Advanced Computer Graphics: Non-Photorealistic Rendering

Introduction and Overview

Tobias Isenberg

What is NPR?

- Non-Photorealistic Rendering and Animation
- as opposed to Photorealistic Rendering
  - simulation of light interaction with surfaces
  - heuristics to achieve good results with as little effort as possible
  - dictate of the photographic camera

Gilles Tran, using POV-Ray 3.6

Photorealism in Artistic Depiction

Ralph Goings:
Hot Fudge Sundae Interior, 1972
(oil on canvas)

Art or Traditional Depiction as Example

- 1st (photographic) camera: camera obscura ca. 1020

17th century illustration

Art or Traditional Depiction as Example

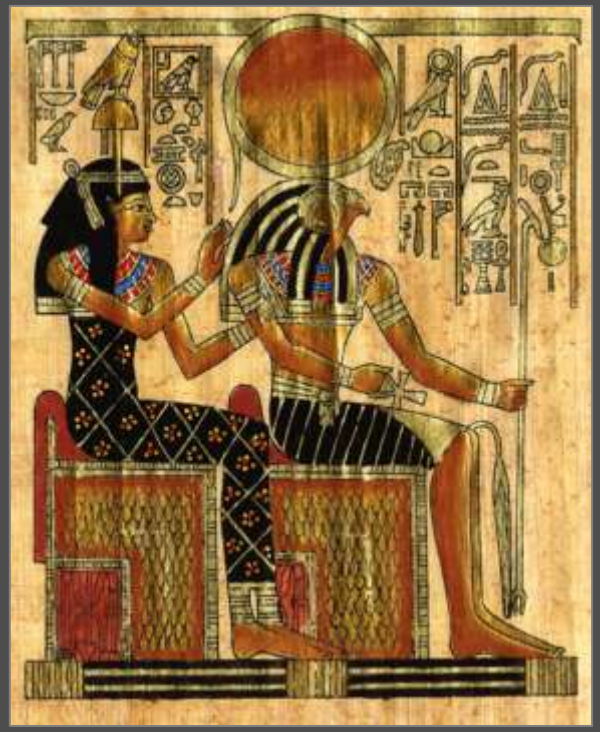
- photographic camera
  - first permanent picture in 1826
  - now: video cameras and digital cameras
  - dominating today's visual world

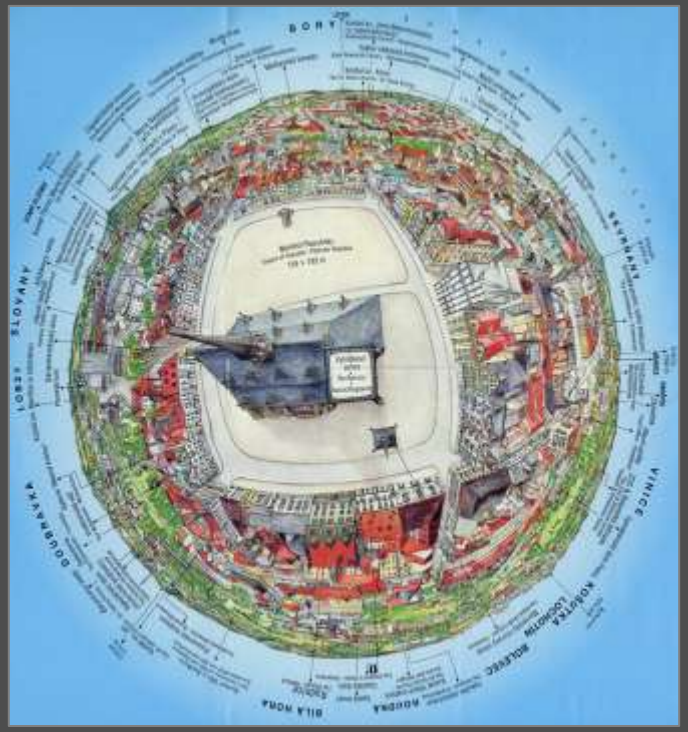
Art or Traditional Depiction as Example

- painting
  - up to 32 000 years old (French cave paintings)
  - up to quite recently dominated visual depiction

Art or Traditional Depiction as Example

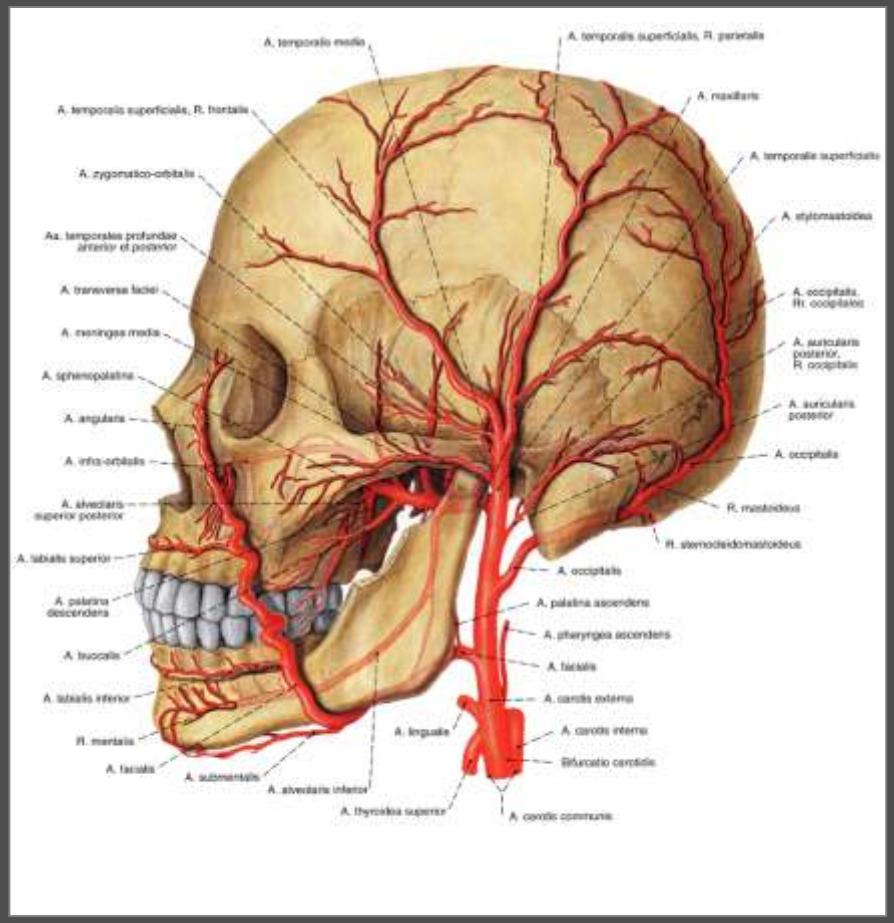
- drawing and similar techniques
  - less visually vivid depiction, possibly with color
  - often used for illustration
  - abstraction and emphasis





