Interactive Graphics Lecture 18

Non-Photorealistic Rendering

Why Photorealistic?

Much graphics research is aimed at producing photo-realism. Techniques that we have discussed include:

- textures
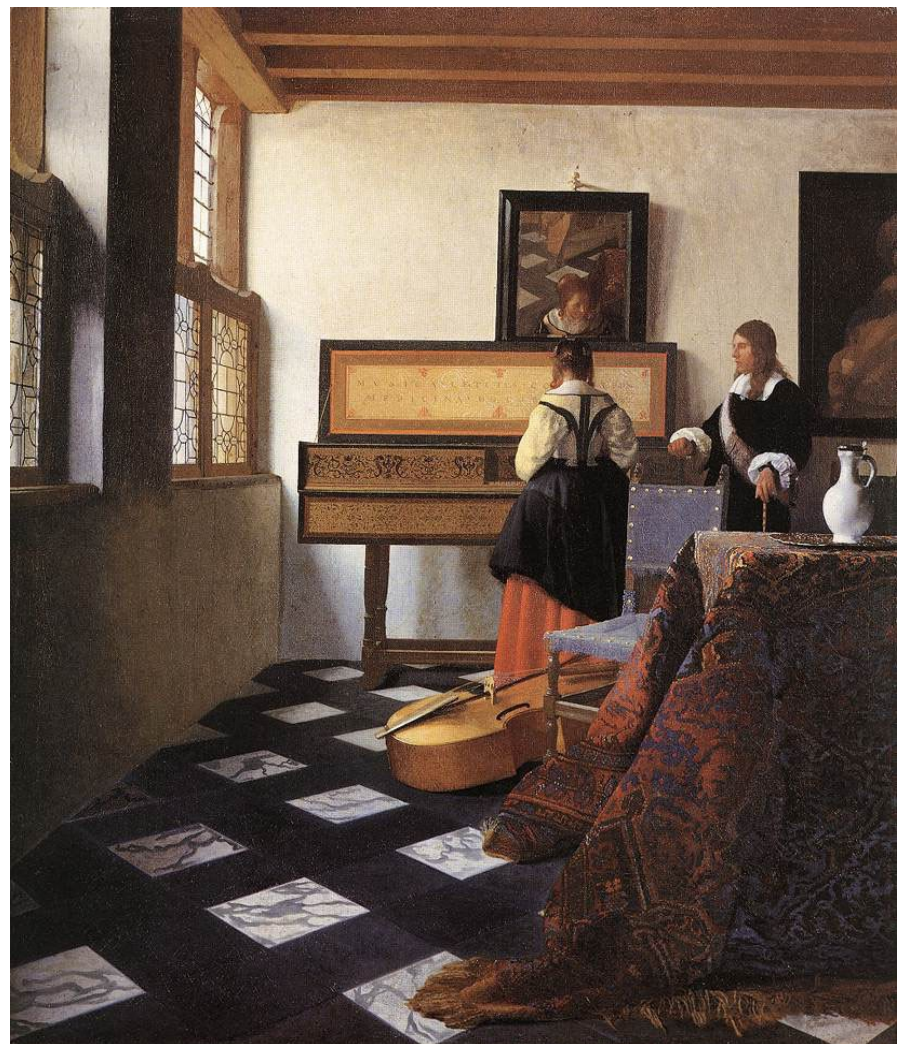- bump mapping
- environment mapping
- ray tracing
- radiosity

Modern research continues this quest.

Photorealistic Rendering
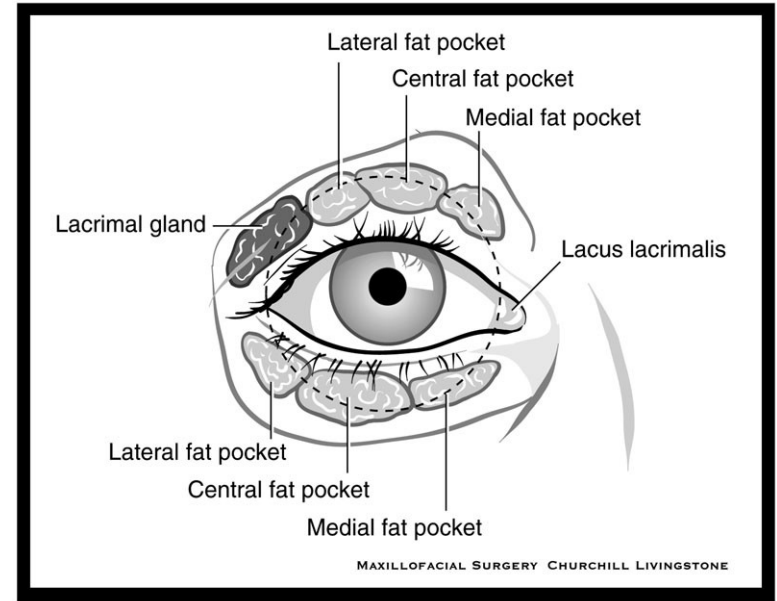Cornell University
circa 1990

Non-photorealistic Rendering
Johannes Vermeer
circa 1660

Why Non-Photorealistic?

