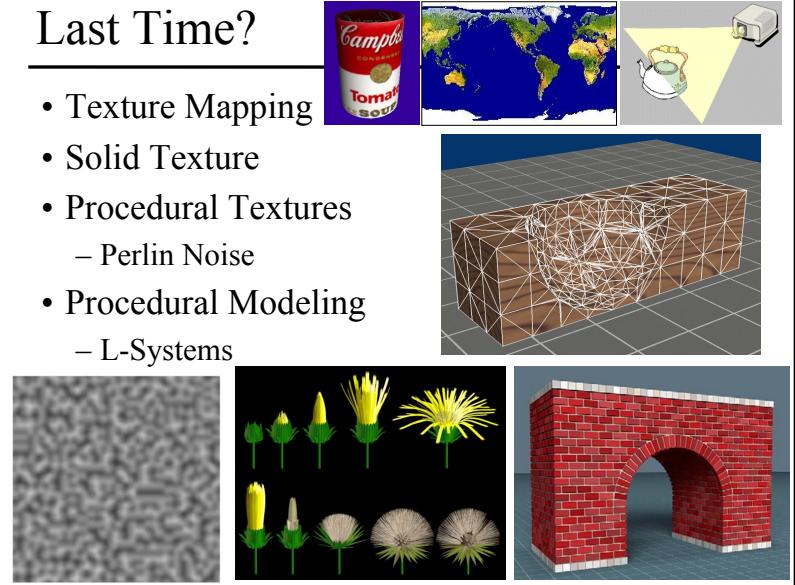


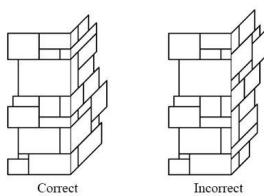
# Non-Photorealistic Rendering (NPR)

## Last Time?

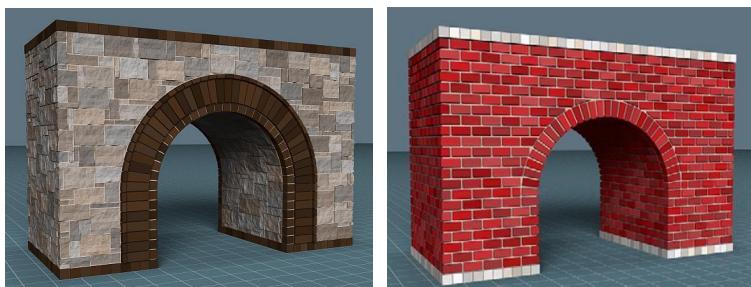
- Texture Mapping
- Solid Texture
- Procedural Textures
  - Perlin Noise
- Procedural Modeling
  - L-Systems



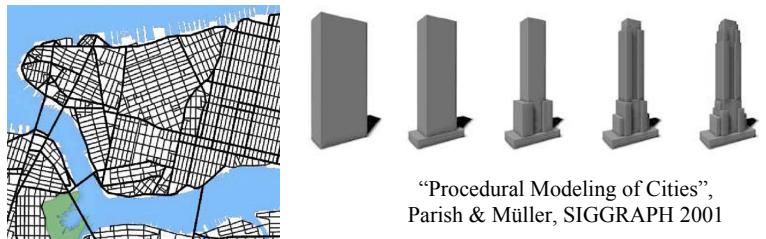
## Cellular Texturing for Architecture



“Feature-Based Cellular Texturing for Architectural Models”, Legakis, Dorsey, & Gortler, SIGGRAPH 2001



## L-Systems for Cities



“Procedural Modeling of Cities”, Parish & Müller, SIGGRAPH 2001



## Procedural Modeling of Buildings



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

## Today: Non Photorealistic Rendering

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

## Frank Lloyd Wright’s *Fallingwater*



## Frank Lloyd Wright’s *Fallingwater*



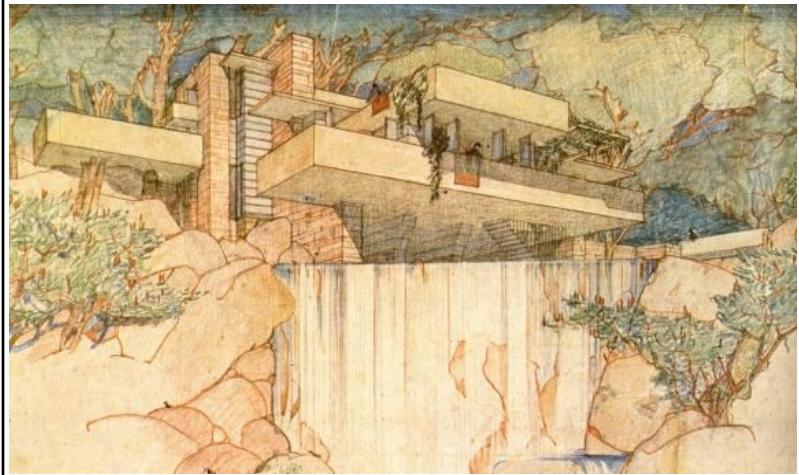
<http://www.thetimesnewroman.com/2011/07/luxe-living-fallingwater.html>

