COL783: Digital Image Processing

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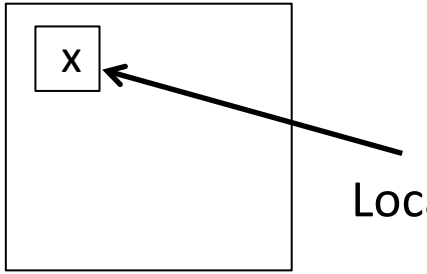
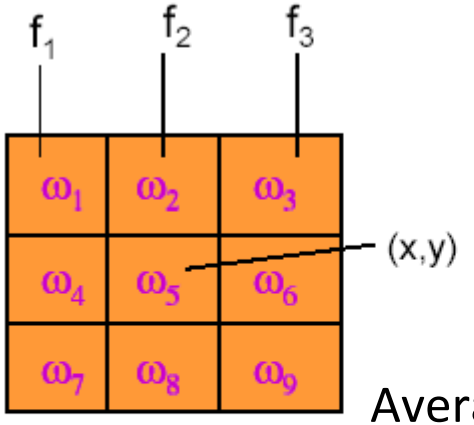
Recap: Image Enhancement in Spatial Domain

Local Histogram Equalization

Intensity at x is changed considering
the local histogram in a neighborhood region



Spatial Filtering



Replace f (x,y) with

$$\hat{f}(x,y) = \sum_i \omega_i f_i$$

Linear filter

Averaging Filter: Simple, Weighted Average
Gaussian

(Low Pass Filter)

Recap: Image Enhancement in Spatial Domain

Spatial Filtering

Median Filter: Salt and Pepper Noise removal
(Non Linear Filter)

Sharpening Filter: Enhance Details
(High Pass Filter)
Gradient Filter: Roberts
Prewitt
Sobel

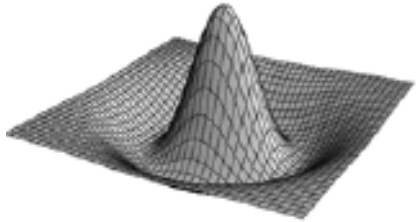
High Boost Filter

Image Enhancement in Spatial Domain

Laplace Filter

$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}$$

	1	
1	-4	1
	1	



In x direction second difference: f(x-1,y)-2f(x,y)+f(x+1,y)

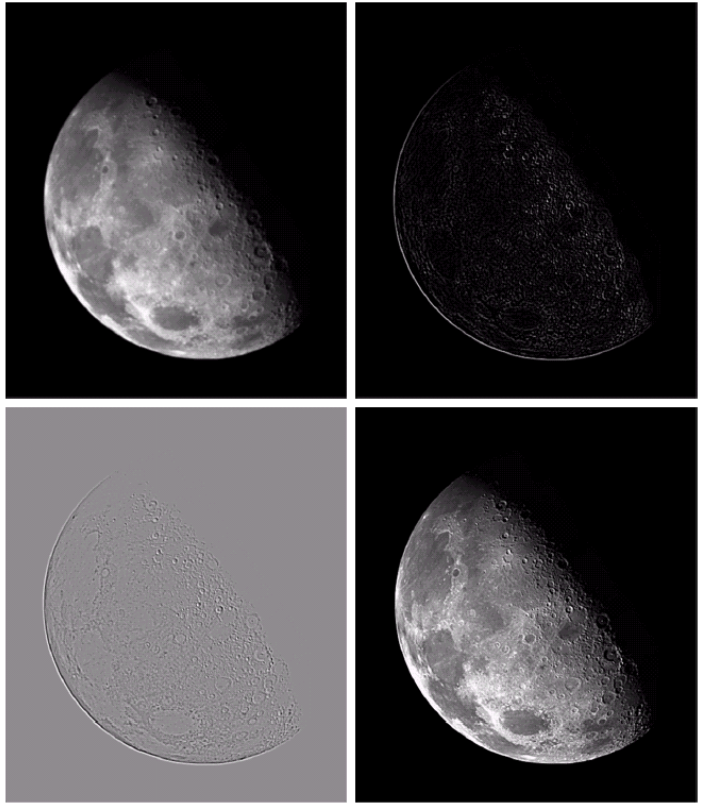
In y direction second difference: f(x,y-1)-2f(x,y)+f(x,y+1)

