

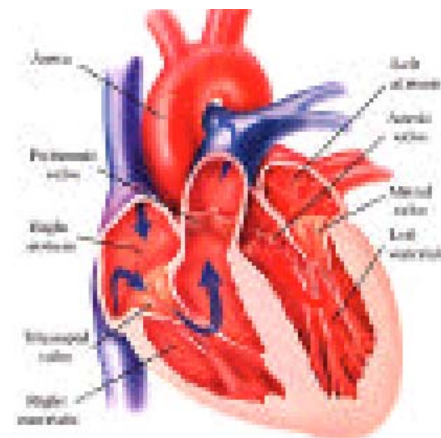
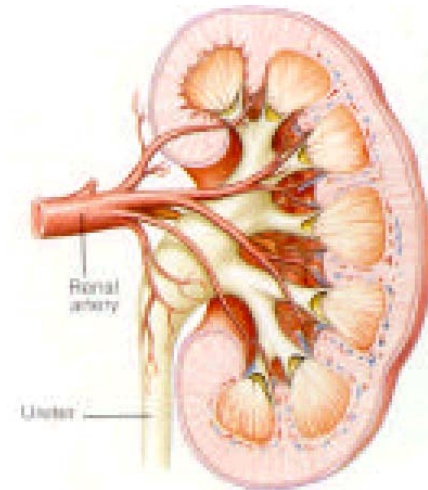
# Non-Photo Realistic Rendering

Jian Huang

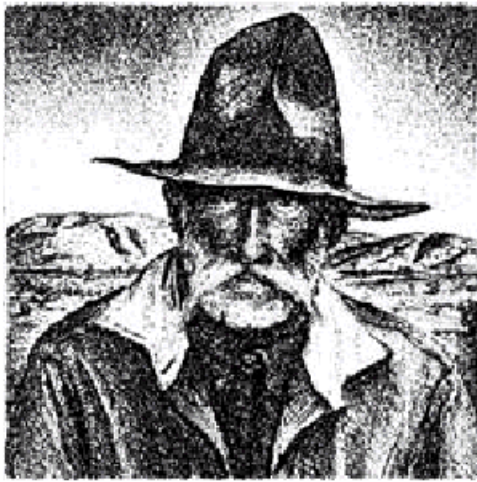
# P and NP

- Photo realistic has been stated as the goal of graphics during the course of the semester
- However, there are cases where certain types of non-photo realistic effects may be favored
  - Illustration: let's show what is the most important (however you define importance) and neglect irrelevant details
  - Painterly drawing
  - ....

# Examples of NPR (illustration)



# Examples of NPR (painterly drawing)



How can computer graphics handle  
traditional art and illustration?

# Simulating Drawing & Painting

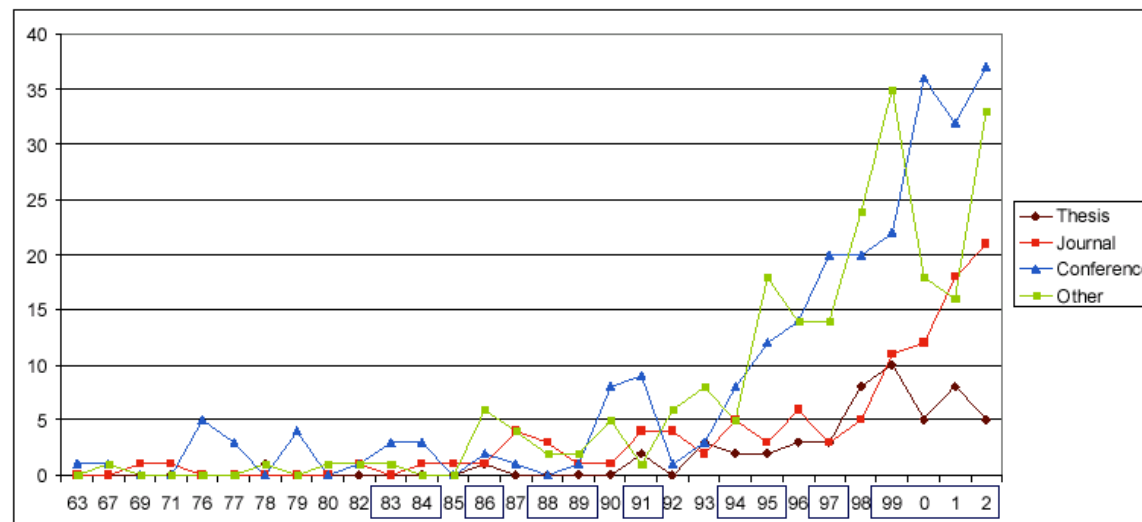
- Two parallels can be followed: science + art
- Processes, materials, information from scientific analysis

