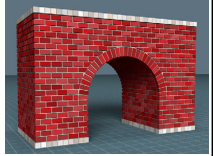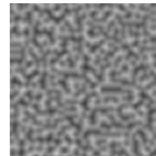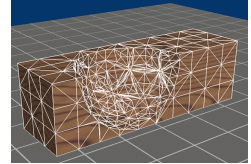# Non-Photorealistic Rendering (NPR)

Last Time?

- Texture Mapping
- Solid Texture
- Procedural Textures
  - Perlin Noise
- Procedural Modeling
  - L-Systems

Today: Non Photorealistic Rendering

- Architectural Rendering
- Reading for Today
- Line Drawing
- Pen & Ink / Hatching
- Technical Illustration
- Artistic Styles and Painterly Rendering

Frank Lloyd Wright's *Fallingwater*

Frank Lloyd Wright's *Fallingwater*

http://www.thetimesnewroman.com/2011/07/luxe-living-fallingwater.html
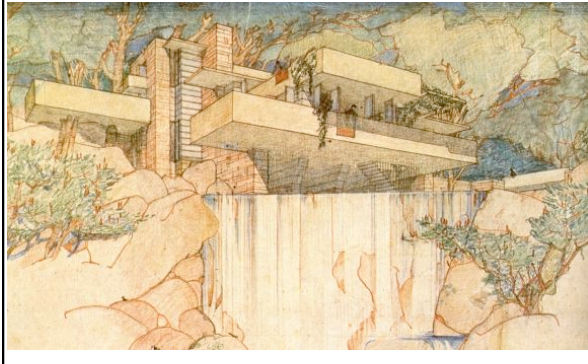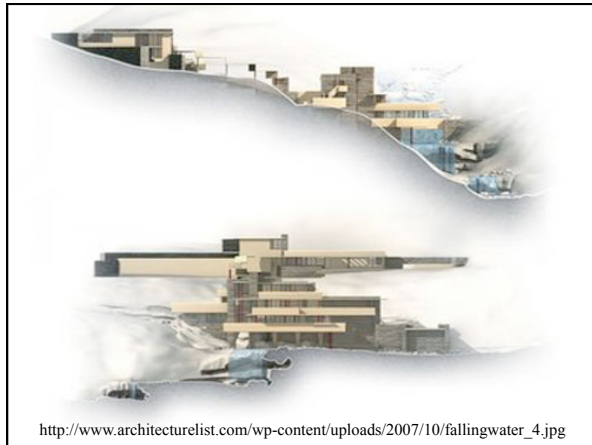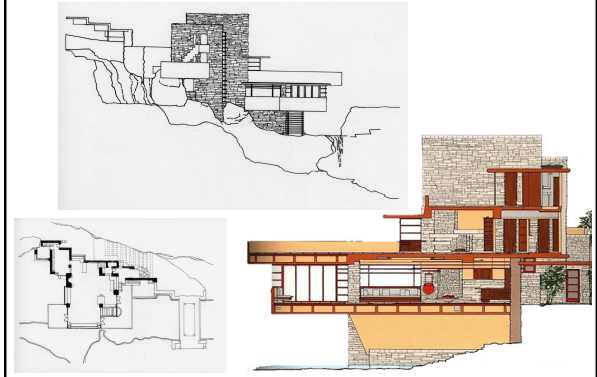
Frank Lloyd Wright's *Fallingwater*

http://www.thetimesnewroman.com/2011/07/luxe-living-fallingwater.html

1

Frank Lloyd Wright's *Fallingwater*

Plan & Section Drawings

http://www.architecturelist.com/wp-content/uploads/2007/10/fallingwater_4.jpg

Digital Models

Pointer 39°54'22.90" N 79°28'04.54" W elev 415 m Streaming |||||||||| 100%   Eye alt   437 m

http://lvlworld.com/t.php/Frank+Lloyd+Wright's+-+Falling+Water
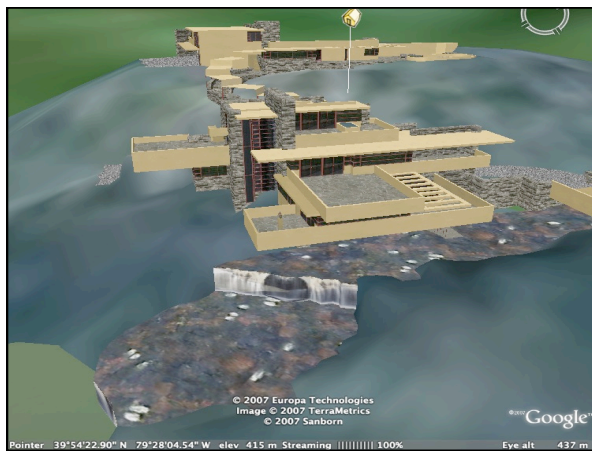
Photorealistic Rendering