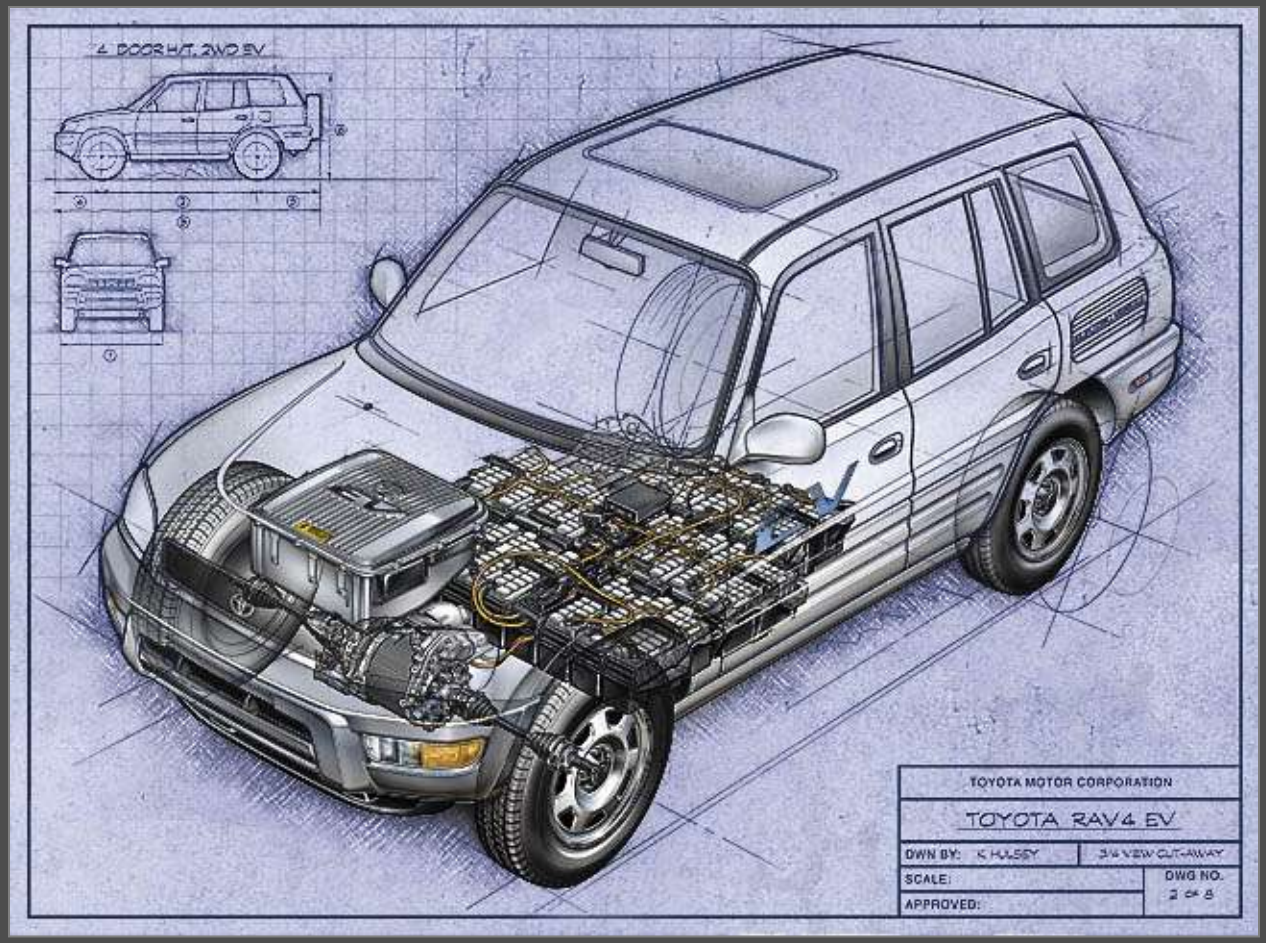
Art or Traditional Depiction as Example

- drawing and similar techniques: modern examples
  - in medical illustration



Art or Traditional Depiction as Example

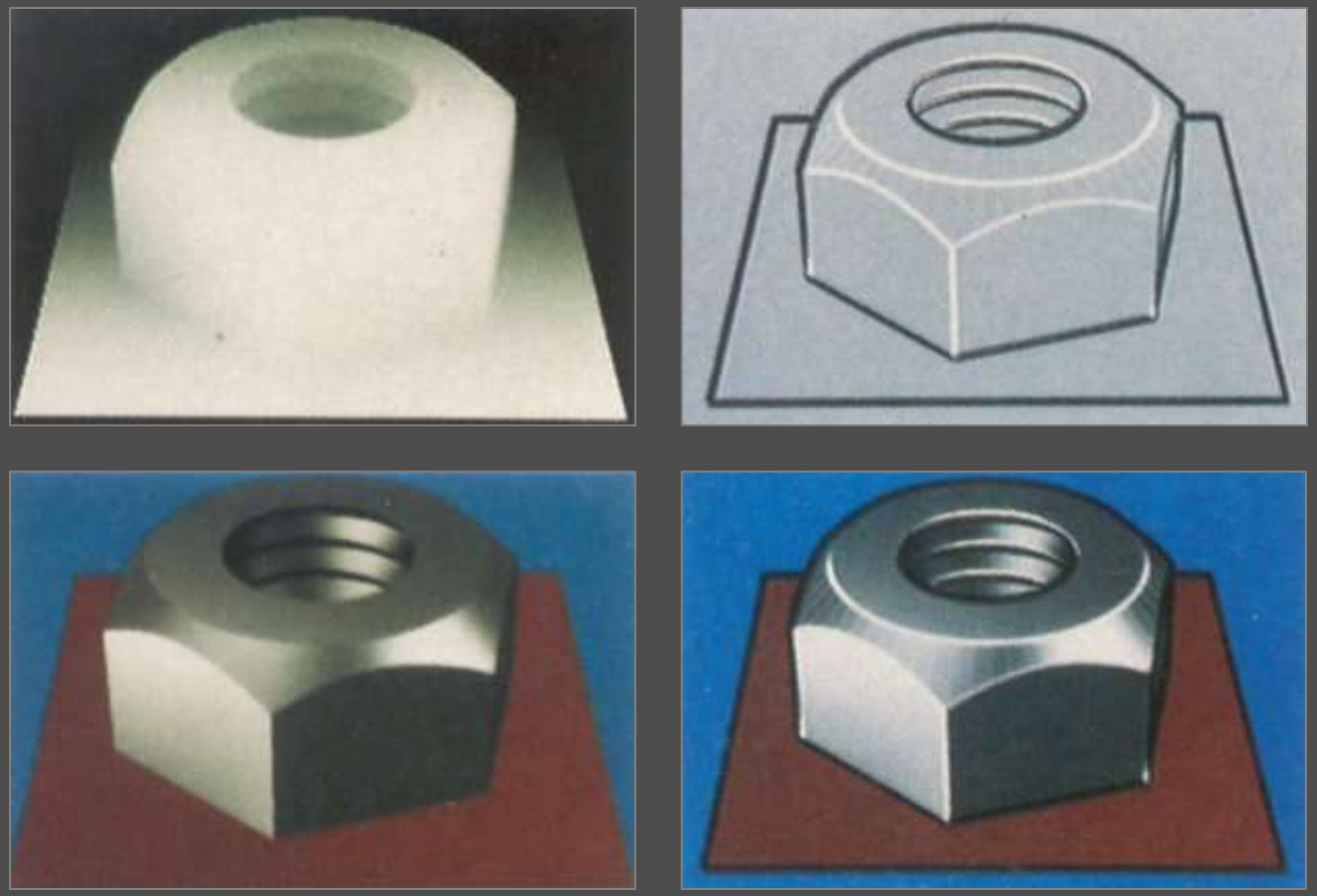
- drawing and similar techniques: modern examples
  - in technical illustration



courtesy of
Kevin Hulsey

What is NPR?