The combined difference:
f(x-1,y)+f(x+1,y)+f(x-1,y)+f(x+1,y)-4f(x,y)

0	0	-1	0	0
0	-1	-2	-1	0
-1	-2	16	-2	-1
0	-1	-2	-1	0
0	0	-1	0	0

Image Enhancement in Spatial Domain

Laplace Filter

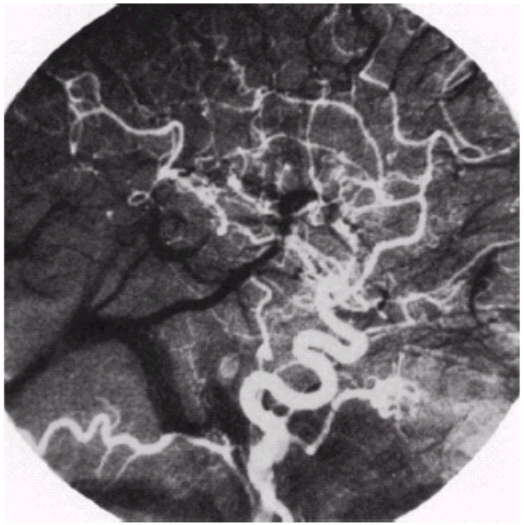


a b
c d

FIGURE 3.40 (a) Image of the North Pole of the moon. (b) Laplacian-filtered image. (c) Laplacian image scaled for display purposes. (d) Image enhanced by using Eq. (3.7-5). (Original image courtesy of NASA.)

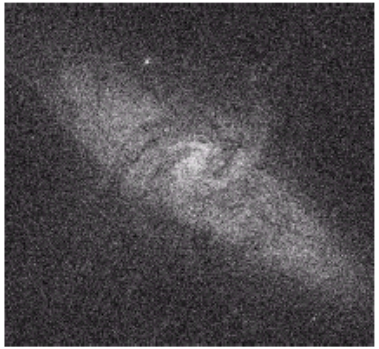
Image Enhancement in Spatial Domain

Image Subtraction



$$g(x,y) = f(x,y) - h(x,y)$$

Image Addition



Uncorrelated zero mean noise

$$g(x,y) = f(x,y) + n(x,y)$$

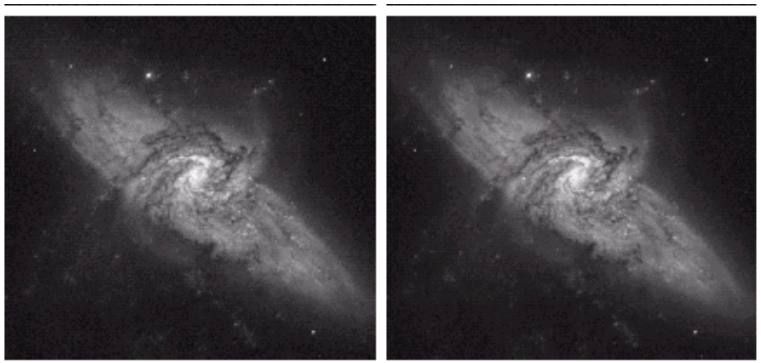
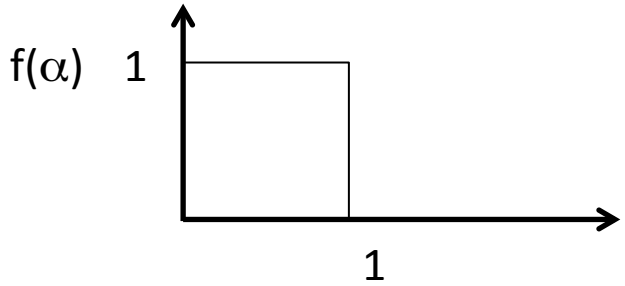


