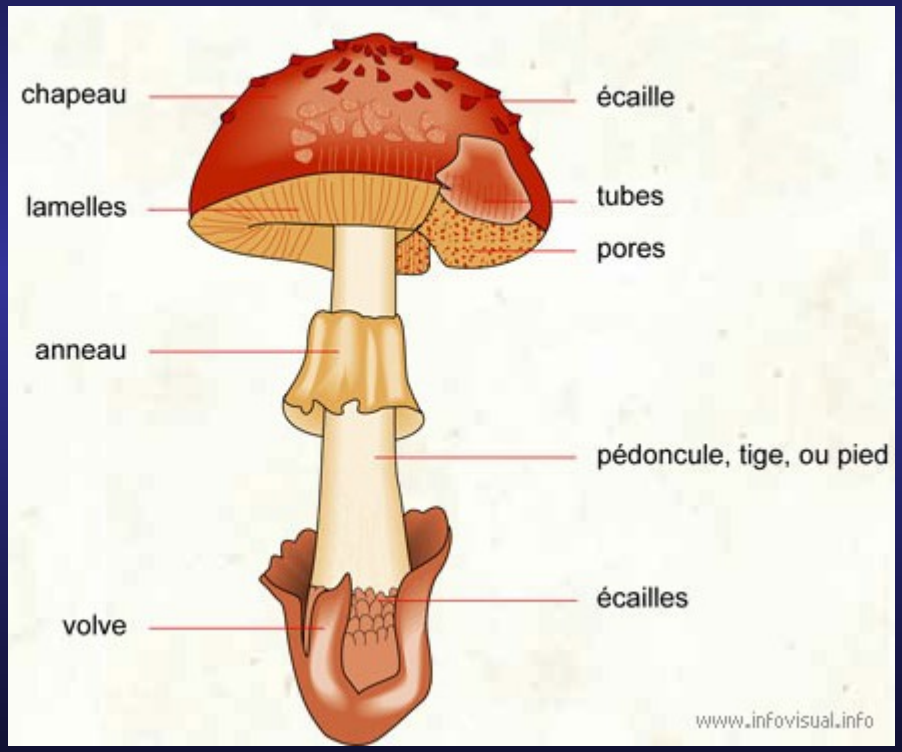
Expressive rendering

Joëlle Thollot

The « Quest for Realism »

$$L_o(x,\vec{w}) = L_e(x,\vec{w}) + \int_\Omega f_r(x,\vec{w}',\vec{w}) L_i(x,\vec{w}')(\vec{w}' \cdot \vec{n}) d\vec{w}'$$

We don't always want photorealism



www.infovisual.info/01/024_fr.html

www.mycomontreal.qc.ca/milletun/Initiation_aux_champignons.htm

Google image « maison »

maison
510 x 318 - 120 ko - gif
www.qctop.com

Deux perspectives de la **maison** ayant ...
800 x 321 - 48 ko - jpg
yapluka.wordpress.com
[Plus de résultats sur yapluka.files.wordpress.com]

Maison à vendre Lille Hellemmes
600 x 450 - 83 ko - jpg
www.achat-maison-lille.fr

Le charme séculaire de la **Maison** ...
550 x 366 - 86 ko - jpg
www.baiedesomme.fr

... de la **maison** constituent un lieu ...
420 x 316 - 22 ko - jpg
www.bretagne.feroc.com

Cette **maison** tire également profit ...
1024 x 732 - 321 ko - jpg
www.le-bois.com
[Plus de résultats sur www.le-bois.com]

Maison de Tiger Wood
720 x 478 - 89 ko - jpg
www.villiard.com

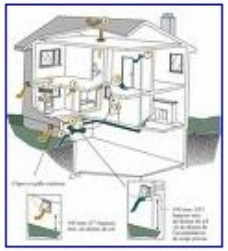
Maison hantée en papier de soie
510 x 507 - 96 ko - jpg
www.teteamodeler.com

Maison 3D
640 x 399 - 34 ko - jpg
www.hervegerard.be

Maison à louer
2272 x 1704 - 1780 ko - jpg
www.pays-basque-tourisme.info

La **Maison** de Gergovie
813 x 559 - 60 ko - jpg
www.ot-gergovie.fr

2/ L'équipe de la **maison** de l'asthme
958 x 1167 - 974 ko - jpg
www.asthme76.com

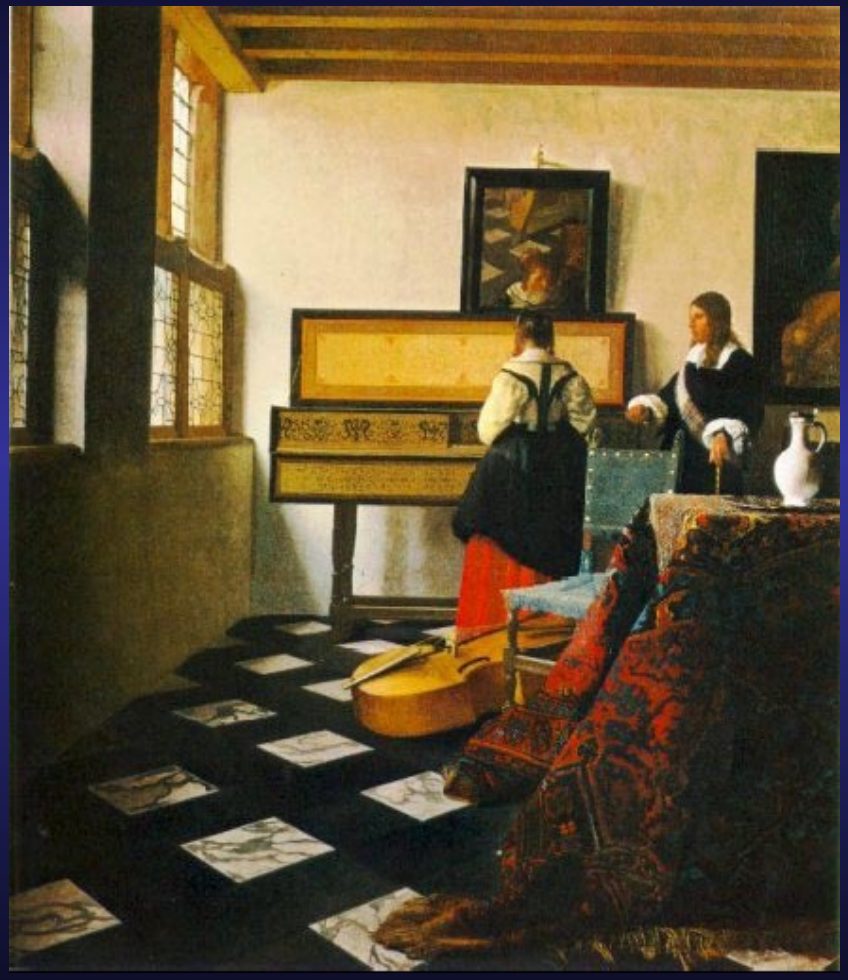


Ventilation de la **maison**
448 x 500 - 43 ko - gif
oee.nrcan.gc.ca

Adieu **maison** de paille, ...
571 x 510 - 430 ko - jpg
www.agoravox.fr

Belle **maison** en pierre de taille, ...
400 x 300 - 40 ko - jpg
www.signalsurf.com

Portait



La jeune fille au virginal – Vermeer

La leçon de musique – Matisse

What are images used for?

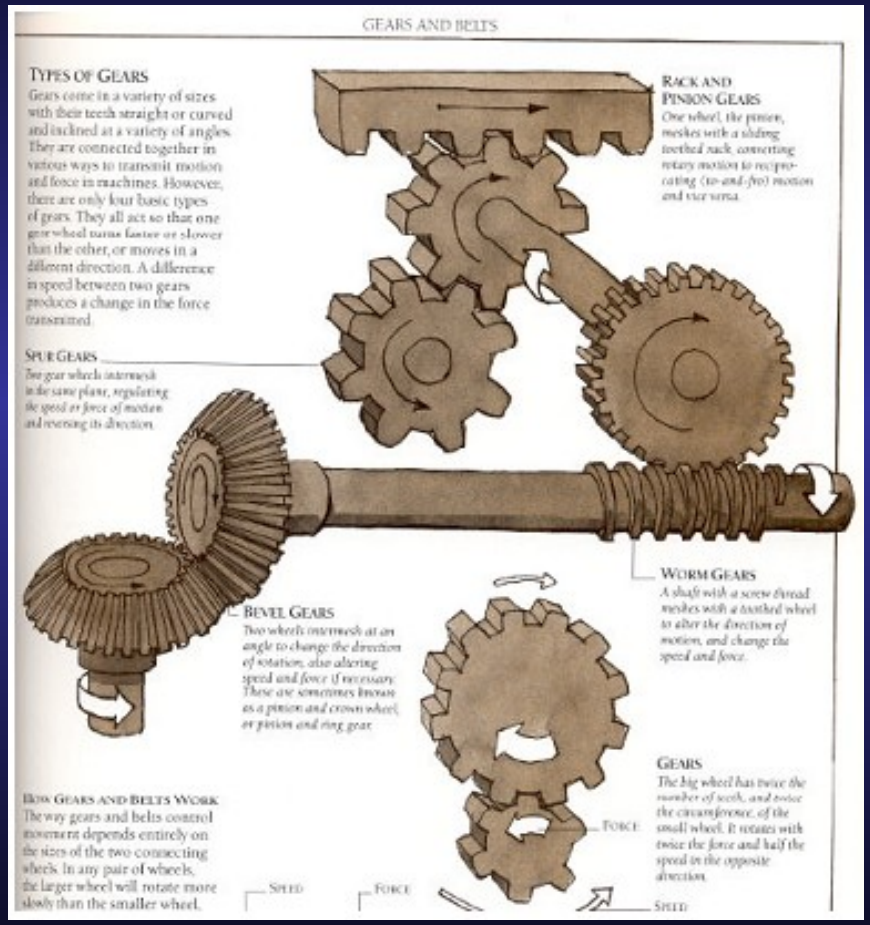
- Give a message
  - Information
  - Emotion
- Depend on the application
  - Architecture
  - Scientific visualisation,
  - Technical doc
  - Teaching
  - Art…

A new question emerges

- How do we create tools for visual communication?

- What are the advantages of illustrations over photorealism?
- What makes an image efficient?

Omitting extraneous detail

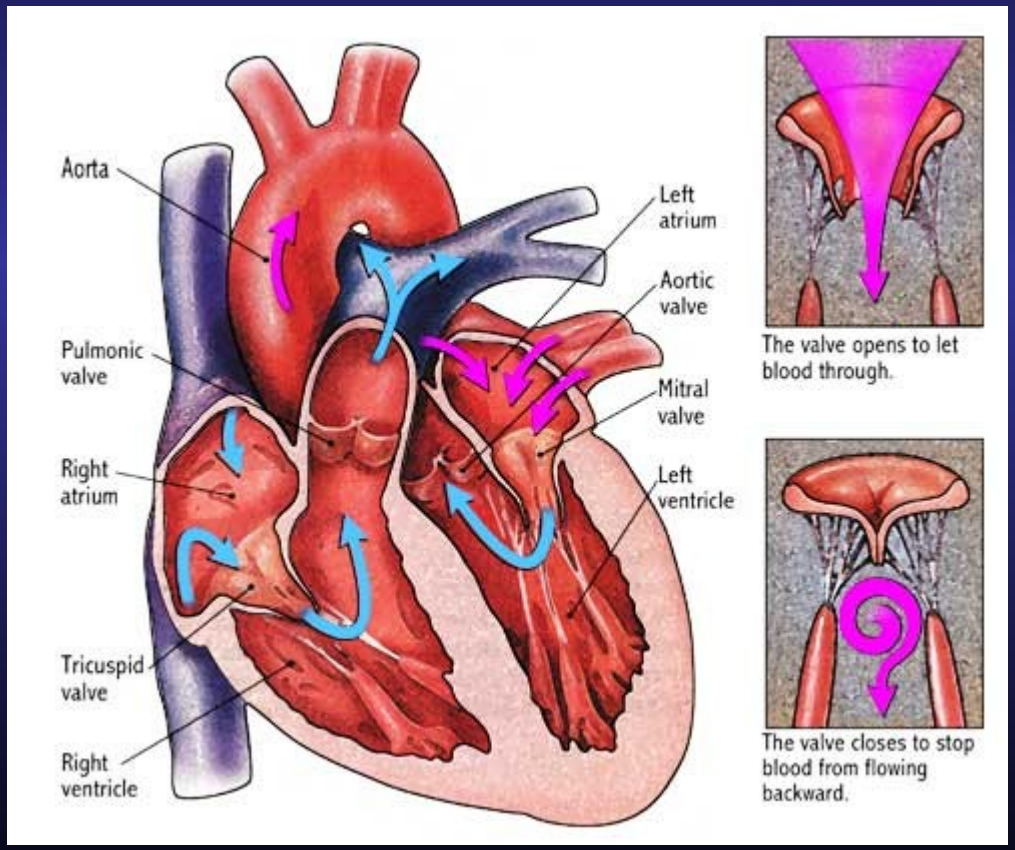


Macaulay: The Way Things Work, 1988

Clarifying & simplifying shapes

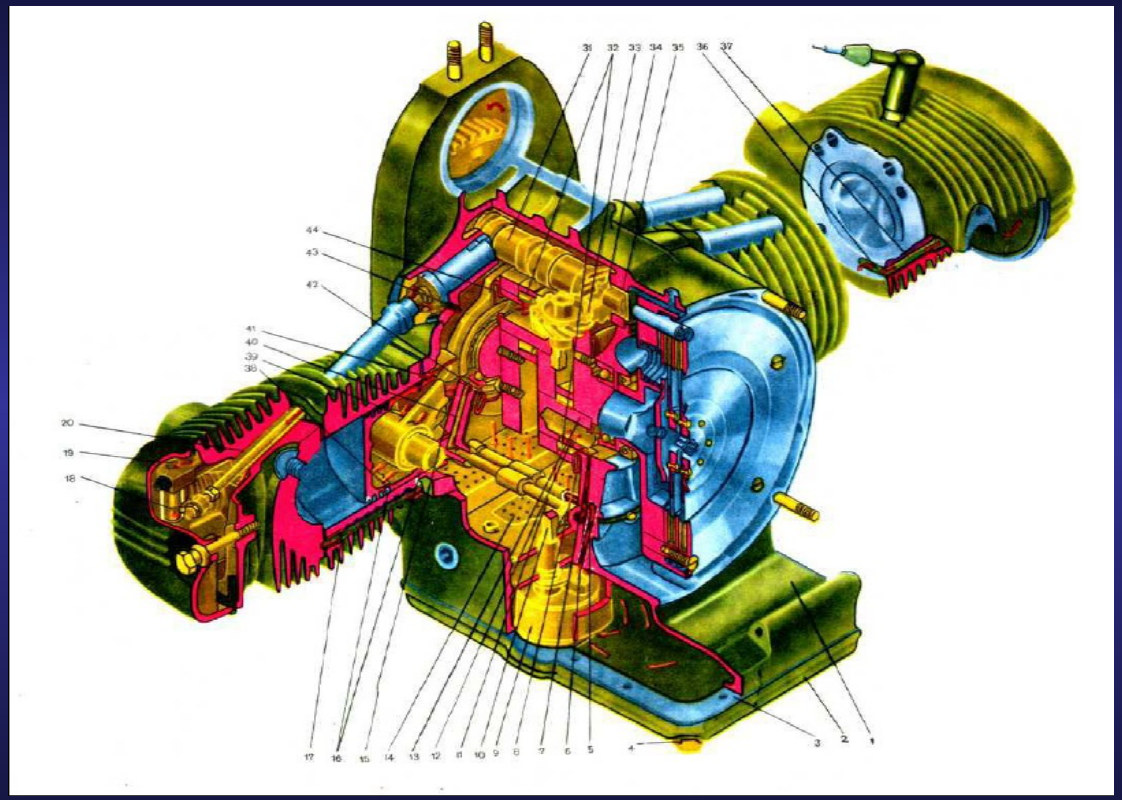
http://www.labiomed.org/cardiology/

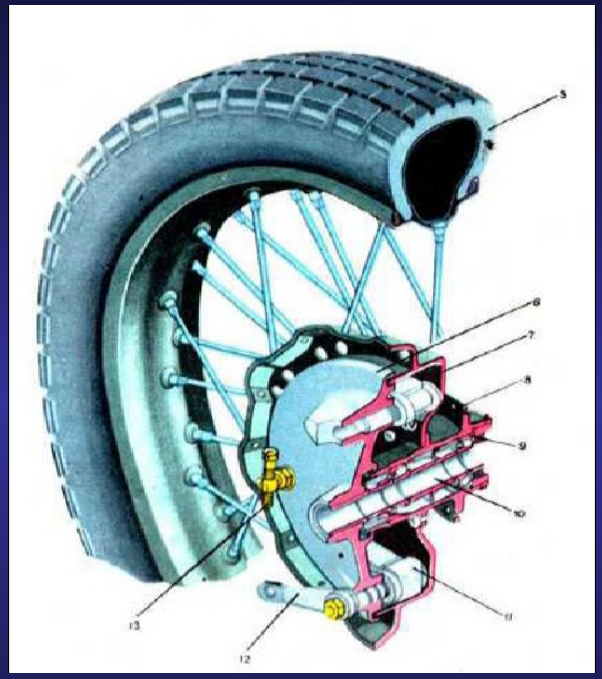
http://www.imagincentres.com/ct.html



http://www.cts.usc.edu/hpg-heartvalvesurgery.html

Exposing parts that are hidden





dnepr.ural.free.fr/Doc_Avtoexport-M66.pdf

Focusing attention

static.howstuffworks.com

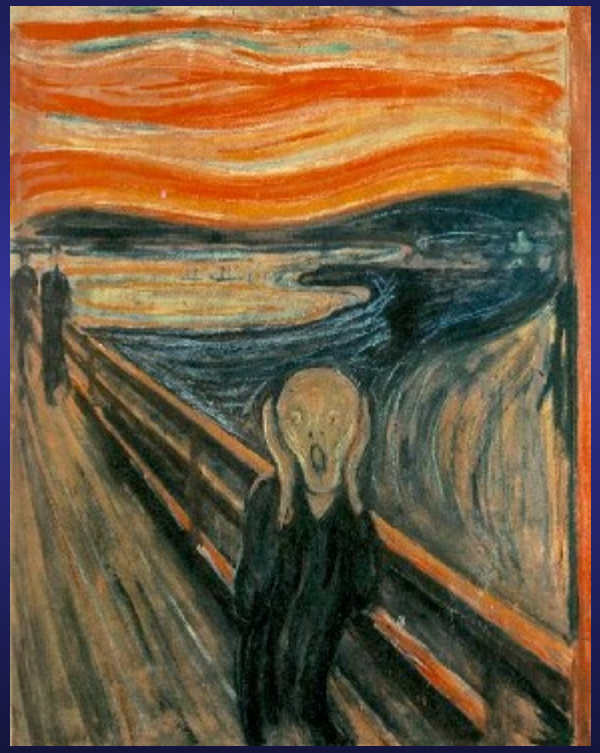
www.lanature.fr

The Stuckeman Family Building for the
School of Architecture and Landscape Architecture

Illustrating approximate ideas

www.artsandarchitecture.psu.edu/news/building_updates/sala/

Conveying mood and emotion



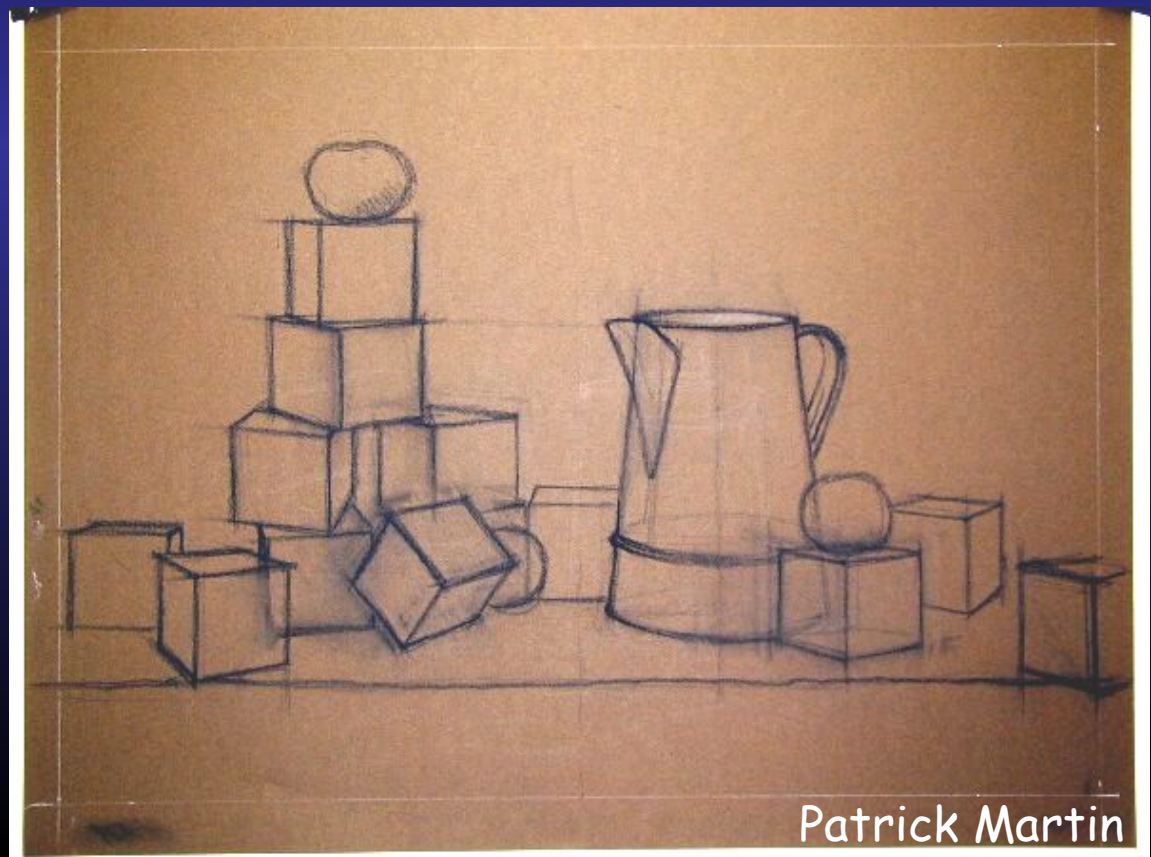
How do we produce such images ?

Actually what is an image?

- 3D scene
  - Objects
  - Materials
  - Shapes
- 2D projection

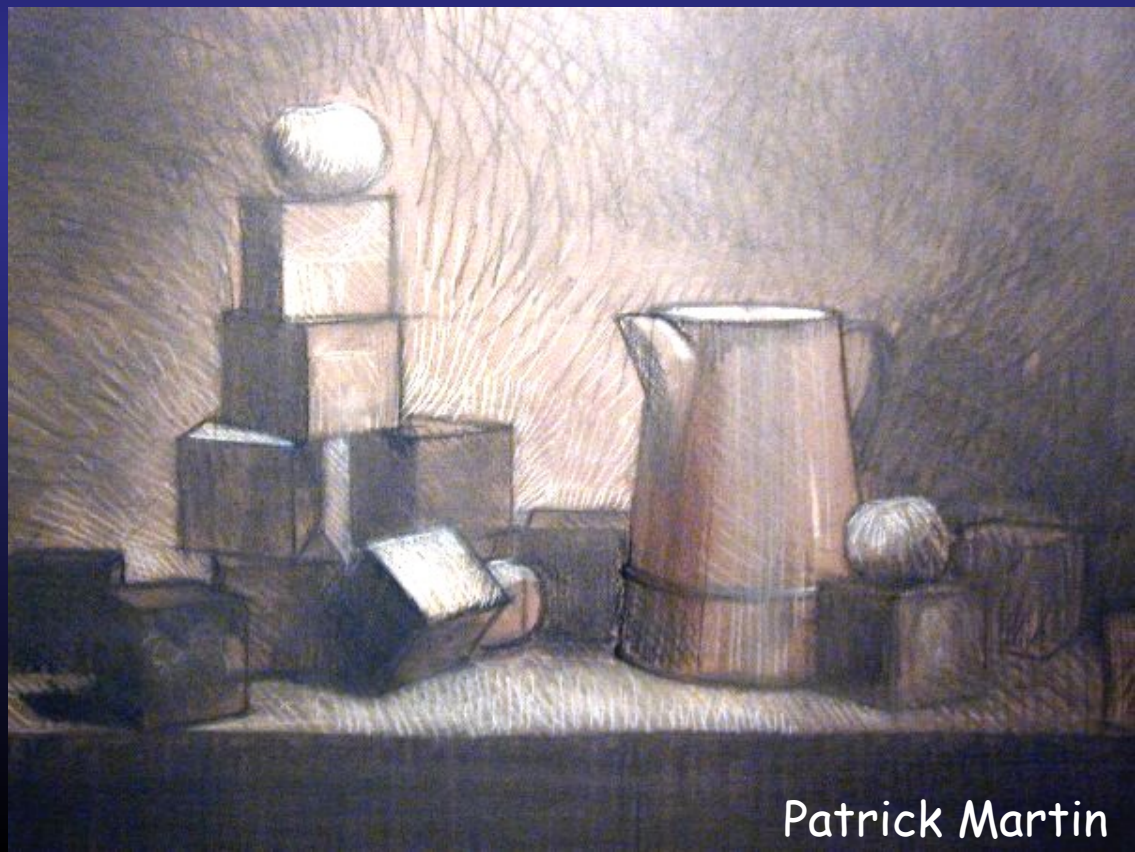
Actually what is an image?

- 2D representation
  - Lines
  - Junctions
  - Regions



Actually what is an image?

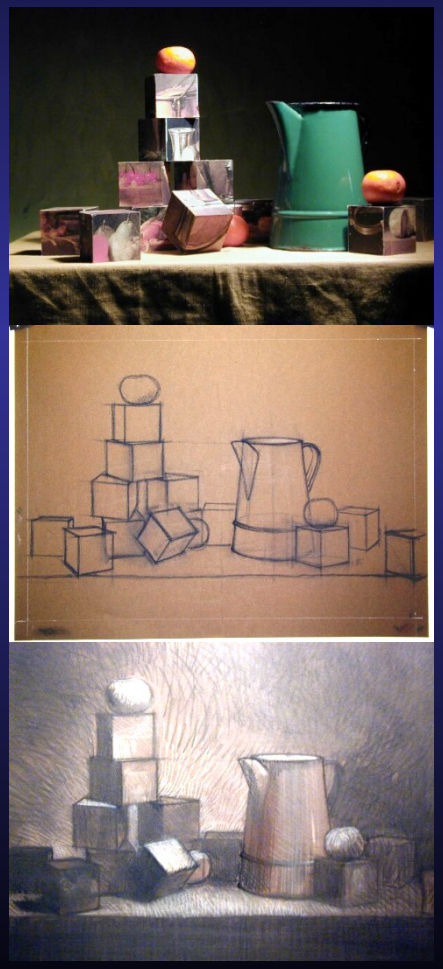
- Medium
  - Haching
  - Pigments
  - Strokes
- Visual cues
  - Light
  - Shape
  - Material



An Invitation to Discuss Computer Depiction

Durand, Willats NPAR 02

- Spatial
  - 3D to 2D
- Primitives
  - Points, lines, regions
- Marks
  - Tool
- Attributes
  - Link everything



An Invitation to Discuss Computer Depiction

Durand, Willats NPAR 02

- Spatial
  - 3D to 2D
- Primitives
  - Points, lines, regions
- Marks
  - Tool
- Attributes
  - Link everything

Style

(part of)

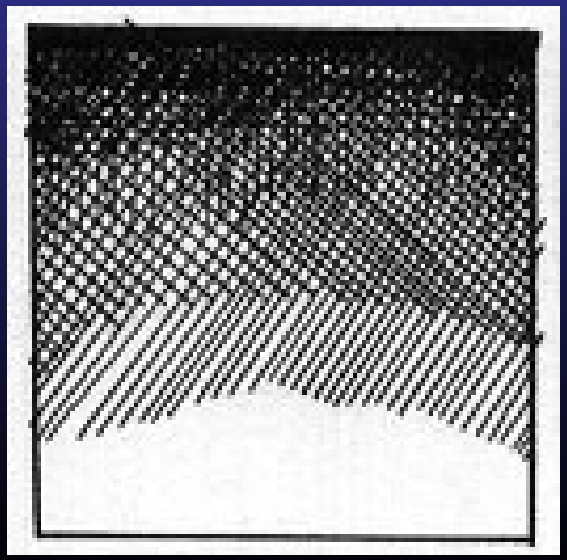
Overview

- Filling the régions
- Lines
- Illumination
- Style

I - Filling

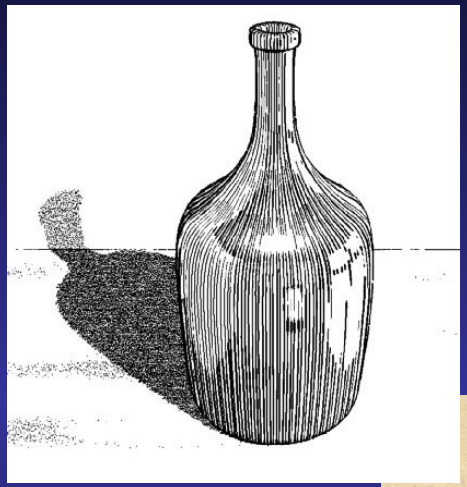
Marks

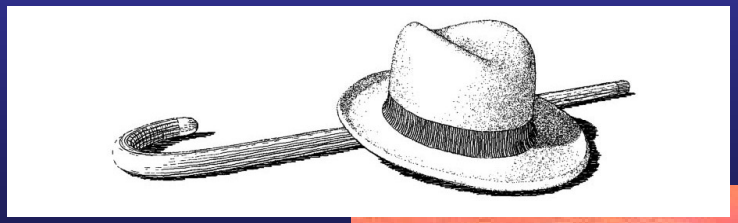
- Physical representation of the medium
  - Region filling
  - Stylisation of lines
- Various styles
  - Pen and ink
  - Watercolor
  - Painting

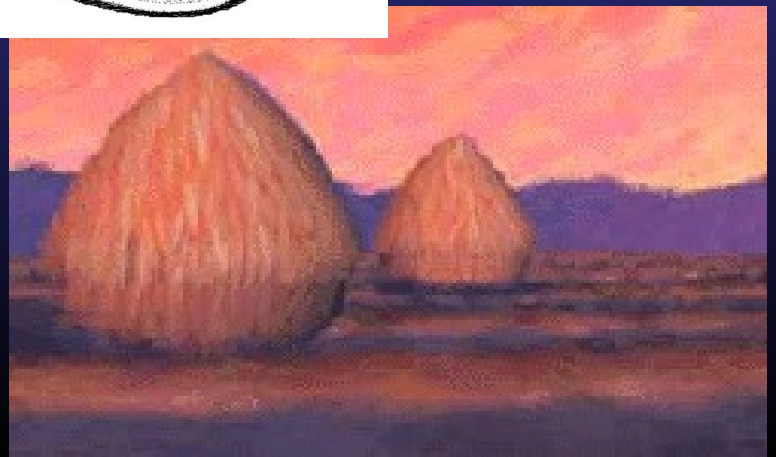


How to describe a medium?

?