http://www.etereaestudios.com/docs_html/fallingwater_htm/fall_still_03.htm
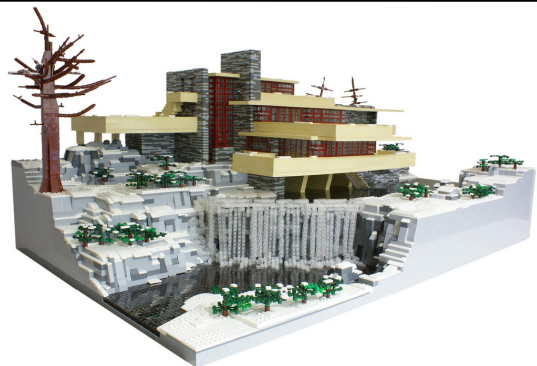
Miniatures

Wiley White
Architectural Models

http://www.architectural-models.com/galfallwat.html

Non-Photorealistic Miniatures

http://shop.lego.com/ByTheme/Product.aspx?p=21005&cn=52
http://www.urbanbydesignonline.com/urbanbydesign/tag/fallingwater

Non-Photorealistic Miniatures

http://www.flickr.com/photos/matijagrguric/sets/72157623778661188/

Non-Photorealistic Miniatures

http://gardenmelodies.blogspot.com/2010/11/falling-water-gingerbread-house.html

Eating Fallingwater

TedWells living : simple

http://twls.libsyn.com/index.php?post_id=35584

HGA Architects & Planners - Cantilevers: Inspired by Falling Water
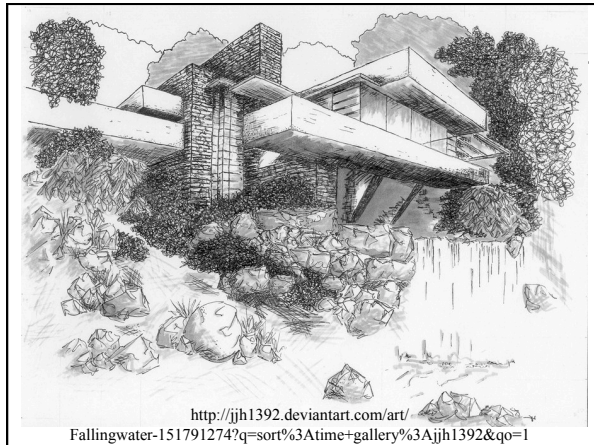http://www.flickr.com/photos/j_bussmann/4549613488/
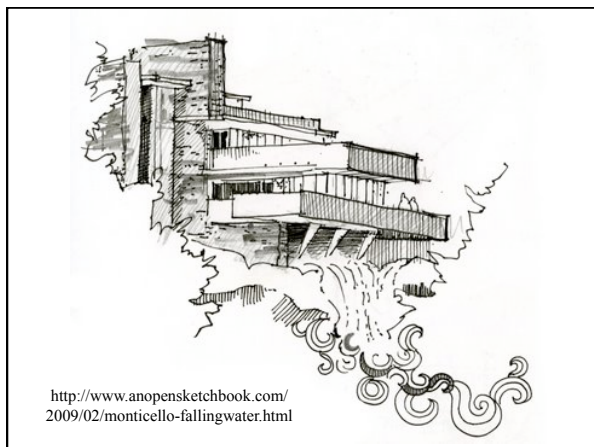
3

Non-Photorealistic Rendering

http://www.studio360.org/2009/may/29/fallingwater/

http://www.fallingwater.org/

http://jjh1392.deviantart.com/art/
Fallingwater-151791274?q=sort%3Atime+gallery%3Ajjh1392&qo=1

http://www.gibson-design.com/images/Slides/fallingwater-entry-100dpi.jpg

http://www.anopensketchbook.com/
2009/02/monticello-fallingwater.html

Brian Bent
http://www.dirtgalleryla.com/bb_falling.html

Non Photorealistic Rendering

http://www.historichollywood.biz/drawings-pennsylvania/fallingwater.htm

## Frank Lloyd Wright's *Fallingwater*
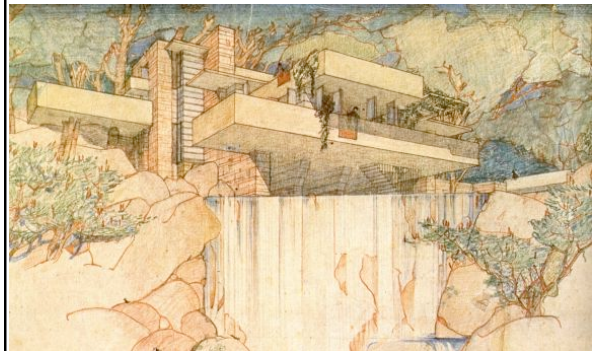
Goals for NPR?

- Exaggerate - *or* - de-emphasize lighting, texture, contrast, perspective, etc.
- May use limited palette of colors, or precision/resolution
- Allow vagueness about material & geometry
- Varying level of detail – draw attention to particular aspects of imagery
- More detail than a single traditional image can show (cross section, transparency, exploded view, multi-viewpoint rendering, etc.)