- computer graphics inspired by non-photographic techniques, thus, non-photorealistic rendering



Saito & Takahashi (1990)

NPR as a Diverse Field

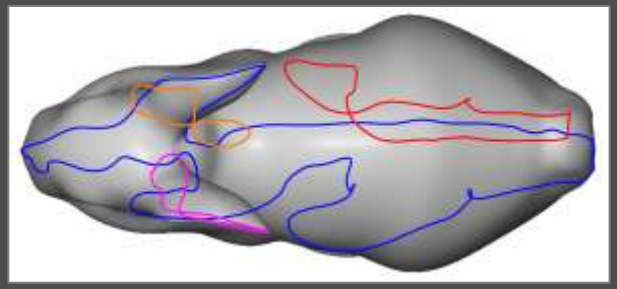
- inspired by traditional techniques
  - very realistic simulations of traditional media
  - heuristics to achieve similar effects, e.g., faster
  - traditional techniques taken to new levels (e.g., video)
- completely new methods
  - interactive techniques
  - non-realistic modeling
  - possibly many other
- application-oriented techniques
  - illustration in various domains (medical, technical, etc.)
  - visualization techniques (medical, technical, etc.)
  - support for other fields, e.g., sketch-based modeling

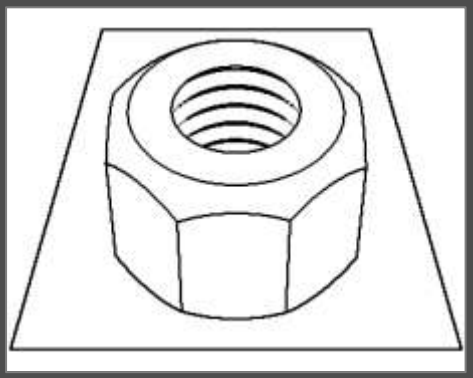
Different Sub-Fields of NPR

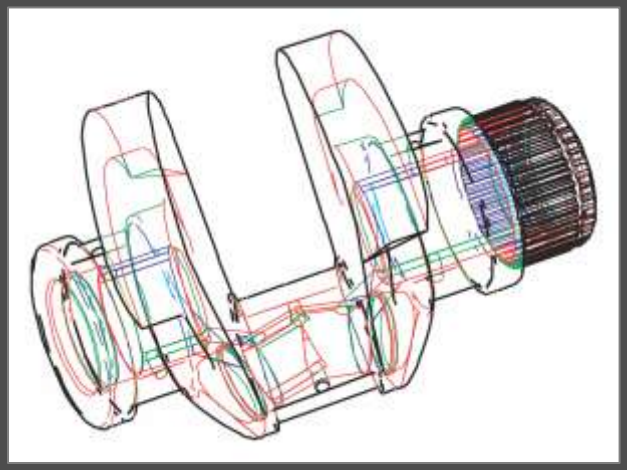
- pixel manipulation
  - halftoning and screening
  - image processing techniques
  - image mosaics
  - texture sampling and synthesis

Different Sub-Fields of NPR

- silhouettes and feature strokes
  - simple silhouette rendering
  - static feature lines
  - dynamic feature lines (suggestive contours etc.)
  - hidden line removal
  - "sparse line drawings"