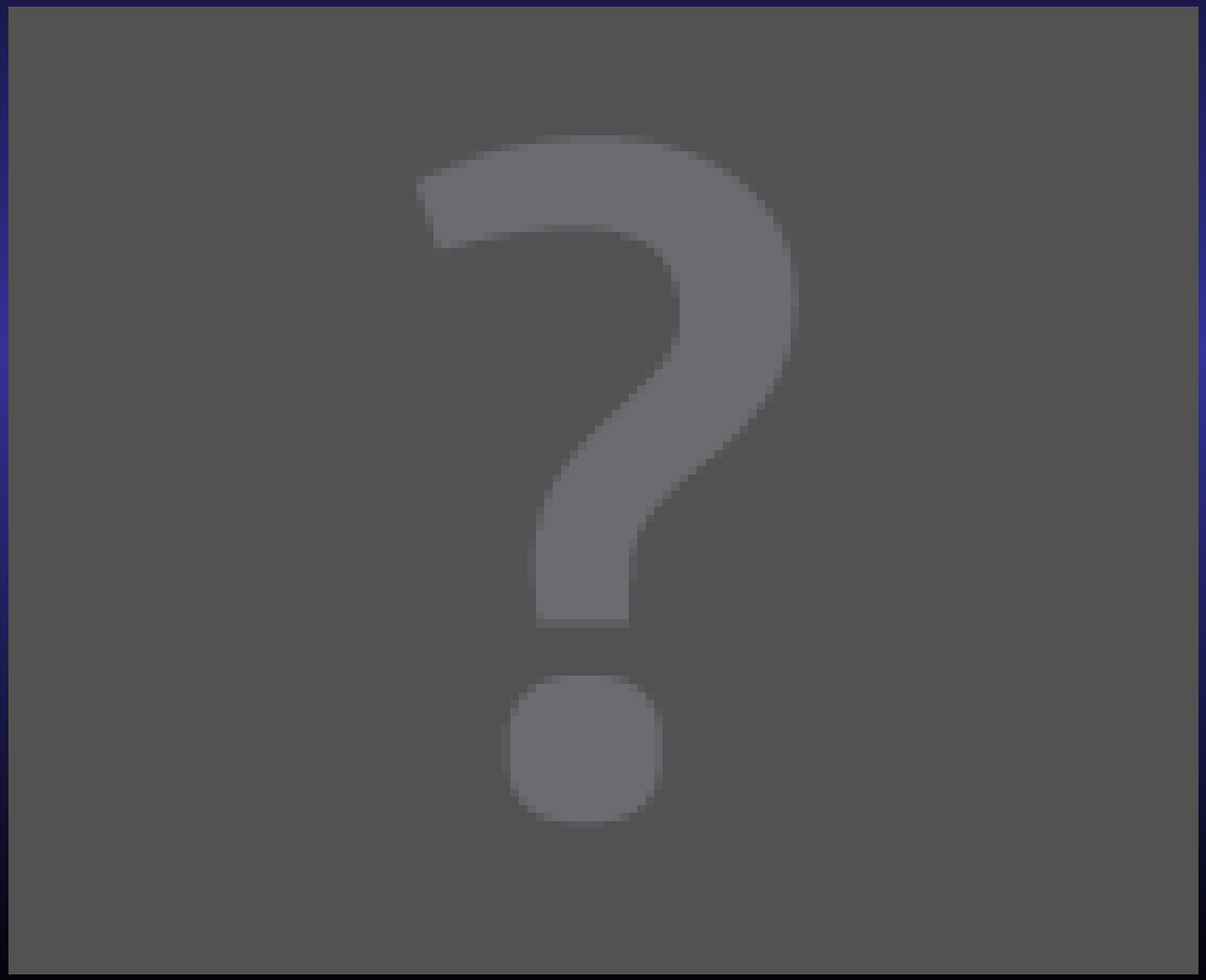


Problems

- Medium simulation
- Temporal coherence for animation

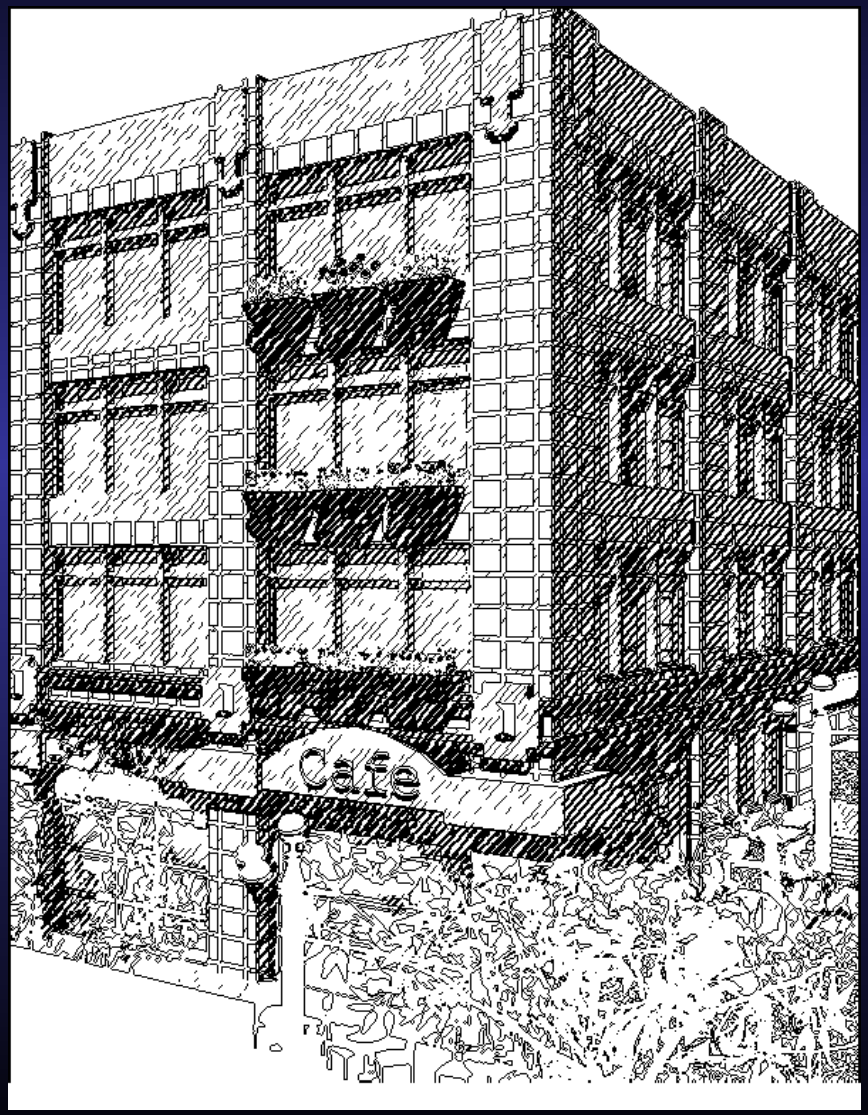
Il pleut bergère

Jérémy Depuydt, *www.toondra.com*

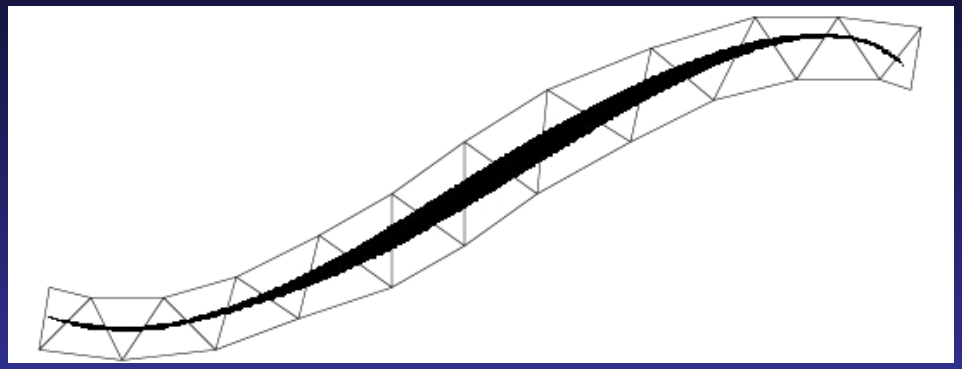


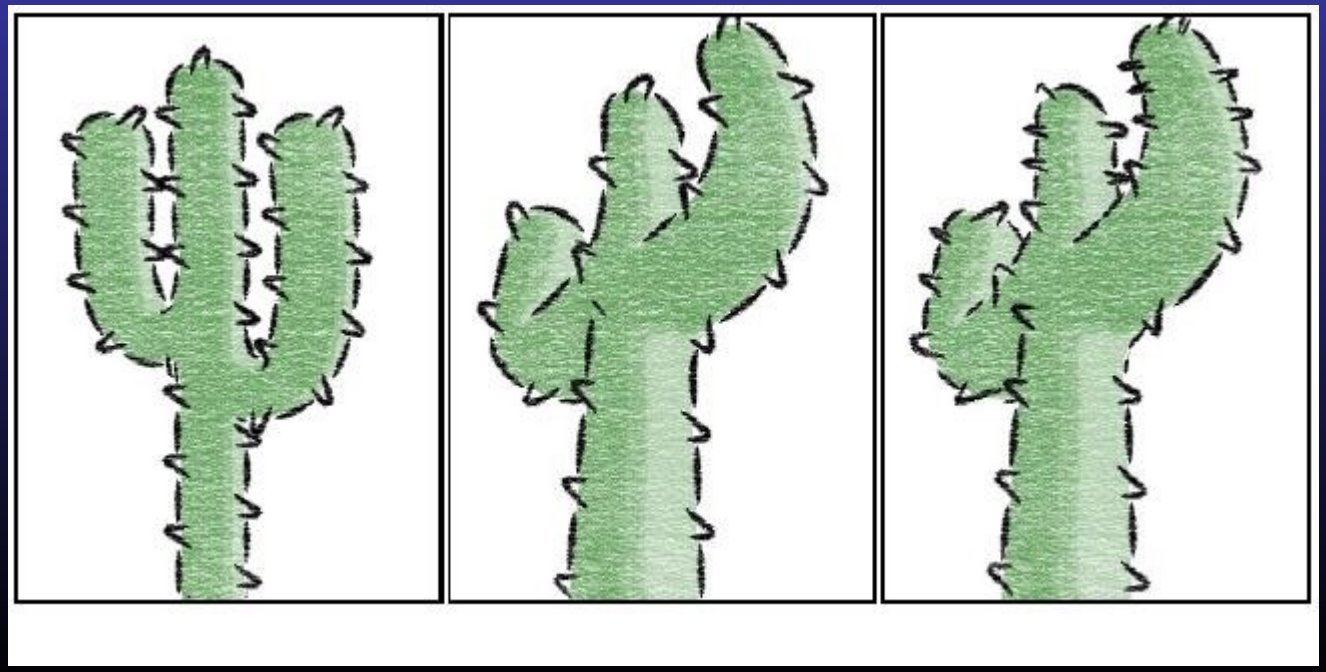
Illustration

- Stylized lines
- Hatchings



Stylized lines



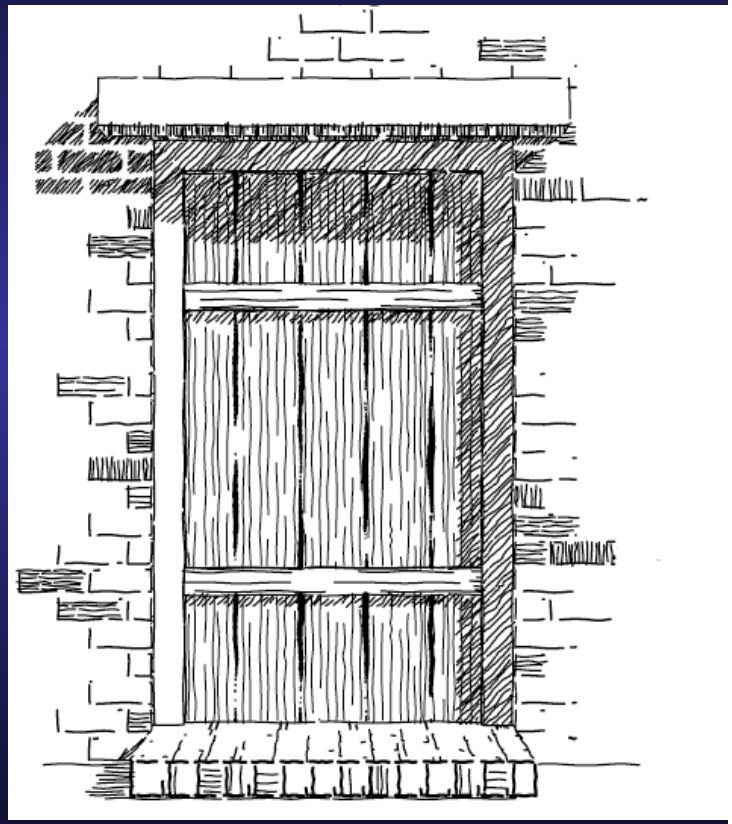


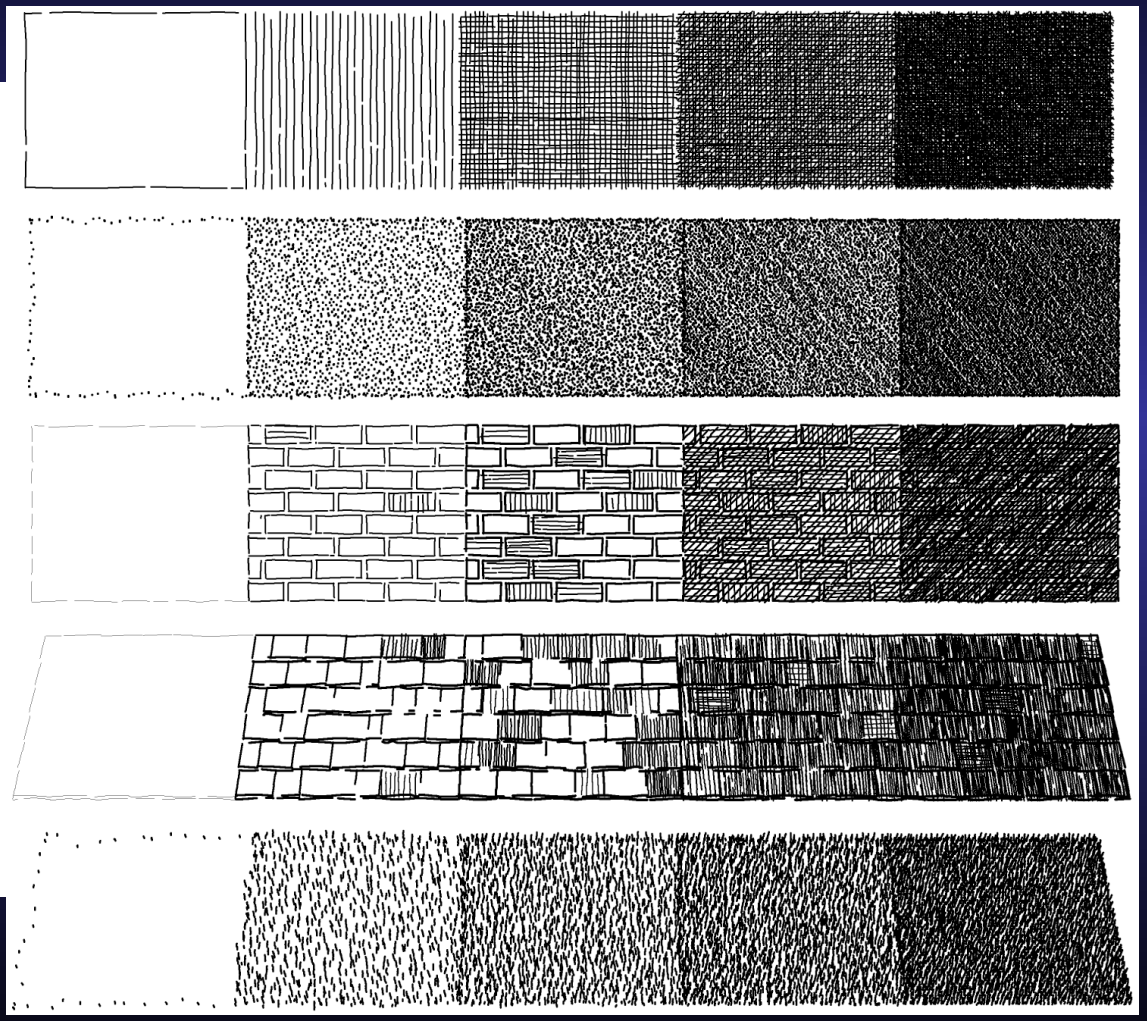
Hatching

- Shape from shading
- Region filling + tone mapping

⇒Attributes (width, orientation) and density

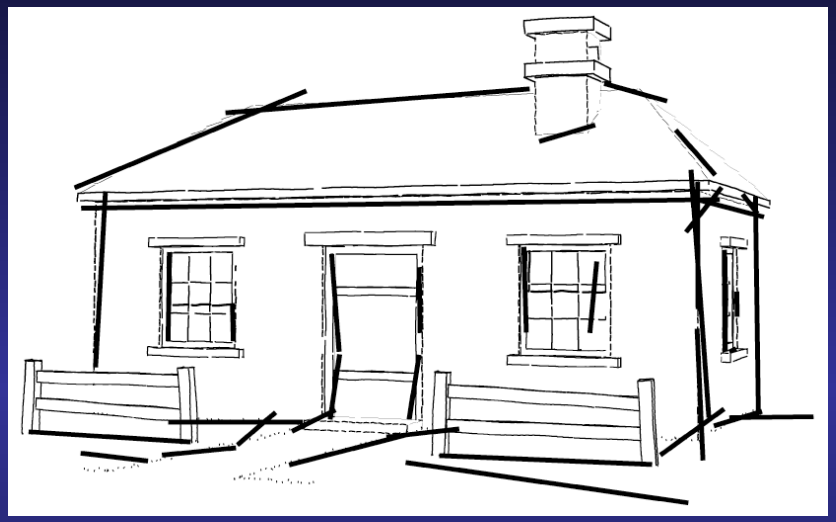
Tone



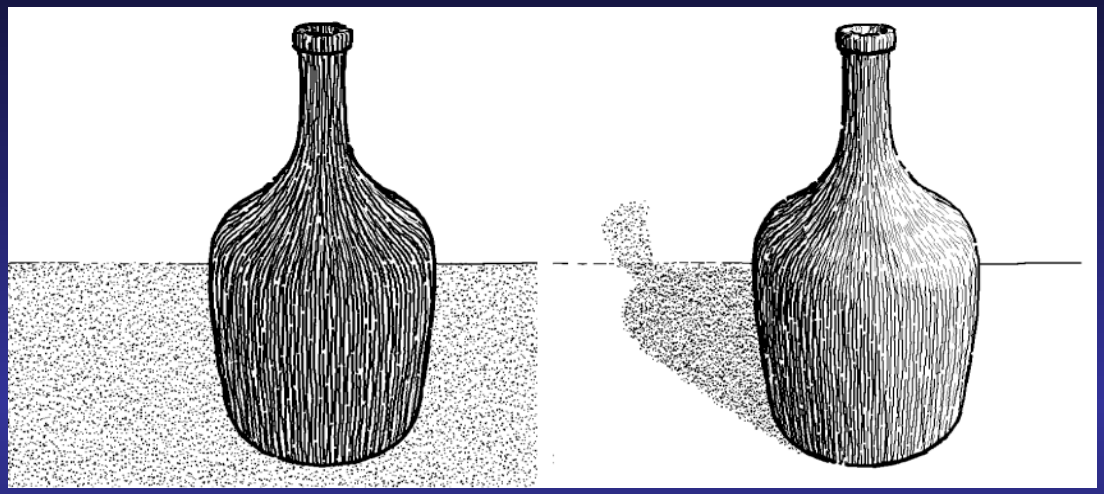


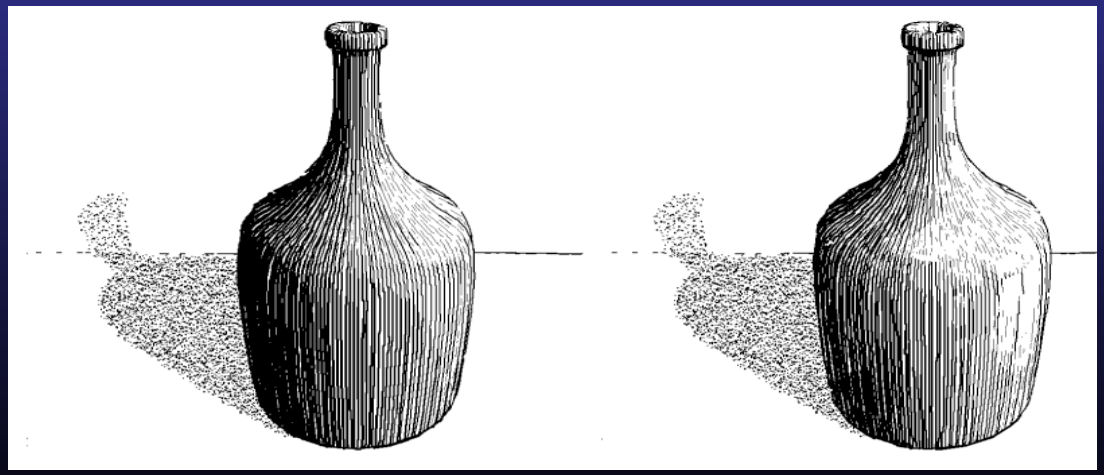
Georges Winkenbach and David H. Salesin. Computer-generated pen-and-ink illustration. SIGGRAPH '94

Indication



Classic rendering + hatchings

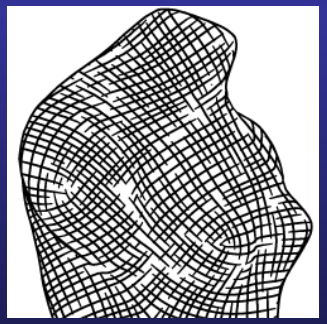


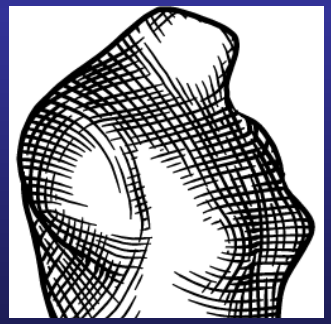


Winkenbach and Salesin.
"Rendering Parametric Surfaces in Pen and Ink." *SIGGRAPH 96*

Illustration 3D

- Principal curvature





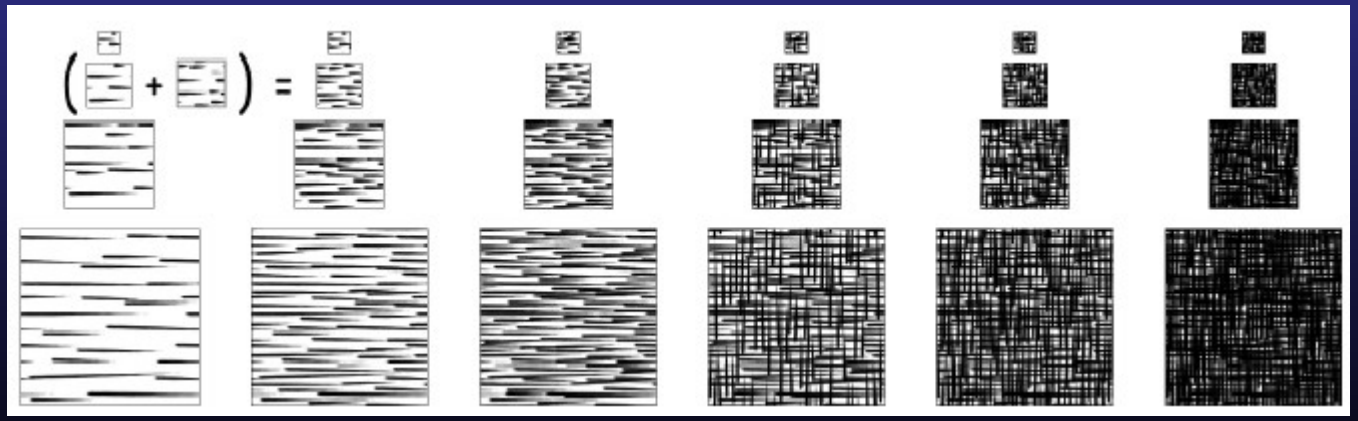
Hertzmann et Zorin - Illustrating smooth surfaces – SIGGRAPH 2000

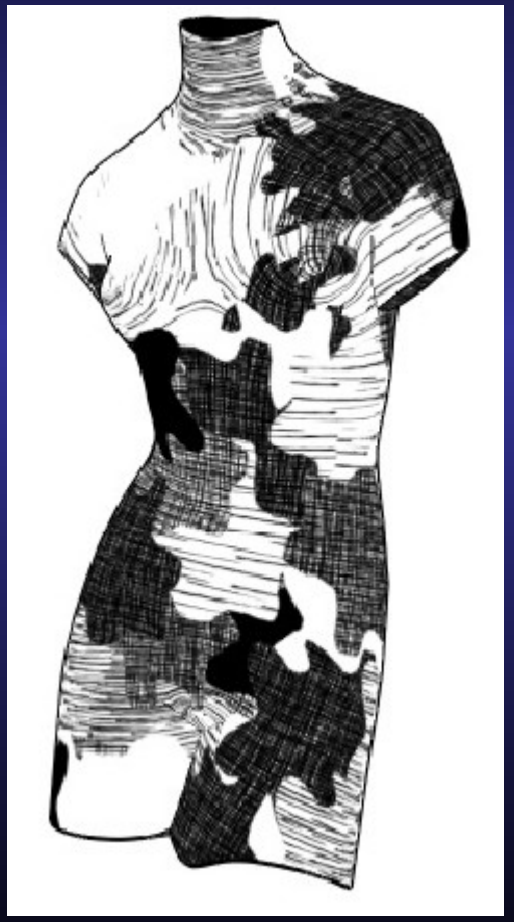
Real-time hatchings

- Tonal arts maps + lap textures

= mip-map

+ easy texture mapping





Emil Praun, Hugues Hoppe, Matthew Webb, and Adam Finkelstein. Real-time hatching. Siggraph 2001

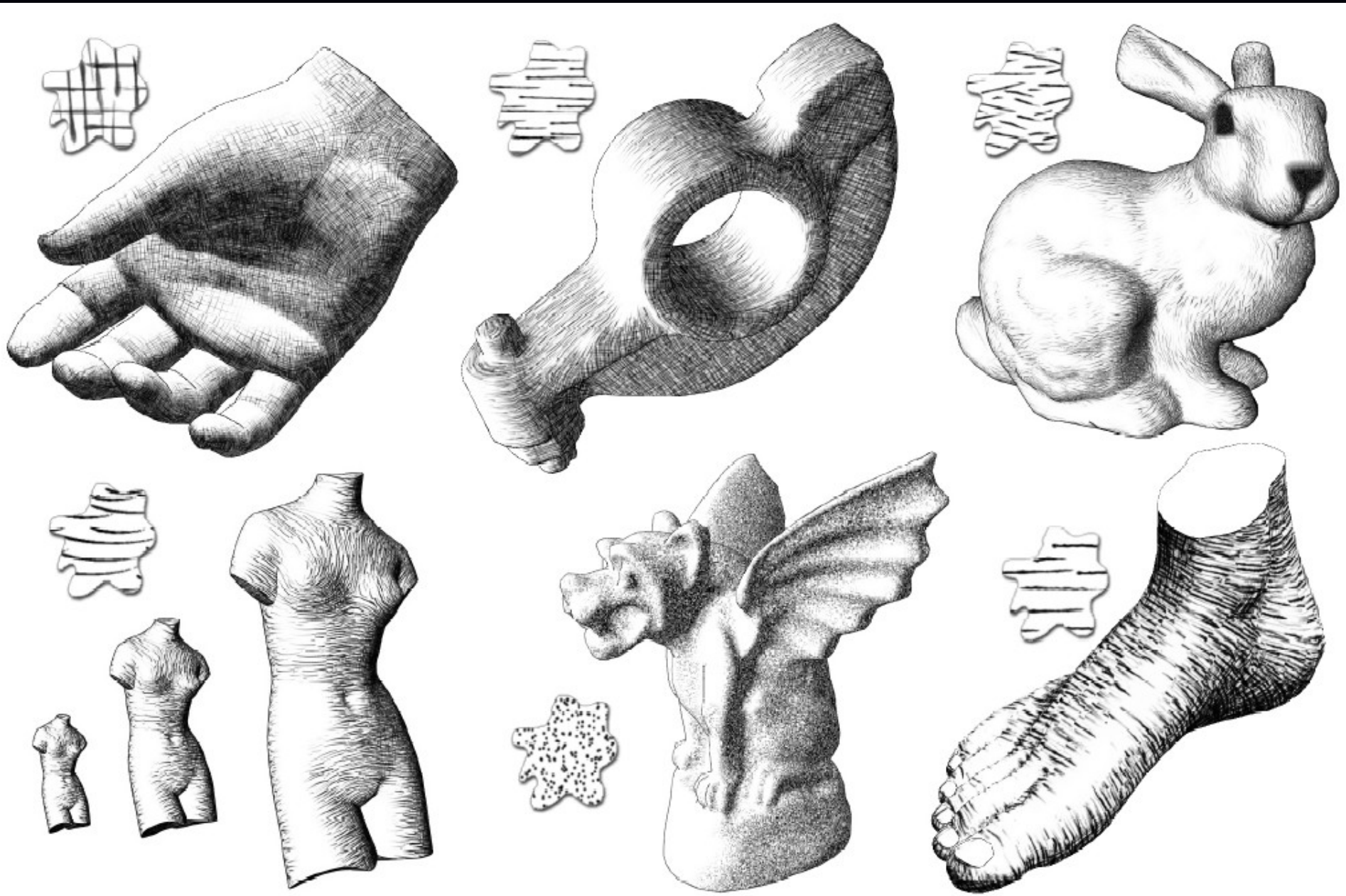


Figure 5: Results. Six models rendered with different TAMs, indicated in the inset texture patches.

