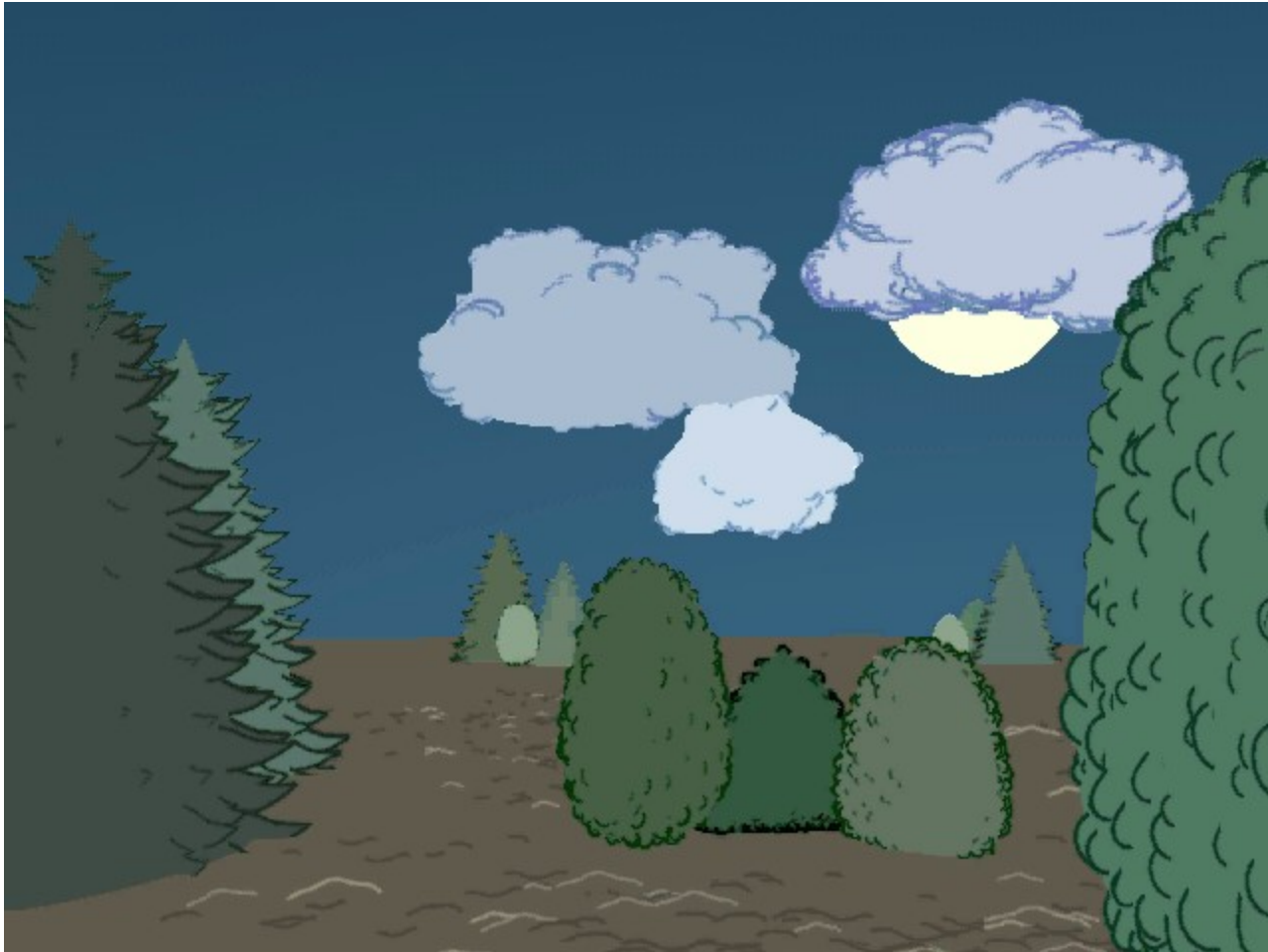


# Orientation

- Value used to selectively suppress LOD
- E.g.:  $1 - |v \cdot n|$



# Movie



# Discussion

- Coherence: much better!
- Slower
- Revealing / hiding elements
  - fading & thinning work well
  - growing looks creepy
- LOD mechanism too inflexible
- Need direct UI

# Pen & Ink: trees

- Deussen and Strothotte, SIGGRAPH 2000
- Problem: temporally coherent pen and ink rendering of trees
- Method:
  - Draw leaf entities w/ controlled size/abstraction
  - Do image processing on depth buffer



Tree I



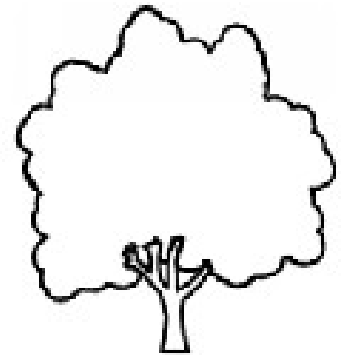
Tree II



Tree III



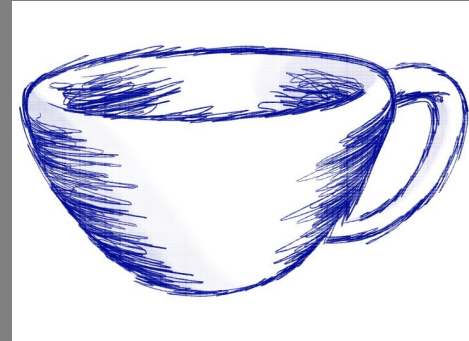
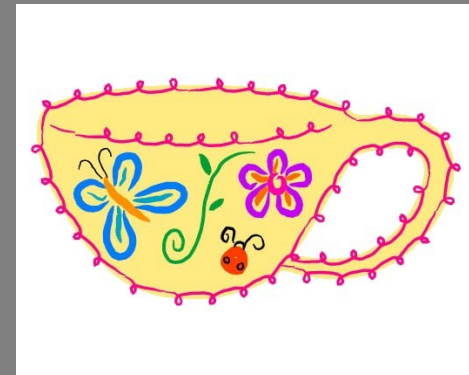
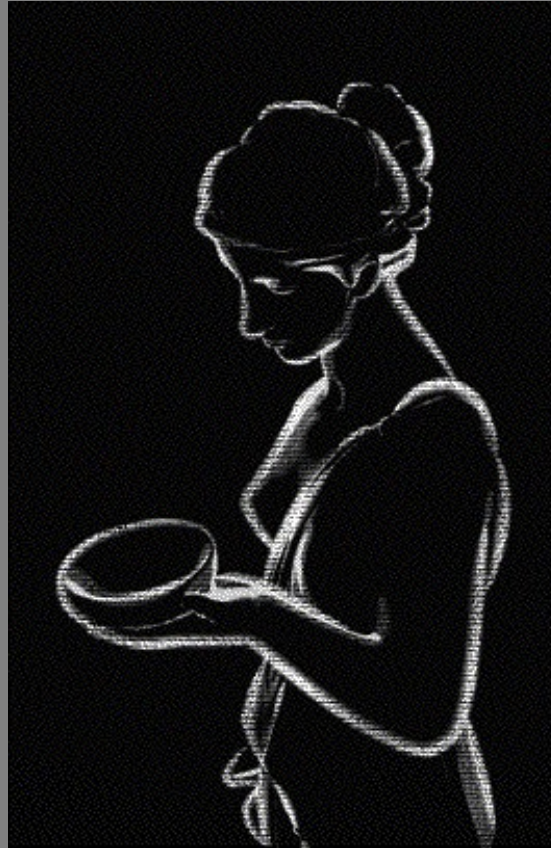




no video! :(

# talk overview

- graftals cont'd
- **stroke-based rendering**
- tonal art maps
- suggestive contours
- dynamic 2D patterns



WYSIWYG NPR: Drawing Strokes Directly on 3D Models.

Kalnins, Markosian, Meier, Kowalski, Lee, Davidson,  
Webb, Hughes & Finkelstein. SIGGRAPH 2002.

