Breaking the Pixel Barrier

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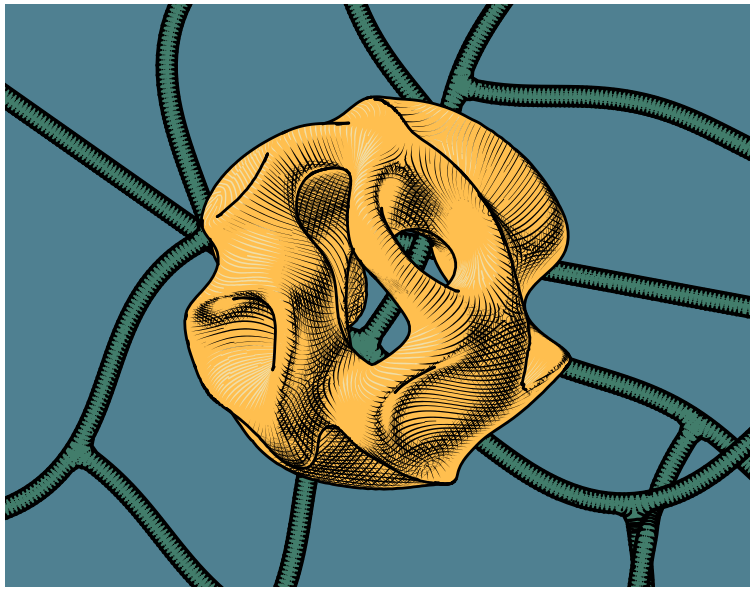

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Main Messages:

- Research for generating high-quality vector graphics has to be intensified.
- Pixels are often just not enough when representing graphical material, in particular, for print reproduction.
- With analytic rendering and high quality vector representation, errors & artifacts in models & technique show up more readily.

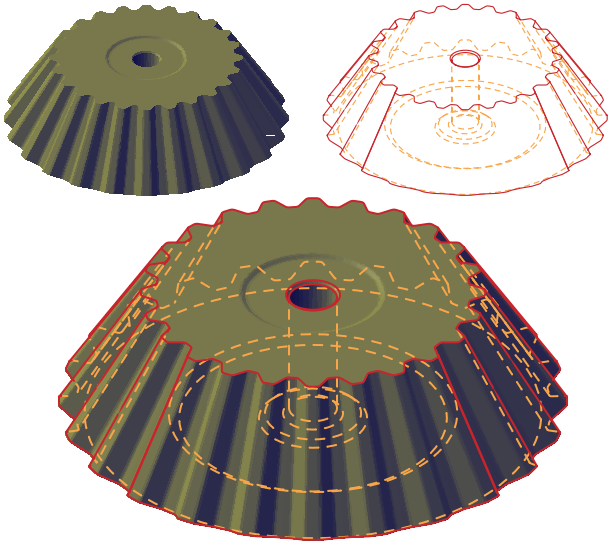
Introduction

- NPR: many traditional and new techniques possible
- recently, quest for speed and realism in NPR
- (ab)use of graphics hardware
- most techniques produce pixel images for screen viewing
- limitations of this development
  - file sizes
  - level of detail
  - print reproduction

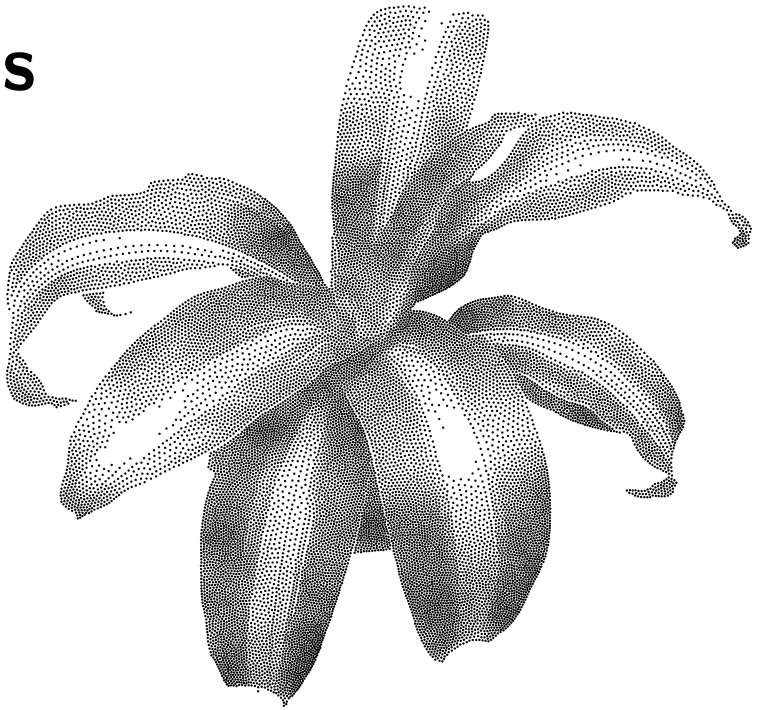
$\Rightarrow$ call for vector graphic rendering