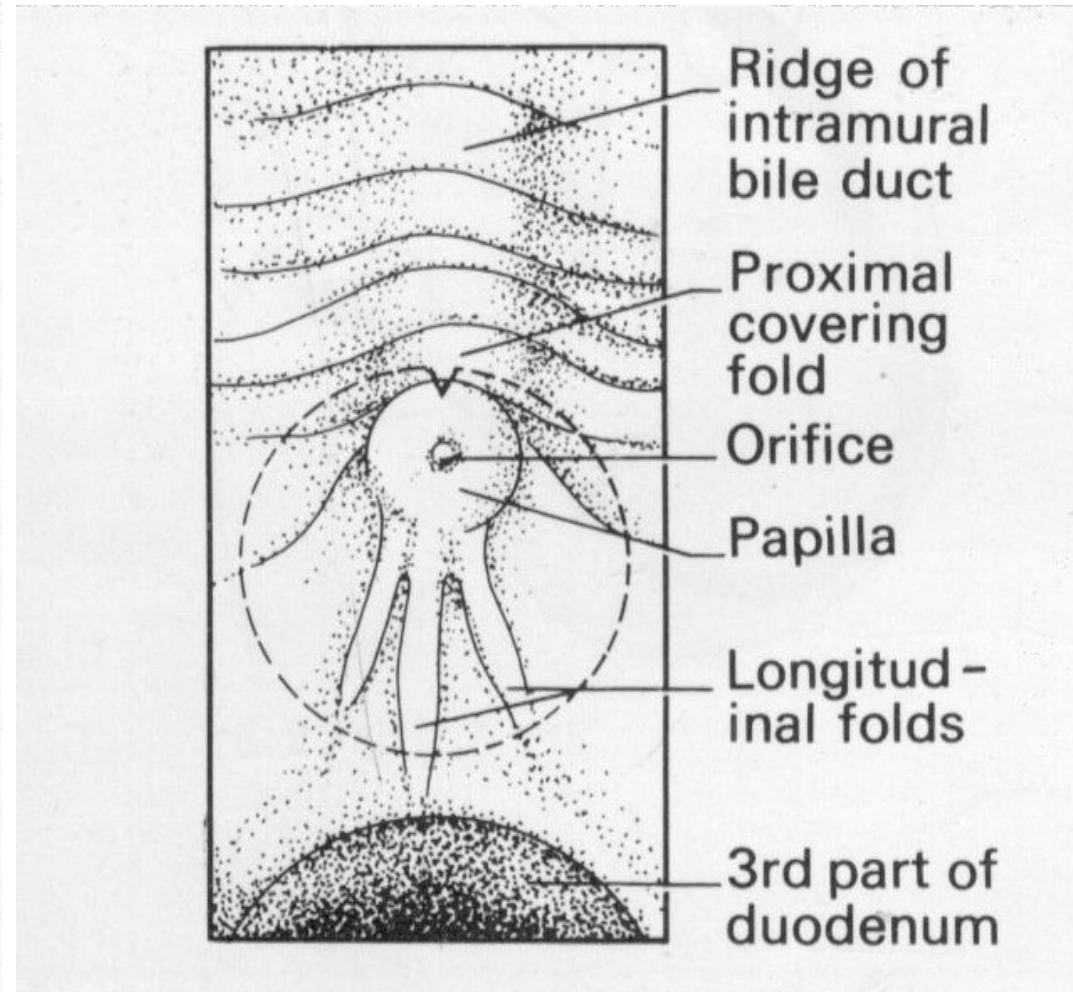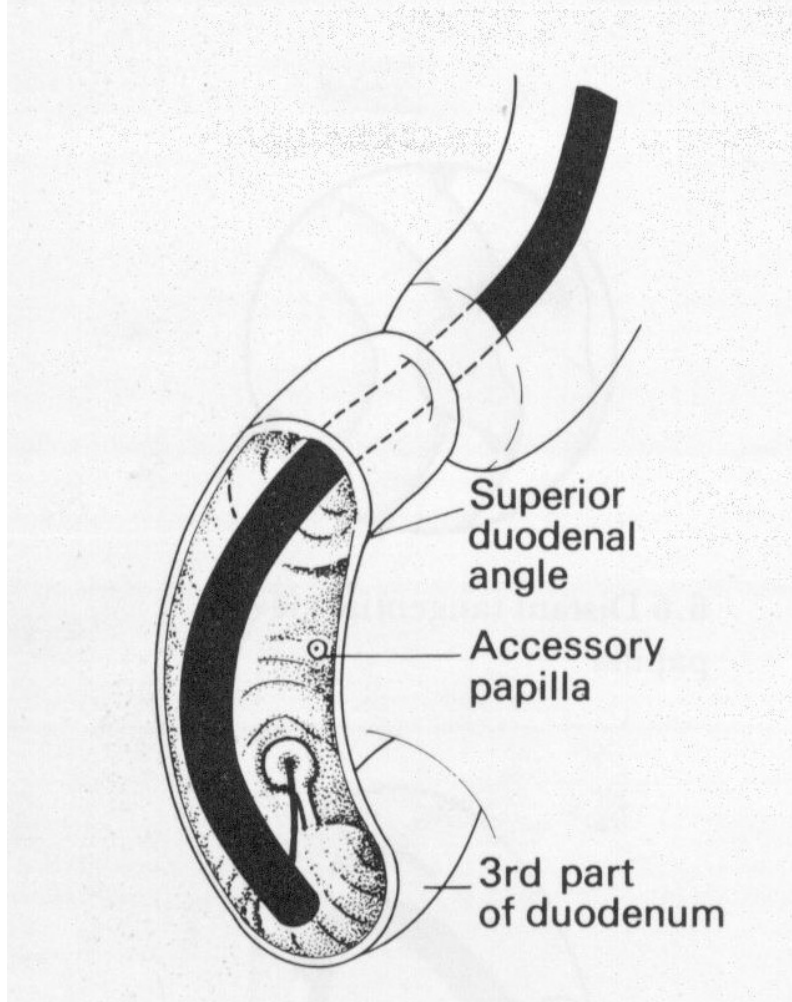Schematic diagrams can show things that photos can't

An artist is often able to (expected to) convey "expressiveness".