## Frank Lloyd Wright's *Fallingwater*

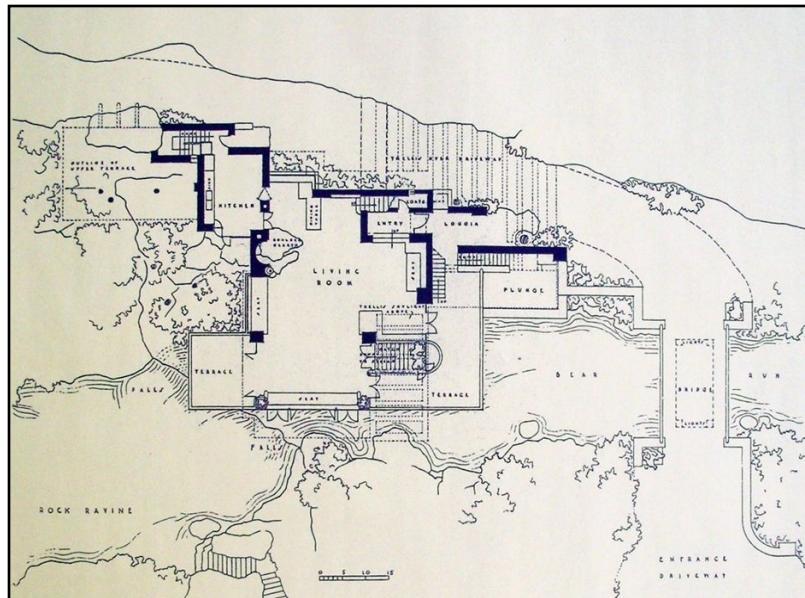


<http://www.thetimesnewroman.com/2011/07/luxe-living-fallingwater.html>

## Frank Lloyd Wright's *Fallingwater*



[https://si.wsj.net/public/resources/images/OD-AG561\\_FALLIN\\_G\\_20110506021738.jpg](https://si.wsj.net/public/resources/images/OD-AG561_FALLIN_G_20110506021738.jpg)



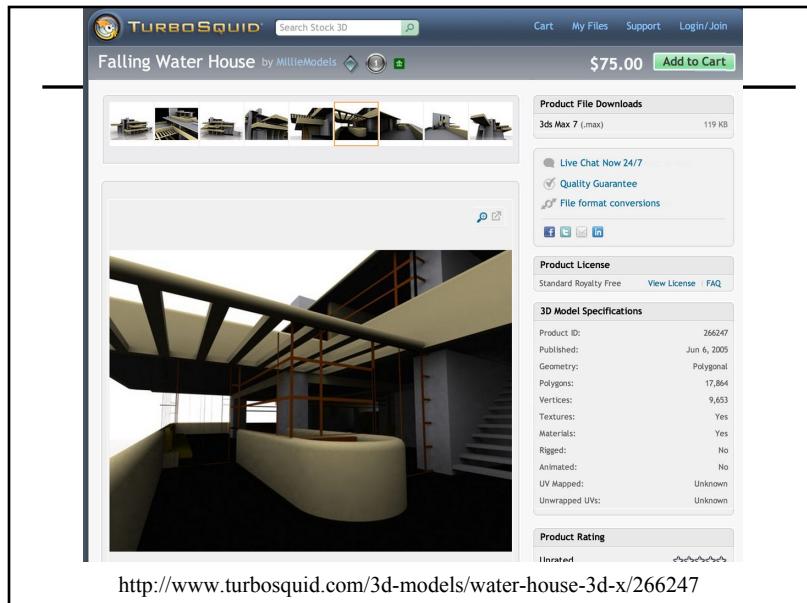
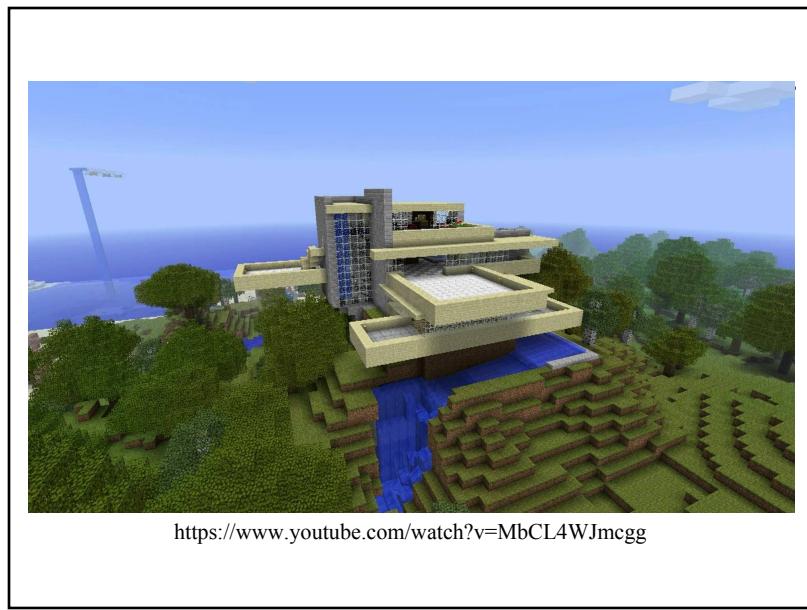
## Plan, Section, & Elevation Drawings