# Contributions

- Direct user-control for NPR
- Better silhouettes
- New media simulation
- Stroke synthesis by example
- Hatching with LODs

# Overview of Components

Base Coat

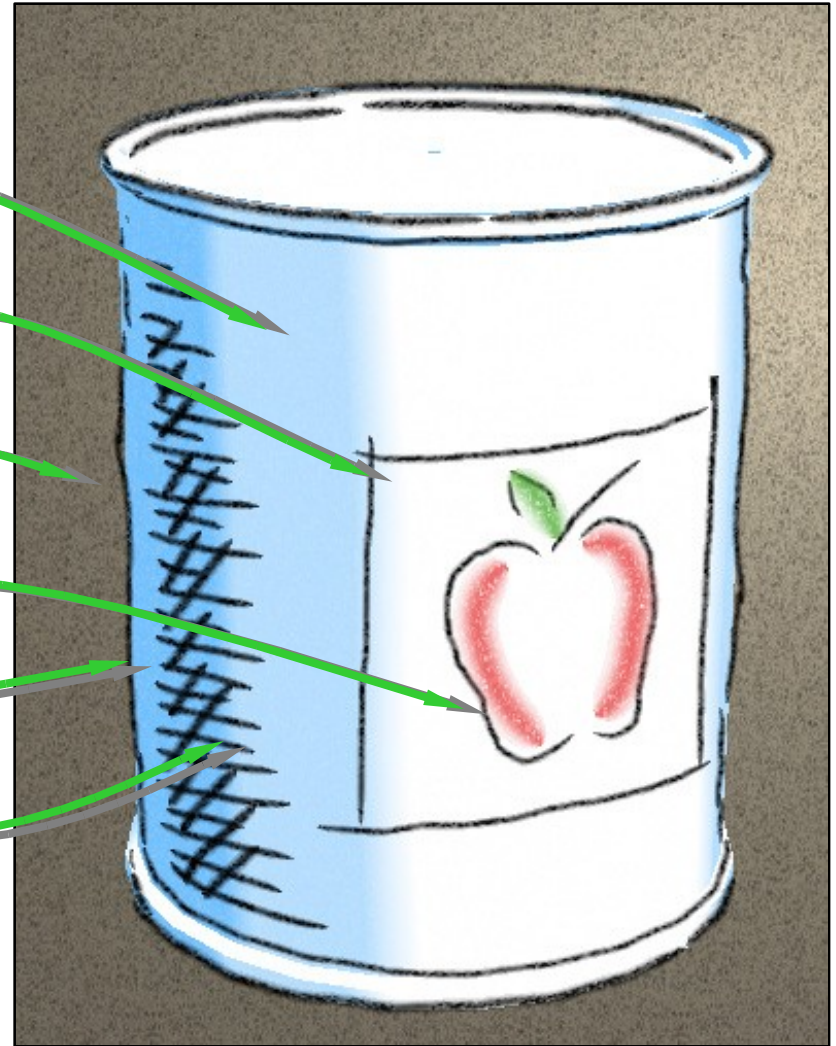
Brush Style

Paper Effect

Decals

Outlines

Hatching

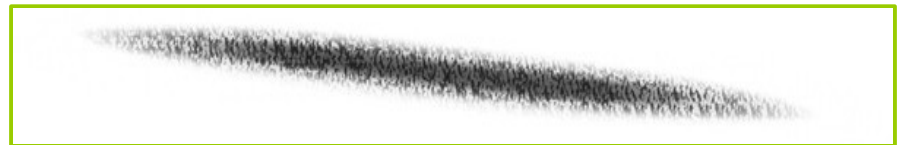
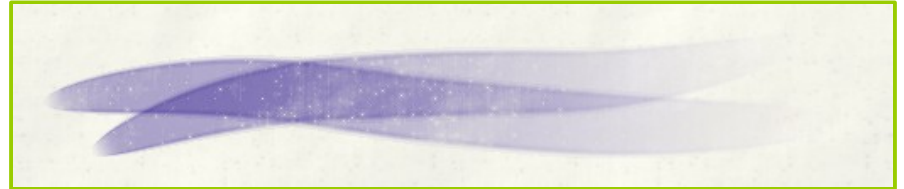




# Brush Style

Per stroke:

- Color
- Width
- Paper effect

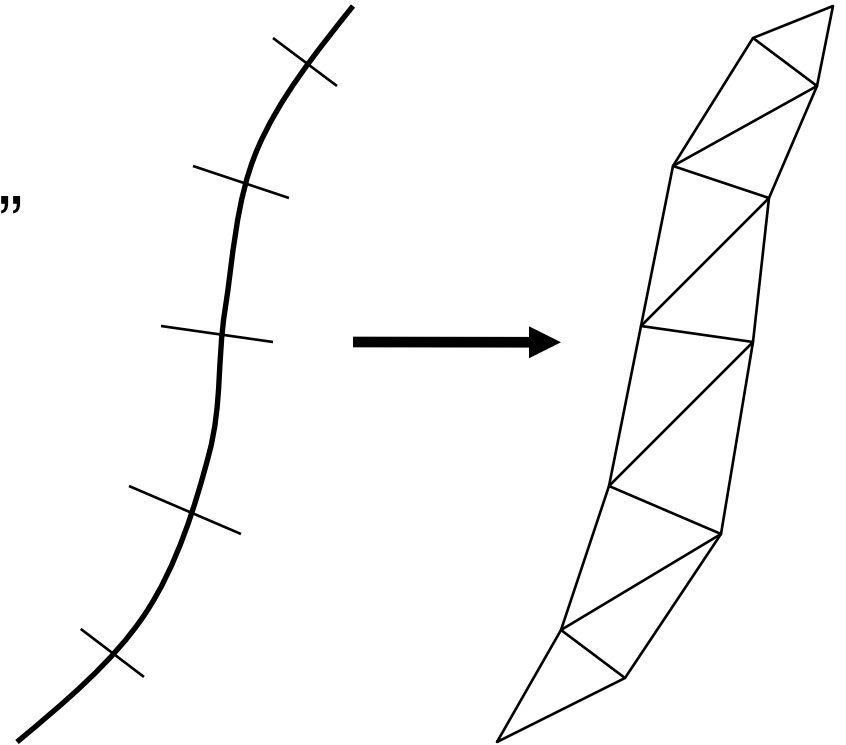


Rendered as triangle strips.

# Strokes in OpenGL

Based on “Skeletal strokes”

Hsu *et al.*, UIST '93



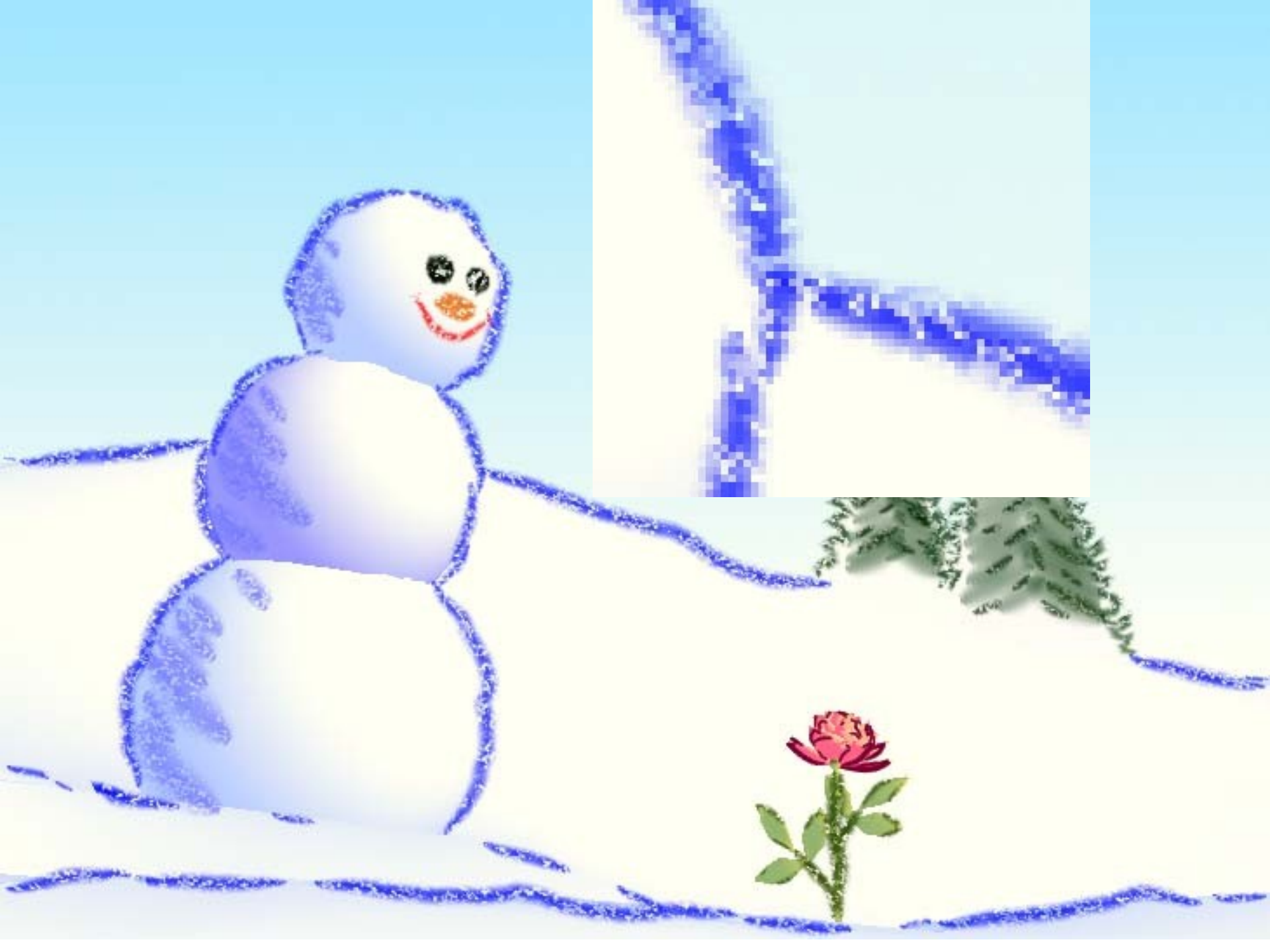
# Paper Effect

- Height field texture:
- Peaks catch pigment
- Valleys resist pigment

## Implementation:

- Pixel shader
- Stroke alpha = pressure





video

# talk overview

- graftals cont'd
- stroke-based rendering
- **tonal art maps**
- suggestive contours
- dynamic 2D patterns