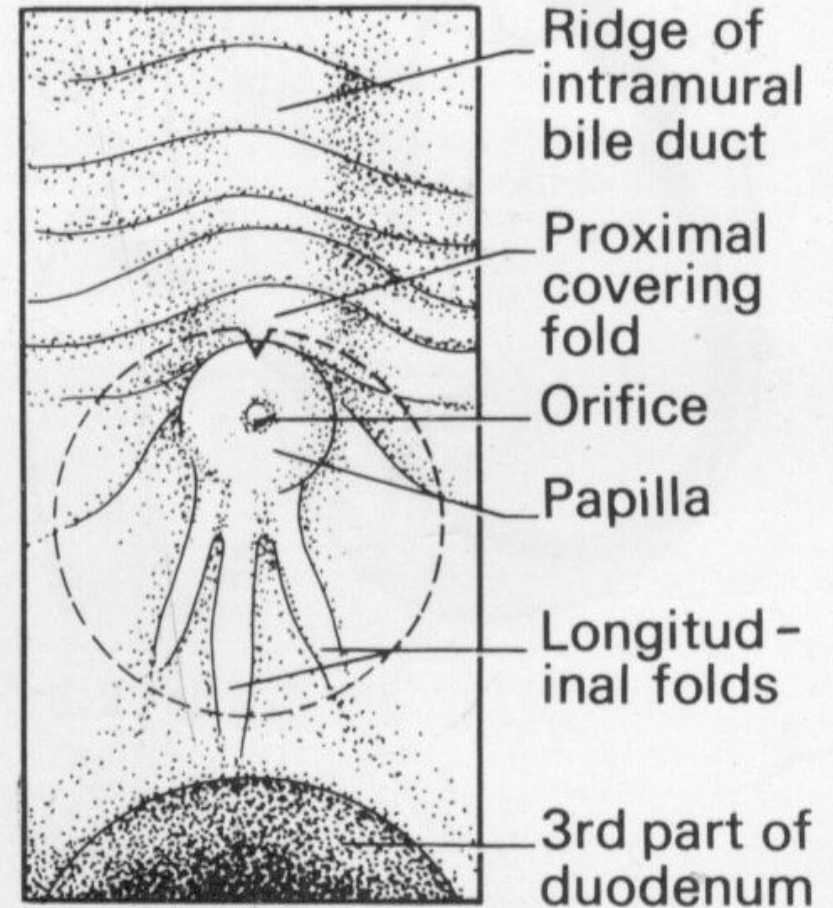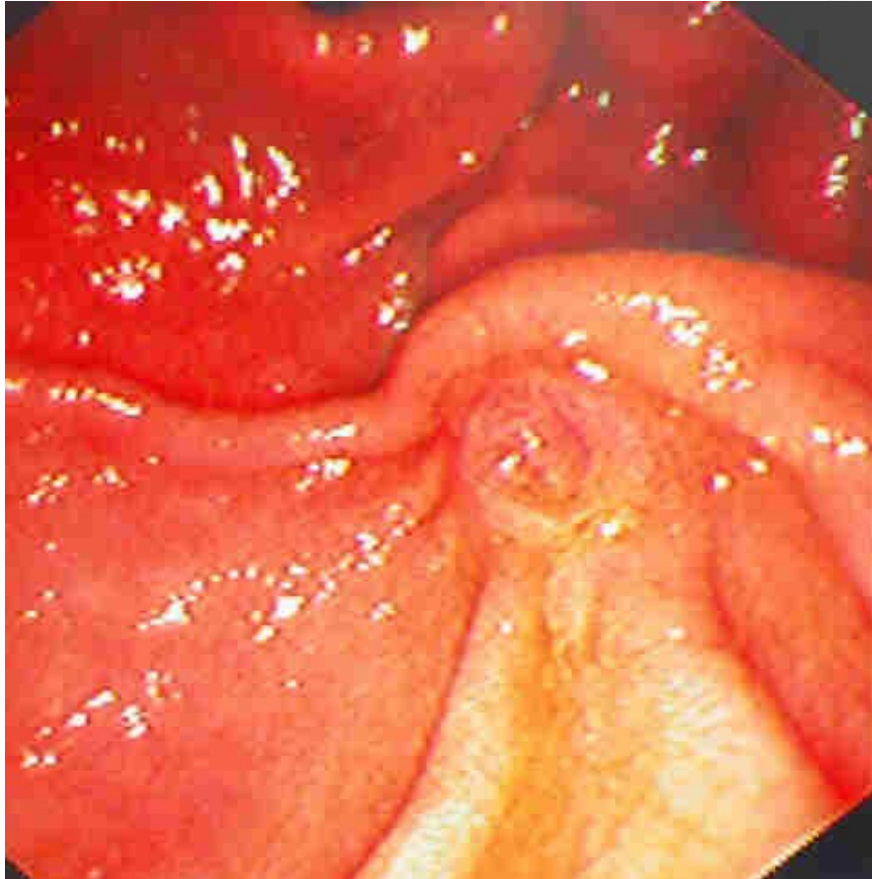This has given rise to the field of non-photorealistic rendering

Medical illustration
From IBLS at University of Glasgow

Non-Photorealistic medical illustrations

Non-Photorealistic medical illustrations

Ridge of intramural bile duct

Proximal covering fold

Orifice

Papilla

Longitud-inal folds

3rd part of duodenum

Styles and Effects for media and games

An important commercial application for NPR is creating special "looks" for games or cartoon films. This can be done by:

Special rendering effects - either based on polygon rendering or on ray tracing

Post processing films or cartoons. This has proved hard to achieve as NPR often doesn't work well on a range of images. Hand processing of single frames is too time consuming.

