CMSC 435/634
Computer Graphics

Penny Rheingans
UMBC

Announcements

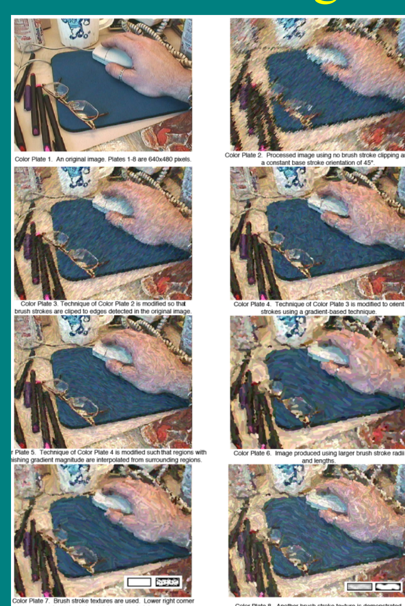
- Proj 5 due Dec 3
- Proj 6 due Dec 14
- Exam Dec 21, 10:30am
  - Same format as midterm
- Sign up for 635

Artistic Rendering

- Computer-generated images in a style similar to some artistic media or style
- Also called non-photorealistic rendering (NPR)
- Different emphases
  - Mimic style
  - Accomplish purpose

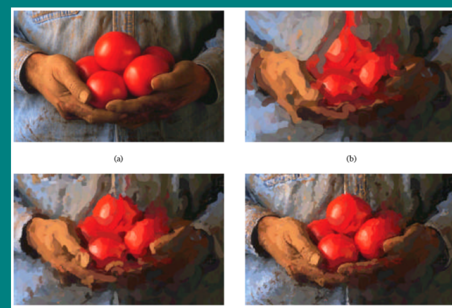
Artistic Image and Video Processing

- Process image or video input to have an artistic appearance
- Key issues:
  - Mimic style
  - Identify features



Artistic Image and Video Processing

- Papers
  - Litwinowicz97
  - Hertzmann98
  - Hays04
  - Liu05



Processing Images and Video for an Impressionist Effect

Pete Litwinowicz

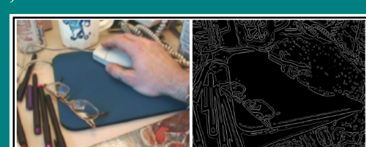
SIGGRAPH 97

Impressionist Video

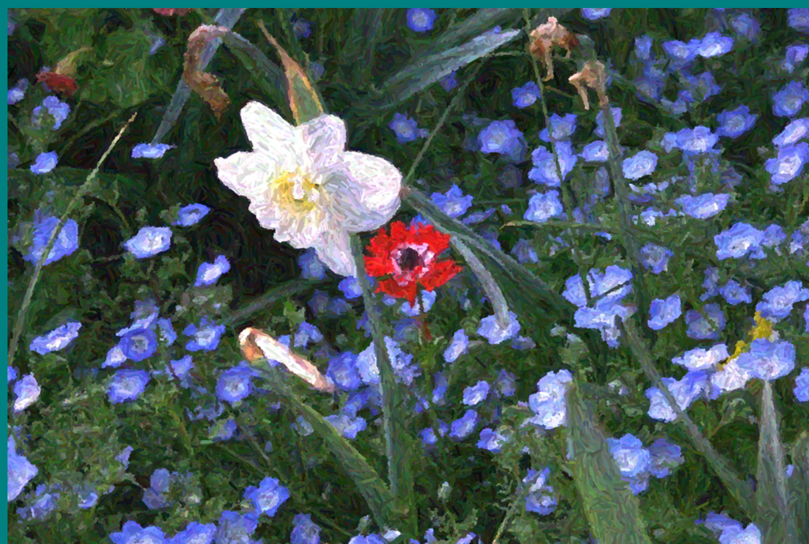
- Image process video streams to look “impressionist”
  - Automatic process
  - Uses optical flow fields to track pixel motion
- Used in film “What Dreams May Come”

Impressionist Video

- Process
  - Rendering strokes
    - Generate line w/length, thickness, orientation
    - Randomly perturb length, radius, color, theta
    - Clip to image edges and render
  - Orienting strokes
    - Orthogonal to color gradient
  - Maintaining coherence
    - Use optical flow to guide stroke movement
    - Fill in strokes when they get too sparse

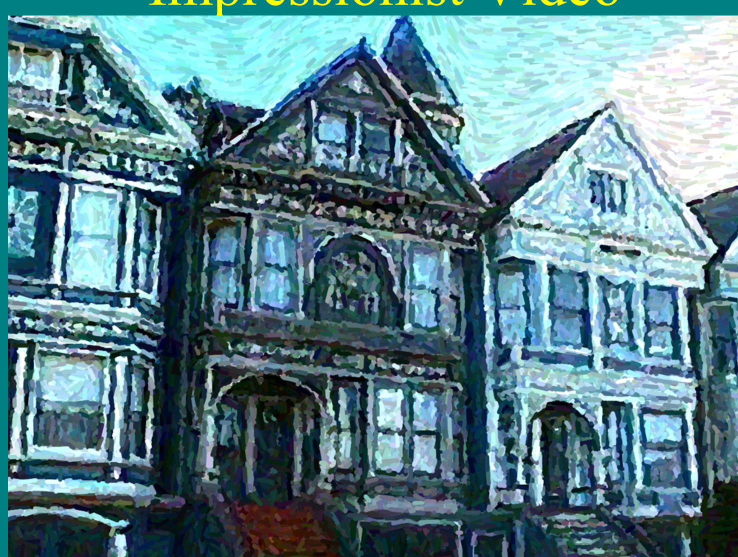


Impressionist Video



Litwinowicz, SIGGRAPH '97

Impressionist Video



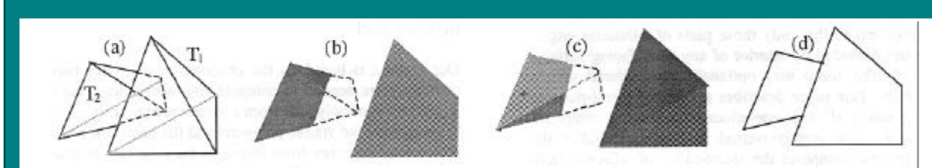
Litwinowicz, SIGGRAPH '97

Impressionist Video

Litwinowicz, SIGGRAPH ‘97

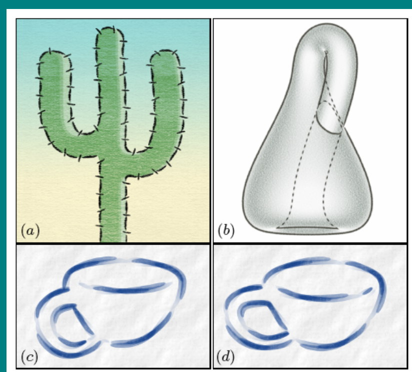
Silhouettes and Outlines

- Draw expressive silhouettes and outlines of objects
- Key issues:
  - Identifying silhouettes
  - Drawing stylized silhouettes