## → Media :

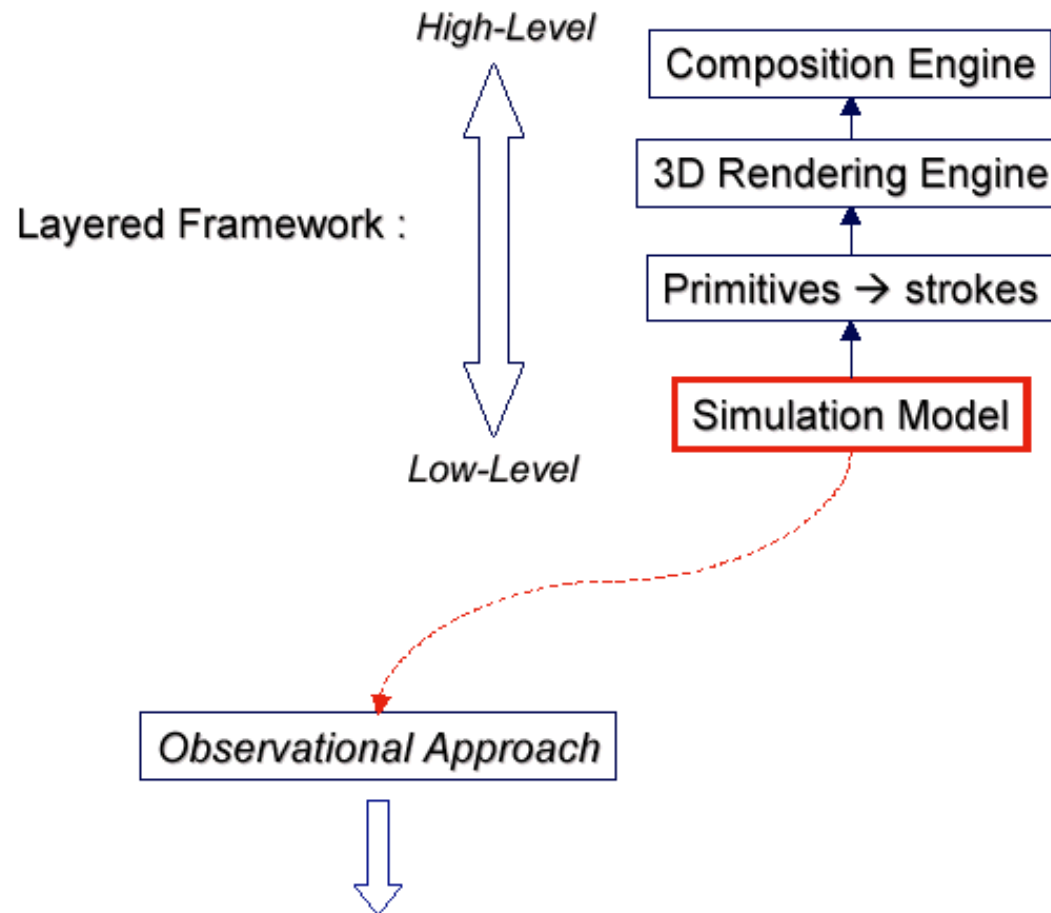
- Pen-and-Ink (91, 94, 99)
- Pencil (89, 99, 00, 01)
- Charcoal (99, 01, 02)
- Paint (84, 92)
- Watercolor (91, 97, 01)

## → Tools :

- Brushes (83, 86, 91)
- Curve Fitting (94)
- Multi-resolution (94, 95)

