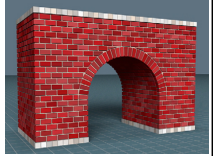
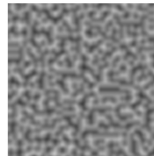
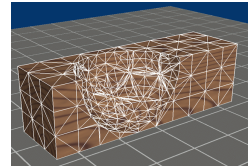


## Non-Photorealistic Rendering (NPR)

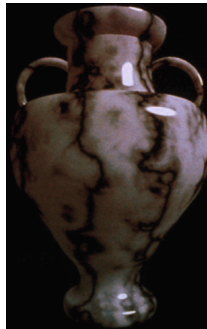
### Last Time?

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



### Reading for Last Time:

- Ken Perlin, “An Image Synthesizer”, SIGGRAPH 1985
- & “Improving Noise”, SIGGRAPH 2002



### Procedural Modeling of Buildings



- “Procedural Modeling of Buildings”, Mueller, Wonka, Haegler, Ulmer & Van Gool, SIGGRAPH 2006

### 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*



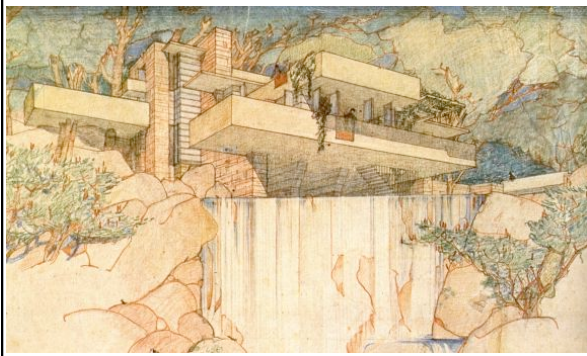
<http://www.thetimesnewroman.com/2011/07/luxe-living-fallingwater.html>

### Frank Lloyd Wright's *Fallingwater*

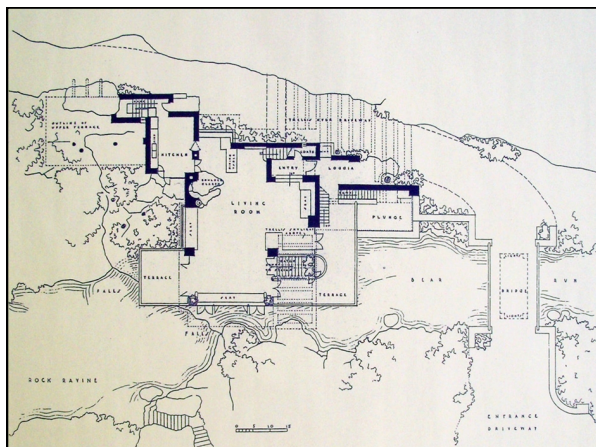
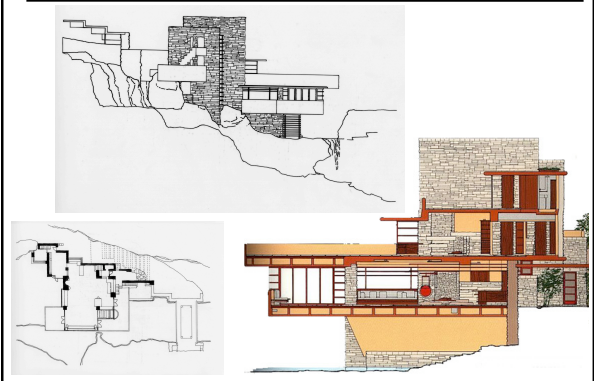


<http://www.thetimesnewroman.com/2011/07/luxe-living-fallingwater.html>

### Frank Lloyd Wright's *Fallingwater*



### Plan, Section, & Elevation Drawings



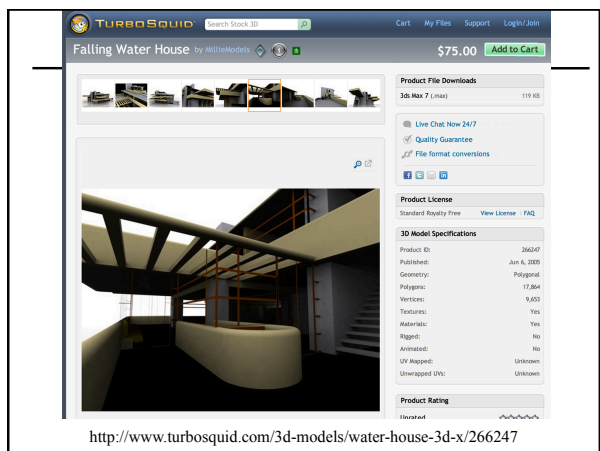
[http://www.architecturelist.com/wp-content/uploads/2007/10/fallingwater\\_4.jpg](http://www.architecturelist.com/wp-content/uploads/2007/10/fallingwater_4.jpg)