Dynamic 2D Patterns

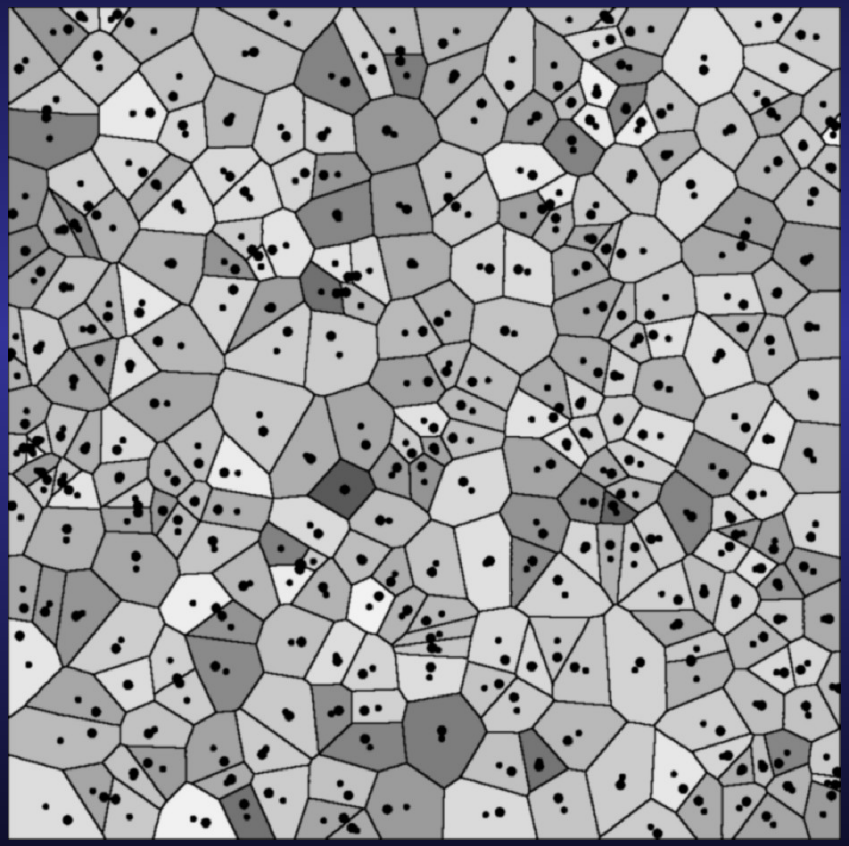
Dynamic 2D Patterns for Shading 3D Scenes
Simon Breslav, Karol Szerszen, Lee Markosian, Pascal Barla, Joëlle Thollot
ACM Transaction on Graphics (Proceedings of SIGGRAPH 2007)

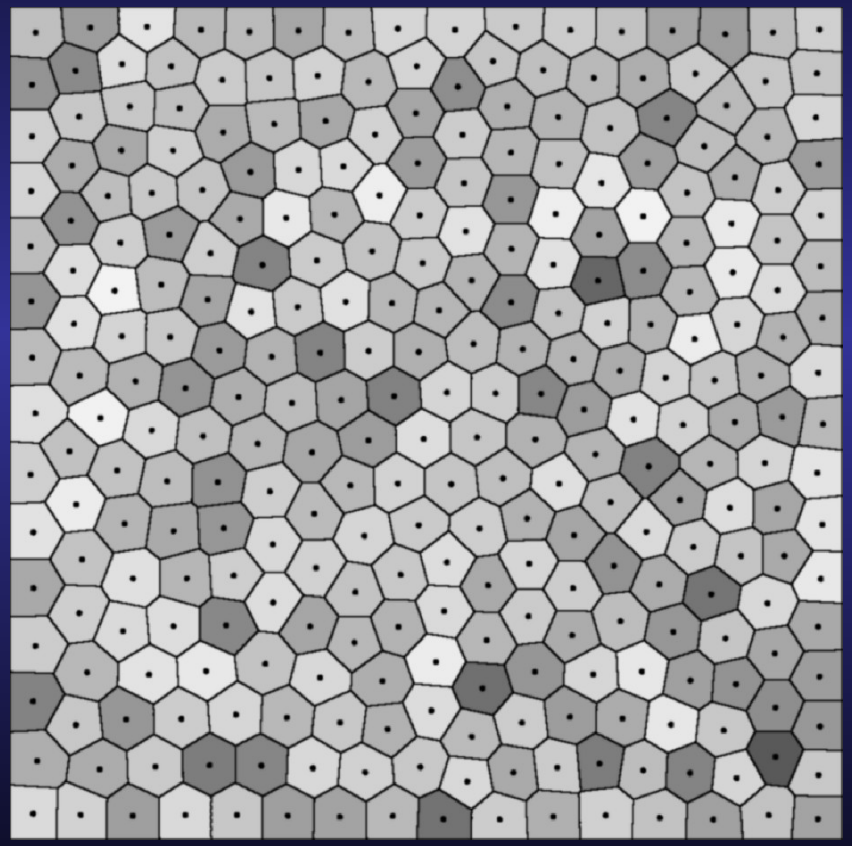
Stippling

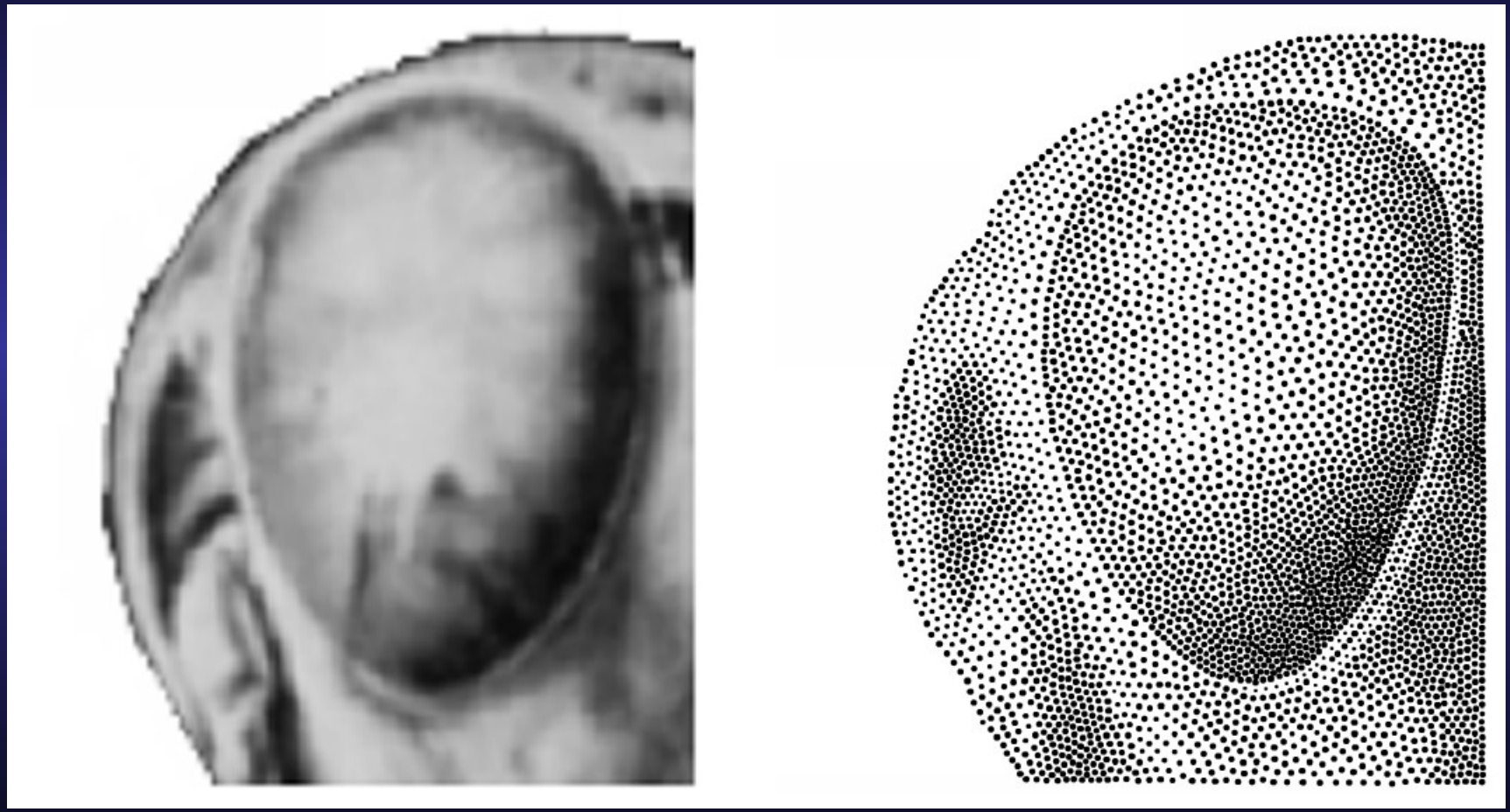
- Shape from shading
- Tone vis point distribution

$\Rightarrow$ Distribution and density

Relaxation de Llyod





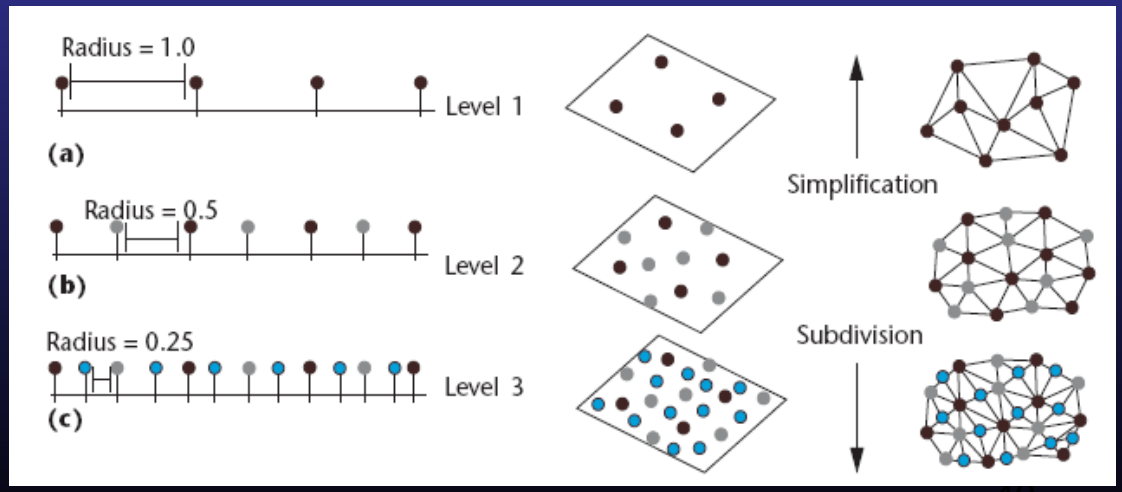


Deussen et al.

Real-time stippling

Oscar Meruvia Pastor, Bert Freudenberg, and Thomas Strothotte

- Points hierarchy on the surface
  - Simplification
  - Subdivision
- Point selection at each frame



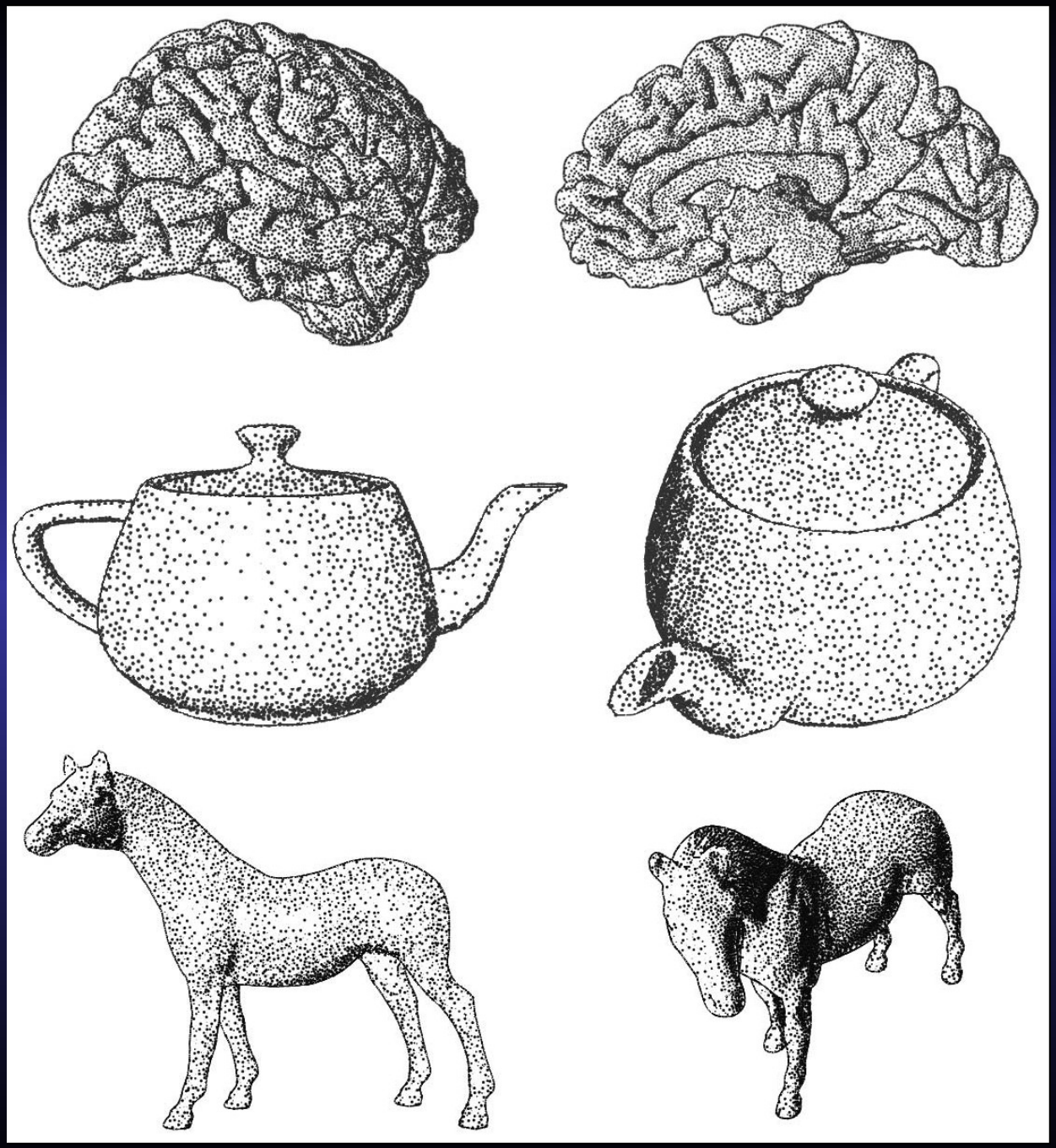
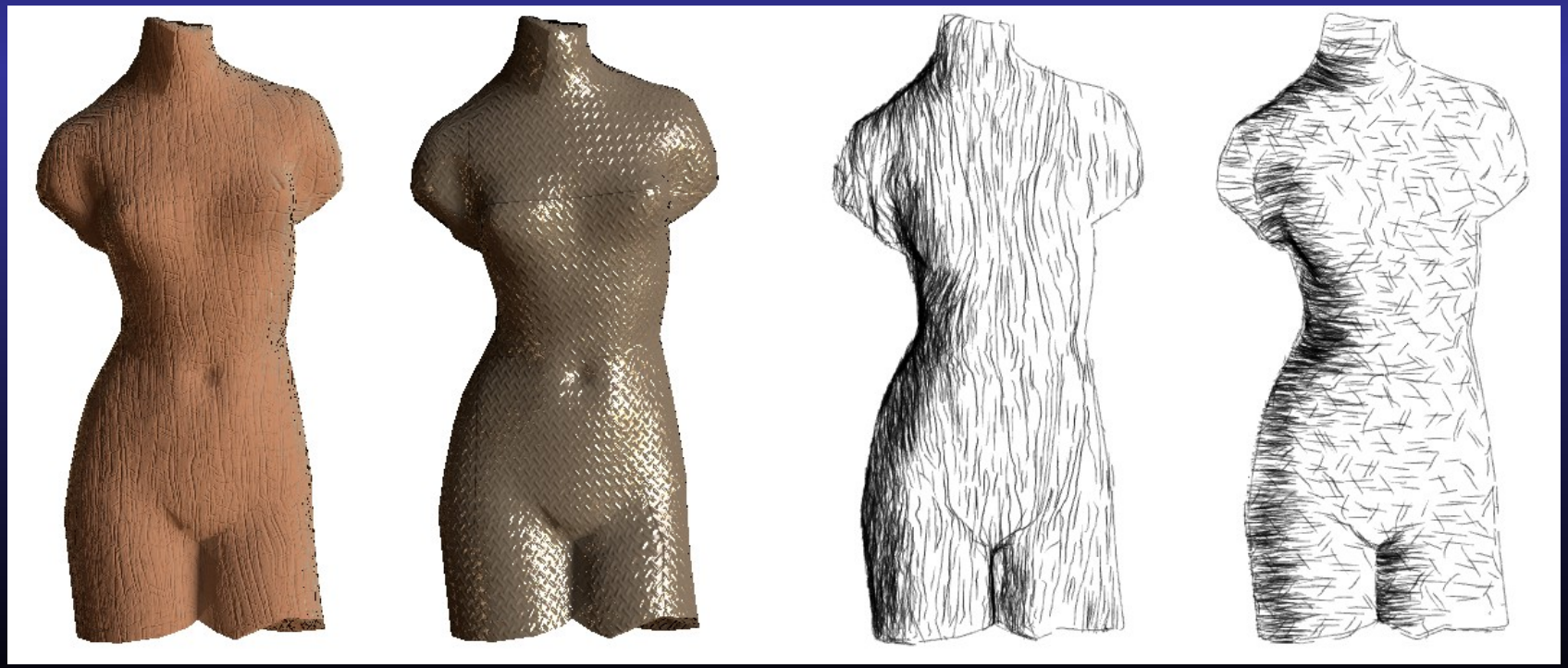
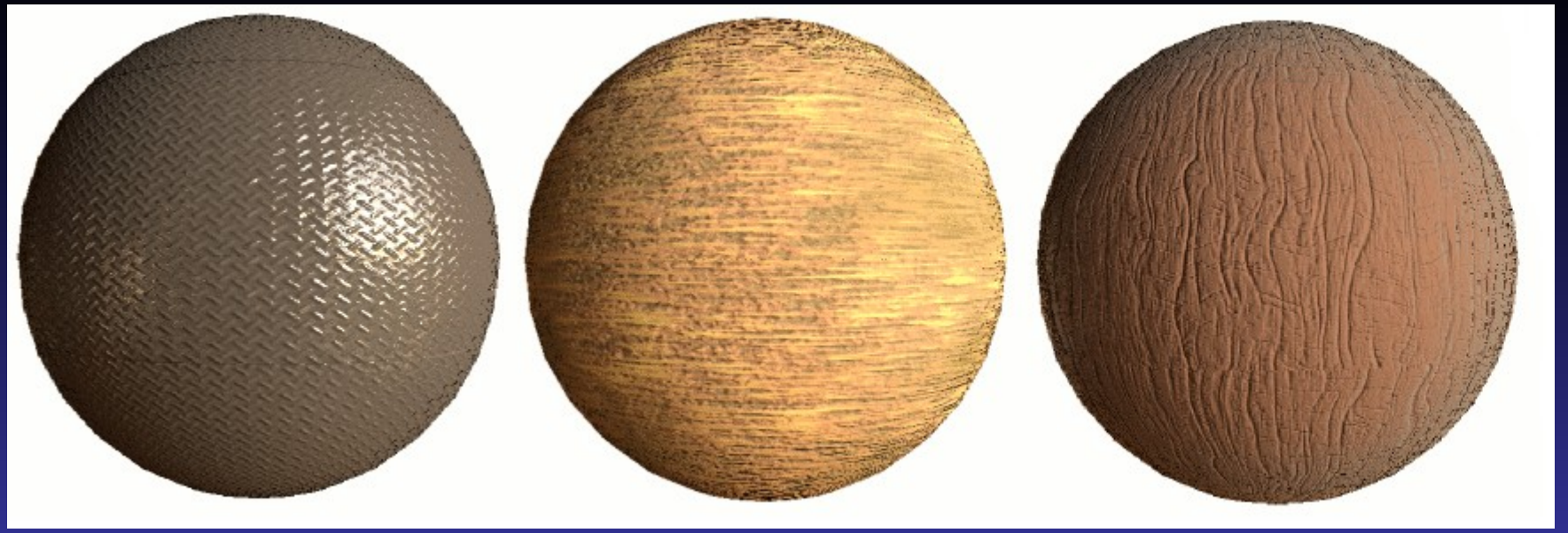


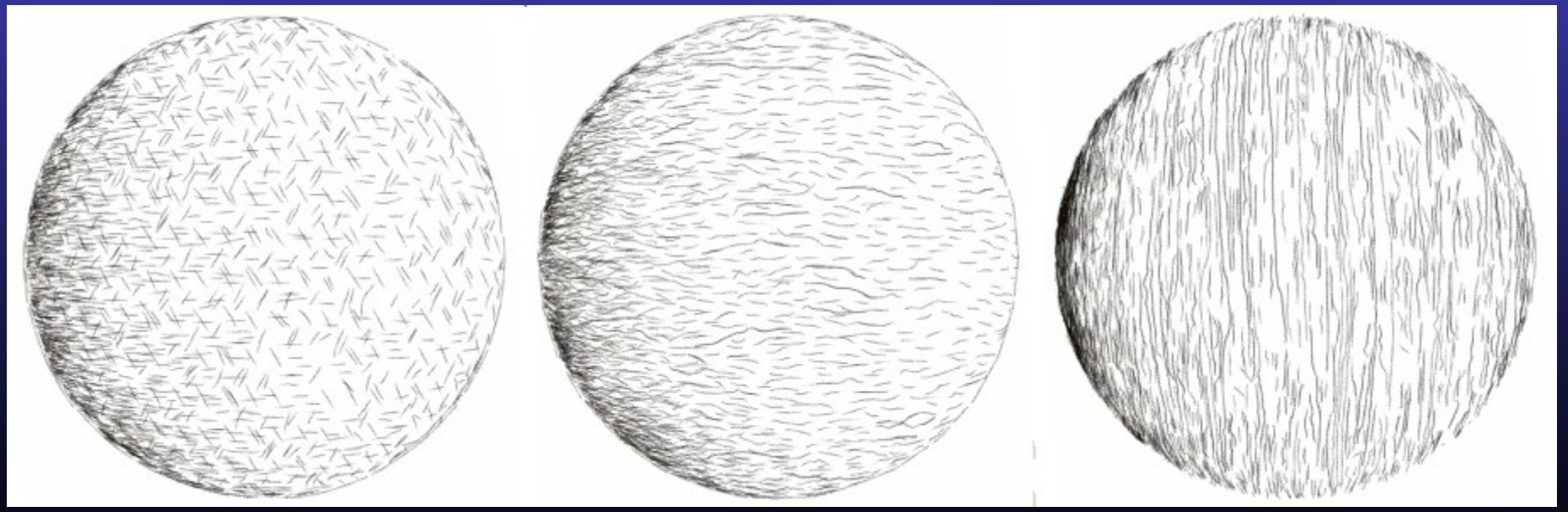
Illustration going further

- Material perception
- Automatic extraction of parameters from a BTF or BRDF



Kaleigh Smith, Thomas Luft, Cyril Soler, Pascal Barla, Joelle Thollot, Oliver Deussen

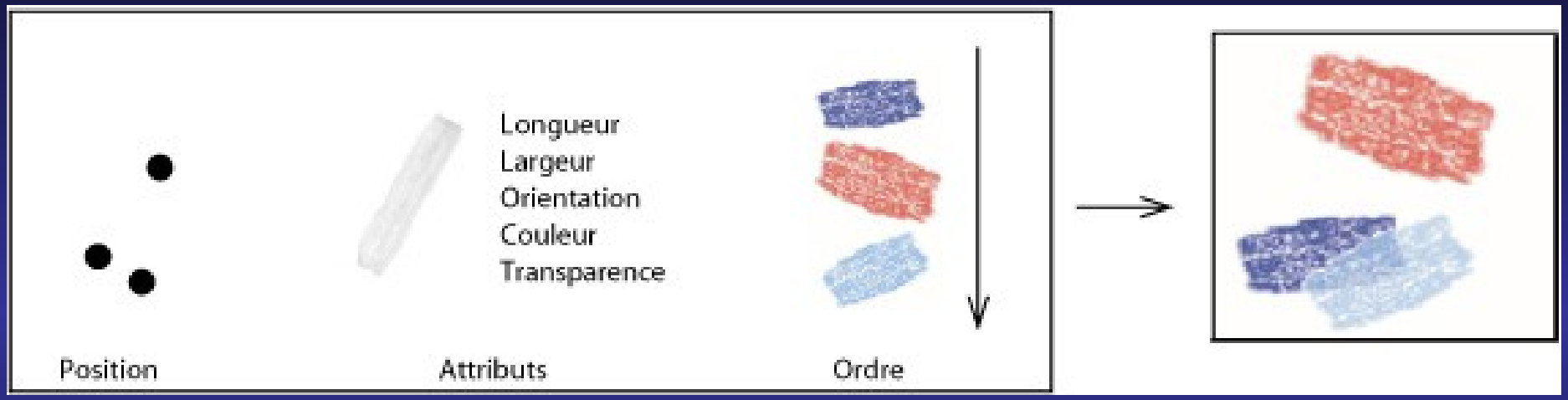




Painting

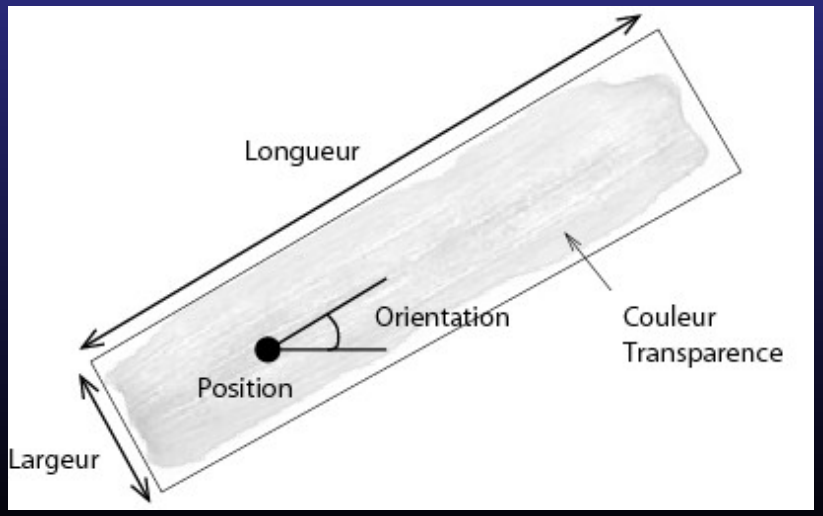
- Color image
- Abstraction and art
- Region filling

Stroke-based approaches



⇒ Position

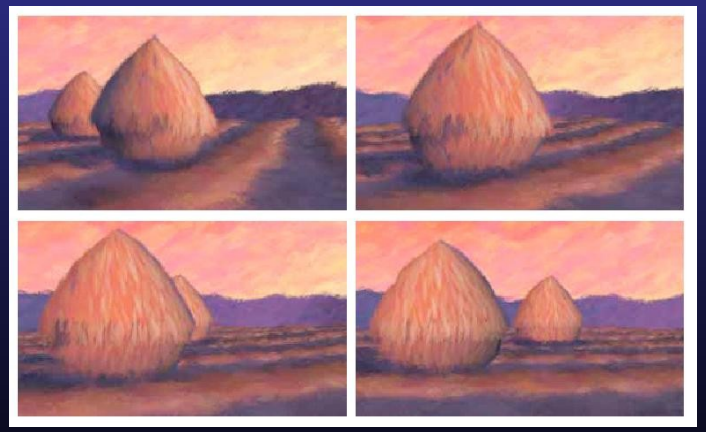
⇒ Attibutes

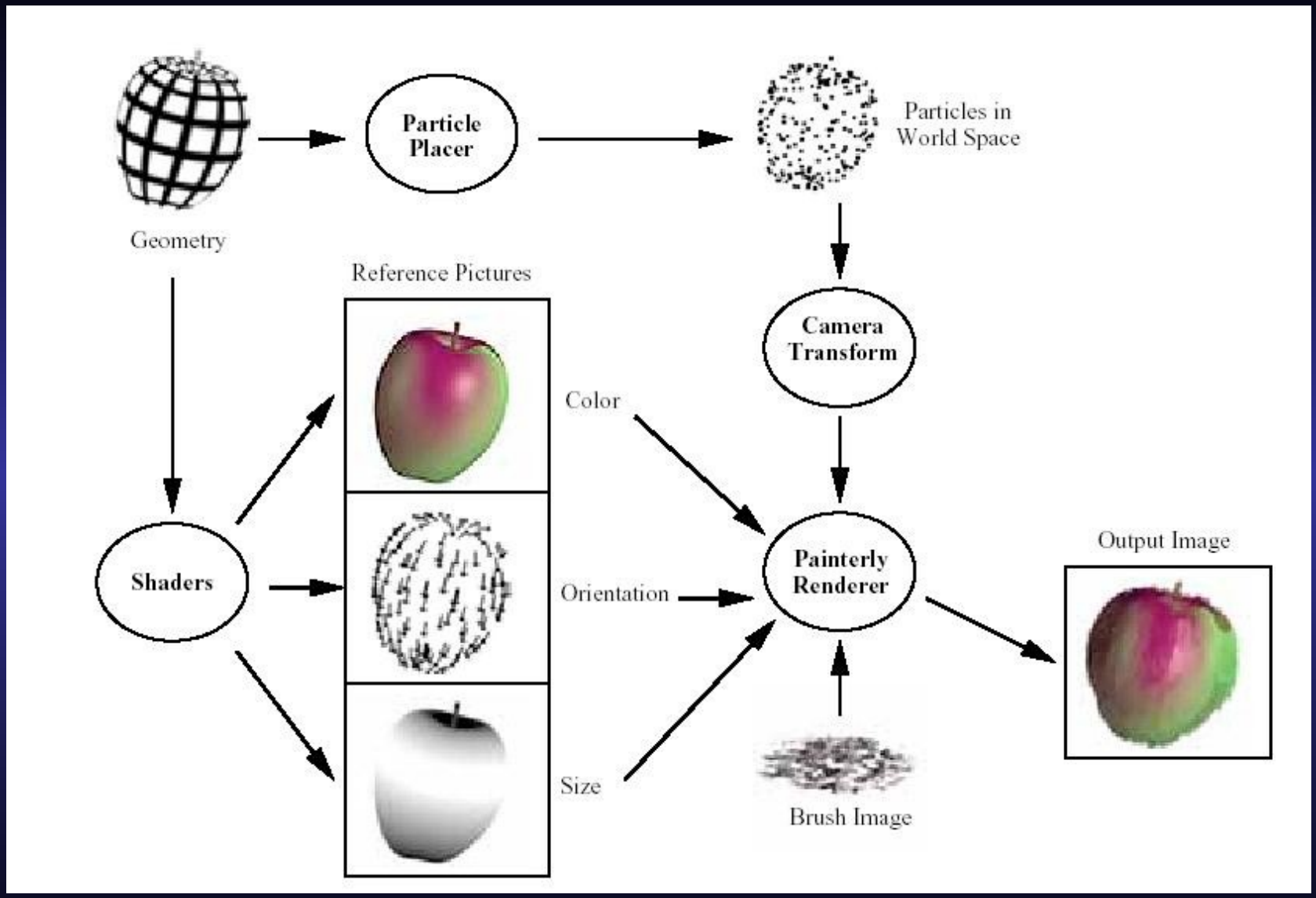




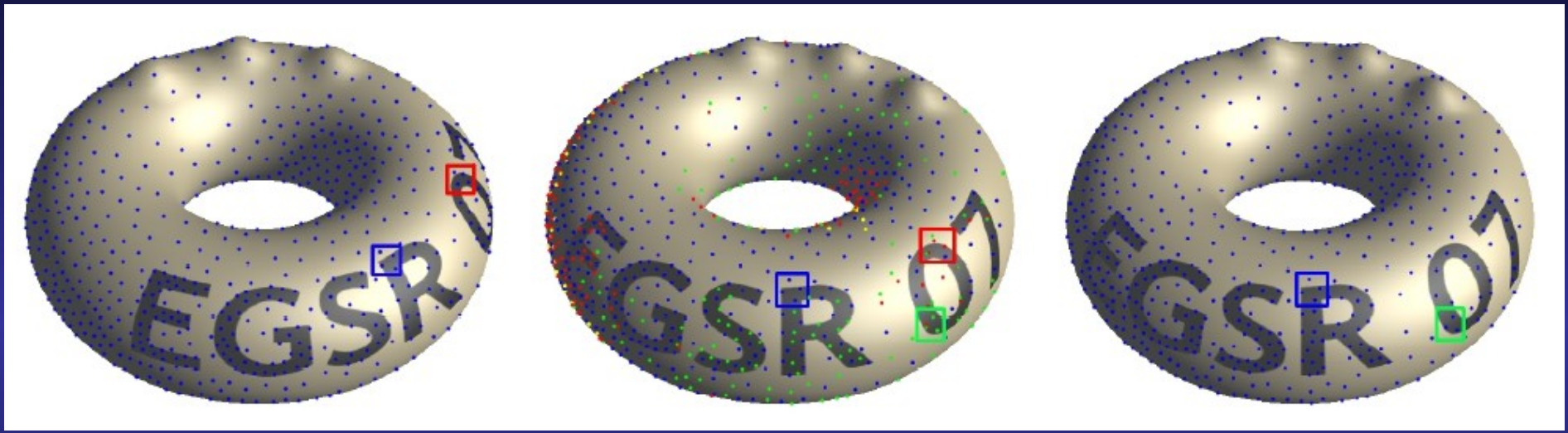

Painterly rendering for animation [Meier]

