

Expressive rendering

Joëlle Thollot

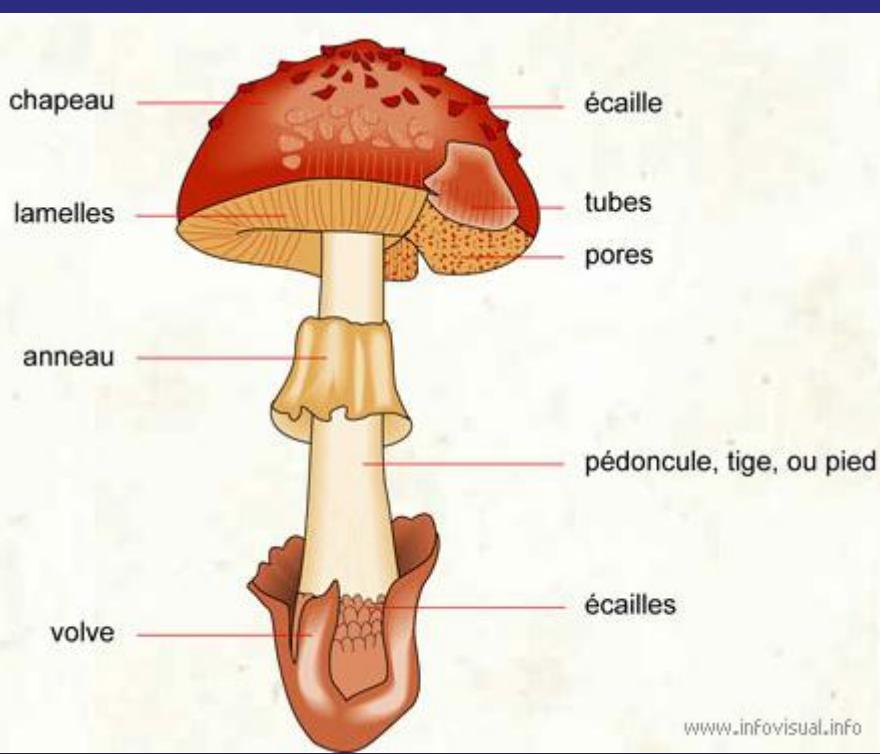
The « Quest for Realism »

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



RENDERED USING DALI - HENRIK HRNIN DENSEN 2000

We don't always want photorealism



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



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](http://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** ... de la **maison** constituent un lieu ...
550 x 366 - 86 ko - jpg
www.baiedesomme.fr



...
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](http://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



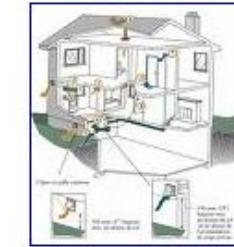
Maison à louer
2272 x 1704 - 1780 ko - jpg
www.pays-basque-tourisme.info



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

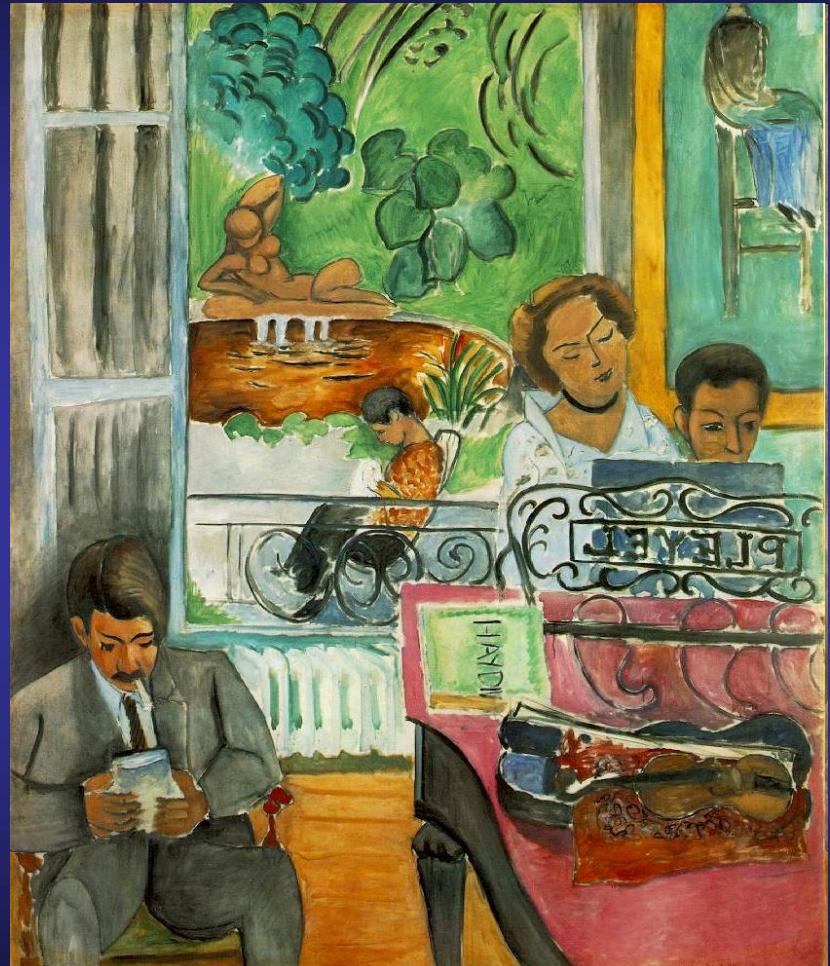


Belle **maison** en pierre de taille, ...
400 x 300 - 40 ko - jpg
www.signalsurf.com

Portrait



La jeune fille au virginal - Vermeer



La leçon de musique - Matisse

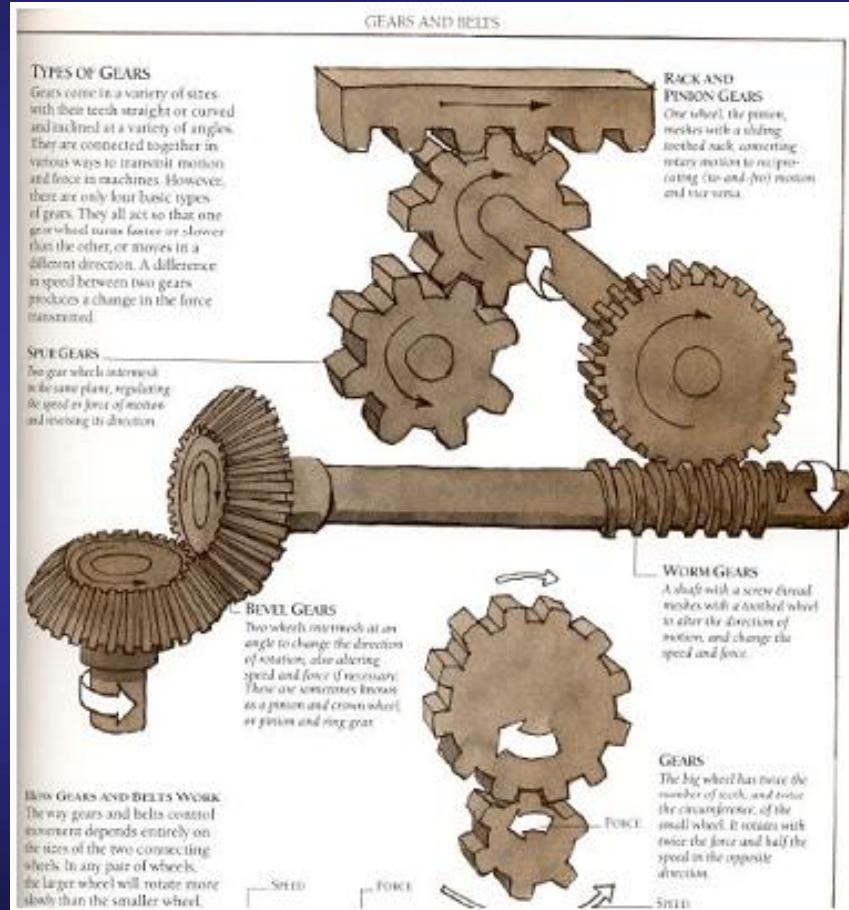
What are images used for?

- 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

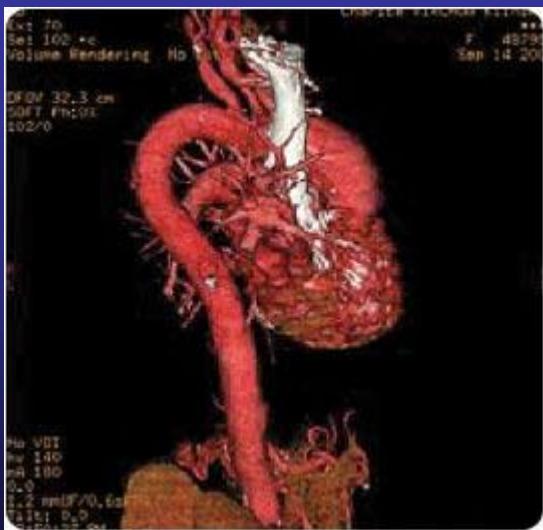


Macaulay: The Way Things Work, 1988

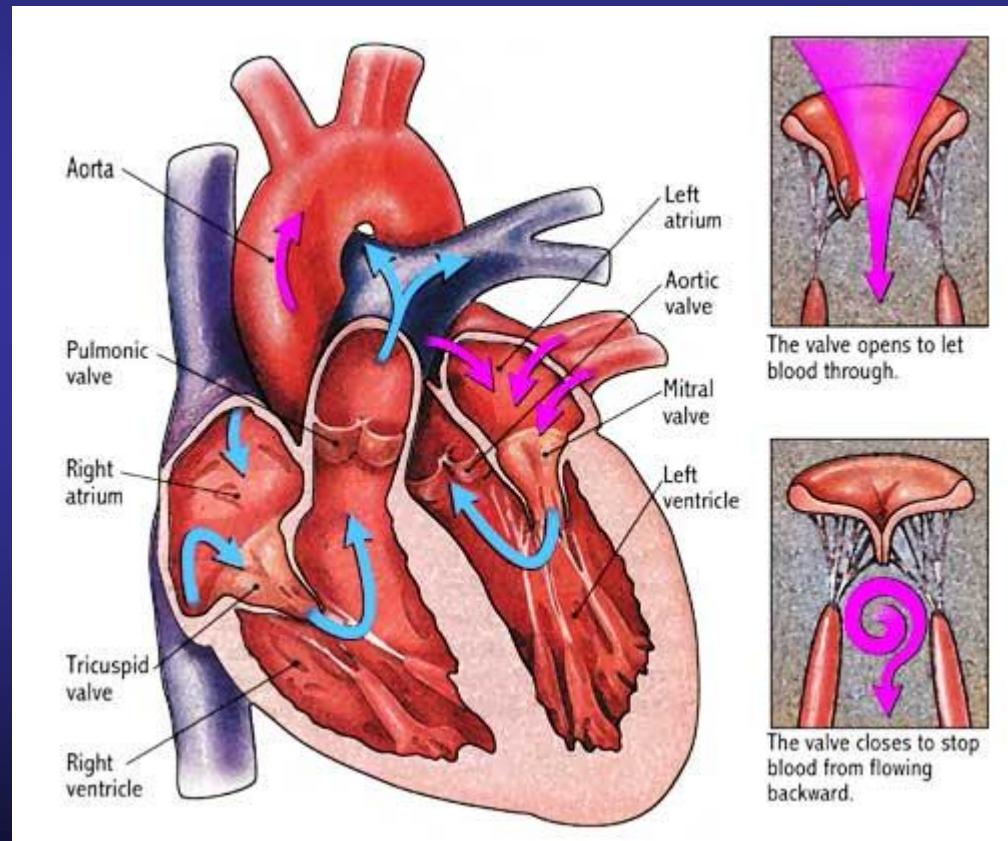
Clarifying & simplifying shapes



<http://www.labimed.org/cardiology/>

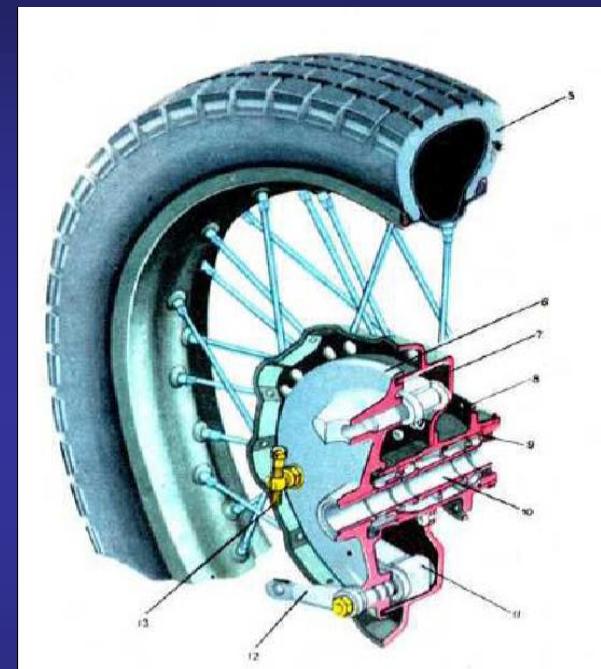
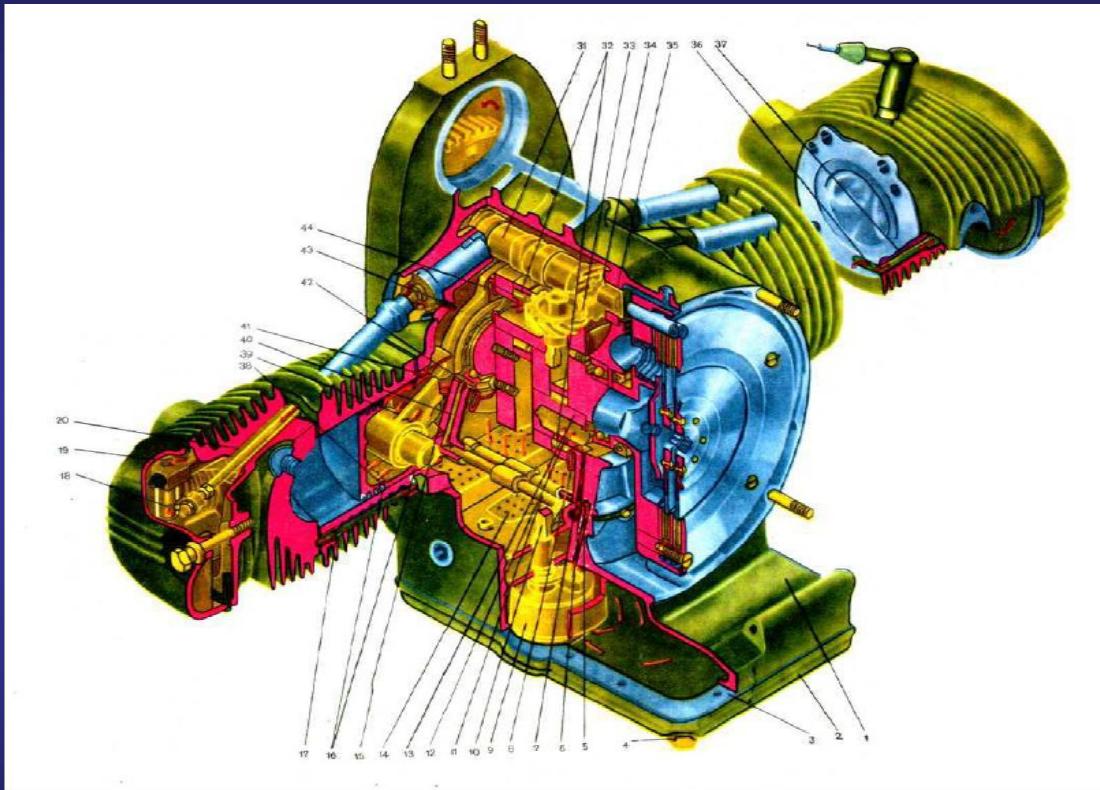


<http://www.imagincentres.com/ct.html>



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

Exposing parts that are hidden



Focusing attention



static.howstuffworks.com

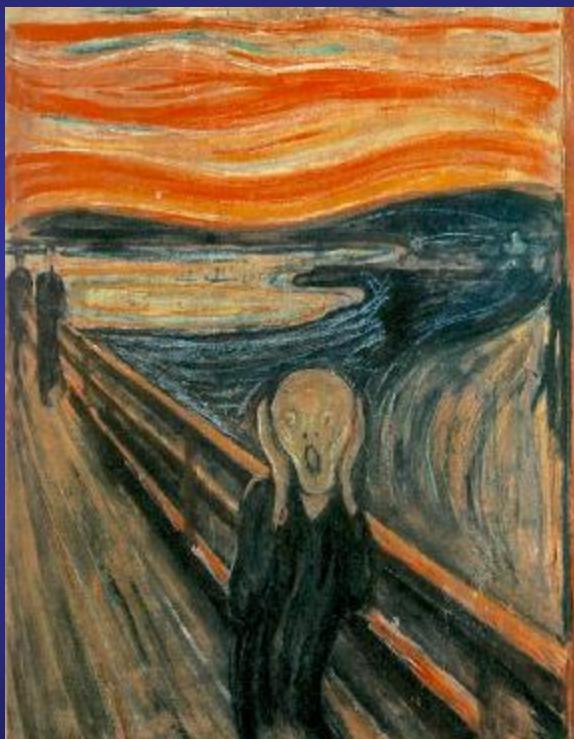
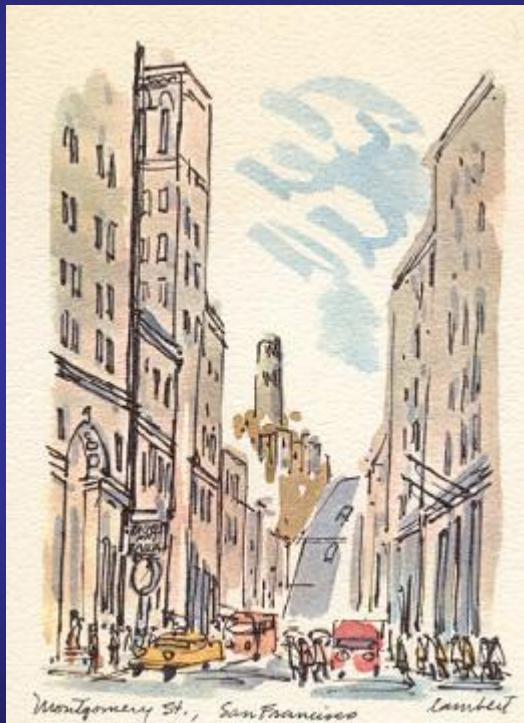


www.lanature.fr

Illustrating approximate ideas



Conveying mood and emotion



How do we produce such
images ?

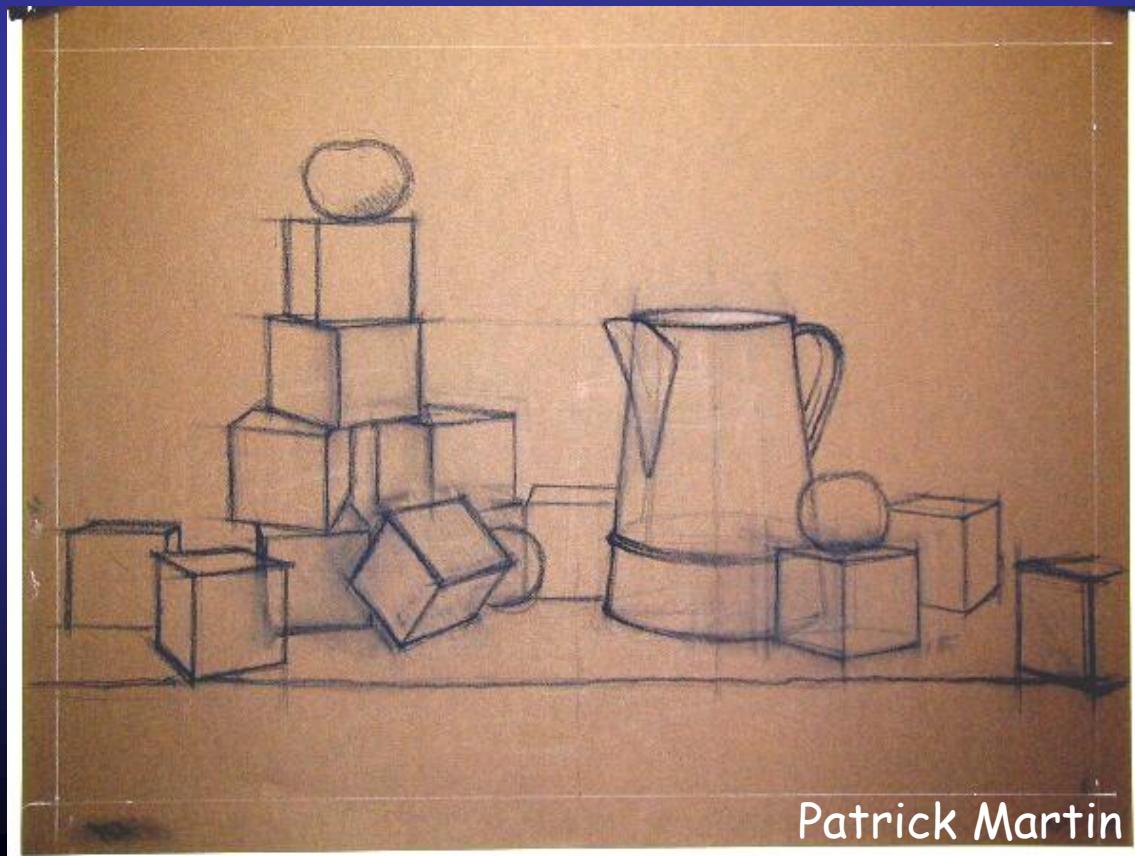
Actually what is an image?

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



Actually what is an image?

- 2D representation
 - Lines
 - Junctions
 - Regions



Actually what is an image?

