Sharpening Filters

Laplacian (second derivative)

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

$$\frac{\partial^2 f}{\partial x^2} = f(x+1, y) + f(x-1, y) - 2f(x, y)$$

$$\frac{\partial^2 f}{\partial y^2} = f(x, y+1) + f(x, y-1) - 2f(x, y)$$

$$\nabla^2 f(x, y) = f(x+1, y) + f(x-1, y) + f(x, y+1) + f(x, y-1) - 4f(x, y)$$

Laplacian operators

0	1	0
1	−4	1
0	1	0

1	1	1
1	−8	1
1	1	1

0	−1	0
−1	4	−1
0	−1	0

−1	−1	−1
−1	8	−1
−1	−1	−1

a b
c d

FIGURE 3.37 (a) Filter mask used to implement Eq. (3.6-6). (b) Mask used to implement an extension of this equation that includes the diagonal terms. (c) and (d) Two other implementations of the Laplacian found frequently in practice.

Laplacian

$$g(x, y) = f(x, y) + c\left[\nabla^2 f(x, y)\right]$$

$$f_m = f - \min(f)$$

$$f_s = K\left[f_m / \max(f_m)\right]$$

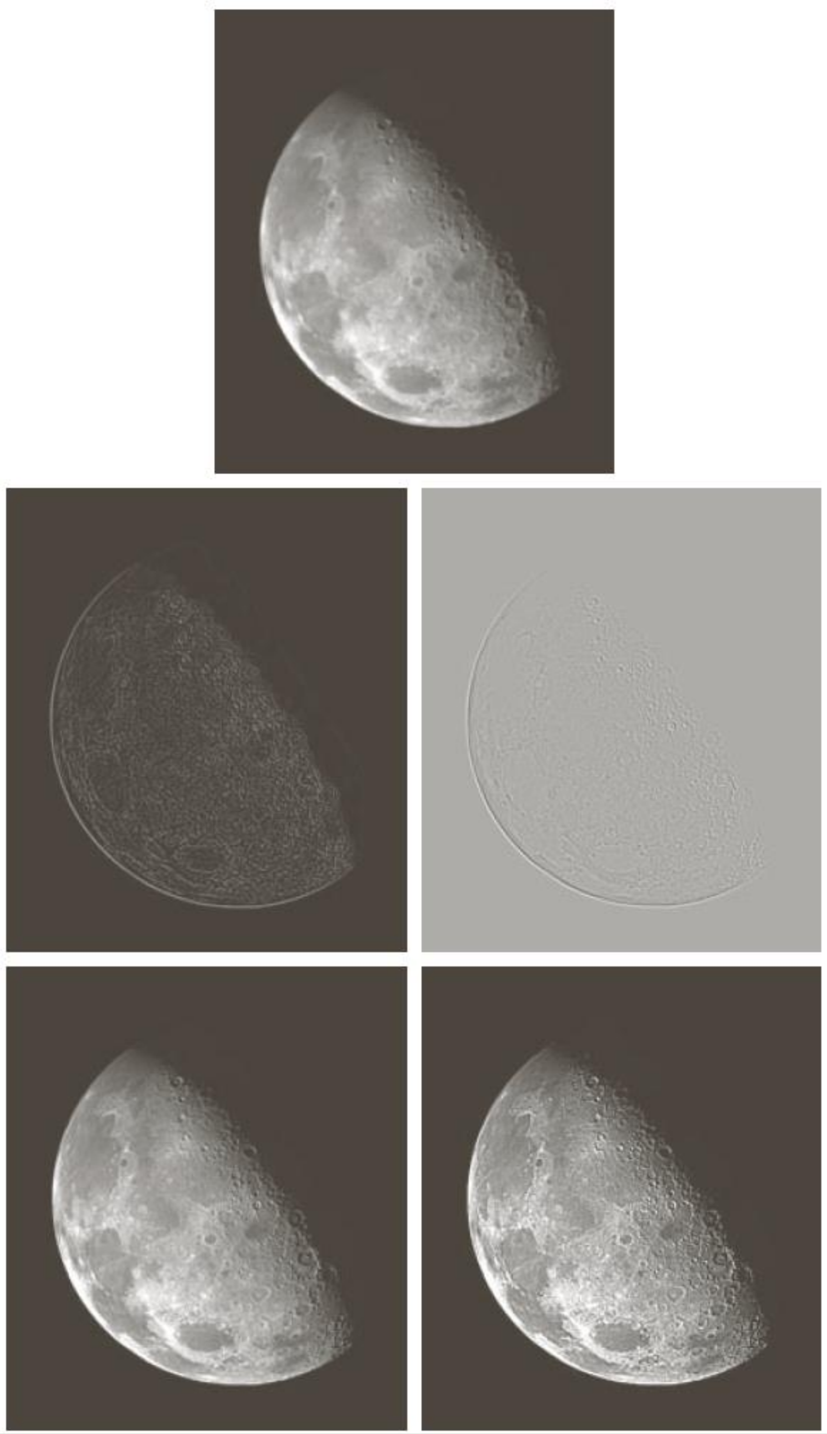

FIGURE 3.38 (a) Blurred image of the North Pole of the moon. (b) Laplacian without scaling. (c) Laplacian with scaling. (d) Image sharpened using the mask in Fig. 3.37(a). (e) Result of using the mask in Fig. 3.37(b). (Original image courtesy of NASA.)

Laplacian in OpenCV

cv2.Laplacian (src, dst, ddepth, ksize)

Cv2. Laplacian(input, laplacian, CV_32F, 1);