Today: Non Photorealistic Rendering

- Architectural Rendering
- Reading for Today
- Line Drawing
- Pen & Ink / Hatching
- Technical Illustration
- Artistic Styles and Painterly Rendering

Reading for Today:

- "Artistic Tessellations by Growing Curves", Li & Mould, Non-Photorealistic Animation and Rendering (NPAR) 2011
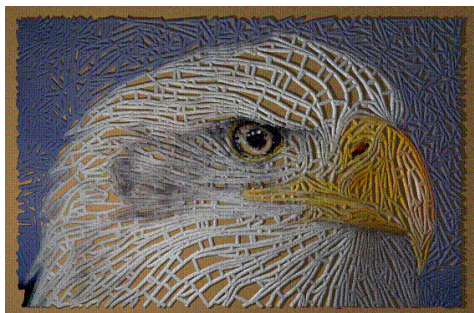
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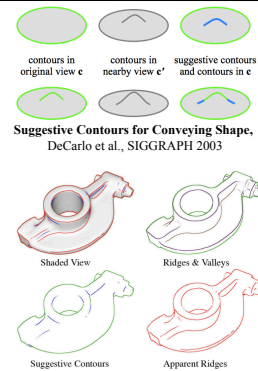- Technical Illustration
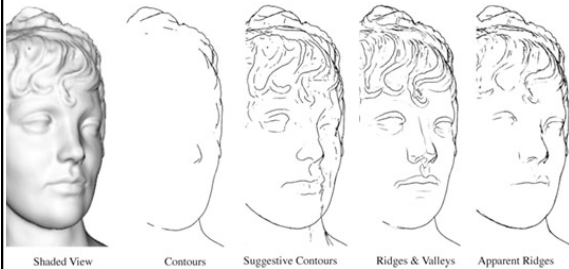- Artistic Styles and Painterly Rendering

Where Do People Draw Lines?
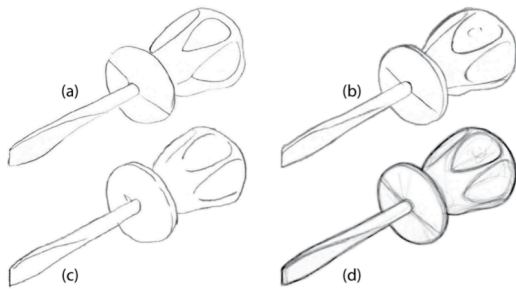
Cole, Golovinskiy, Limpaecher, Stoddart Barros, Finkelstein, Funkhouser, & Rusinkiewicz, SIGGRAPH 2008

Types of Edges in Line Drawings

- Silhouettes/Contours: where normal is perpendicular to the view direction
- Suggestive Contour: inflection points of the surface normal
- Ridges & Valleys: extremum of curvature
- Apparent Ridges: based on *view dependent* curvature

contours in original view **c**   contours in nearby view **c'**   suggestive contours and contours in **c**

Suggestive Contours for Conveying Shape,
DeCarlo et al., SIGGRAPH 2003

Shaded View   Ridges & Valleys

Suggestive Contours   Apparent Ridges

Types of Edges in Line Drawings

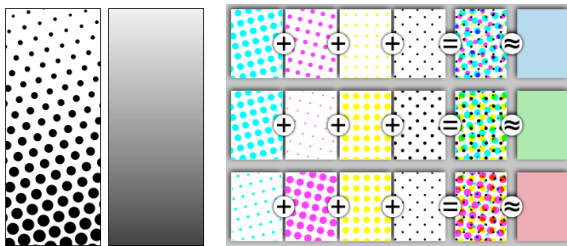Shaded View   Contours   Suggestive Contours   Ridges & Valleys   Apparent Ridges