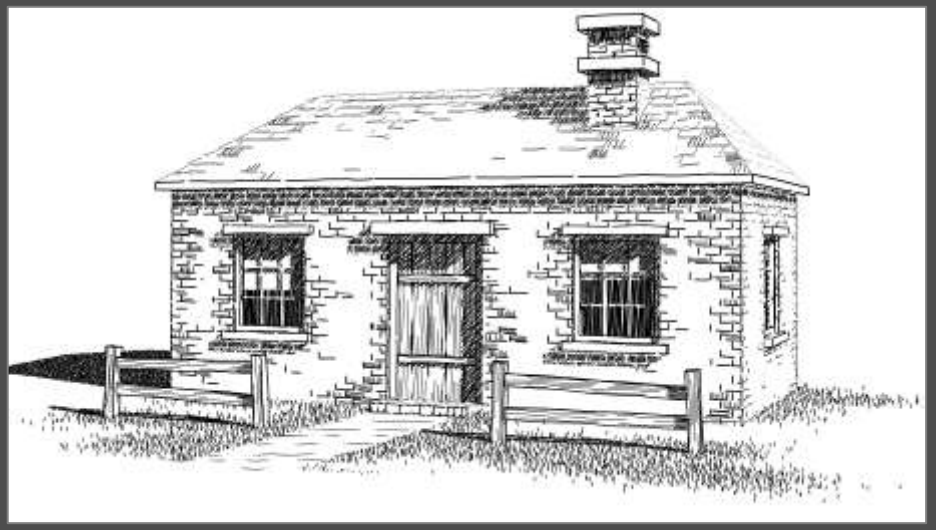


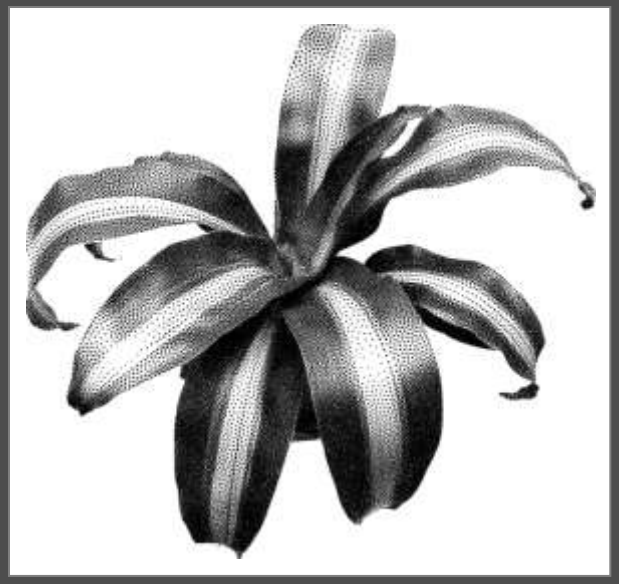


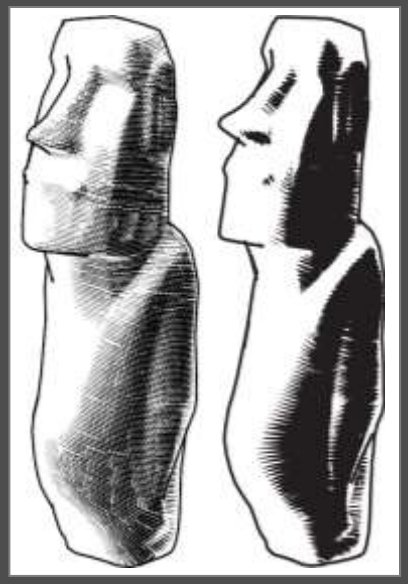


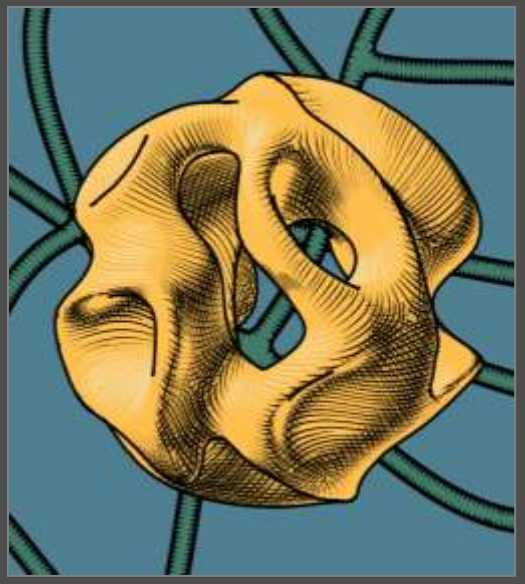
Different Sub-Fields of NPR

- pen-and-ink rendering
  - black-and-white only
  - pen-and-ink style
  - dot primitives: stippling
  - line primitives: hatching







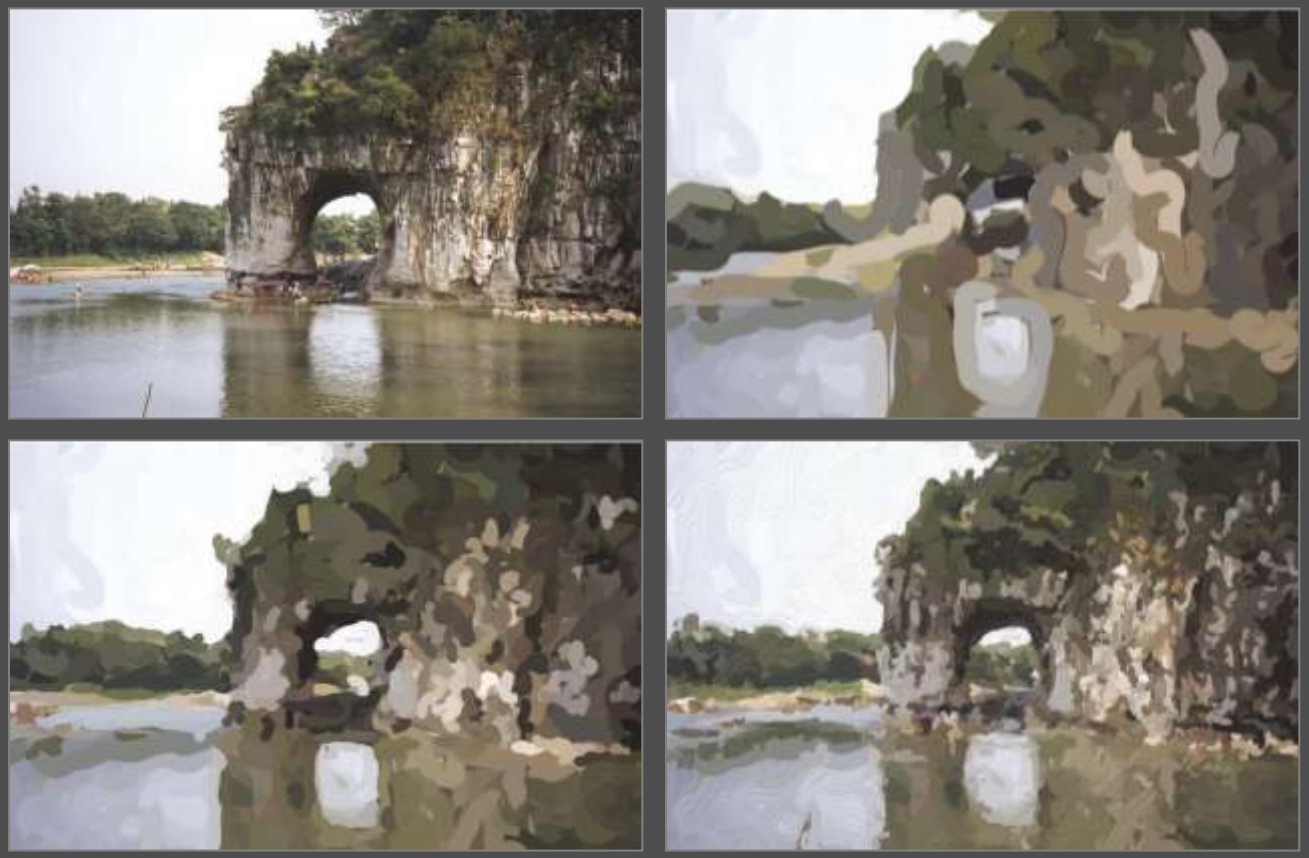


Different Sub-Fields of NPR

- simulation of natural material
  - pencil drawing on paper
  - wax crayons
  - wet paint on paper
  - oil painting
  - etc.