# Real-Time Hatching

Emil Praun

Princeton University

Hugues Hoppe

Microsoft Research

Matthew Webb

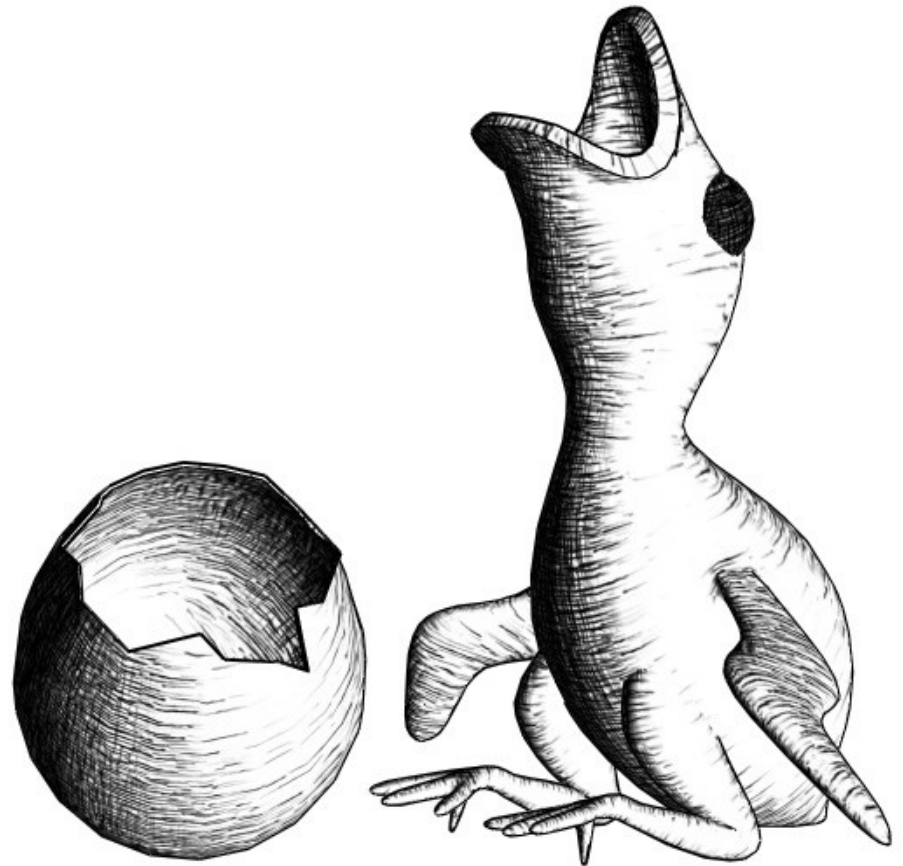
Princeton University

Adam Finkelstein

Princeton University

# Goal

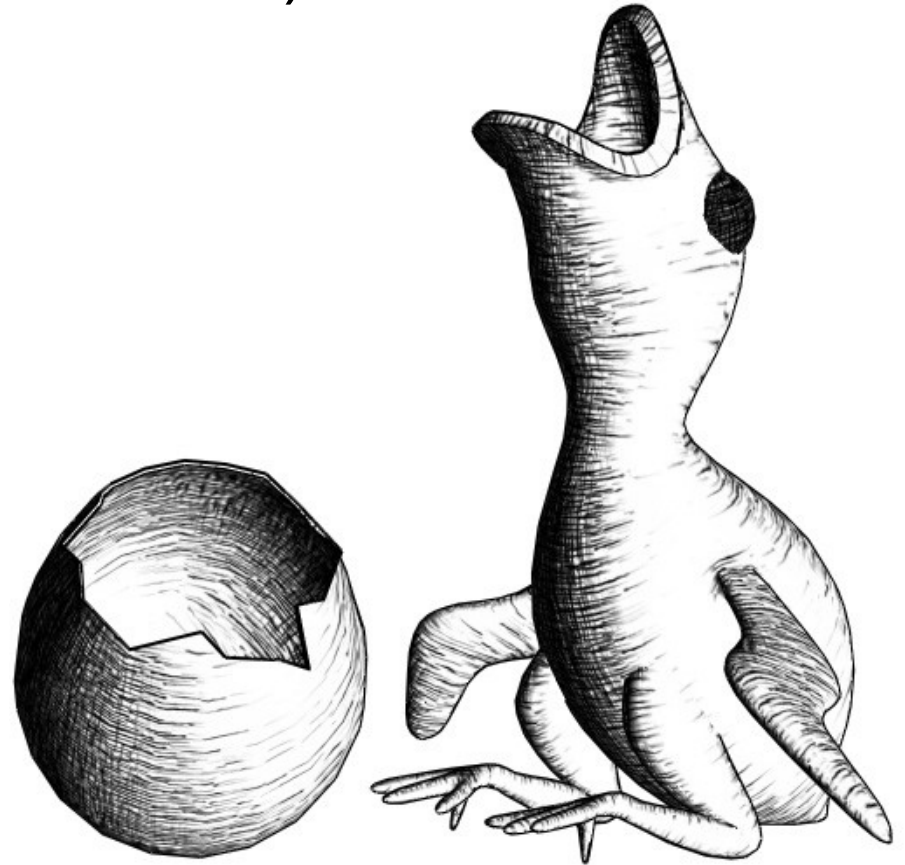
- Stroke-based rendering of 3D models
- Strokes convey:
  - tone
  - material
  - shape





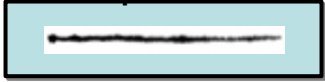
# Challenges

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

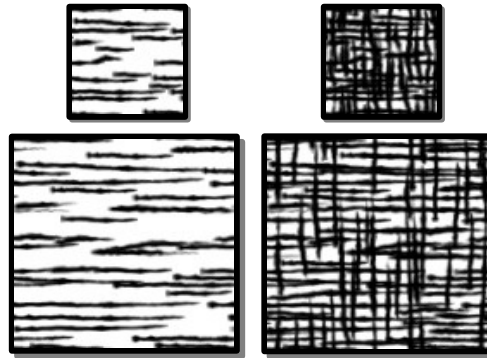


# Approach

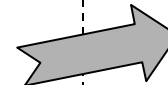
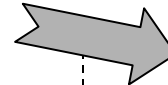
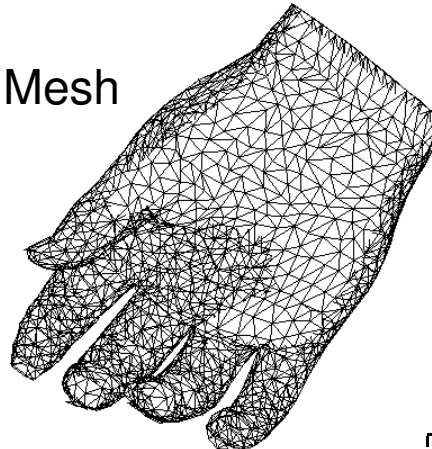
Example stroke