Unsharp Masking and Highboost Filtering

1. Blur the original image
2. Subtract the blurred image from the original (the resulting difference is called the mask)

$$g_{\text{mask}}(x, y) = f(x, y) - \bar{f}(x, y)$$

3. Add the mask to the original

$$g(x, y) = f(x, y) + k * g_{\text{mask}}(x, y)$$

Mechanics of unsharp masking

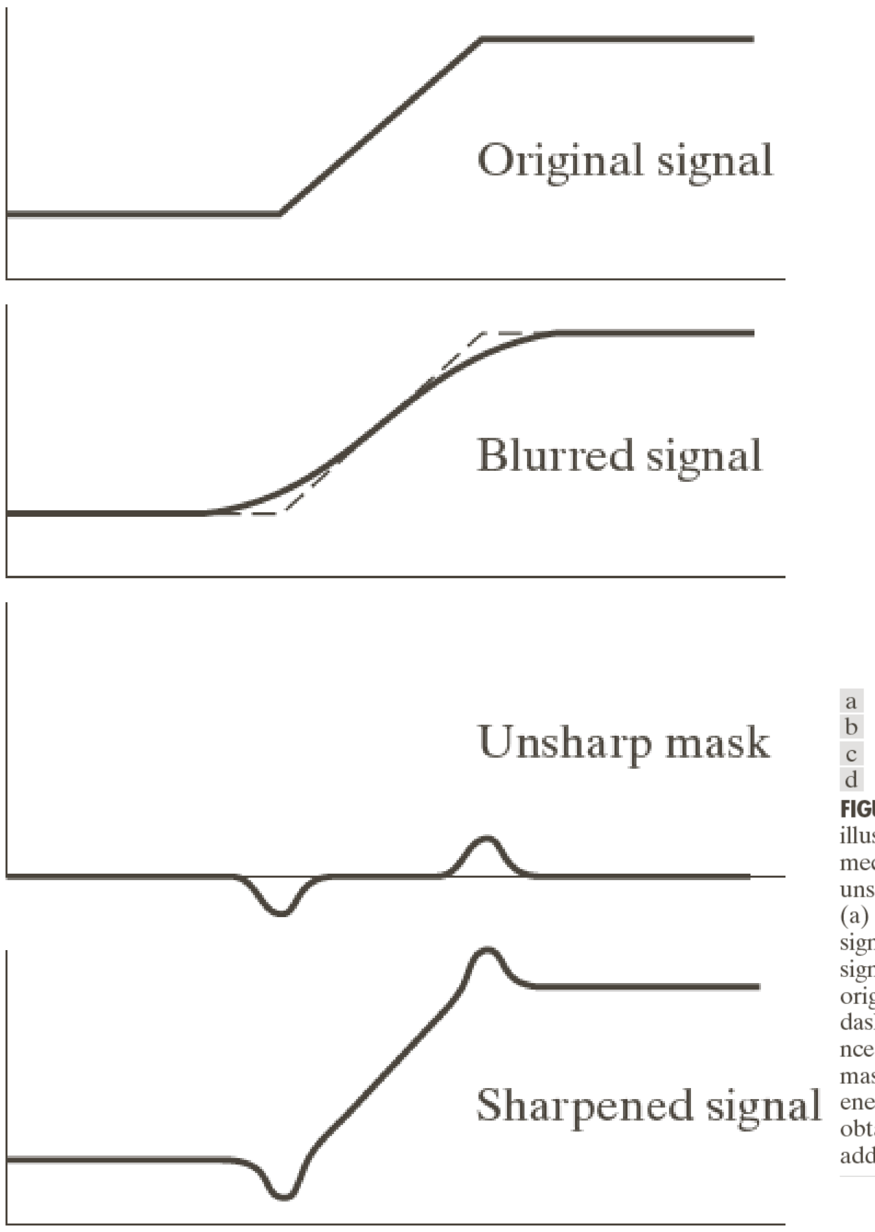