[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







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

## Digital Models

From Half Life 2



## Photorealistic Rendering



[http://www.eteraeaestudios.com/docs\\_html/fallingwater\\_htm/fall\\_still\\_03.htm](http://www.eteraeaestudios.com/docs_html/fallingwater_htm/fall_still_03.htm)



<http://luftwerk.net/projects/fallingwater/>  
<https://www.youtube.com/watch?v=6RJbnA7ESKk>

## Miniatures

Wiley White  
Architectural Models



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

## Non-Photorealistic Miniatures



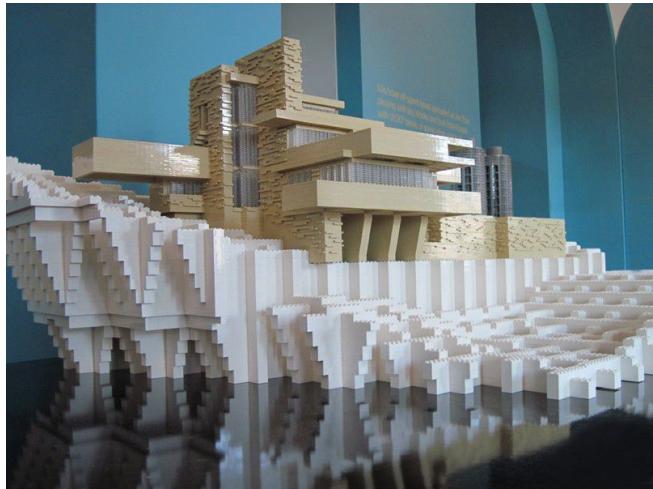
<http://shop.lego.com/ByTheme/Product.aspx?p=21005&cn=52>  
<http://www.urbanbydesignonline.com/urbanbydesign/tag/fallingwater>

