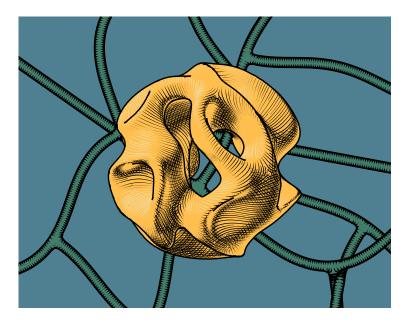
# **Breaking the Pixel Barrier**

Tobias Isenberg Mario Costa Sousa Sheelagh Carpendale



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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.

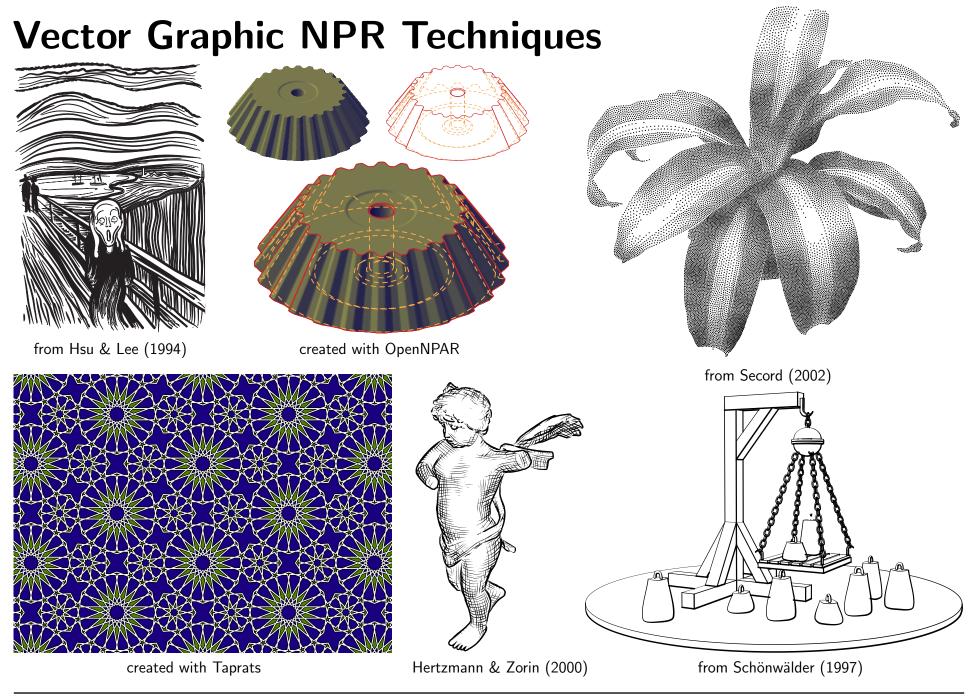


### Introduction

- 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





T. Isenberg, M. C. Sousa, S. Carpendale

Breaking the Pixel Barrier



# Initial Motivation<sup>1</sup>

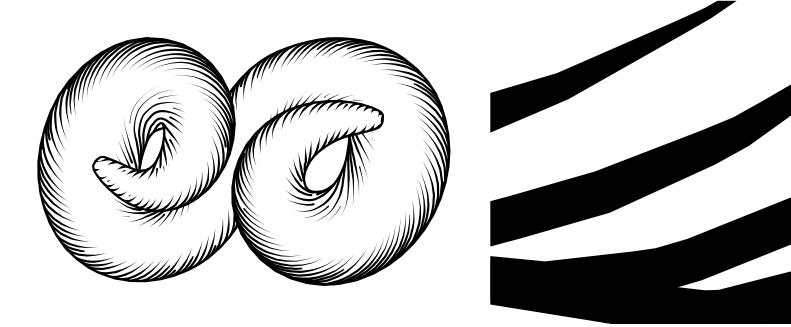
• comparison of pixel images with vector graphics