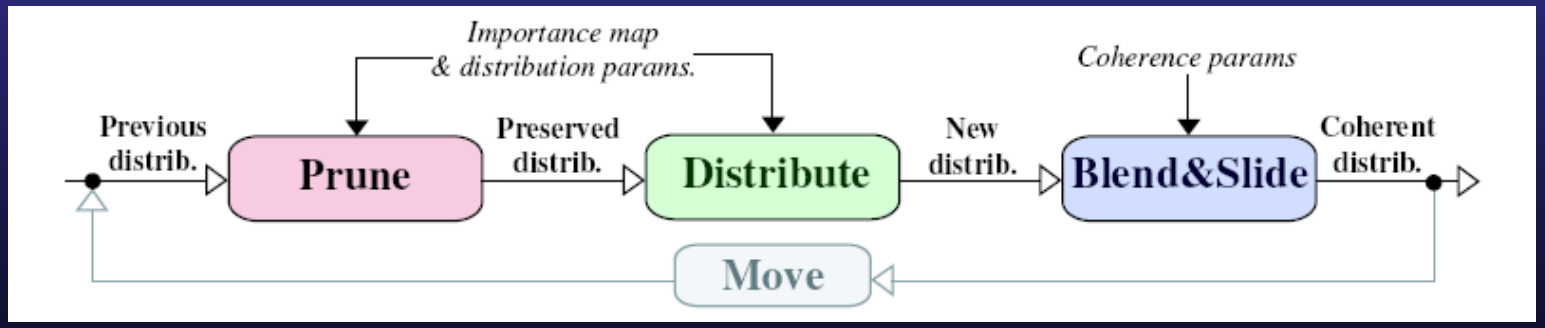
- Temporal coherence
- Strokes attached to particules on the surface
- 2D rendering via billboards




Particle Placer
Particles in World Space
Geometry
Reference Pictures
Camera Transform
Color
Shaders
Orientation
Painterly Renderer
Output Image
Size
Brush Image

Distribution dynamique





Dynamic point distribution for stroke-based rendering
David Vanderhaeghe, Pascal Barla, Joëlle Thollot, François Sillion
Rendering Techniques 2007 (Proceedings of the Eurographics Symposium on Rendering)

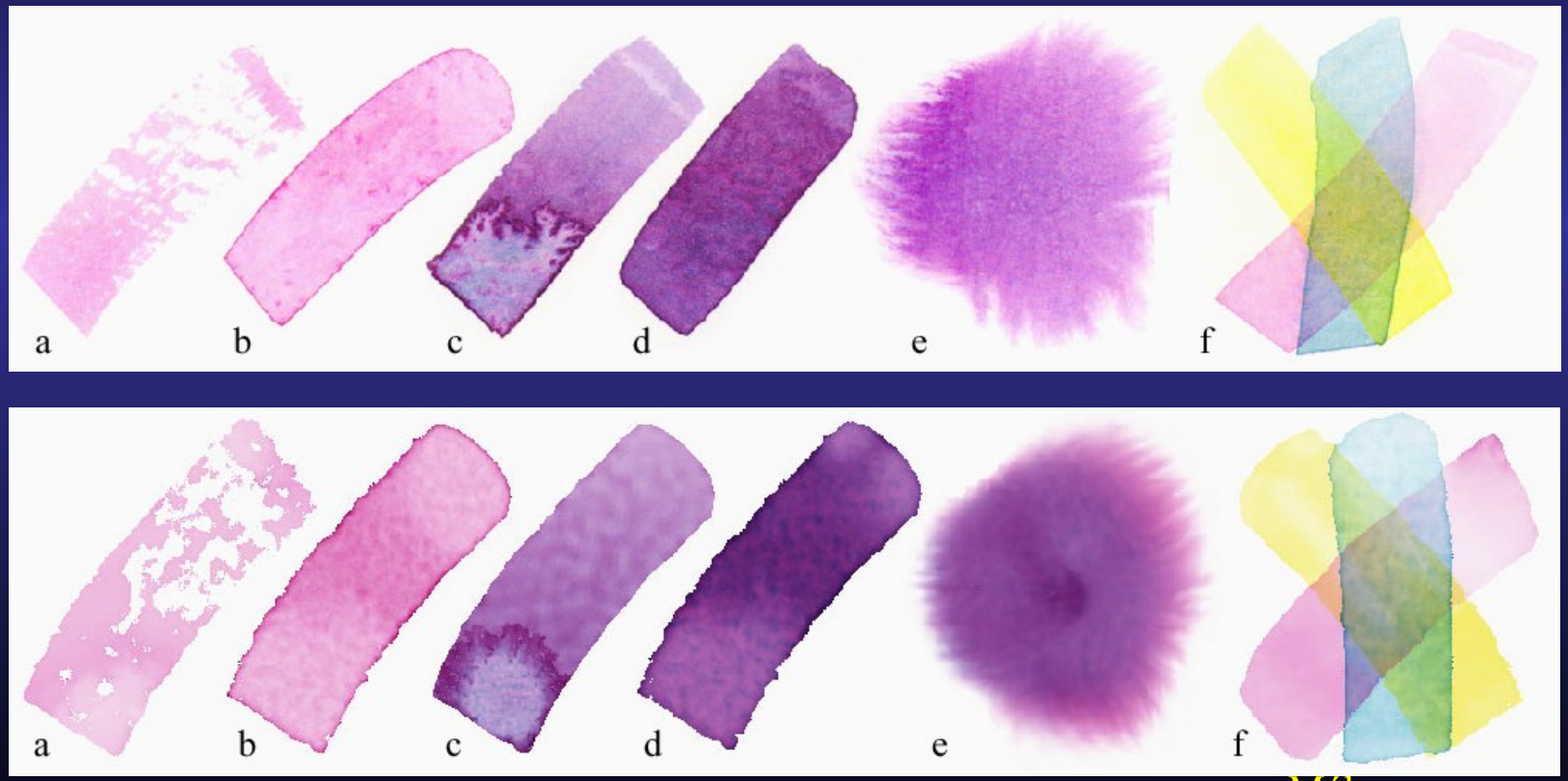
Watercolor

- Region filling
- Watercolor effects

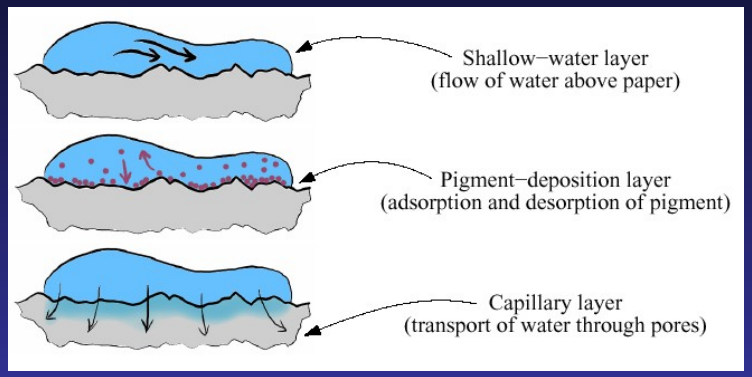
Max Cabanes

Watercolor (*Curtis*)

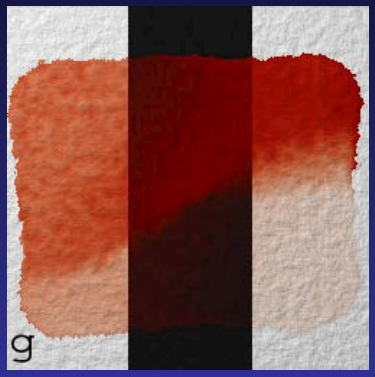
- Physical simulation



Watercolor: simulation



Diffusion



Interaction pigments/paper

Segmentation

Pigments choice

Liquid simulation

Color simulation

Animated watercolor

- Watercolor as an image processing

Adrien Bousseau, Matthew Kaplan, Joëlle Thollot, François Sillion
Interactive watercolor rendering with temporal coherence and abstraction
International Symposium on Non-Photorealistic Animation and Rendering (NPAR) - 2006

Video

- Following the optical flow

Video Watercolorization using Bidirectional Texture Advection
Adrien Bousseau, Fabrice Neyret, Joëlle Thollot, David Salesin
ACM Transaction on Graphics (Proceedings of SIGGRAPH 2007)

3D Object

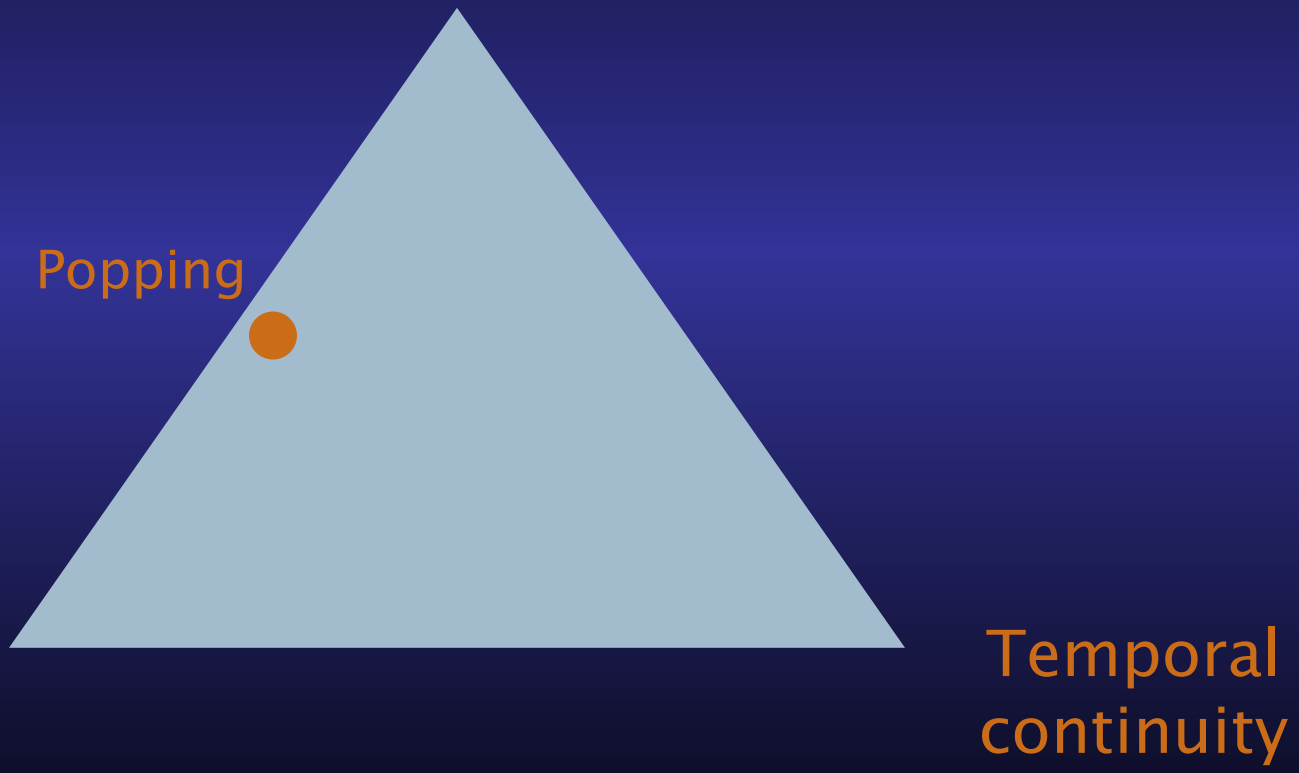
- 3D texture mapping
- Infinite zoom mechanism

Stylizing 3D animations
I3D 2009
Pierre Bénard, Adrien Bousseau,
Joëlle Thollot

Summary
Temporal coherence

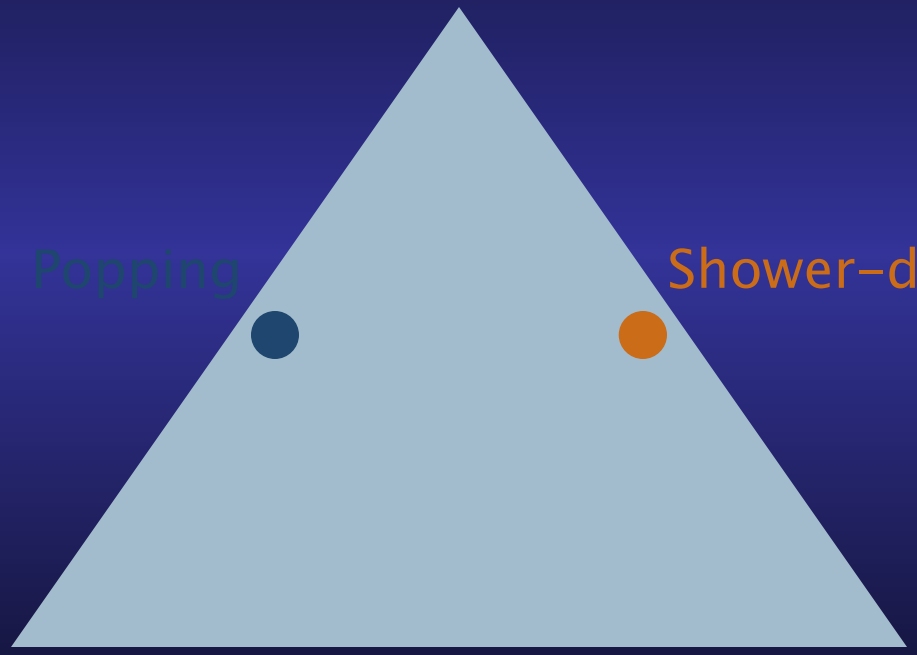
Flickering and popping

Temporal coherence



Sliding (*shower-door* effect)

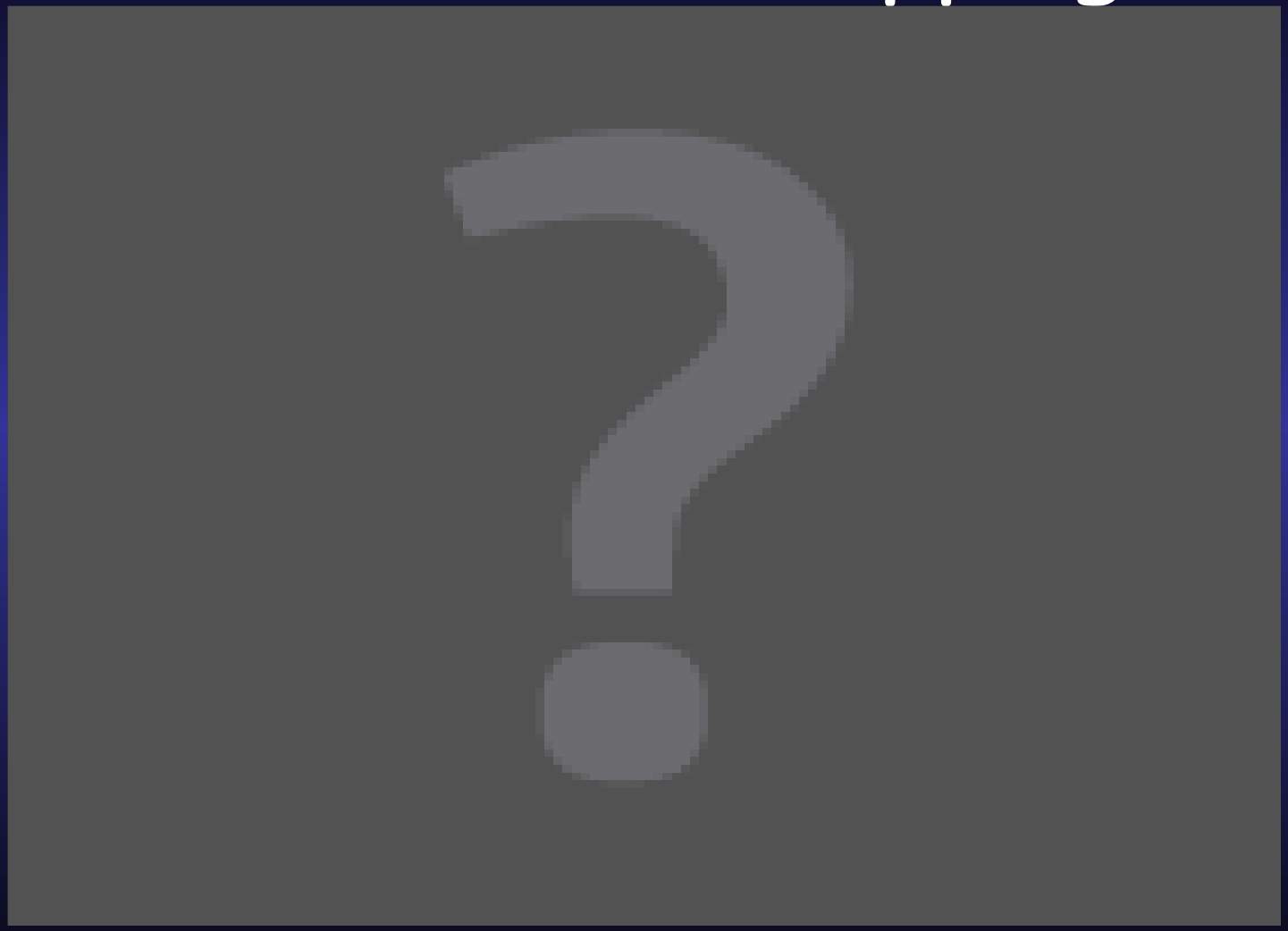
Temporal coherence



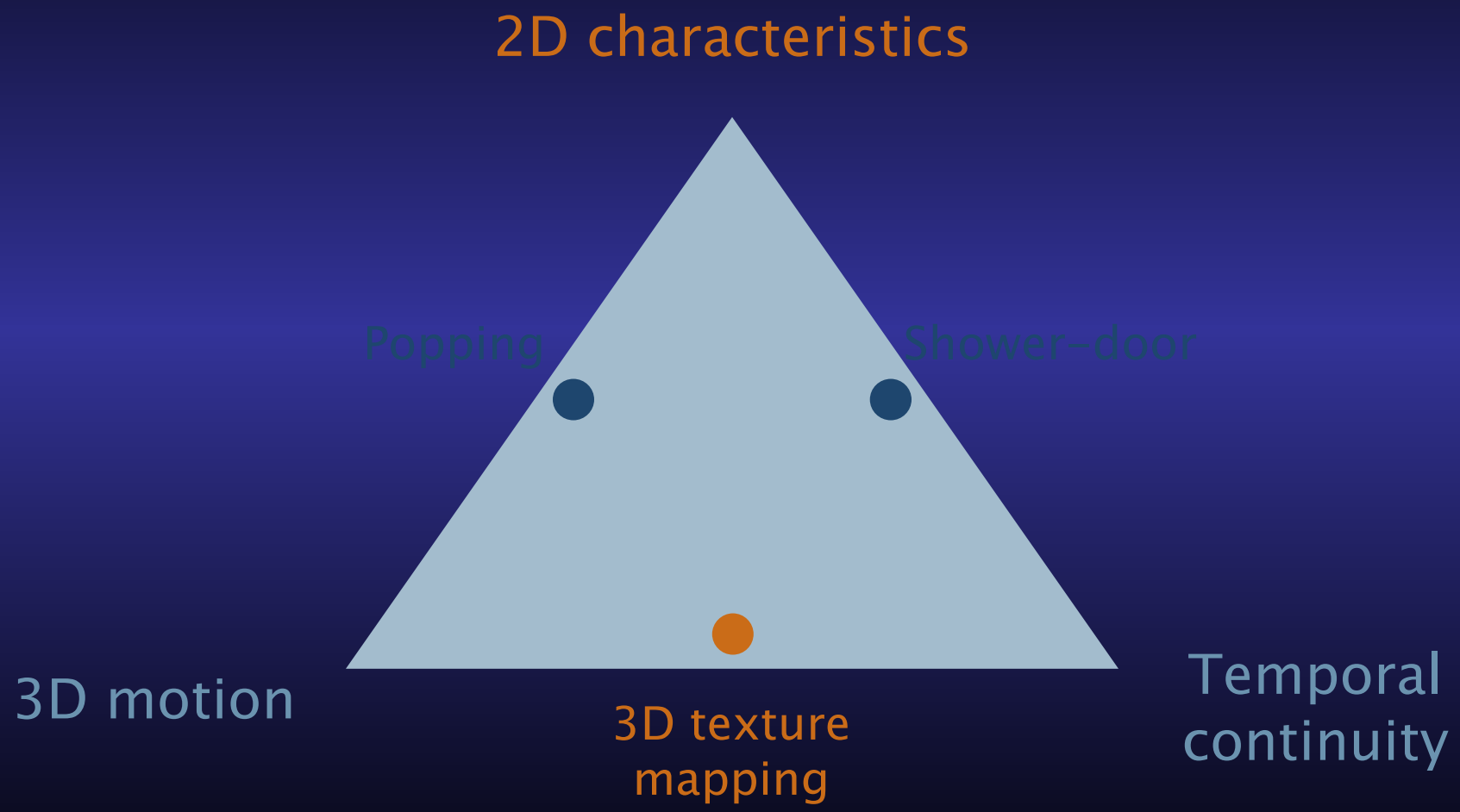
3D motion

Temporal continuity

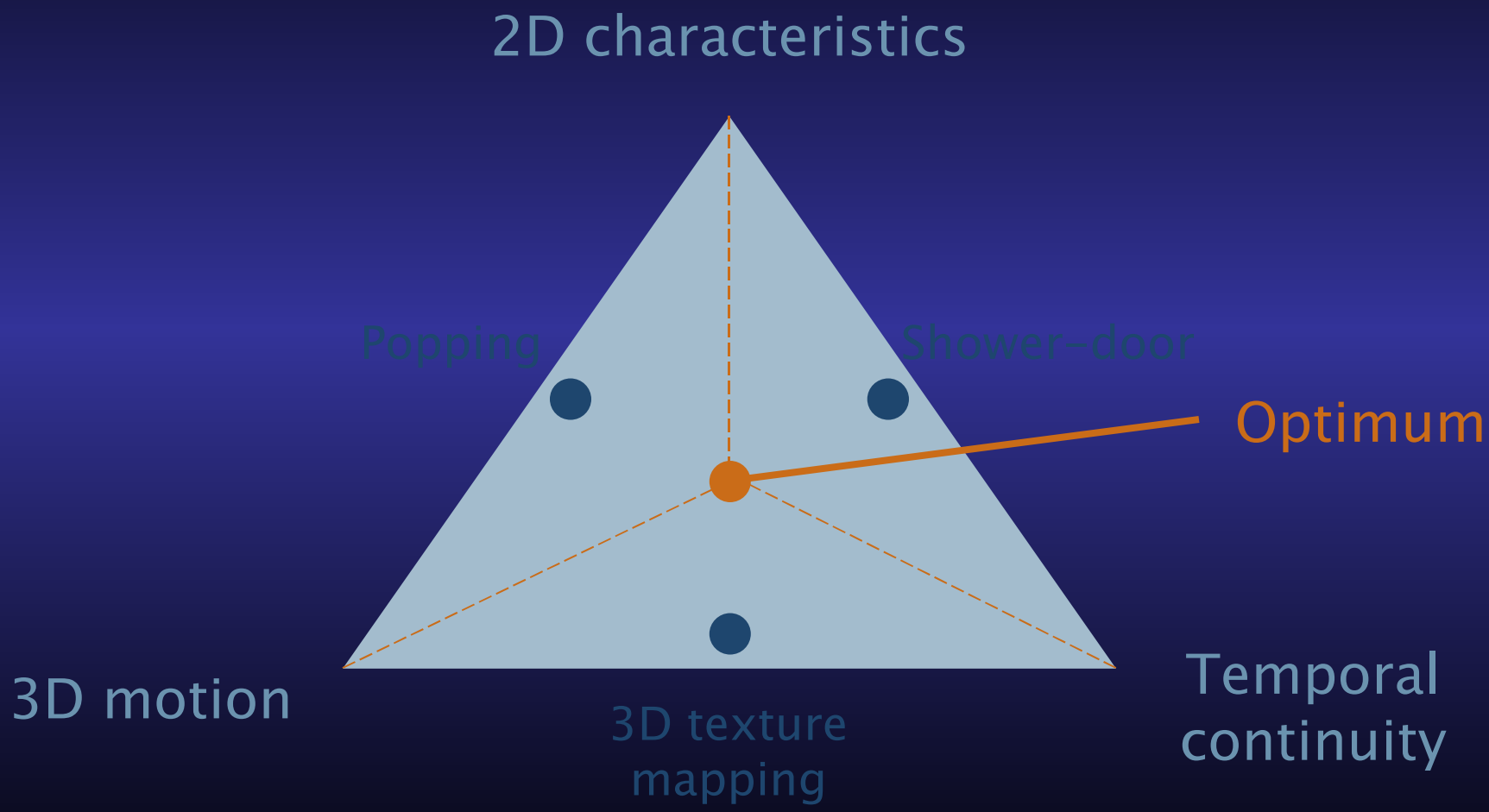
3D texture mapping



Temporal coherence

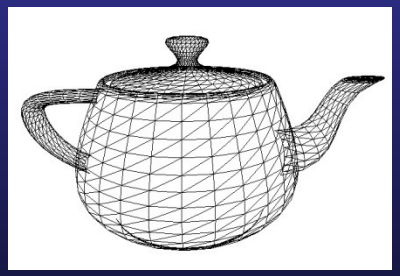


Temporal coherence

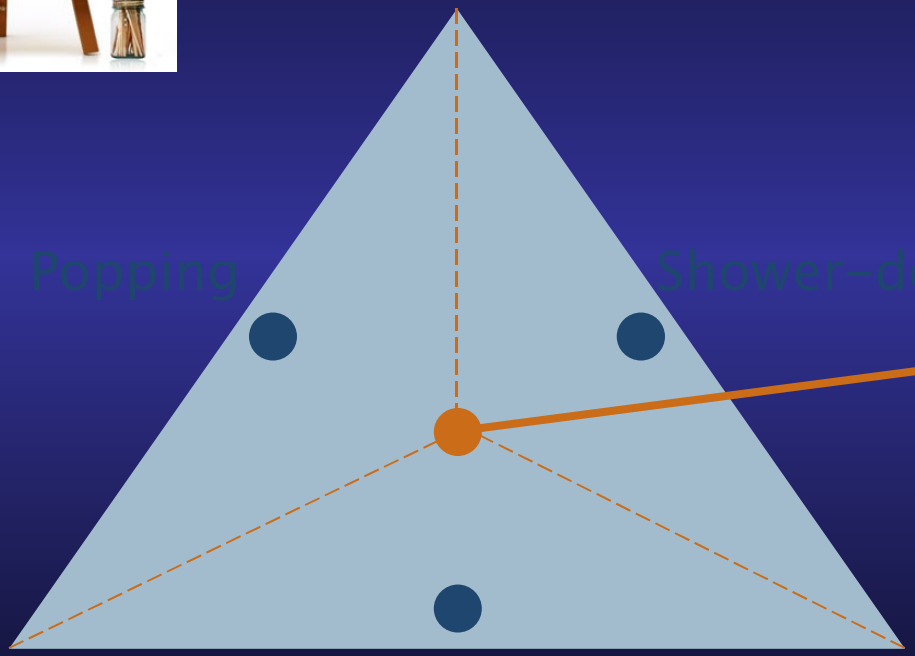


Contradictory requirements : how to reconcile them?

2D characteristics



3D motion



[Vanderhaeghe et al. 07]

2D characteristics

Popping

Shower-door

Primitive distribution [Mei96, VBTS07]

3D motion

3D texture mapping

Temporal continuity

[Breslav et al. 07]

2D characteristics

Popping

Shower-door

Primitive distribution [Mei96, VBTS07]

Screen-space texture mapping [CTP*03, BSM*07]

3D motion

3D texture mapping

Temporal continuity

[Praun et al. 01]

2D characteristics

Popping

Shower-door

Primitive distribution [Mei96, VBTS07]

Screen-space texture mapping [CTP*03, BSM*07]

3D motion

3D texture mapping

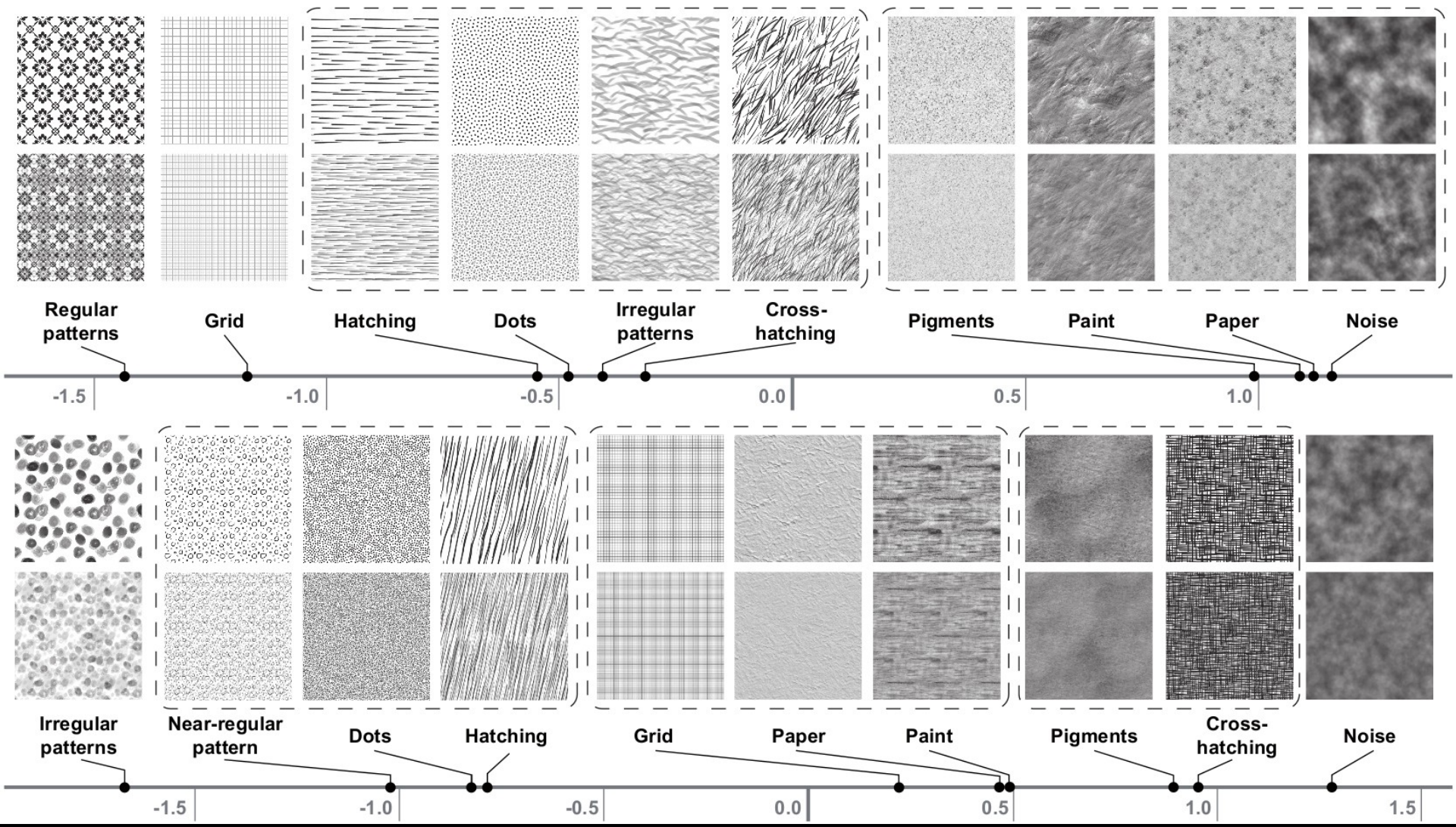
Temporal continuity

Object-space texture mapping [KLK*00, PHWF01]

What next?