Vector Graphic NPR Techniques

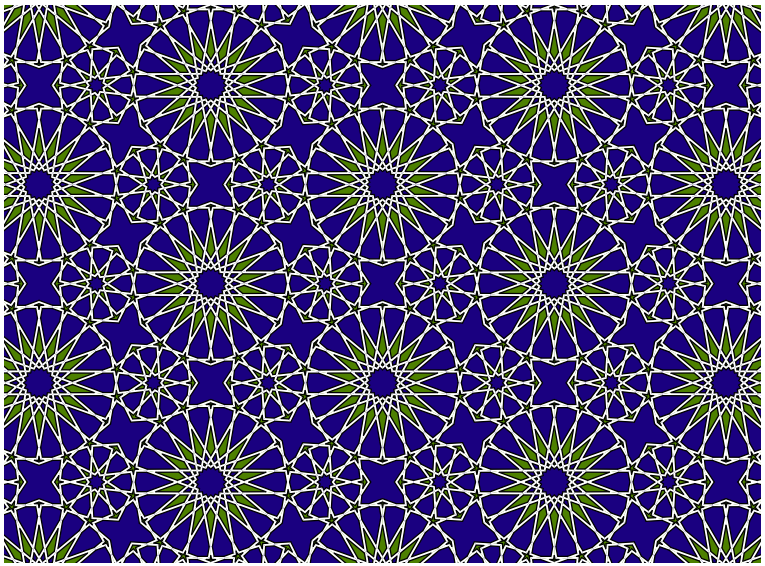
from Hsu & Lee (1994)



created with OpenNPAR

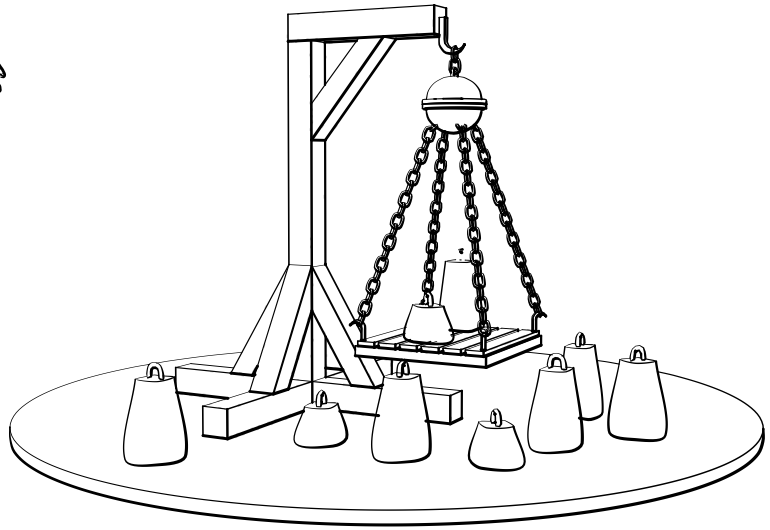


from Secord (2002)



created with Taprats

Hertzmann & Zorin (2000)



from Schönwälder (1997)

Initial Motivation[1]

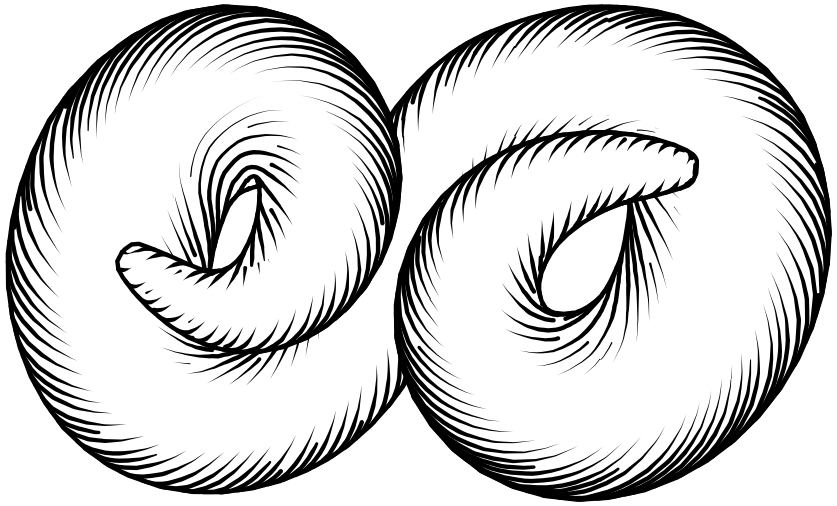
- comparison of pixel images with vector graphics

	pixel images	**vector graphics**
resolution	fixed	adaptive
printing	resolution problems	always rasterized at correct resolution
file sizes	depend on image resolution	depend on objects & object detail
magnification	"fat pixels"	easily possible (to a certain degree)
description	sampled	analytic
display speeds	fast	slower
modifications	hardly possible	easily possible
domains	screen viewing, PR	print and screen viewing, NPR