Cell-Shading – Rendering a 3D polygon scene as a cartoon. Used in video games (dreamcast)

Cell Shading - uses polygon rendering

Create a Light map: this is a 1-Dimensional texture map that indicates the shade of an object. It is set up using a few discrete regions.
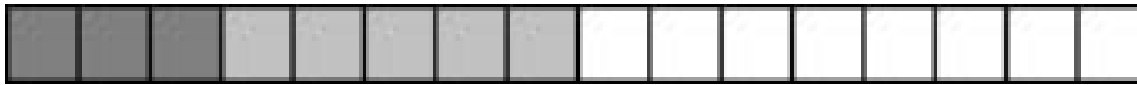
Find a reflectance with Lambert's cosine law, use its value to select from the light map

Add black lines at the visible polygon boundaries (or some of them, eg occluding boundaries)
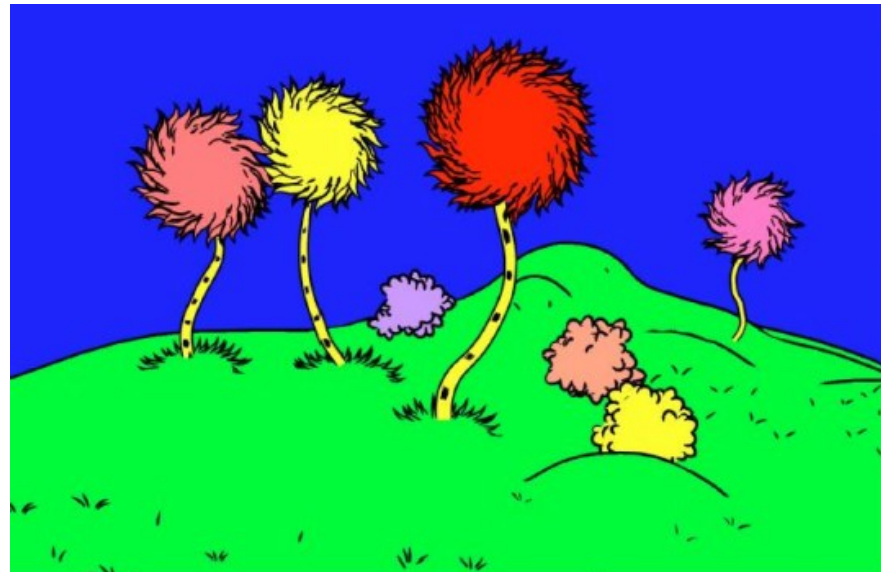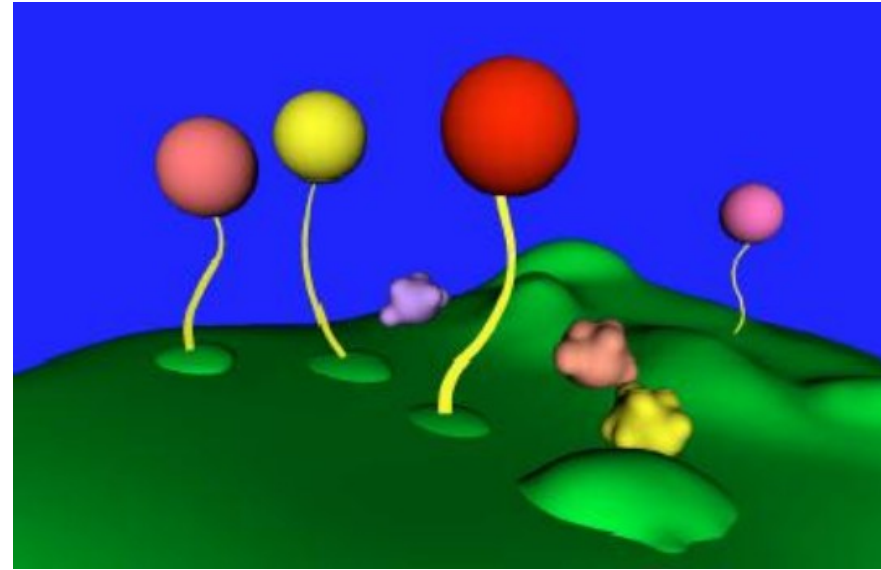
Creating other "animator" effects through rendering

Remove shading

Outline strong edges

Add Embellishments

Work by Kowalski et al

Many NPR Systems Use Image filters

Start with a photograph

Blur - using the same techniques discussed for anti-aliasing

Quantise - Change colour or spatial resolution

Texture - combine texture and image by blending

Composite Filtering in different resolutions (more interesting)

Blurring is done using the anti-aliasing filter

Replace each pixel by a weighted average of its neighbourhood:

1/36	1/9	1/36
1/9	4/9	1/9
1/36	1/9	1/36

Use several applications for more blurring, or use a larger filter kernel

Blurring

Blurring images is fast and simple, but it doesn't really produce very interesting results.

It is important in combination with other filters

Quantising Colour Depth

Change the number of colours or grey levels used to represent a picture.

Can produce interesting effects

Quantising resolution and colour depth

Edge Enhancement

Like blurring but with a different filter

Vertical Edge

-1	0	1
-2	0	2
-1	0	1

Horizontal Edge

1	2	1
0	0	0
-1	-2	-1

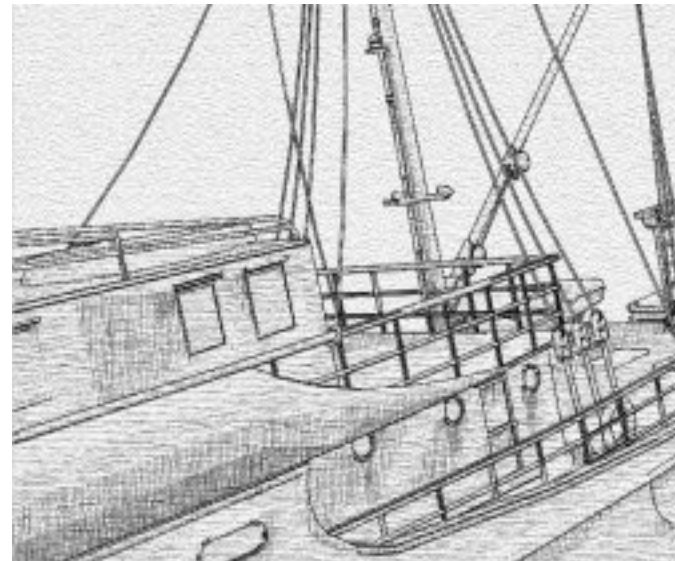Find the magnitude of the two components

Change image depending on edge strength

Creating pen images

Edges are found and reinforced

Shading is replaced with textures

Pictures from Intel 3D Software Technologies pages

Composite filtering

Filtering in more complex manners can produce oil paint effects (Hertzmann and Perlin see http://www.mrl.nyu.edu/projects/npr/painterly/)

Outline Algorithm

Initialise the output image to blank

For a given brush size (eg 32,16, 8 or 4 pixels)

Blur the source image using a filter size comparable to the brush size.