## Non-Photorealistic Miniatures



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

## Non-Photorealistic Miniatures



Adam Reed Tucker <http://www.mocpages.com/moc.php/220533>

## Non-Photorealistic Miniatures



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

Eating Fallingwater

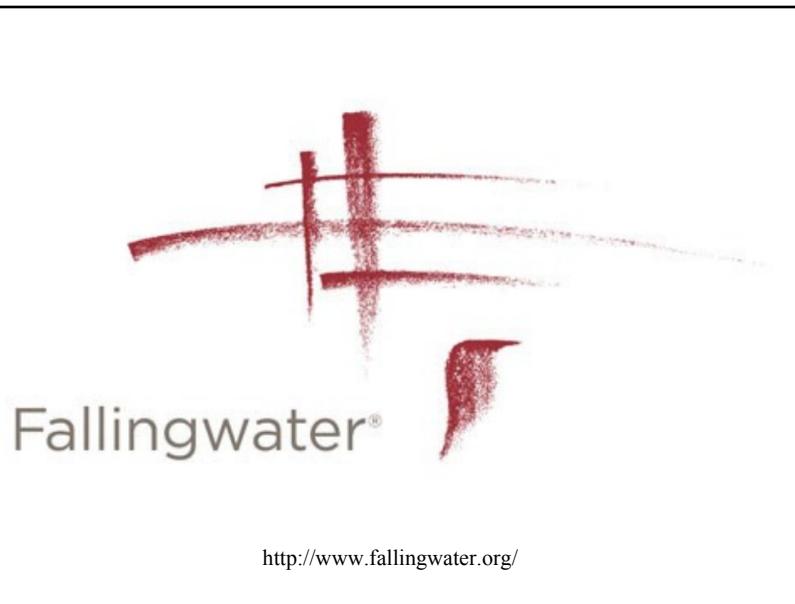


TedWells living : simple

[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

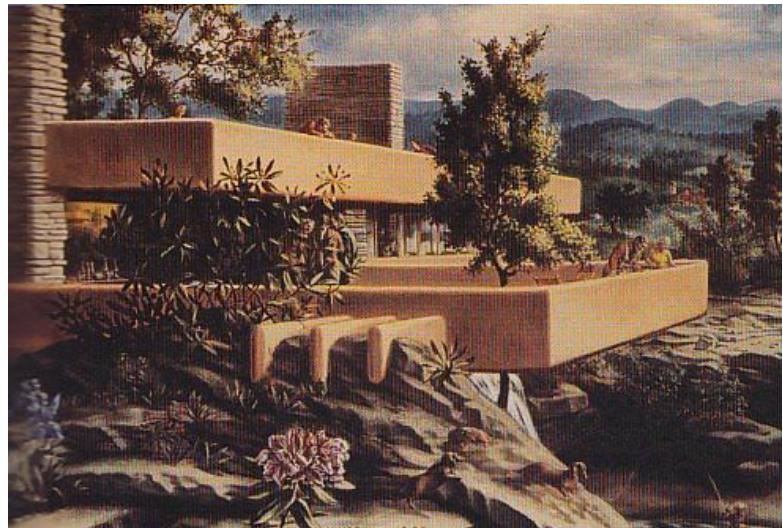


Fallingwater

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



<http://www.funnyfishdesign.com/casestudies/craft-lights/?ckattempt=1>



“House At Falling Water”, Peter Blume, 1938-1968.  
First painting of Fallingwater. Commissioned by the owners.