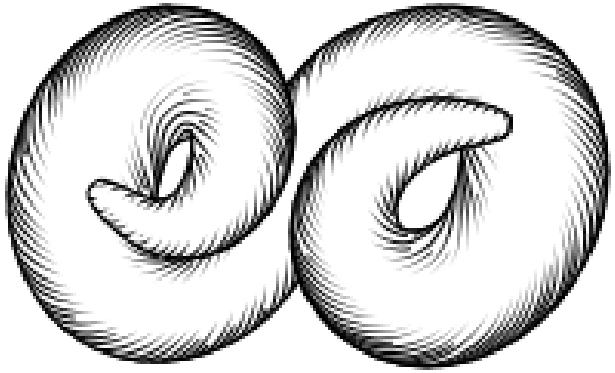
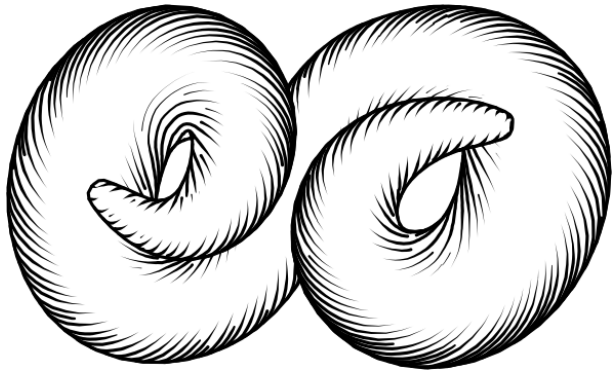
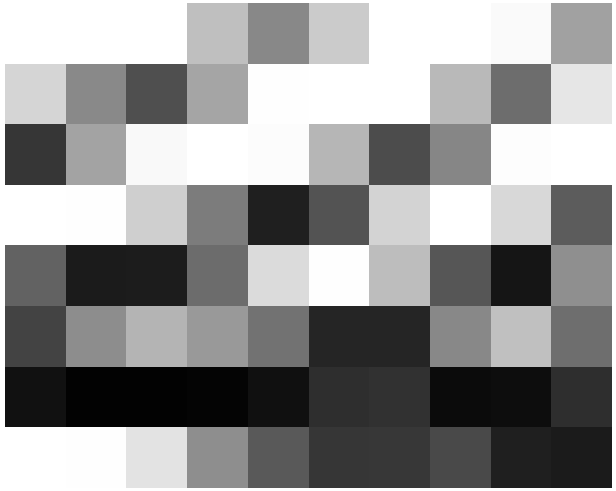
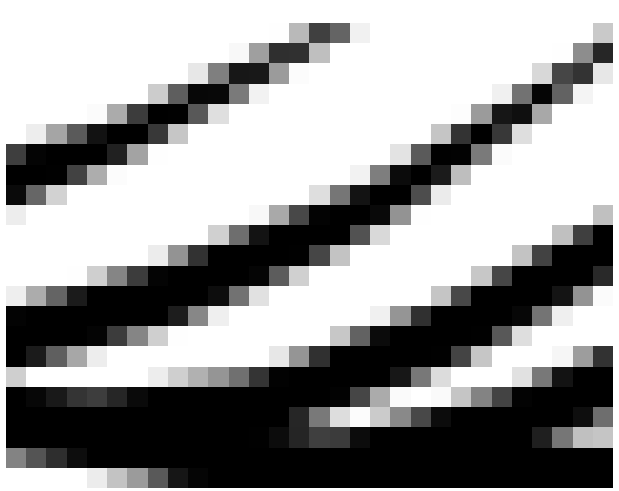
[1] Most of you will know this already.

Case Study

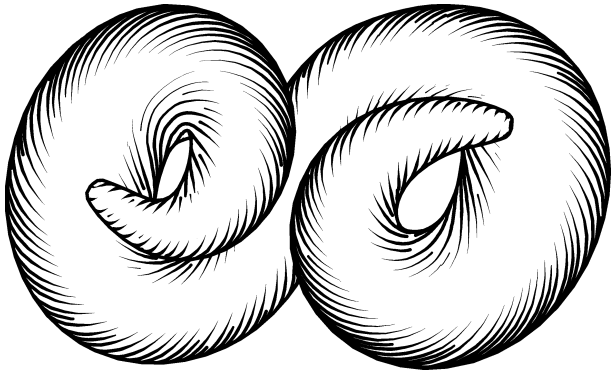
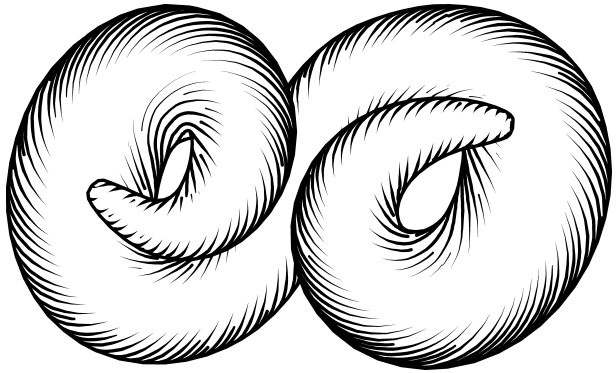
- for image displayed/printed at 5 cm x 3 cm (1.96 in x 1.19 in)
- comparison to pixel images in terms of quality and file size
- vector graphic: 417 kB uncompressed (EPS), 117 kB compressed (PDF)
- *see handout*



Case Study: Screen View (with anti-aliasing)