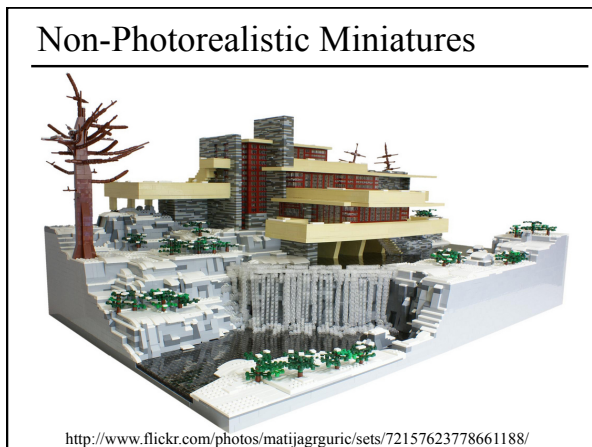
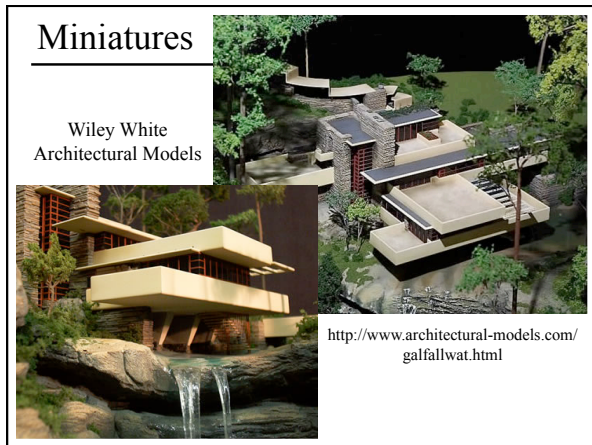
## Digital Models



## Digital Models

From Half Life 2





## 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](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/](http://www.flickr.com/photos/j_bussmann/4549613488/)

Fallingwater®

<http://www.fallingwater.org/>

## Non-Photorealistic Rendering



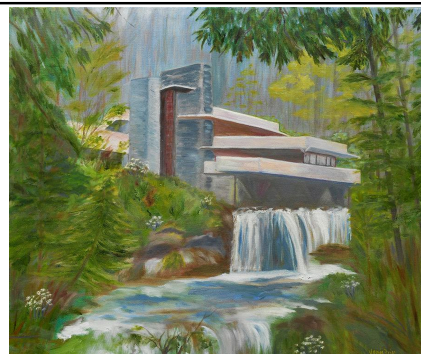
<http://www.studio360.org/2009/may/29/fallingwater/>