## Painting / Painterly Rendering



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

## Painting / Painterly Rendering

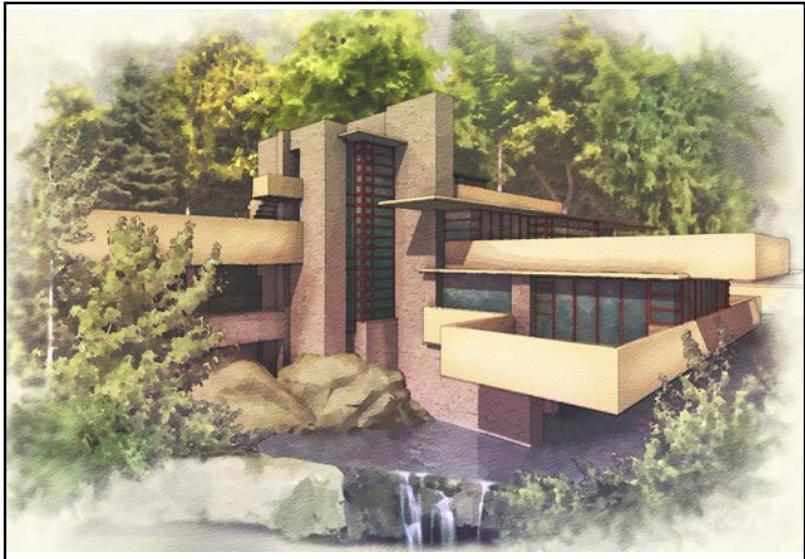


<http://disney.go.com/create/art/2gs11k6UcUbS000010040000-g-bce863>

## Painting / Painterly Rendering



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



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

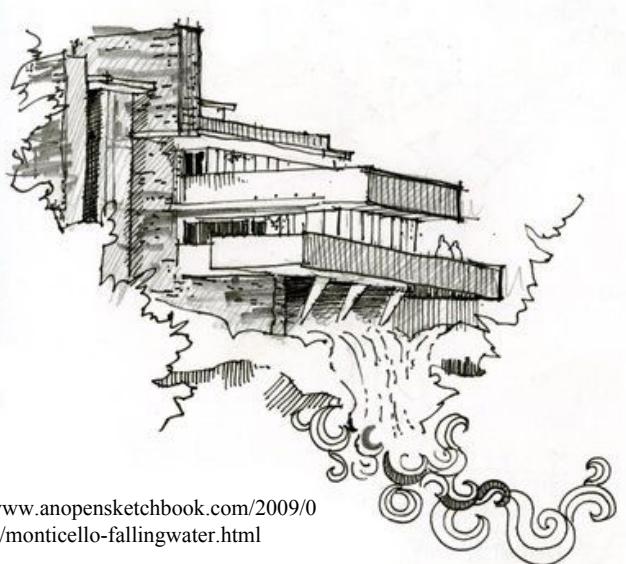
## Non Photorealistic Rendering



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



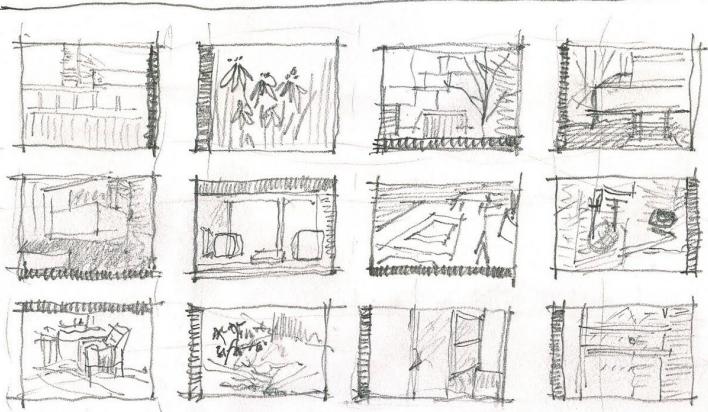
Brian Bent  
[http://www.dirtgalleryla.com/bb\\_falling.html](http://www.dirtgalleryla.com/bb_falling.html)



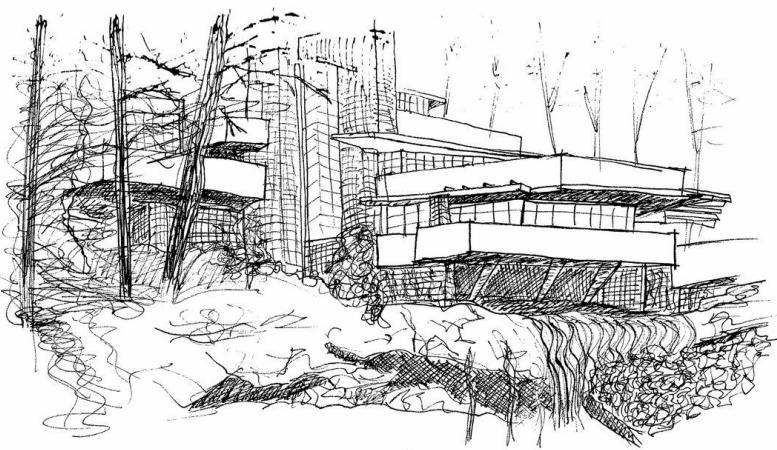
<http://www.anopensketchbook.com/2009/02/monticello-fallingwater.html>



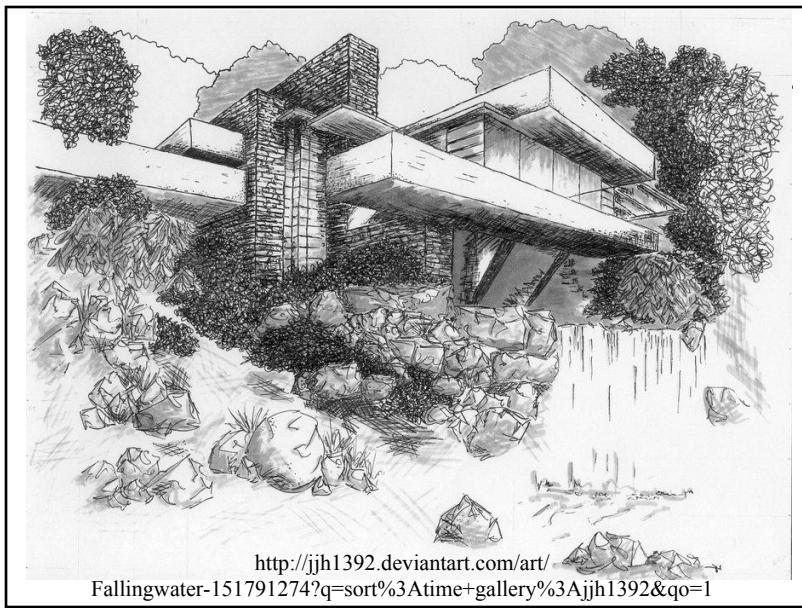
<http://www.gibson-design.com/images/Slides/fallingwater-entry-100dpi.jpg>