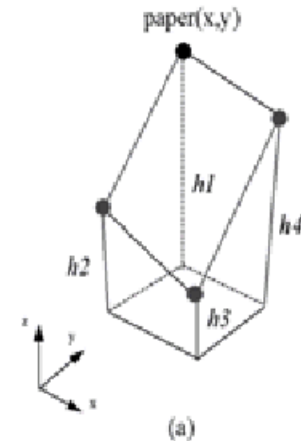
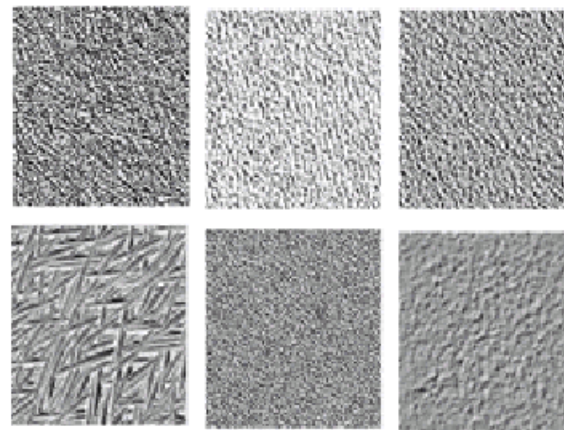
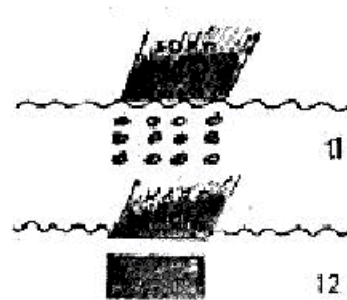
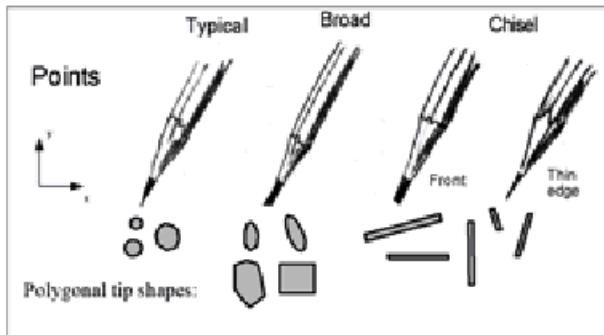


# A Layered Framework



# Among many possibilities, let's look at one in as an example

- Pencil + Paper Interaction





# Pencil Paper Interaction

FOR each new pencil position over paper

Evaluate polygonal tip shape

Setup paper lead threshold volume

Distribute pencil pressure

FOR each paper grain interacting with pencil tip

    Compute grain porous threshold volume

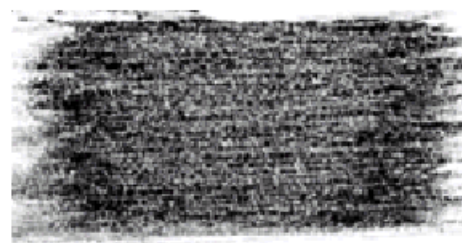
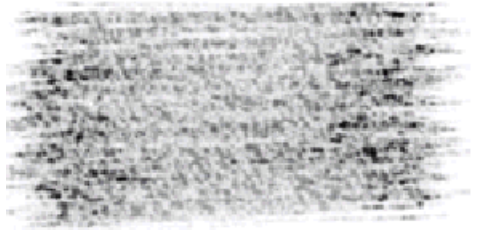
    Process grain biting the lead

    Compute paper damage

    Compute reflected lead intensity

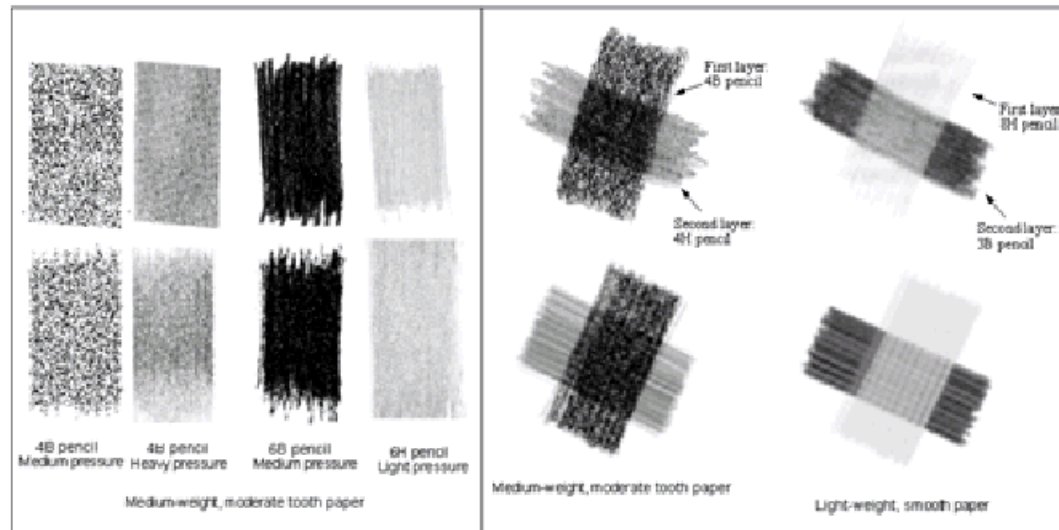
# Pencil Paper Interaction

- After resolving many issues, and adding operations like smudging, ...
- Paper damage:



# Creating Tones

- From paper damage, different tones can be created



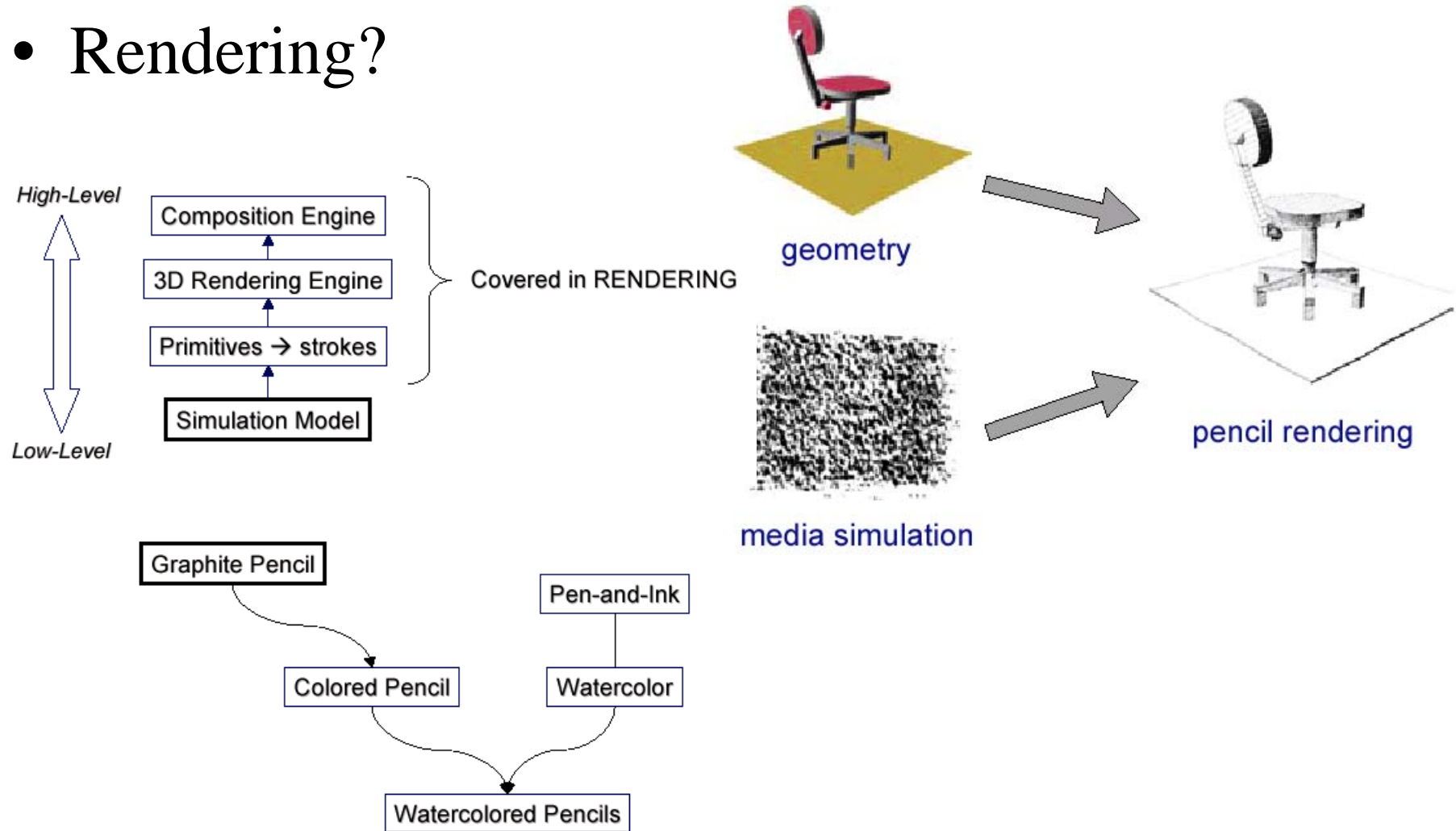
# Resulting Images

- So, what is the missing link between varying tones and shading?













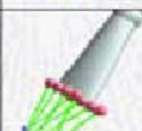

# Putting It All Together

- Rendering?