## Non Photorealistic Rendering



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

## Painting / Painterly Rendering



<http://fineartamerica.com/featured/falling-water-jamie-frier.html/>

Painting / Painterly Rendering



<http://disney.go.com/create/art/2gs11k6UcUbS000010040000-g-bce863>

Painting / Painterly Rendering



<http://www.ivonneimagines.com/487/falling-water/>



<http://kempersmith.com/fallingwater.html>



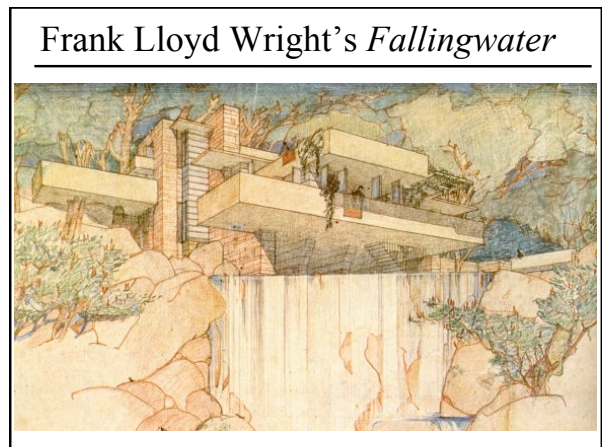
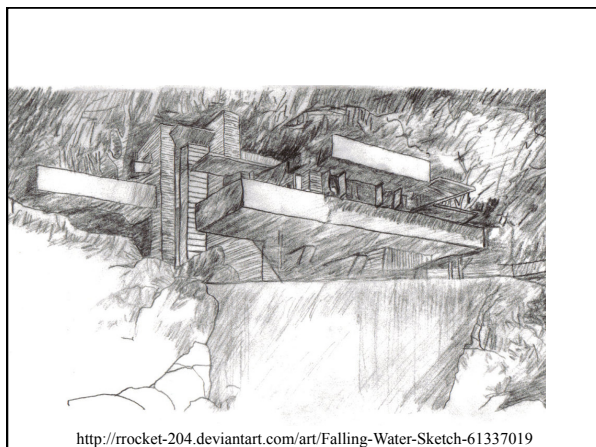
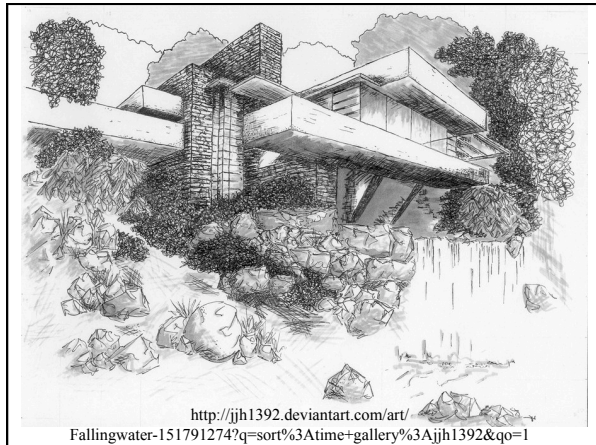
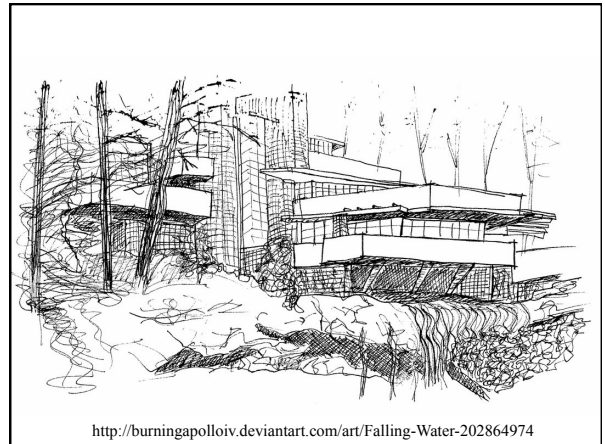
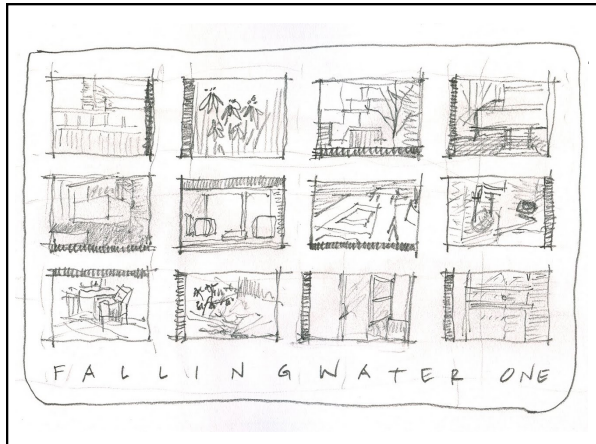
Brian Bent  
[http://www.dirtgalleryla.com/bb\\_falling.html](http://www.dirtgalleryla.com/bb_falling.html)



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



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



## 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:

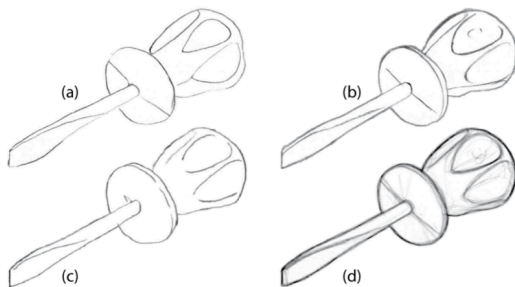
- “Artistic Tessellations by Growing Curves”, Li & Mould, Non-Photorealistic Animation and Rendering (NPAR) 2011



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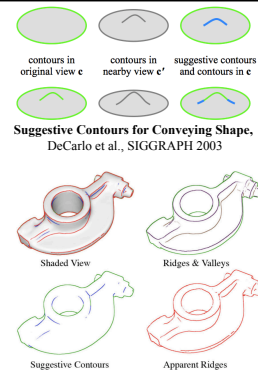
## Where Do People Draw Lines?



Cole, Golovinskiy, Limpaecher, Stoddart Barros, Finkelstein, Funkhouser, & Rusinkiewicz, SIGGRAPH 2008

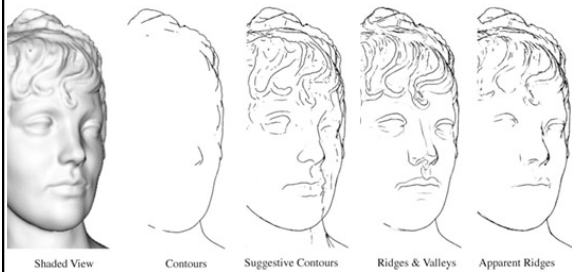
## Types of Edges in Line Drawings

- 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





## Types of Edges in Line Drawings



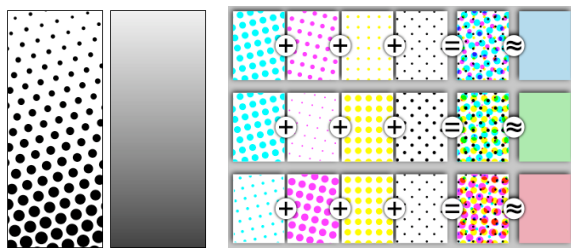
Shaded View      Contours      Suggestive Contours      Ridges & Valleys      Apparent Ridges