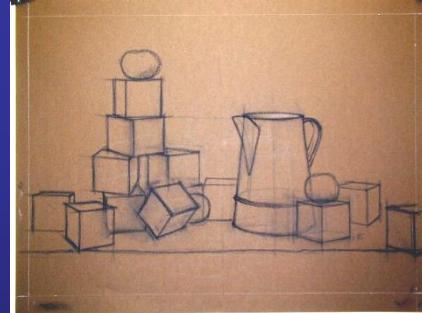
- Medium
 - Hatching
 - Pigments
 - Strokes
- Visual cues
 - Light
 - Shape
 - Material



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

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Style
(part of)

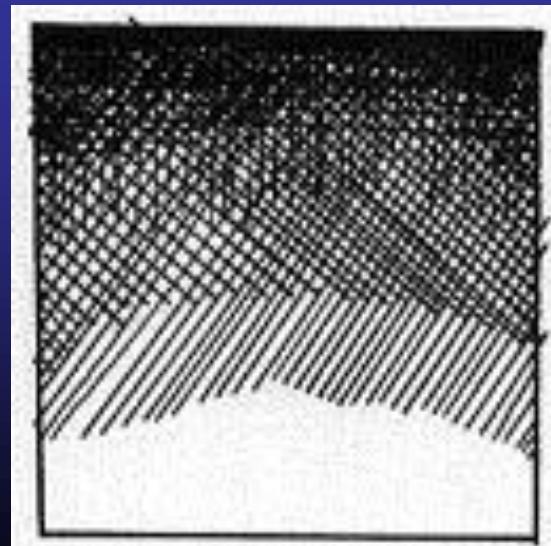
Overview

- Filling the regions
- Lines
- Style

I - Filling

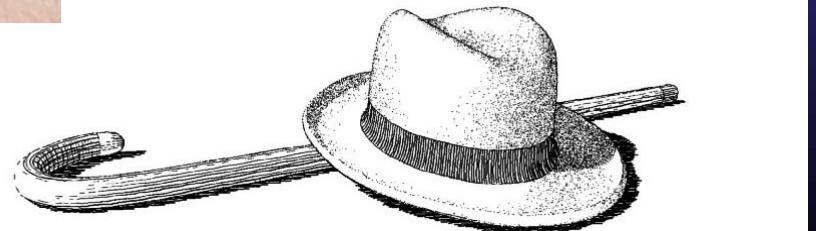
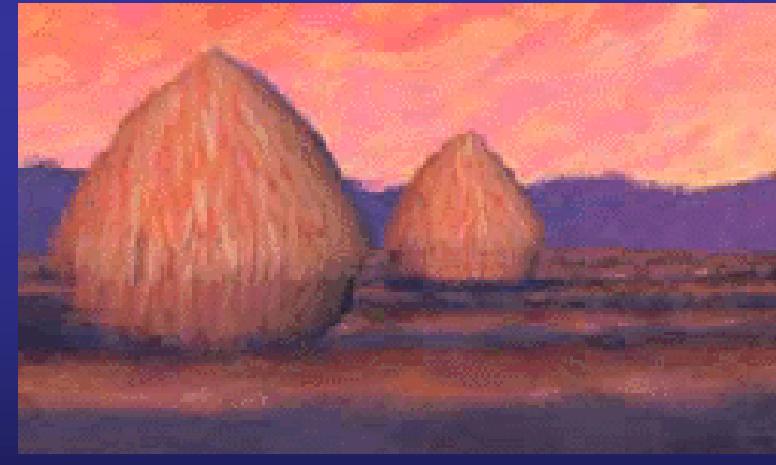
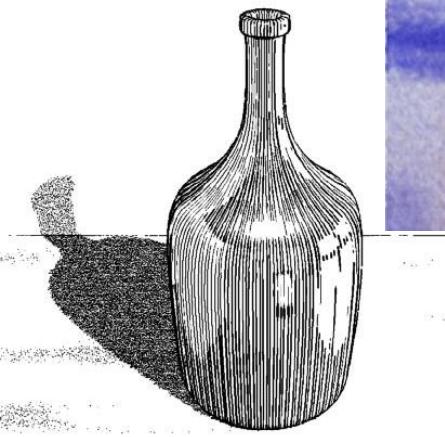
Marks

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



Problems

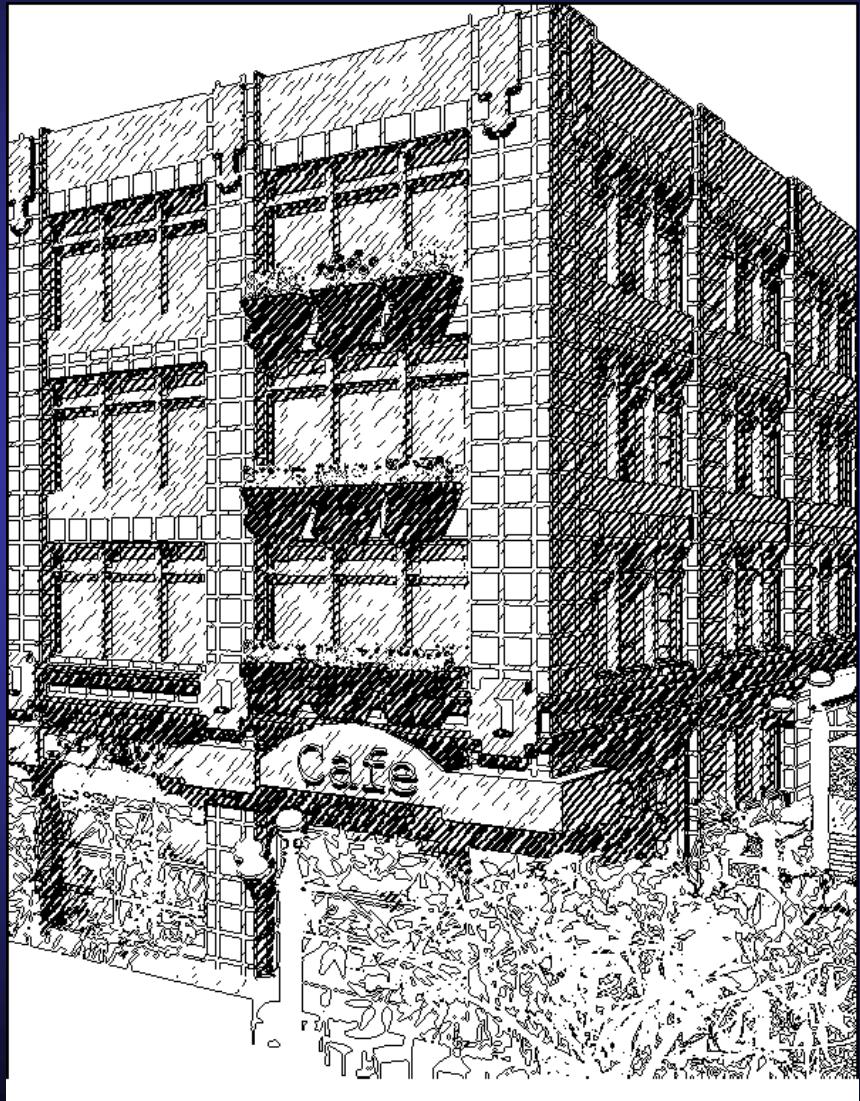
- Medium simulation
- Temporal coherence for animation
- Paper reading - discussion



- Comment modélise-t'on un médium ?
- Quel est le problème de la cohérence temporelle ?
- Quelles sont les difficultés ?
- Quelles sont les contributions de ces articles ?
- Quelles sont les limitations des solutions proposées ?
- Quelle démarche générale peut-on tirer de ces articles ?

Illustration

- Stylized lines
- Hatchings

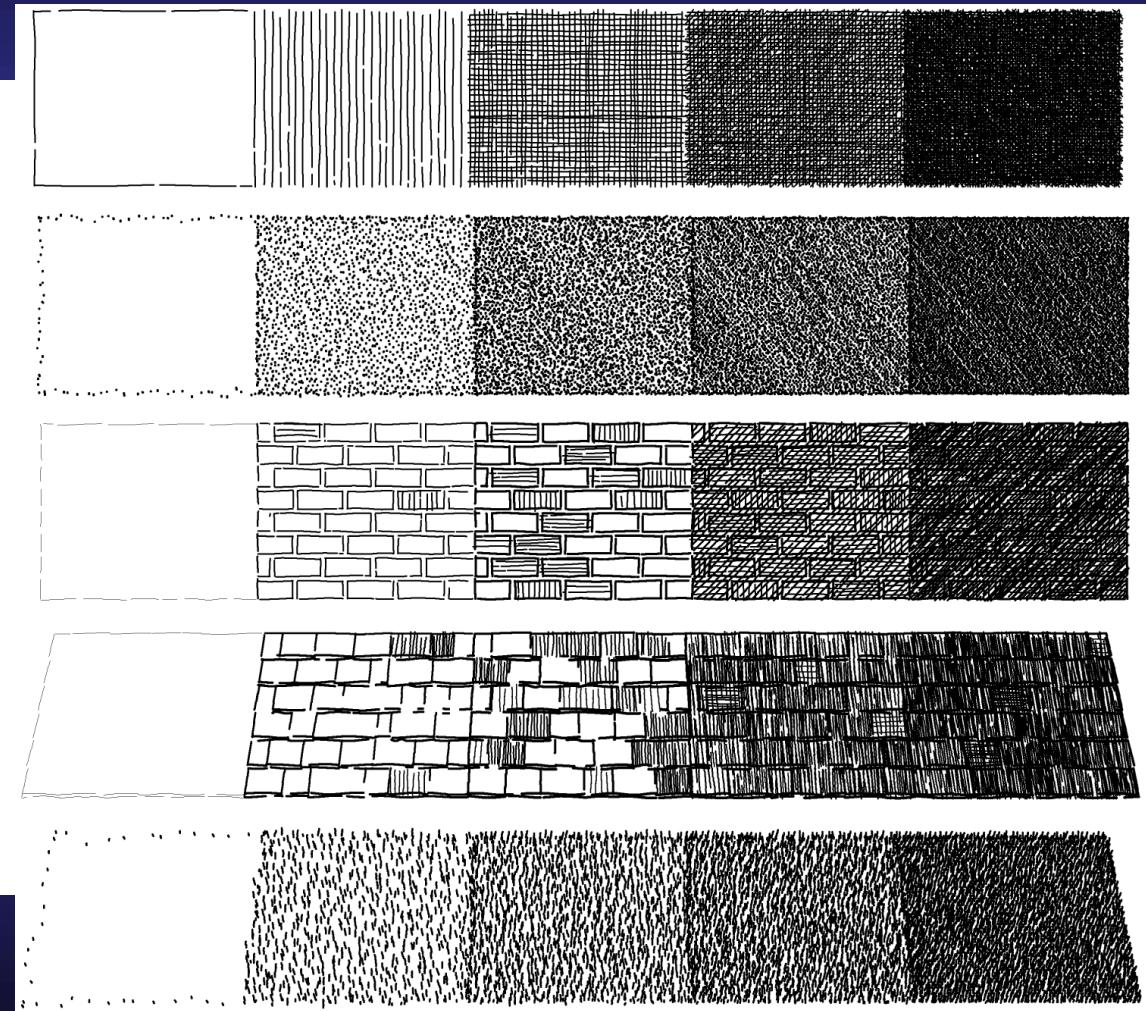
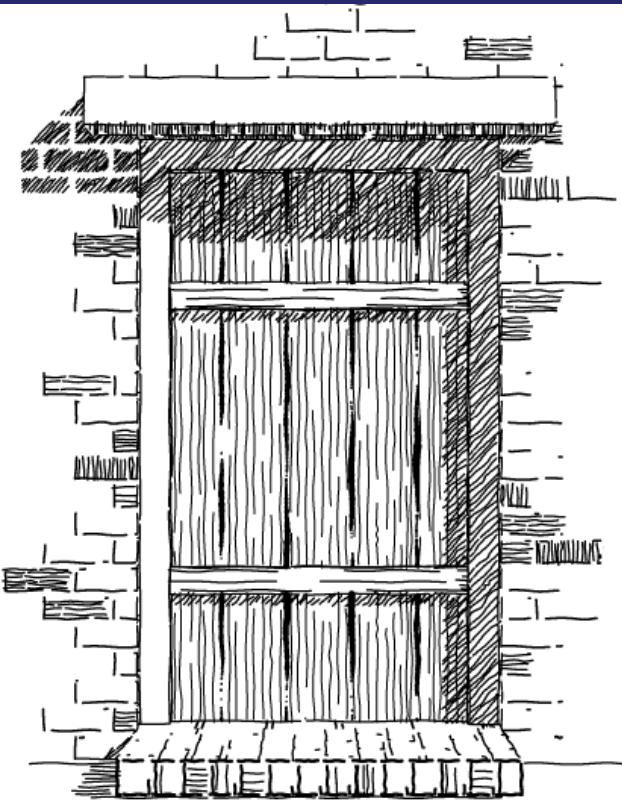


Hatching

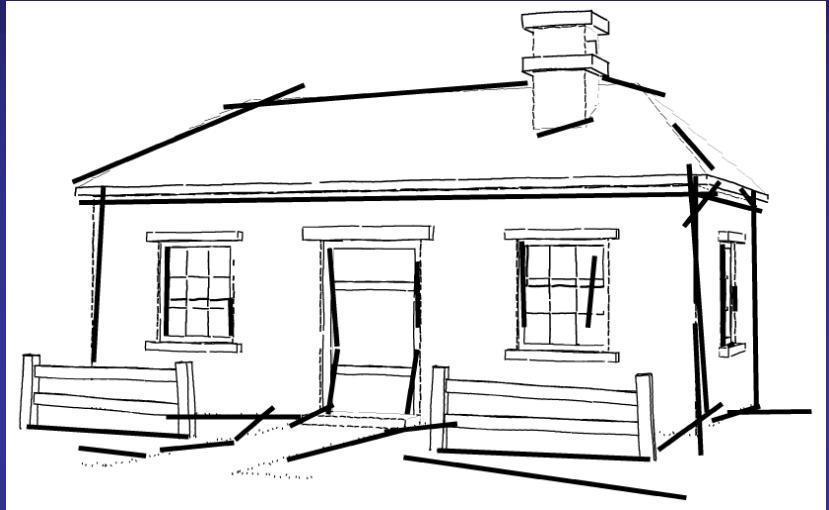
- Shape from shading
- Region filling + tone mapping

⇒ Attributes (width, orientation) and density

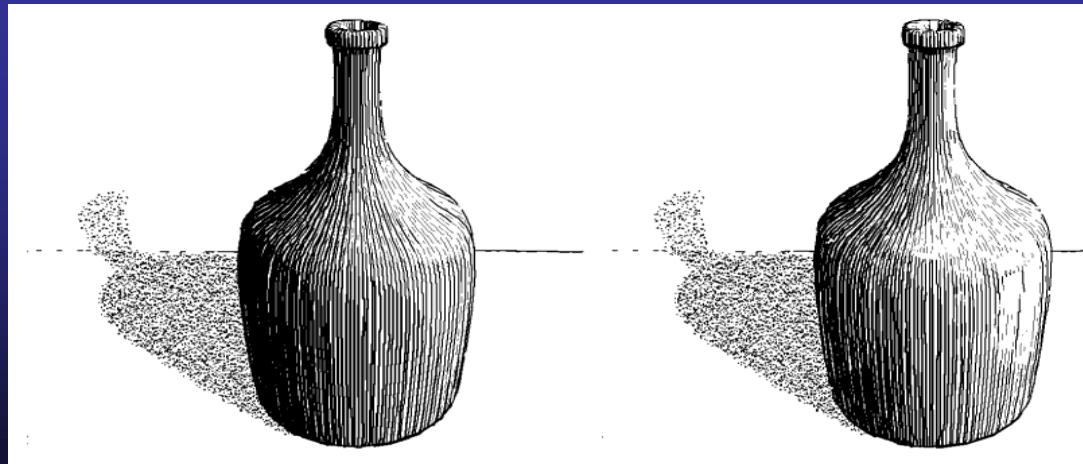
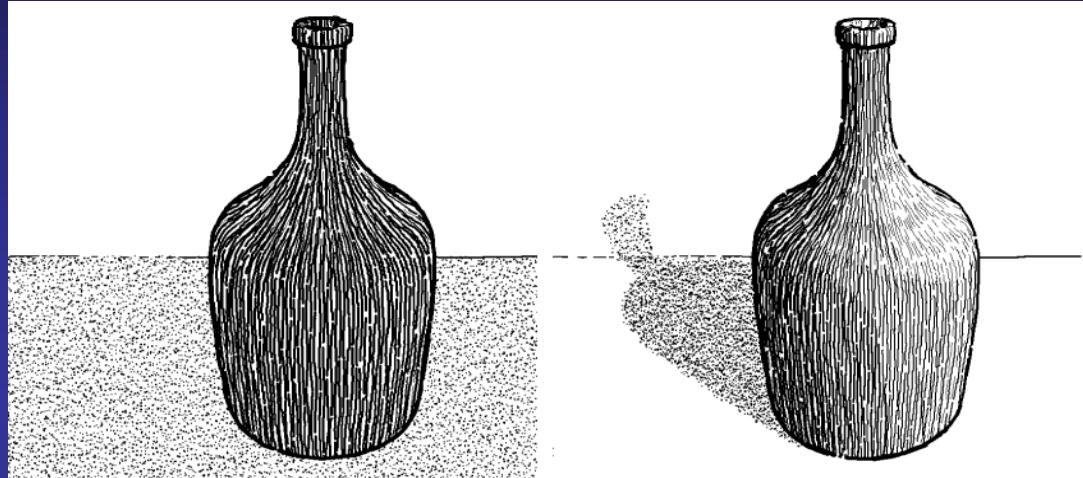
Tone



Indication



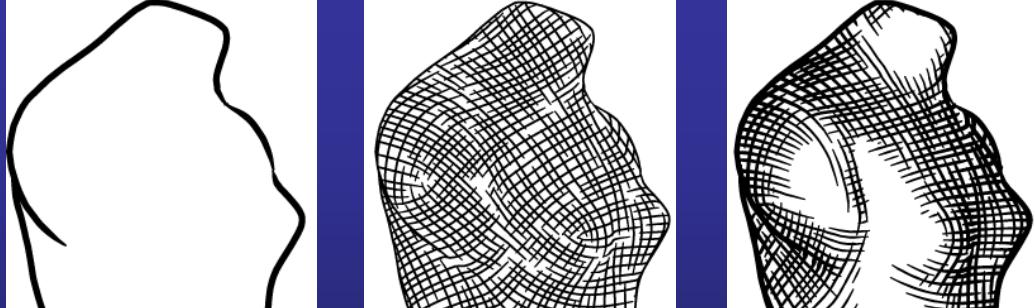
Classic rendering + hatchings



Winkenbach and Salesin.
“Rendering Parametric Surfaces
in Pen and Ink.” SIGGRAPH 96
₂₉

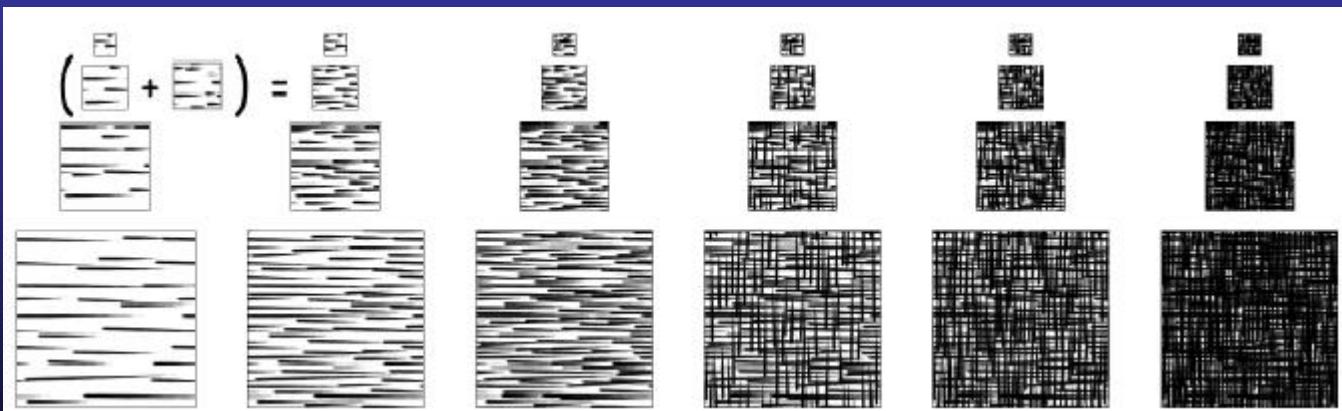
Illustration 3D

- Principal curvature



Real-time hatchings

- Tonal arts maps + lap textures
= mip-map
+ easy texture mapping



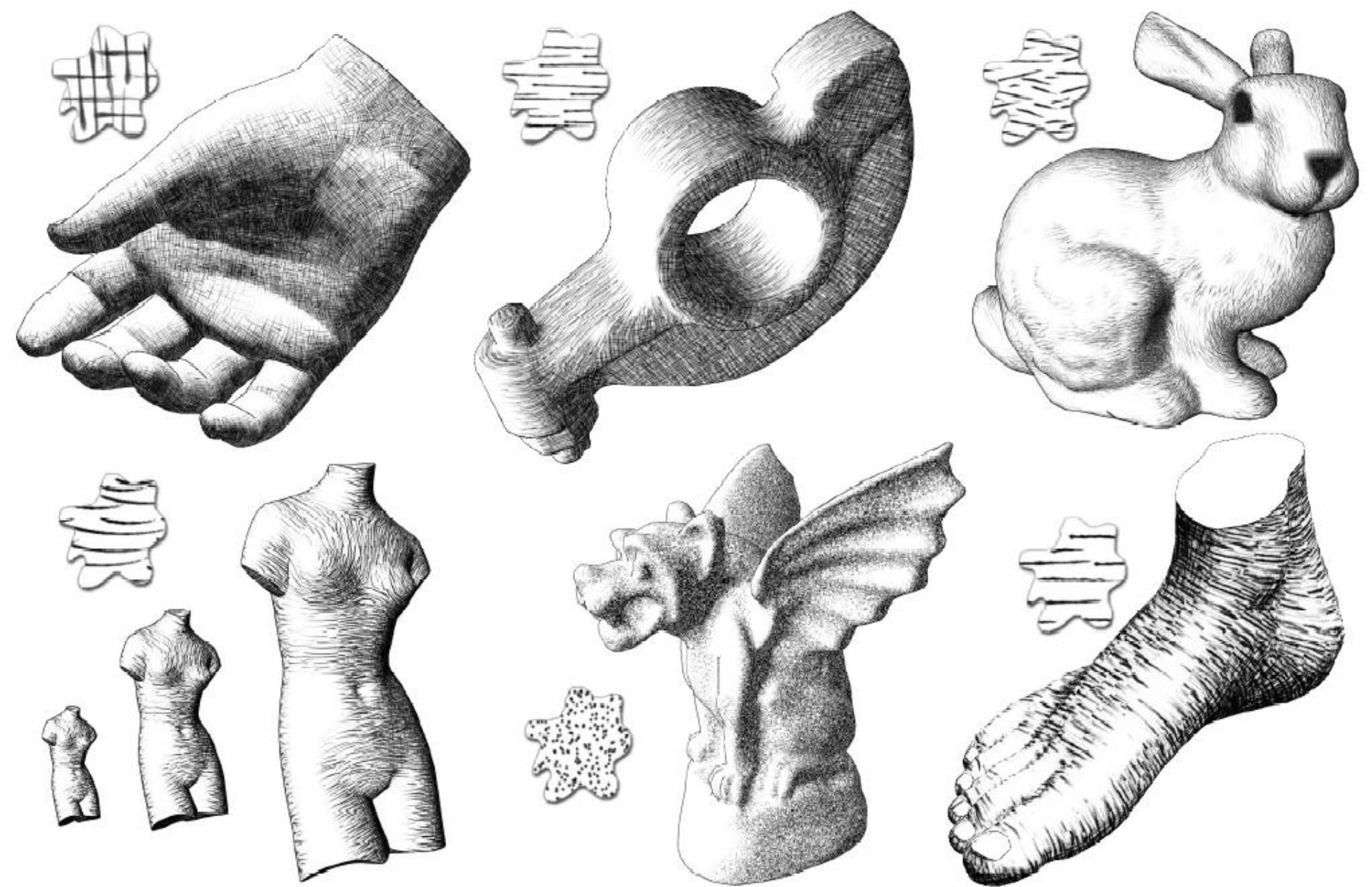


Figure 5: Results. Six models rendered with different TAMs, indicated in the inset texture patches.