Set of textures



Mesh



Result

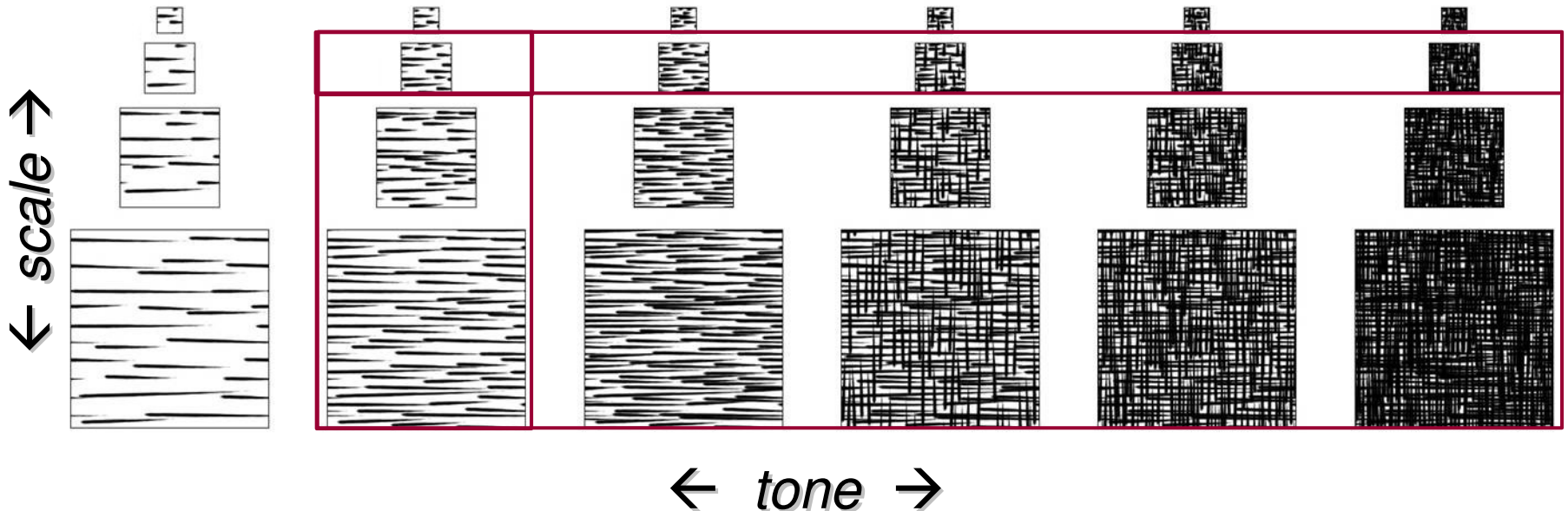


Preprocess

Real-Time

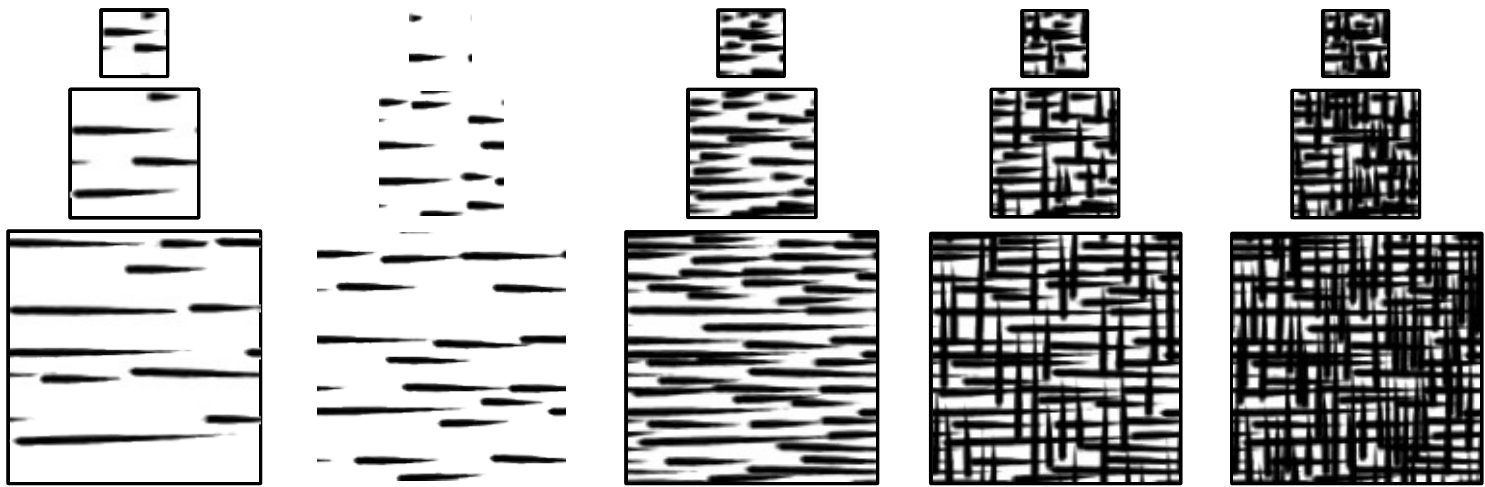
# Tonal Art Maps

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



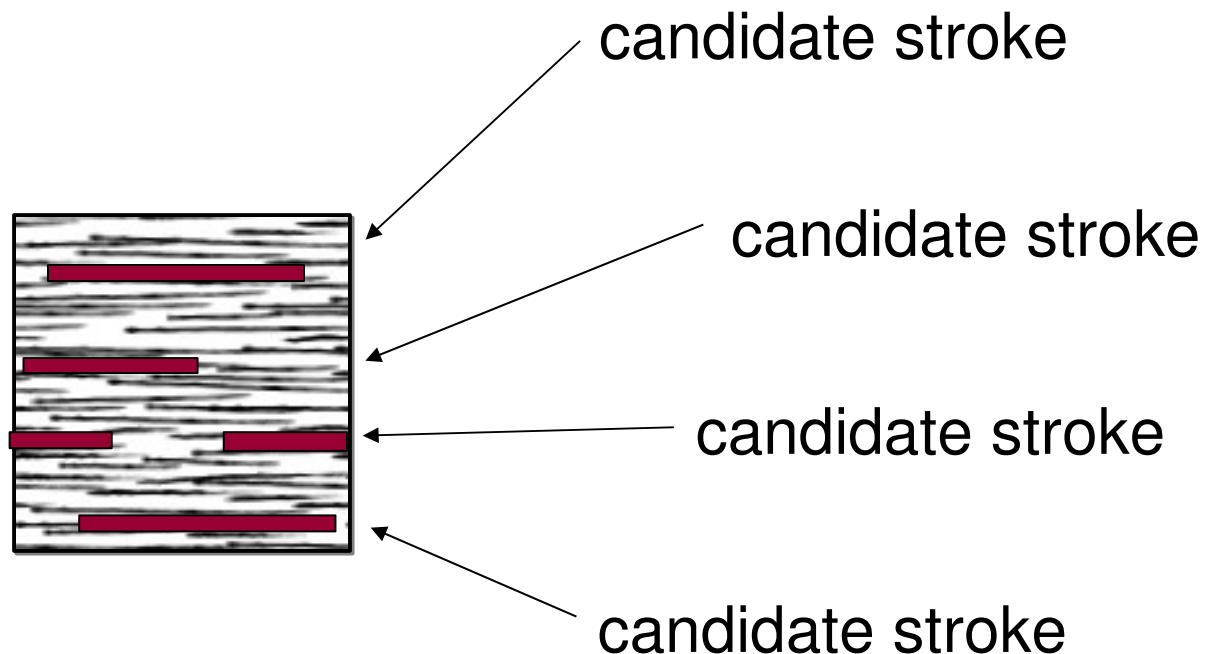
# Generating Tonal Art Maps

- 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

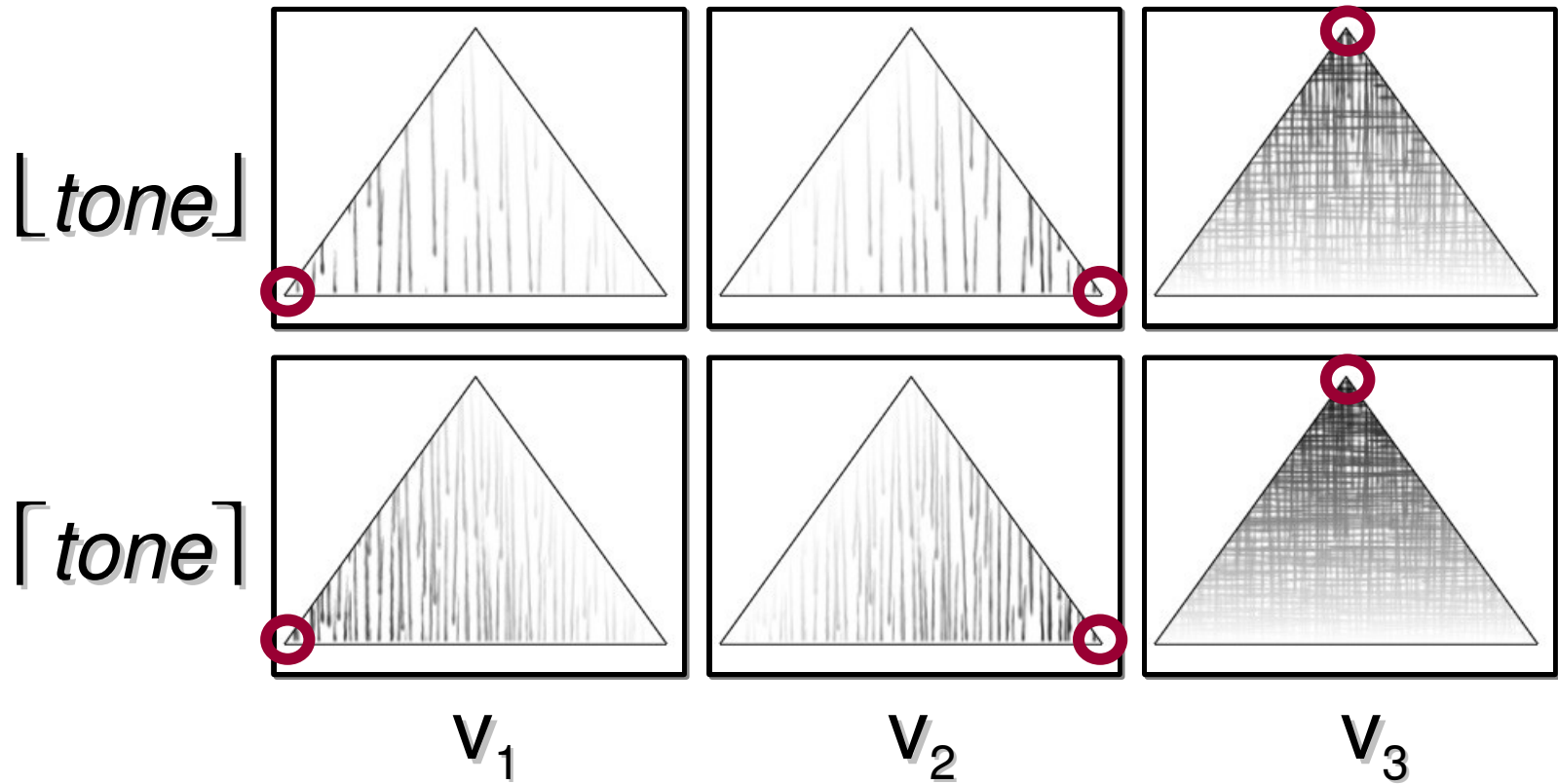