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

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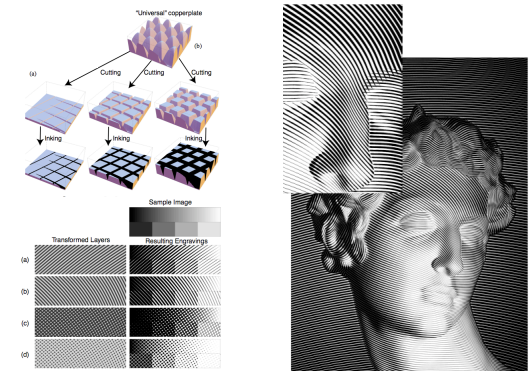
## Halftoning



[http://en.wikipedia.org/wiki/File:Halftoning\\_introduction.svg](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

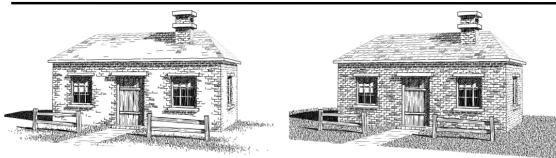
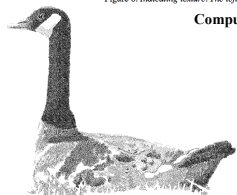


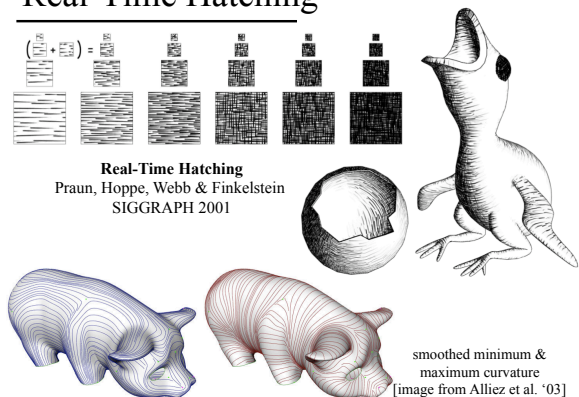
Figure 6. Indicating texture. The left house is drawn using “indication”; the right house is not.

**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

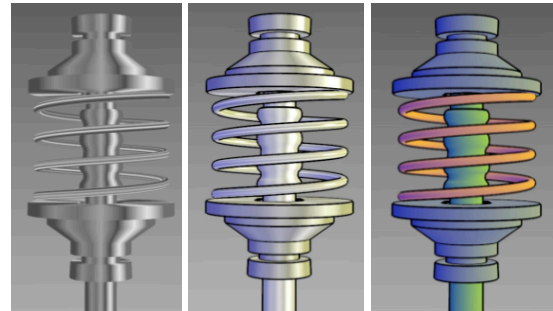


<http://artis.imag.fr/Publications/2009/BBT09/DynSolidTextures.mov>

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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

## Today: Non Photorealistic Rendering

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## Painterly Rendering



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

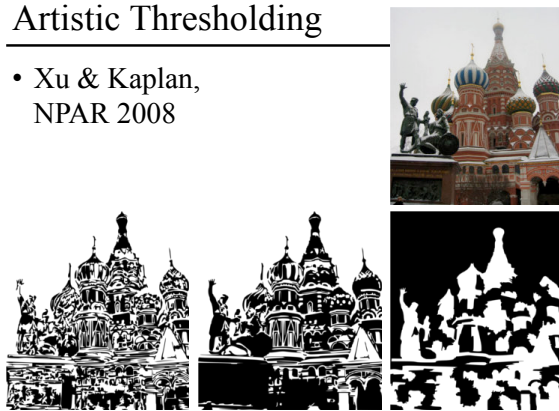
## “Towards Artistic Minimal Rendering”, Rosin & Lai, NPAR 2010



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 Today/Discuss Friday:

- “WYSIWYG NPR: Drawing Strokes Directly on 3D Models”,  
Kalmans, Markosian, Meier, Kowalski, Lee, Davidson, Webb,  
Hughes, & Finkelstein, SIGGRAPH 2002



## Reading for Friday: “Fragment-based image completion”, Drori, Cohen-Or, Yeshurun, SIGGRAPH 2003