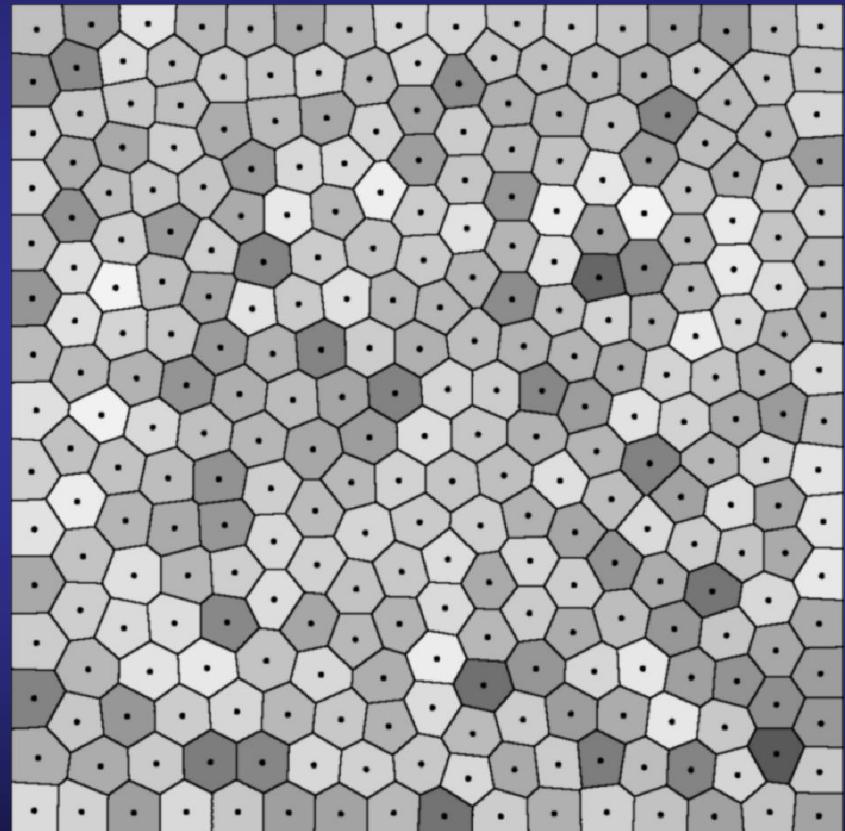
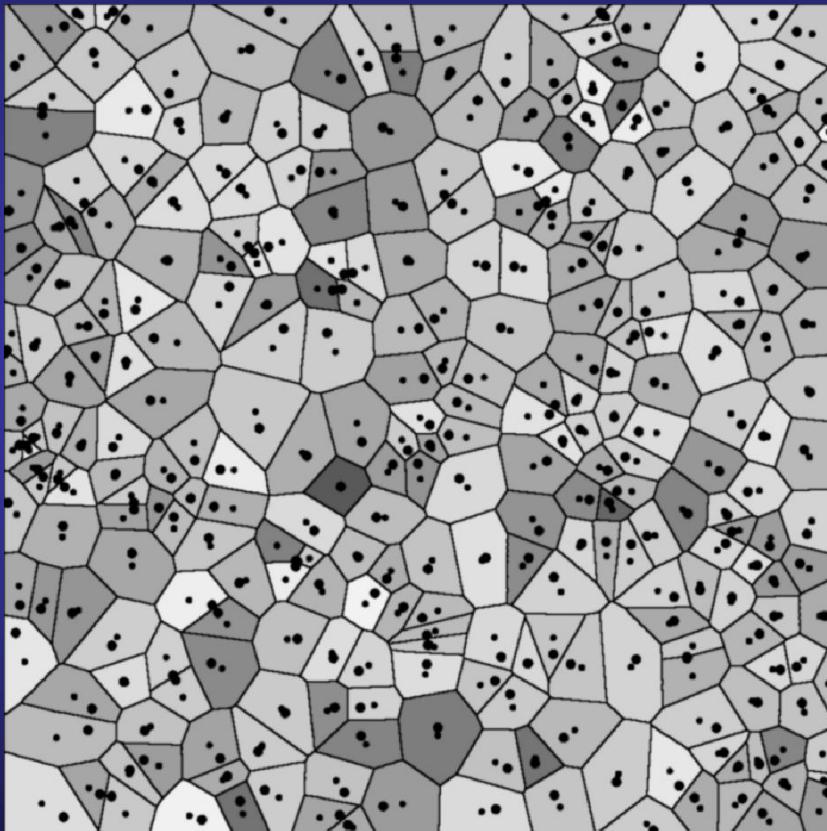


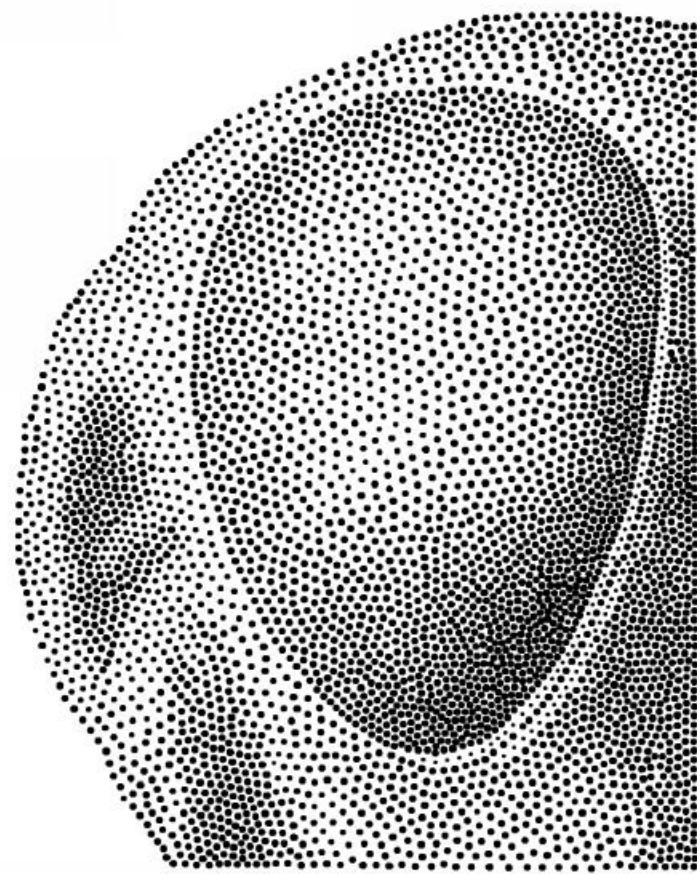
Stippling

- Shape from shading
- Tone via point distribution

⇒ Distribution and density

Lloyd relaxation

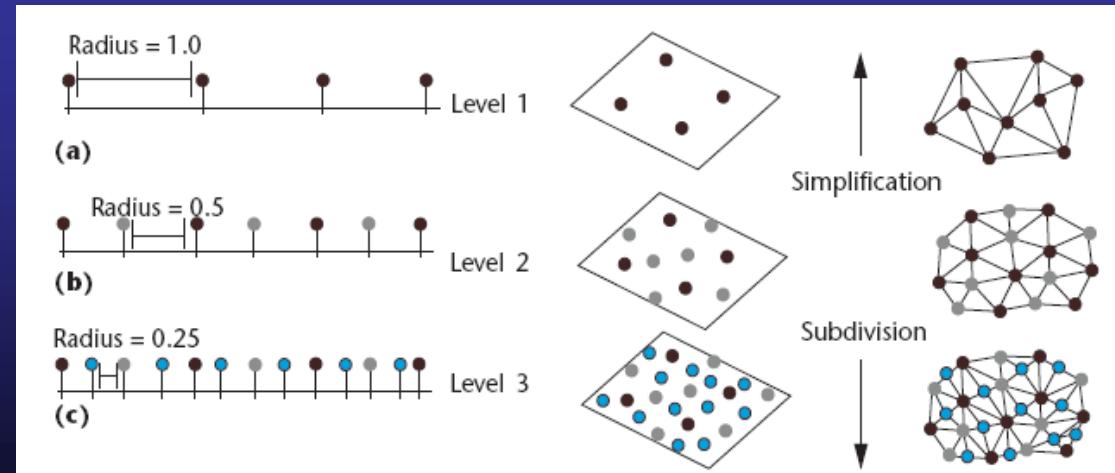




Real-time stippling

Oscar Meruvia Pastor, Bert Freudenberg, and Thomas Strothotte

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



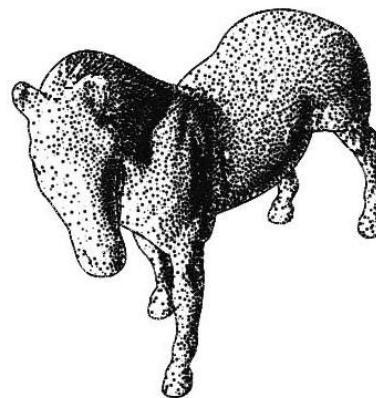
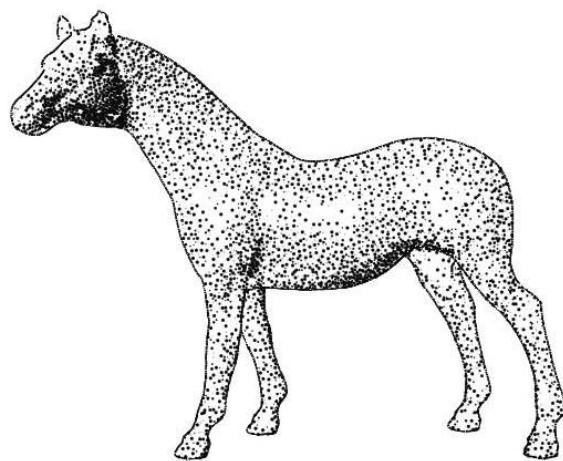
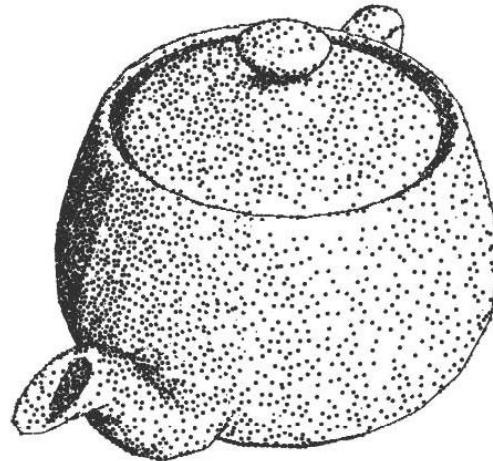
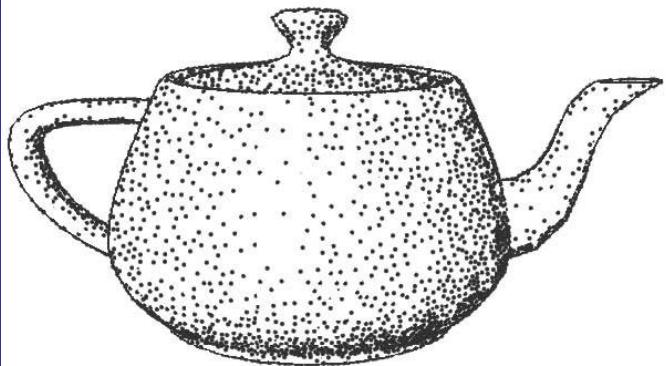
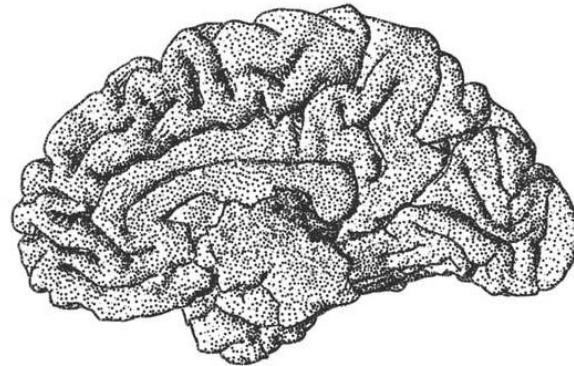
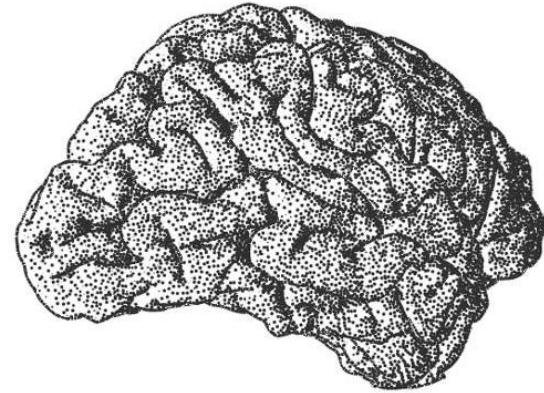
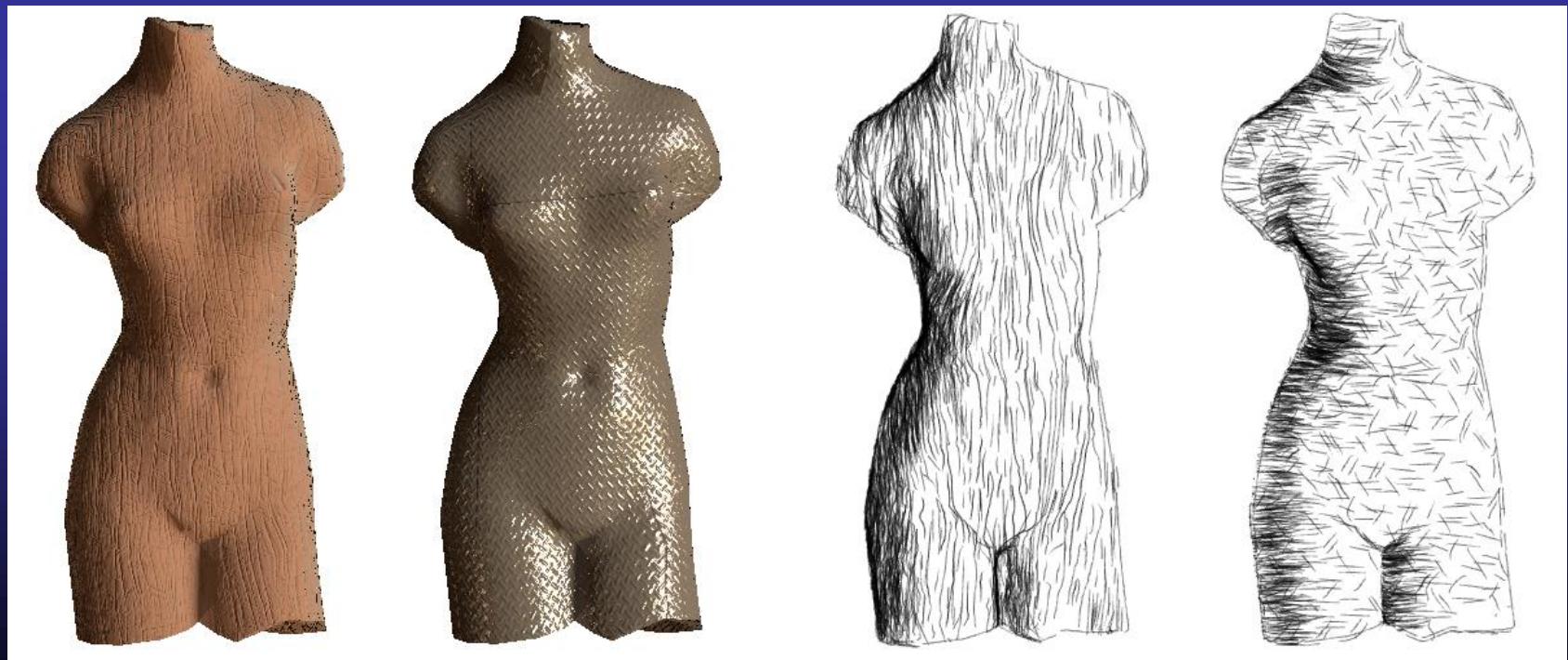
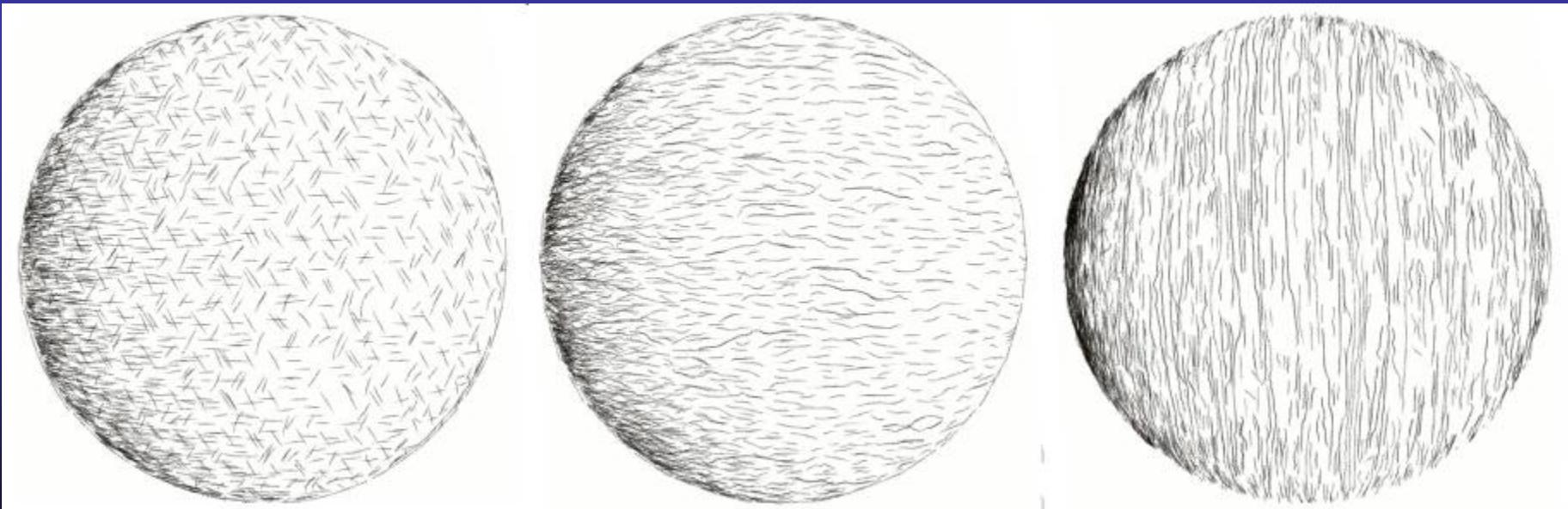
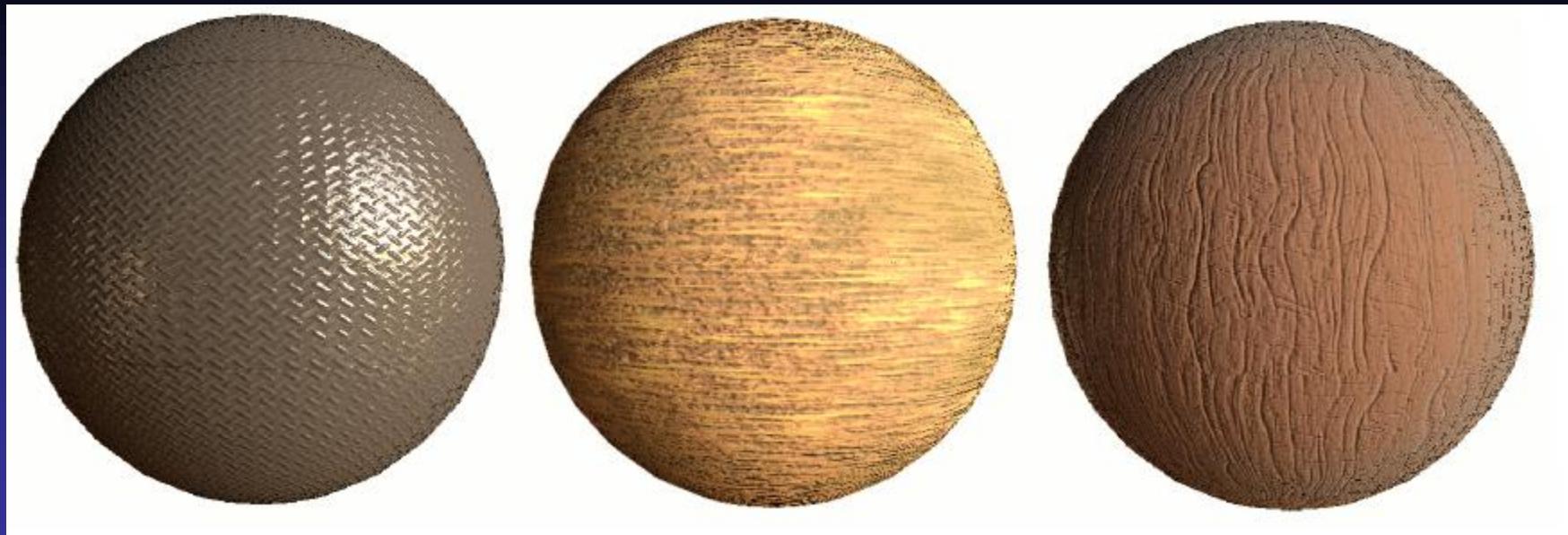


Illustration going further

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

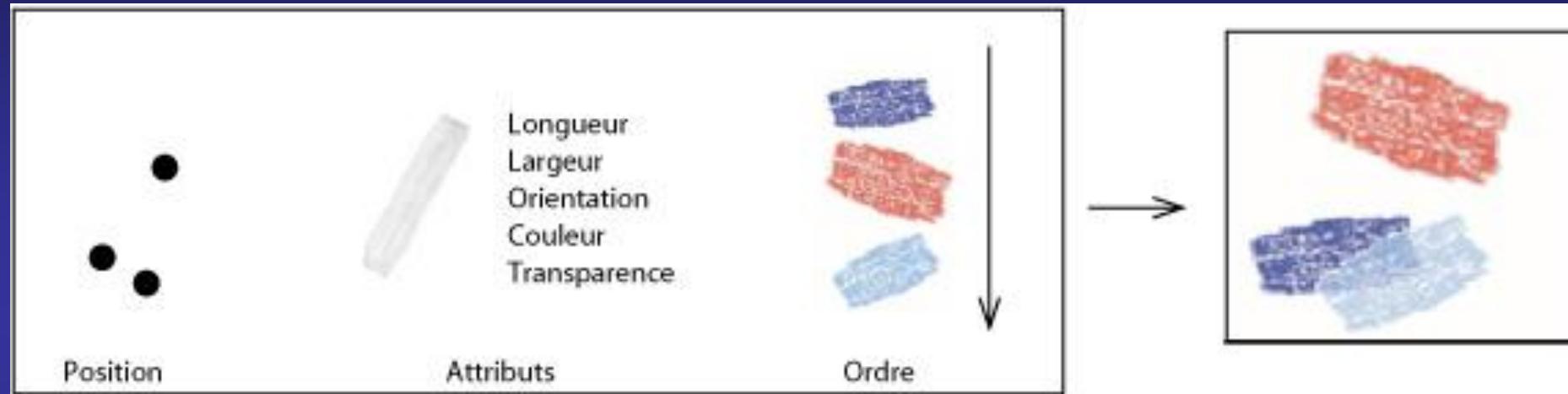




Painting

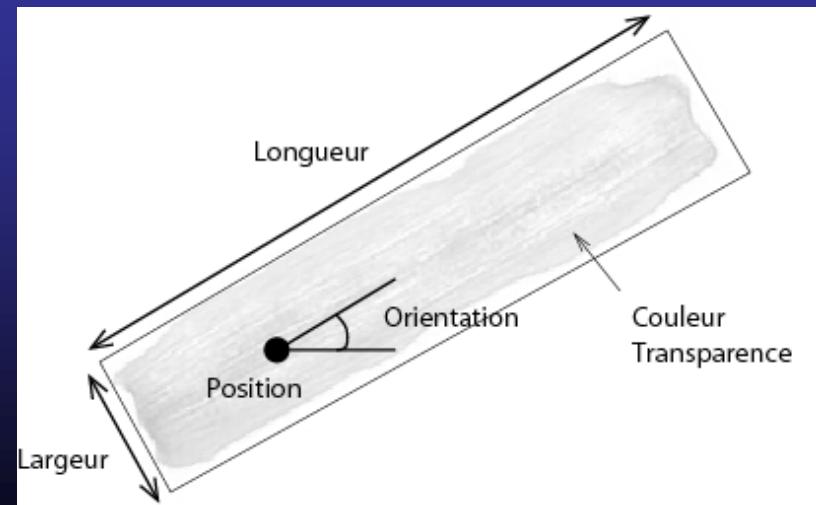
- Color image
- Abstraction and art
- Region filling

Stroke-based approaches



⇒ Position

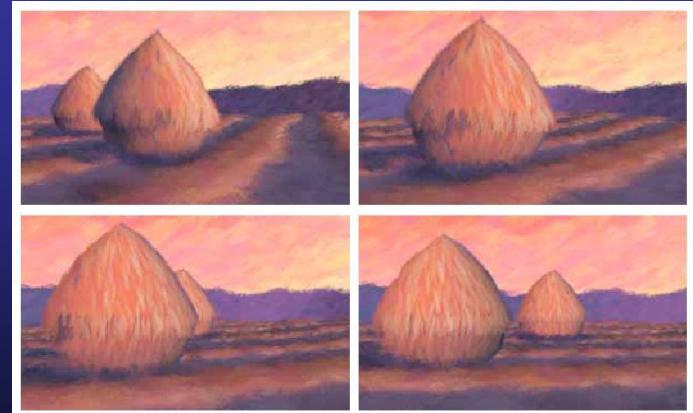
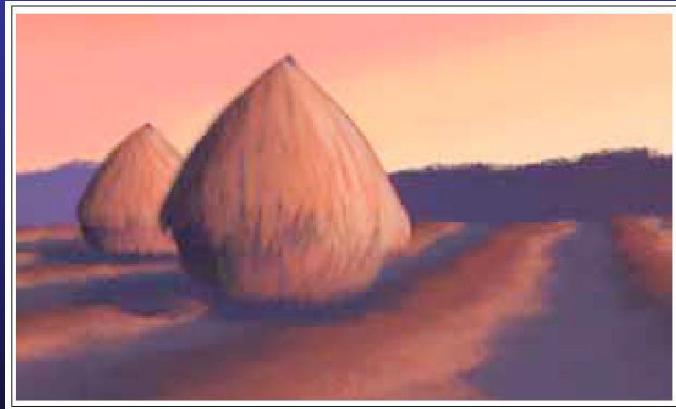
⇒ Attributes