# Even Spacing of Strokes

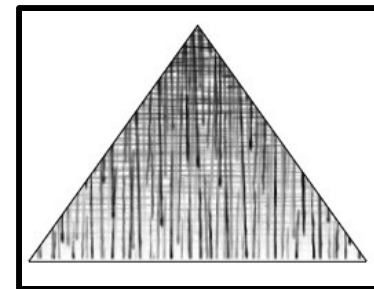
- Choose best stroke from large candidate pool
- Fitness = uniformity & progress towards tone



# Texture Blending

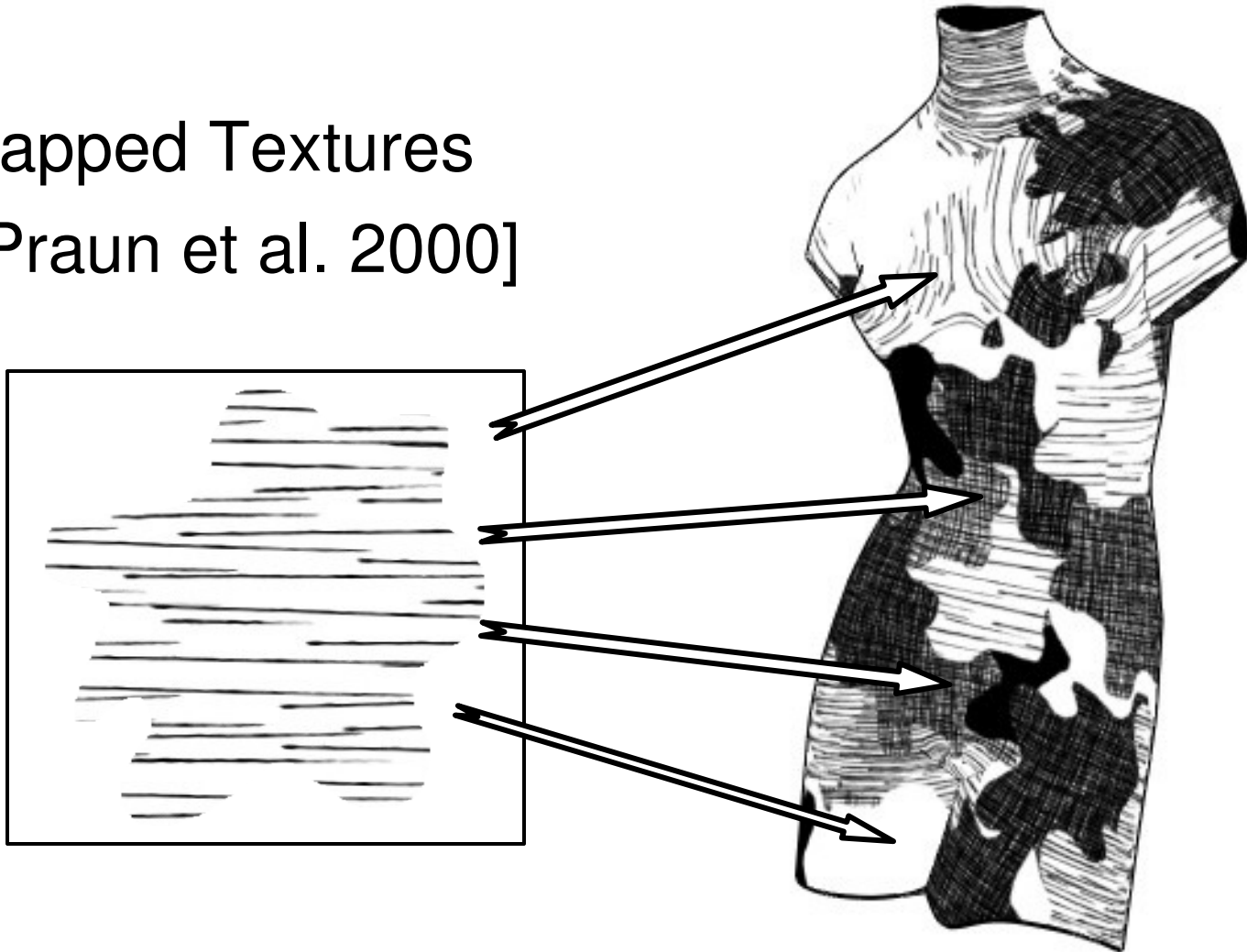


**6-way blend**  $\rightarrow$  *final*



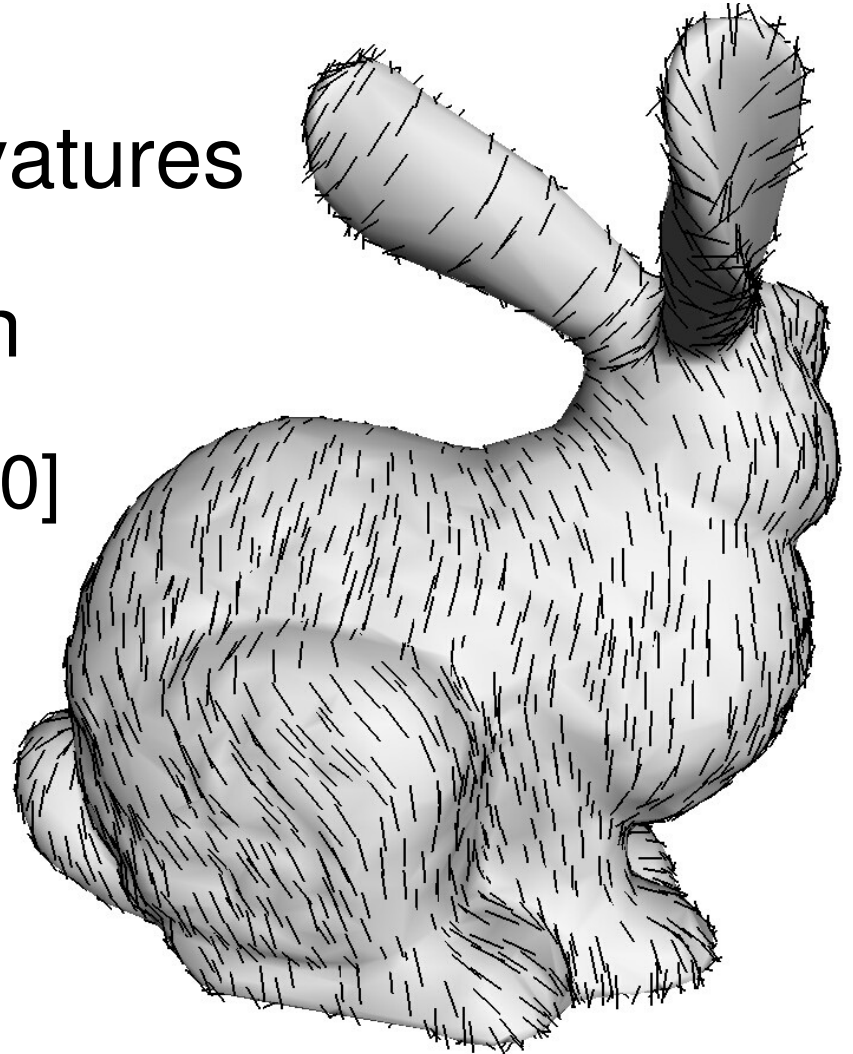
# Texturing Arbitrary Surfaces

- Lapped Textures  
[Praun et al. 2000]