Find a difference image between the blurred source image and the current output image.

Threshold the difference image, so only large changes are retained.

Find local maxima on a coarse grid

Place a brush stroke on the output image at the local maximum using the corresponding image colour

First stages of the technique using circular brush strokes

Source Image

1. Circular brush strokes, radius 16

2. Circular brush strokes, radius 8

Images Angela Phuong IC 2006

Refinement using small circular brush strokes

3. Circular brush strokes, radius 4

4. Circular brush strokes, radius 2

Source Image

Images Angela Phuong IC 2006

Hertzmann's original using elongated strokes

A lakeside scene using circular brush strokes

Images by Angela Phuong,
(IC-DOC project 2006)

Creating effects by analogy

Work done by Hertzman Jacobs Oliver Curless and Salesin, University of Torronto (SIGGRAPH 2001)

The idea is to use effects created for one image on another image. Done using multi-resolution representation with local searches to find the best match.

The following examples are from:
http://www.mrl.nyu.edu/publications/image-analogies/

Creating an analogy image

Given:

    A: The original source image.

    A': The original filtered image.

    B: A new image to be filtered.

For each pixel of the target image:

    Search for the best matching corresponding pair in A, A'

A naive search does not work well. We need to have matching metrics that take into account the coherence of the evolving image.

Creating Image Analogies

The algorithm uses a multiscale approach, working from coarse to fine representations.

At each stage the search for the best match takes into account the local areas and the pixels in the previous level of the pyramid.
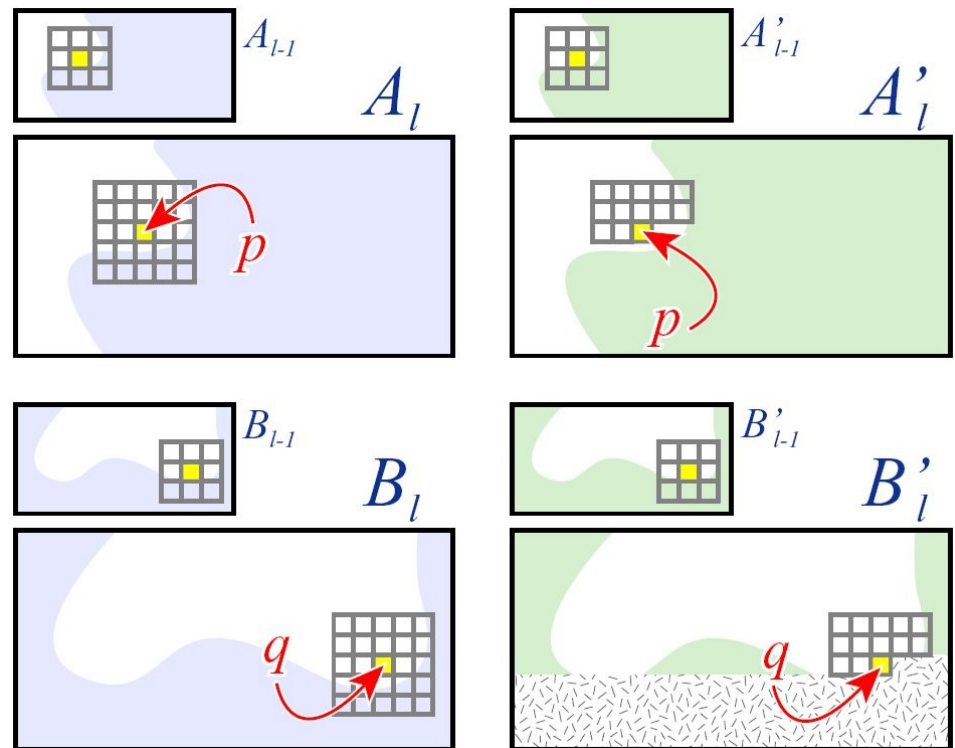
Image from Hertzmann et al.