FALLINGWATER ONE



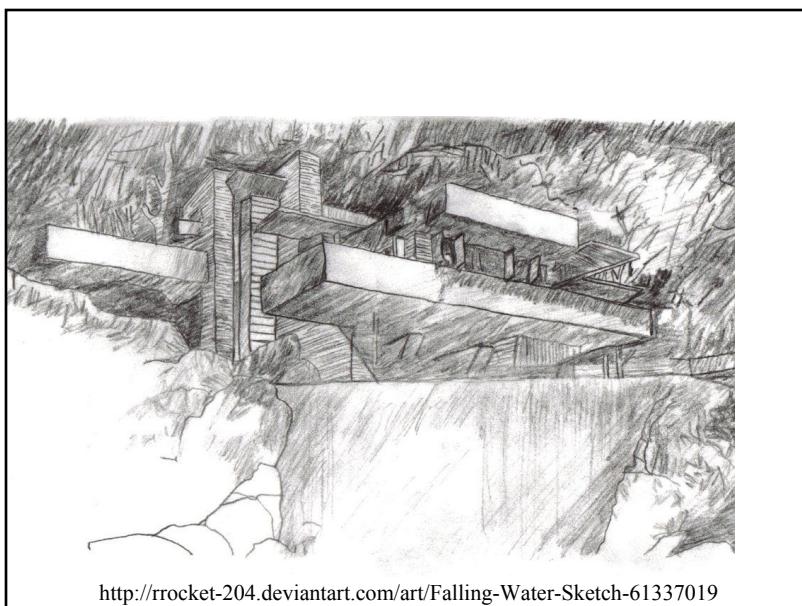
<http://burningapolloiv.deviantart.com/art/Falling-Water-202864974>



[http://jjh1392.deviantart.com/art/  
Fallingwater-151791274?q=sort%3Atime+gallery%3Ajjh1392&qq=1](http://jjh1392.deviantart.com/art/Fallingwater-151791274?q=sort%3Atime+gallery%3Ajjh1392&qq=1)

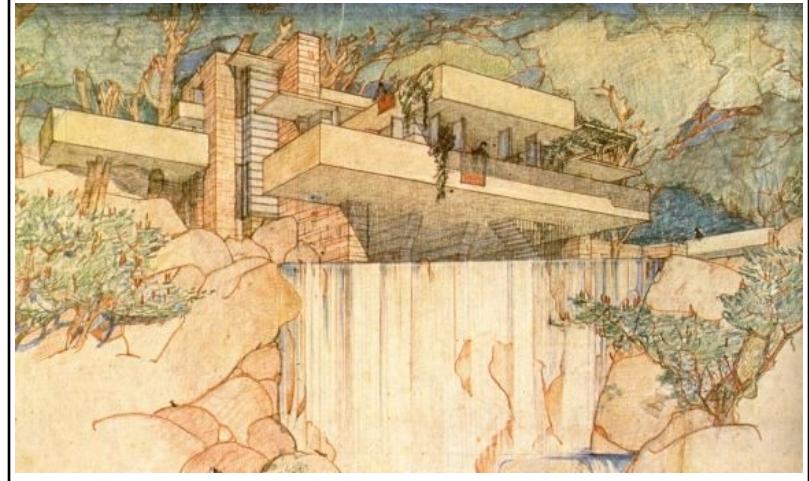


<http://obrasdearteacarvao.blogspot.com/>



[http://rrocket-204.deviantart.com/art/  
Falling-Water-Sketch-61337019](http://rrocket-204.deviantart.com/art/Falling-Water-Sketch-61337019)

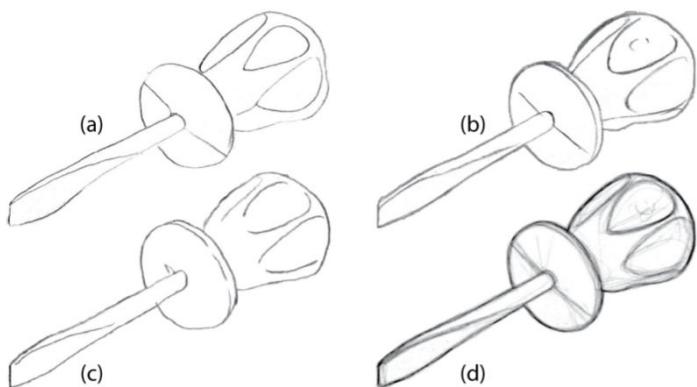
## Frank Lloyd Wright's *Fallingwater*



## Goals for NPR?

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

## Where Do People Draw Lines?



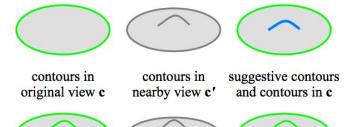
Cole, Golovinskiy, Limpachet, Stoddart Barros, Finkelstein, Funkhouser, & Rusinkiewicz, SIGGRAPH 2008