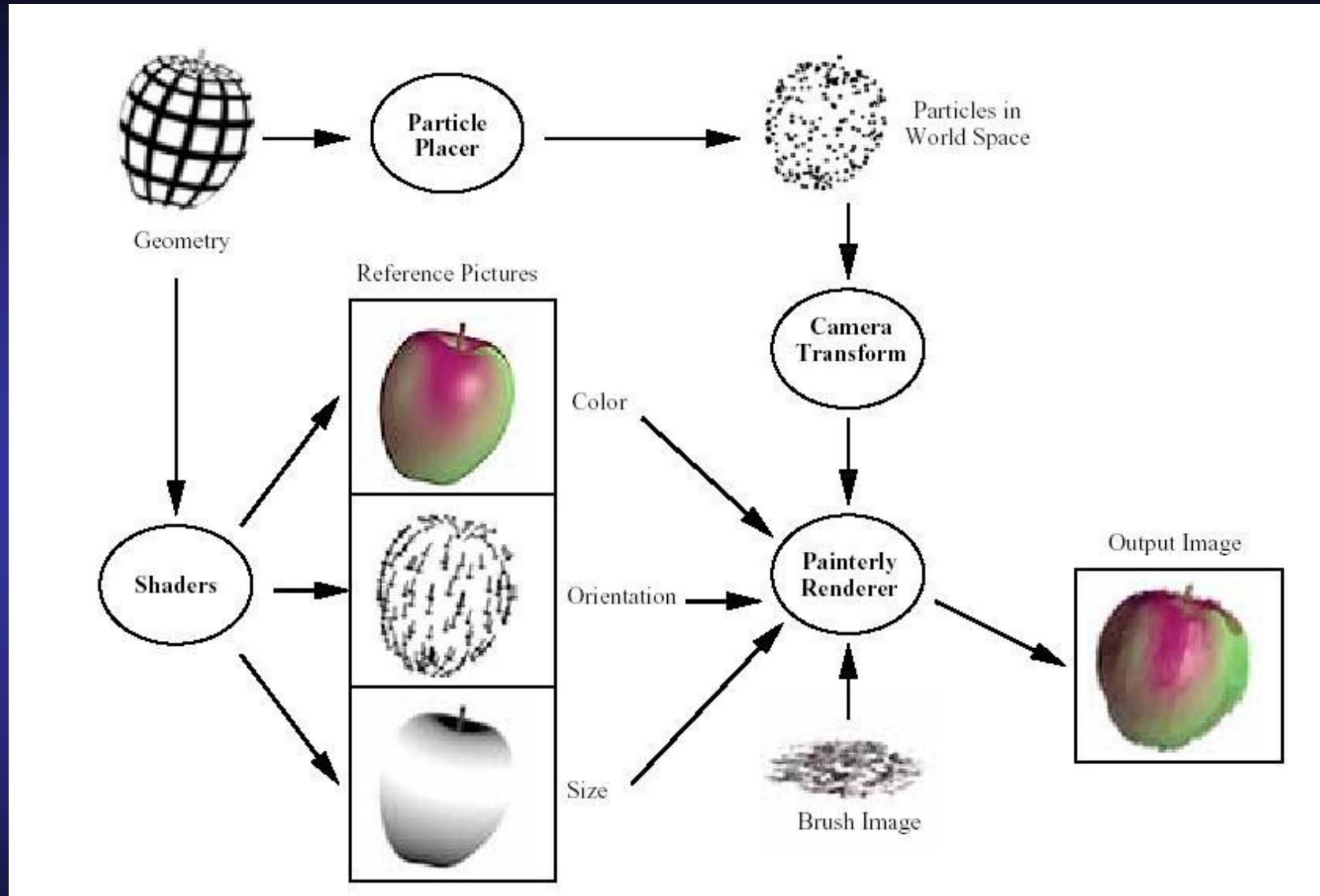




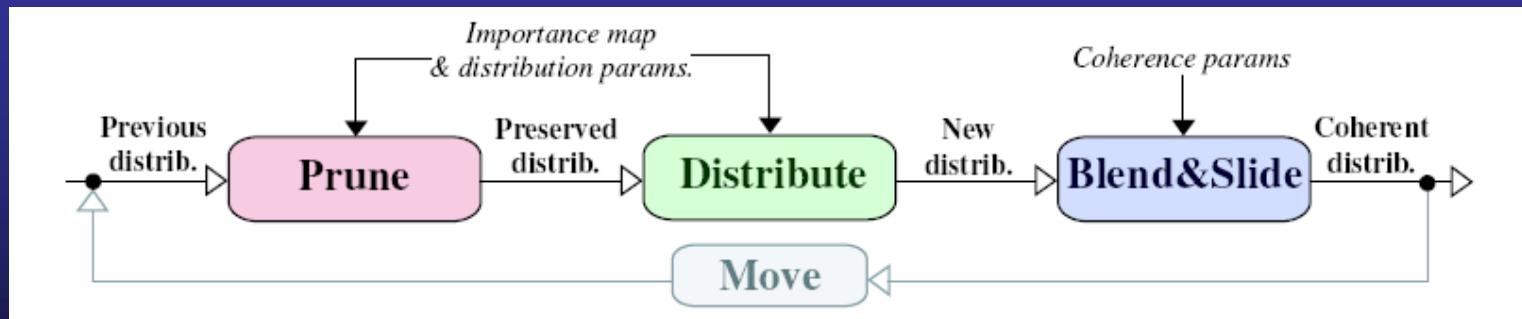
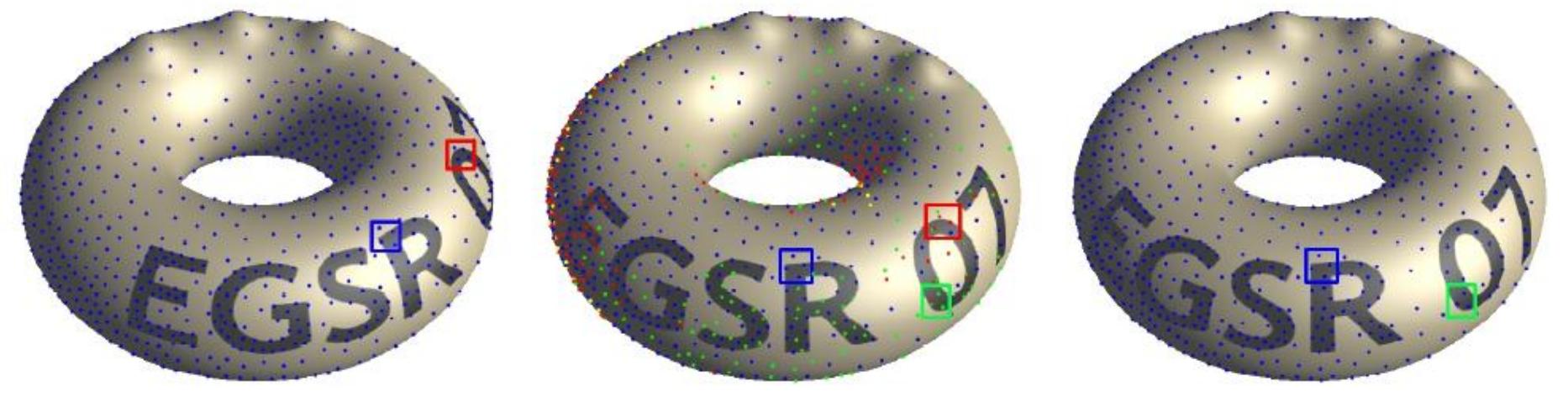
Painterly rendering for animation [Meier]

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





Dynamic distribution



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)

Texture-based approach

- 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

3D Object

- 3D texture mapping
- Infinite zoom mechanism

Stylizing 3D animations

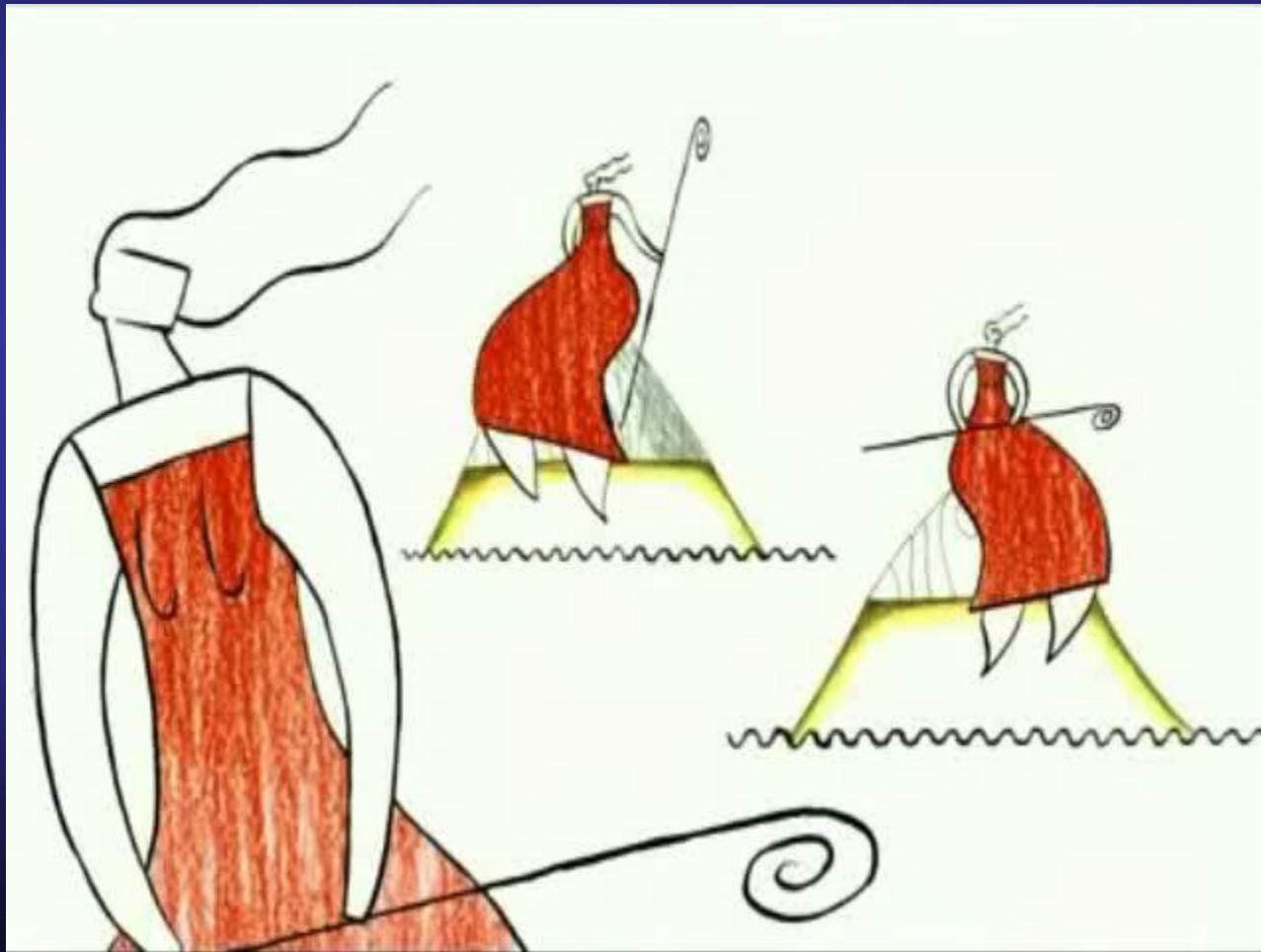
I3D 2009

Pierre Bénard, Adrien Bousseau,
Joëlle Thollot

Summary
Temporal coherence

Il pleut bergère

Jérémy Depuydt, www.toondra.com



Naive solutions



Shower door



Texture mapping
© 2010

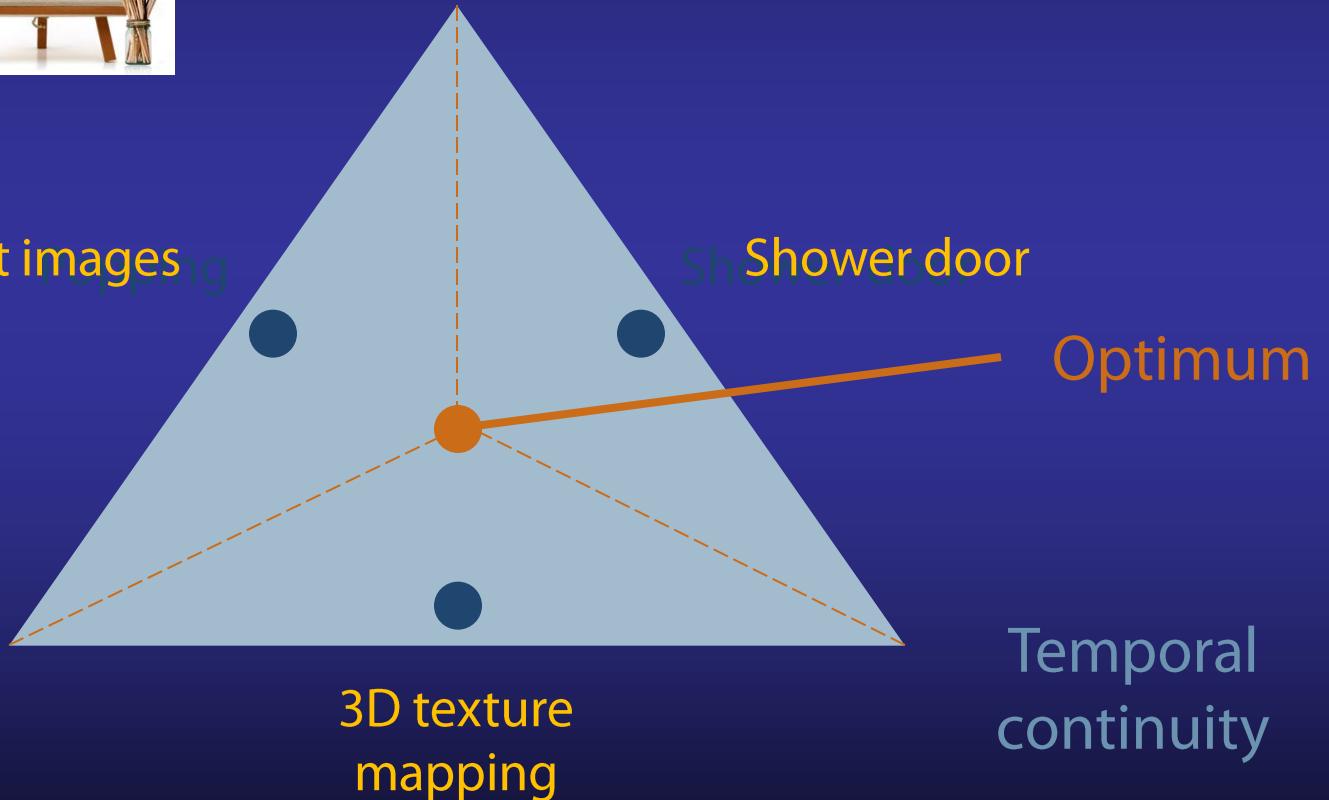
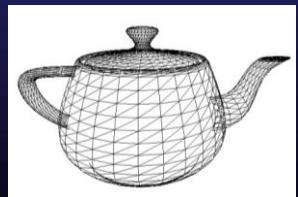
Contradictory goals



2D characteristics

Independent imaging

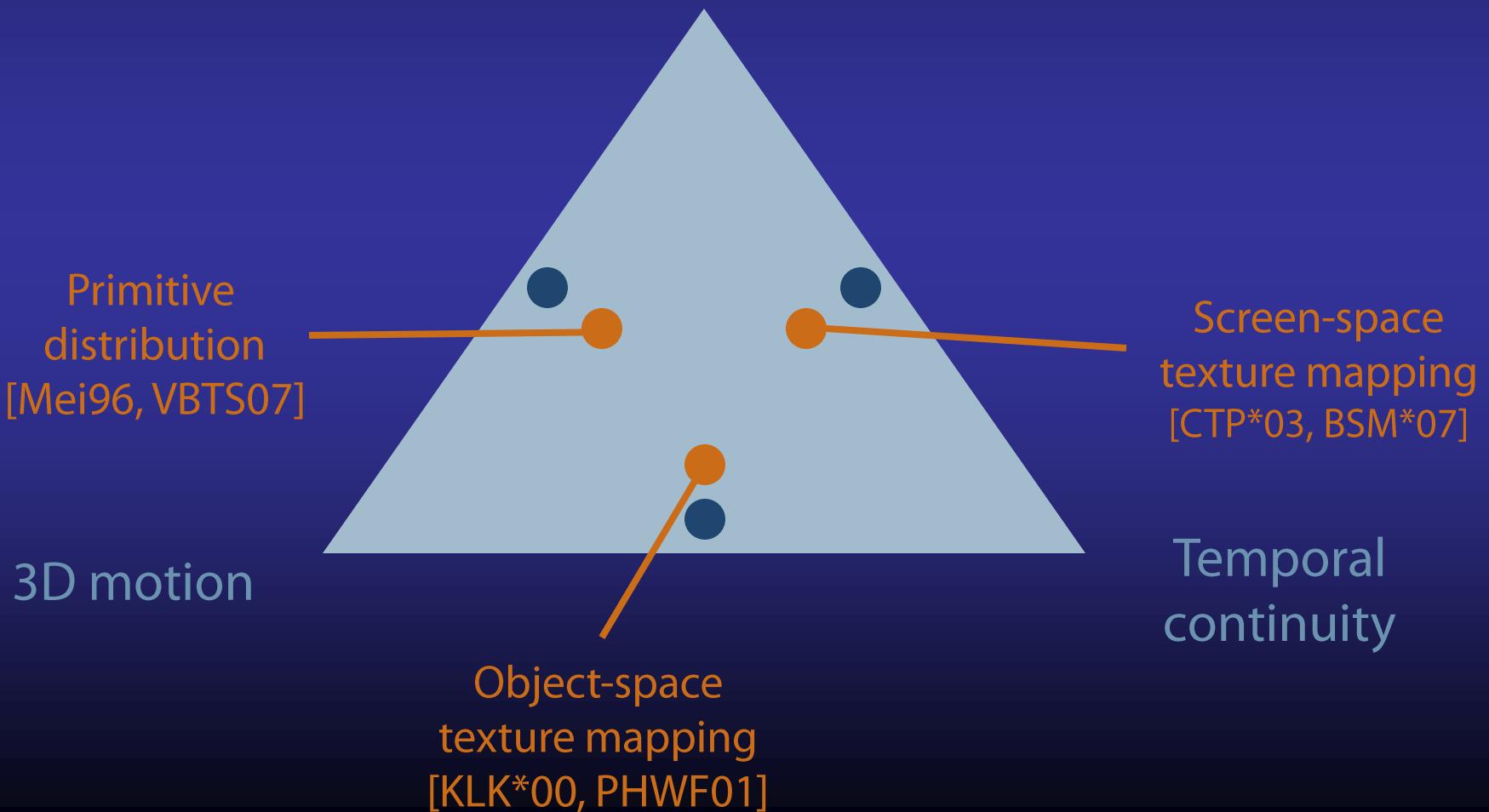
3D motion



Temporal
continuity

Current solutions

2D characteristics



What next?

- How to evaluate the various compromises?
- Perceptual study

Adv



D2D



DST



ours



SD



TM



Adv



D2D



DST



ours



SD



TM

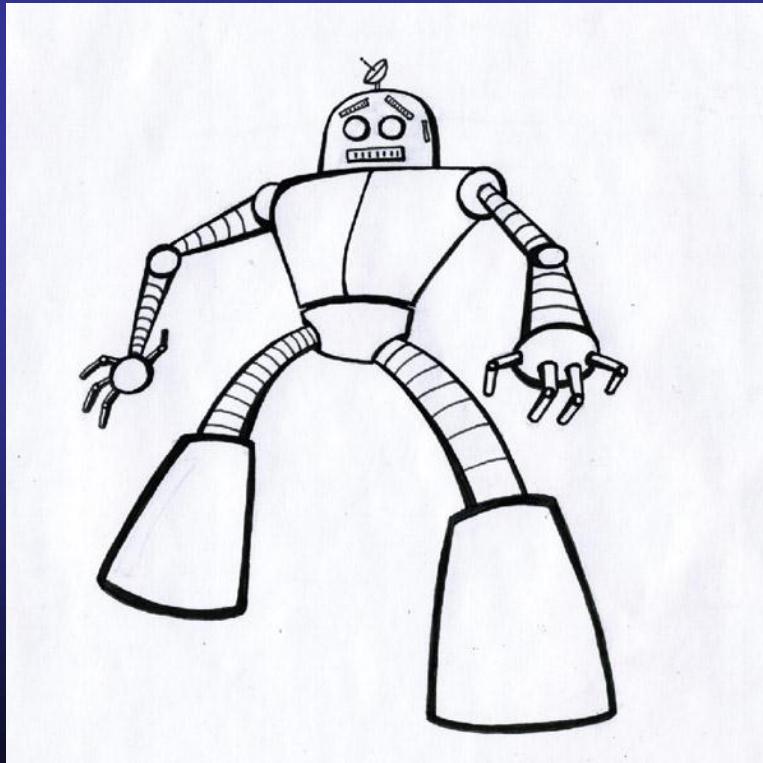


II - Lines

Lines



- What are the lines that may depict a shape?



©JOSH DORIUS

Lines

- Silhouettes
- Boundaries
- Ridges and valleys
- Depends on surface properties
 - Depth
 - Curvature
 - Normal
 - Viewpoint

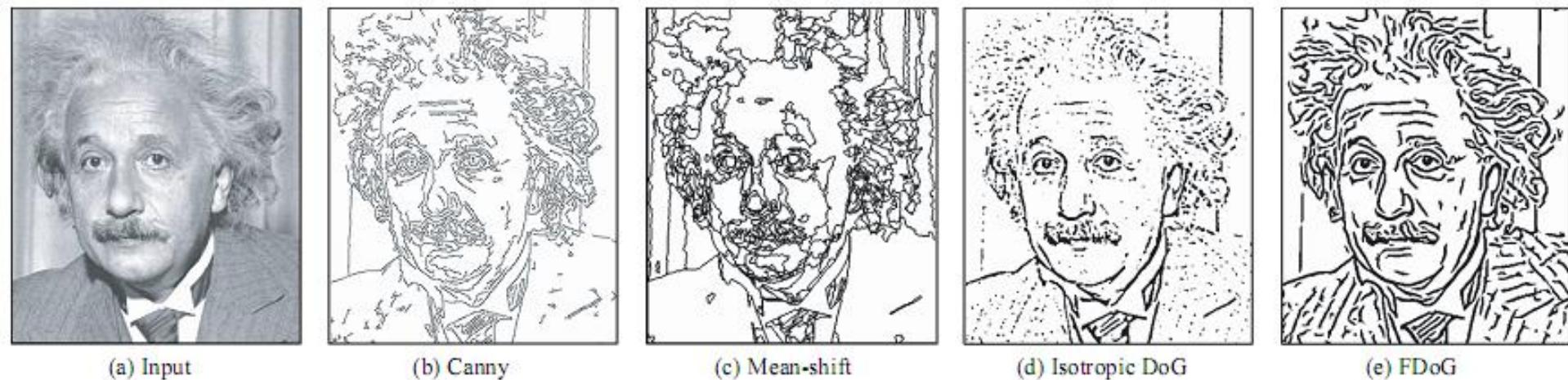
Lines detection

- How can we do that?
 - In image space
 - In object space
- What are the problems?