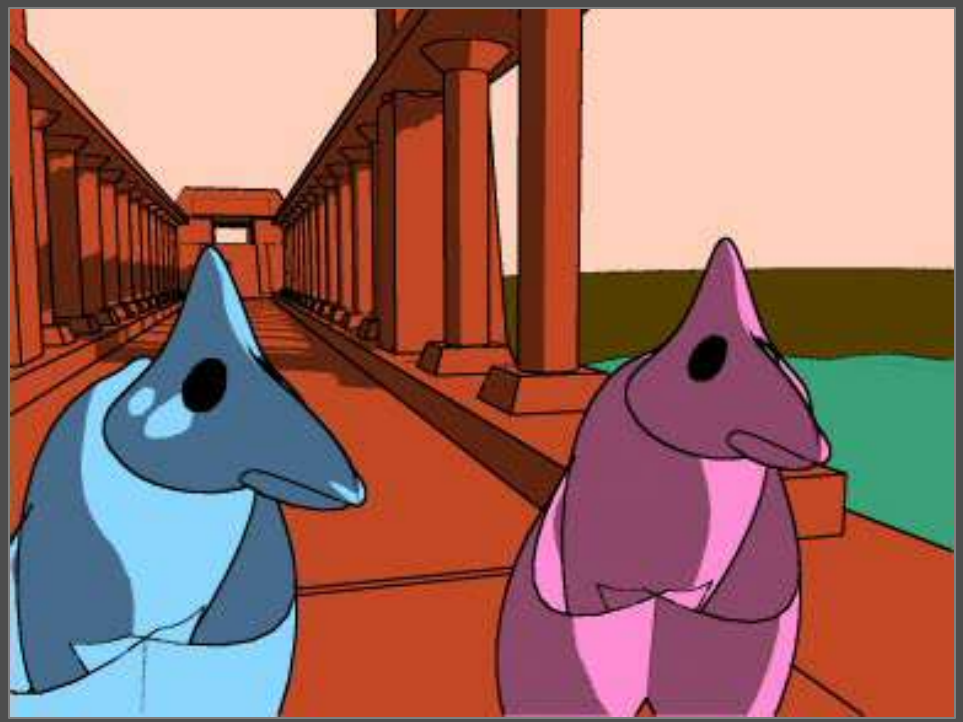
Different Sub-Fields of NPR

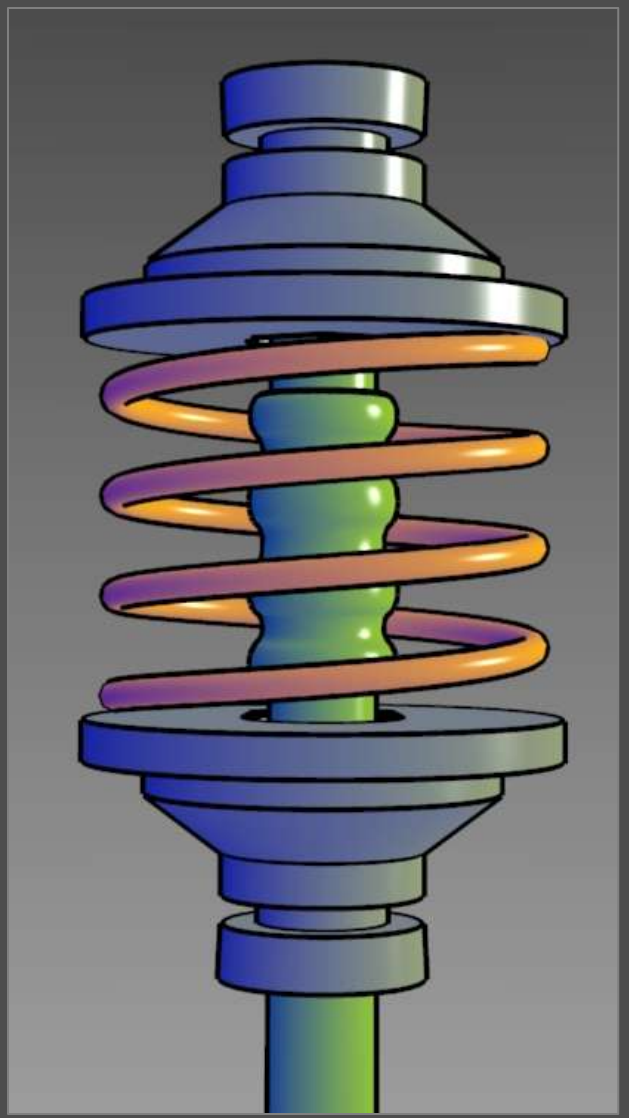
- stroke-based rendering
  - considering the stroke as the fundamental NPR primitive
  - abstraction through strokes



Different Sub-Fields of NPR

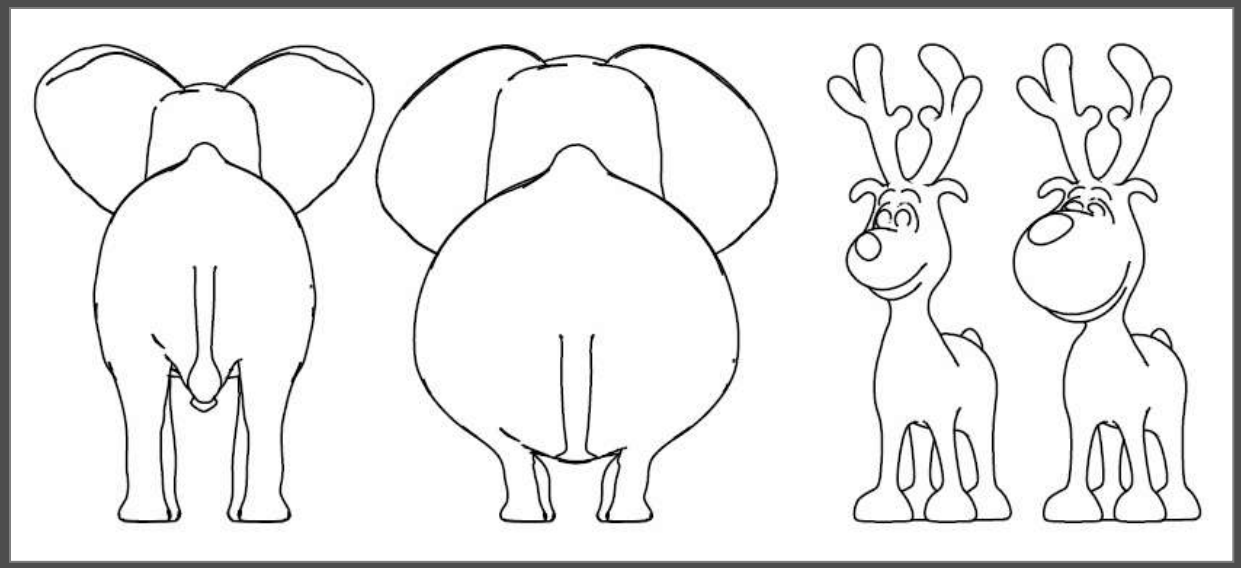
- lighting models and shading
  - cel shading
  - Gooch shading
  - line shading