Silhouettes and Outlines

- Papers
  - Raskar99
  - Hertzmann00
  - DeCarlo03
  - Kalnins03



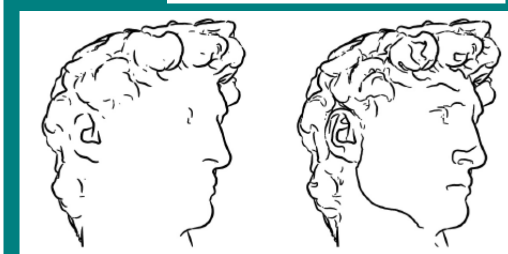


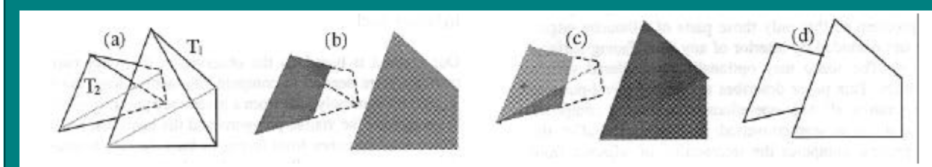
Image Precision Silhouette Edges

Ramesh Raskar and Michael Cohen

I3D 99

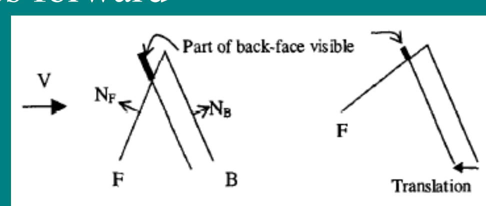
Basic Approach

- Use hardware to draw silhouette edges at image precision
- General method:
  - Identify all front facing visible pgons
  - Identify back facing polygons
  - The intersection of these two is the silhouette

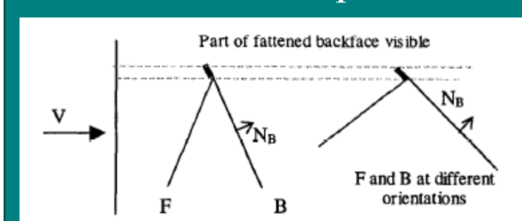


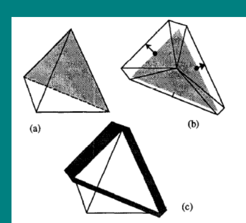
Fattening Lines

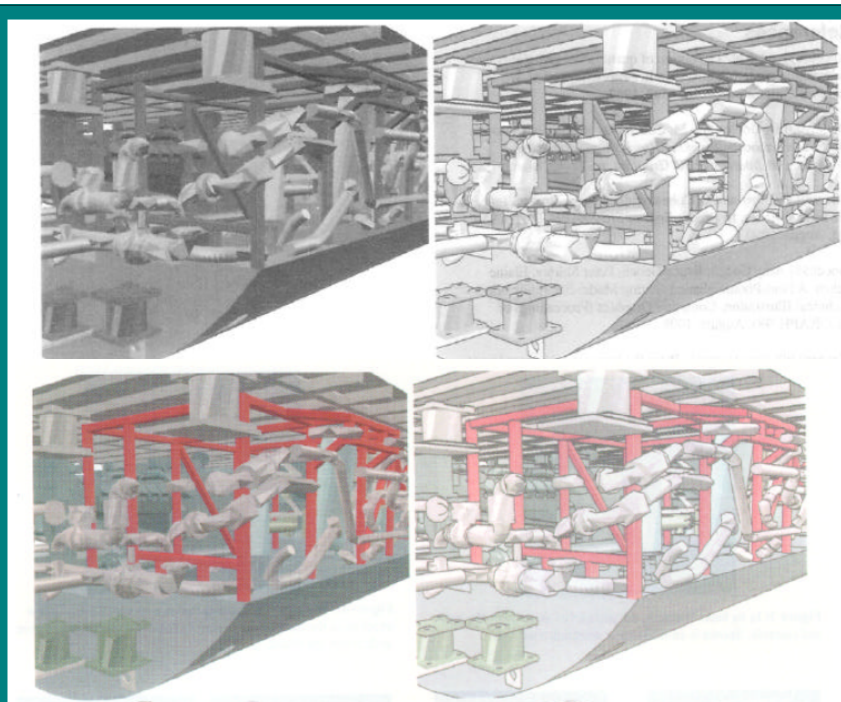
- Render back in wireframe using ≤
- Translate back faces forward