Image Enhancement in Spatial Domain

Convolution

1D Continuous Domain

$$f(x) * h(x) = \int_{-\infty}^{\infty} f(\alpha)h(x-\alpha)d\alpha$$



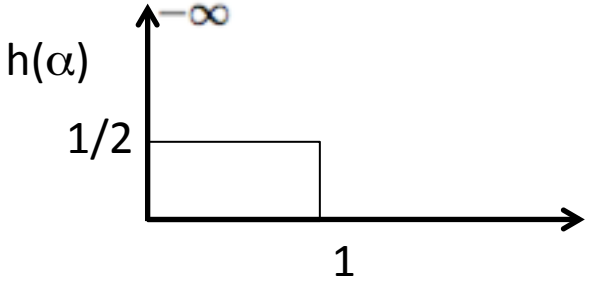
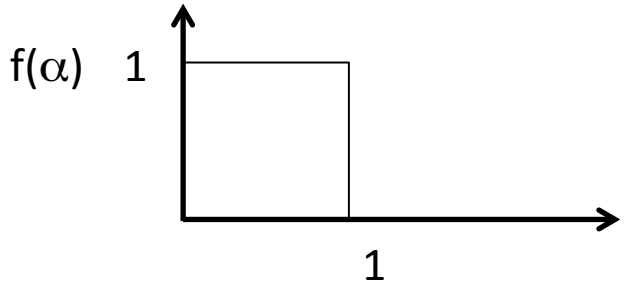


Image Enhancement in Spatial Domain

Convolution

1D Continuous Domain

$$f(x) * h(x) = \int_{-\infty}^{\infty} f(\alpha)h(x-\alpha)d\alpha$$



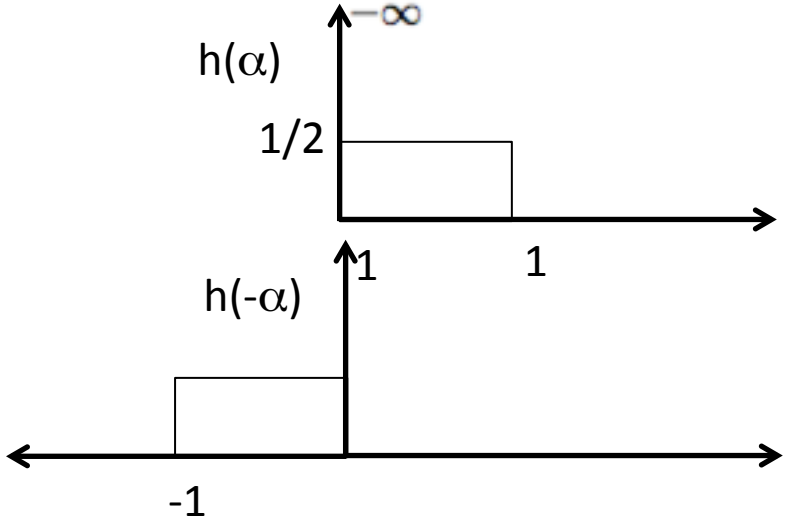


Image Enhancement in Spatial Domain

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1D Continuous Domain

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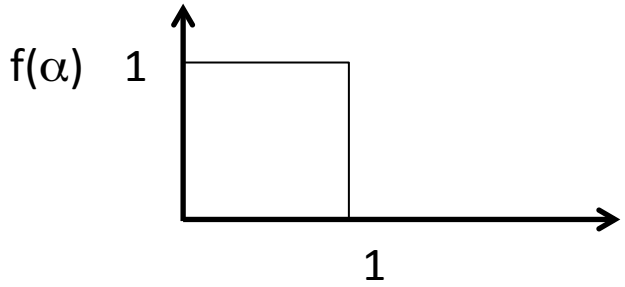