	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

<sup>1</sup> 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			

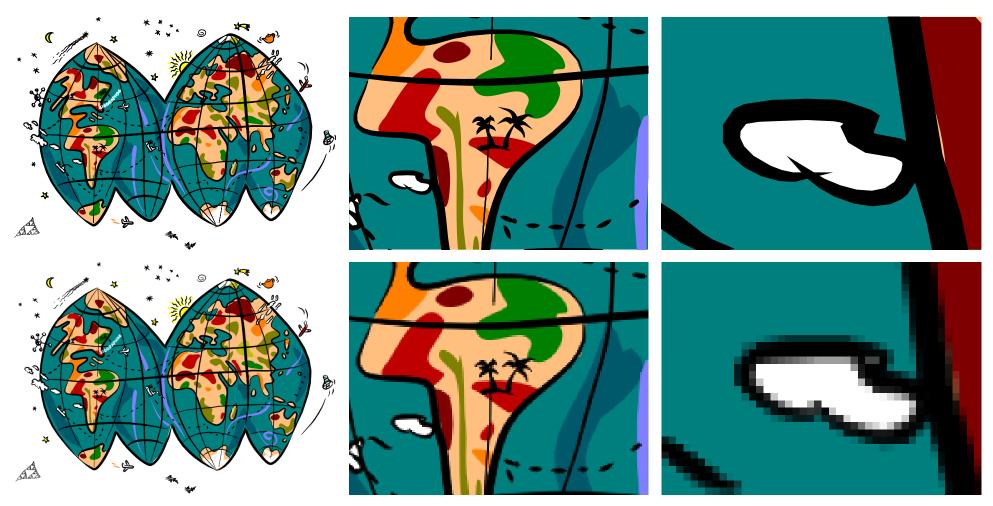
## Case Study: Print (in b/w)

	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

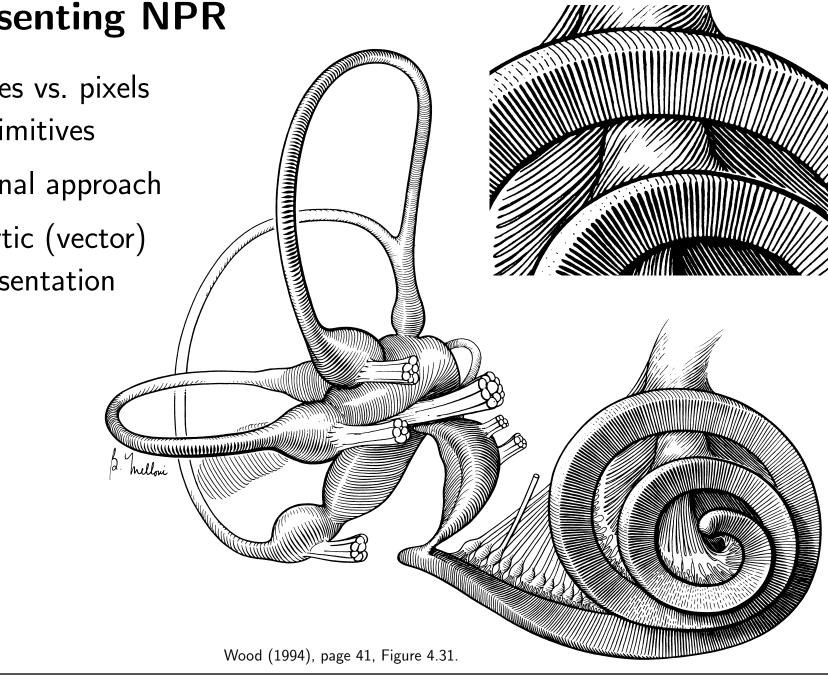


vector image from Hsu & Lee (1994); pixel image produced at 800 x 590 pixels



# **Representing NPR**

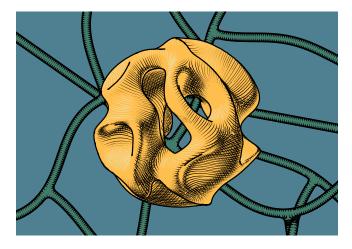
- strokes vs. pixels as primitives
- regional approach
- $\Rightarrow$  analytic (vector) representation