- How to evaluate the various compromises?
- Perceptual study

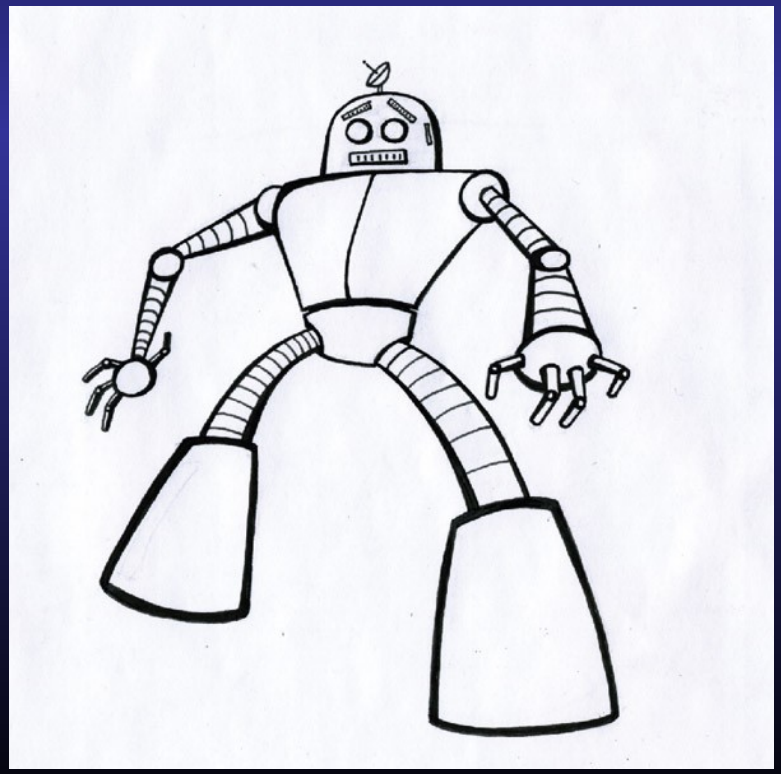
Blending effect



II - Lines

Lines

- What are the lines that may depict a shape?



http://www.chrisgovias.com/blog/stompy_drawn1.jpg

Lines

- Silhouettes
- Boundaries
- Ridges and valleys

- Depends on surface properties
  - Depth
  - Curvature
  - Normal
  - Viewpoint

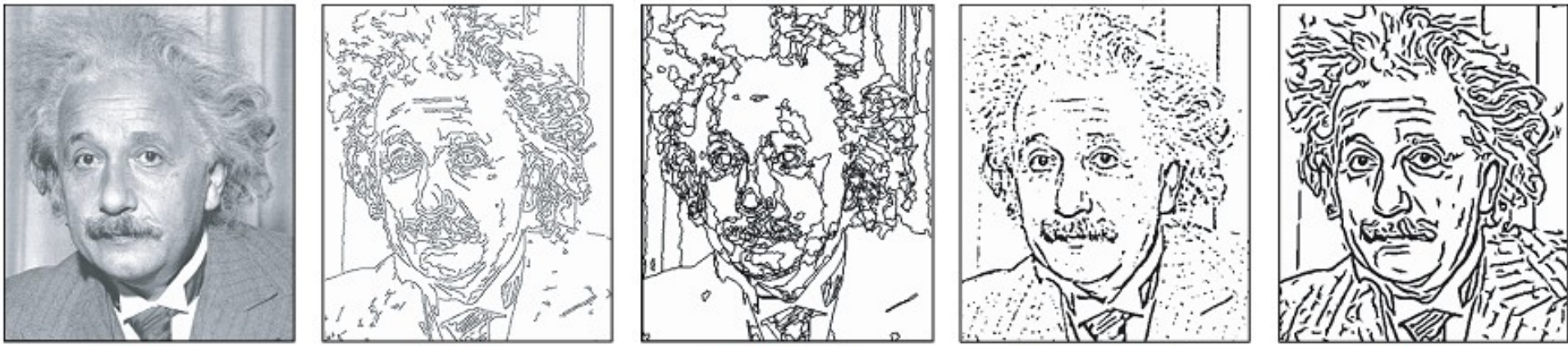
Lines detection

- How can we do that?
  - In image space
  - In object space

- What are the problems?

Image space

- Edge detection
  - Numerous techniques in image processing



(a) Input (b) Canny (c) Mean-shift (d) Isotropic DoG (e) FDoG

H. Kang, S. Lee, C. Chui. "Coherent Line Drawing“ NPAR 07

(a) Lena (b) Lighthouse (c) Tiger

(d) Pantheon (e) Flowers (f) Paolina

Image space + depth

- Detect C_0 surface discontinuities
- Via a Z-buffer or a computed depth map

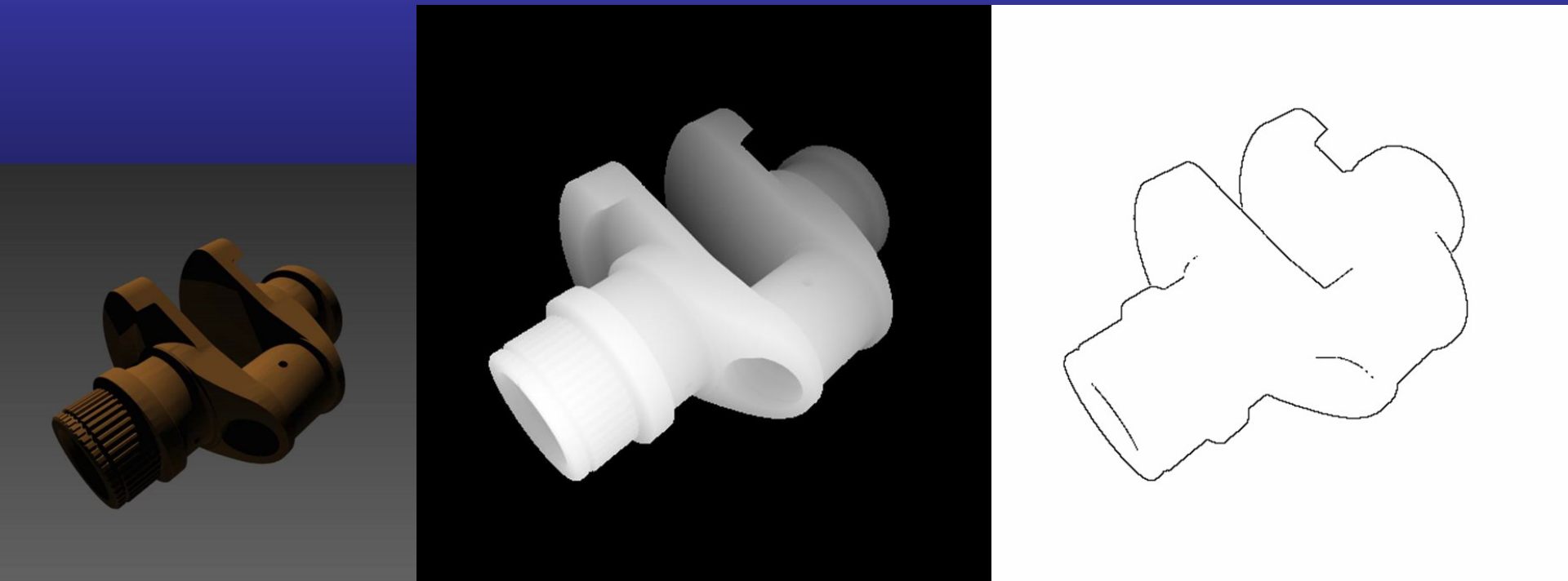
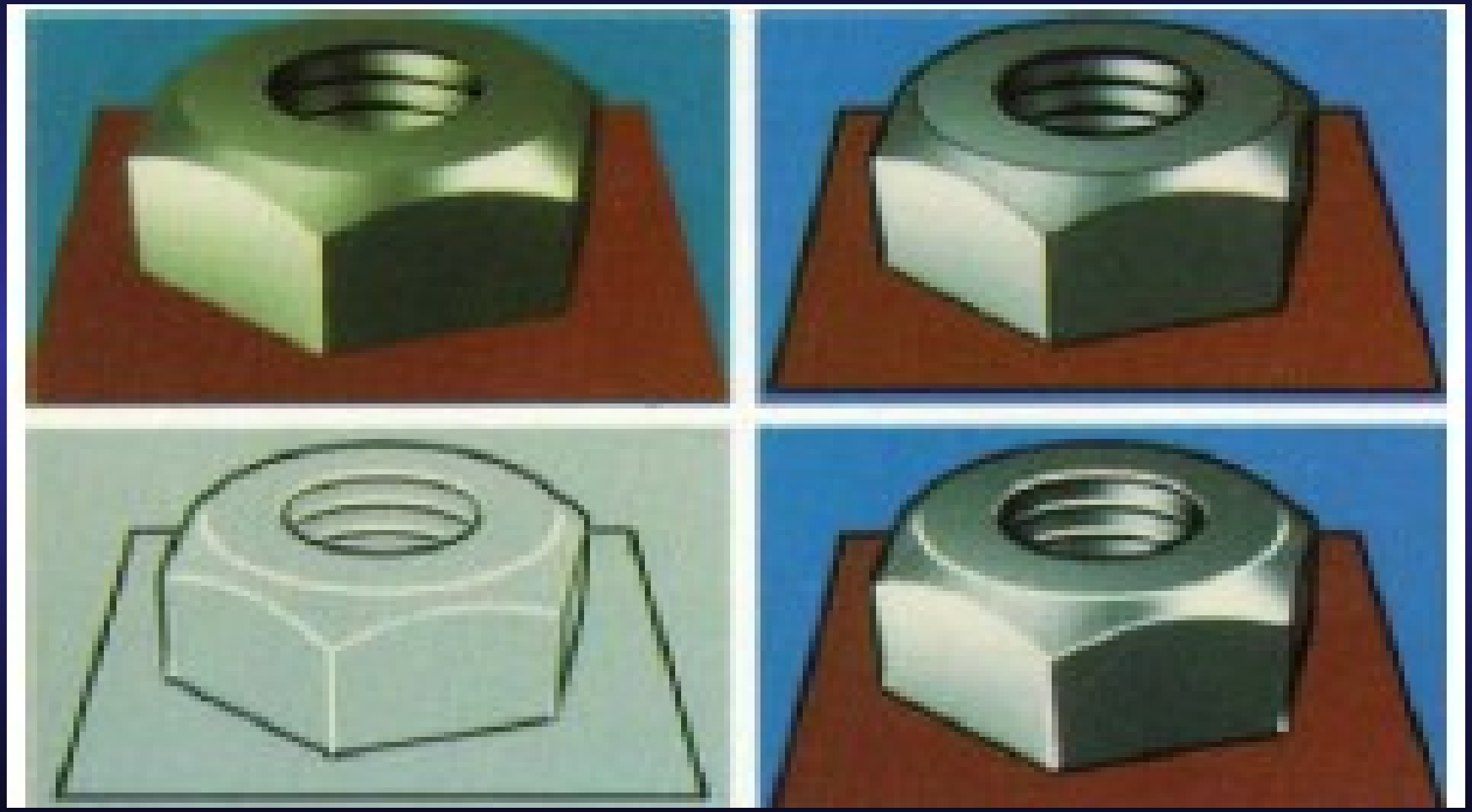


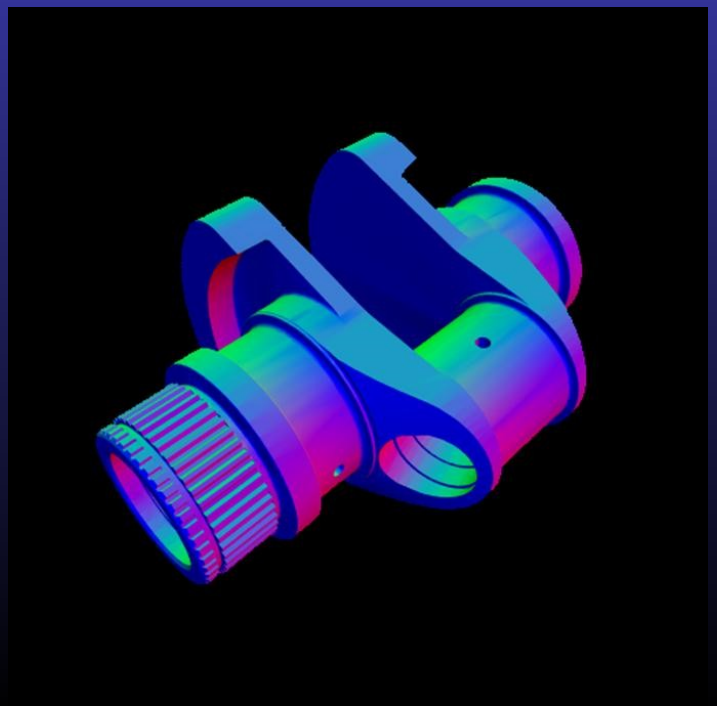
Image space + depth

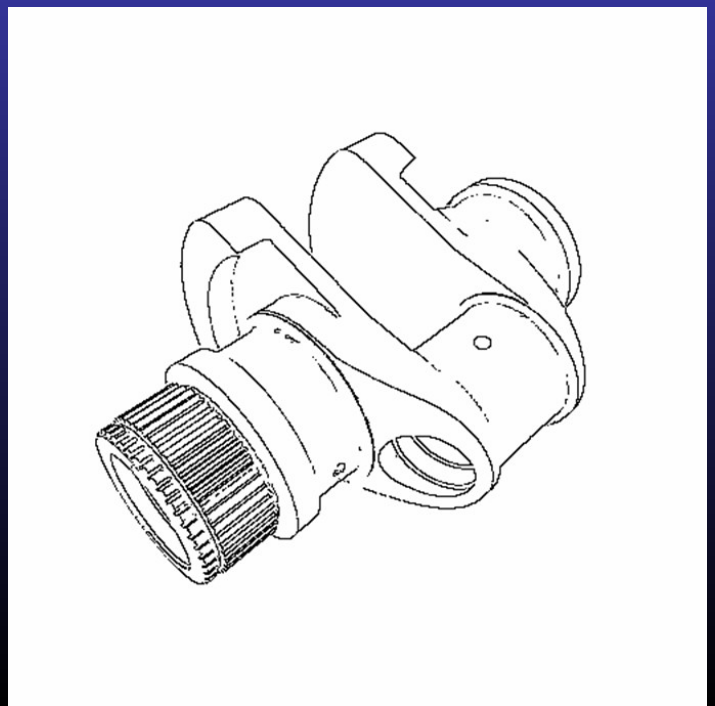


Saito and Takahashi "Comprehensible rendering of 3-D shapes" *SIGGRAPH*. 1990

Image space + normals

- Detect C_1 surface discontinuities
- Via normal computation
  - Maybe noisy: 2nd order differential





Depth + normal map

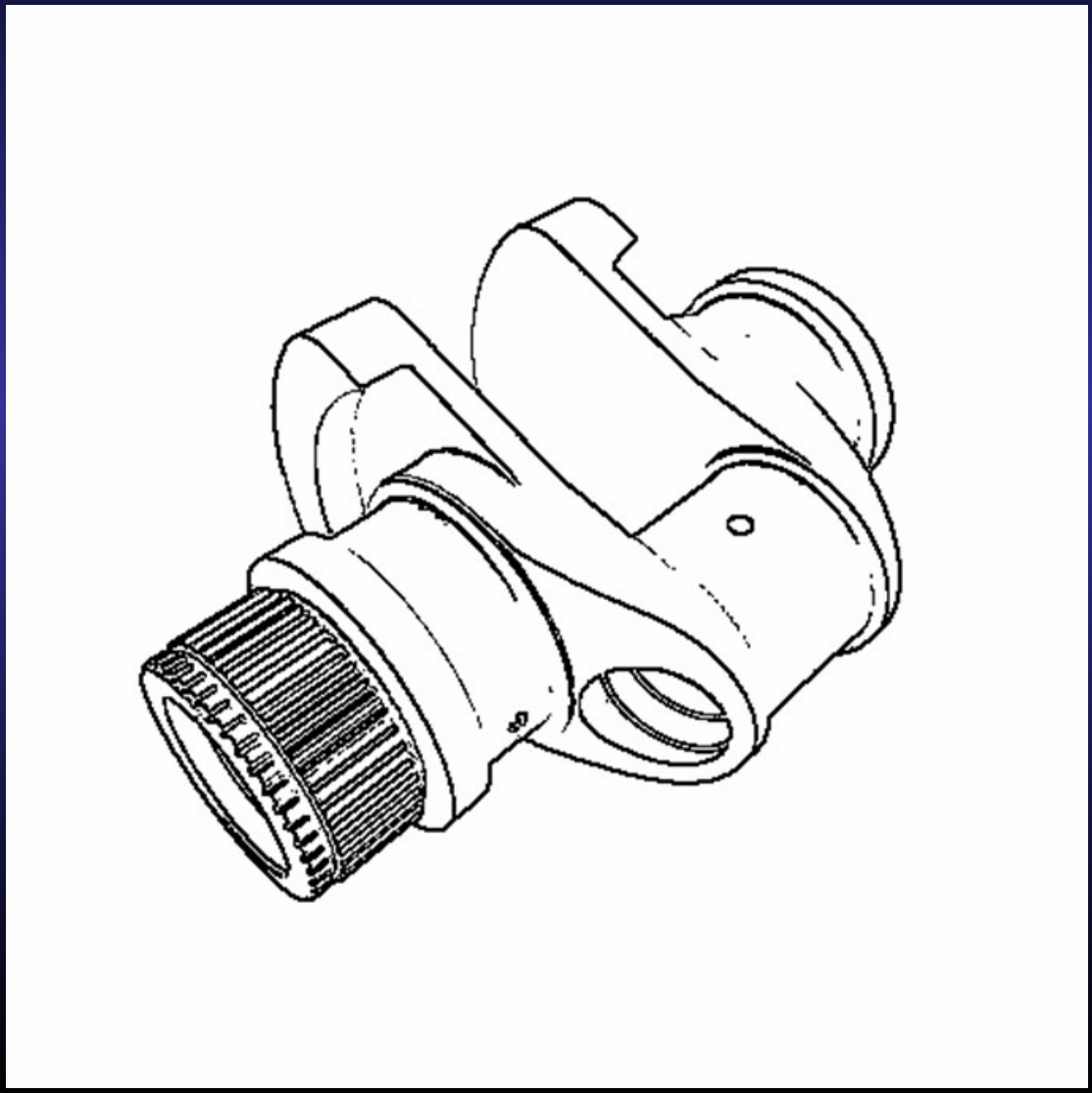
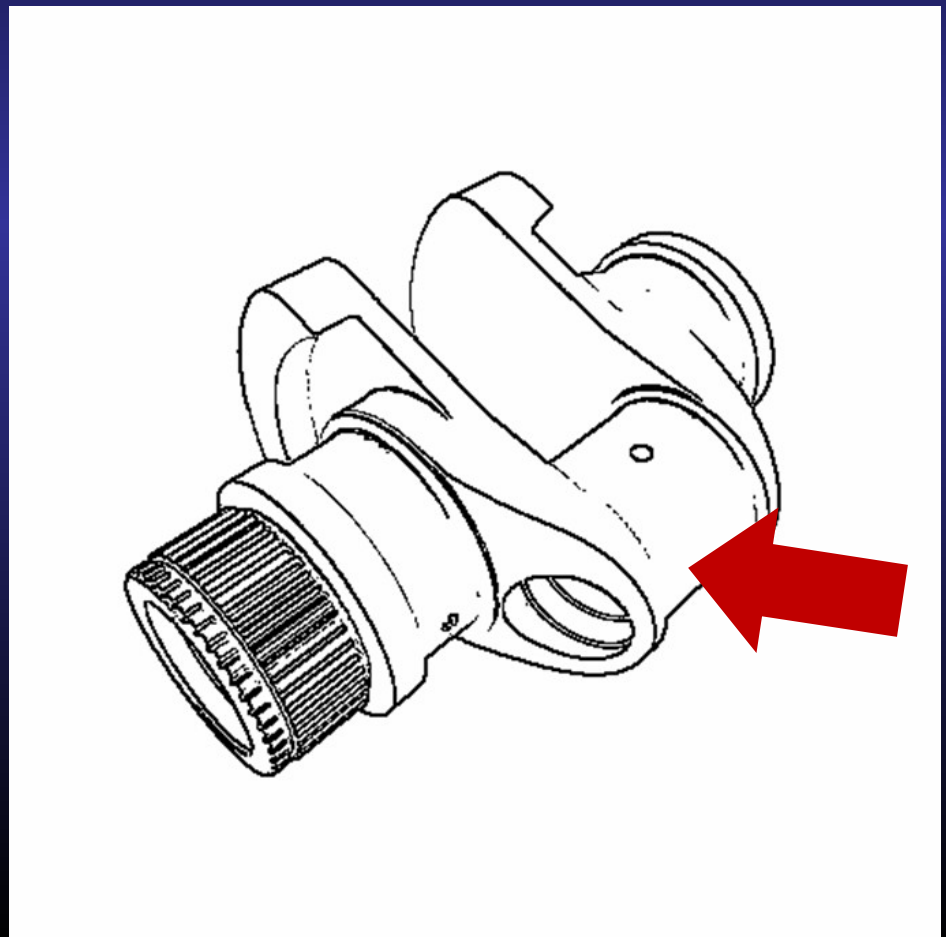


Image space limitations

- We loose the 3D information

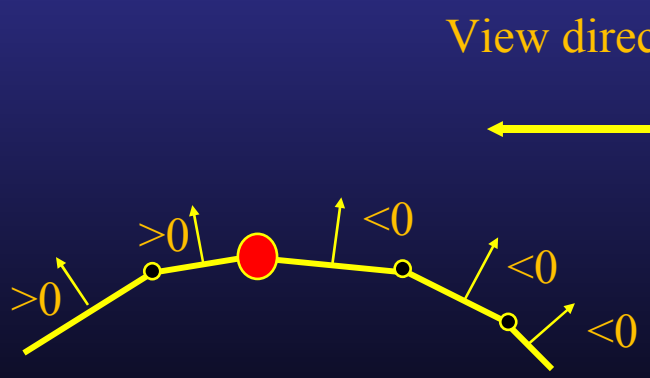


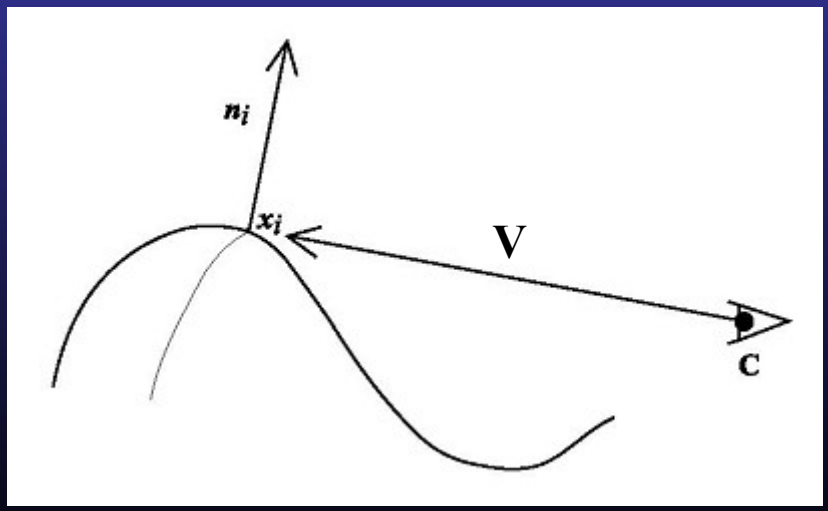
Object space

- More complicated and costly
- Various types of lines
  - Silhouettes
  - Creases
  - Ridges and valleys

Silhouettes – object space

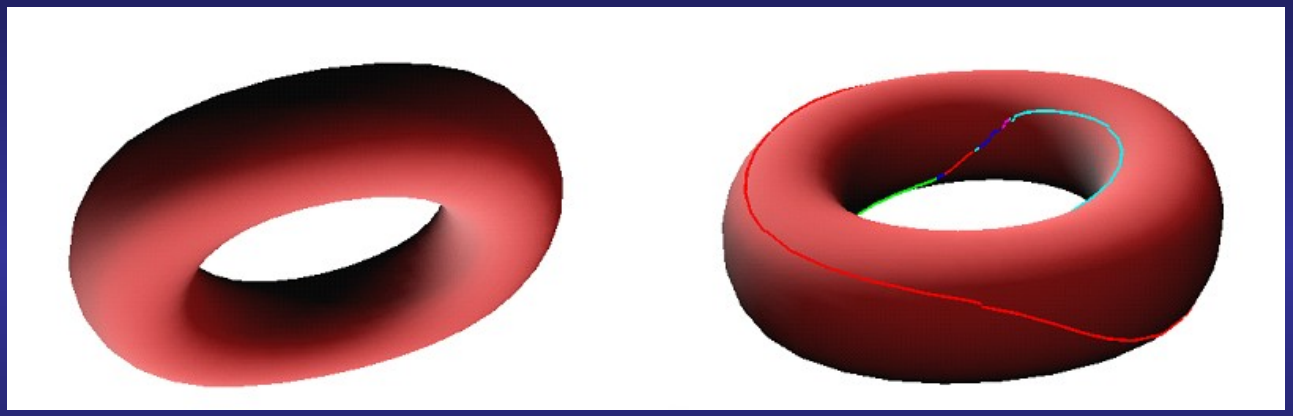
- Edges that connect back and front Faces
- Surface points such that N.V=0



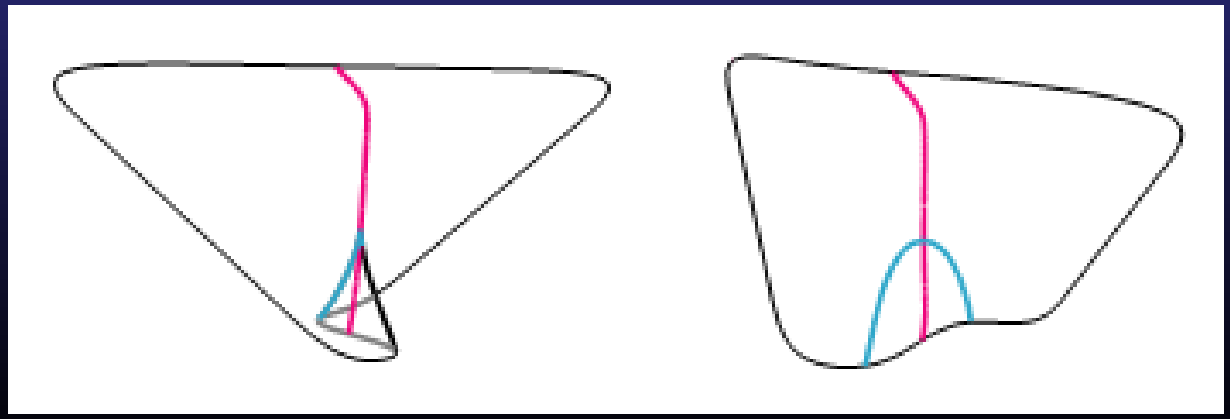


Silhouette properties

- View dependant

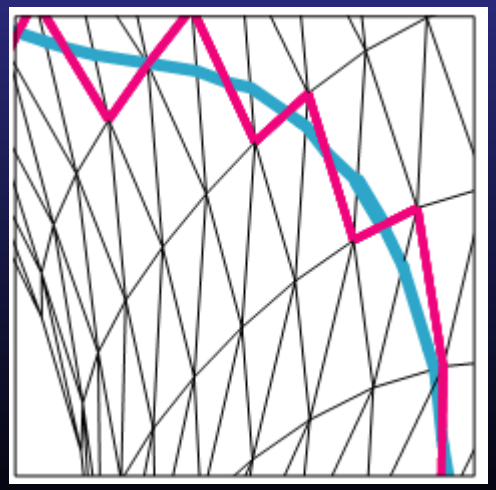


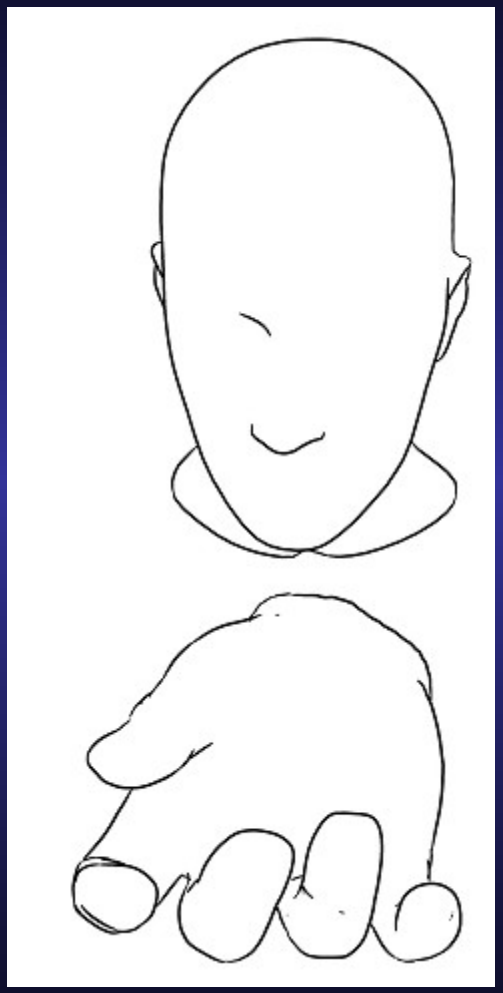
- Cusps



Smooth silhouettes

- Compute N.V for each vertex
- Interpolate to find the 0 place on the edges

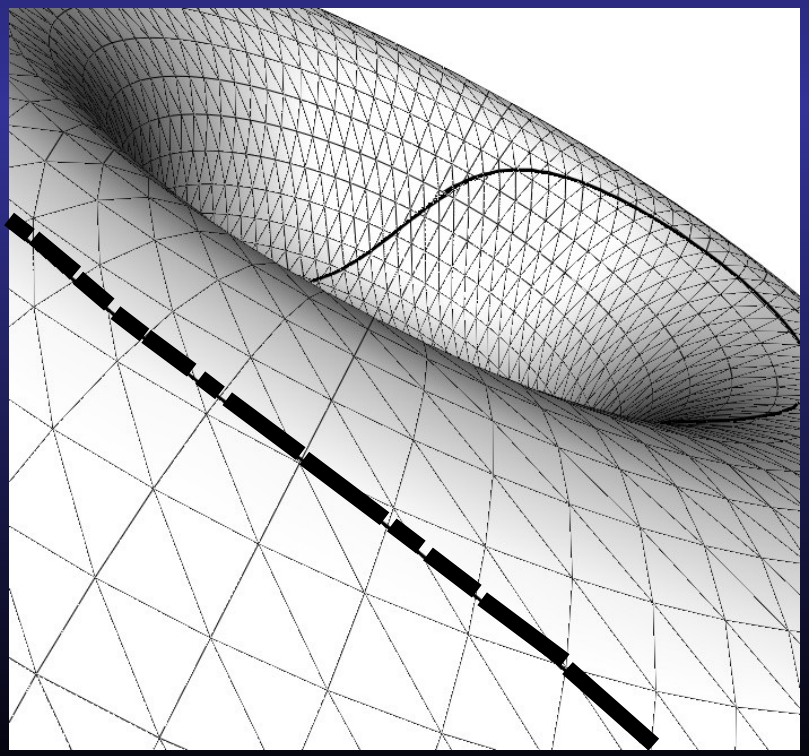


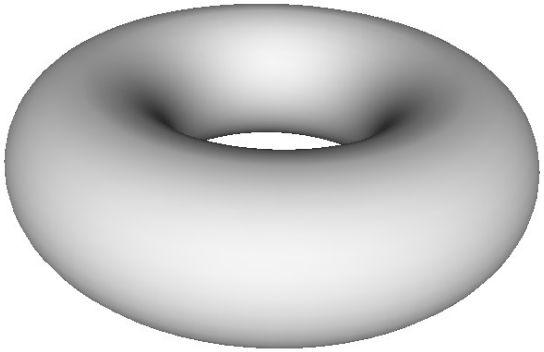


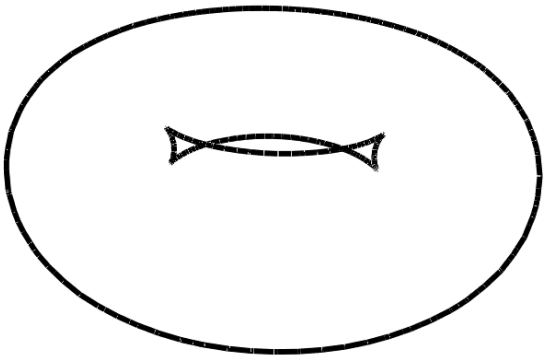
Illustrating smooth surfaces
A. Hertzmann, D. Zorin
SIGGRAPH 2000

What is missing?