Original Image

Image with a special effect

Take another image

Create an analogous effect
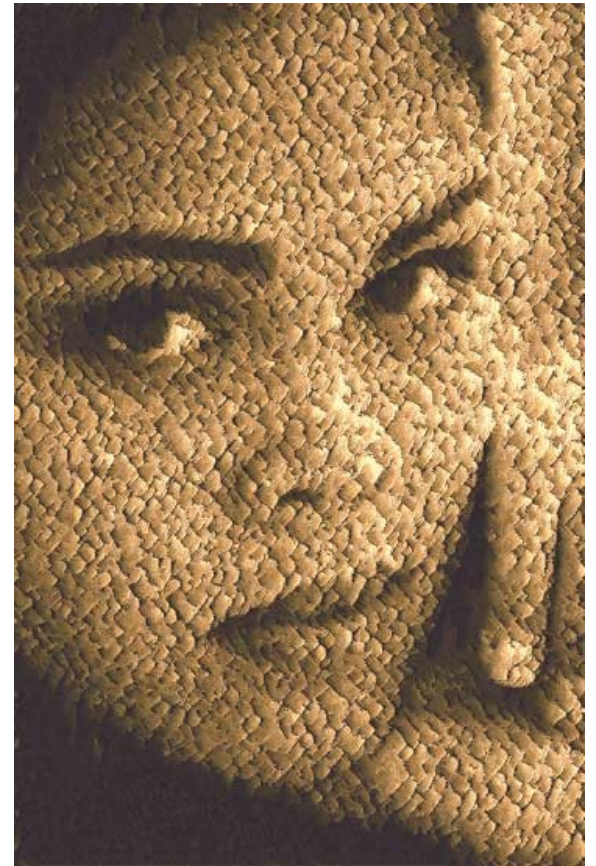
Analogies of basic filters -eg embossing
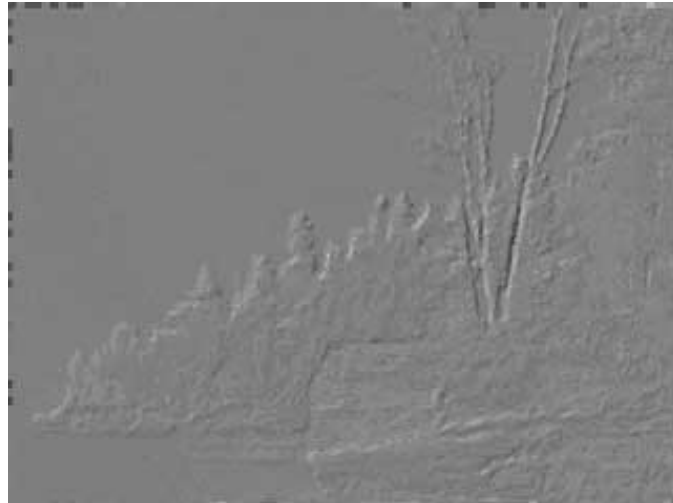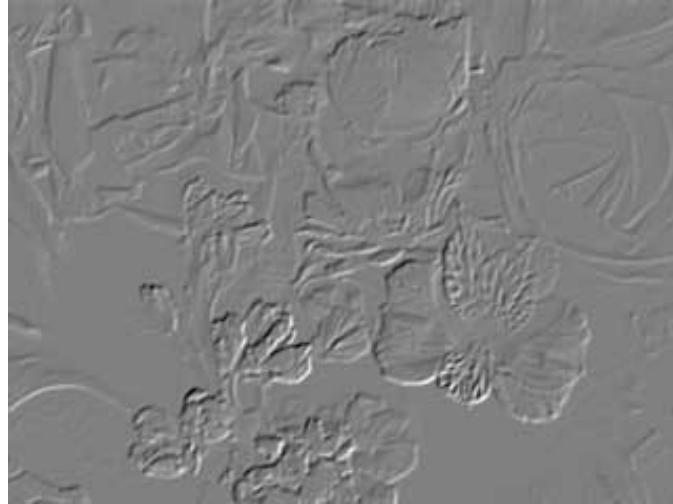
Textures - mapped by analogy

Blending textures into images can create interesting results - The texture is used for A and A'

Textures

Different textures create different effects

Rendering Methods

Non photorealistic rendering can be applied directly to polygon maps
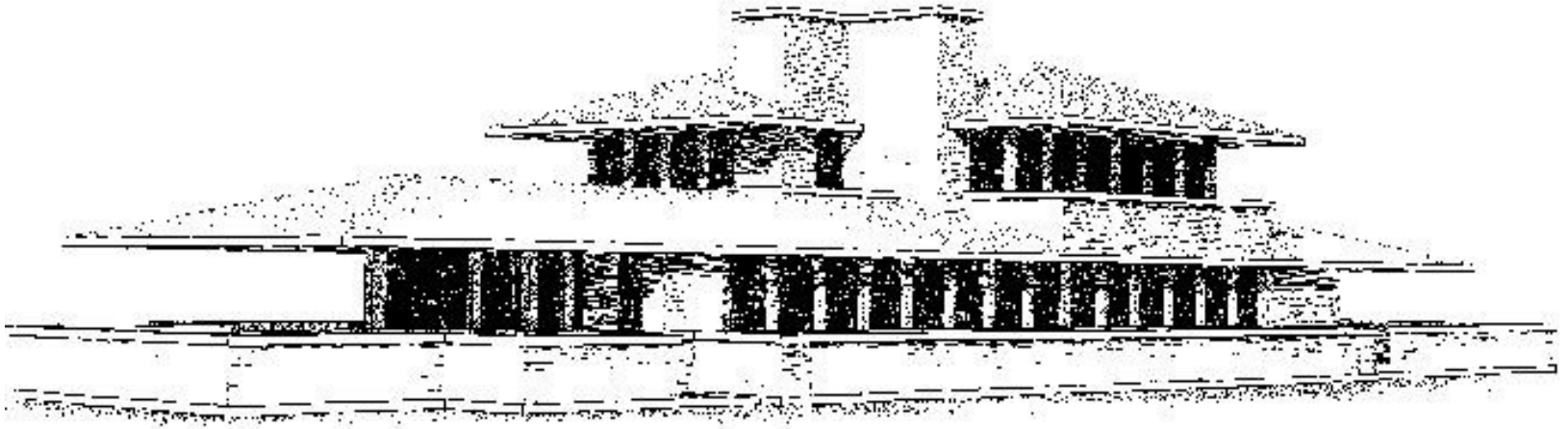
Creating pencil drawing effects

Pencil drawings are made up from "strokes" of the pencil which have:

variation in width from pressure and direction

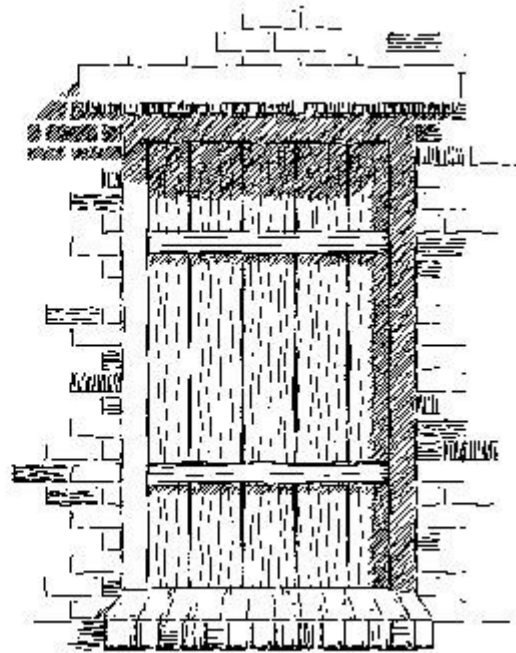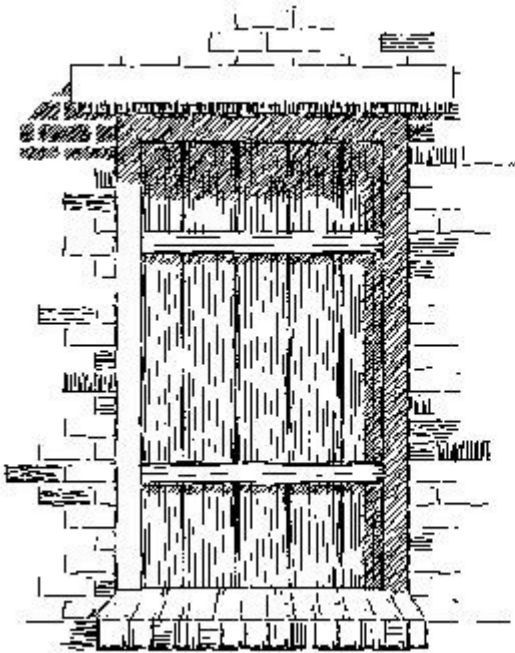Tones (gradations of shade) and textures are created by