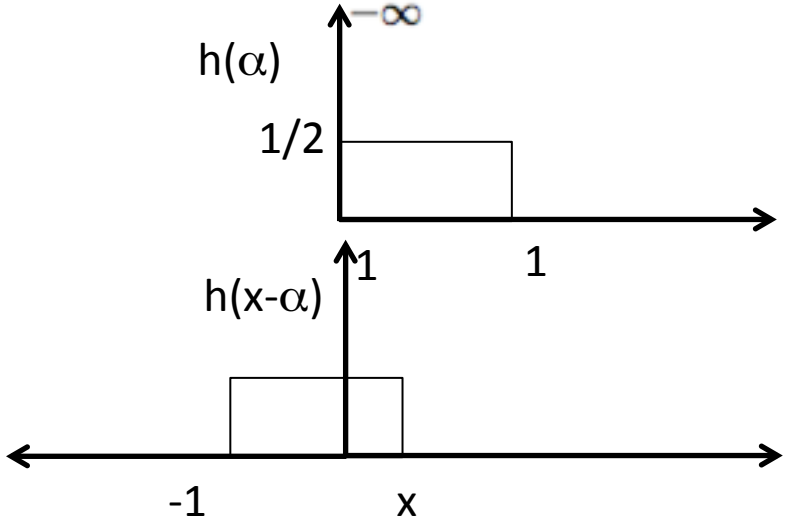


Image Enhancement in Spatial Domain

Convolution

1D Continuous Domain

$$f(x) * h(x) = \int_{-\infty}^{\infty} f(\alpha)h(x-\alpha)d\alpha$$

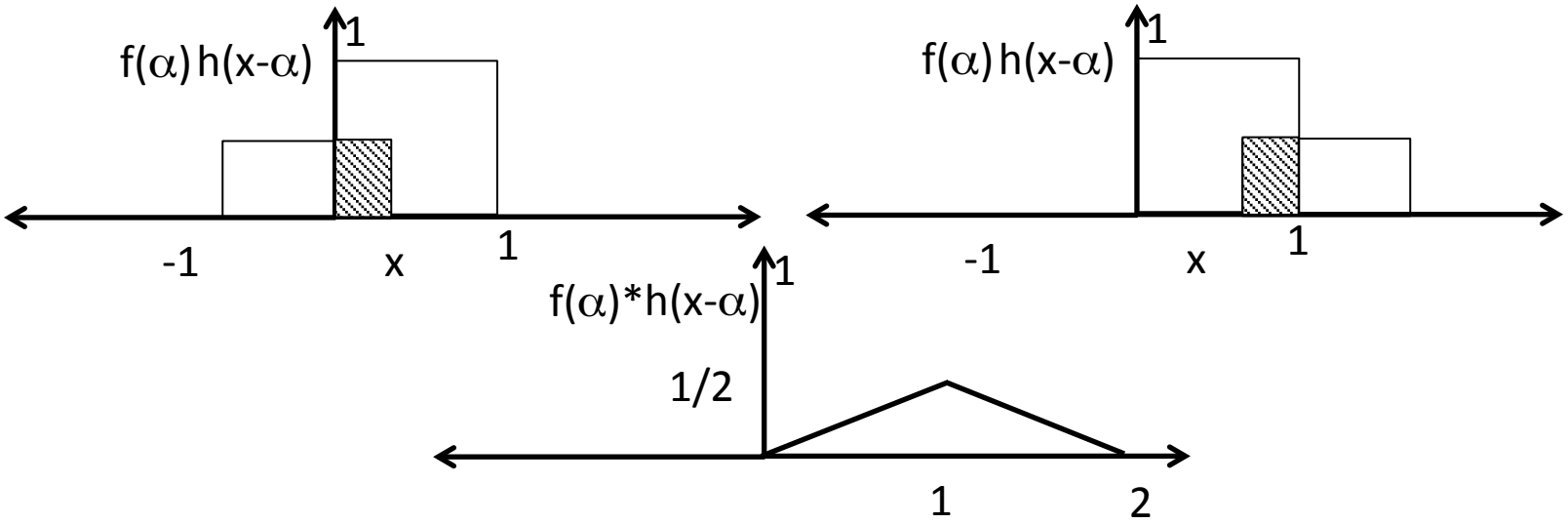


Image Enhancement in Spatial Domain

Convolution

1D Discrete Domain

$$f(x) * h(x) = \sum f(\alpha)h(x-\alpha)$$

f(α)