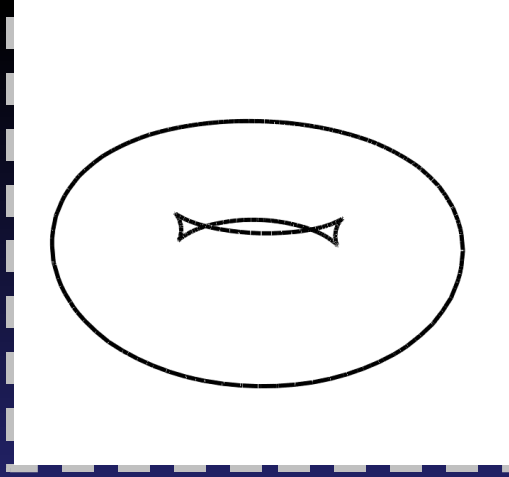
- Keep only visible edges
- Build a continuous curve

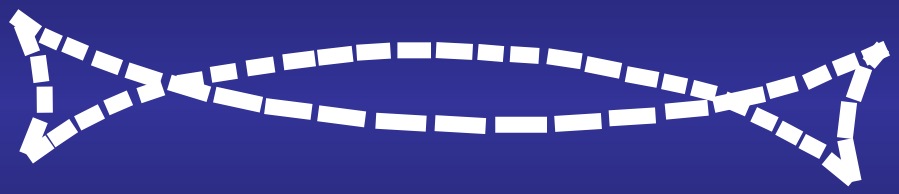




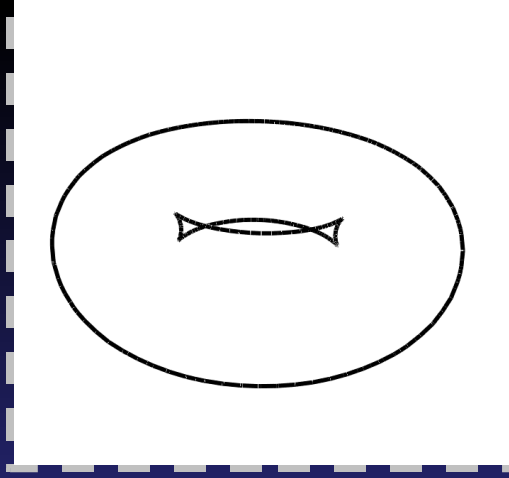


Chosen edges

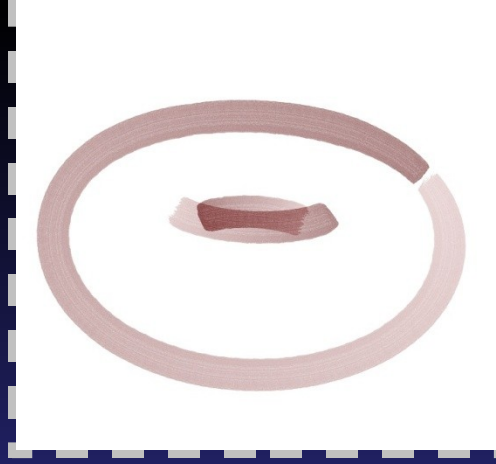




Visible edges

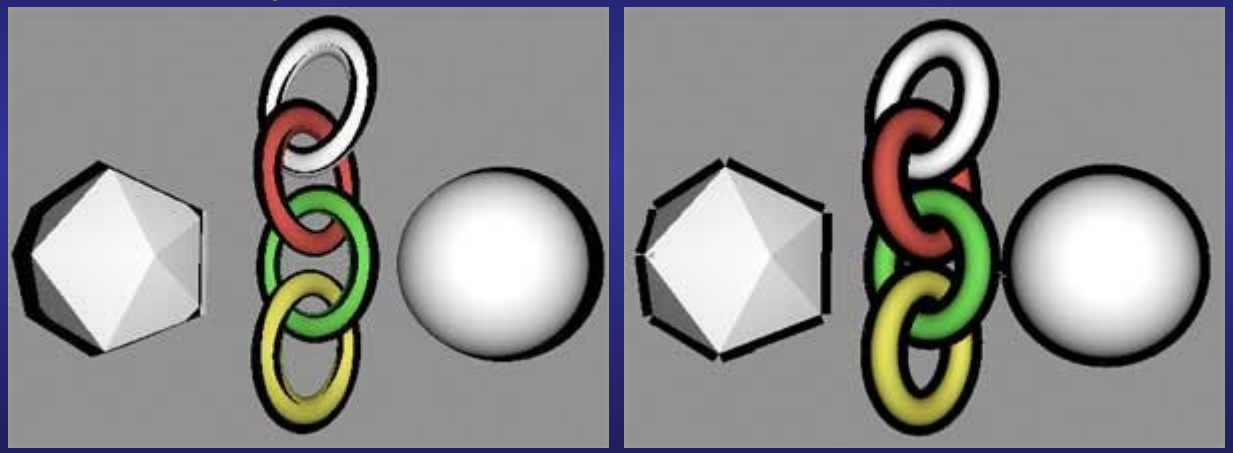


Curve

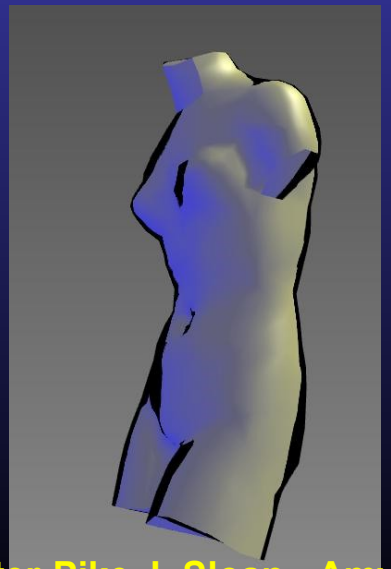


Silhouettes on the GPU

- Perturb the back facing polygons
  - Multiple renderings



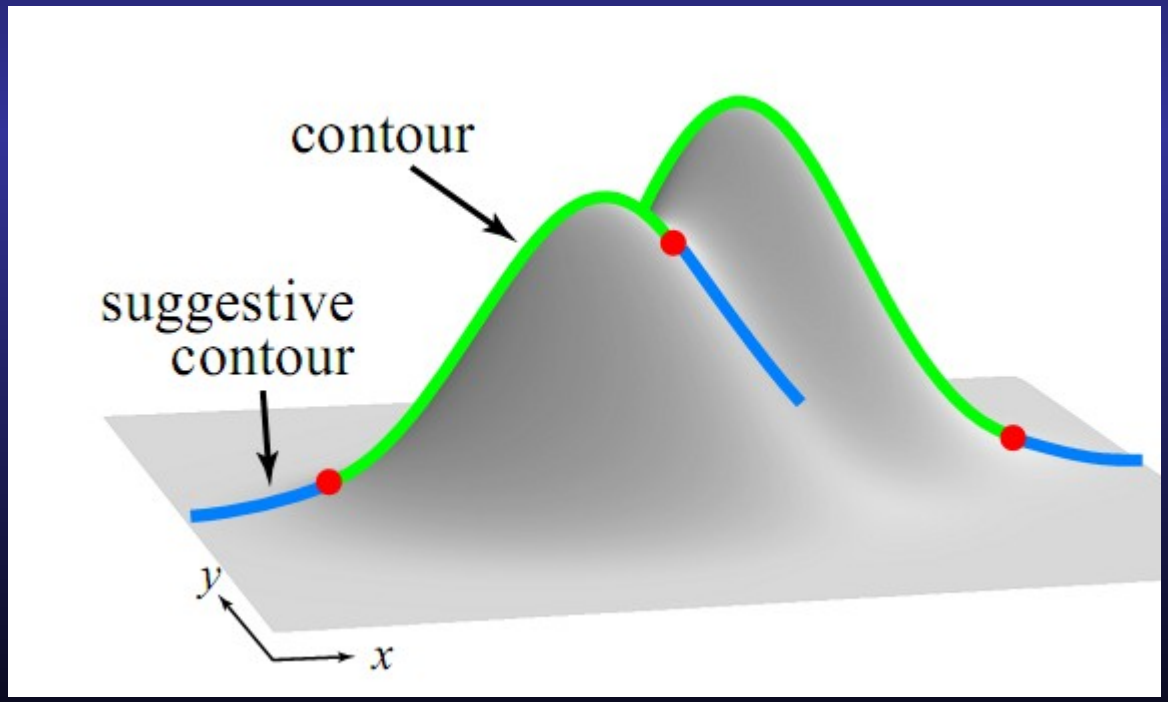
- Use an envmap



Interactive Technical Illustration, Bruce Gooch - Peter-Pike J. Sloan - Amy Gooch - Peter Shirley - Richard Riesenfeld

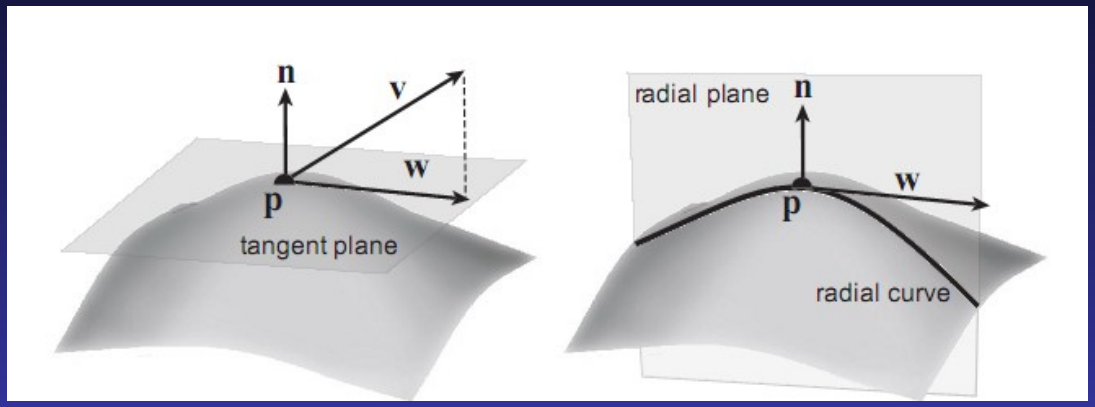
Now what else?

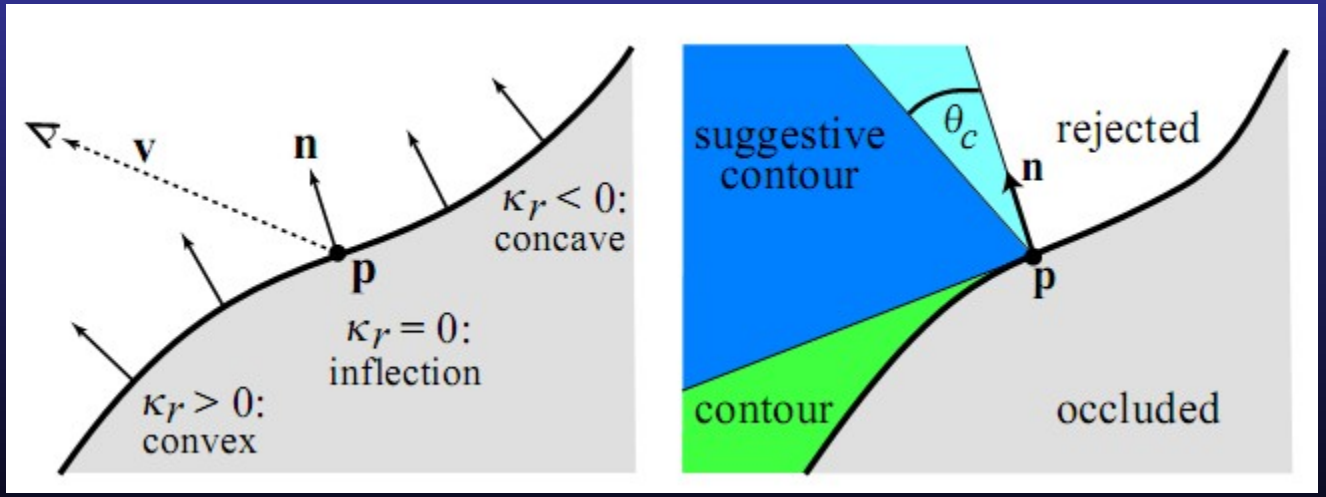
- Near silhouettes



Suggestive contours (1)

- Zeros of radial curvature

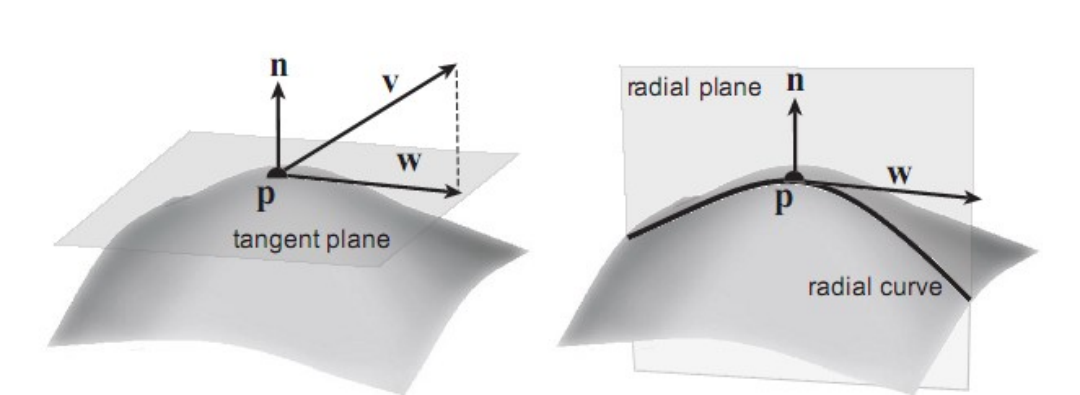


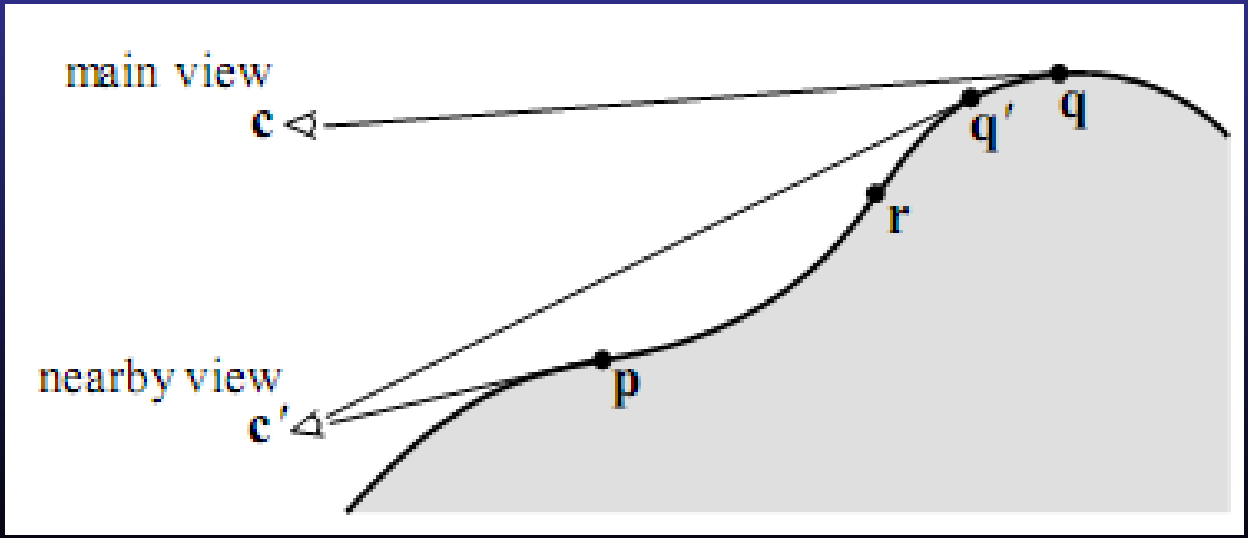


Suggestive Contours for Conveying Shape – SIGGRAPH 2003
Doug DeCarlo, Adam Finkelstein, Szymon Rusinkiewicz, Anthony Santella

Suggestive contour (2)

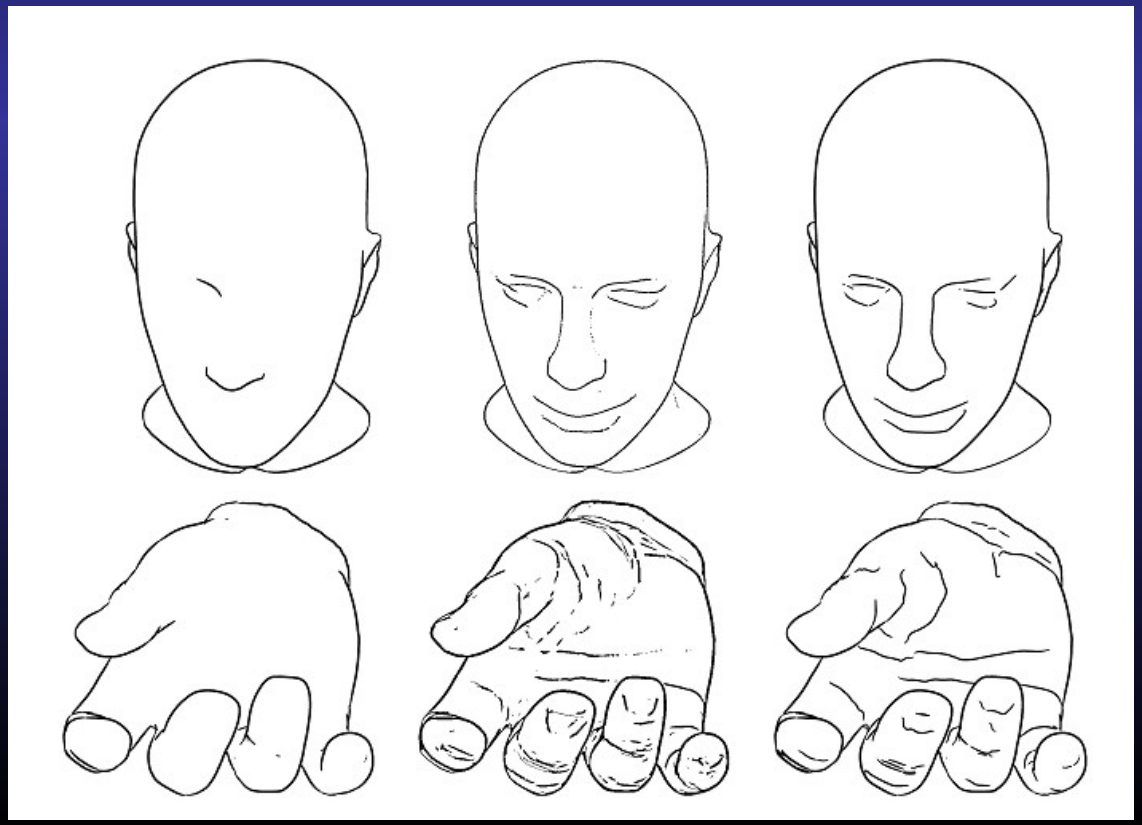
- Set of minima of N.V in the direction of W





Two rendering algo

- in image space (min of N.V)
- in object space (zero of Kr)

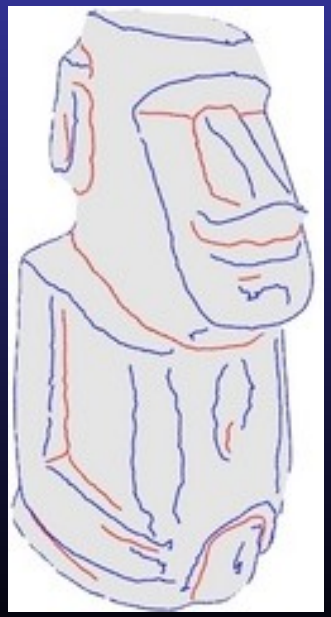


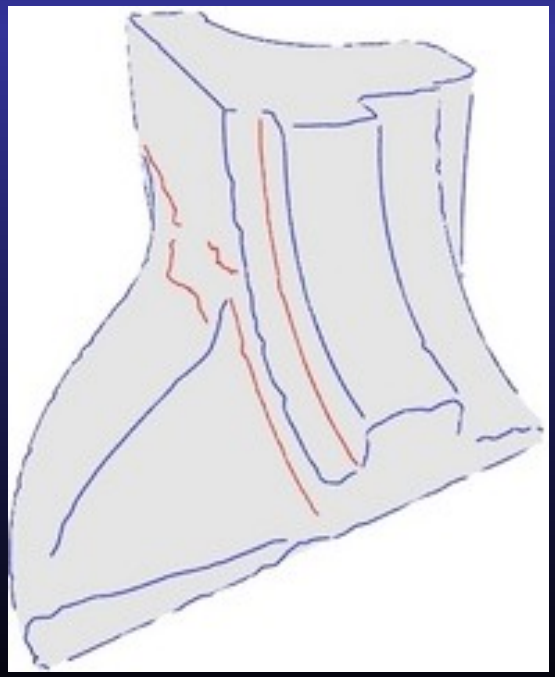
Object space

- More complicated and costly
- Various types of lines
  - Silhouettes
  - Creases
  - Ridges and valleys

Crease

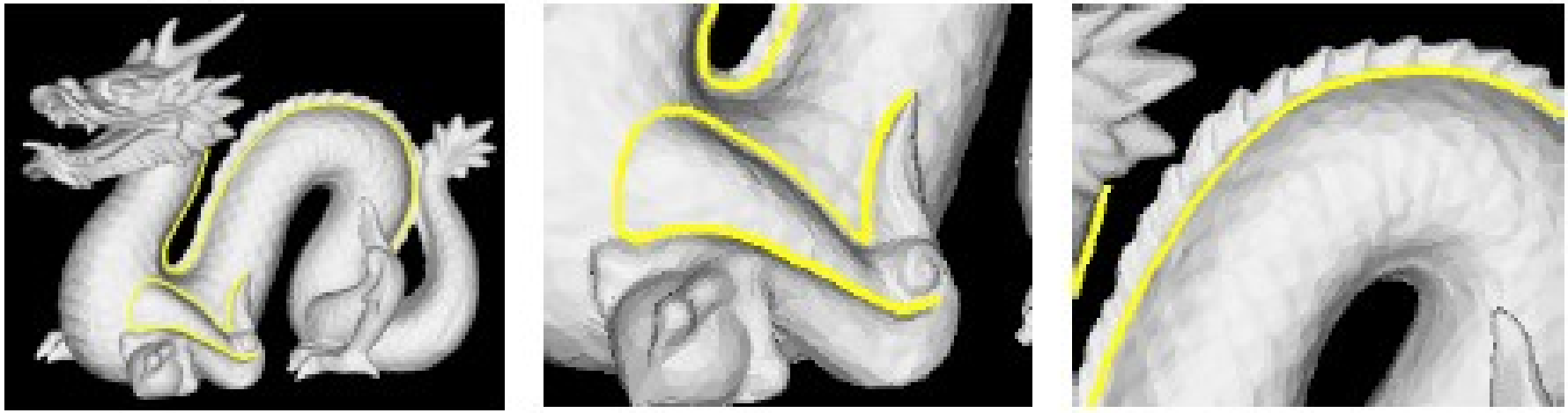
- Sharp edges
- Threshold the normal difference between to faces





Riges and valleys

- Creases extension
- Curvature max in principal direction

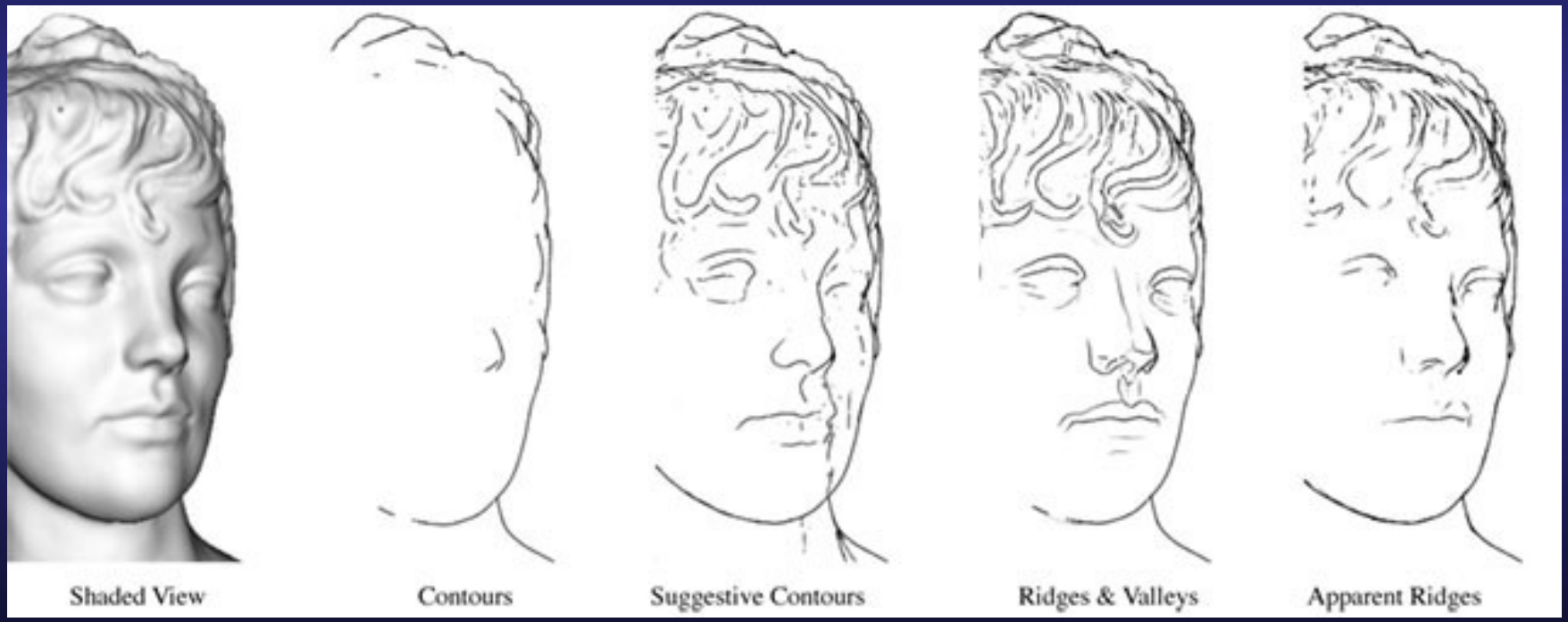


Main problem

- Curvature computation
  - Object space: differential geometry
  - Image space: gradient

Are ridges what we need?

- A view dependent version



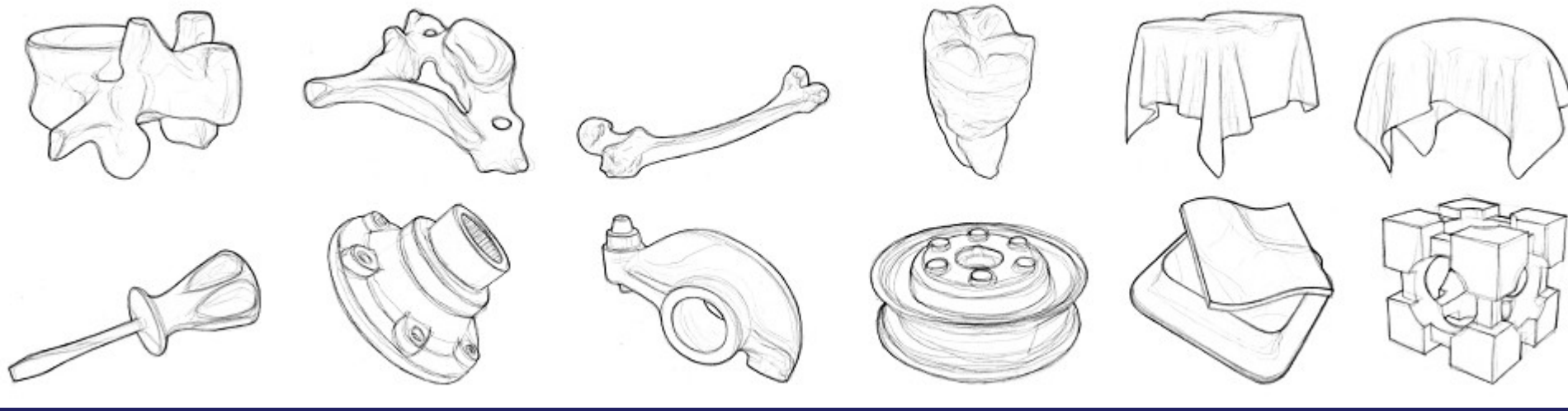
Apparent Ridges for Line Drawings
Tilke Judd Frédo Durand Edward Adelson

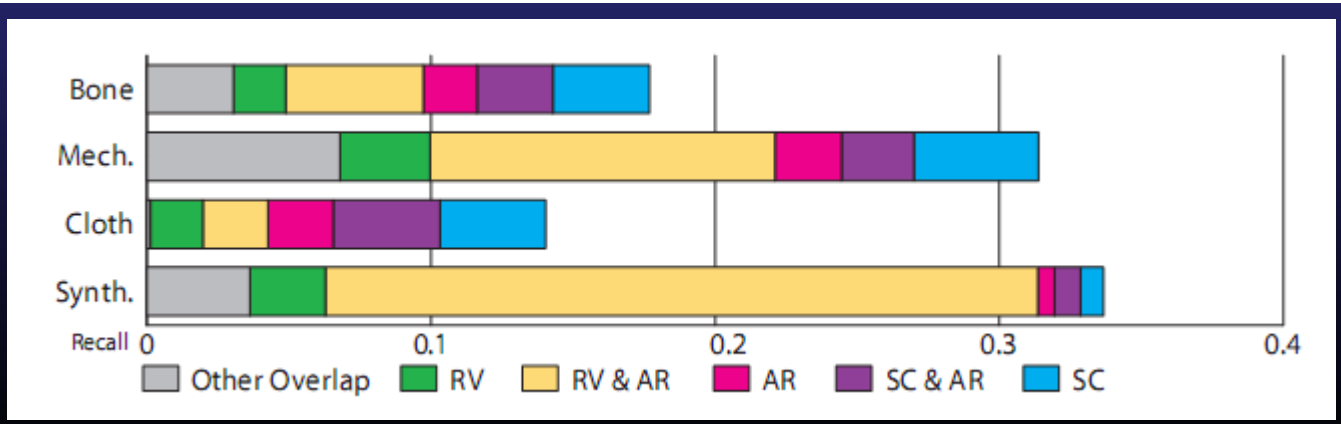
Now what?

What lines do we really need?