- Use view-dependent extension of back faces

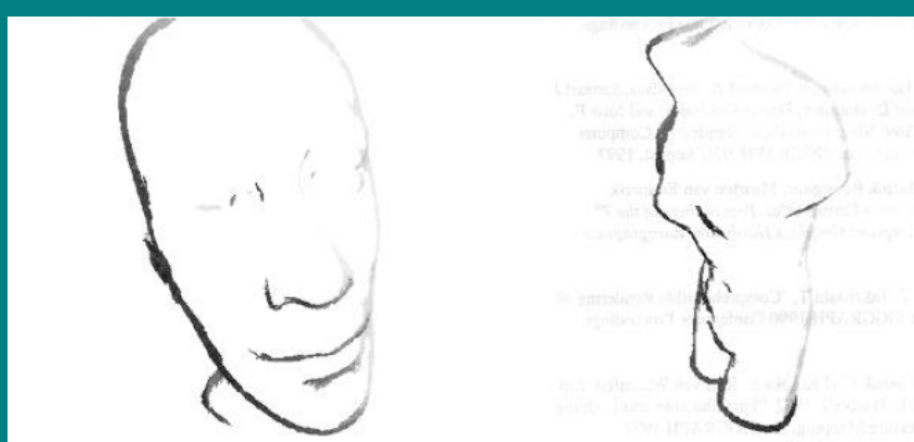






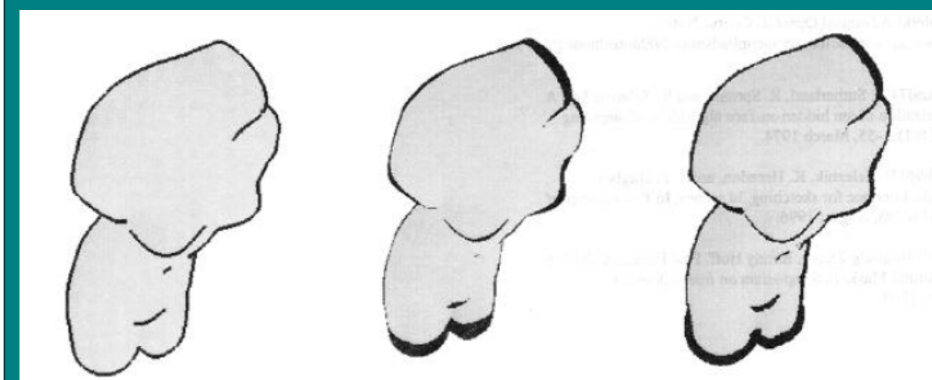
Results

- Fattening to produce a charcoal-like style



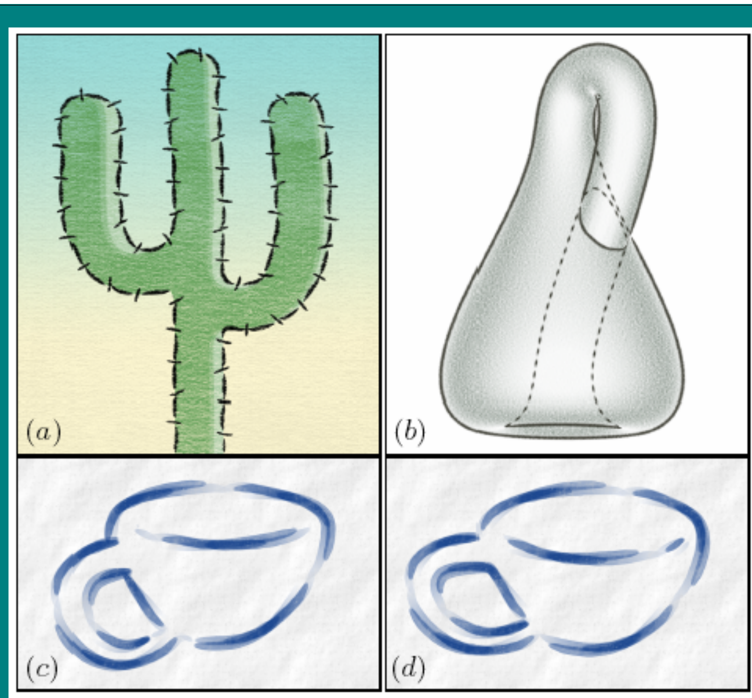
Basic Approach

- Fattening using wirefame, translation, lengthening methods



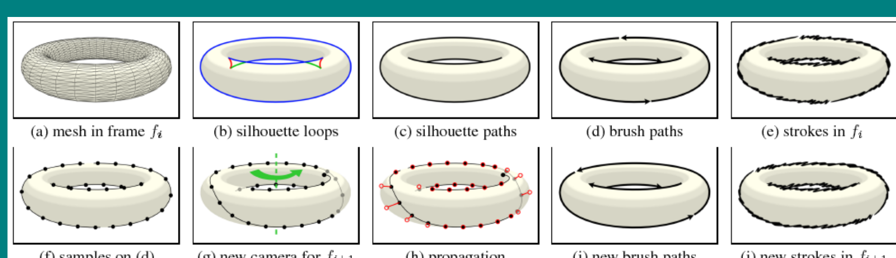
Coherent Sylized Silhouettes

Robert Kalnins, Philip Davidson, Lee Markosian, and Adam Finkelstein

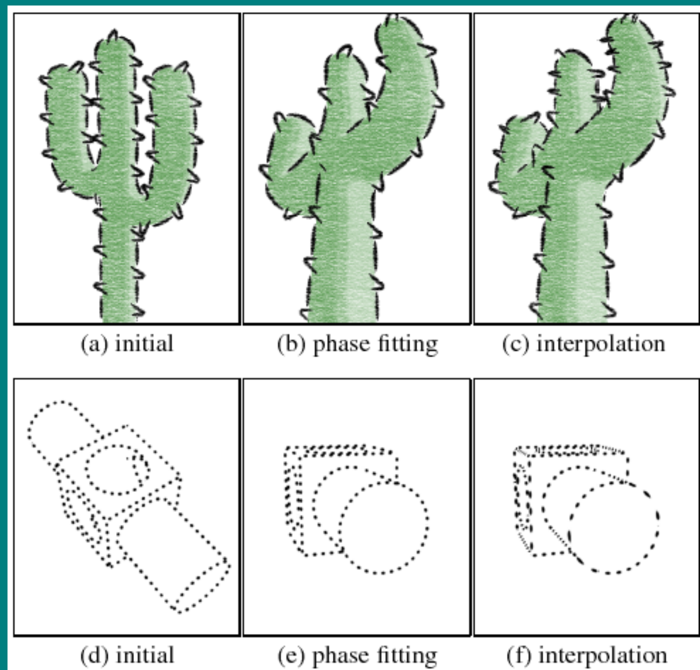


Kalnins 03

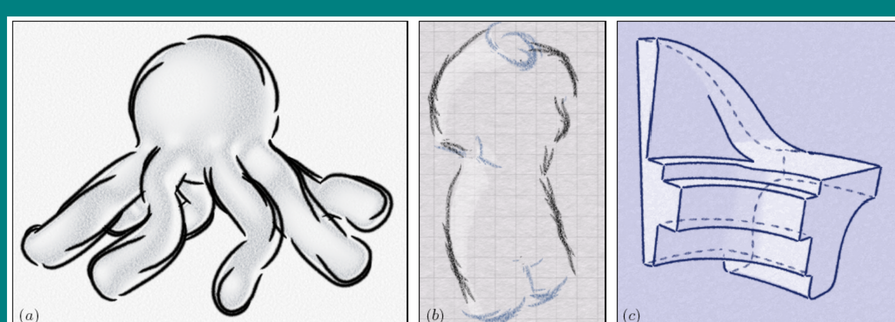
Stylized Silhouette Process



Kalnins 03

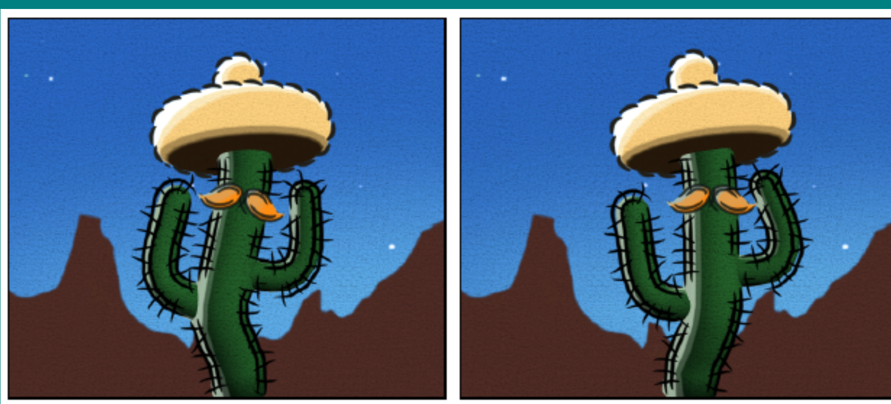


Kalnins 03



Kalnins 03

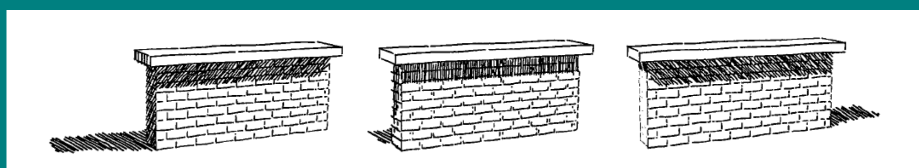
Kalnins 03



Kalnins 03

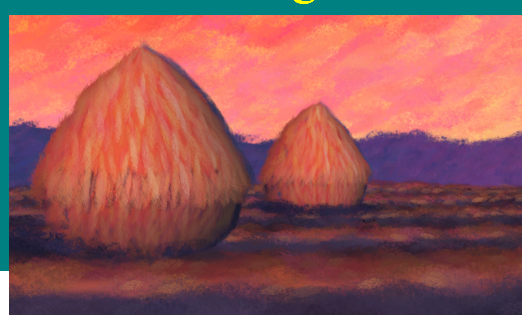
Shading and Texturing

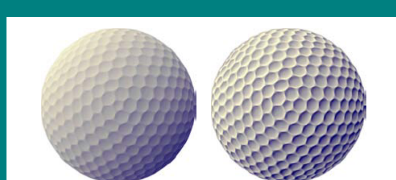
- Generating appropriate tone and texture
- Key issues:
  - Matching tone representing shaded surfaces
  - Using strokes appropriate to style
  - Matching desired textures
  - Using tone and texture to clarify shape