## Today: Non Photorealistic Rendering

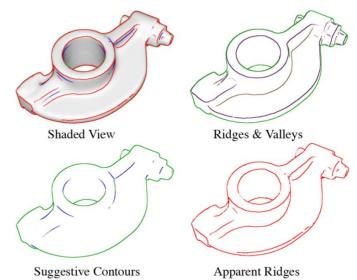
- Architectural Rendering
- **Line Drawing**
- Pen & Ink / Hatching
- Technical Illustration
- Artistic Styles and Painterly Rendering

## Types of Edges in Line Drawings

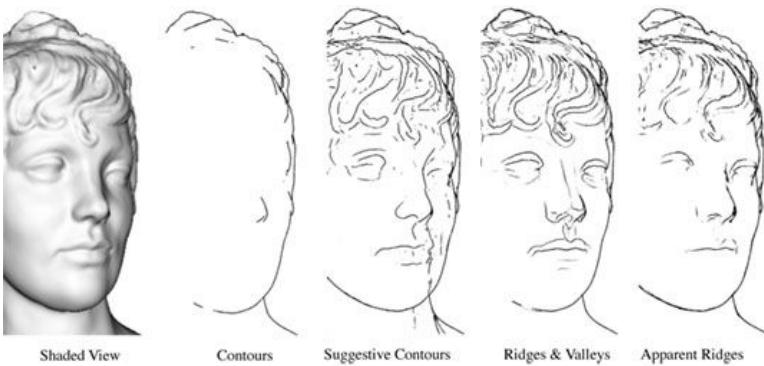
- Silhouettes/Contours: where normal is perpendicular to the view direction
- Suggestive Contour: inflection points of the surface normal
- Ridges & Valleys: extremum of curvature
- Apparent Ridges: based on *view dependent* curvature



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

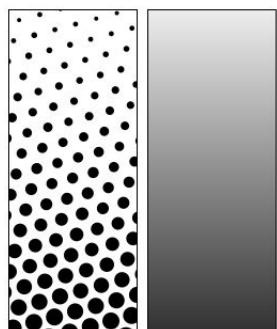


## Types of Edges in Line Drawings

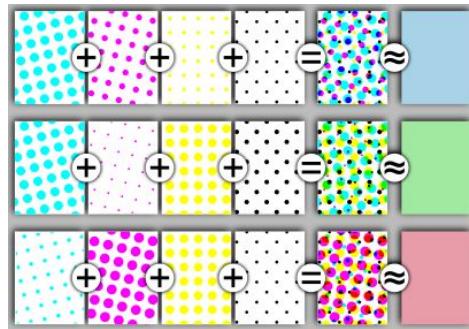


**Apparent Ridges for Line Drawings**  
Judd, Durand & Adelson, SIGGRAPH 2007

## Halftoning



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

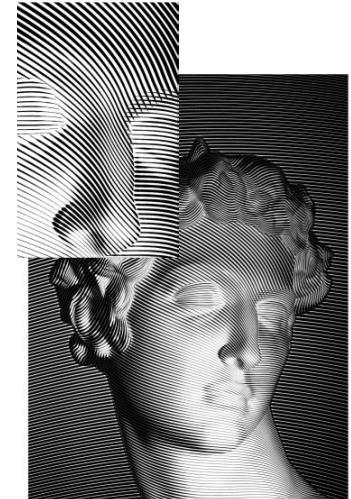
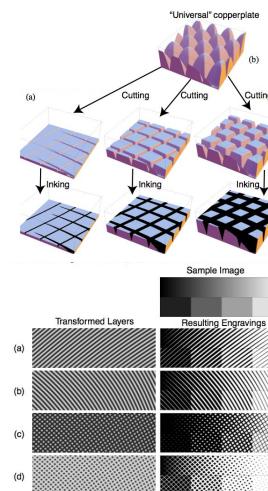


<http://en.wikipedia.org/wiki/File:Halftoningcolor.svg>

## Today: Non Photorealistic Rendering

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

**“Digital Facial Engraving”,  
Ostromoukhov, SIGGRAPH 1999**



## Pen & Ink Illustration

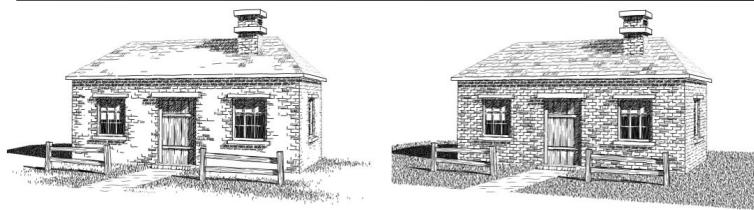
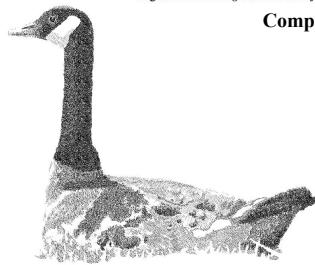