# Direction Field

- Based on principal curvatures
- Optimized to be smooth
  - [Hertzmann & Zorin 2000]
  - Symmetry:  $180^\circ$  not  $90^\circ$





video

# Summary

- Real-time hatching for NPR
- Strokes rendered as textures
- High coherence TAMs prevent blend artifacts
- 6-way blend very fast on modern graphics

# talk overview

- graftals cont'd
- stroke-based rendering
- tonal art maps
- **suggestive contours**
- dynamic 2D patterns

(see separate slides)

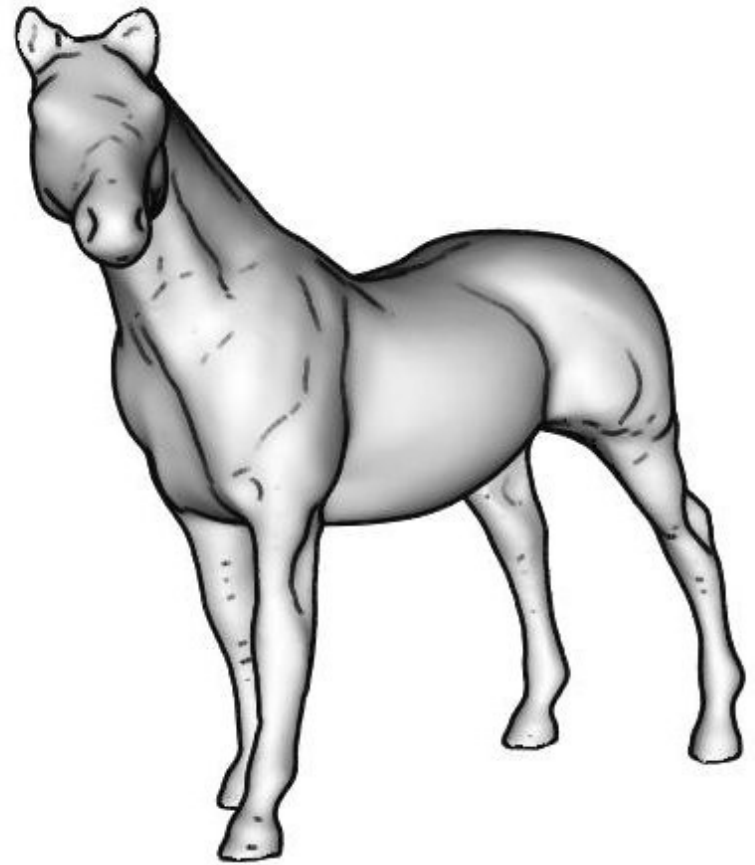
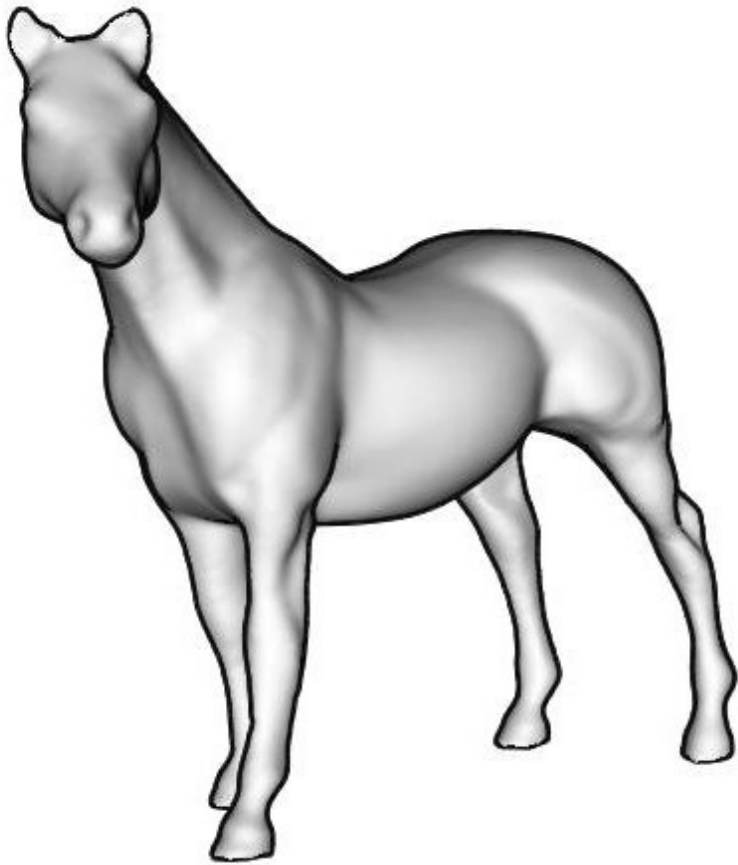
**Line drawings via  
abstracted shading.**

Yunjin Lee, Lee Markosian,  
Seungyong Lee, and  
John F. Hughes

Conditionally accepted to  
SIGGRAPH 2007



connection between suggestive  
contours and shading?



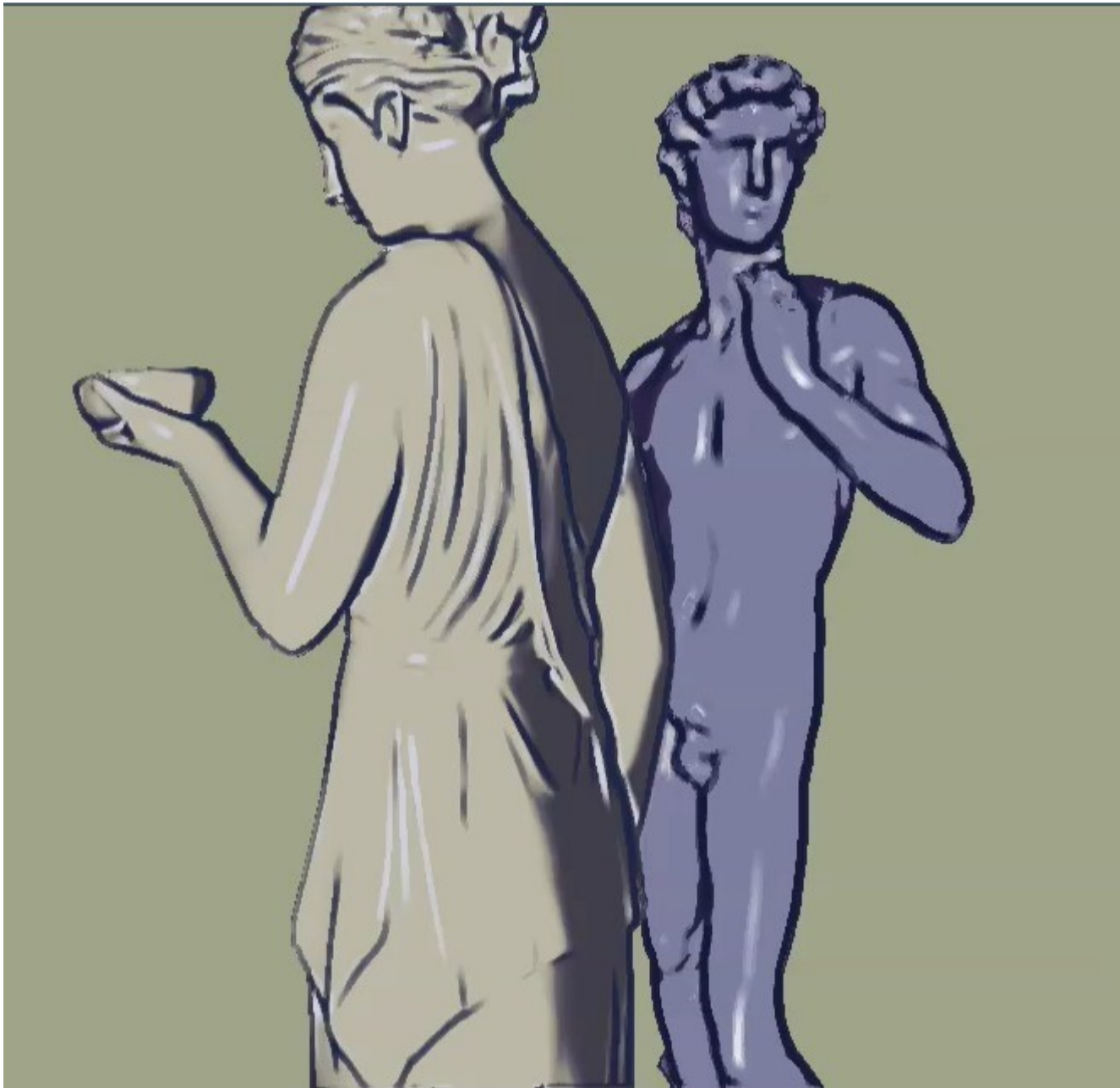
# key observation

- suggestive contours show up where shading forms thin, dark bands
- i.e., suggestive contours are an abstraction of shading
  - substitute lines for thin bands of shading