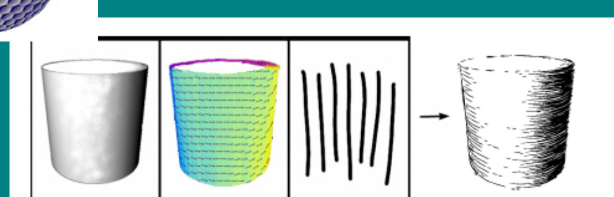


Shading and Texturing

- Papers
  - Winkenbach94
  - Meier96
  - Salisbury97
  - Rusinkiewicz06







Computer-Generated Pen-and-Ink Illustration

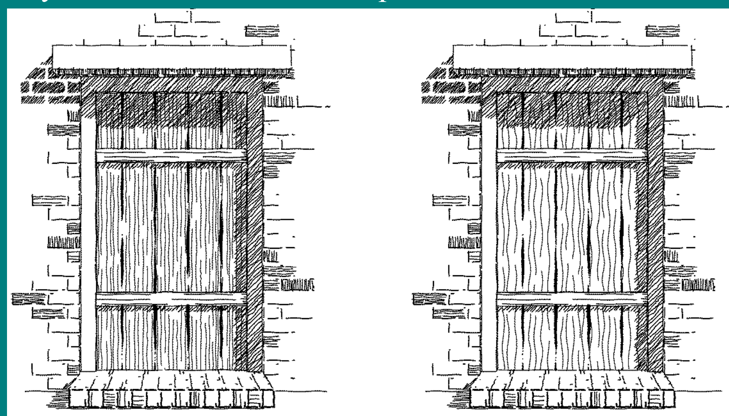
Georges Winkenbach, David Salesin
SIGGRAPH 94

Basic Approach

- Adapt techniques of traditional pen-and-ink illustration for automatic generation
- Major Topics:
  - strokes
  - tone and texture
  - outlines

Stroke Principles

- Stroke thickness should correspond to level of detail
- Line thickness should vary over stroke length
- Wavy lines indicate schematic parts



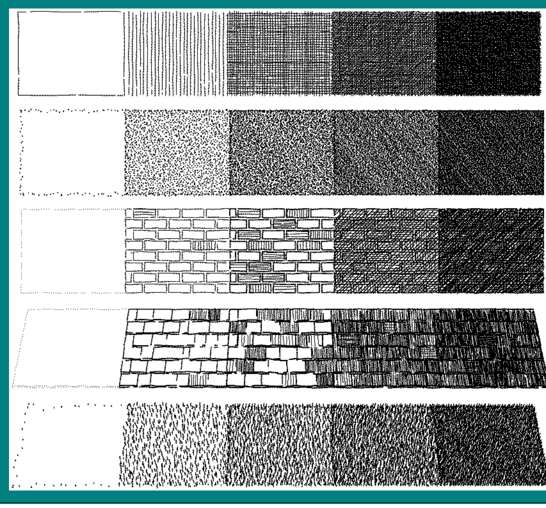
- Winkenbach and Salesin '94

Stroke Implementation

- Stroke specified with
  - path
  - nib: footprint as function of pressure
  - character function: waviness and pressure
- Strokes clipped to region
- Initial implementation
  - circular nibs
  - randomly perturbed sine wave character funcs

Tone and Texture Principles

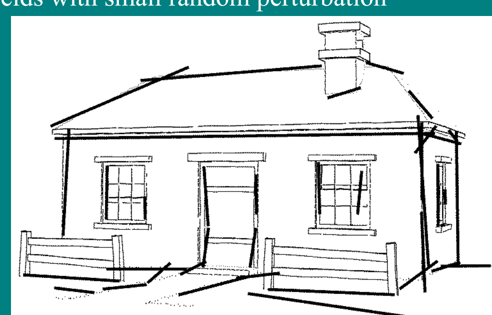
- Tones should be created from lines of roughly equal weight and spacing
- Relative tones more important that absolute
- Textures convey material types
- Tone can be implied by "indication"



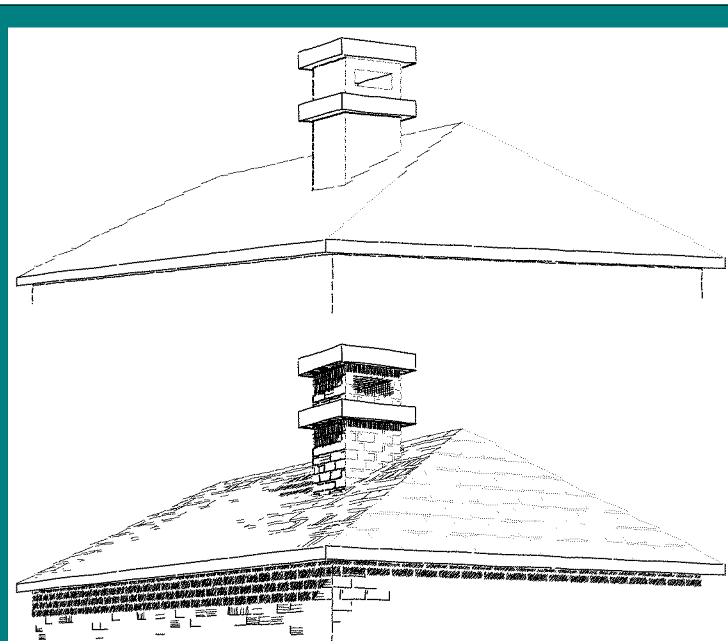
Winkenbach and Salesin '94

Texture Implementation

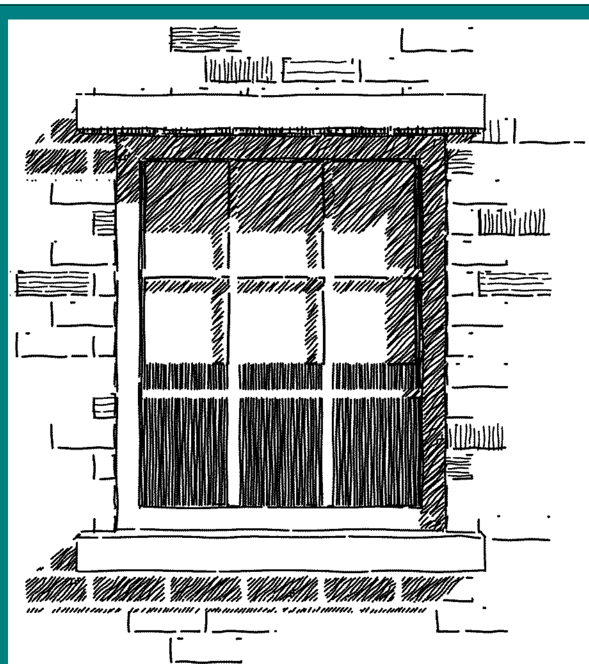
- Stroke texture
  - each stroke has a priority
  - strokes together achieve desired tone (computed from simple Phong lighting model)
  - procedural prioritize specification for texture
- Interactive indication specification
  - detail segments generate fields with small random perturbation