# More sophistication

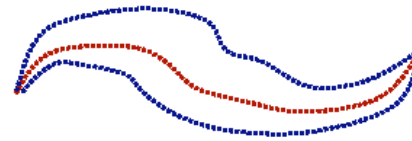
- The simulation can be more complicated like a 3D brush:  
Geometry + Physics + Behavior

Type	Examples	Model	Structure	Surface
Round				
Flat/ Bright				
Filbert				



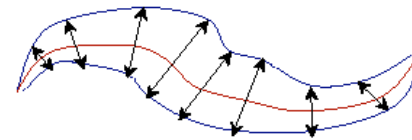
User via keyboard:

→ positions + pressures

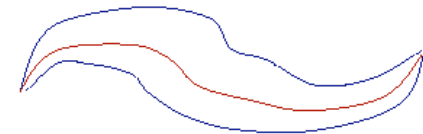


→ (red) B-spline #1 : position (x, y)

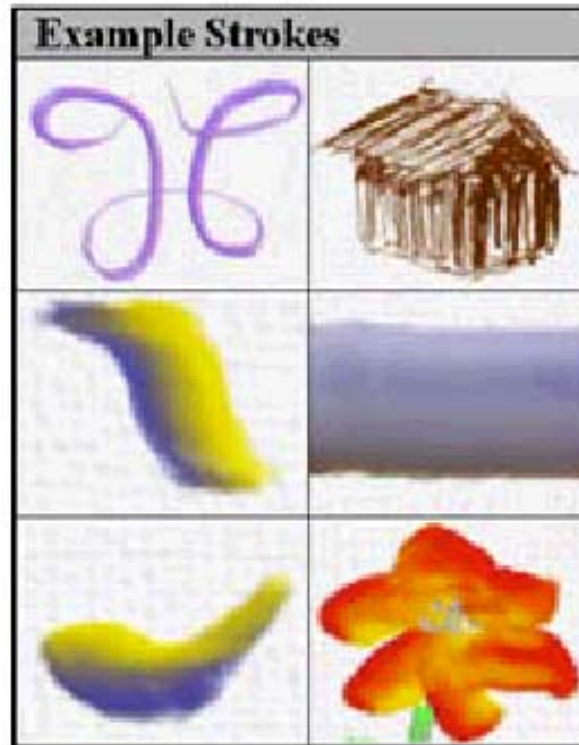
→ (blue) B-spline #2 :  
pressure and distance (p, d)



→ unit normals + width:



# Images with Brushes



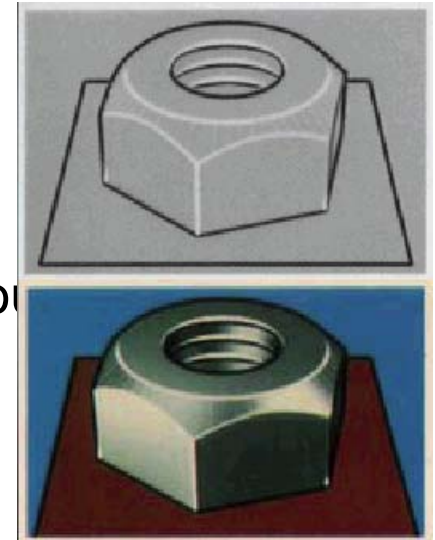
Now that we know what tools we have, let's start drawing

- Feature line drawing: silhouettes, contour lines
- Toon shading
- Illustration
- ...



# Feature Line Drawing

- The most important perceptual cues probably should be critical intrinsic shape features
- Derived from the object geometry
  - Lines of curvature (principal directions)
  - Ridge and valley lines (extrema of curvature along)
- Silhouettes
  - separate figure from ground separate figure from ground
- Contour lines
  - emphasize discontinuities
  - in depth (*viewpoint dependent*)
  - in curvature in curvature (*viewpoint independent*)