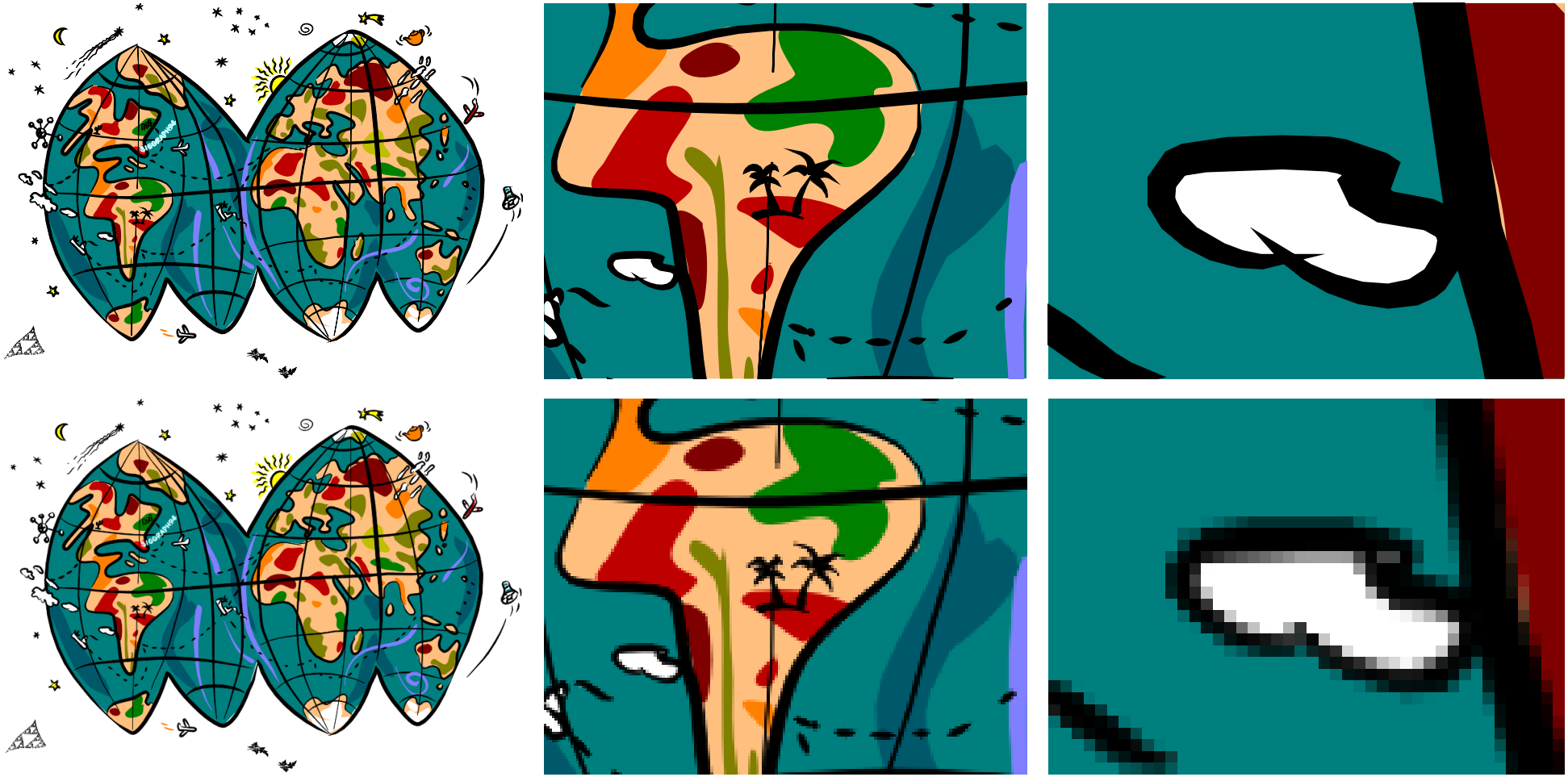
	197 x 119, 100 ppi, 8 bit	591 x 356, 300 ppi, 8 bit	vector graphic
uncompr.	23 kB	205 kB	417 kB
PNG/PDF	11 kB	52 kB	117 kB
image			
detail			

Case Study: Print (in b/w)

	2362 x 1423, 1200 dpi, 1 bit	4724 x 2846, 2400 dpi, 1 bit	vector graphic
uncompr.	410 kB	1,641 kB	417 kB
PNG/PDF	68 kB	166 kB	117 kB
image			
detail			