User study

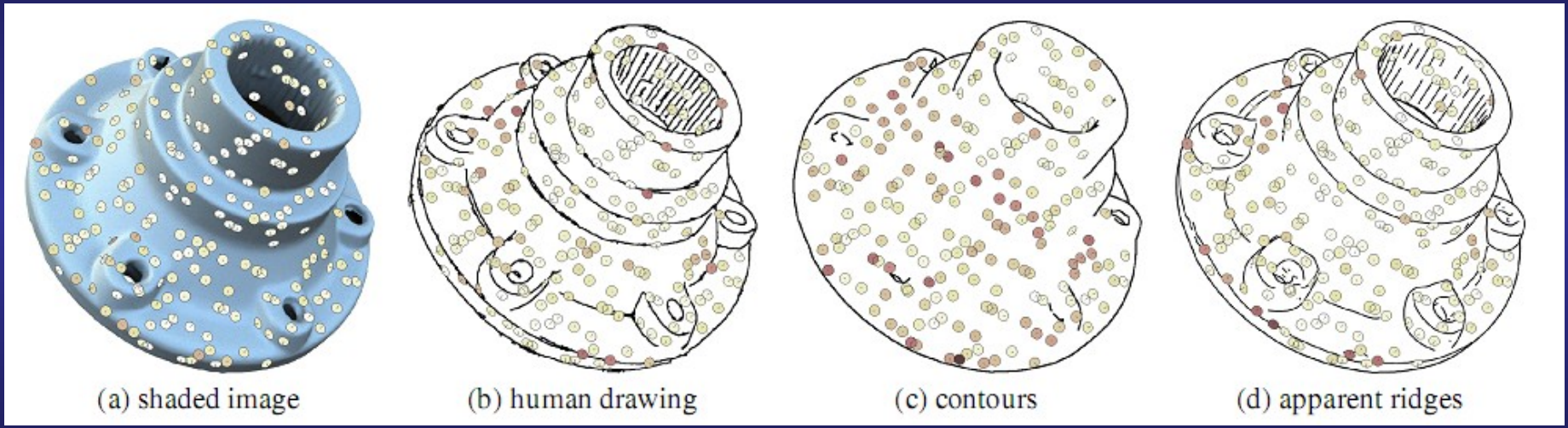
"Where Do People Draw Lines?," Forrester Cole, Aleksey Golovinskiy, Alex Limpaecher, Heather Stoddart Barros, Adam Finkelstein, Thomas Funkhouser, and Szymon Rusinkiewicz, *SIGGRAPH 2008*





User study

"How Well Do Line Drawings Depict Shape?," Forrester Cole, Kevin Sanik, Doug DeCarlo, Adam Finkelstein, Thomas Funkhouser, Szymon Rusinkiewicz, and Manish Singh,. *SIGGRAPH 2009)*



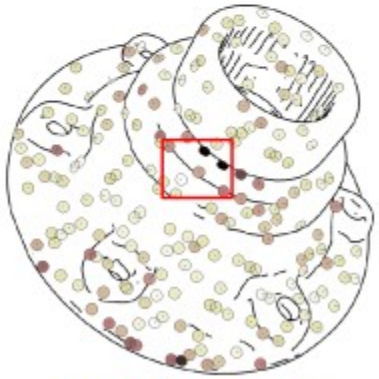
Results unclear yet
To be continued…

ridges and valleys

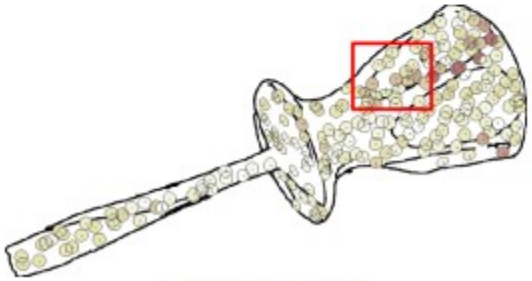
contours only

ridges and valleys

artist's drawing

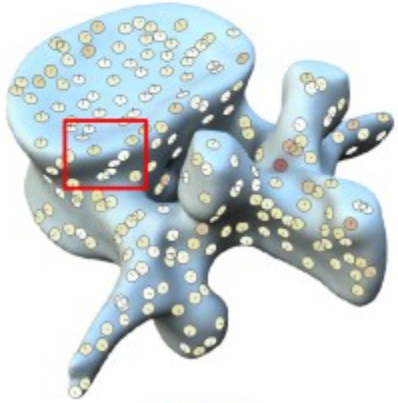


suggestive contours



artist's drawing

suggestive contours



shaded

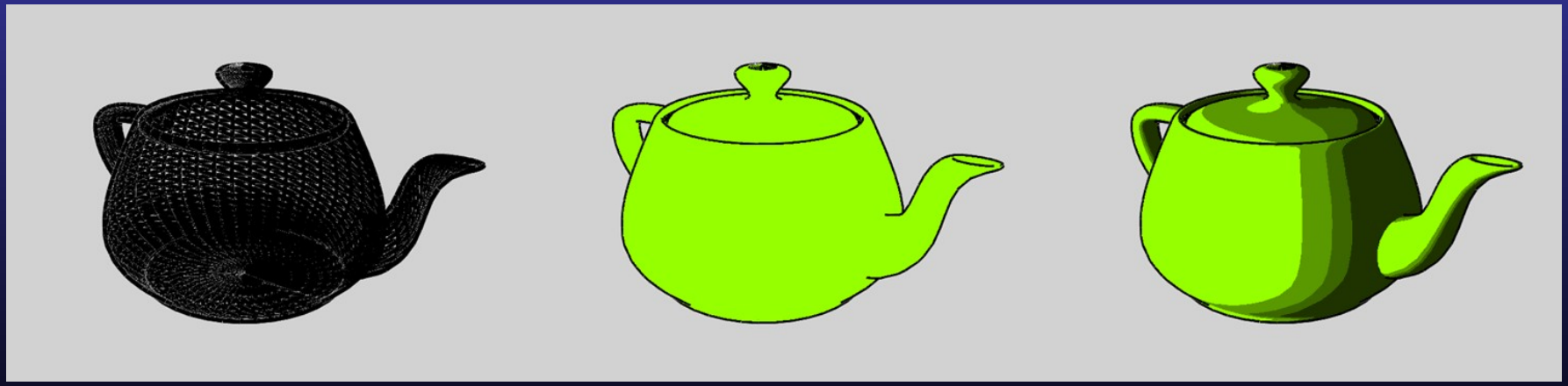
III - Illumination

Cartoon shading

- Shading model in 2D cartoon
  - Use material color and shadow color
  - Present lighting cues, shape, and context
- Stylistic
- Used in many animated movies
- Developing real-time techniques for games

Cartoon shading

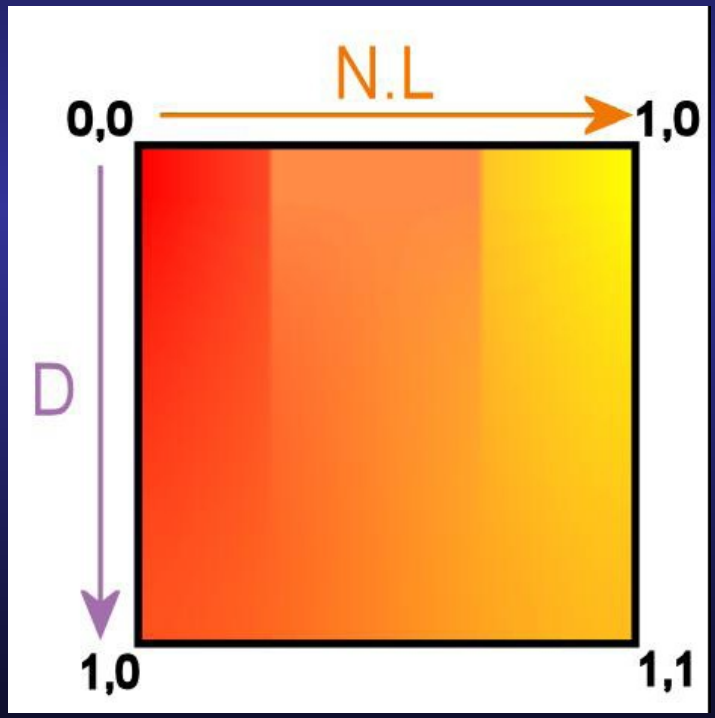
- Apply shading as 1D texture map
- Texture lookup according to N.L

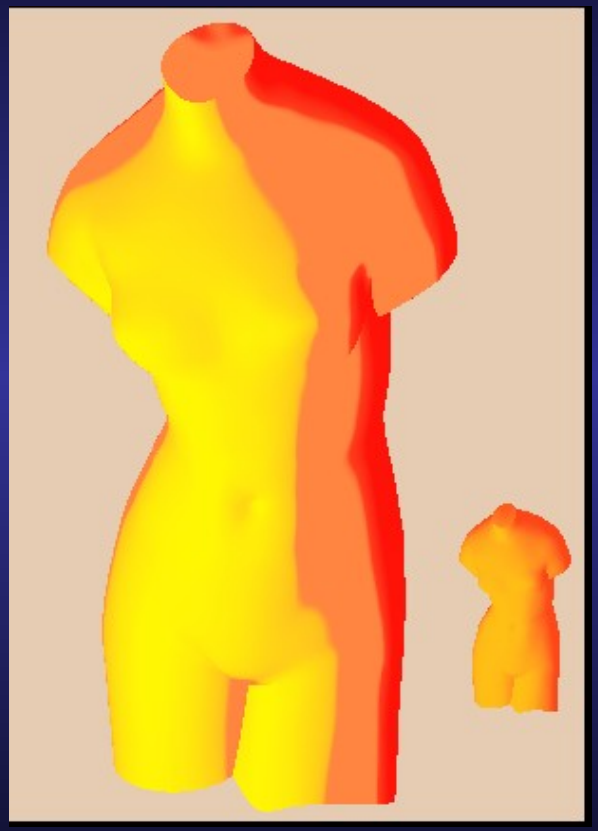



www.wakfu.com

X-toon

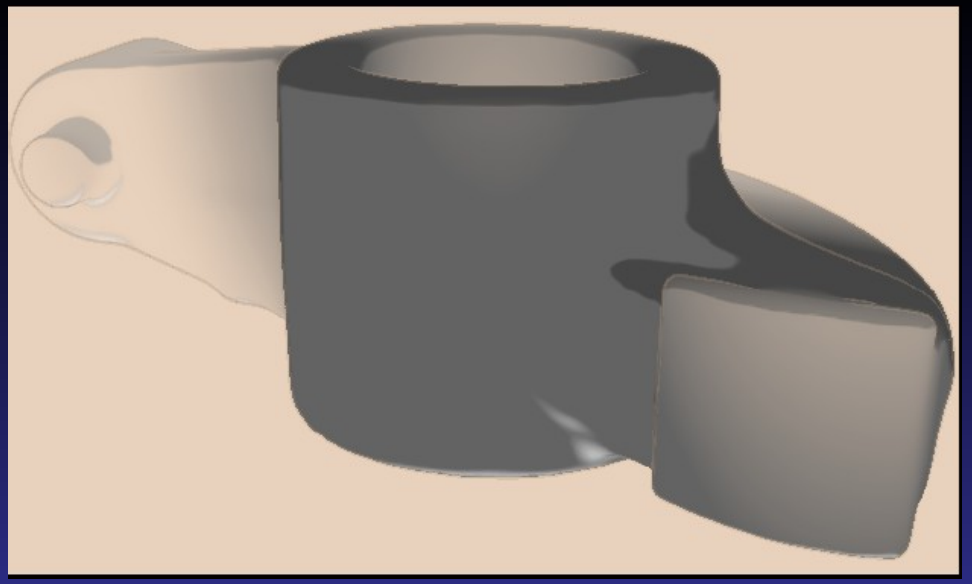
- 2D texture map



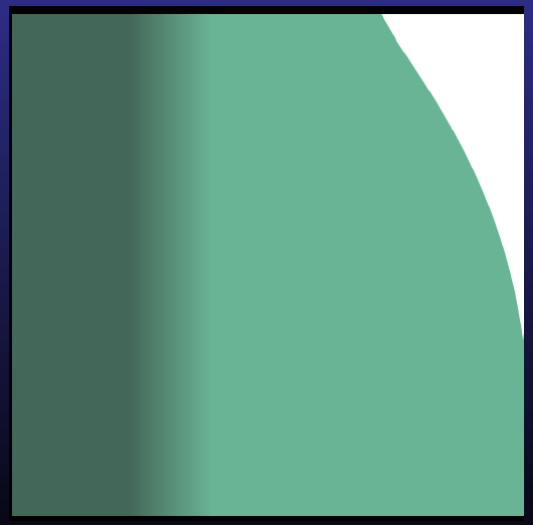


D = depth

NPAR, 2006 - Pascal Barla, Joëlle Thollot, Lee Markosian



D = distance to a 3D point



D = distance to reflexion angle

Playing with Phong

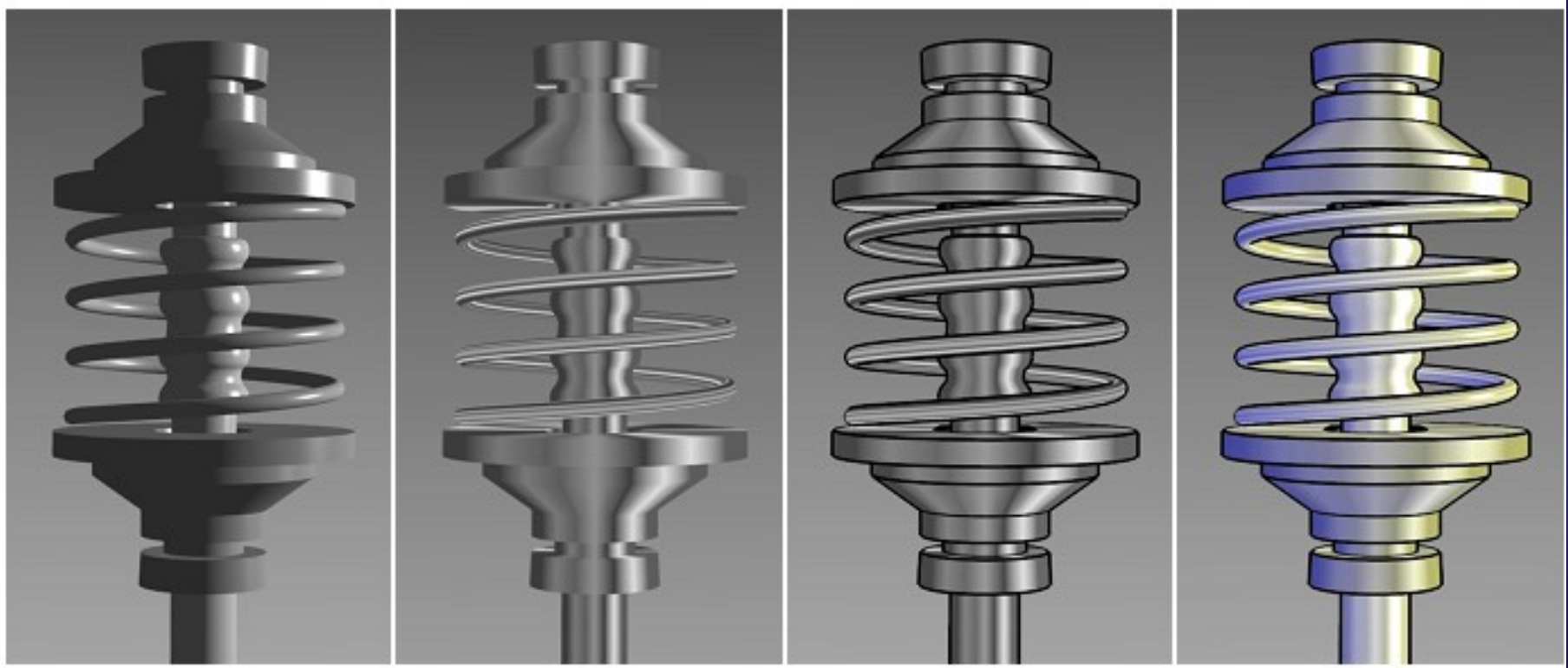


Figure 10: Left to Right: a) Phong shaded object. b) New metal-shaded object without edge lines. c) New metal-shaded object with edge lines. d) New metal-shaded object with a cool-to-warm shift.

A Non-Photorealistic Lighting Model For Automatic Technical Illustration
Amy Gooch, Bruce Gooch, Peter Shirley, Elaine Cohen

IV - Style

Attributes

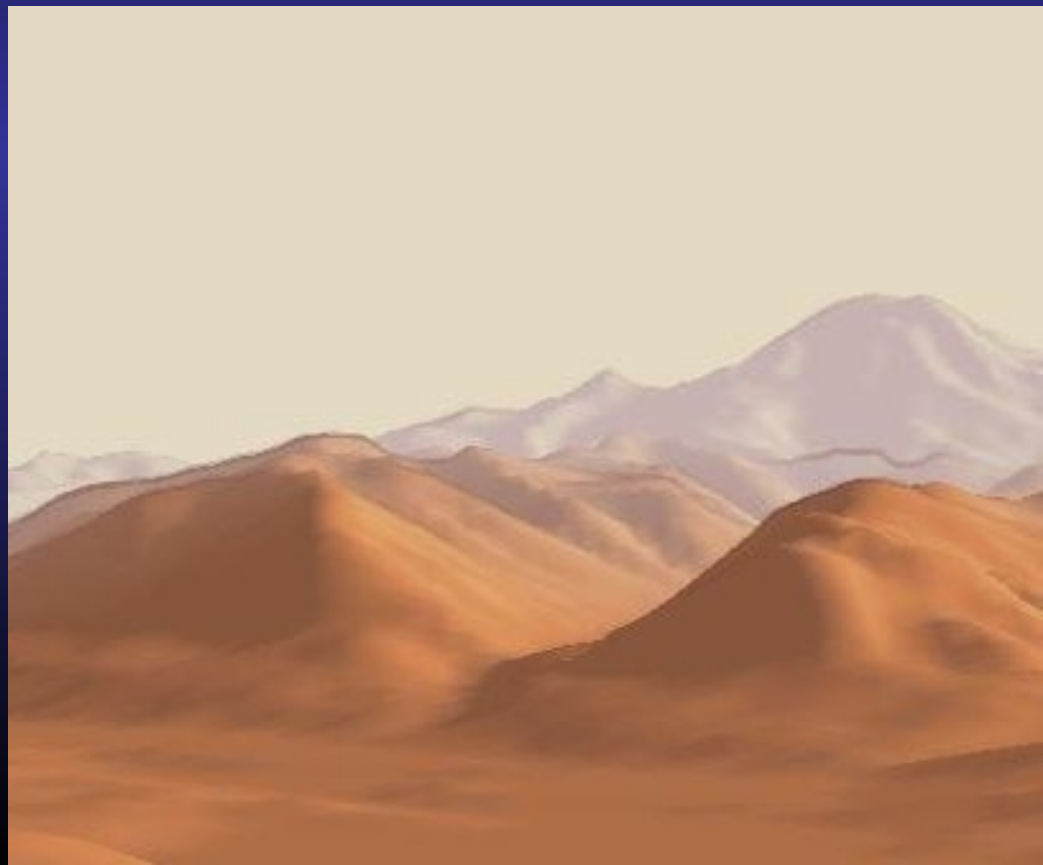
- Style = transfer function
- From scene to marks attributes

⇒ How to combine user choices and scene information?

⇒ Compromise automatic vs manual

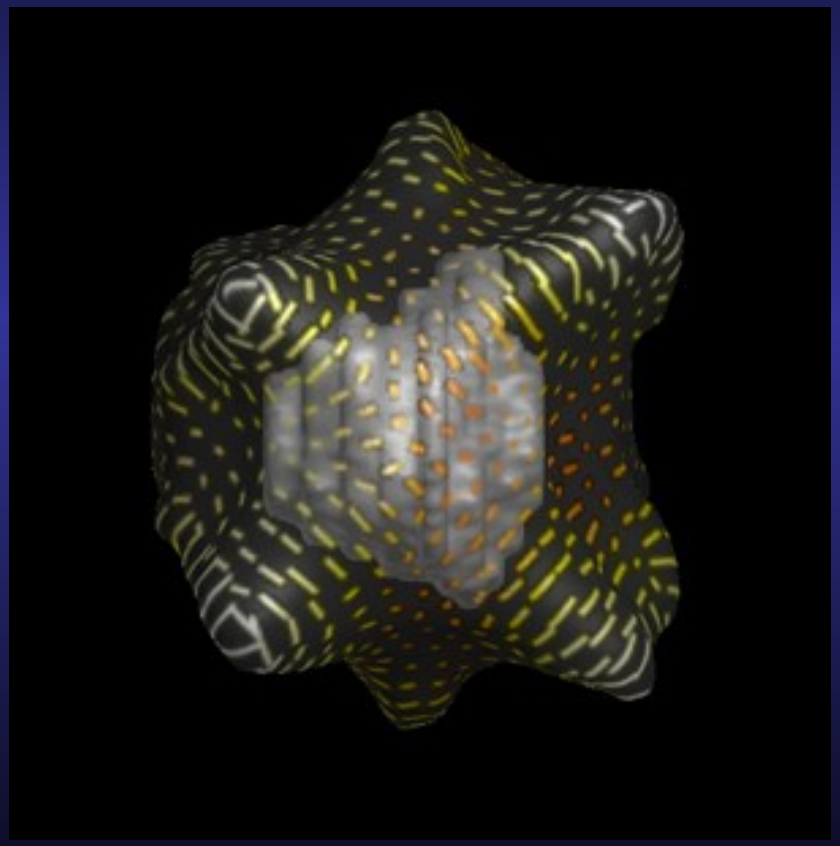
Depth to Color

- Atmospheric perspective
- $C = f(z)$



BARLA P., MARKOSIAN L., THOLLOT J.
« X-Toon : An extended toon shader »
NPAR 2006

Curvature to orientation

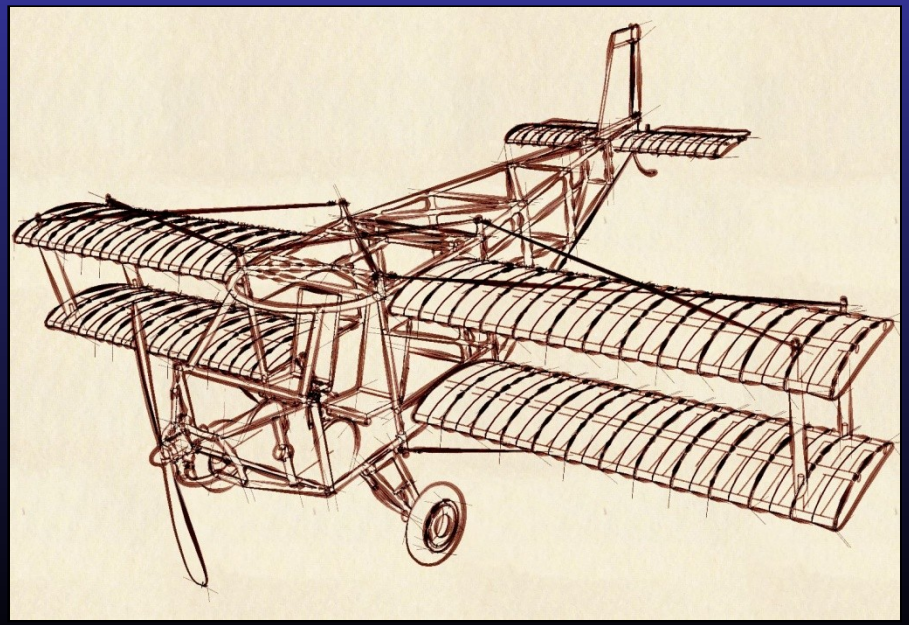


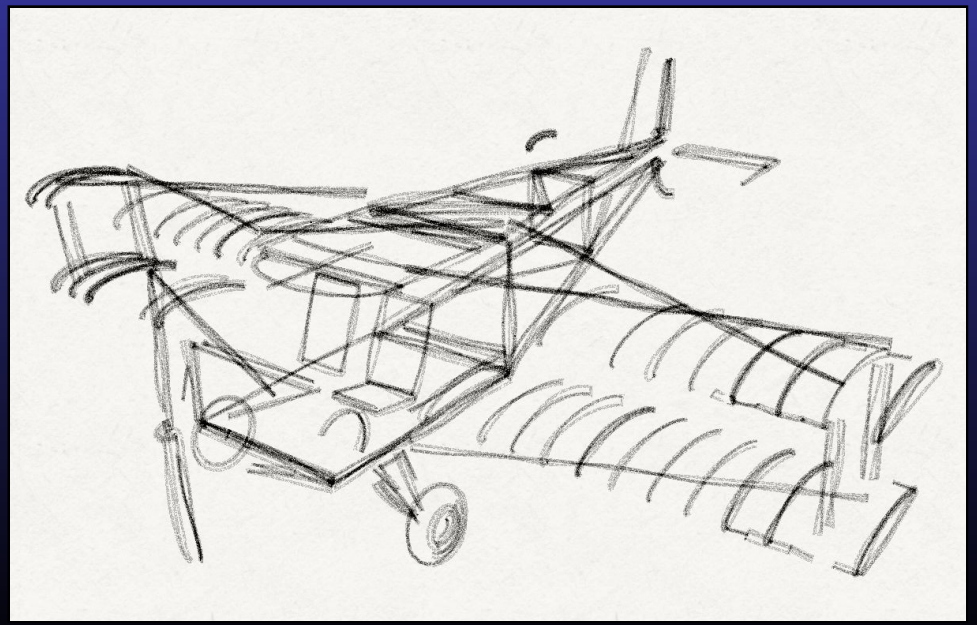
INTERRANTE V., « Illustrating surface shape in volume data via principal direction driven 3D line integral convolution » *Siggraph 97*