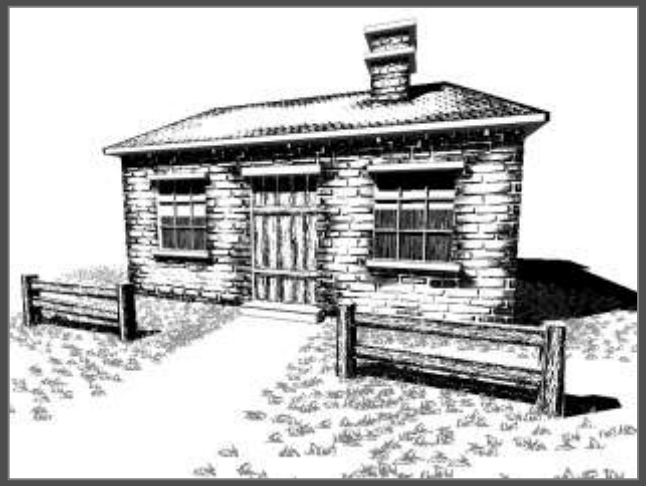
Different Sub-Fields of NPR

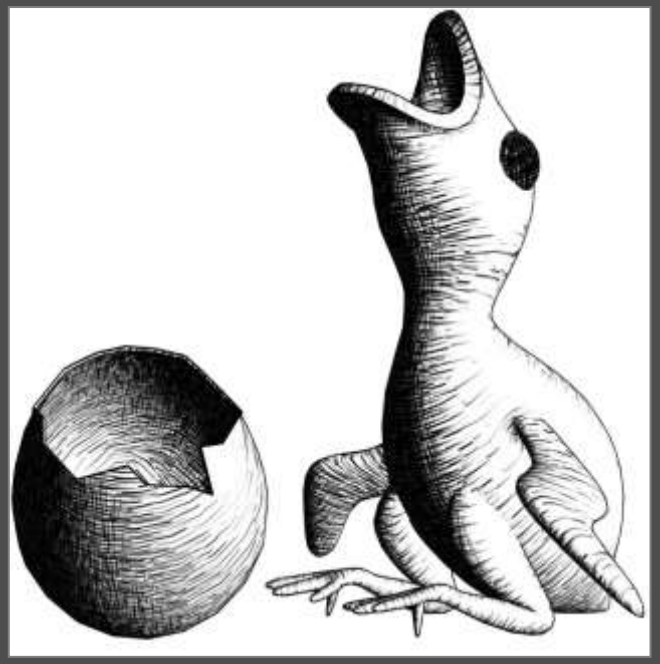
- distortion techniques
  - image-space distortion
  - object-space distortion
  - understandable and intentional distortion
  - distortion for animation



Different Sub-Fields of NPR

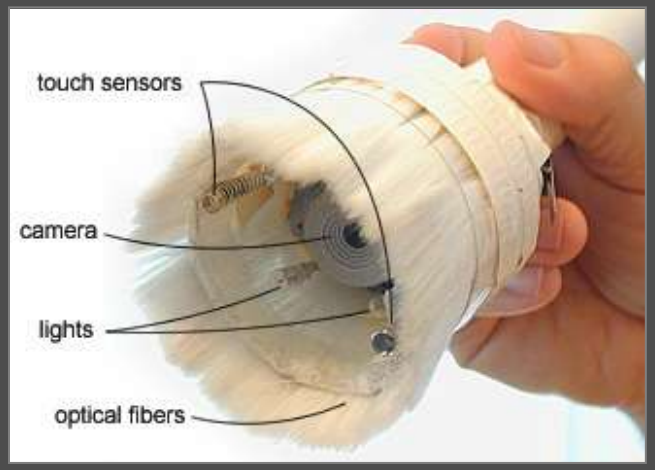
- real-time rendering techniques
  - real-time heuristics for many previously mentioned areas

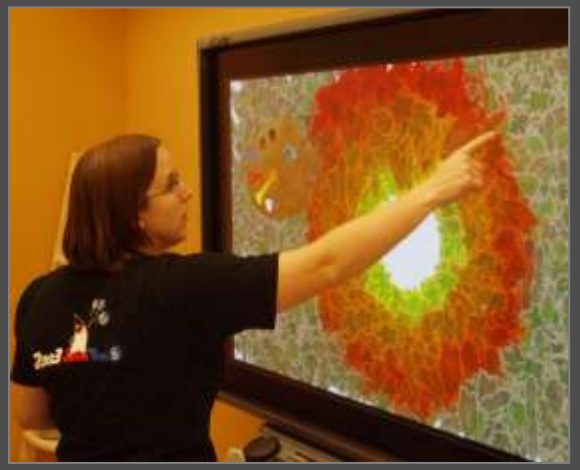




Different Sub-Fields of NPR

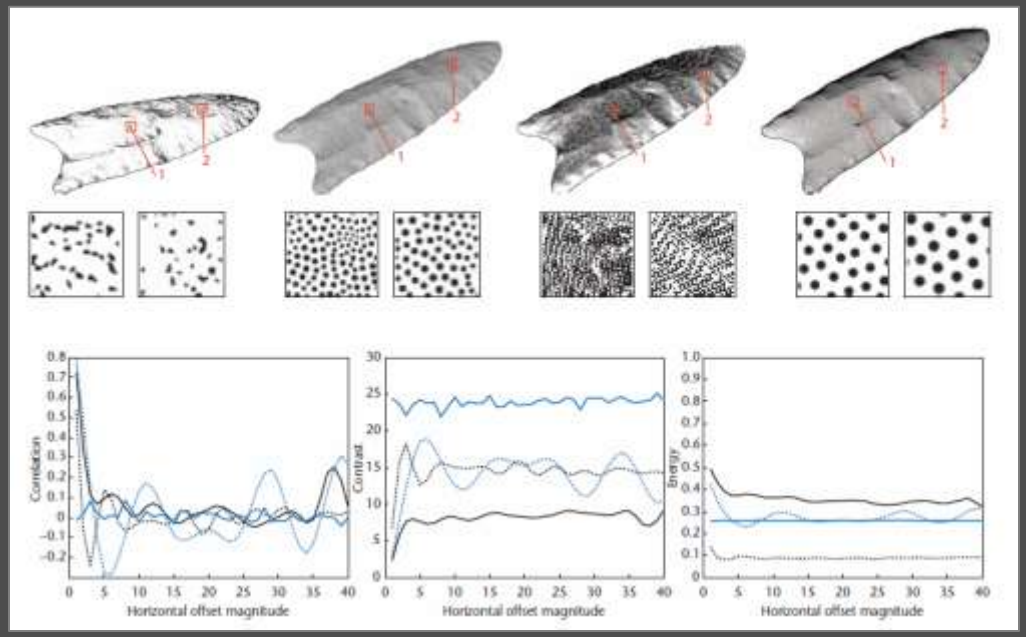
- interaction with or for NPR techniques
  - dedicated hardware simulating the traditional tools
  - dedicated hardware for novel interaction
  - general-purpose hardware
  - emotional interaction