Image space

- Edge detection
 - Numerous techniques in image processing



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



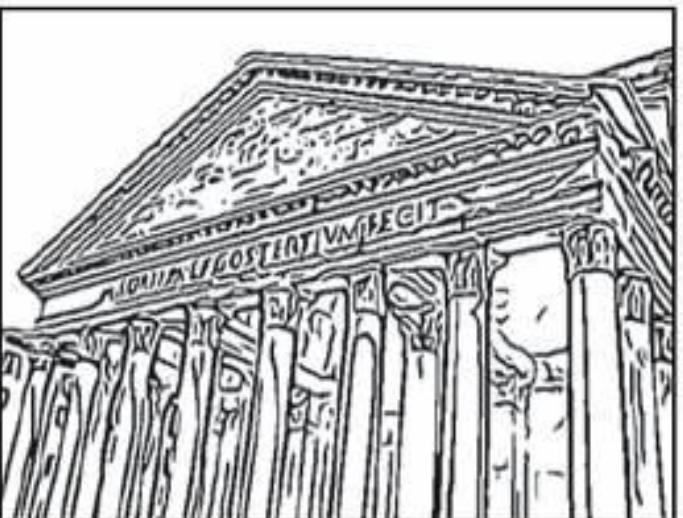
(a) Lena



(b) Lighthouse



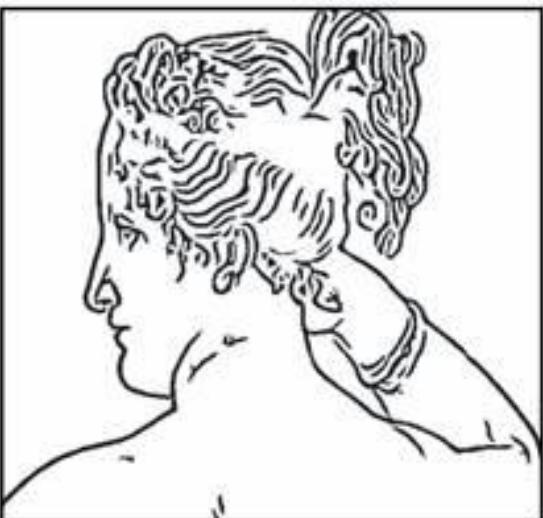
(c) Tiger



(d) Pantheon



(e) Flowers



(f) Paolina

Image space + depth

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

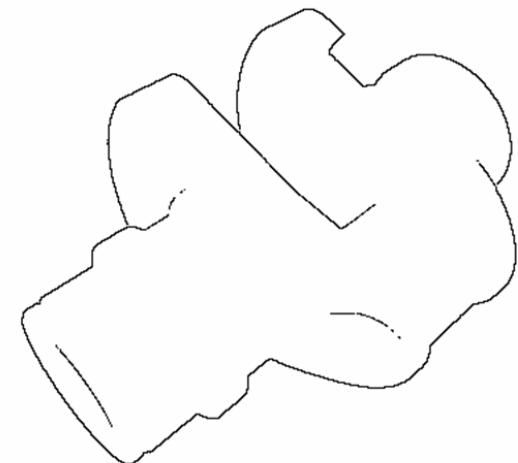
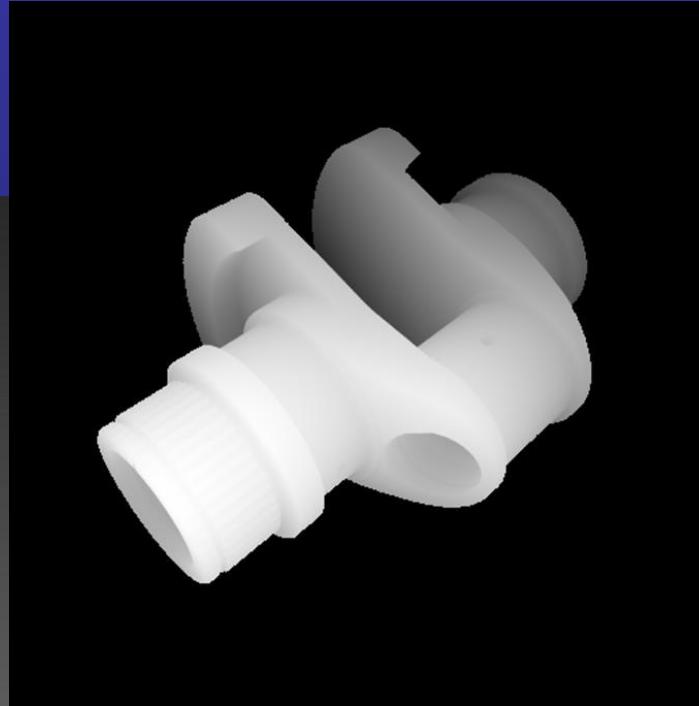
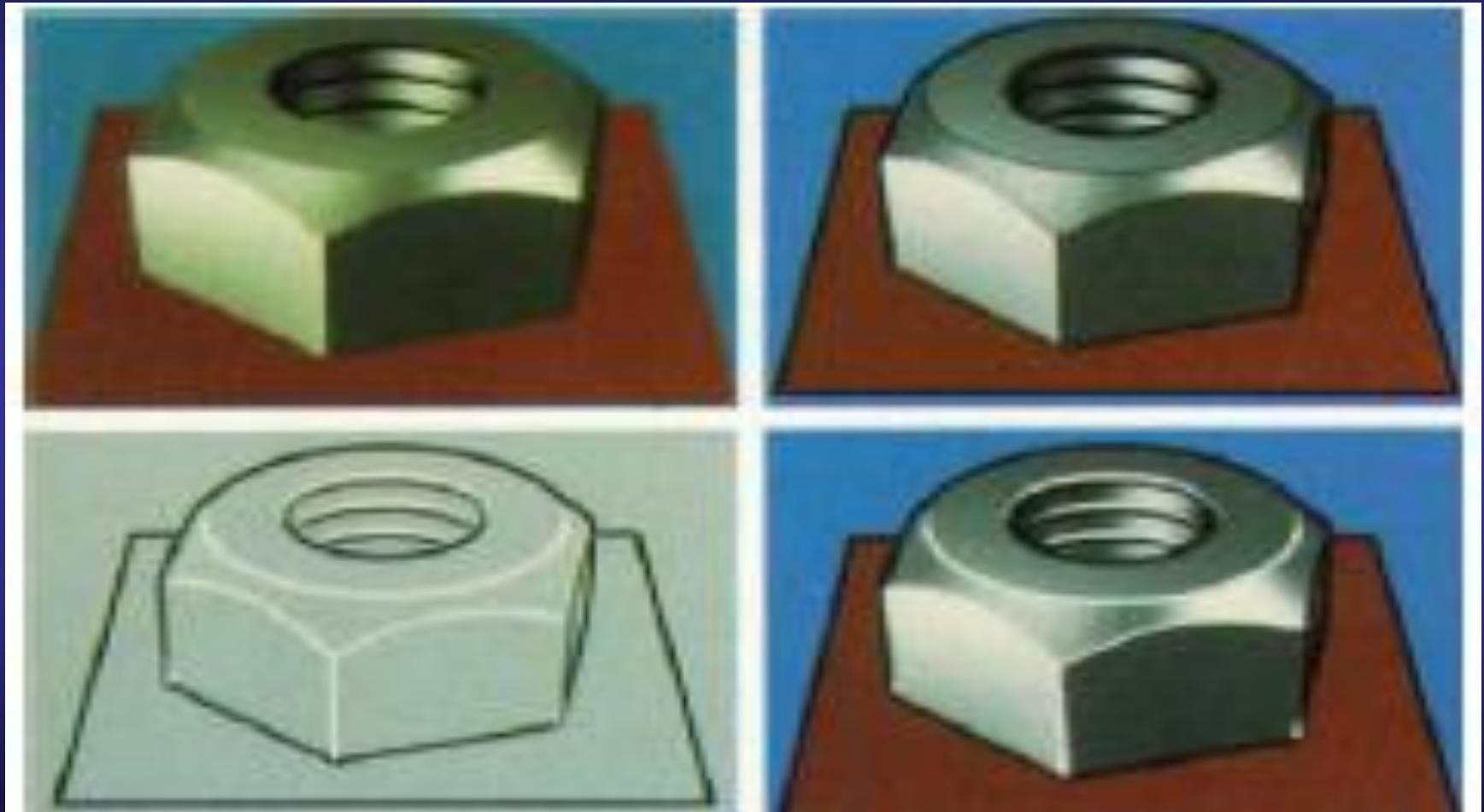


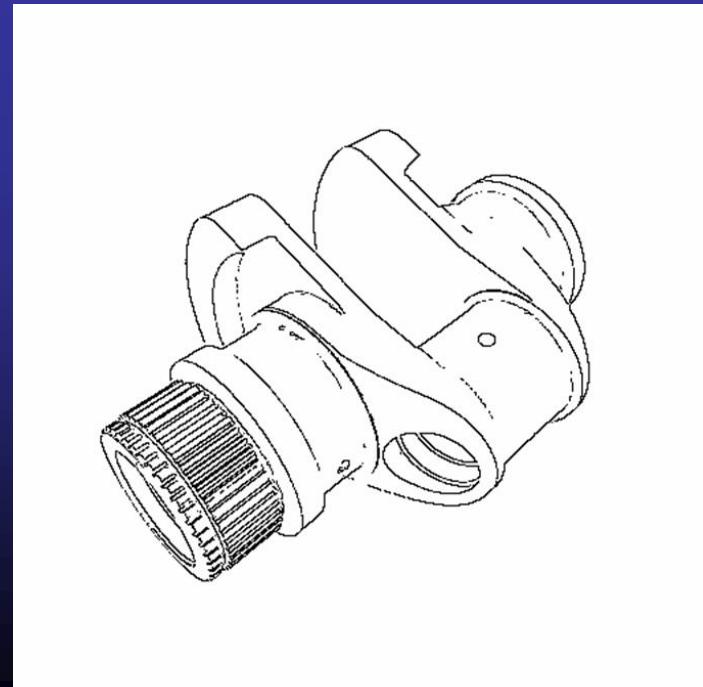
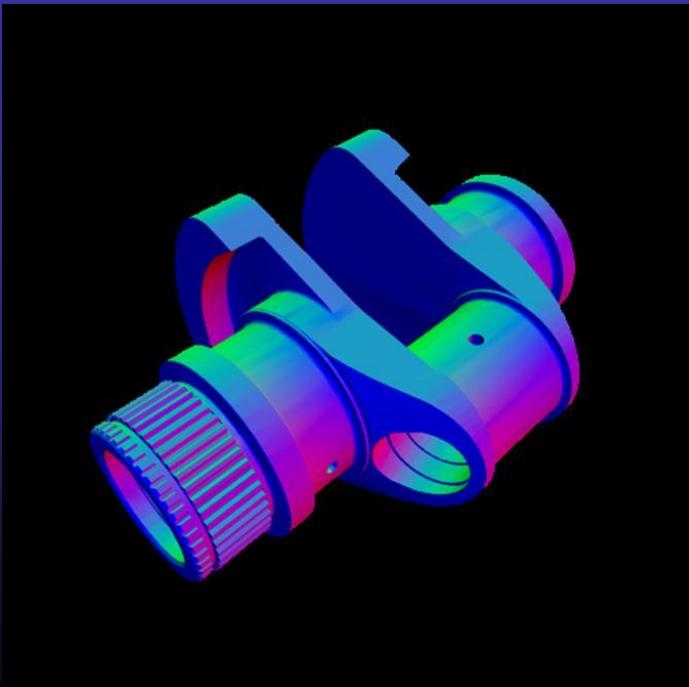
Image space + depth



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

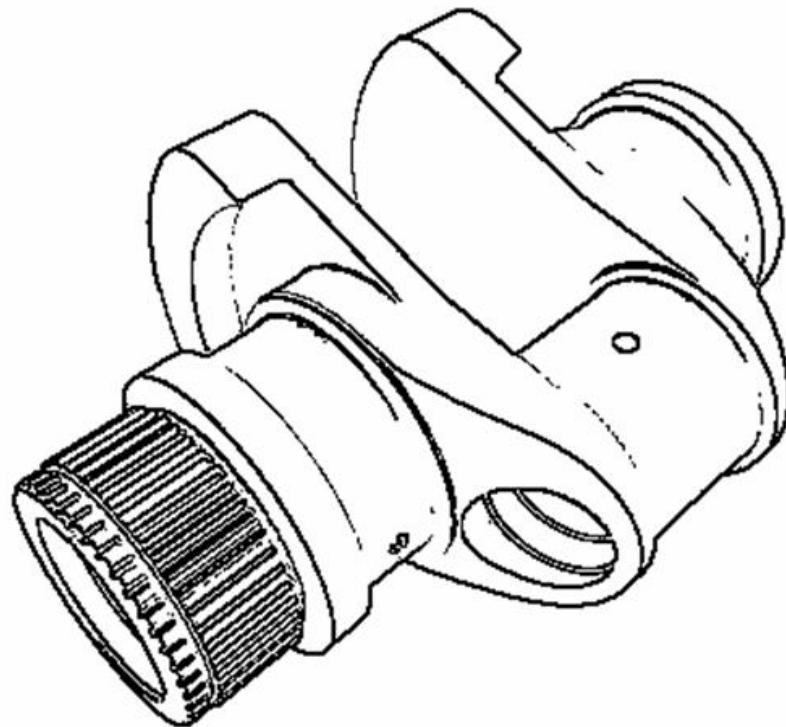
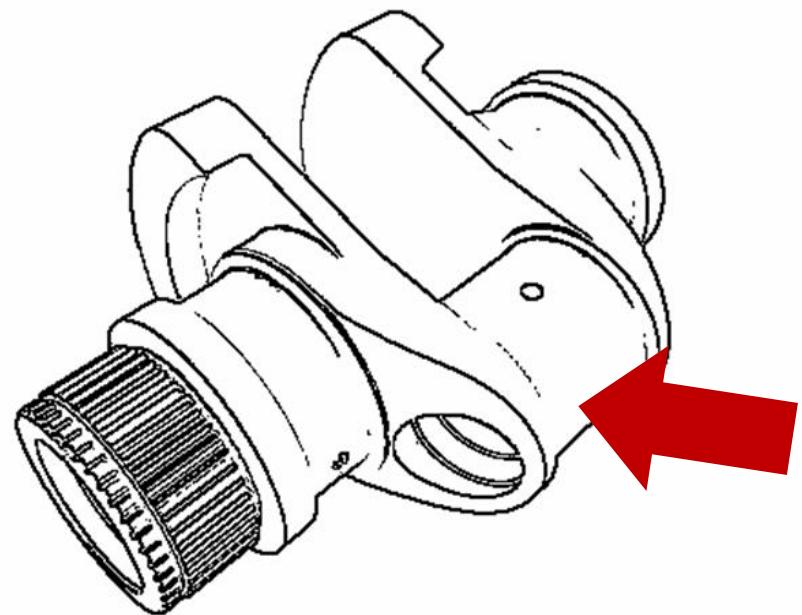


Image space limitations

- We loose the 3D information

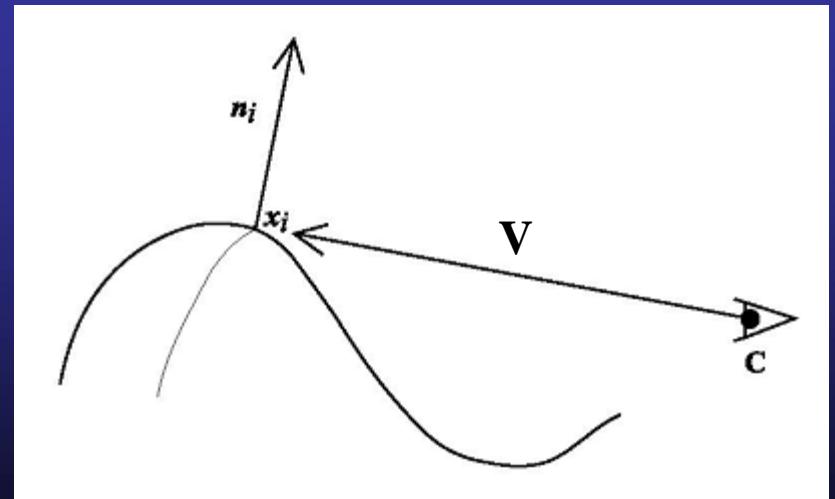
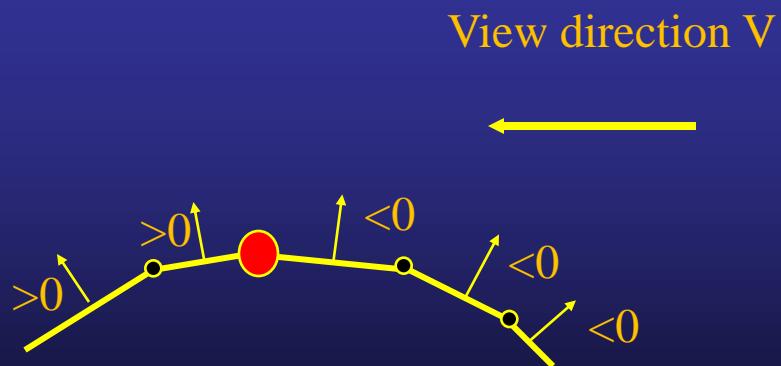


Object space

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

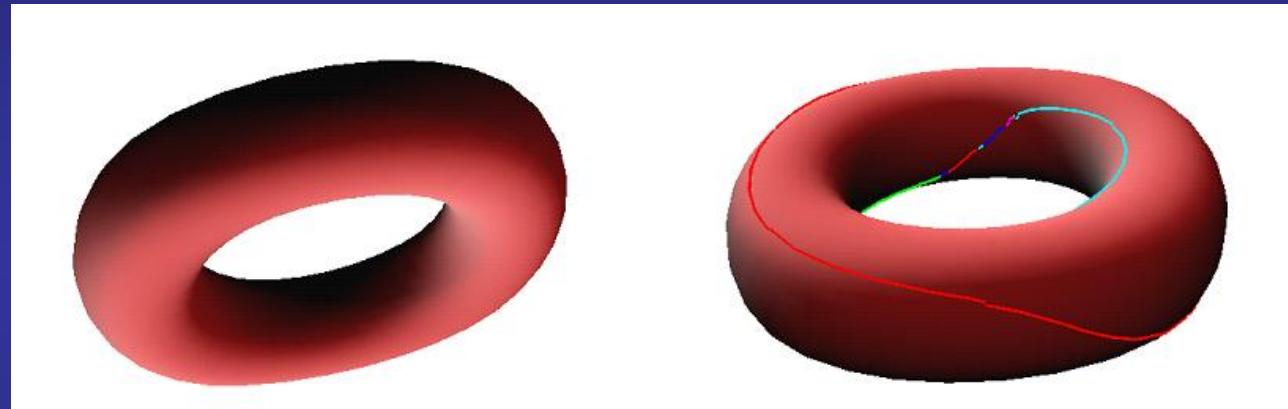
Silhouettes - object space

- Edges that connect back and front Faces
- Surface points such that $\mathbf{N} \cdot \mathbf{V} = 0$

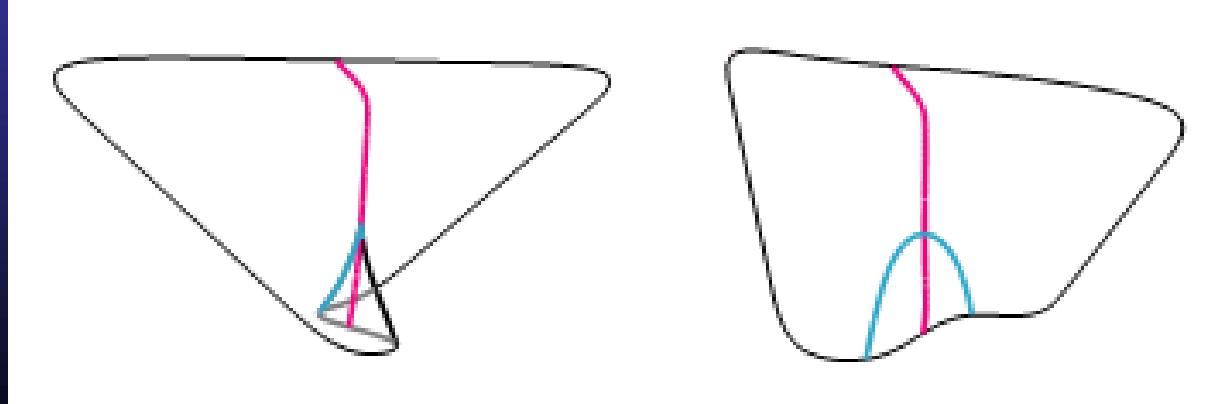


Silhouette properties

- View dependant

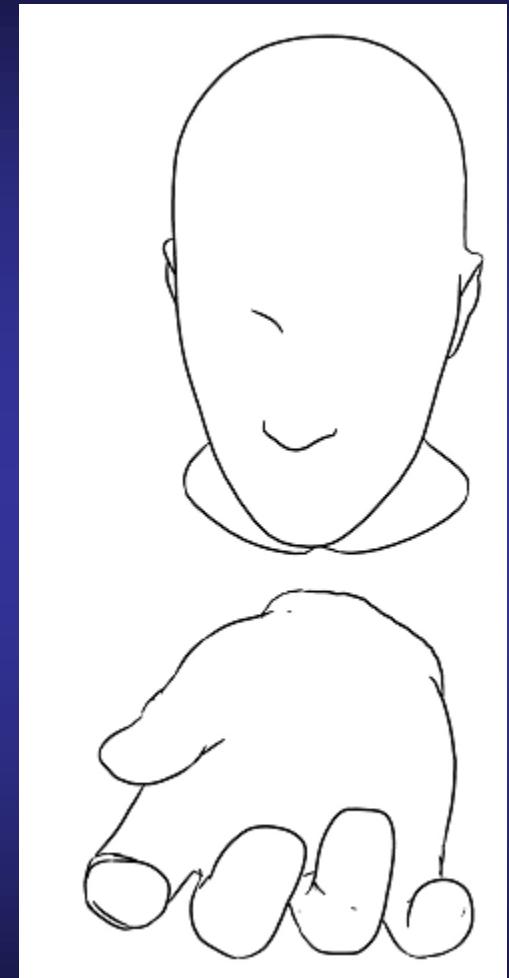
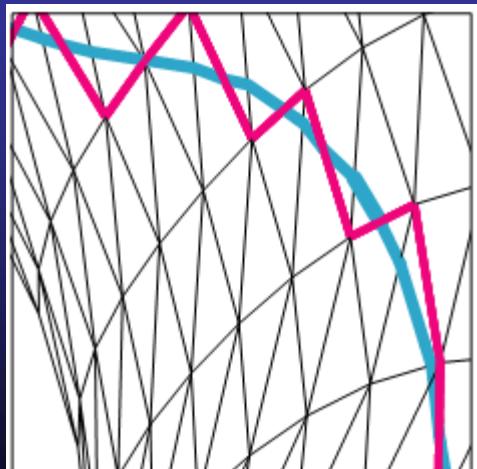