Winkenbach and Salesin '94

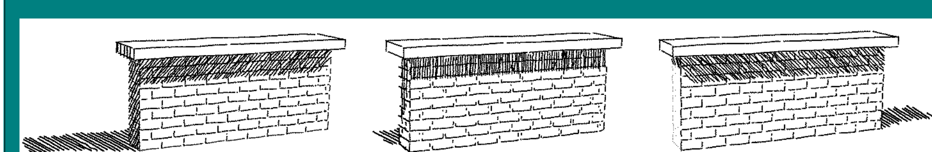


- Winkenbach and Salesin '94

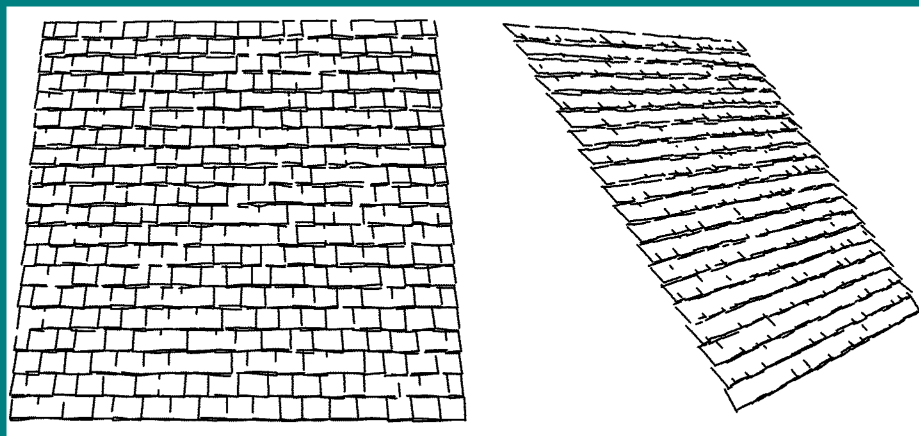


- Winkenbach and Salesin '94

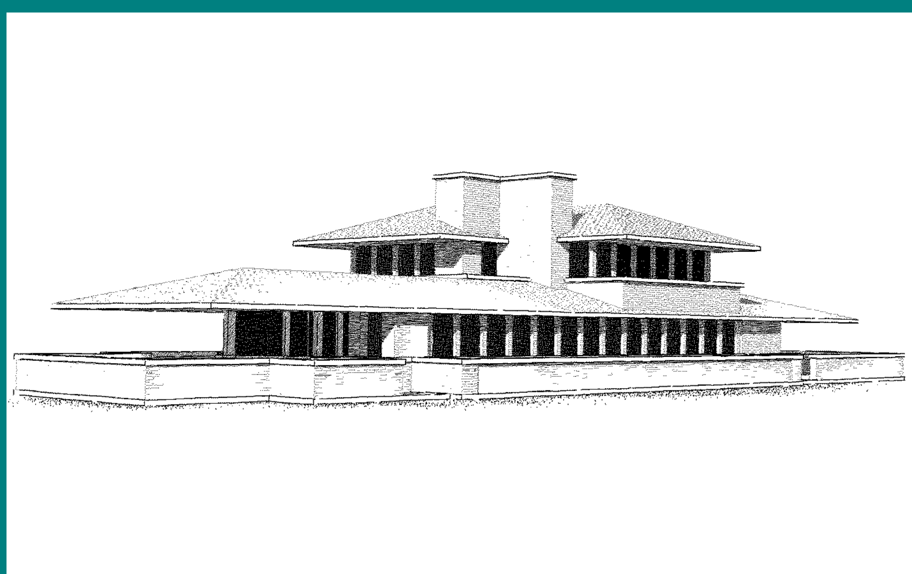
Light Dependence



View Dependence



- Winkenbach and Salesin '94



- Winkenbach and Salesin '94

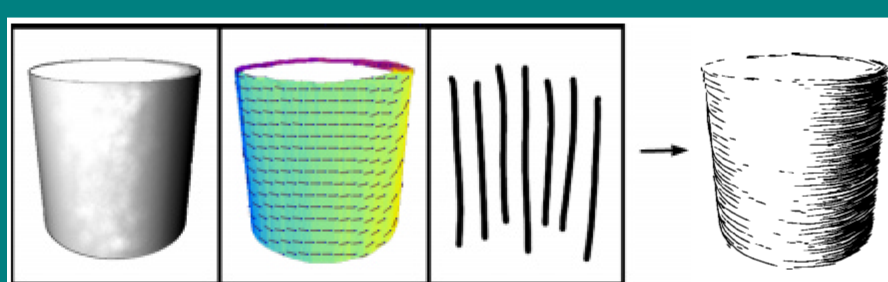
Orientable Textures for Image-Based Pen-and-Ink Illustration

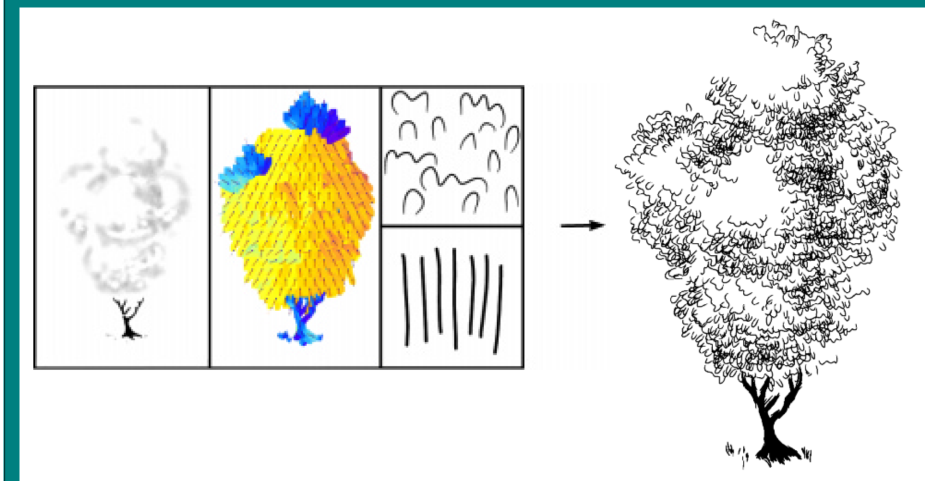
Michael Salisbury, Michael Wong,
John Hughes, and David Salesin

SIGGRAPH 97

Basic Approach

- Illustration created from
  - grey-scale tone target
  - direction field
  - stroke example set