# algorithm

- 1 produce tone image, copy to texture memory
- 2 blur the tone image, copy to texture memory
- 3 in fragment shader:
  - output ink on “ridges” and “valleys” of tone  
(think of tone values as a height field)
- 4 use toon shader for base coat
  - conveys *broad* areas of tone



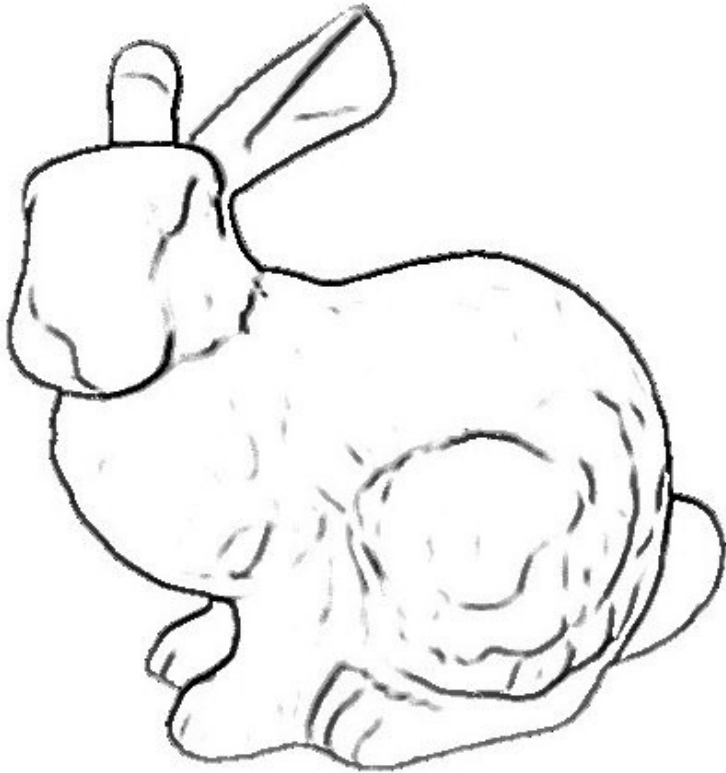


# advantages

- get highlight lines as well as dark lines
- lines depend on lighting
  - they help you visualize the lighting
  - good for combining with toon shading, hatching, etc.
- image space: automatic LOD
- generalization: point light at camera produces suggestive contours

# comparison to s.c.

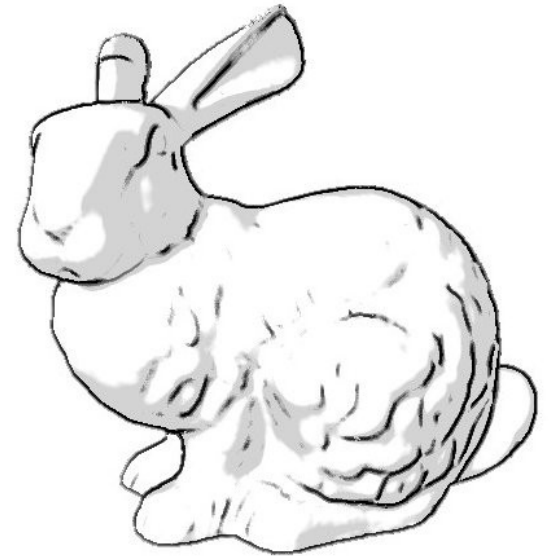
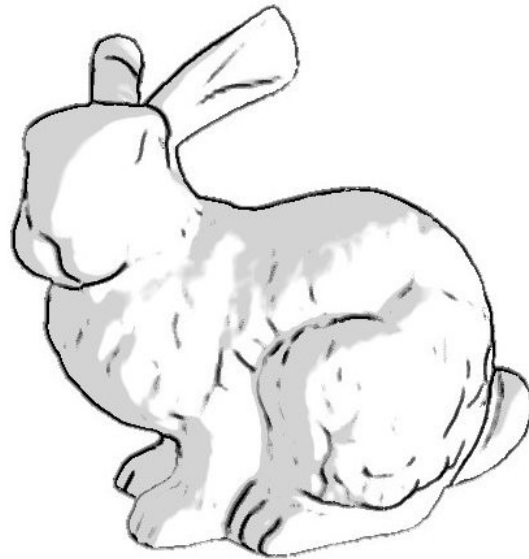
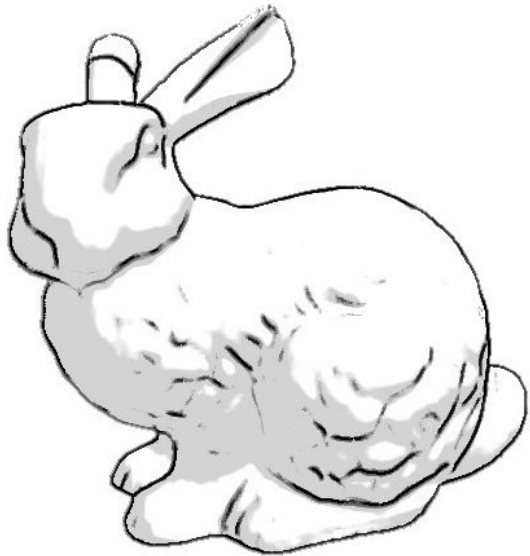
new method  
(light at camera)