Considering Detail

- resolution and detail on demand; fine details can be represented

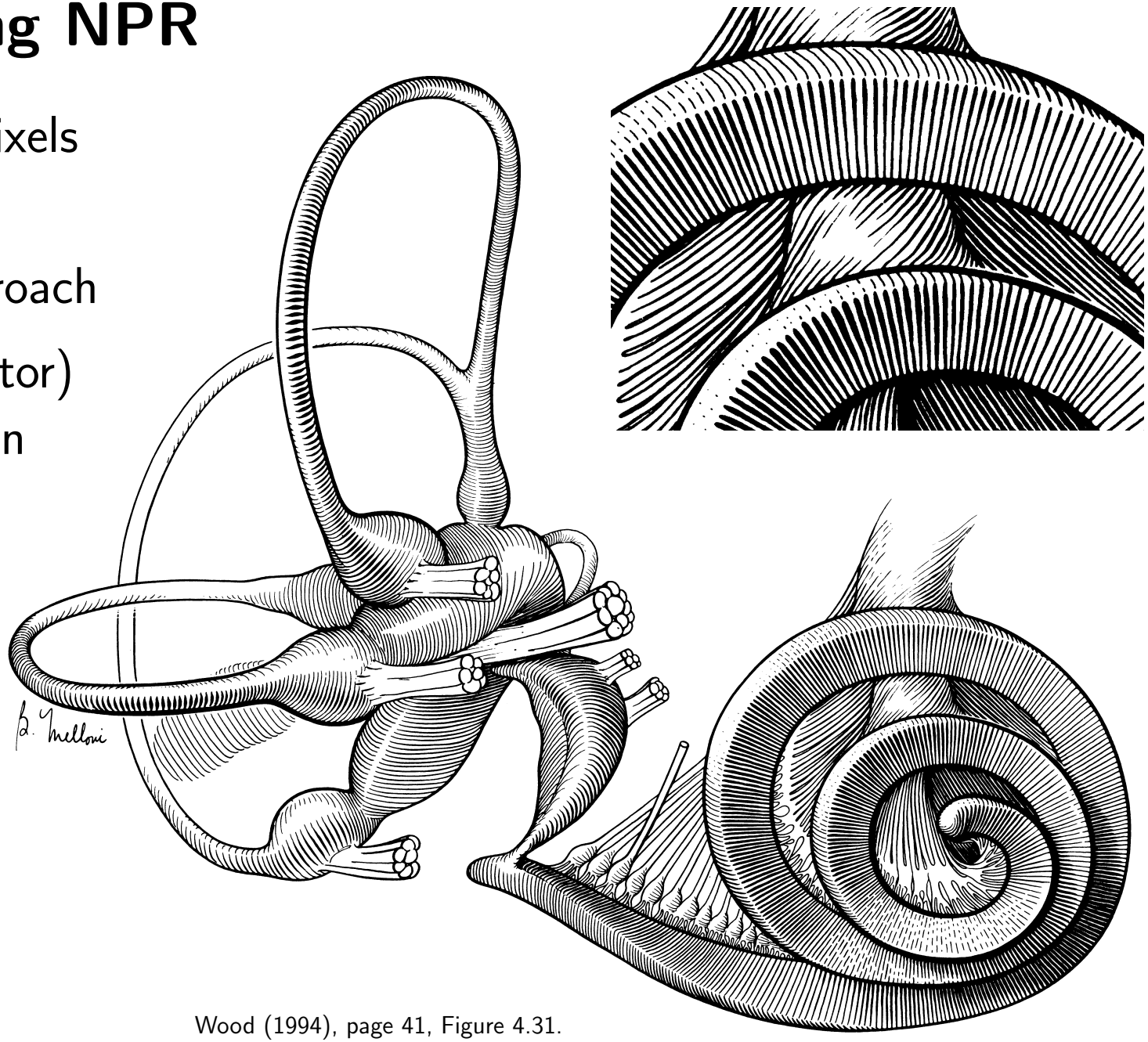


vector image from Hsu & Lee (1994); pixel image produced at 800 x 590 pixels

Representing NPR

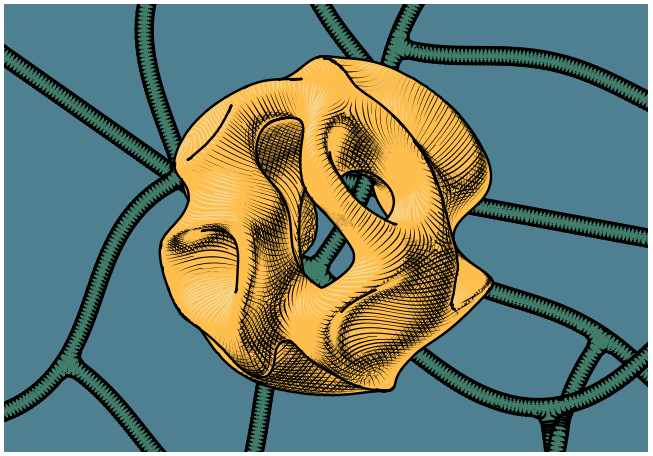
- strokes vs. pixels as primitives
- regional approach

$\Rightarrow$ analytic (vector) representation

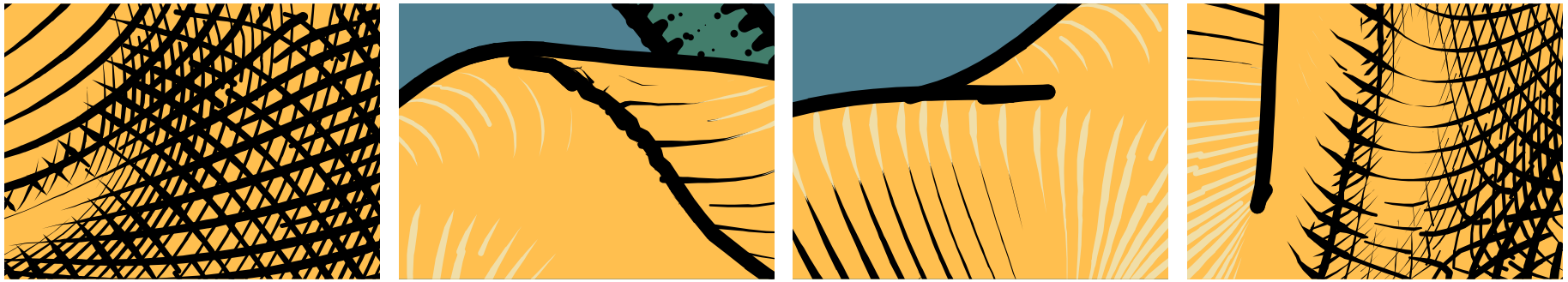


Wood (1994), page 41, Figure 4.31.

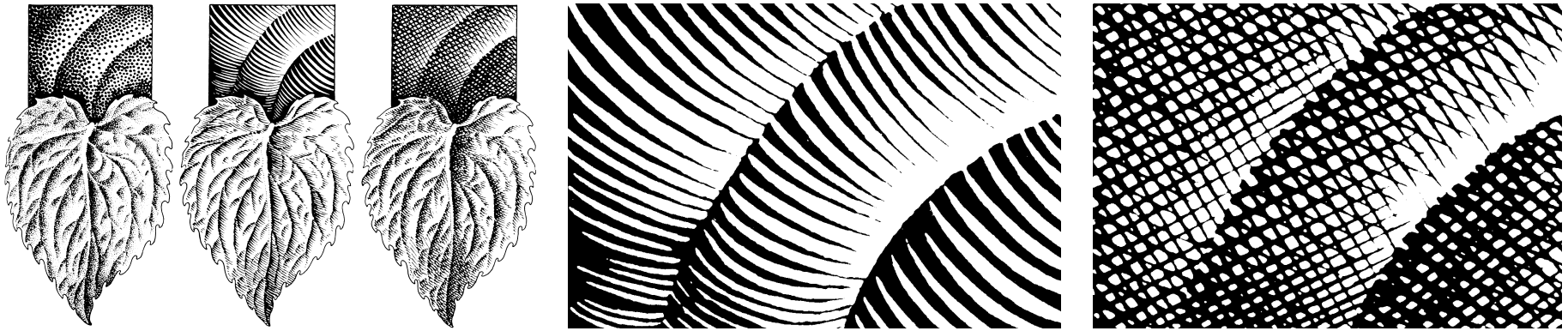
Quality in Vector Rendering



- what lines to place & where?
  - → local vs. regional techniques
  - → input from illustrators and graphic designers
- which artifacts to avoid and how?