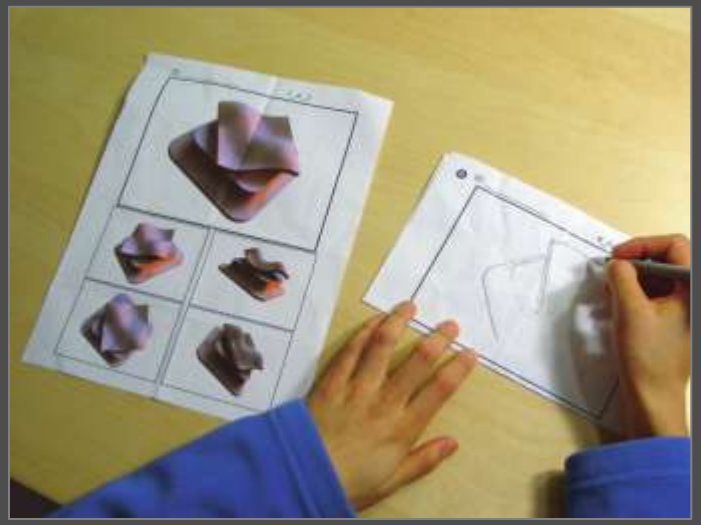




Different Sub-Fields of NPR

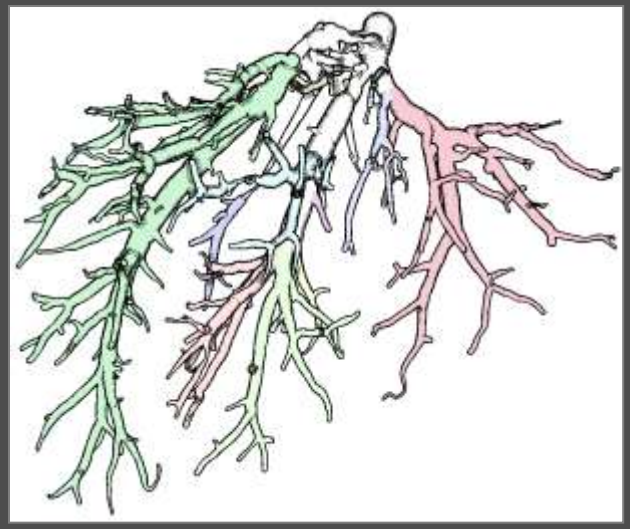
- evaluation of NPR techniques
  - comparison with depictions created by people traditionally, asking people or statistics
  - impact of the created images

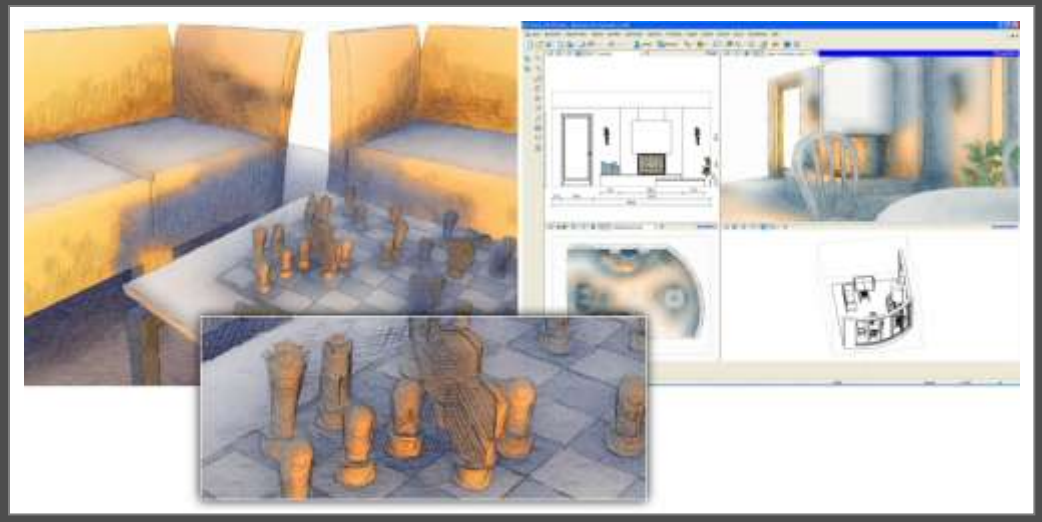




Different Sub-Fields of NPR

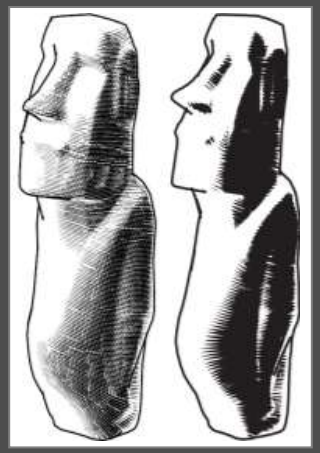
- application of NPR techniques
  - why is NPR important in practice
  - different application domains: entertainment, architecture medicine, general illustration, visualization

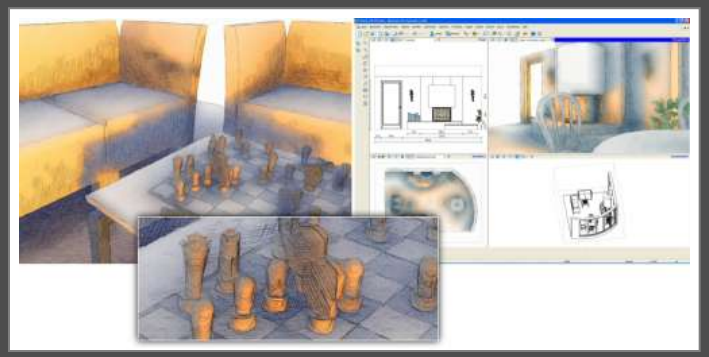


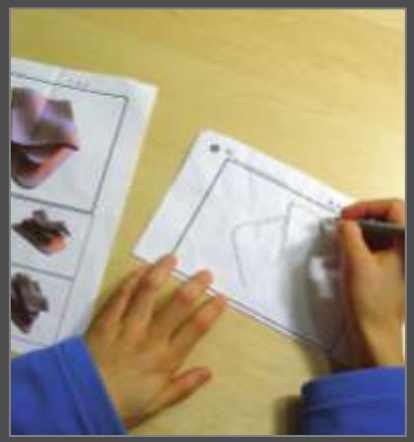


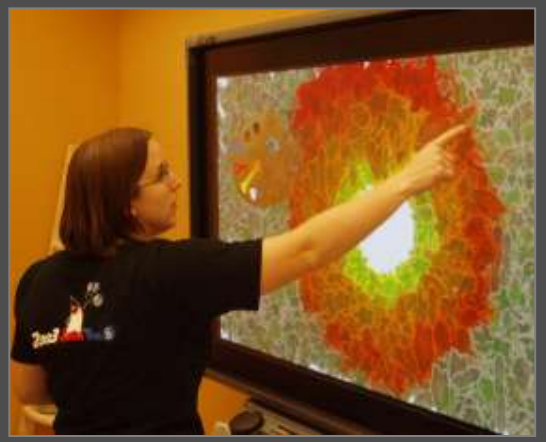
Remainder of the Class: 1st Half

- lectures on a selected subset of areas:
  - black-and-white techniques (pen-and-ink)
  - stoke-based rendering
  - NPR and interaction
  - evaluation of NPR
  - applications of NPR









Remainder of the Class

- student lectures on selected topics
  - topic: 2–3 high-quality scientific papers
  - papers from suggested list or own suggestion
  - about 25–30 minute lecture on the topic
  - about 5 minutes for questions
  - goal: overview of the topic plus some details on specifics
  - slides provided for all students

- gives overview of the rest of the field

Class Schedule

1.1	introduction to NPR and the class
1.2	introduction to scientific work and writing
1.3	computer graphics refreshing course
1.4	silhouettes and line-based rendering
1.5	black-and-white techniques not based on lines
1.6	stroke-based rendering
1.7	NPR interaction
1.8	NPR evaluation
1.9	NPR applications
2	*student presentations*