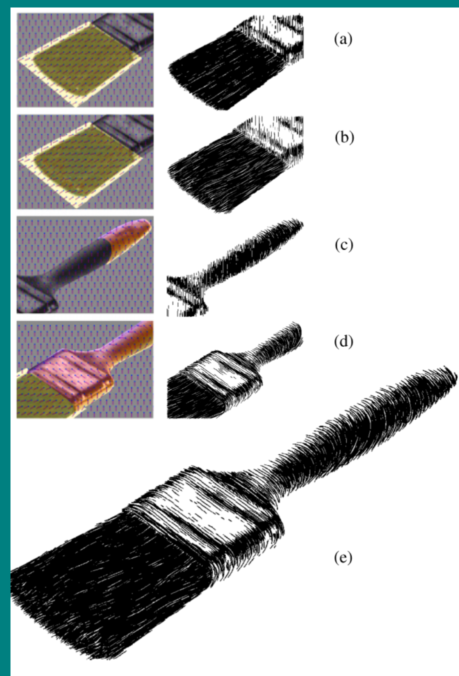


- Salisbury et al. '97

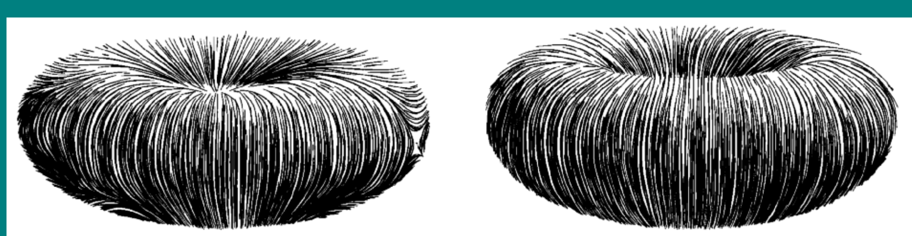
Interactive System

- Tone target
  - paint
  - clone source
- Direction field
  - paint
  - blend
  - interpolated fill
- Stroke example splines

- interpolated fill
- irregularities added
- curves on handle
- metal ferrule
- final image
- Salisbury et al. ‘97



Direction Magnification



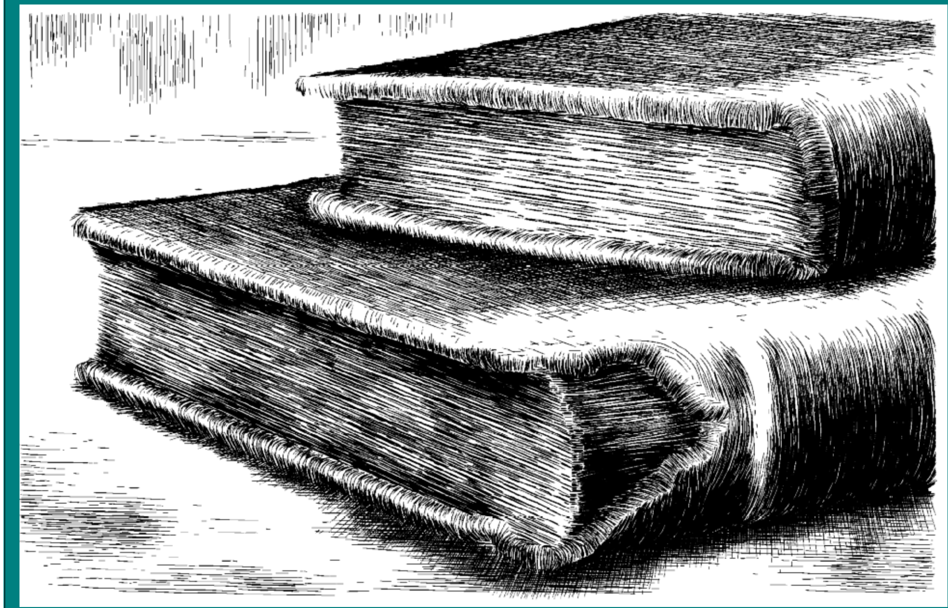
- Salisbury et al. ‘97

Rendering Process

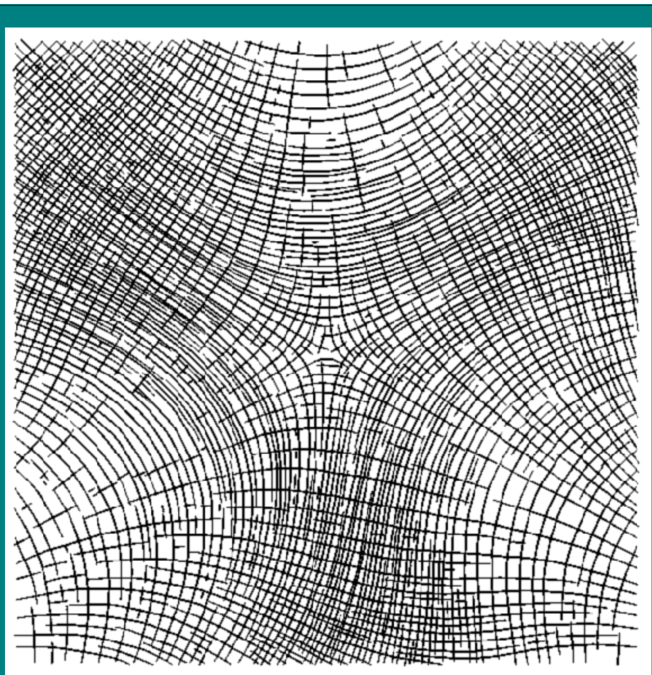
- Match illustration tone to target
  - each stroke increases region darkness
  - difference image compares tone images to blurred illustration
  - importance image generated from difference image, also maintains separation
- Stop when importance image reaches termination threshold

Rendering Details

- Strokes oriented and bent
- Strokes clipped to stay within boundaries
- Incremental calculation of difference image
- Lightening factor to handle tone differences
- Stroke enhancements in printing
  - variable width
  - wiggles



• Salisbury et al. '97



• Salisbury et al. '97

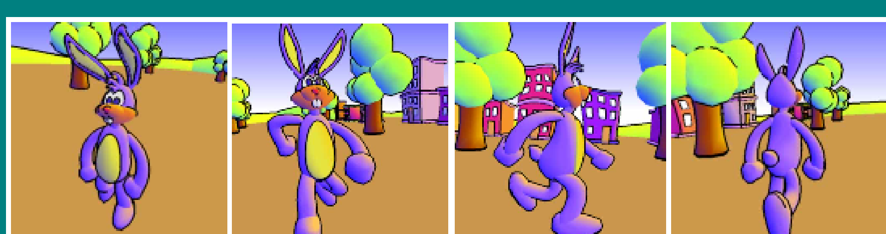
• Salisbury et al. ‘97

• Salisbury et al. ‘97

• Salisbury et al. '97

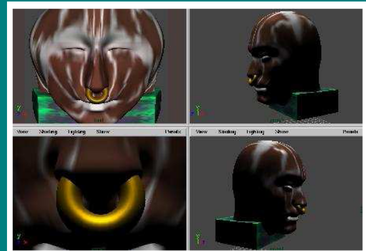
Geometry and Perspective

- Use non-rigid geometry or non-linear perspective
- Key issues:
  - Capturing key geometric features
  - Overcoming obscuration
  - Preserving relationships

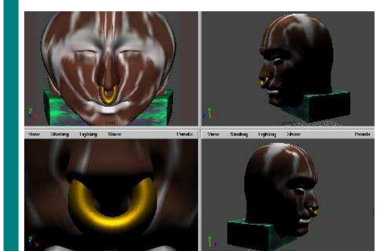


Geometry and Perspective

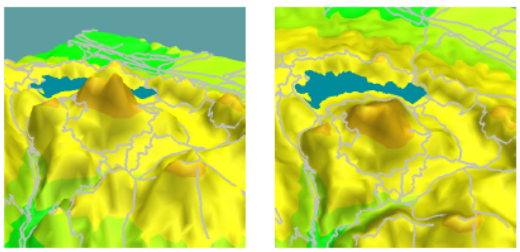
- Papers
  - Rademacher99
  - Singh02
  - Takahashi02