0	0	0	0	1	0	0	0	0	0

h(-α)

5	4	3	2	1

0	0	0	0	1	0	0	0	0	0

h(α)

1	2	3	4	5

Origin

Image Enhancement in Spatial Domain

Convolution

1D Discrete Domain

$$f(x) * h(x) = \sum f(\alpha) h(x - \alpha)$$

f(α)

0	0	0	0	1	0	0	0	0	0

h(x-α)

5	4	3	2	1

0	0	0	0	1	0	0	0	0	0

h(α)

1	2	3	4	5

Image Enhancement in Spatial Domain

Convolution

1D Discrete Domain

$$f(x) * h(x) = \sum f(\alpha)h(x-\alpha)$$

f(α)

0	0	0	0	1	0	0	0	0	0

h(x-α)

5	4	3	2	1

0	0	0	0	1	0	0	0	0	0

h(α)

1	2	3	4	5

Image Enhancement in Spatial Domain

Convolution

1D Discrete Domain

$$f(x) * h(x) = \sum f(\alpha)h(x-\alpha)$$

f(α)

0	0	0	0	1	0	0	0	0	0

h(x-α)

5	4	3	2	1

0	0	0	0	1	0	0	0	0	0

h(α)

1	2	3	4	5

Image Enhancement in Spatial Domain

Convolution

1D Discrete Domain

$$f(x) * h(x) = \sum f(\alpha)h(x-\alpha)$$

f(α)

0	0	0	0	1	0	0	0	0	0

h(x-α)

5	4	3	2	1

0	0	0	0	1	0	0	0	0	0

h(α)

1	2	3	4	5

Image Enhancement in Spatial Domain

Convolution

1D Discrete Domain

$$f(x) * h(x) = \sum f(\alpha)h(x-\alpha)$$

f(α)

0	0	0	0	1	0	0	0	0	0

h(α)

1	2	3	4	5

5	4	3	2	1

h(x-α)

0	0	0	0	1	2	3	4	5	0

Image Enhancement in Spatial Domain

Convolution

1D Discrete Domain

$$f(x) * h(x) = \sum f(\alpha)h(x-\alpha)$$

f(α)

0	0	0	0	1	0	0	0	0	0

h(α)

1	2	3	4	5

5	4	3	2	1

h(x-α)

0	0	0	0	1	2	3	4	5	0	0

Image Enhancement in Spatial Domain

Convolution

1D Discrete Domain

$$f(x) * h(x) = \sum f(\alpha)h(x-\alpha)$$

f(α)

0	0	0	0	1	0	0	0	0	0

h(α)

1	2	3	4	5

5	4	3	2	1

h(x-α)