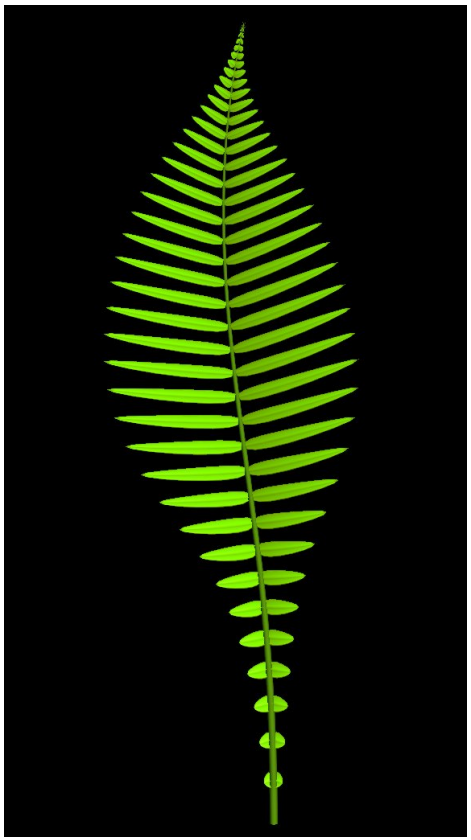
- which artifacts to produce intentionally to make images less sterile?

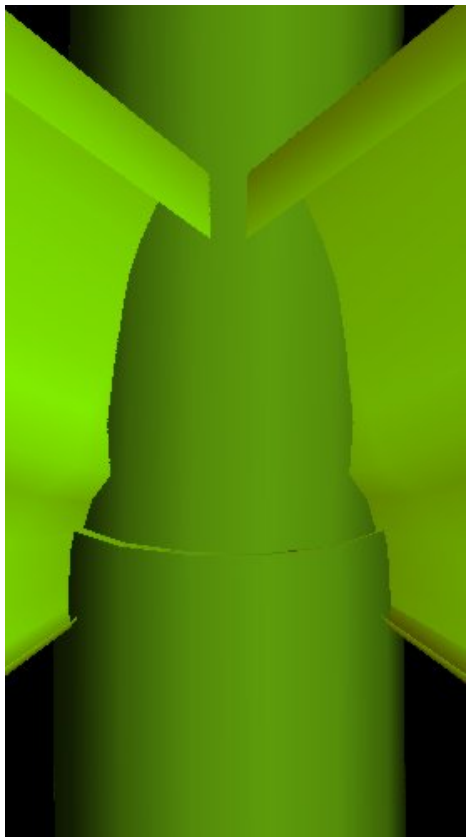


from West (1983)

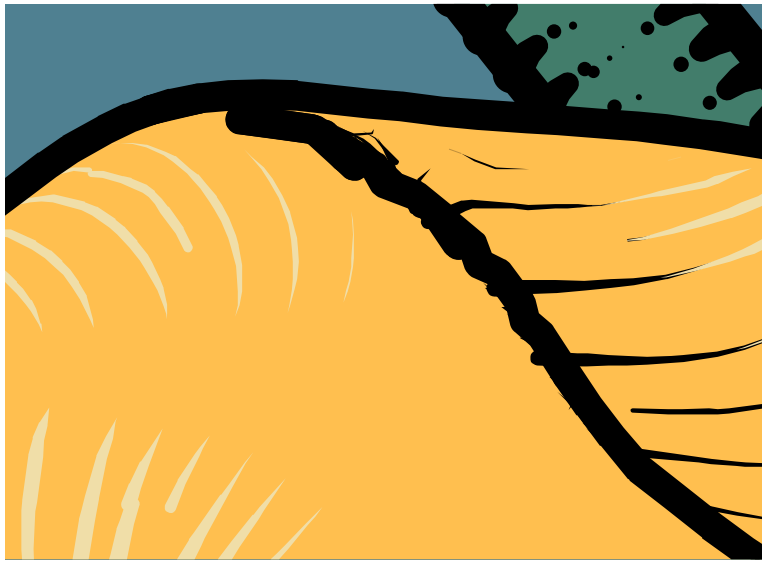
Vector Rendering & Models

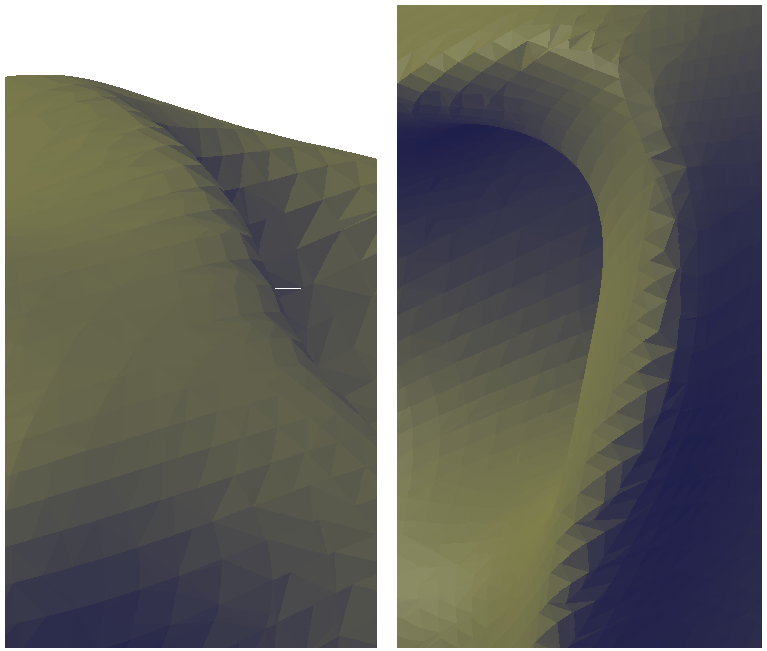
- 3D model quality issues, e. g.,
  - restrictions on triangles
  - restrictions on model correctness
  - restrictions on surface properties