- Cusps



Smooth silhouettes

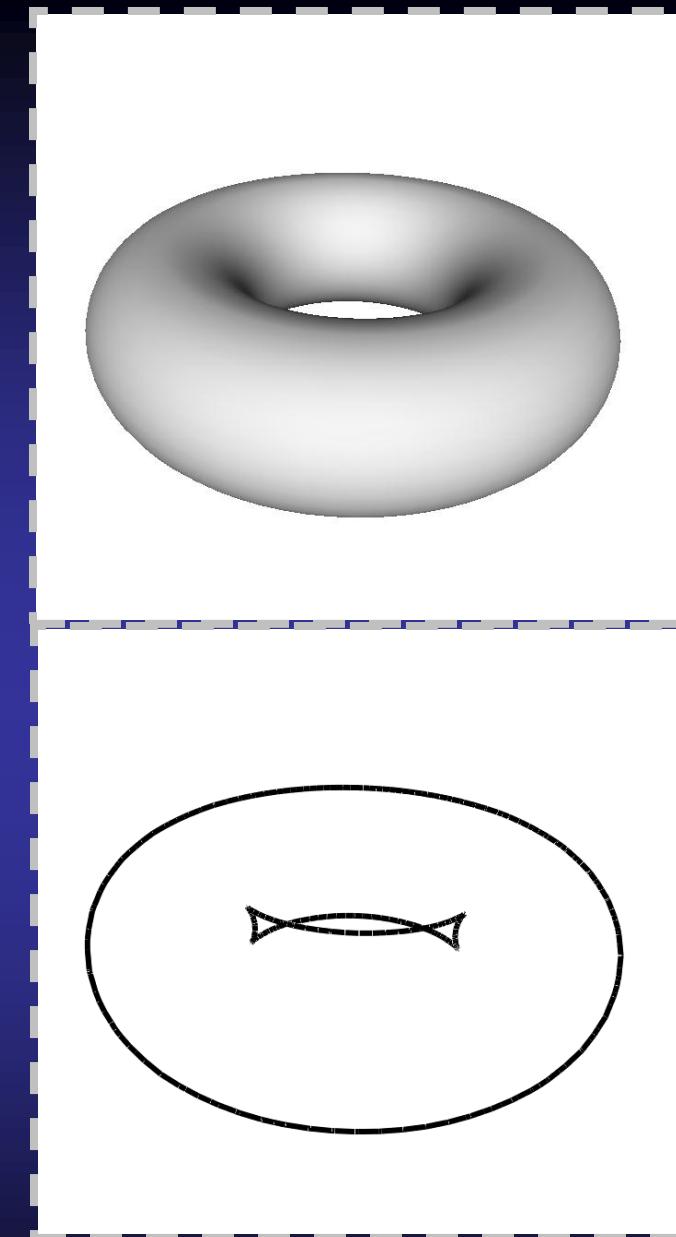
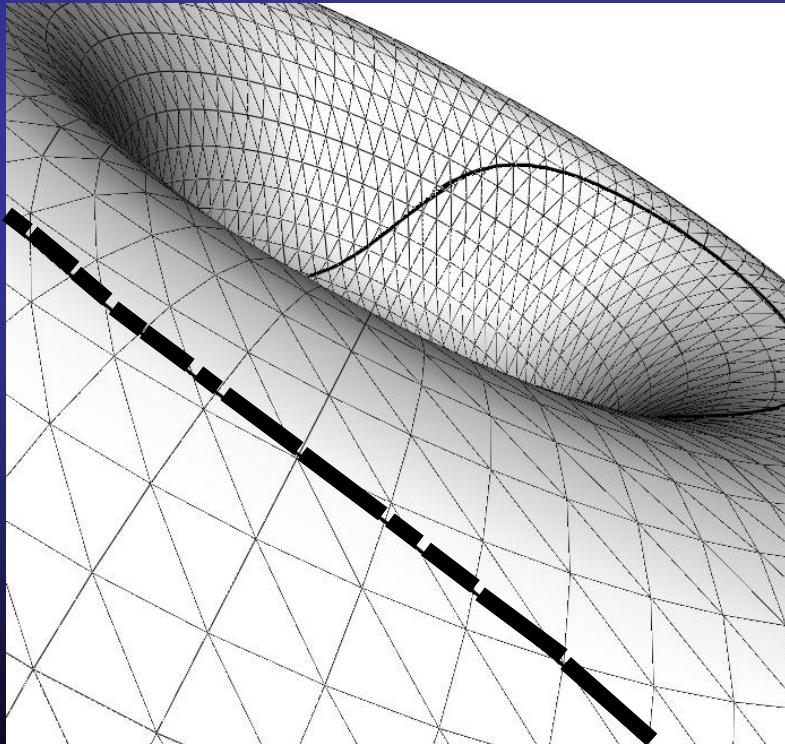
- Compute N.V for each vertex
- Interpolate to find the O place on the edges



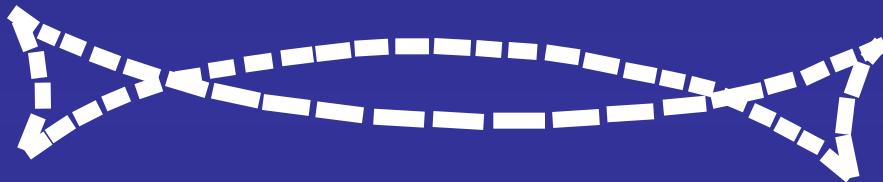
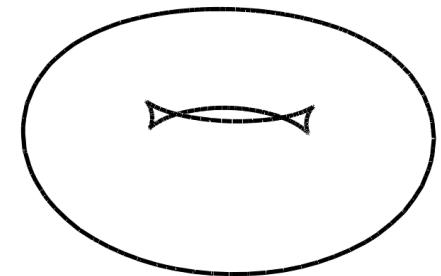
Illustrating smooth surfaces
A. Hertzmann, D. Zorin
SIGGRAPH 2000

What is missing?

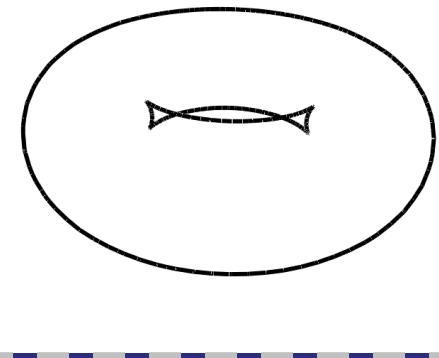
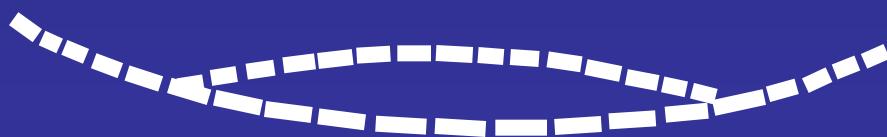
- Keep only visible edges
- Build a continuous curve



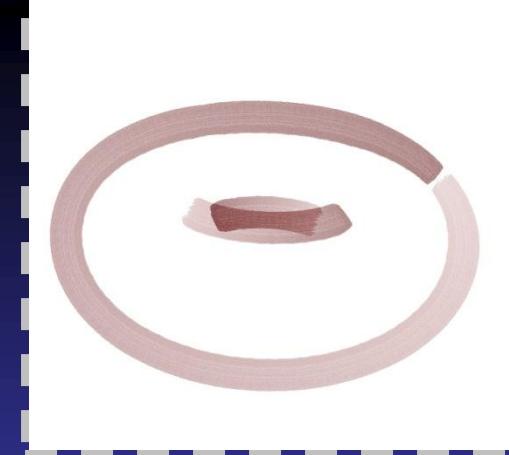
Chosen edges



Visible edges

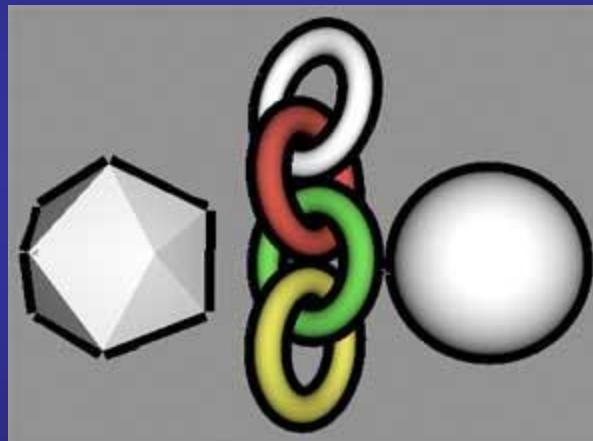
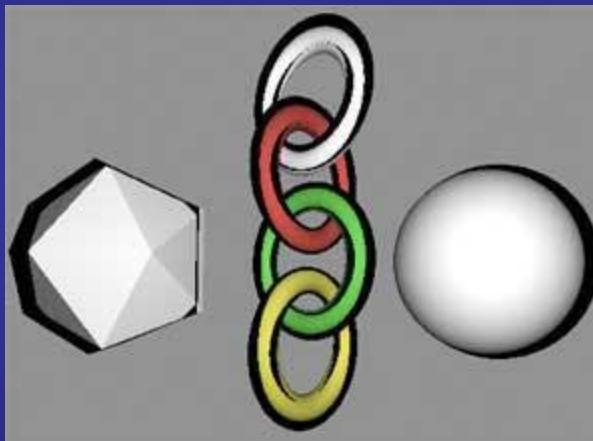


Curve

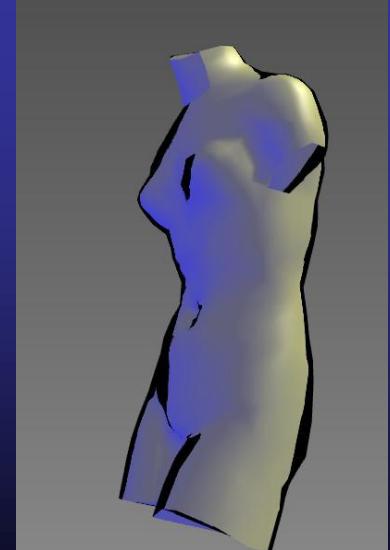


Silhouettes on the GPU

- Perturb the back facing polygons
 - Multiple renderings

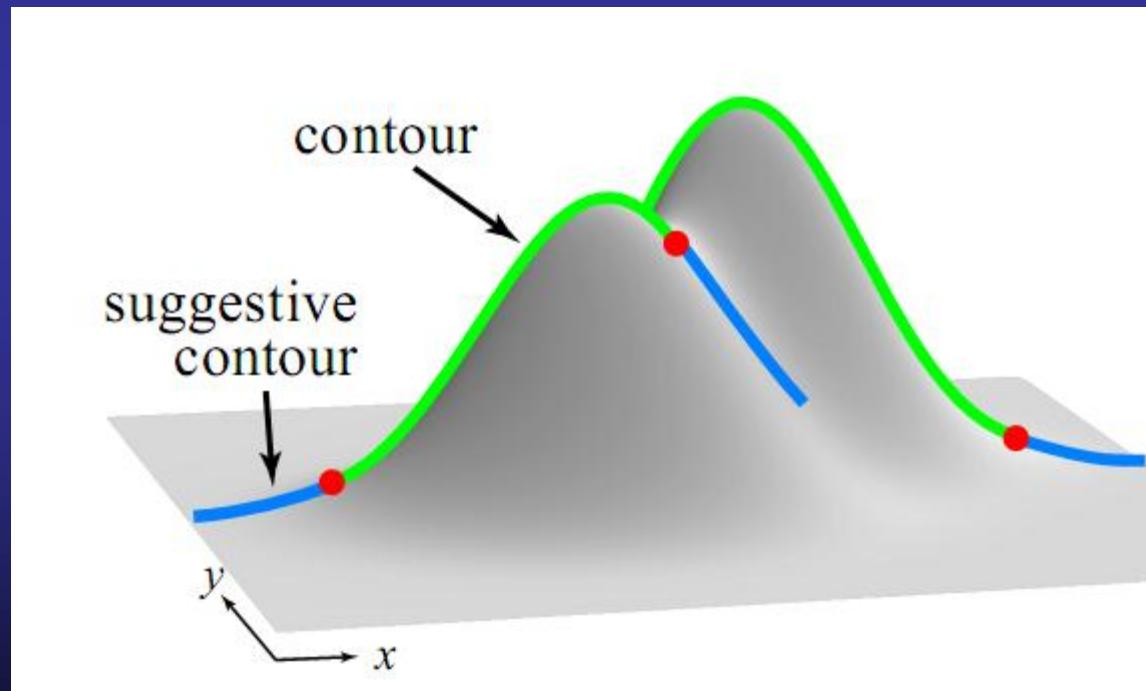


- Use an envmap



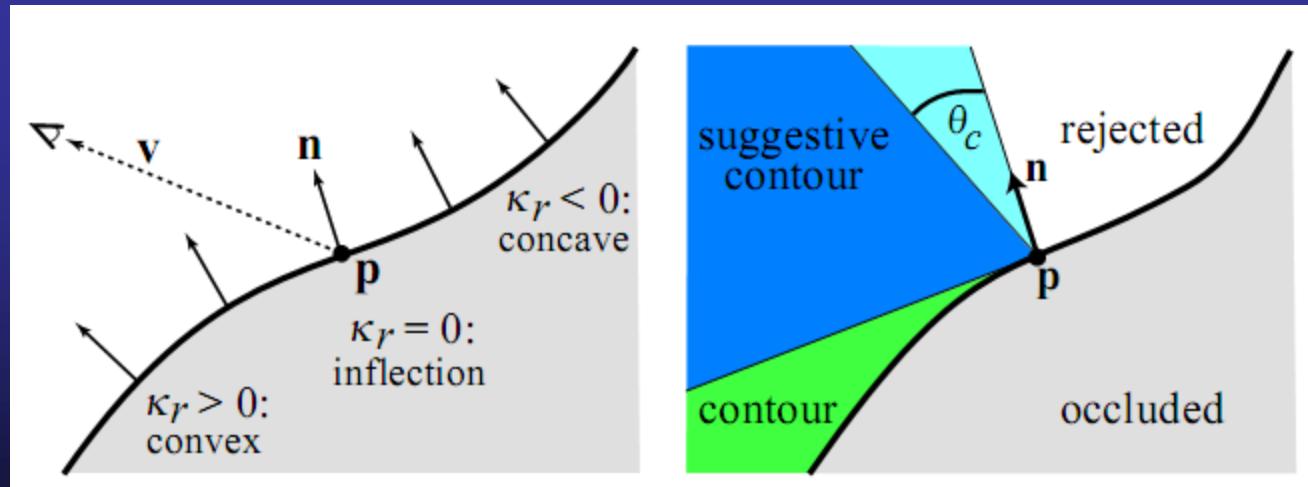
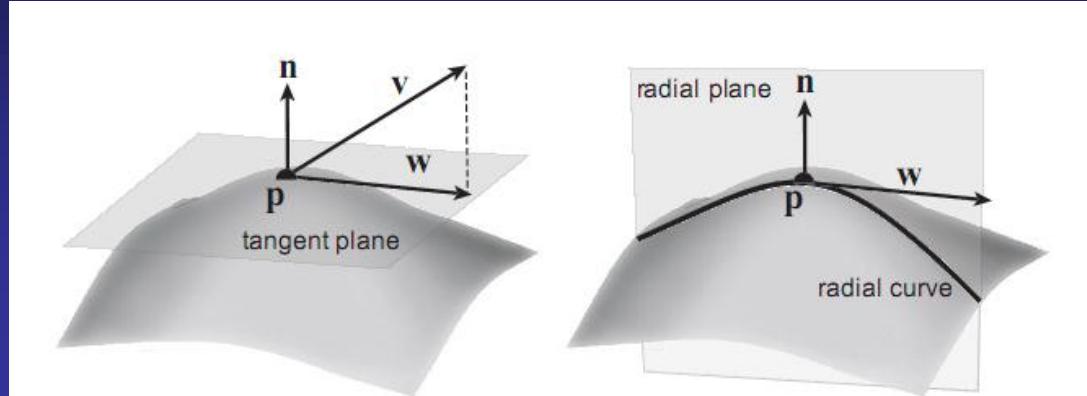
Now what else?

- Near silhouettes



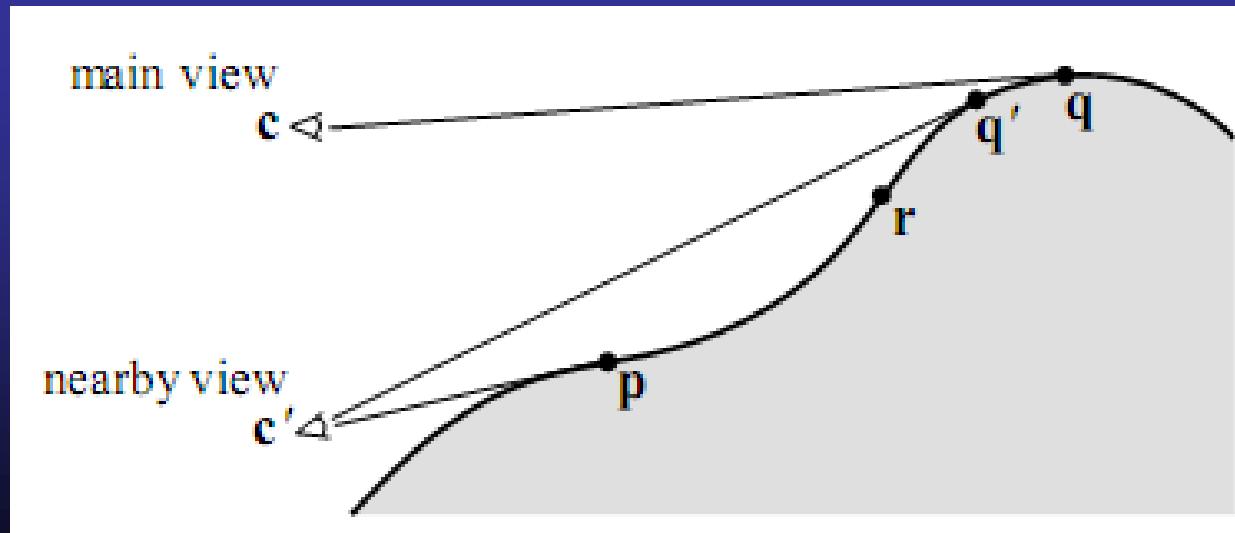
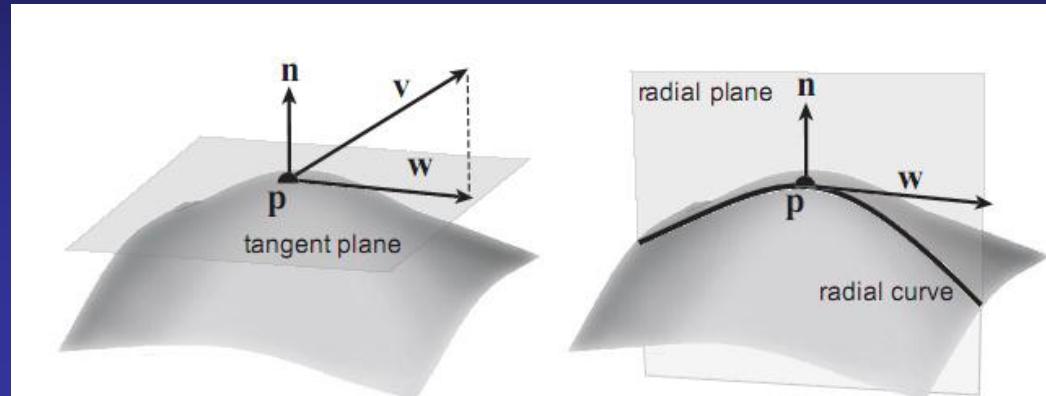
Suggestive contours (1)

- Zeros of radial curvature



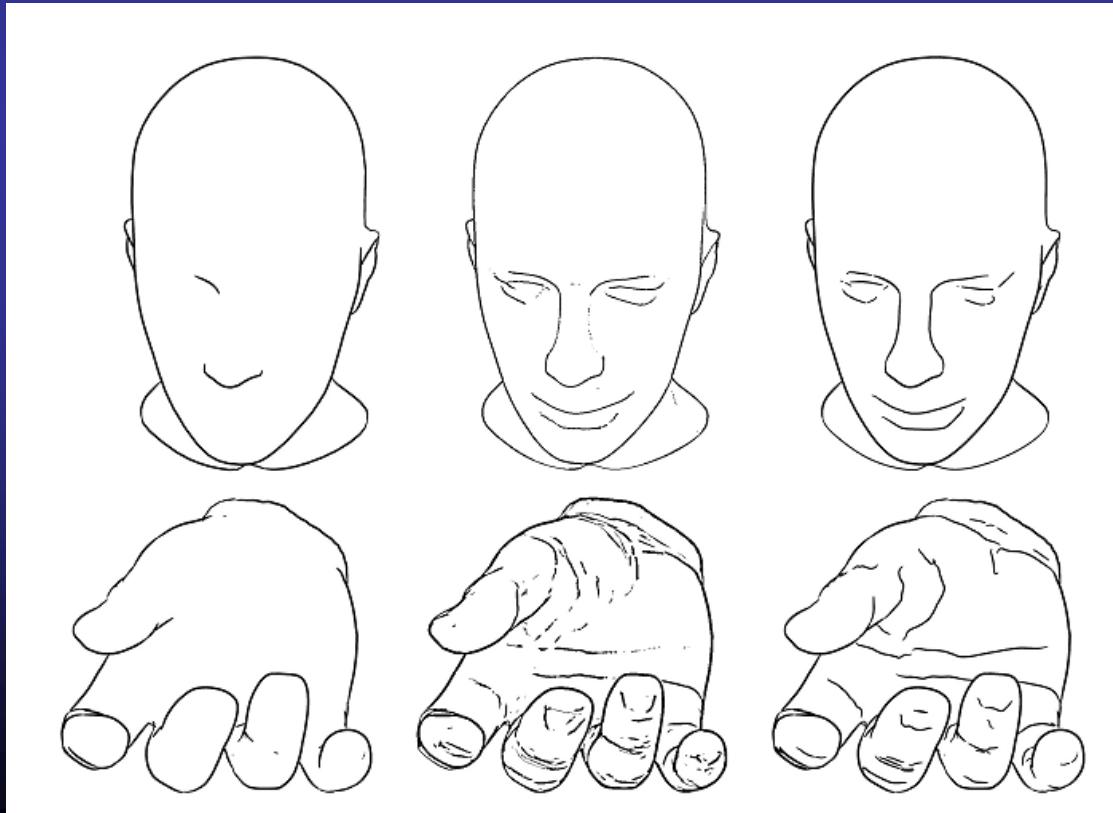
Suggestive contour (2)

- 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)

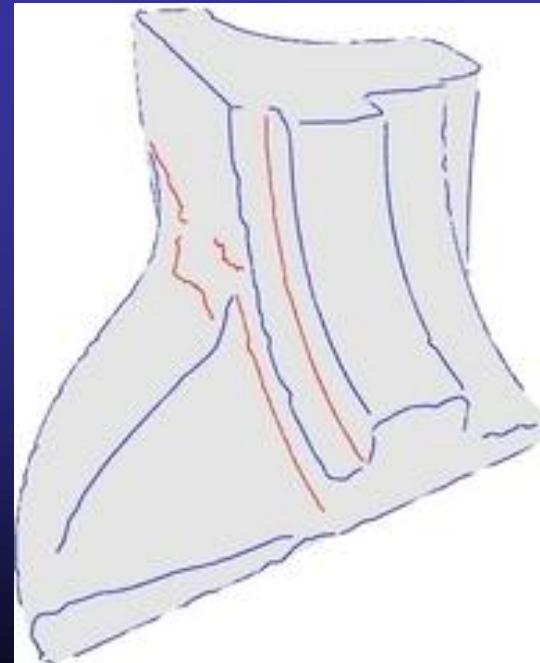
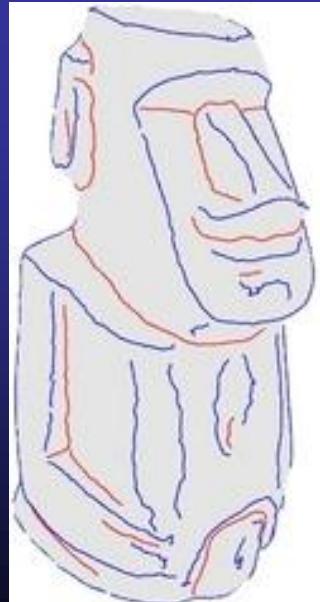