Combining strokes in different patterns

Different textures and tones

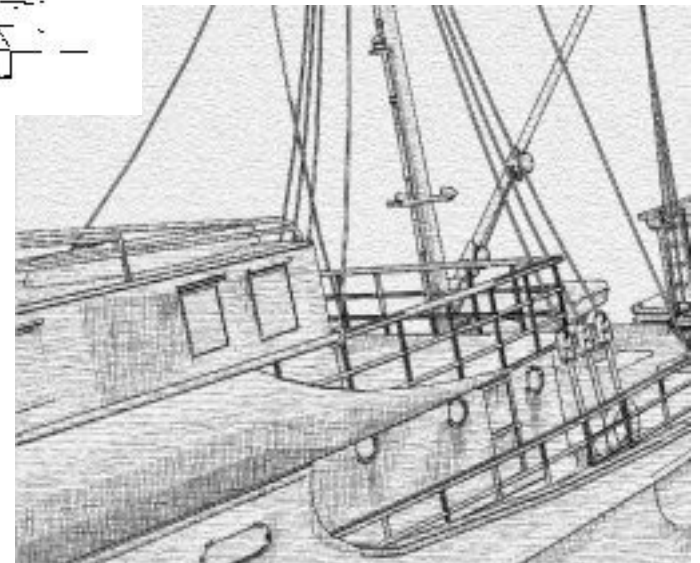Textures and
tones can be
pre-computed
then used for
rendering.
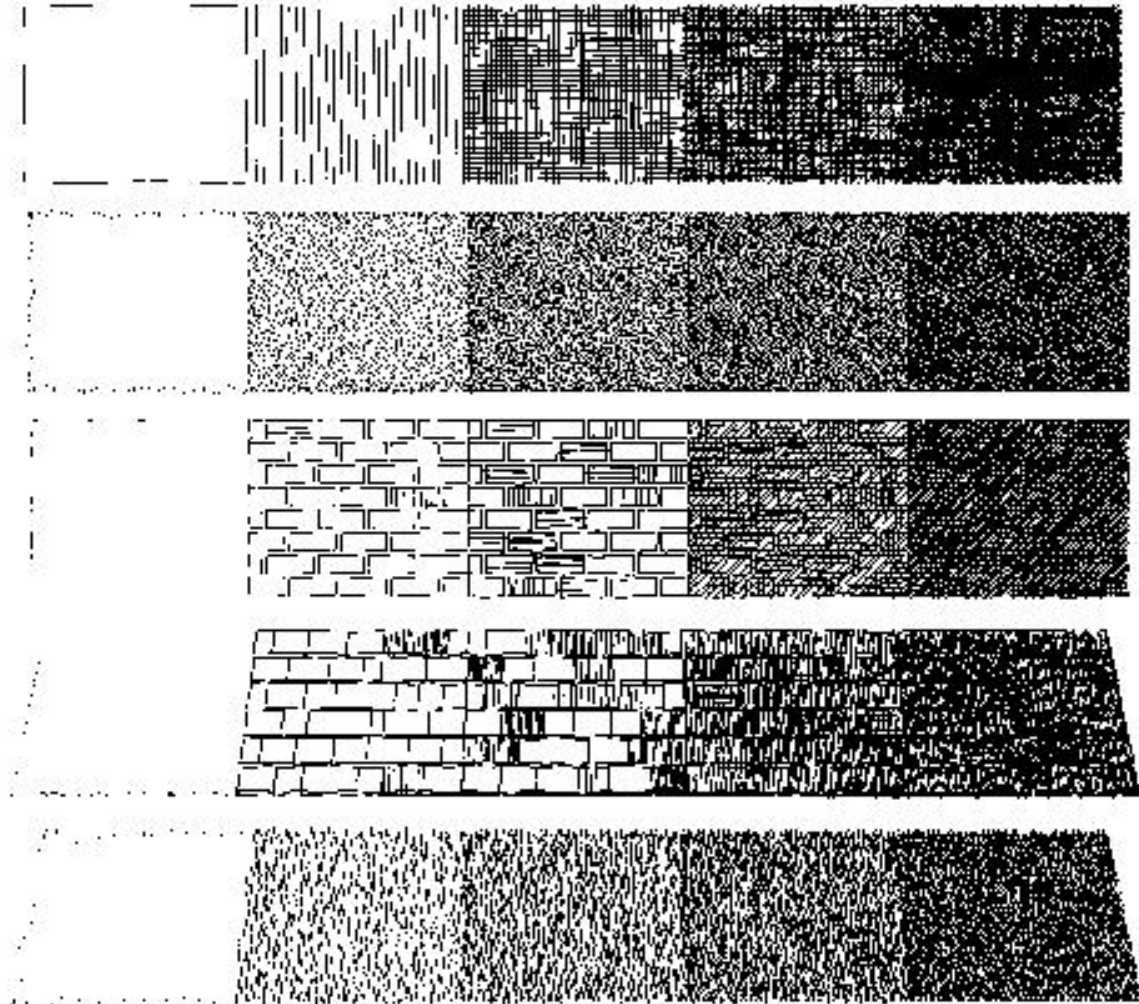
Effects of different strokes, tones and textures