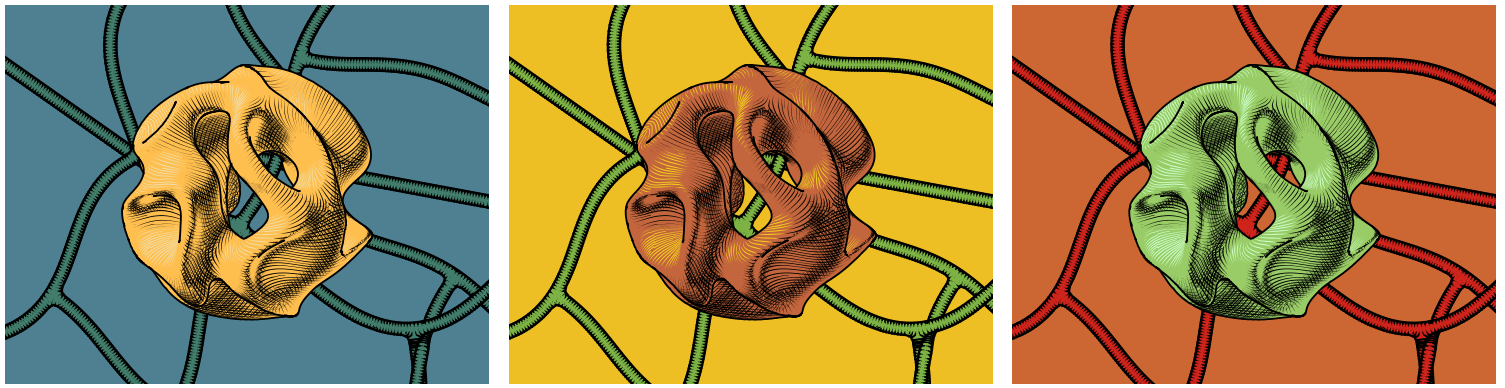
Courtesy of Martin Fuhrer





Future Research Directions

- effective use of spot colors, shading with spot colors?

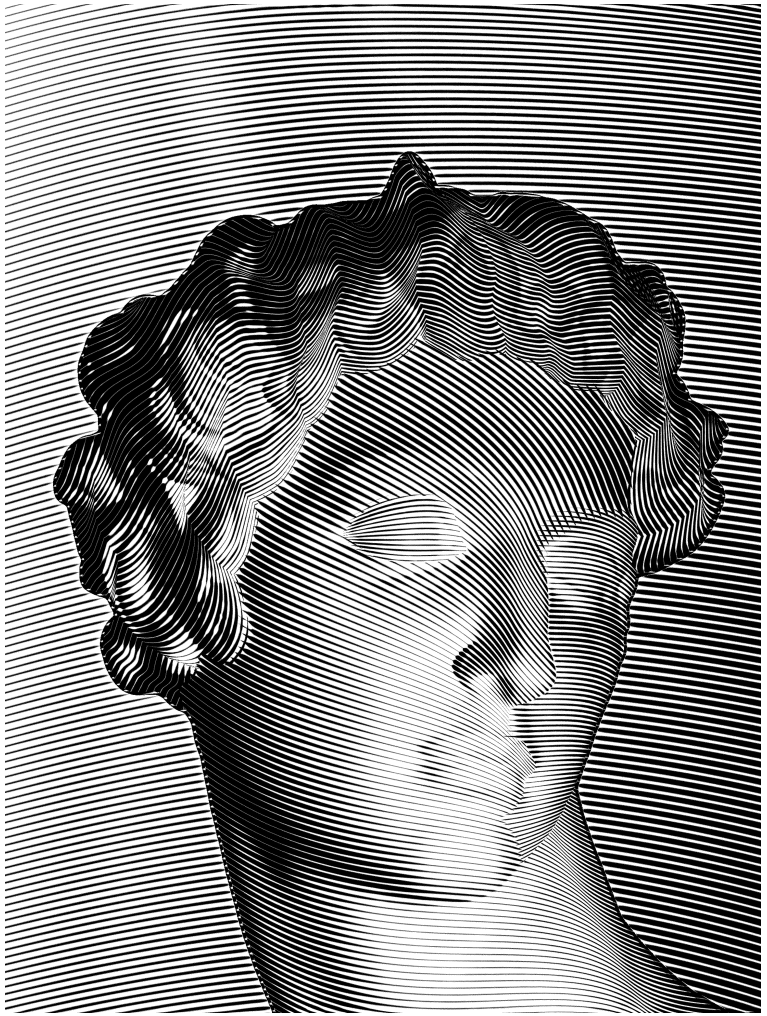


- vector graphic rendering pipeline, what is different, hardware?
- how to reproduce the specific characteristics of traditional tools as vector graphics rather than by textures (e. g., Hsu & Lee, 1994)?
- interactive level-of-detail, vector graphic mip-mapping (Salisbury et al., 1996)?
- vector graphic format standards

Other NPR Techniques as Vector Graphics!