Object space

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

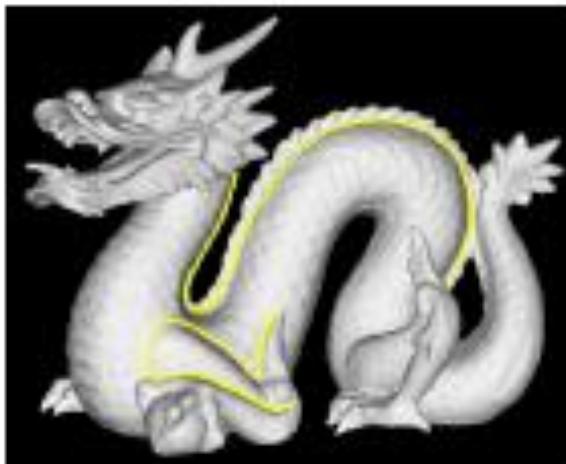
Crease

- Sharp edges
- Threshold the normal difference between two faces



Riges and valleys

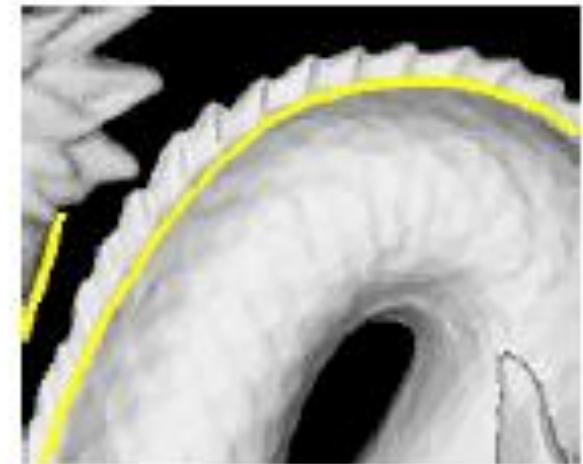
- Creases extension
- Curvature max in principal direction



(a)



(b)



(c)

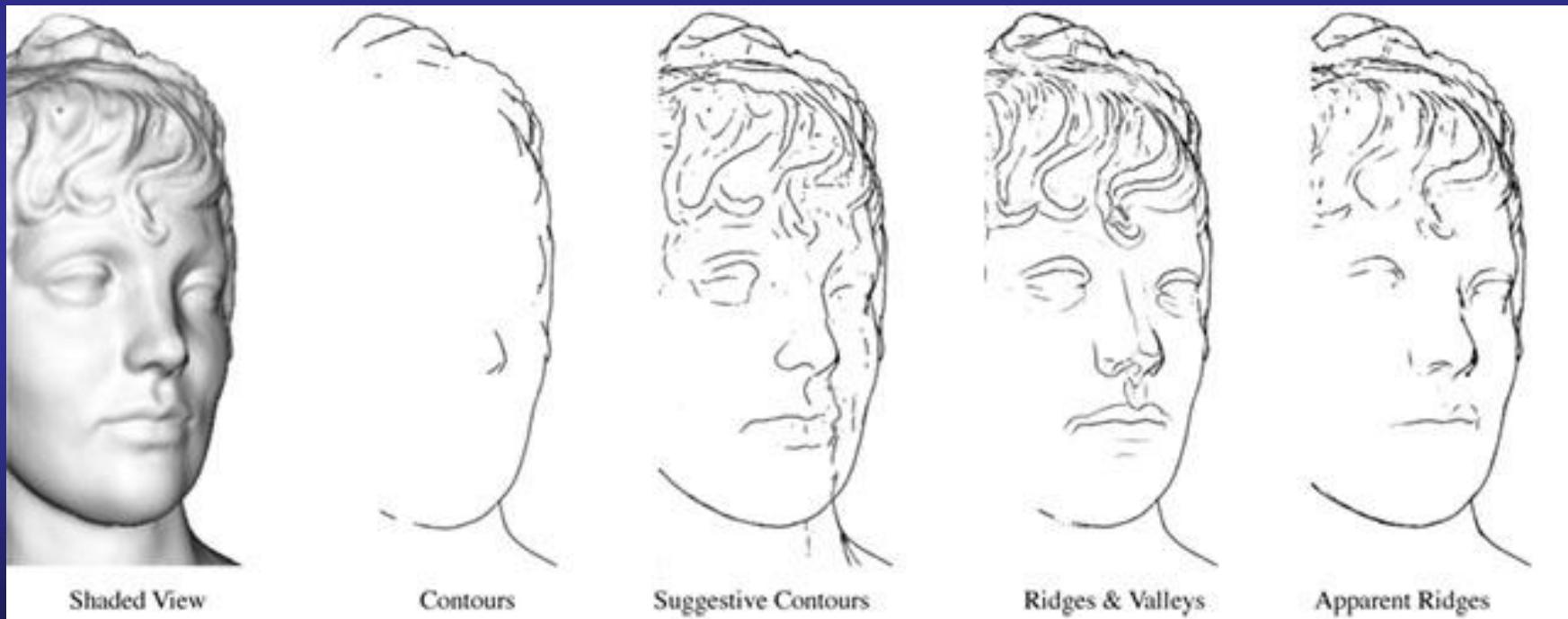
Main problem

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



Are ridges what we need?

- A view dependent version



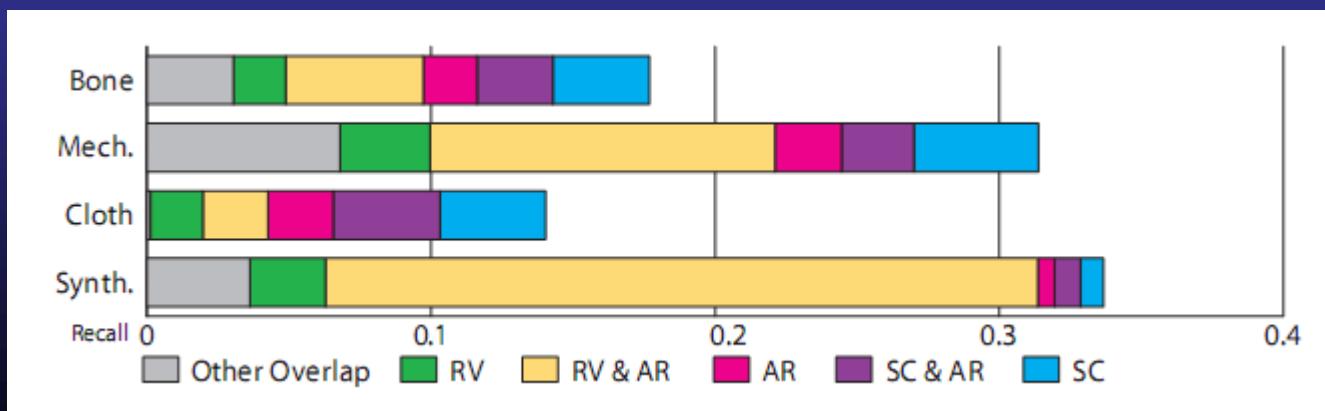
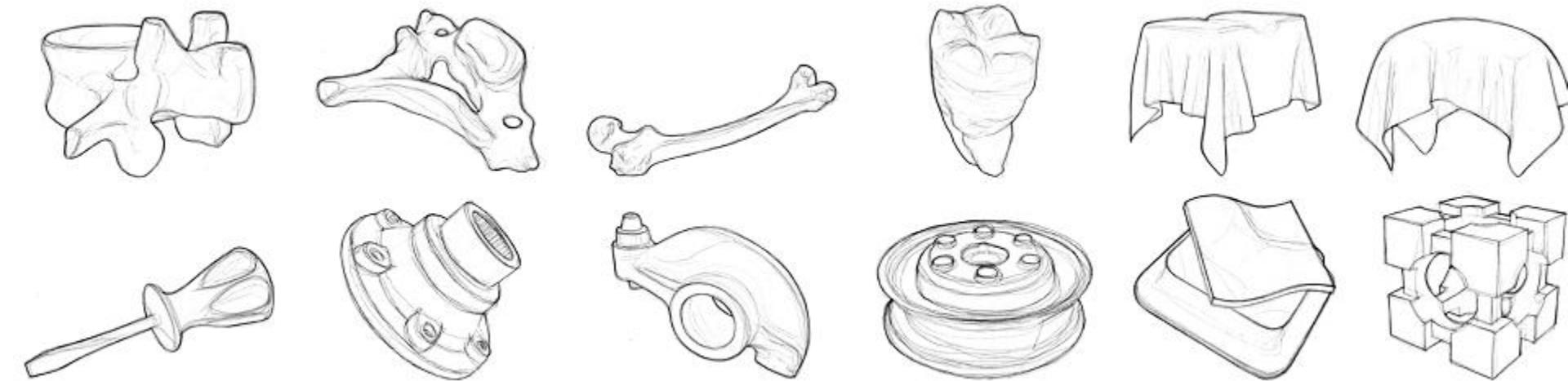
Apparent Ridges for Line Drawings
Tilke Judd Frédo Durand Edward Adelson

Now what?

What lines do we really need?

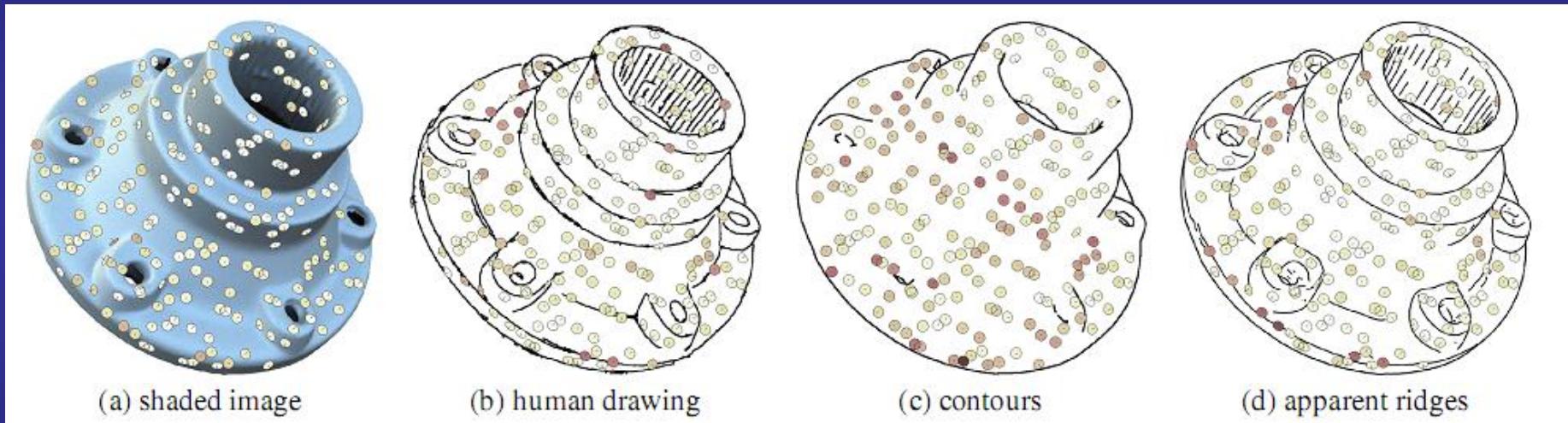
User study

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

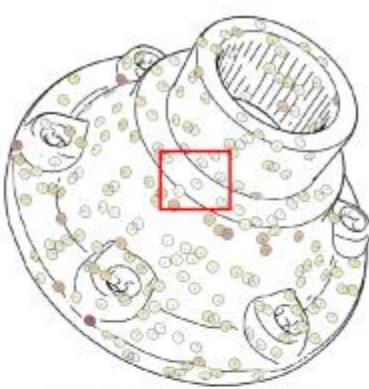


User study

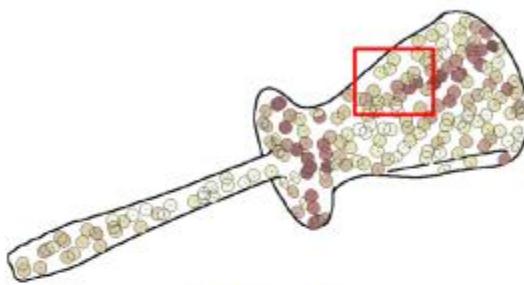
"[How Well Do Line Drawings Depict Shape?](#)," Forrester Cole, Kevin Sanik, Doug DeCarlo, Adam Finkelstein, Thomas Funkhouser, Szymon Rusinkiewicz, and Manish Singh,. *SIGGRAPH 2009*)



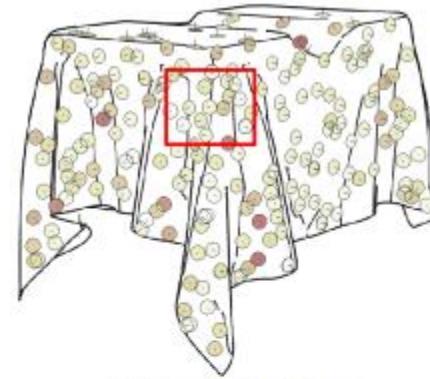
Results unclear yet To be continued...



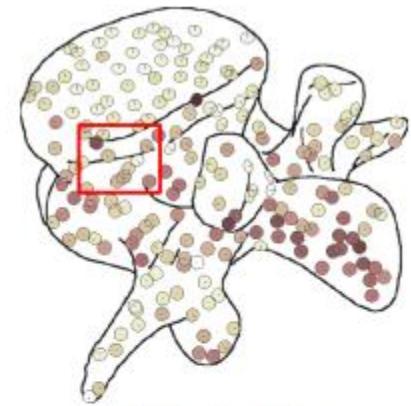
ridges and valleys



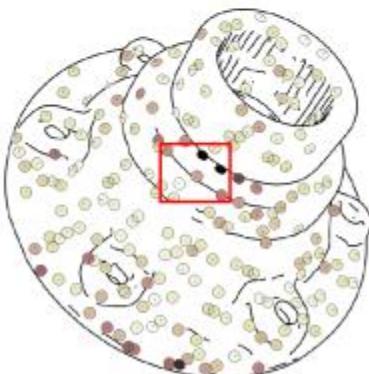
contours only



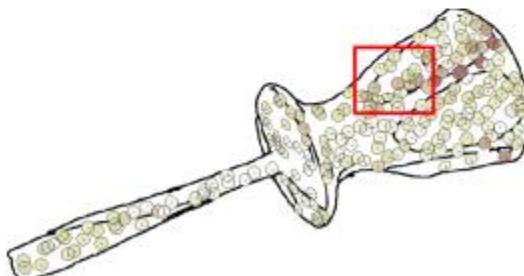
ridges and valleys



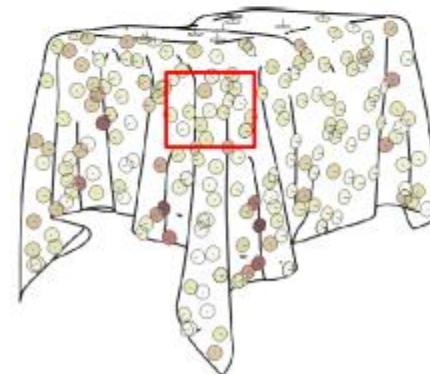
artist's drawing



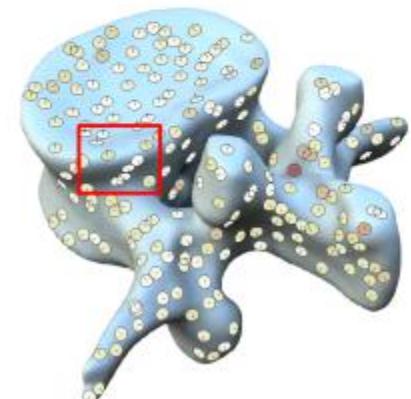
suggestive contours



artist's drawing

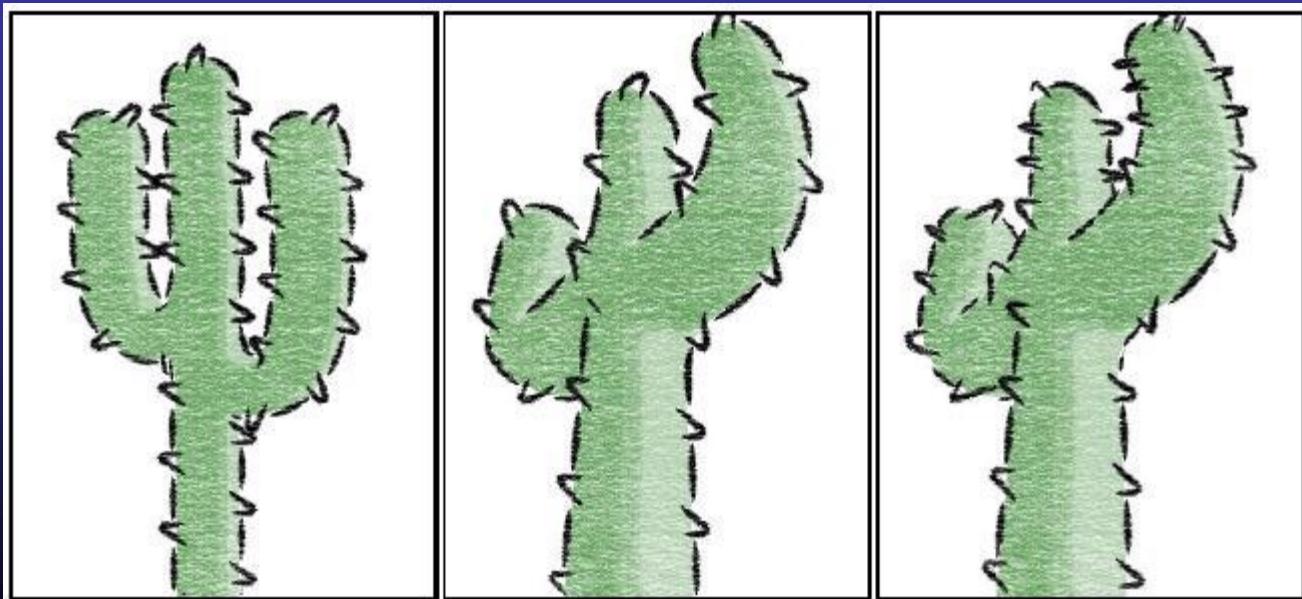
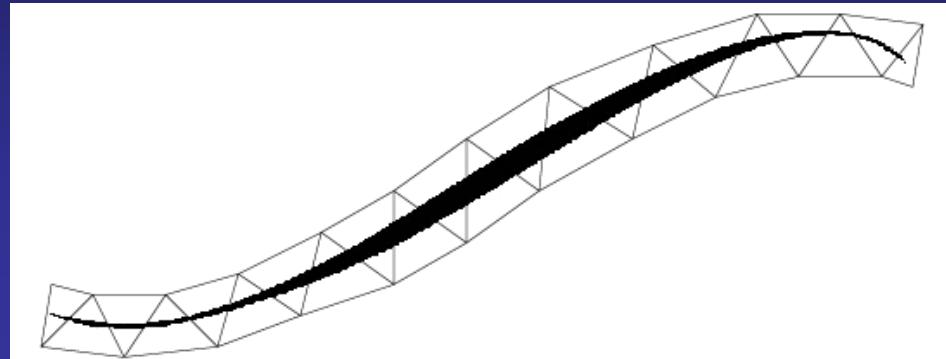


suggestive contours



shaded

Temporal coherence - lines



IV - Style

Attributes

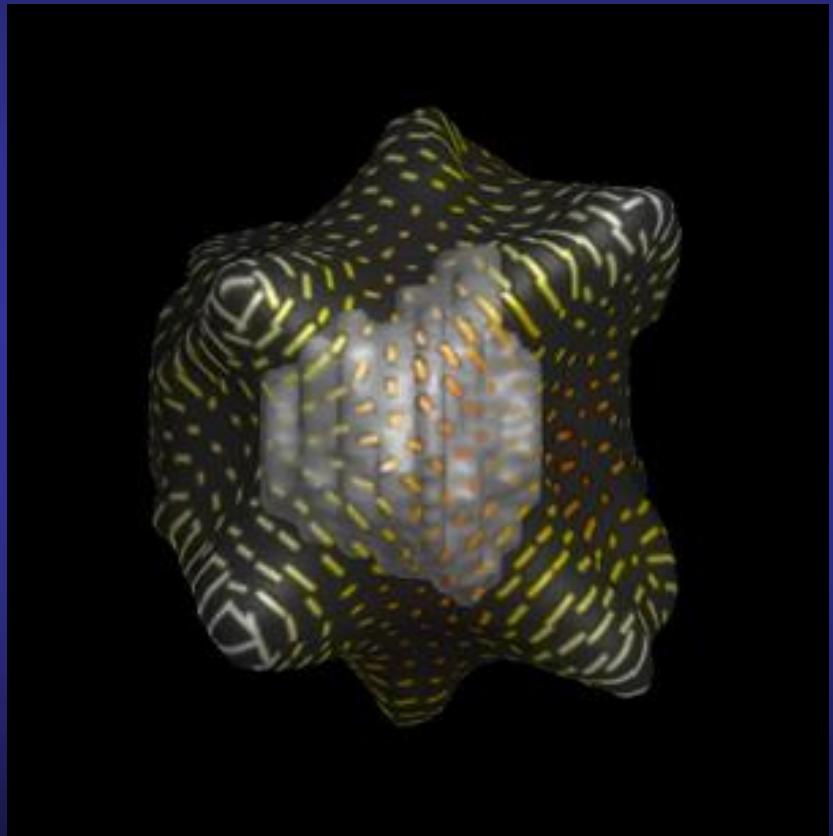
- Style = transfer function
 - From scene to marks attributes
- ⇒ How to combine user choices and scene information?
- ⇒ Compromise automatic vs manual

Depth to Color

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



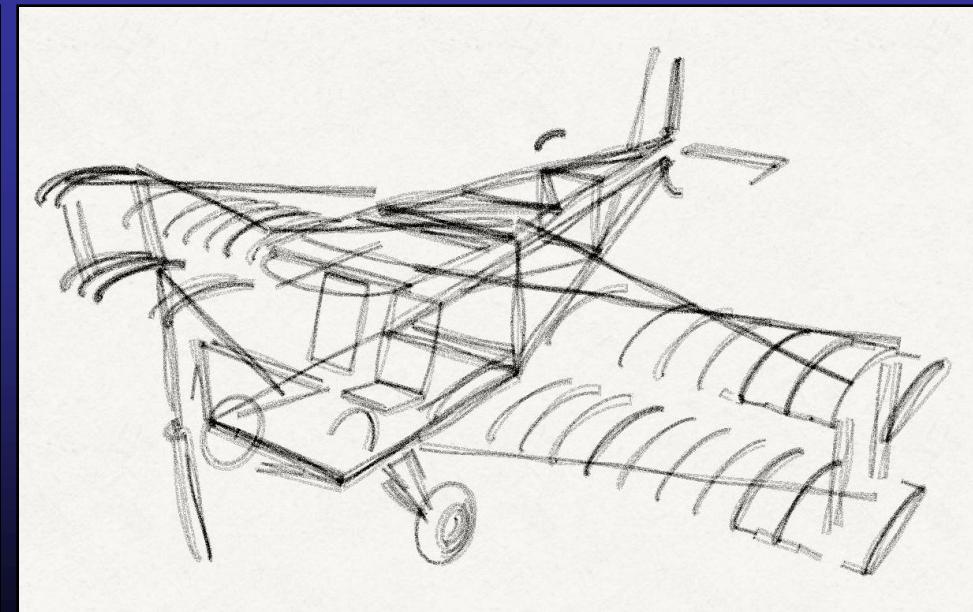
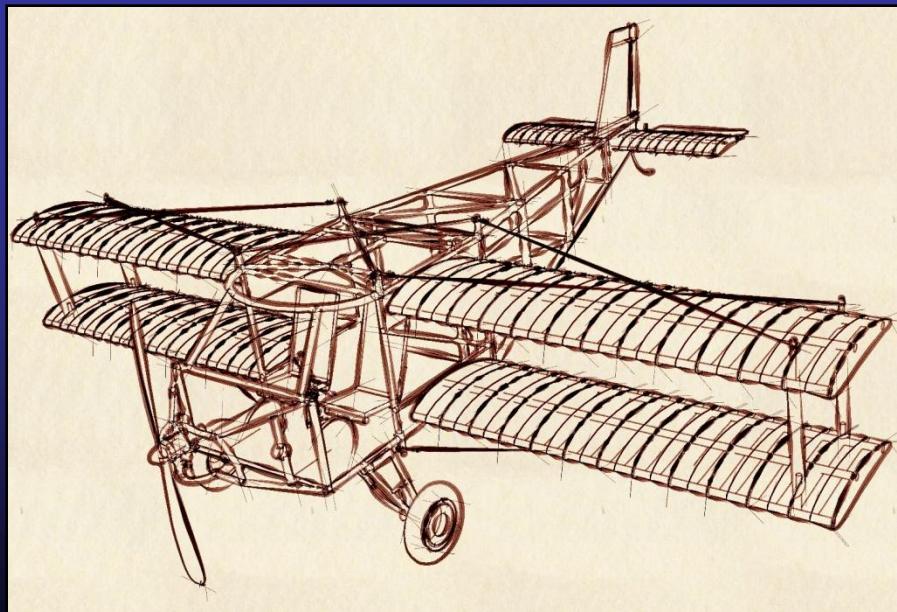
Curvature to orientation