Apparent Ridges for Line Drawings
Judd, Durand & Adelson, SIGGRAPH 2007

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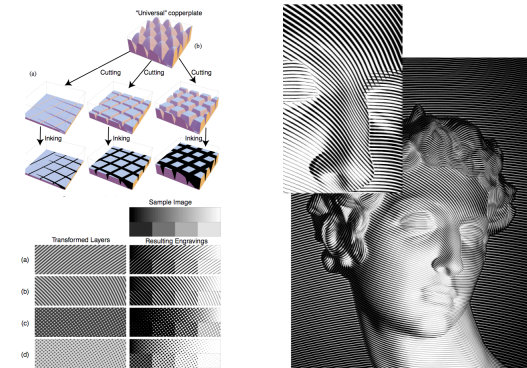- Artistic Styles and Painterly Rendering

Halftoning

http://en.wikipedia.org/wiki/File:Halftoning_introduction.svg   http://en.wikipedia.org/wiki/File:Halftoningcolor.svg

"Digital Facial Engraving", Ostromoukhov, SIGGRAPH 1999
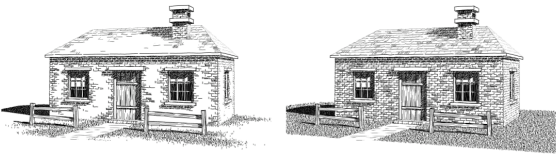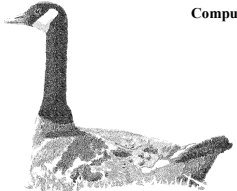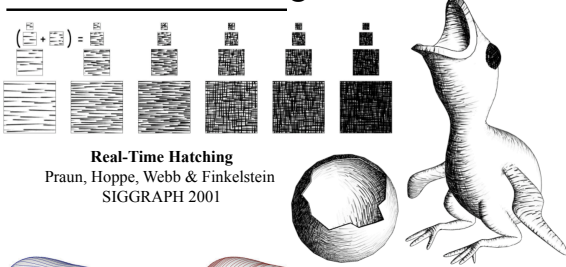
Pen & Ink Illustration

Figure 6: *Indicating texture. The left house is drawn using "indication"; the right house is not.*

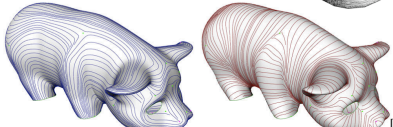**Computer-generated pen-and-ink illustration**
Winkenbach & Salesin 1996

Interactive Pen-and-Ink Illustration
Salisbury et al., SIGGRAPH 1994

Real-Time Hatching

Real-Time Hatching
Praun, Hoppe, Webb & Finkelstein
SIGGRAPH 2001

smoothed minimum & maximum curvature
[image from Alliez et al. '03]

Real-time NPR

- (Before programmable pixel shaders)
  - Create 1D texture map of shading tones
  - Local lighting (normal, view, & light directions) turned into texture coordinate
  - Texture lookup is final color

- Concerns about spatial & temporal coherence
  - popping
  - "Shower door" effect

Dynamic Solid Textures for Real-Time Coherent Stylization
Bénard, Bousseau, and Thollot, I3D 2009

http://artis.imag.fr/Publications/2009/BBT09/DynSolidTextures.mov

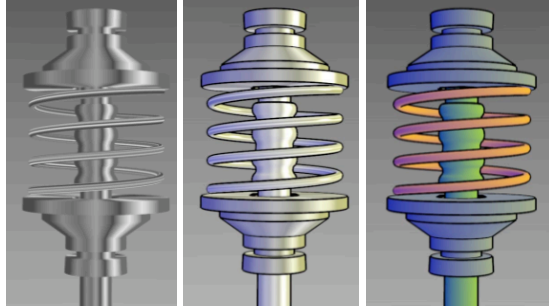## Today: Non Photorealistic Rendering

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Technical Illustration

A non-photorealistic lighting model for automatic technical illustration
Gooch, Gooch, Shirley, & Cohen SIGGRAPH 1998

Technical Illustration

Rendering Effective Route Maps: Improving Usability Through Generalization
Agrawala & Stolte, SIGGRAPH 2001

Designing Effective Step-By-Step Assembly Instructions
Agrawala et al. SIGGRAPH 2003

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Painterly Rendering

Painterly rendering with curved brush strokes of multiple sizes
Hertzmann SIGGRAPH 1998

"Towards Artistic Minimal Rendering", Rosin & Lai, NPAR 2010

(a) (b) (c) (d) (e)

Figure 1: *Mona Lisa rendered in different styles. (a) line drawing, (b) image abstraction, (c)(d)(e): three styles of the proposed approach in this paper (single level, texture and pyramid).*

Artistic Thresholding

- Xu & Kaplan, NPAR 2008

Reading for Friday:

"Fragment-based image completion", Drori, Cohen-Or, Yeshurun, SIGGRAPH 2003