(a) Nose camera active



(b) Nose camera inactive



(a) (b)

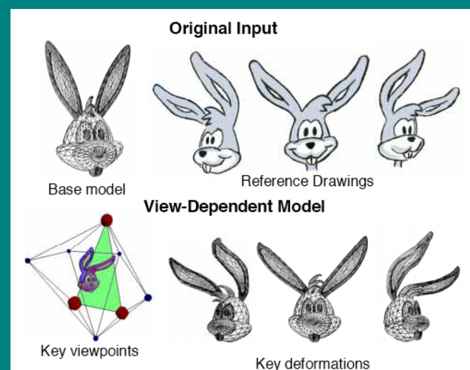
View Dependent Geometry

Paul Rademacher

SIGGRAPH 99

View-dependent Geometry

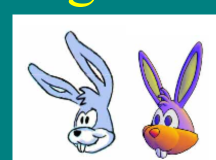
- Replicate view-specific distortions common to cel animation
- View-dependent model
  - 3D model
  - Set of view-specific deformations

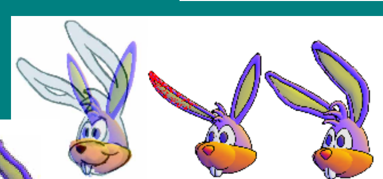


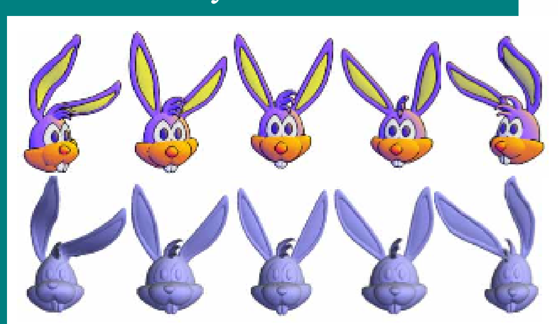
Rademacher, '99

View-dependent Rendering

- Rendering
  - Identify closest reference viewpoints
  - Interpolate between nearby models







Rademacher, '99

Time-dependent Deformations

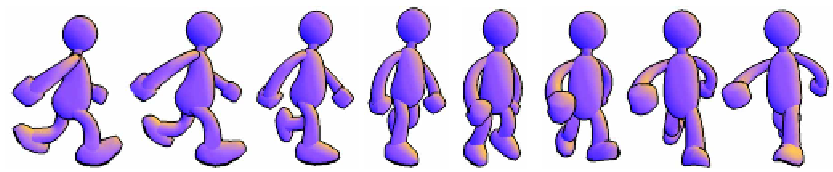


Figure 11 The base (undeformed) model animated over time, viewed by a rotating camera. At each frame, both the base model and the viewpoint changes. Since this is a conventional animated model, there are no viewpoint-specific distortions.

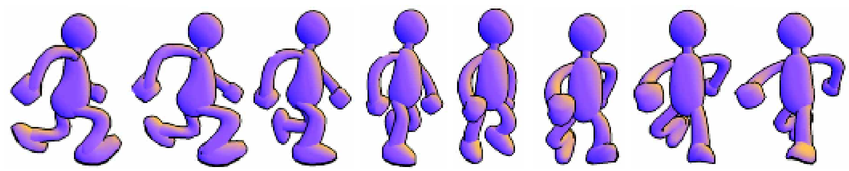


Figure 12 The view-dependent model animated over time, viewed by a rotating camera. The animated model's shape changes based on the viewpoint. The distortions of Figure 9 are seen in the 2nd and 7th frames – all other frames use offset-interpolated deformations.

Rademacher, '99

Specific Media: Algorithms

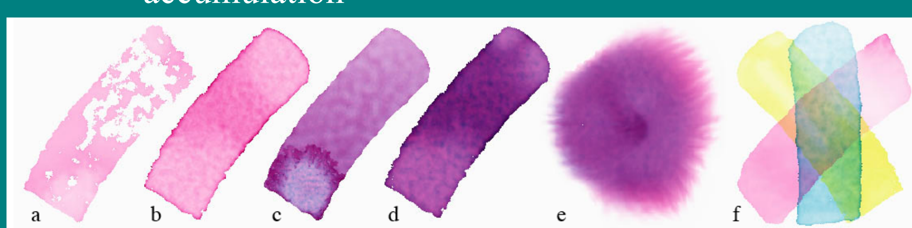
- Mimic appearance of a media/style
- Issues
  - Define appearance rules/characteristics
  - Automate steps in creation

Specific Media: Algorithms

- Papers
  - Stippling: Deussen00
  - Mosaic: Hausner01
  - Batik: Wyvill04

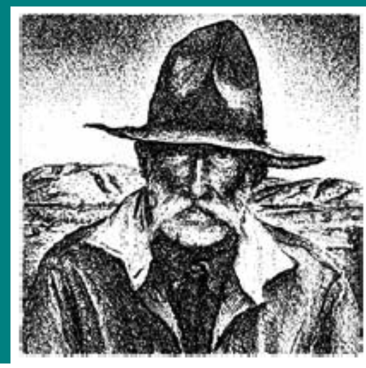
Specific Media: Physical Simulation

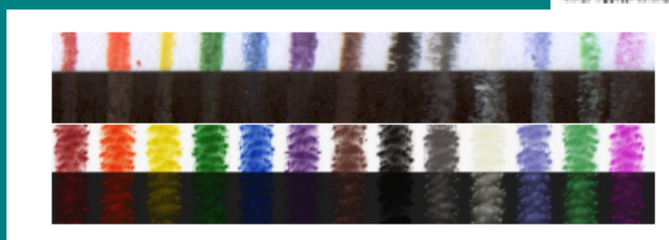
- Create image through physical simulation of process of creation
- Issues
  - Model physical properties of surface and art supplies
  - Accurately model mechanism of transfer and accumulation



Specific Media: Physical Simulation

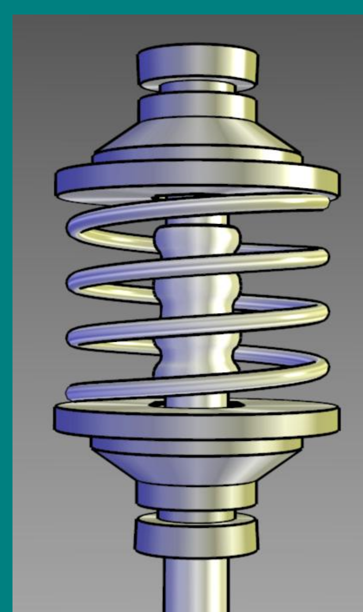
- Papers
  - Watercolor: Curtis97
  - Pencil: Sousa00
  - Crayon: Rudolf05