- artistic halftoning
- comic and cartoon rendering
- ornaments & calligraphy, see Salesin (2002), Challenges 1.2 and 1.3
- font initials & book decorations

from Anjyo & Hiramitsu (2003)

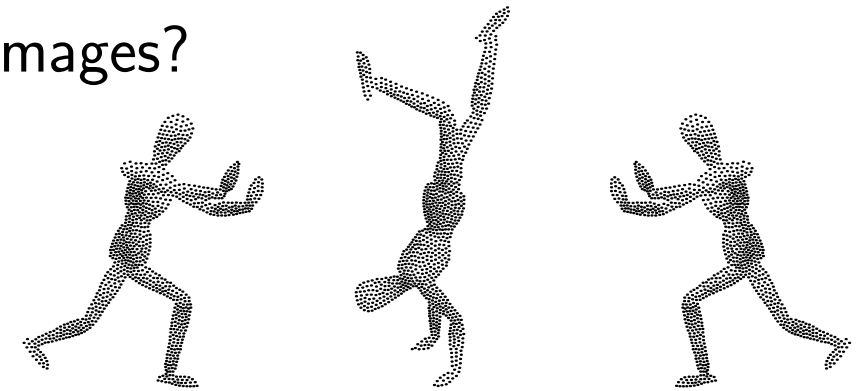


from Ostromoukhov (1999)

Courtesy of Göttingen State and University Library, Germany (http://www.gutenbergdigital.de/)

Why so Little Use?

- technology for vector graphic processing not easily available?
- (too much) more effort necessary for vector output?
- (more) technical problems with documents containing vector graphics?
- we don't teach the necessity for and rendering of vector graphics?
- (model & technique) errors show up much more readily?
- dominance of (hardware-accelerated) pixel pipeline?
- high quality (print) results not encouraged?
- fear of people stealing high-quality images?
- issues with standards?

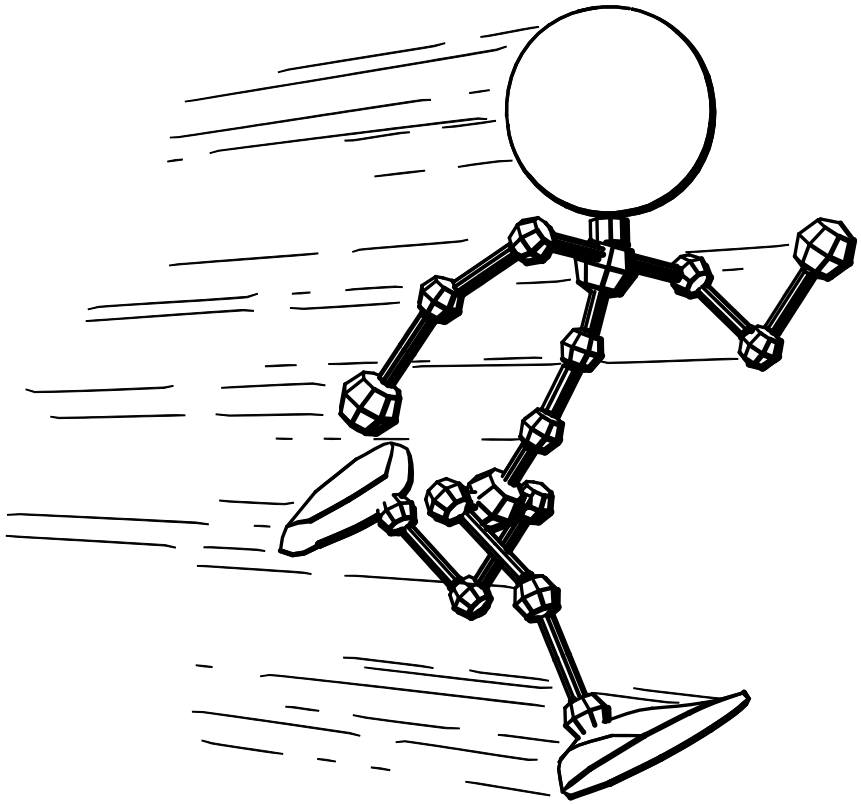


from Secord (2002)

Conclusion

- vector graphics: better quality for both screen view and printing for many NPR techniques—but not for all
- vector rendering matches the non-local character of strokes
- put more emphasis into rendering vector images
  - use and keep analytic vector information, vector pipelines
  - make use of available tools
- improvement through
  - using input from illustrators and graphic designers
  - thinking about artifacts in images and models
  - teaching why and how to produce high quality images
- what about (photo-)realism?

This work has been supported by the Natural Sciences and Engineering Research Council of Canada (NSERC).



No pixel images were harmed during the creation of this presentation.

Case Study: Handout

- for image displayed/printed at 5 cm x 3 cm (1.96 in x 1.19 in)
- 100 ppi: 197 x 119; 300 ppi: 591 x 356;
  1200 dpi: 2362 x 1423; 2400 dpi: 4724 x 2846

	screen (with anti-aliasing)		print (in b/w)		both
	100 ppi, 8 bit	300 ppi, 8 bit	1200 dpi, 1 bit	2400 dpi, 1 bit	vector graphic
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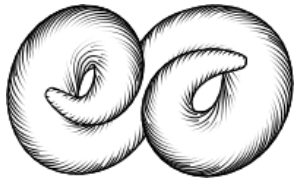
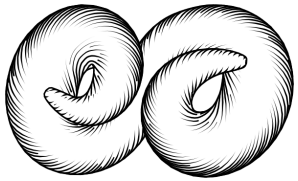
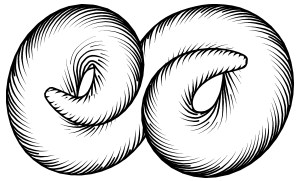
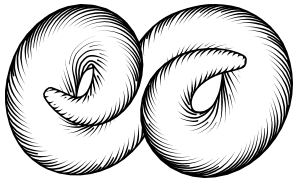
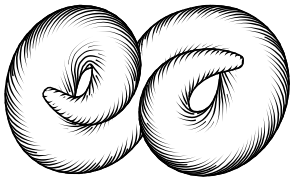
image					
detail