0	0	0	0	1	2	3	4	5	0	0	0	0	0	0

Result

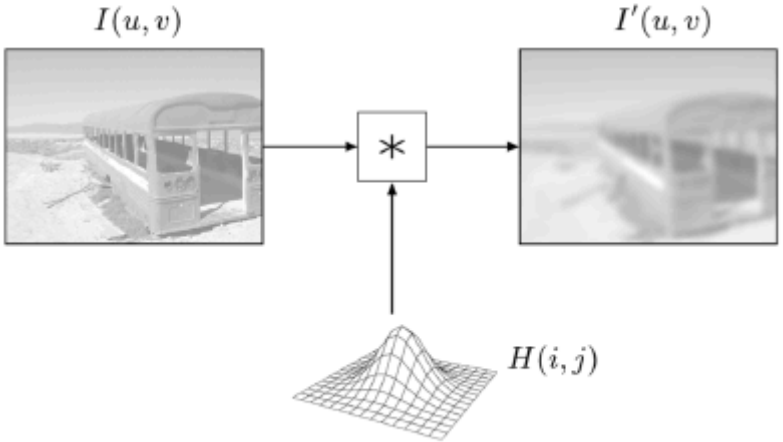
Image Enhancement in Spatial Domain

Convolution

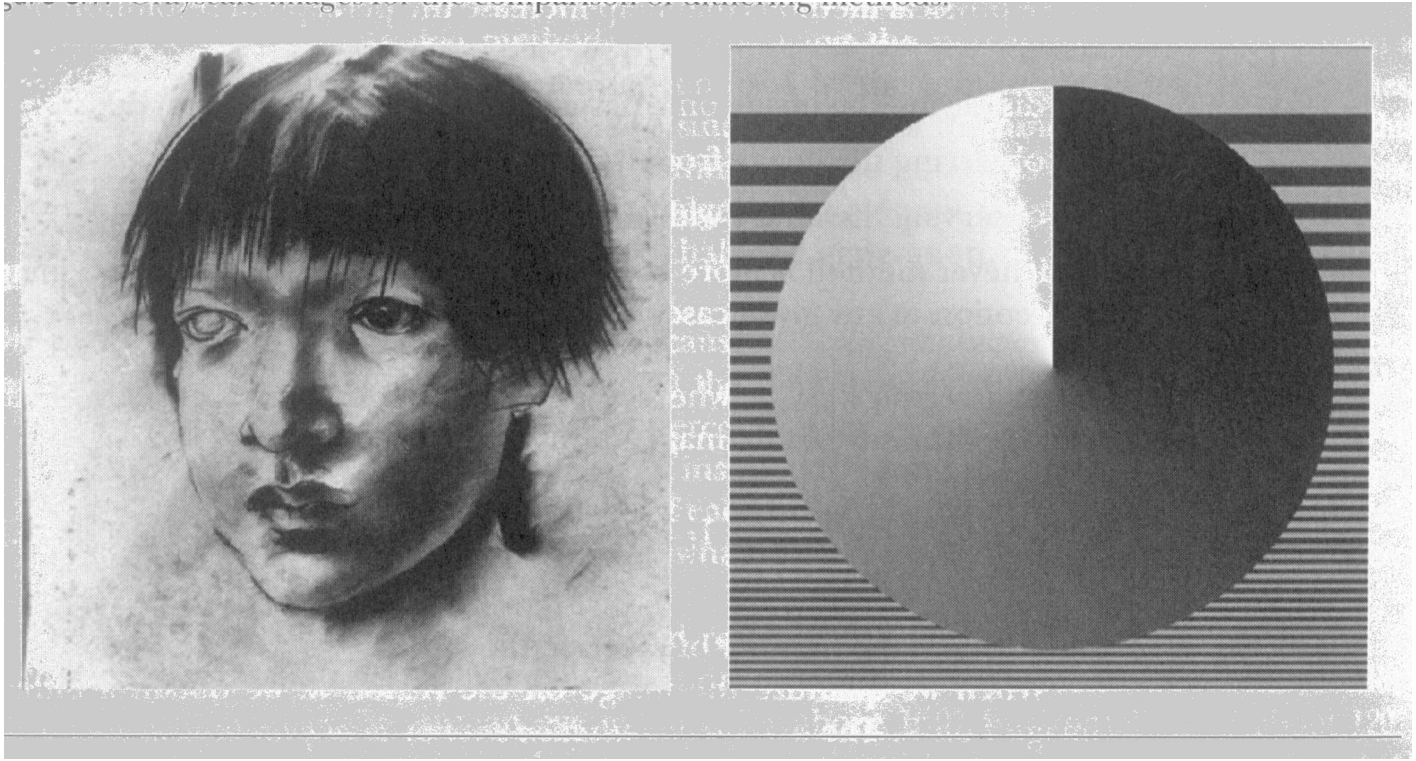
$$I'(u,v) = \sum_{i=-\infty}^{\infty} \sum_{j=-\infty}^{\infty} I(u-i, v-j) \cdot H(i,j)$$