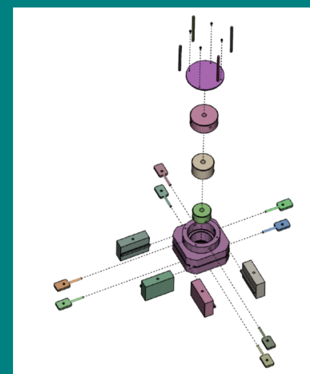
Illustration

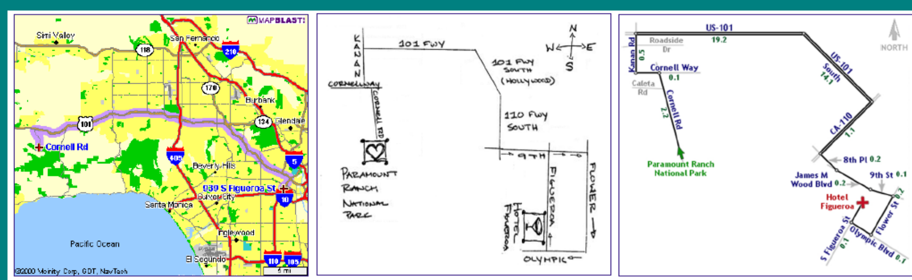
- Create images in style of scientific or technical illustration
- Issues:
  - Clearly convey shape
  - Abstract away unnecessary detail



Illustration

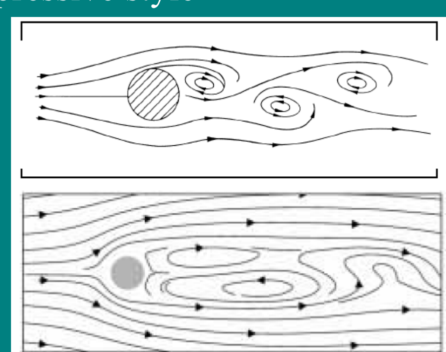
- Papers
  - Tone/silhouettes: Gooch98
  - Route maps: Agrawala01
  - Assembly instructions: Agrawala03





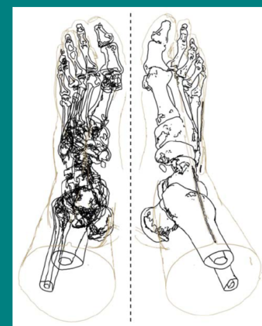
Illustrative Visualization

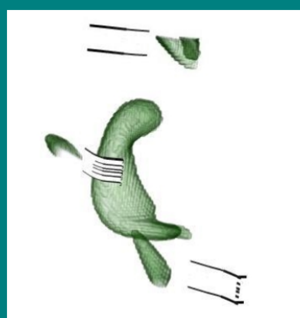
- Create illustration-style images from data
- Issues:
  - Identify features of interest
  - Render features in expressive style

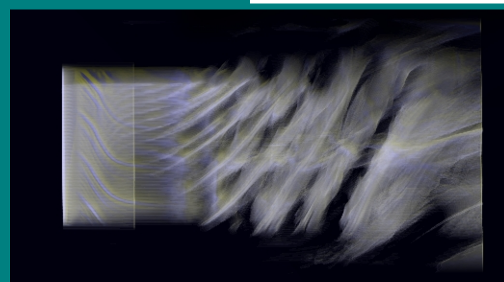


Illustrative Visualization

- Papers
  - Lines from 2D flows: Turk96
  - Lines from volumes: Burns05
  - Flow volumes: Rheingans01
  - Flow illustration: Joshi05

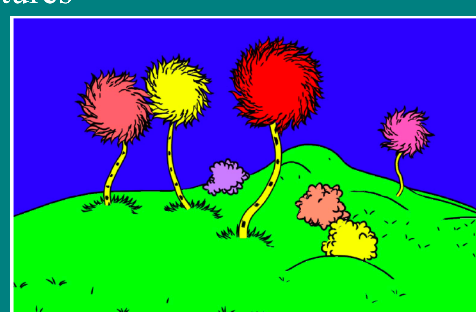






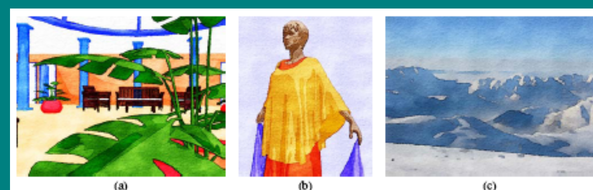
Animation and Real-time AR

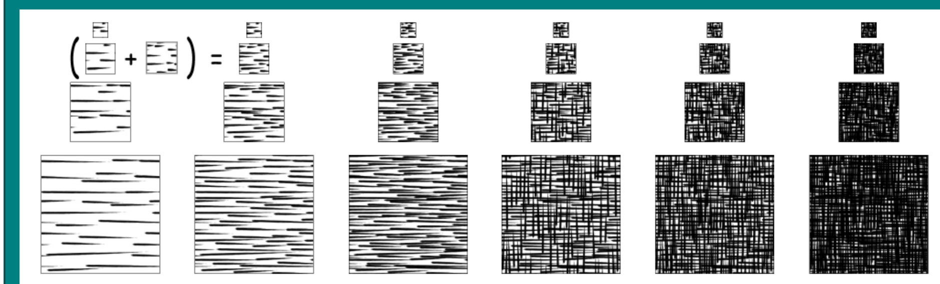
- Generate artistic renderings fast enough for interactive rates
- Issues
  - Ensure frame-to-frame coherence
  - Pre-build stroke textures
  - Exploit hardware



Animation and Real-time AR

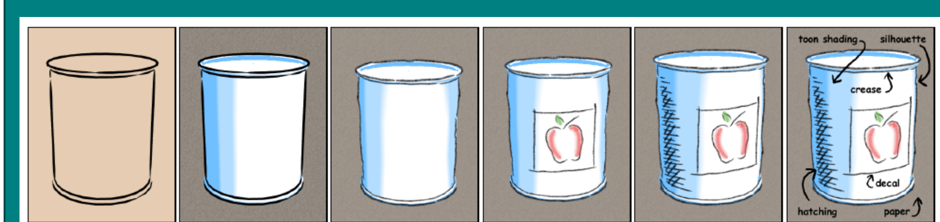
- Papers:
  - Kowalski01
  - Praun01
  - Bousseau06





Systems and Strategies

- Analyze AR systems and unifying strategies
- Issues
  - Address implementation issue
  - Identify unifying concepts



Systems and Strategies

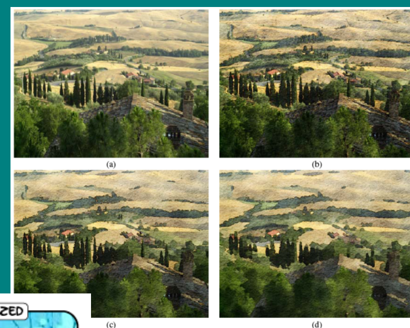
- Papers:
  - Kalnins02
  - Hertzmann03

Abstraction

- Derive meaningful abstractions of dense models
- Issues:
  - Identify most important features
  - Direct attention to most important features

Abstraction

- Papers:
  - Sketch: Sousa03
  - Motion: Nienhaus05
  - Video: Winnemoller06



Learning/Specifying Styles

- Learn new styles or compactly specify appearance
- Issues:
  - Capture characteristics and mechanism of styles
  - Parameterize styles

Learning/Specifying Styles

- Papers:
  - Hertzmann01
  - Lum05
  - Lu05
  - Shugrina06