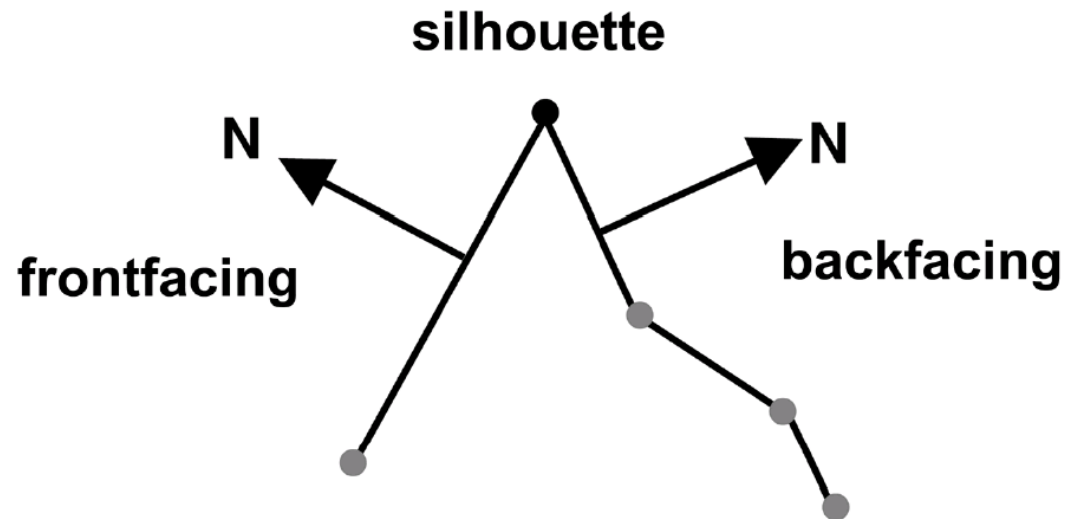


# Definition of Silhouette

- All points on an object surface with normal perpendicular to the viewing ray
- This include both
  - Internal silhouette
  - Object's outline (aka halo)
- The silhouette set are view dependent and can be computed in
  - object space, or
  - image space (often involves image processing operators like edge detection)

# Silhouette Set for Polygon Meshes

- All edges shared by a front and back facing polygon



# Example Obj Space Silhouette Algo's

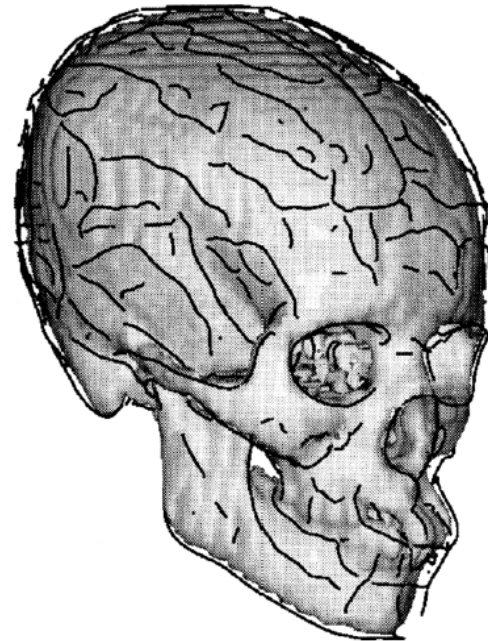
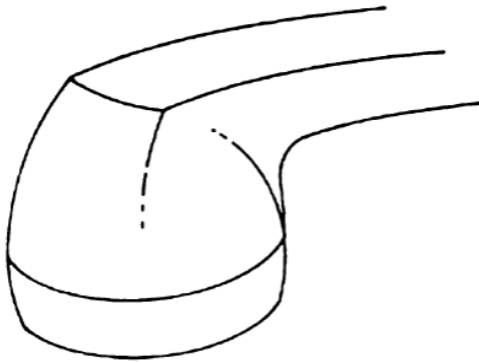
- Brute Force – Iterate through each edge in a polygonal model and test whether each edge is a silhouette edge.
- Edge Buffer – Using the “Edge Buffer” data structure to iterate over facets instead of edges.
- Gauss Map Arc Hierarchy – The angles of arcs between front and back facing polygons are stored in a tree structure.
- Normal Cone Hierarchy – Polygon normals are grouped into cones and these cones are stored in a tree structure.

# Example Img Space Silhouette Algo's

- Two Pass Methods – Back facing polygons are rendered first with either their depth decreased or their field of view narrowed. Front facing polygons are then rendered on top.
- Environment Map – Silhouette lines are added to a shading environment map as a preprocess.
- One Pass Method – During a preprocess phase two cube maps are created, one of surface normals and one of eye linear maps. At runtime per pixel dot products are computed yielding silhouettes.
- Depth Discontinuity Methods – Pixel depth is compared on a per pixel basis, if the depth difference between two pixels is above a user defined tolerance one of the pixels is colored black.