Formal definition:
Sum to ± ∞

$$I' = I * H$$



Halftoning



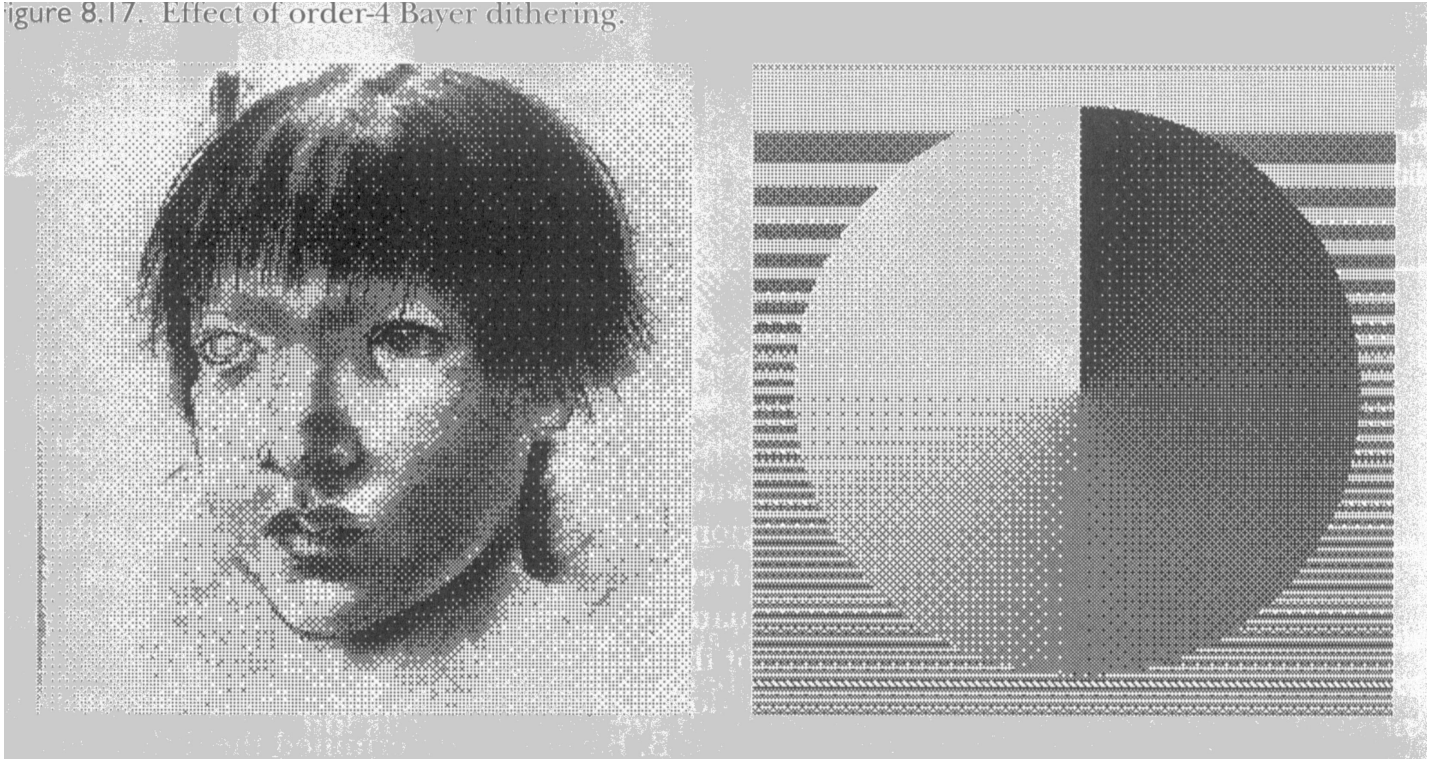
Halftoning

Figure 8.2. Two-level quantization with 50% threshold.

Halftoning

Figure 8.3. Effect of dithering by random modulation.

Halftoning



Halftoning

Floyed Steinberg Method

Halftoning

Floyed Steinberg Method

original image

original image after the application of Floyd-Steinberg dithering