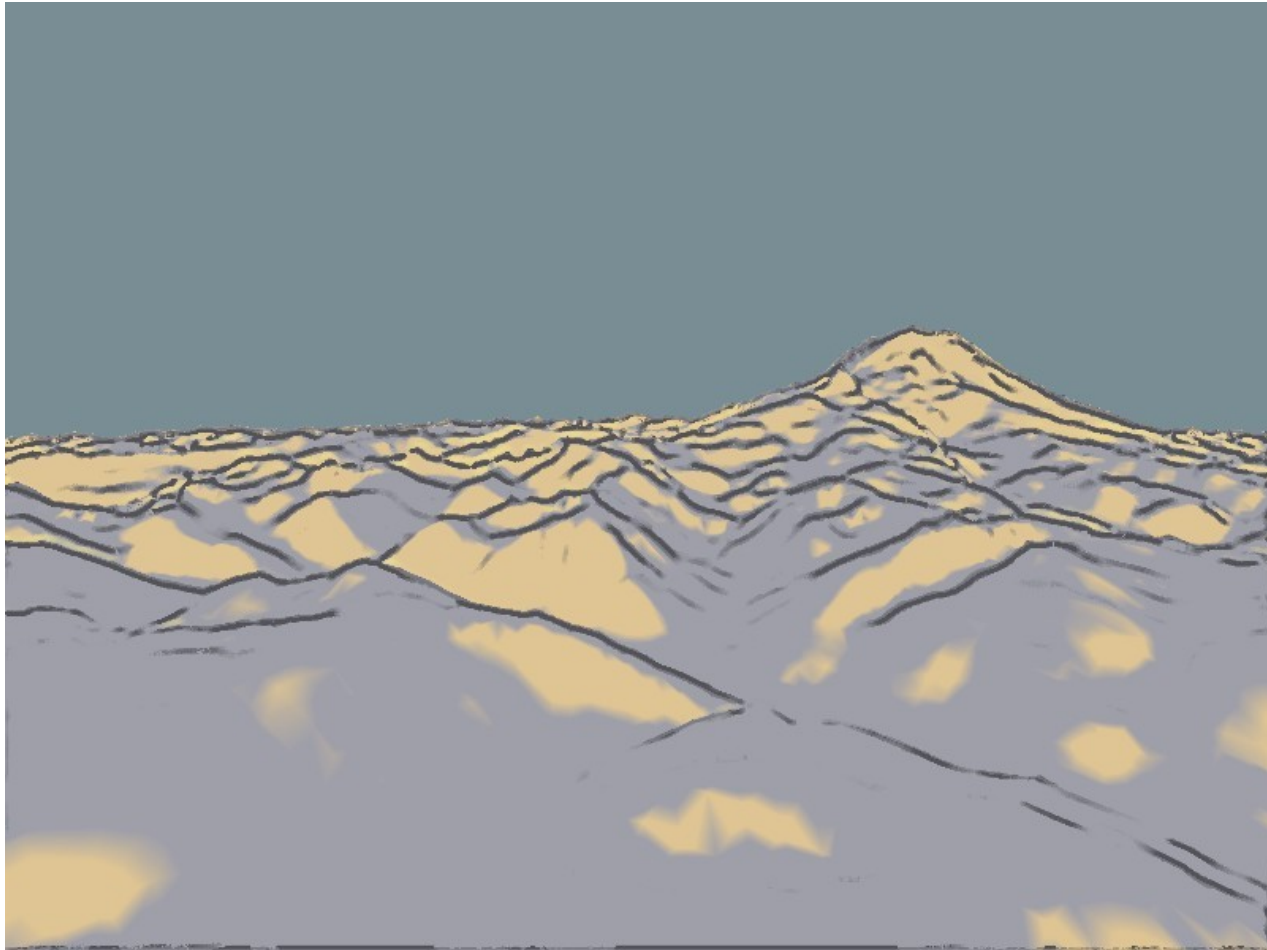
suggestive contours



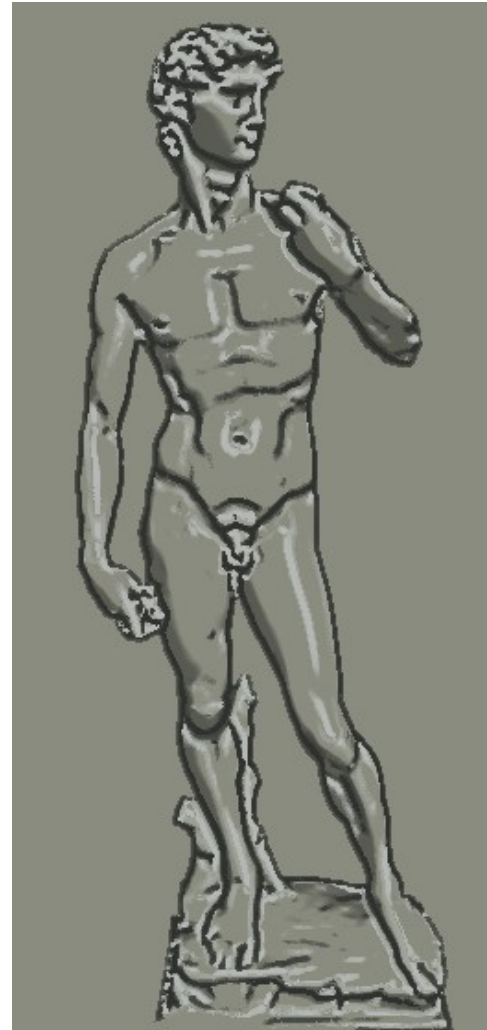
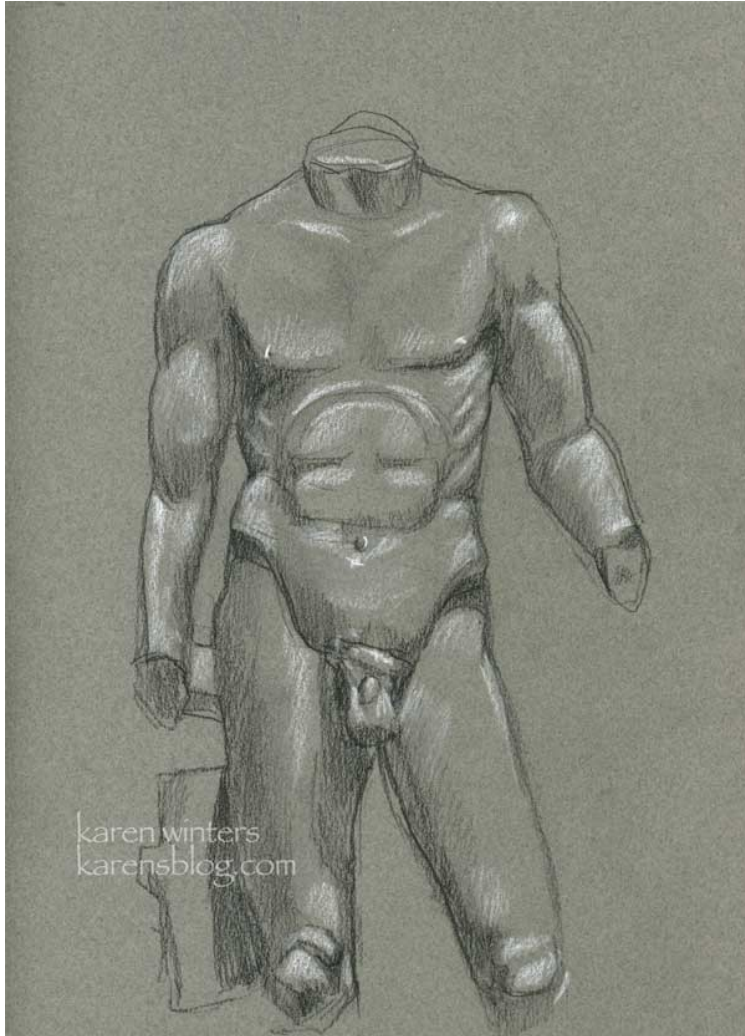
lighting not at camera



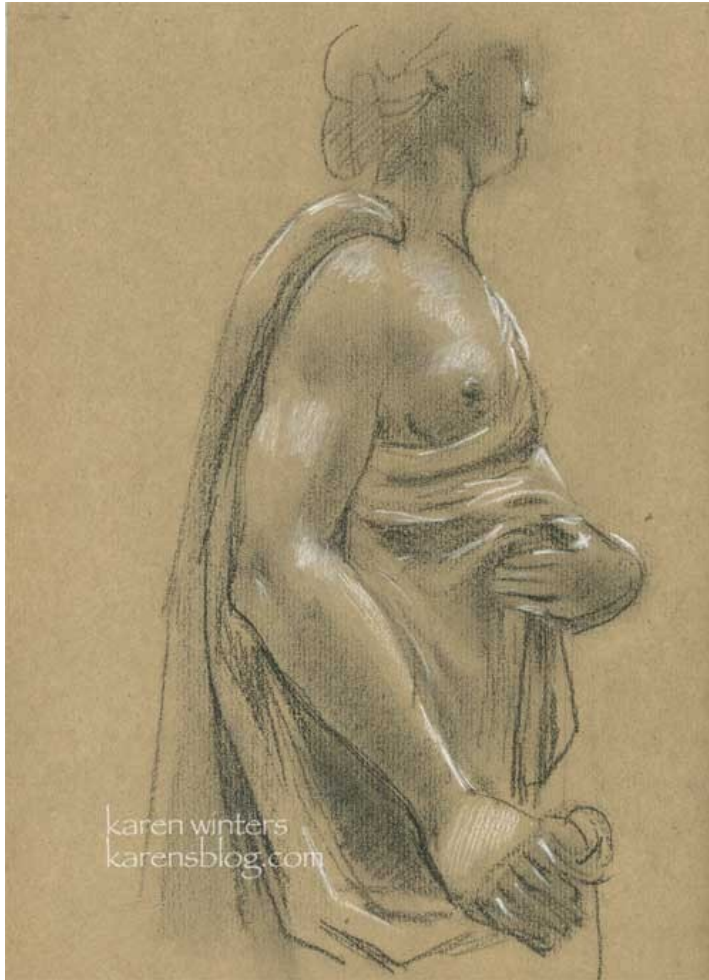
# automatic LOD



# comparison to real drawings



# comparison to real drawings



video



# talk overview

- graftals cont'd
- stroke-based rendering
- tonal art maps
- suggestive contours
- dynamic 2D patterns



**Dynamic 2D Patterns for Shading 3D Scenes.**

Simon Breslav, Karol Szerszen, Lee Markosian

Pascal Barla, and Joëlle Thollot.

Conditionally accepted to SIGGRAPH 2007

video

# Next up

- No lab Friday
- Monday:
  - course evaluations
  - review for final
  - homework due
- Final exam:
  - 4/20, 4-6 pm
  - CSE 1670