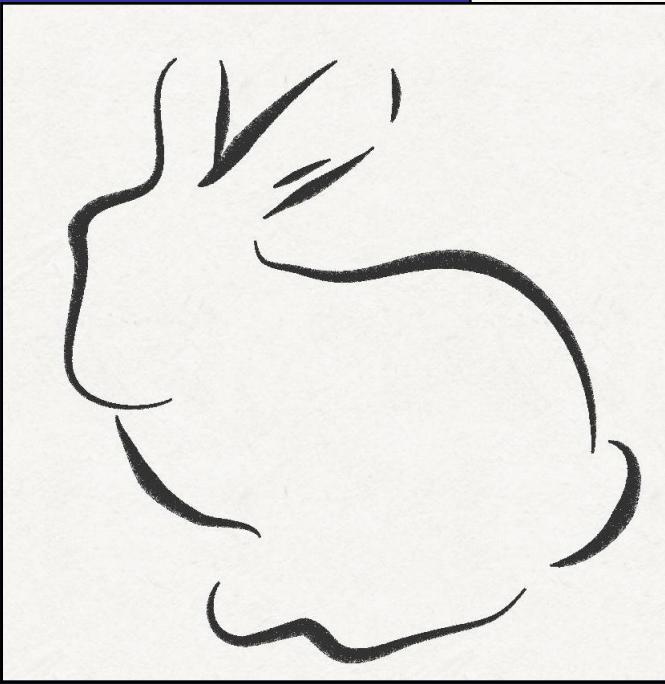
INTERRANTE V., « Illustrating surface shape in volume data via principal direction driven 3D line integral convolution » *Siggraph 97*

Freestyle

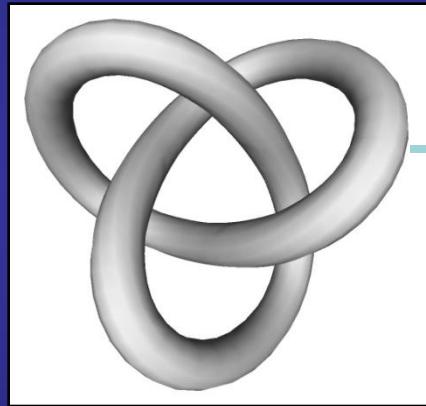
- Style coding



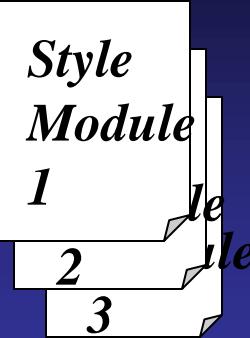
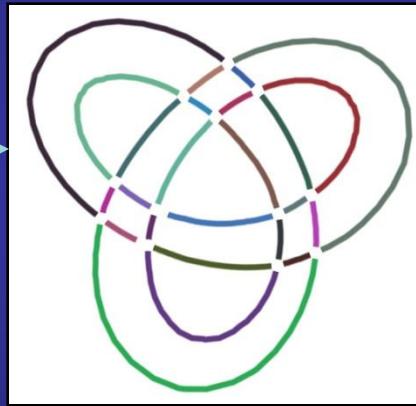
- Independant from the 3D model



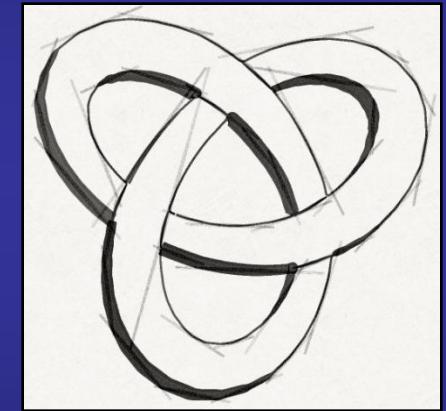
3D



« View Map »



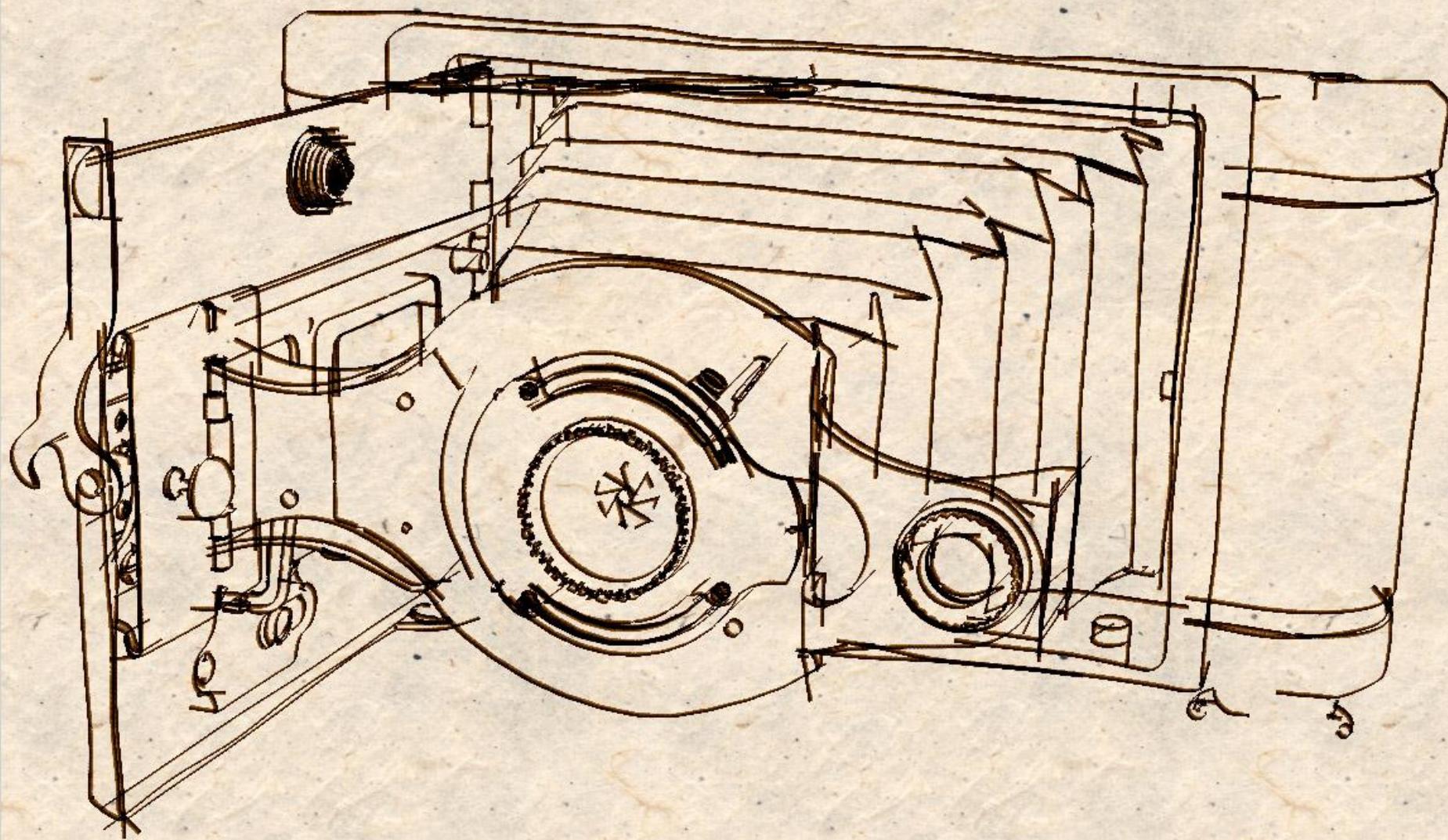
Drawing

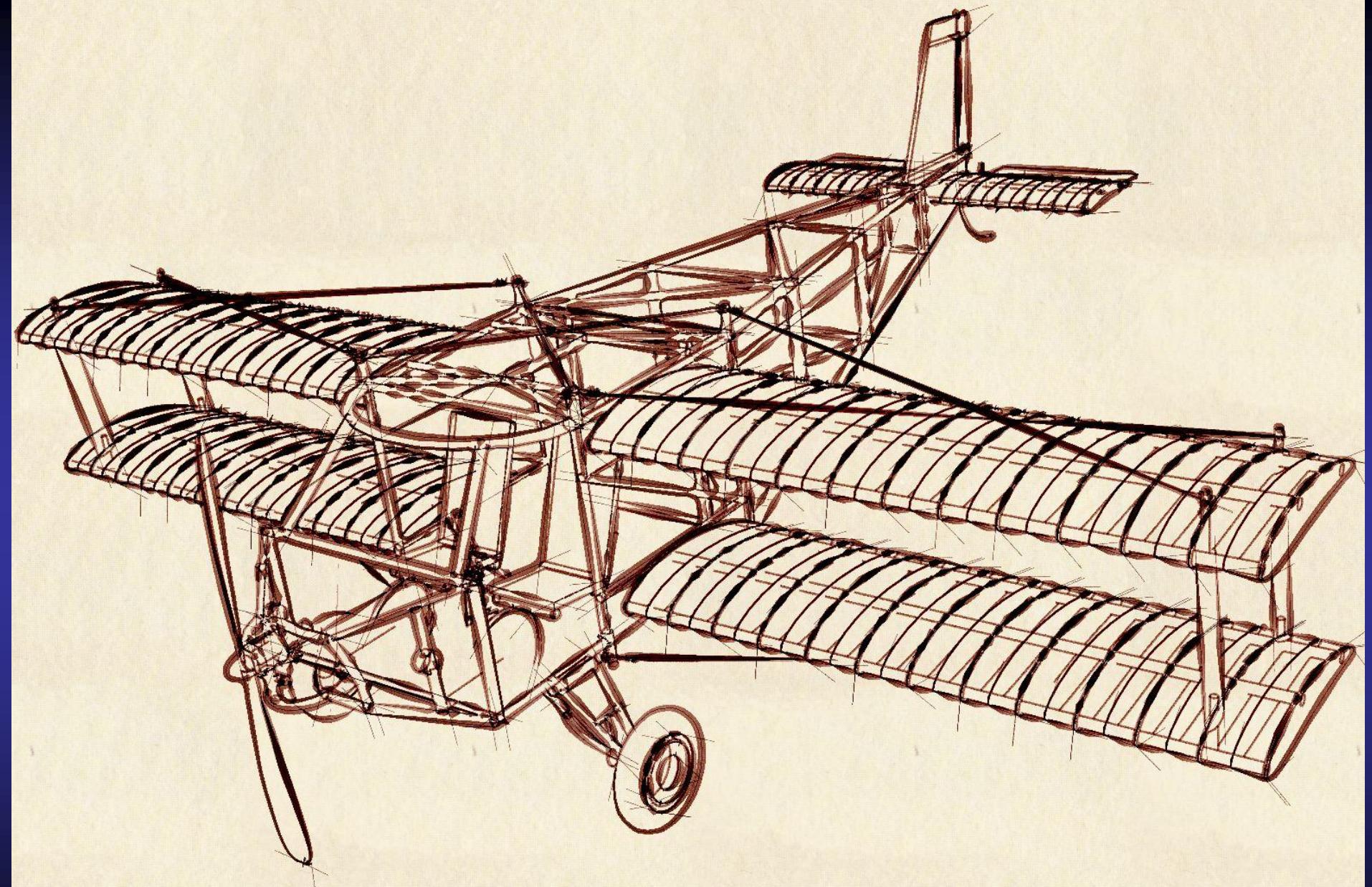


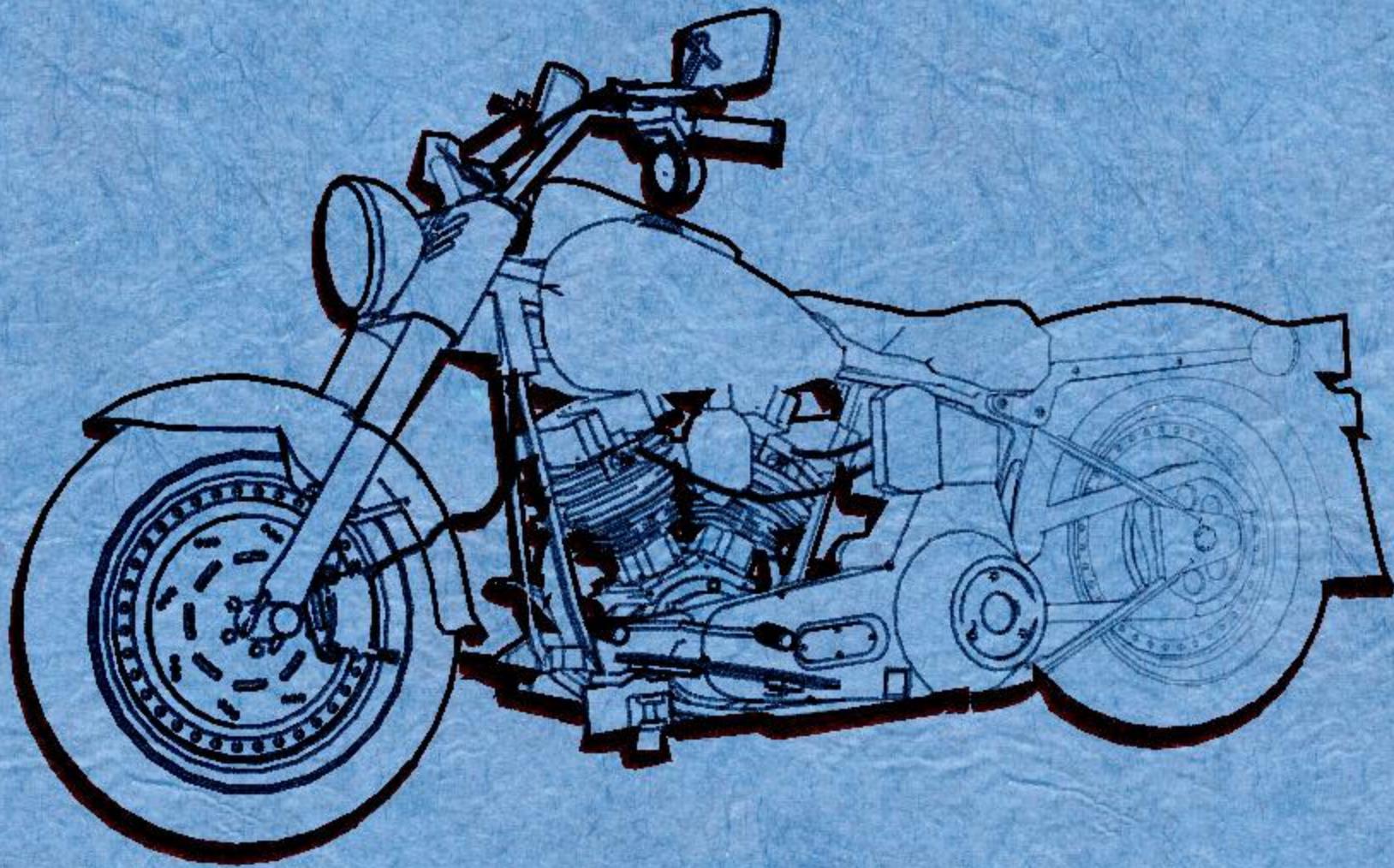
+
information

Parameters

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



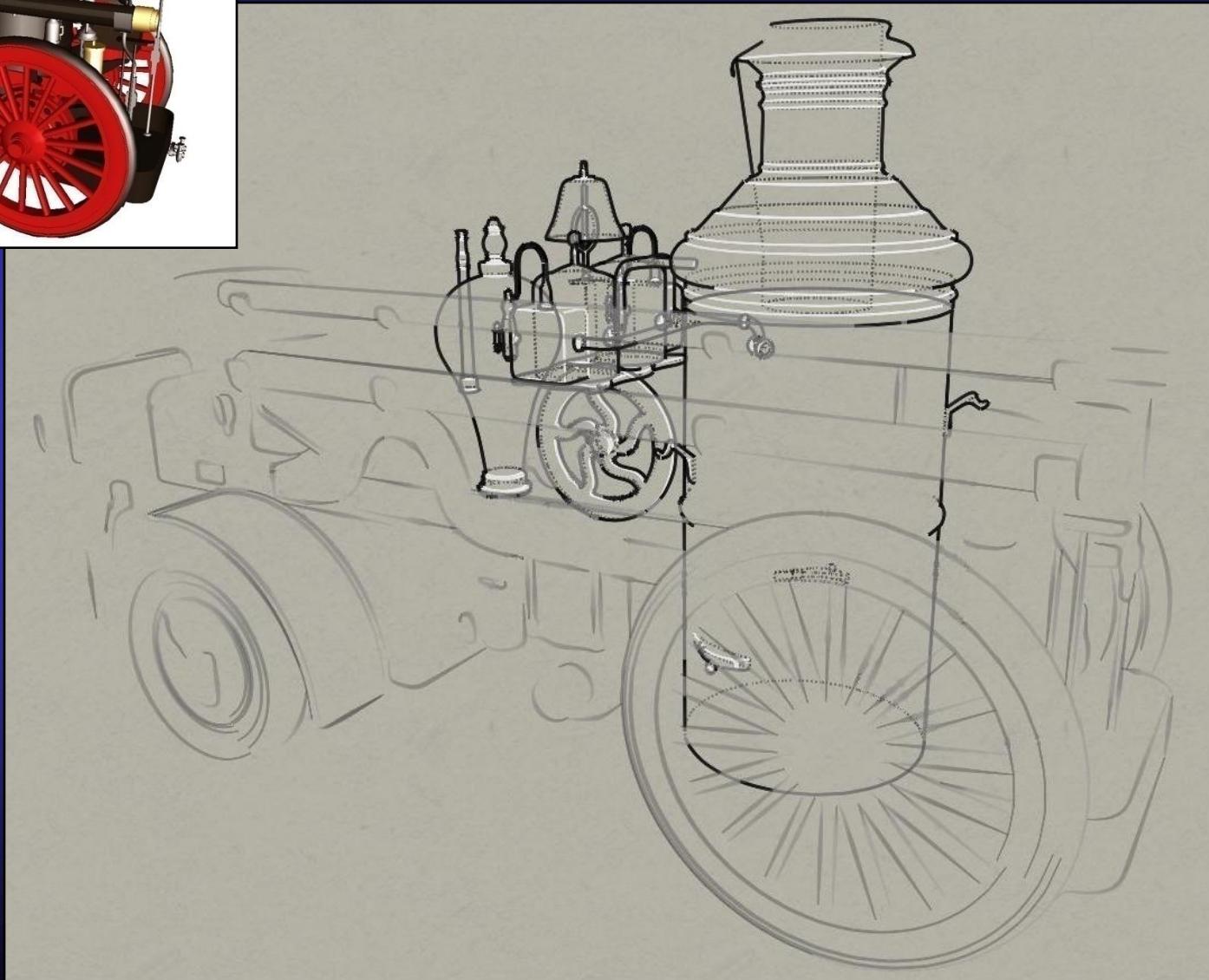








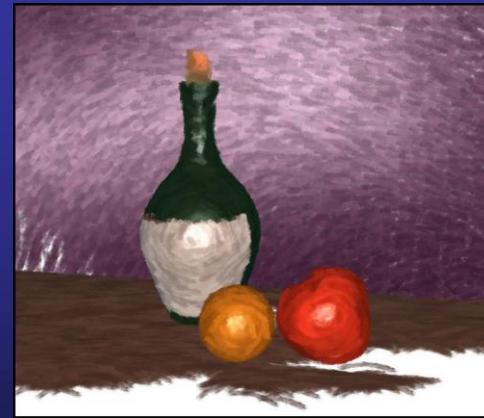
<http://artis.imag.fr/Projects/Style>



So what is the « style »

- A way for the artist to express something
- How to model that?
 - A set of parameters?
 - A set of techniques?
- Style = attributes + movement?

Procedural style

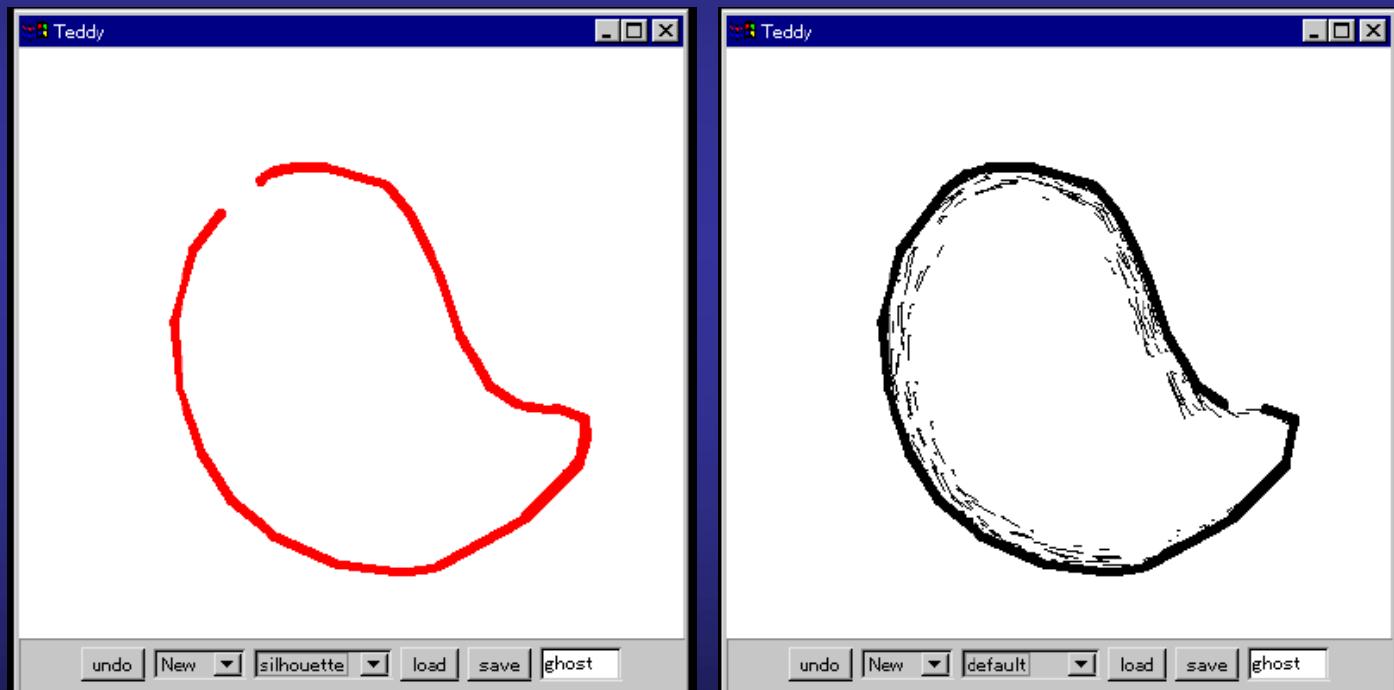
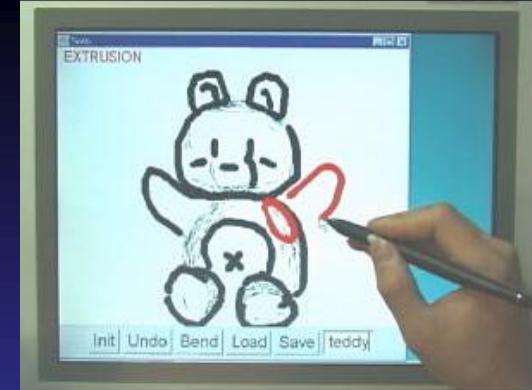


David Vanderhaeghe, Pascal Barla, Joëlle Thollot, François Sillion
A dynamic drawing algorithm for interactive painterly rendering
Siggraph technical sketch: SIGGRAPH'2006 - aug 2006

Conclusions

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

- Inverse problem
 - Sketch based modeling



Teddy: A Sketching Interface for 3D Freeform Design
Copyright (C) 1999 Takeo Igarashi