### **Quality in Vector Rendering**

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





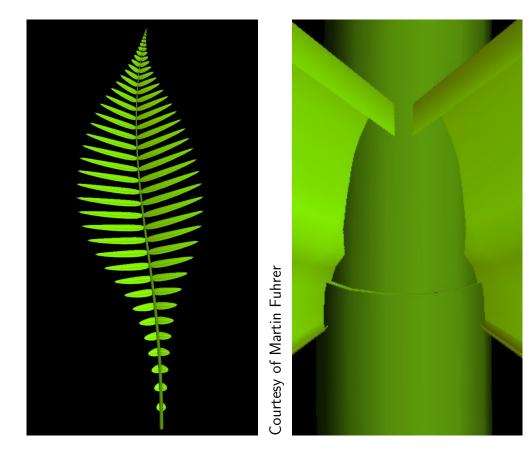
• which artifacts to produce intentionally to make images less sterile?





### **Vector Rendering & Models**

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

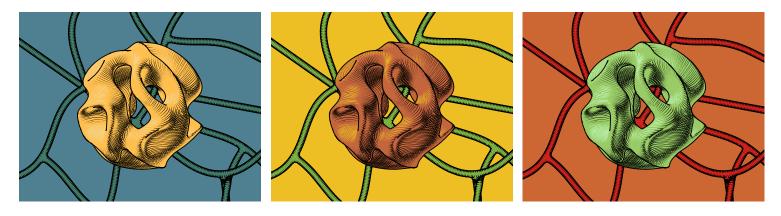






#### **Future Research Directions**

• 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

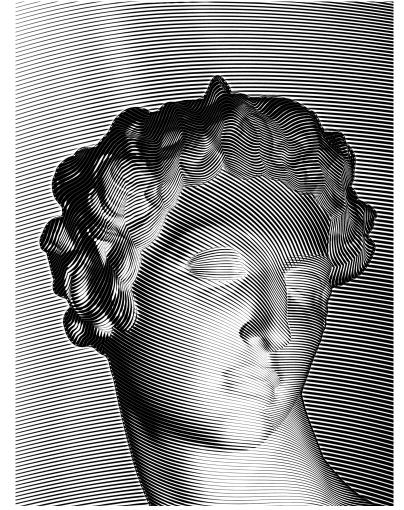
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#### **Other NPR Techniques as Vector Graphics!**

- 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)

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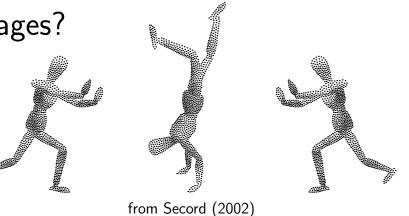
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## Why so Little Use?

- 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?





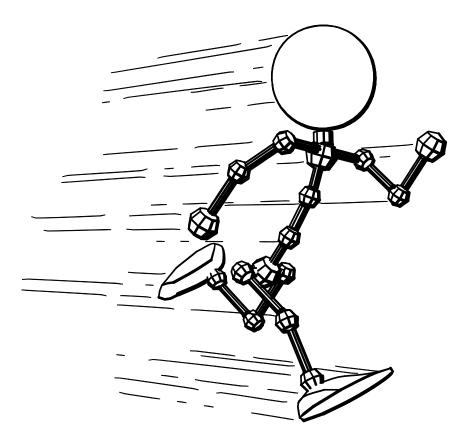
## Conclusion

- 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  $5 \text{ cm} \times 3 \text{ cm} (1.96 \text{ in} \times 1.19 \text{ in})$
- 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
uncompr.	23 kB	205 kB	410 kB	1,641 kB	417 kB
PNG/PDF	11 kB	52 kB	68 kB	166 kB	117 kB
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