Polygon rendering
with stroke textures

Image filtering with
stroke textures

Stroke Textures

Collection of strokes to give texture and tone

Prioritised so that different tones can be achieved

    first only highest priority drawn

    to increase tone, lower priorities drawn

For example:

    highest priority to outline

    next could be horizontal lines
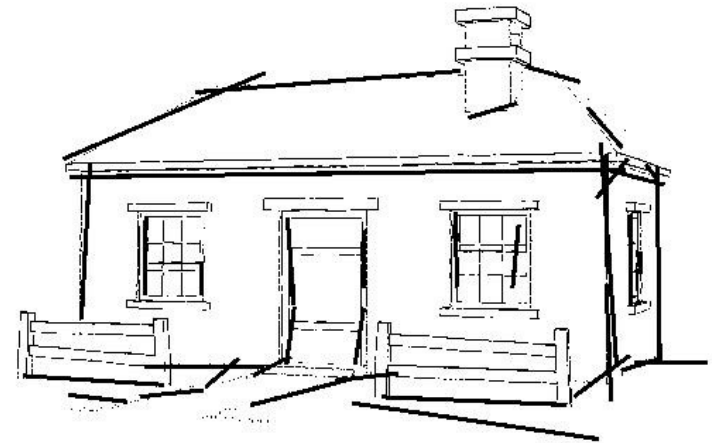
    then vertical, and so on

Indication

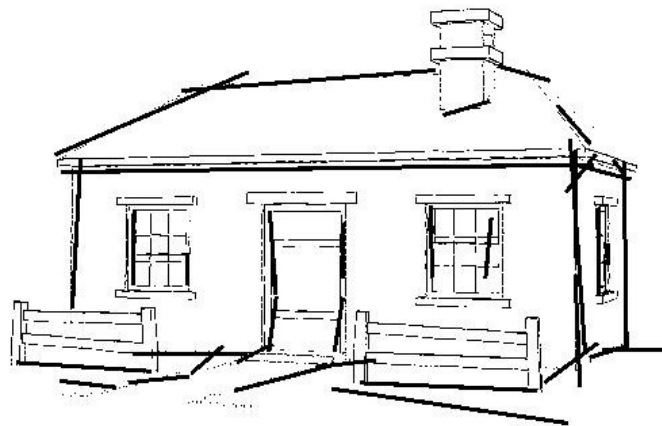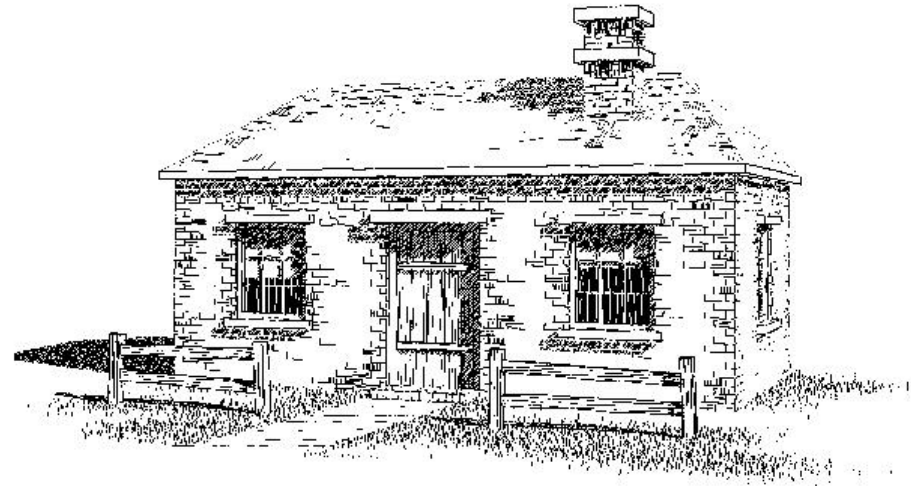Texturing uniform areas uniformly does not produce good results.
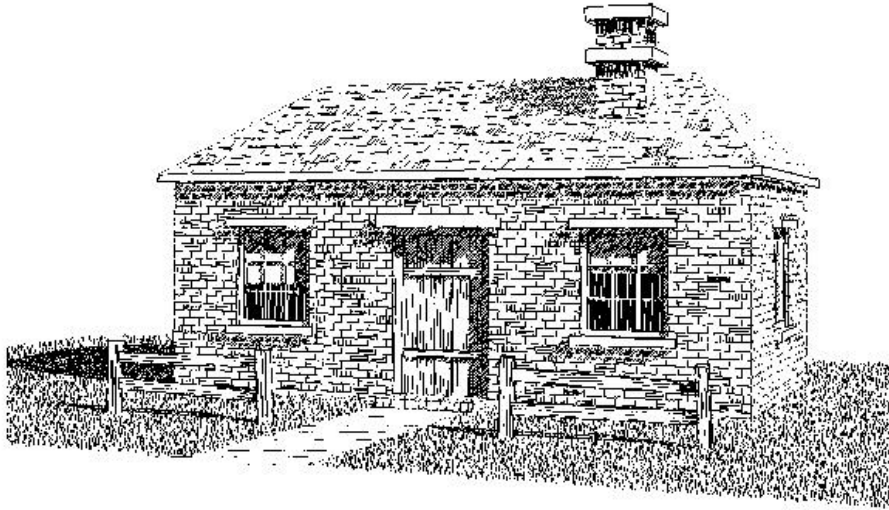
Indication is the process of adding guidelines for texturing

The distance of a pixel from the guide line indicates the amount of texture used

(Could be defined in the graphics scene)

Using Indication

Pencil Sketch - Quake

Main polygons shown - simple line shading - polygon edges rendered with stroke textures