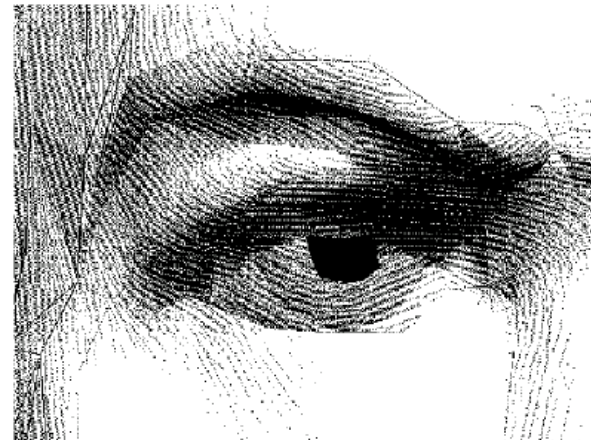
# Other Feature Lines

- Ridge and Valley Lines



# Yet another tool: artistic texturing

- Collection of marks or strokes in a specific arrangement
  - The type of strokes, as well as the density & orientation or alignment define the texture
  - Can convey information as well as enhance visual representation
- To use it, select (emphasize) essential information to be communicated
  - Detail, shape, tone and contrast
  - Reduce unnecessary information
  - Control of detail, tone
  - Convey Shape



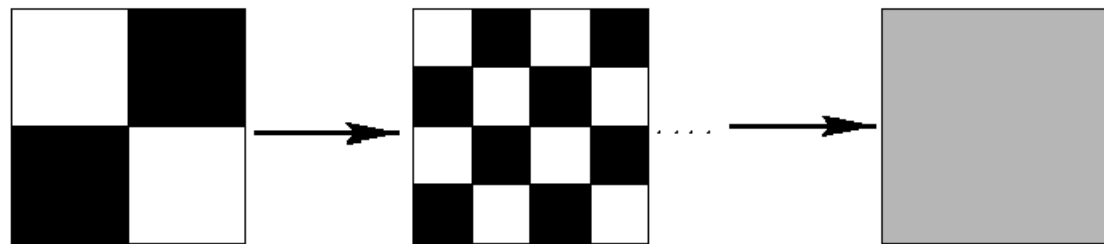
# Approaches

- Geometric:
  - Specialized particals, graftals represent
  - strokes, attached to objects, rendered in screen space.
- Texture:
  - A collection of texture mip-maps with pre-rendered strokes.
- “Toon” shading:
  - Augment (e.g. quantized) conventional shading models
- Animated threshold textures
  - A hybrid of toon shading and texture



# A Long Time Ago ...

- Halftoning:
  - process to represent continuous tone in binary media -print or display (ever heard of dithering?)
- Necessary loss of information due to limited resolution
- Approximate tone by using the human visual system

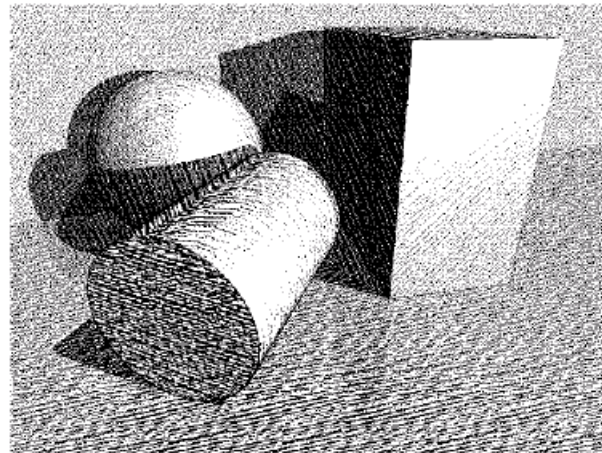


# Adaptive methods

- Inherent loss of information - choose what to preserve
- Selection of dither screen for type of image
- Importance driven halftoning
- The decision of "what to represent" and "how to represent" similar to those artists make to create depictions of real life
- Create real and representative textures