Assignment Overview

1. lecture on special topic on February 12 or 19
2. implementation of technique within chosen topic
3. summarizing research paper about topic and implementation (8–10 pages in IEEE VIS style)

- details about assignment topics on class web page: http://tobias.isenberg.cc/advanced-graphics/

Assignment Procedure

- groups of 2 people
- choose topic today or by end of this week (e-mail)
- proposal for topic, lecture, & implementation:
  - which topics/papers to cover in lecture and paper
  - plan of what to implement
  - 1–2 pages, PDF format, send by e-mail by **January 26**
- send in slides 1 week prior to your lecture for feedback (e-mail URL of slide package/Dropbox)
- implementations and papers due **March 23**
- strict deadlines
- contact me early if there are questions/problems

Assignment Topics (Suggestions)

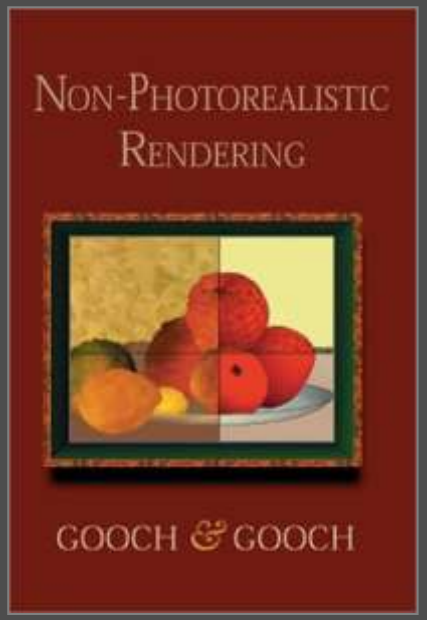
- specific simulation of natural material
- NPR lighting models: non-photorealistic illumination
- NPR in (medical) illustrative visualization
- real-time techniques w/ GPU programming
- non-photorealistic modeling
- NPR and abstraction
- distortion for artistic applications & visualization
- rigid deformations
- application of NPR techniques in games
- text-based artistic rendering
- self-chosen technique from NPAR/CAe/SIGGRAPH/VIS

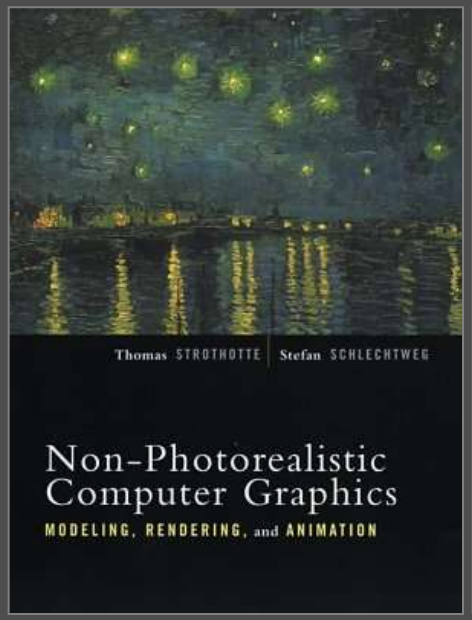
Grading and Rules

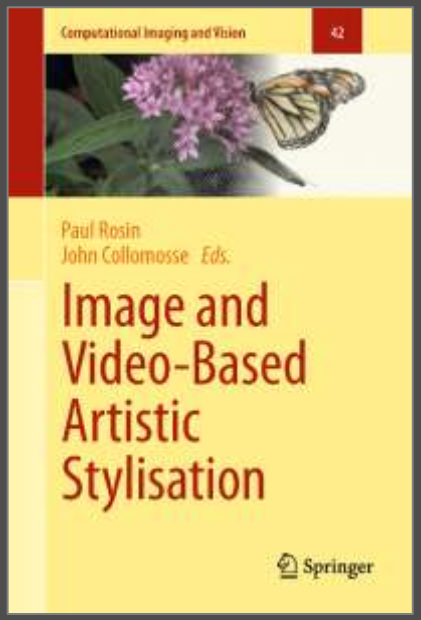
- grading and rules:
  - 25% from presentation, 10% from participation, 25% from implementation, 40% from paper
  - for each part at least 50% of points necessary
  - at least 60% of total to pass the class
  - presence in lectures is mandatory
  - cheating: no points
  - sick during class: call/e-mail me beforehand

Further Information: 3 Books on NPR

- Bruce Gooch & Amy A. Gooch. Non-Photorealistic Rendering. A K Peters, Ltd., Natick, 2001.
- Thomas Strothotte & Stefan Schlechtweg. Non-Photorealistic Computer Graphics. Modeling, Animation, and Rendering. Morgan Kaufmann, San Francisco, 2002.
- Paul Rosin & John Collomosse, editors. Image-Based Artistic Stylisation. Springer, Berlin, 2013.







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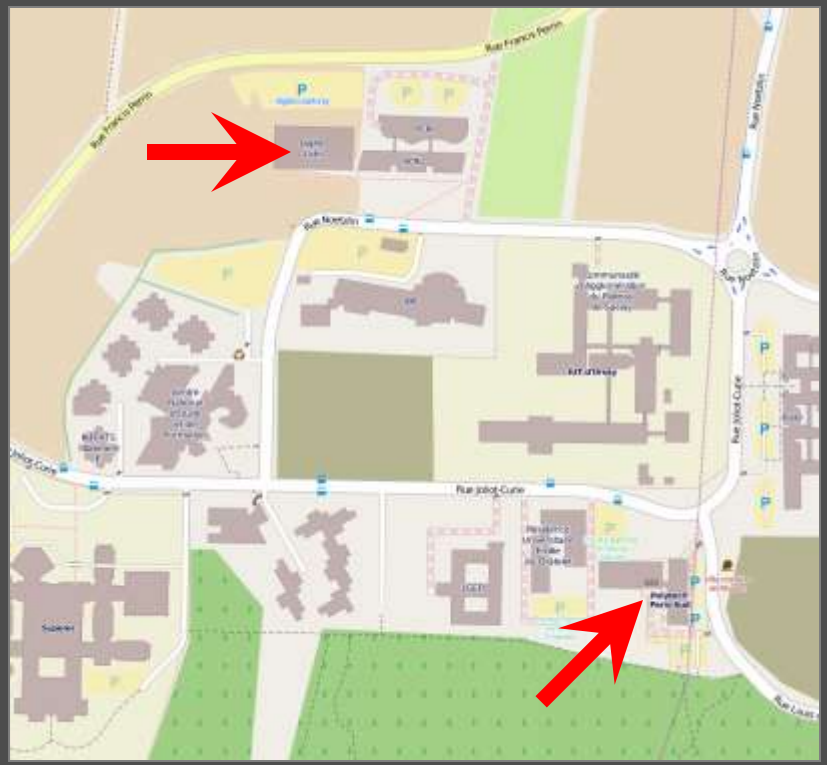

Questions?