FIGURE 3.39 1-D illustration of the mechanics of unsharp masking. (a) Original signal. (b) Blurred signal with original shown dashed for reference. (c) Unsharp mask. (d) Sharpened signal, obtained by adding (c) to (a).

Unsharp Masking and Highboost Filtering

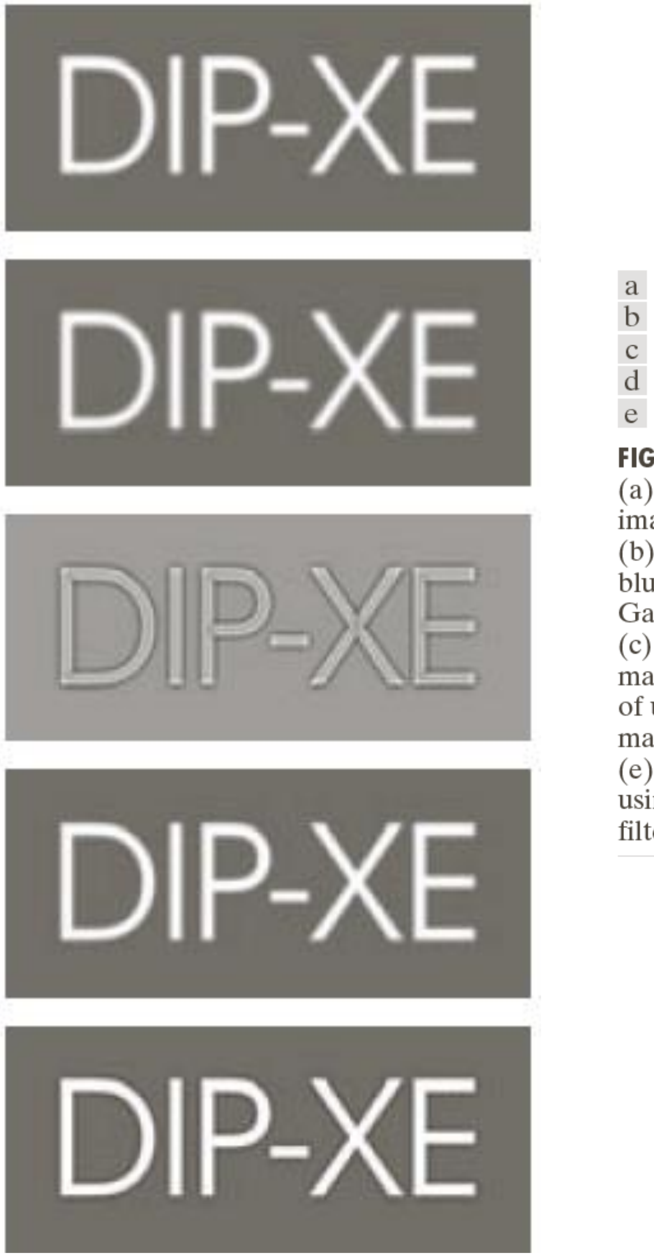

FIGURE 3.40 (a) Original image. (b) Result of blurring with a Gaussian filter. (c) Unsharp mask. (d) Result of using unsharp masking. (e) Result of using highboost filtering.