OSTROMOUKHOV V., « Digital facial engraving », *Siggraph 99*

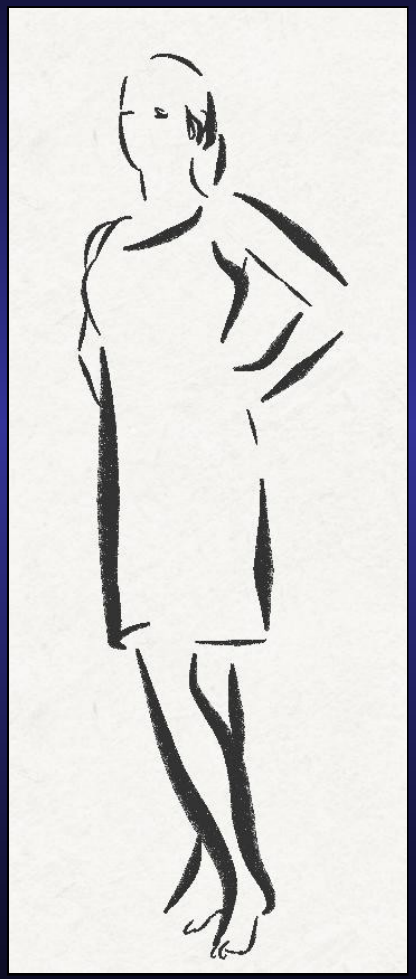
Freestyle

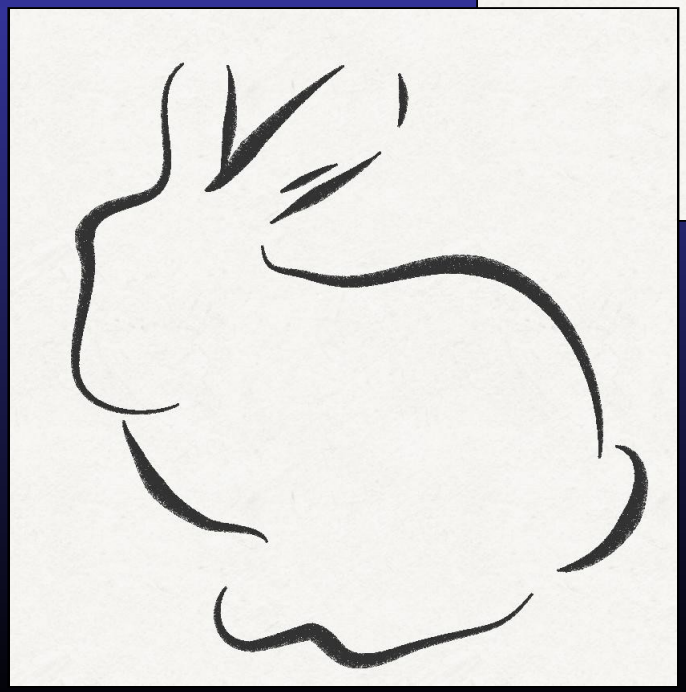
- Style coding

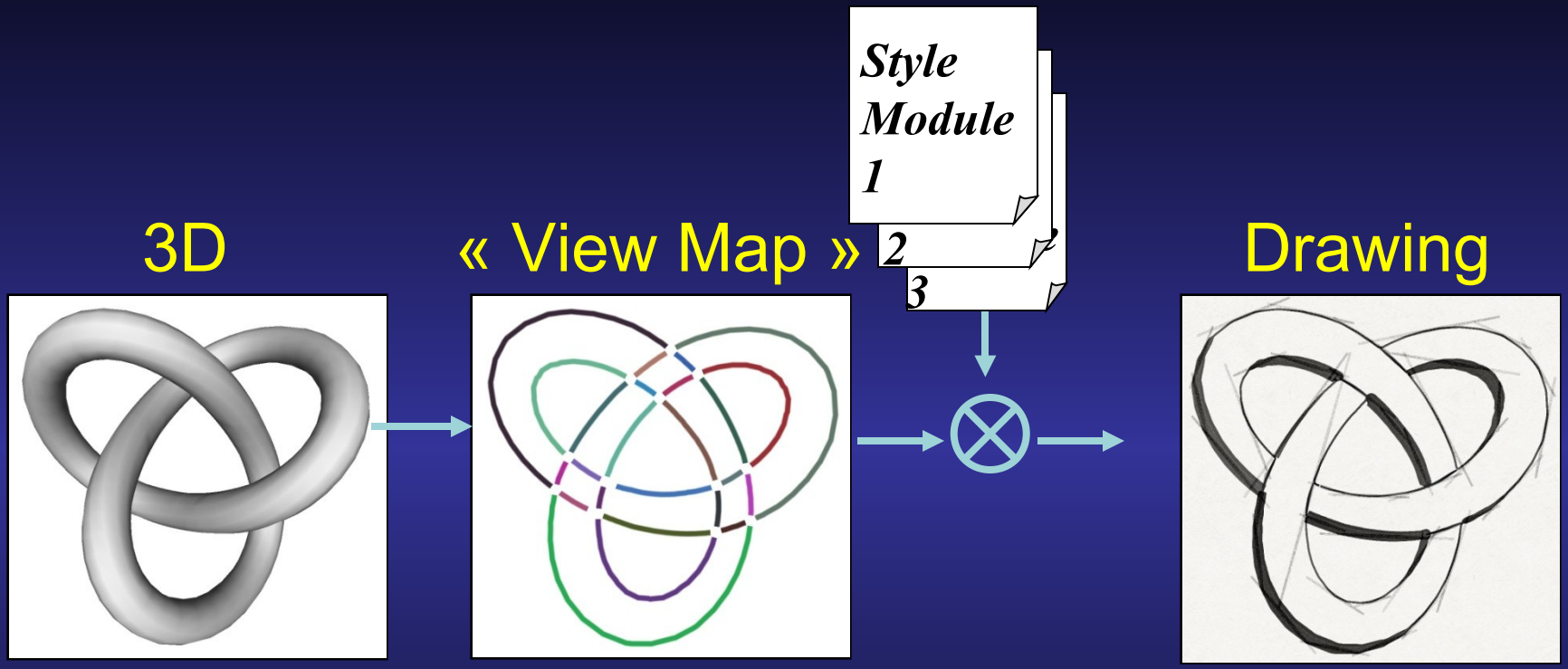




- Independant from the 3D model

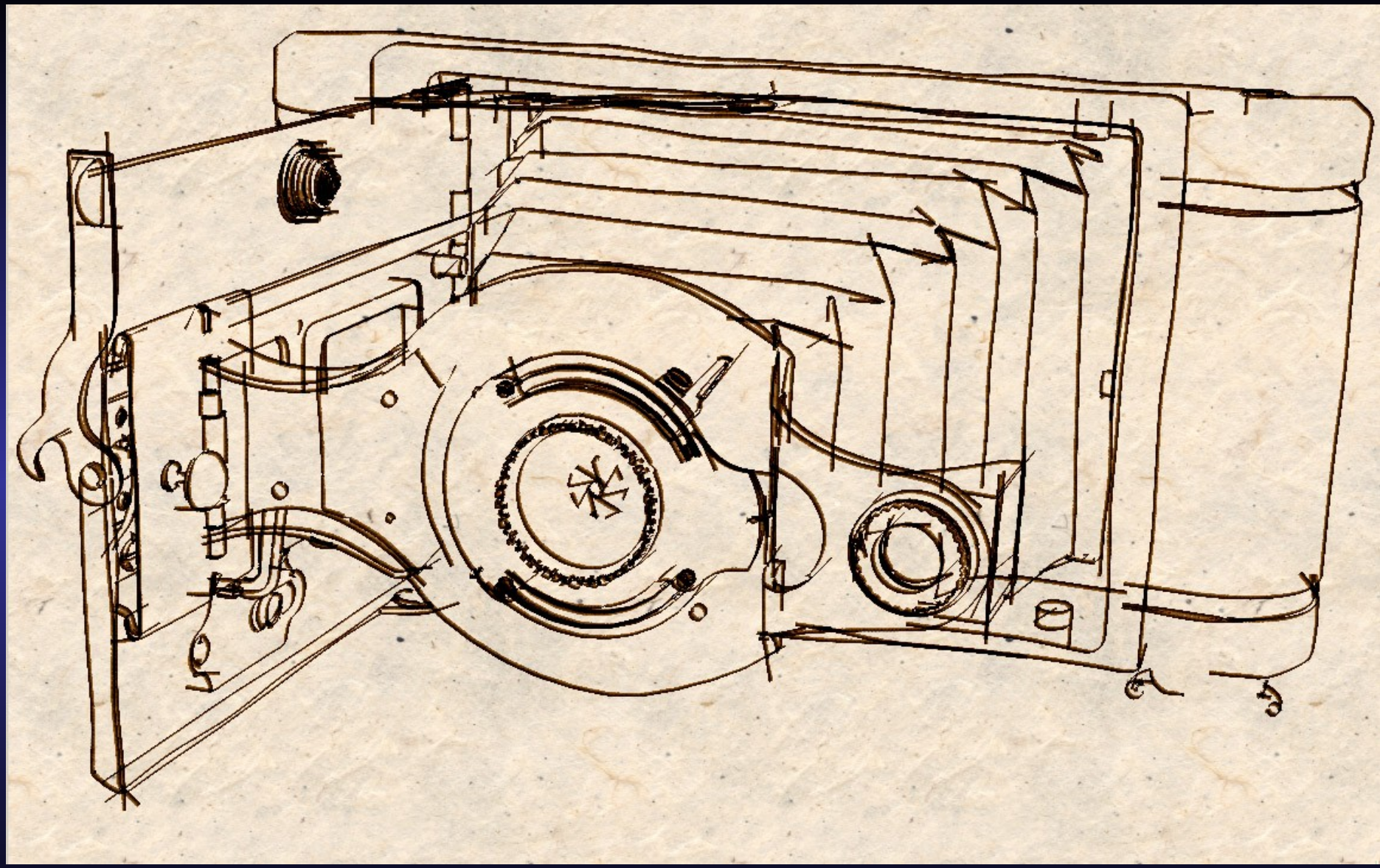


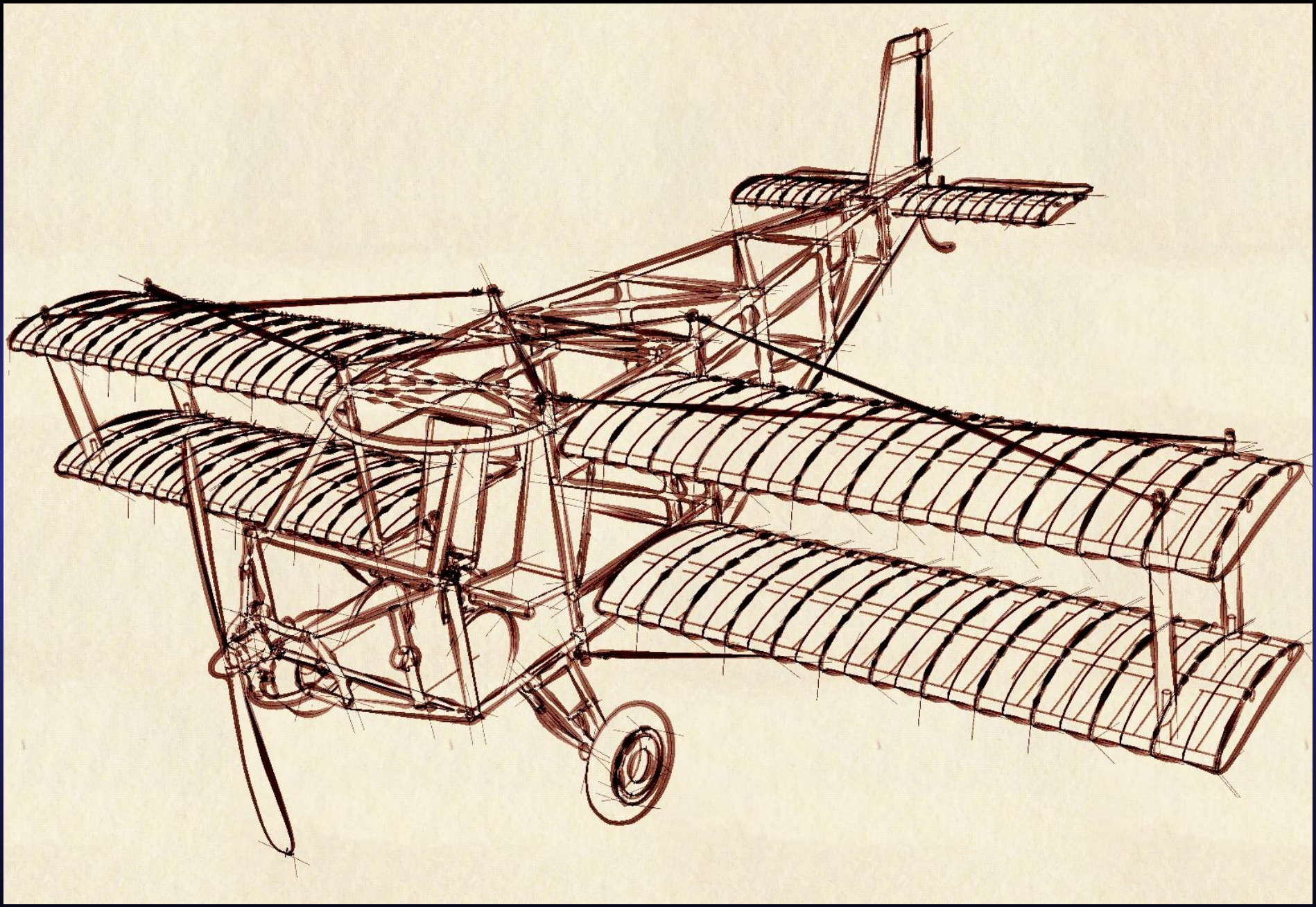


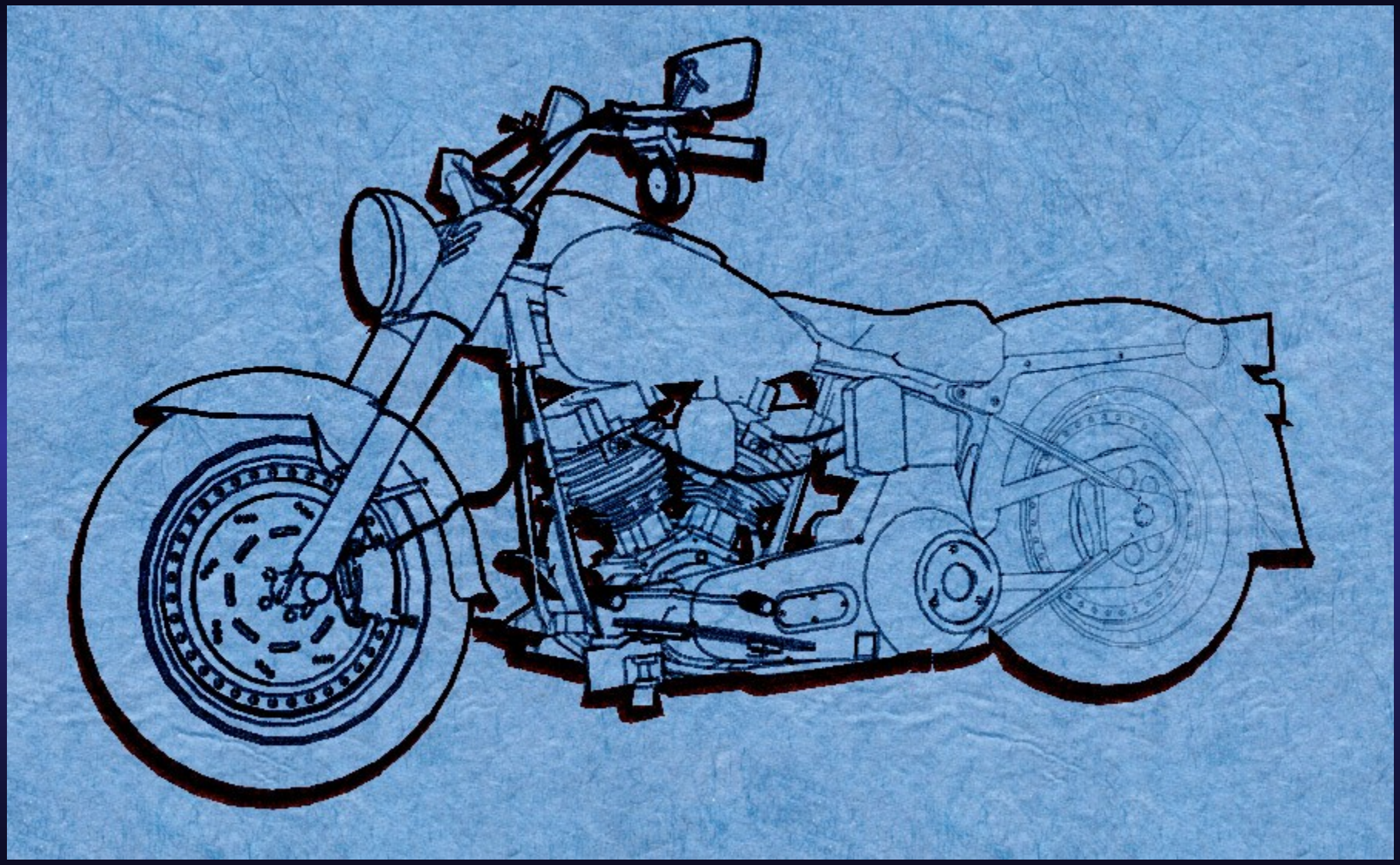

3D
« View Map »
Style Module 1
2
3
Drawing
+
information

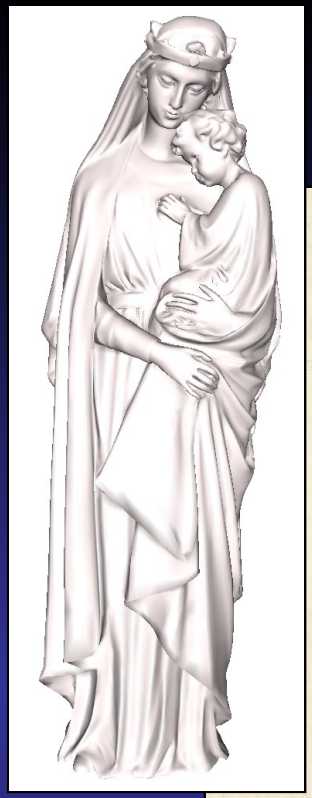
Parameters

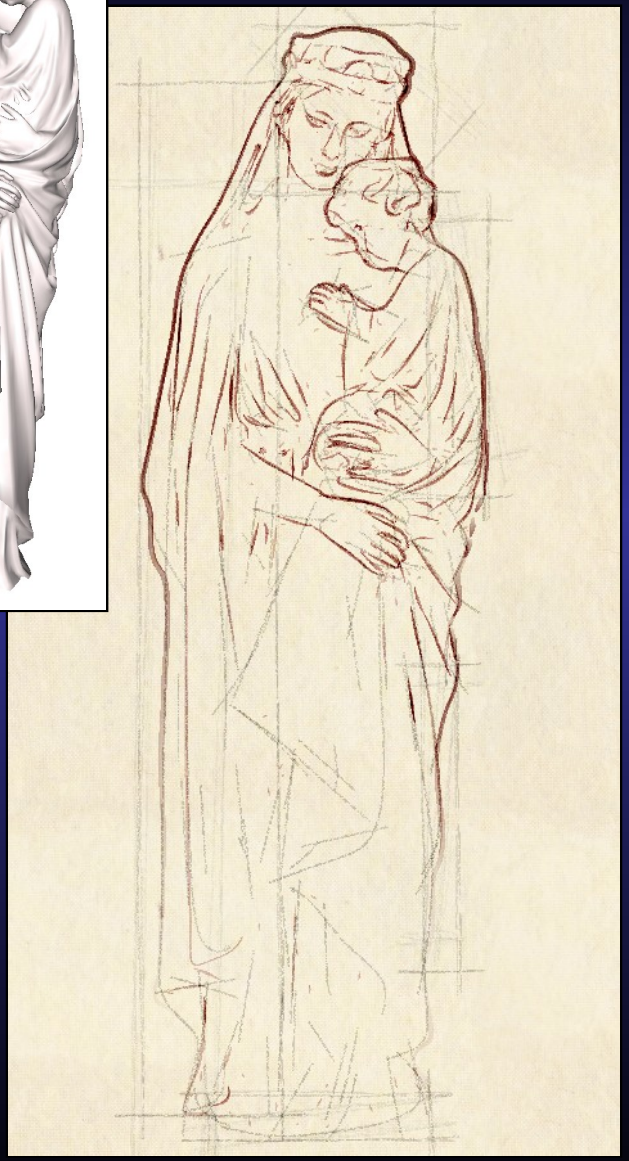
- Geometry (2D, 3D coord, normals…)
- Curvature
- Lines: adjacence, nature (contours, valleys…)
- Visibility, occlusion, depth discontinuity
- Material
- Density
- …



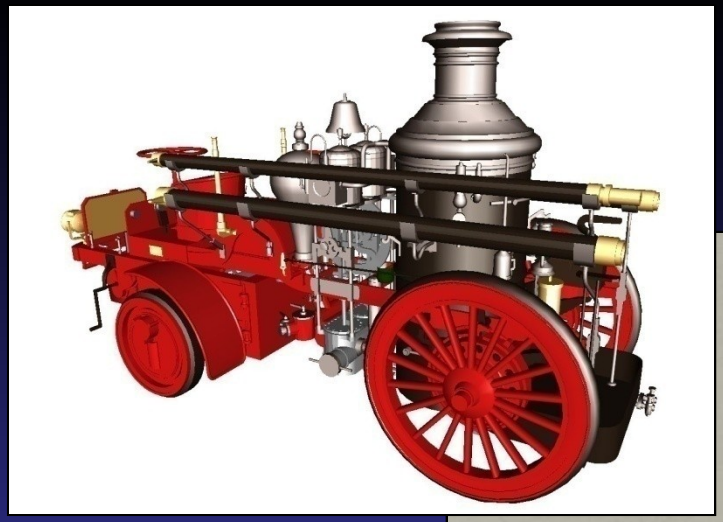


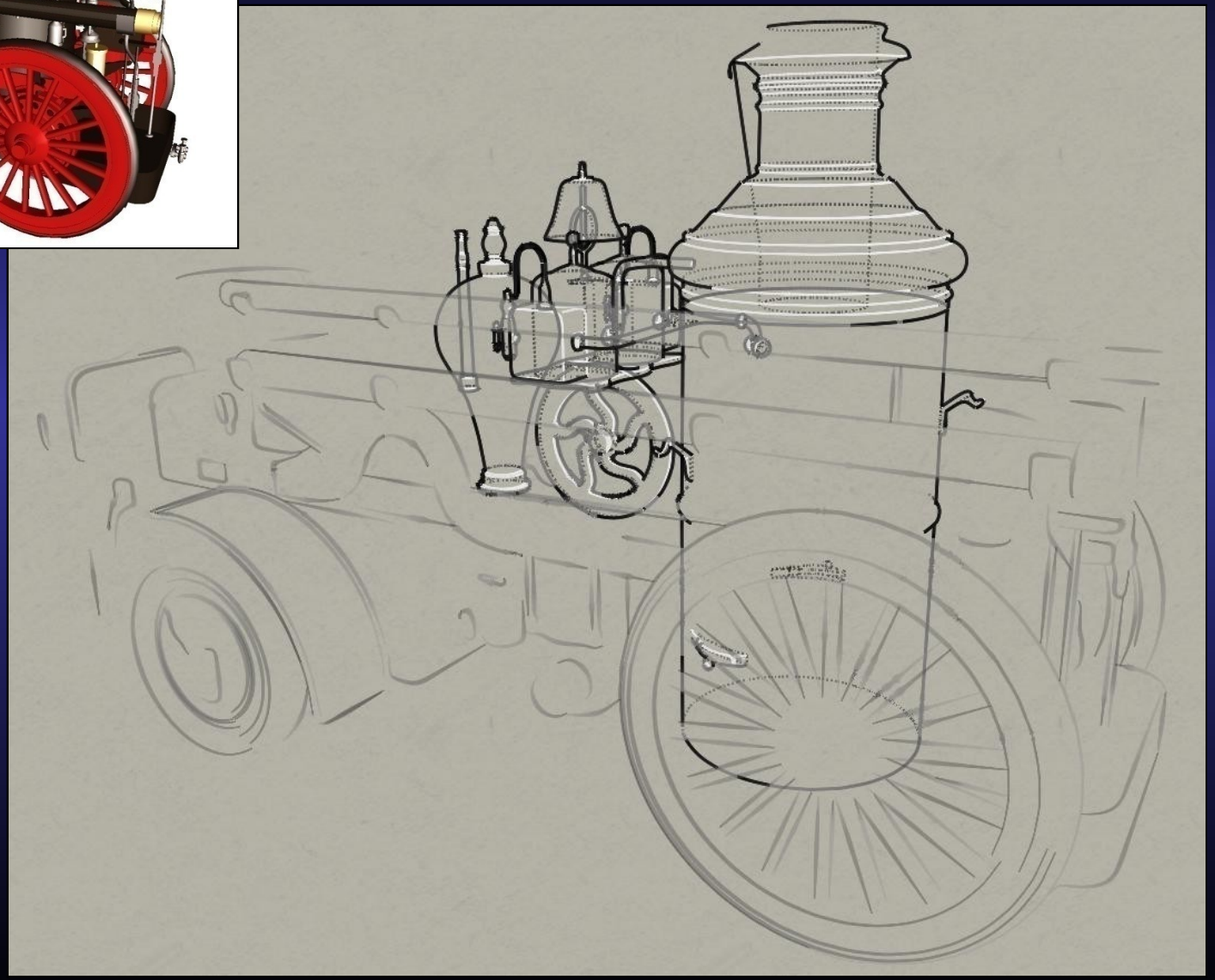






http://artis.imag.fr/Projects/Style



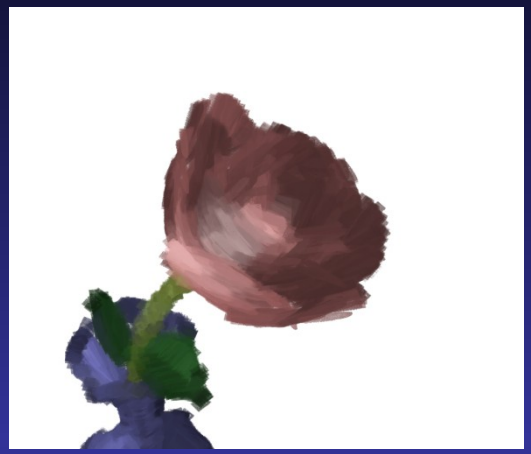


So what is the « style »

- A way for the artist to express something
- How to model that?
  - A set of paramters?
  - A set of techniques?

- Style = attributes + movement?

Procedural style

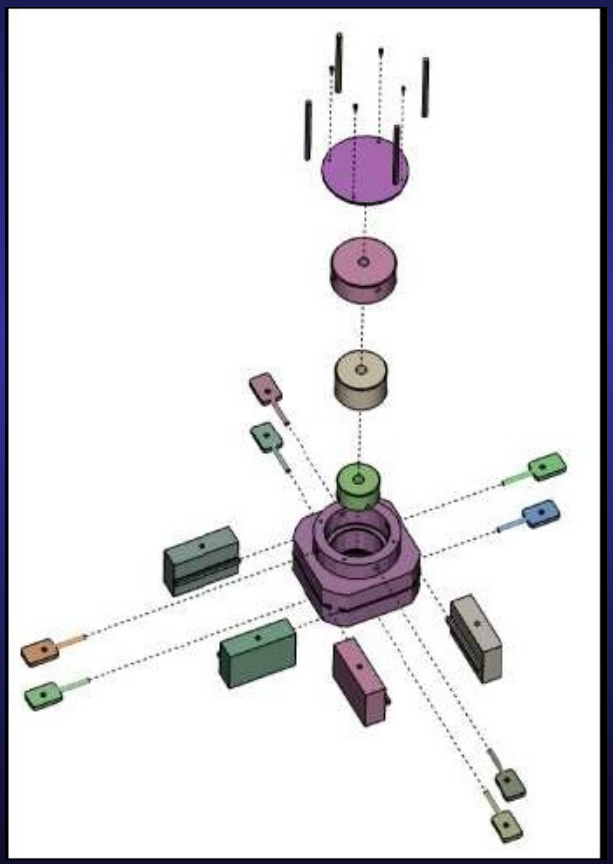

David Vanderhaeghe, Pascal Barla, Joëlle Thollot, François Sillion
A dynamic drawing algorithm for interactive painterly rendering
Siggraph technical sketch: SIGGRAPH'2006 - aug 2006

Conclusions

- Tons of things to do in research
- Link with other fields
  - Cognitive sciences
  - Human vision
  - Art
- A lot of applications in industry

Projection

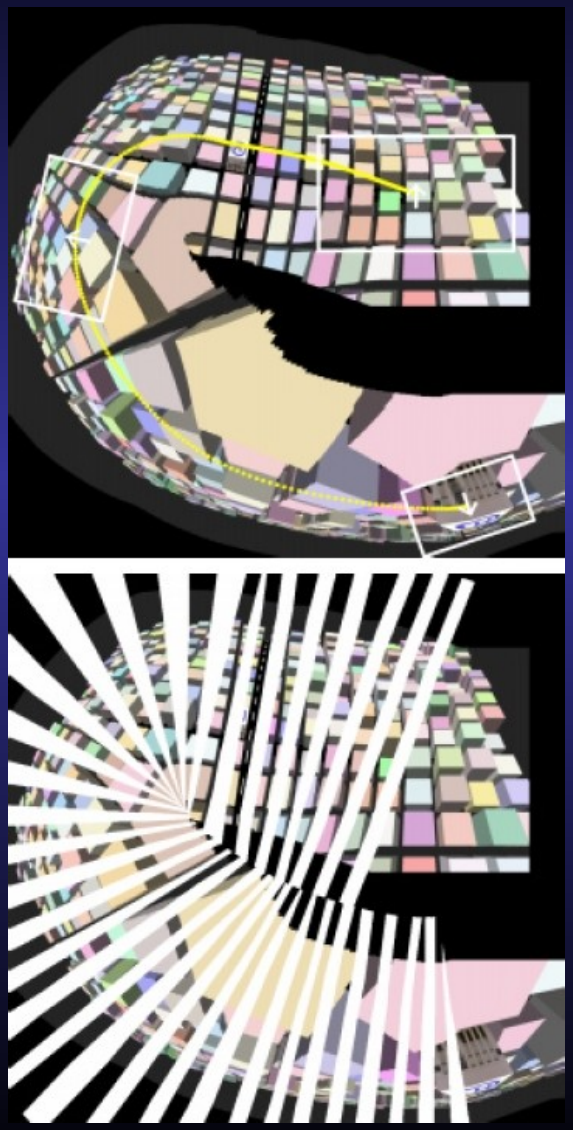
- 3D to 2D

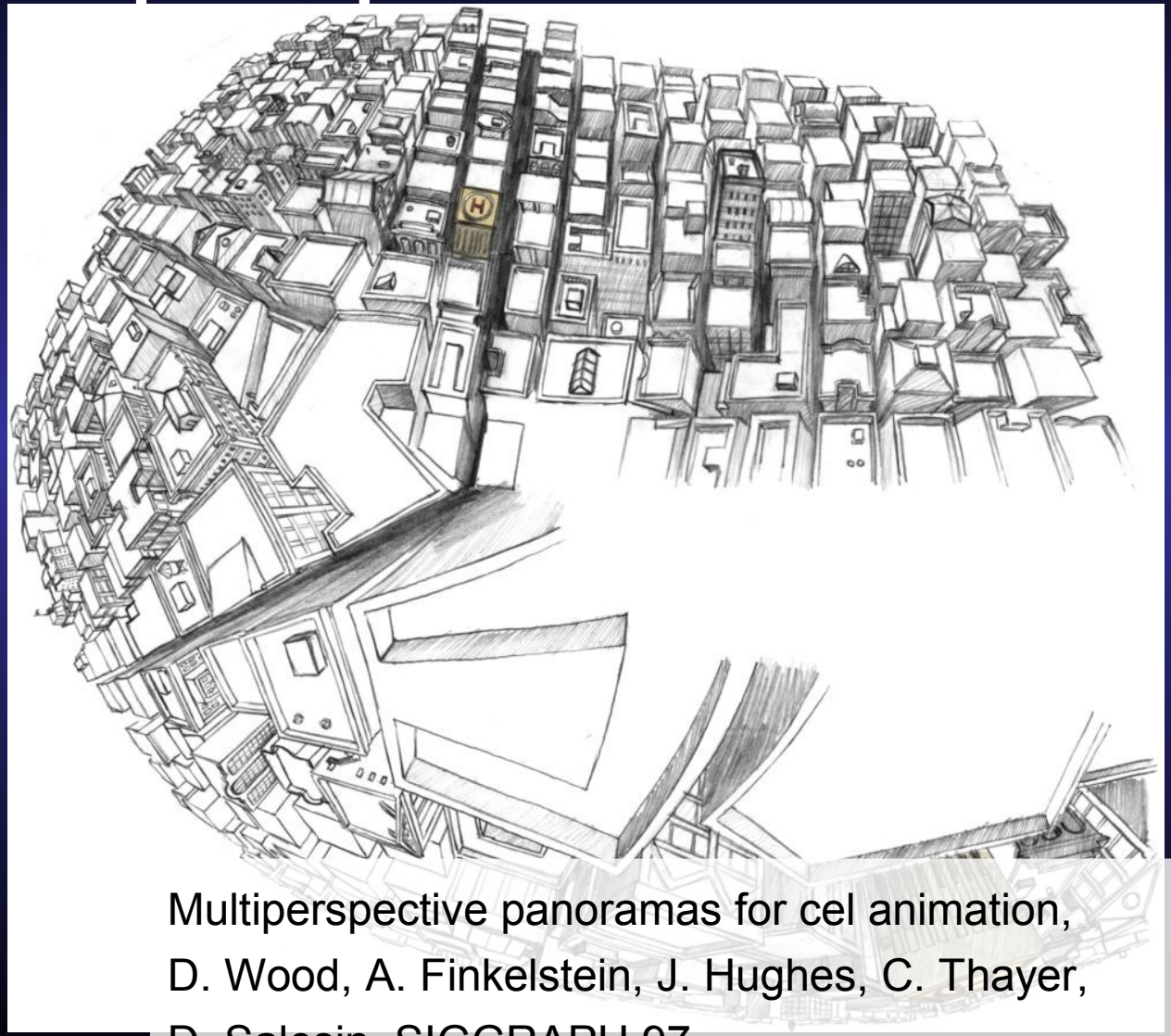


COLEMAN P., SINGH K.,
« RYAN : Rendering your animation nonlinearly projected», NPAR'04

AGRAWALA M., PHAN D., HEISER J., HAYMAKER J., KLINGNER J., HANRAHANP., TVERSKY B.,
« Designing effective step-by-step assembly instructions », ACM Trans. Graph., 2003

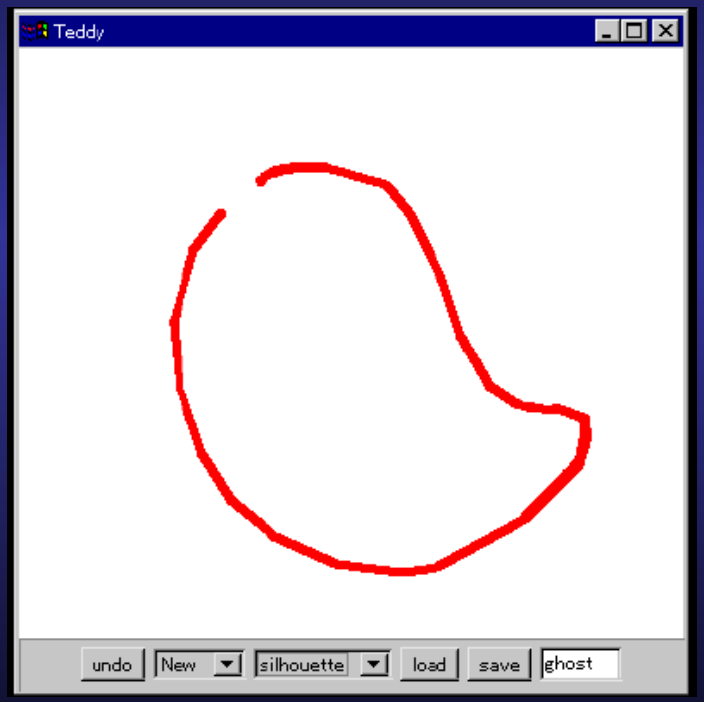
Multiperspectives

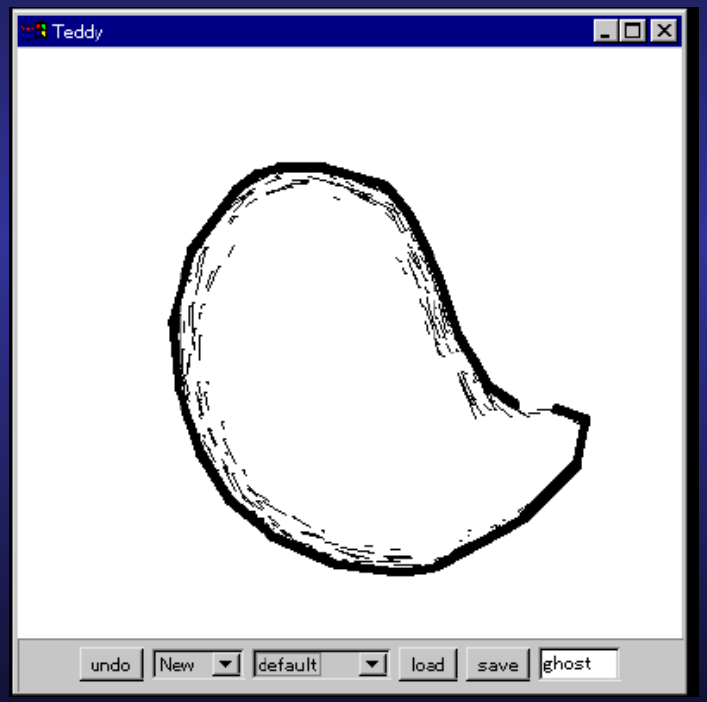




Multiperspective panoramas for cel animation,
D. Wood, A. Finkelstein, J. Hughes, C. Thayer,
D. Salesin, SIGGRAPH 97

- Inverse problem
  - Sketch based modeling





Teddy: A Sketching Interface for 3D Freeform Design