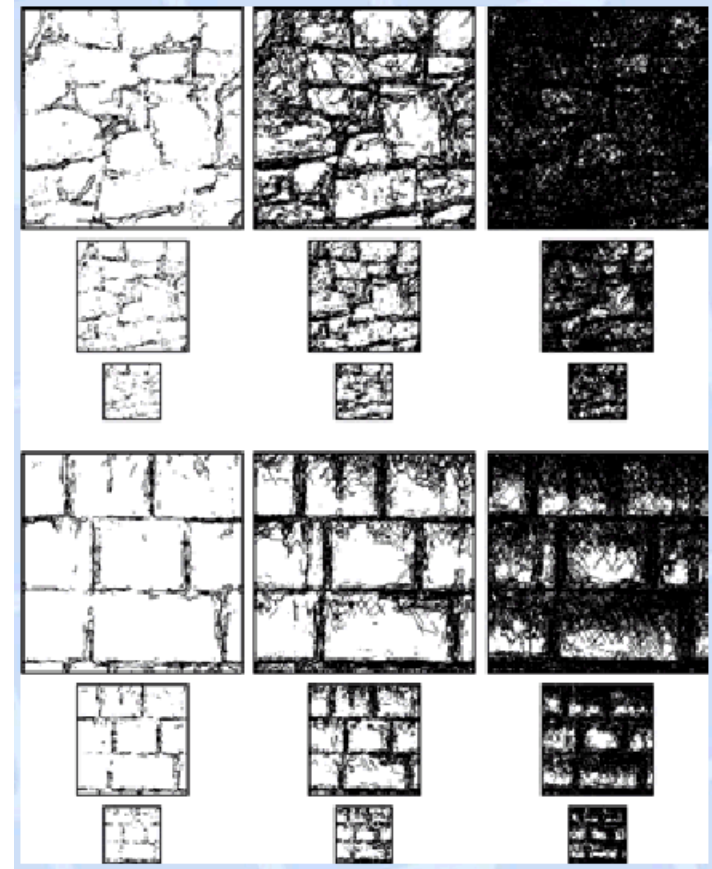
# Halftoning 3D scenes

- Image-based approach:
  - **I**d-buffer-object identifiers
  - **L**-buffer-illumination –shape
  - **N**-buffer-normals – direction
  - **Z**-buffer-depth, edges, and silhouettes shape, contrast

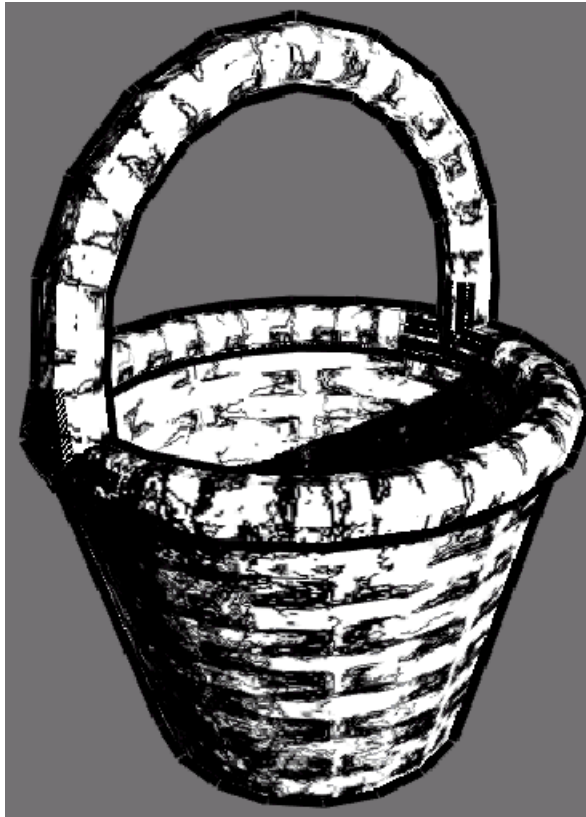


# Textures for real-time NPR

- Principles:
  - Strokes are pre-rendered: a collection of mip-map textures corresponds to a small number of tones. (e.g. TAMs)
  - Consistency of strokes: low resolution stroke set is included in higher resolutions sets
  - Lighter tone set is a subset of the darker stroke set.

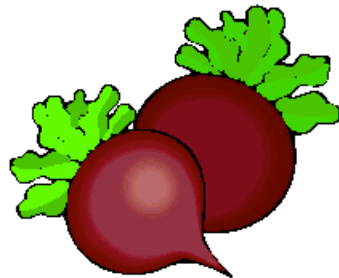
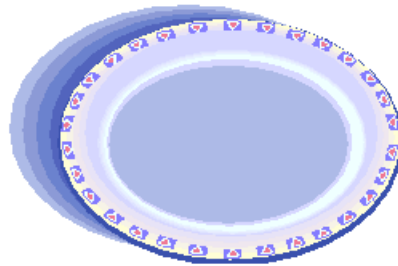


# TAM Results



# Toon Shading

- Toon: cartoon, to show shading effects on a surface patch with only two or three colors



# Other Common NPR Techniques

- Stippling:use a series of properly scaled and spaced spots
- Crosshatching consists in crossing a series of lines of various lengths, widths and at various angles with which the artist constructs areas of tone and texture.