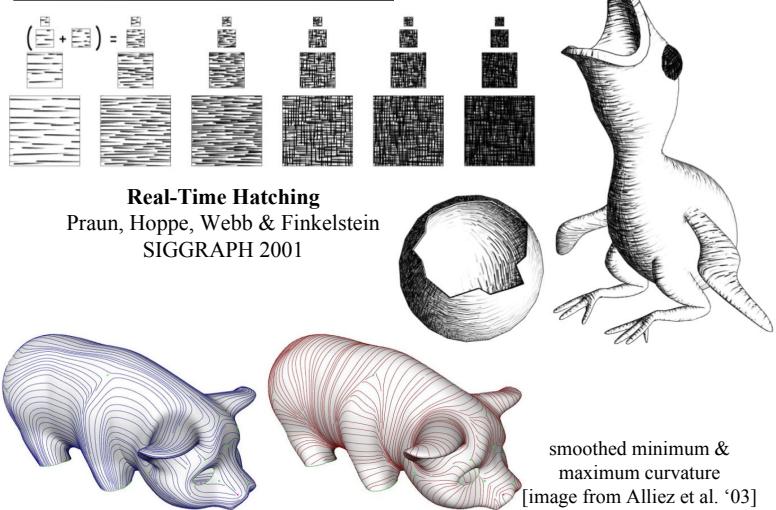
Figure 6: Indicating texture. The left house is drawn using "indication"; the right house is not.

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

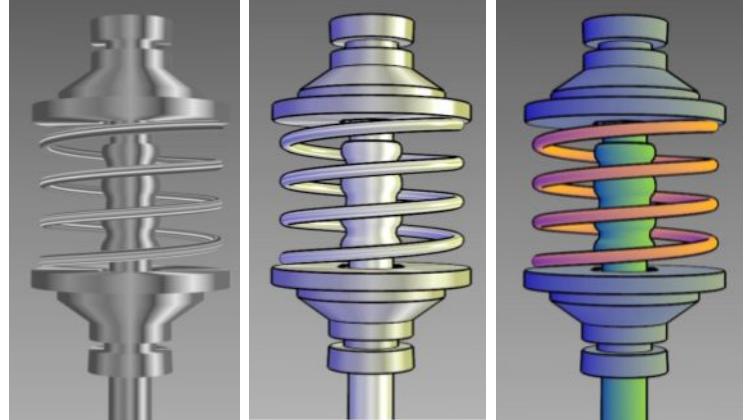


<http://artis.imag.fr/Publications/2009/BBT09/DynSolidTextures.mov>

# Today: Non Photorealistic Rendering

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

# Technical Illustration

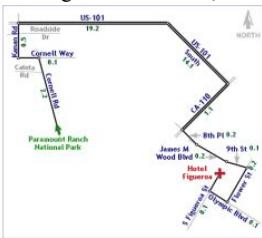


A non-photorealistic lighting model for automatic technical illustration  
Gooch, Gooch, Shirley, & Cohen SIGGRAPH 1998

# 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

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

## Painterly Rendering



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

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

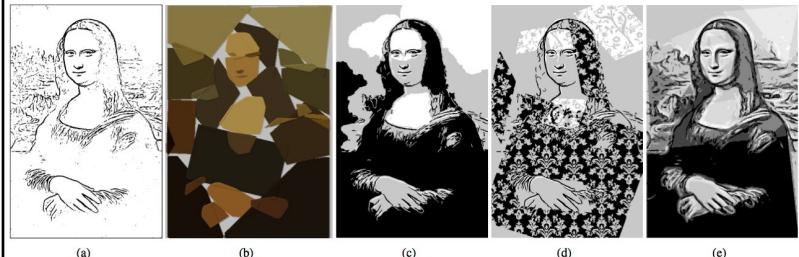
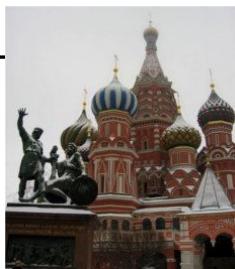


Figure 1: *Mona Lisa* rendered in different styles. (a) line drawing, (b) image abstraction, (c)(d)(e): three styles of the proposed approach in this paper (single level, texture and pyramid).

## Artistic Thresholding

- Xu & Kaplan,  
NPAR 2008



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



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



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

