SLIIT

Discover Your Future

IT4130 – Image Understanding and Processing

Lecture 05 – Sharpening Filters

SLIIT
FACULTY OF COMPUTING

Averaging and Sharpening

- Averaging
  - Blurs and reduces noise
  - Averaging/integration
  - Used in removing small details and object extraction
- Sharpening
  - Highlight fine details
  - Differentiation
  - Used in enhancing edges and other discontinuities.

Differentiation

- Differentiation may be used for edge enhancement (detail sharpening)
- The most common method for differentiating is the *gradient*.
- For *f(x,y)* the gradient of *f* at *(x,y)* is defined as:

$$\nabla f = \begin{bmatrix} \dfrac{\partial f}{\partial x} \\ \dfrac{\partial f}{\partial y} \end{bmatrix}$$

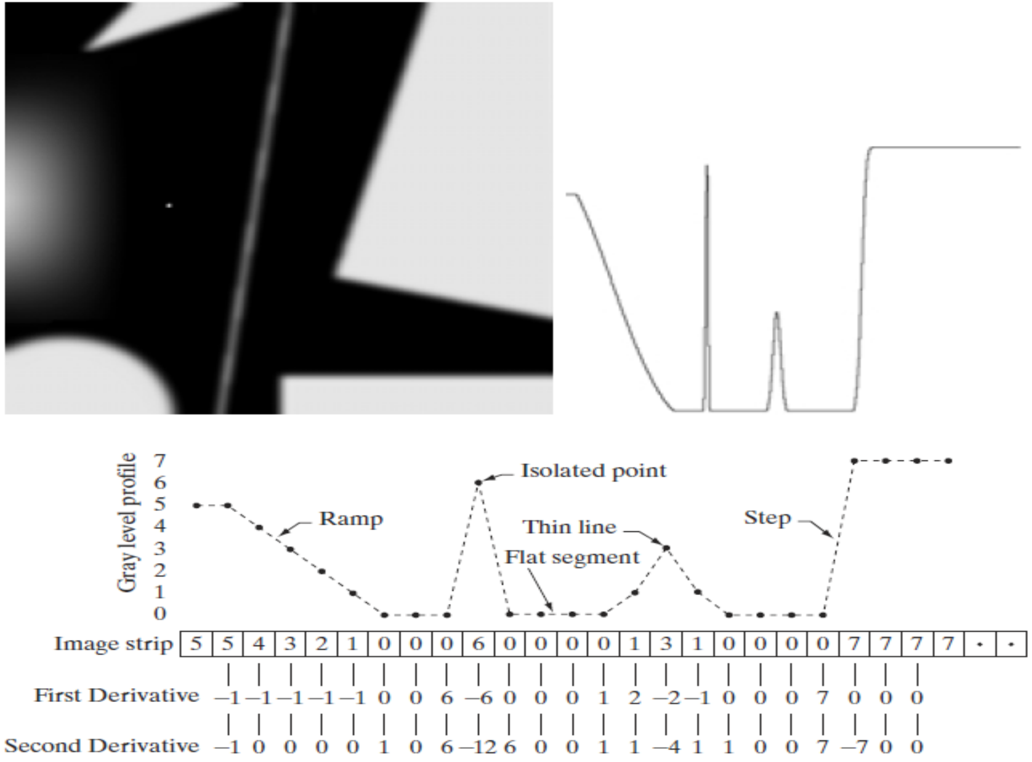
Derivative Functions

- First-order derivative of a 1-D function, $f(x)$, $$\frac{\partial f}{\partial x} = f(x+1) - f(x)$$
- Second-order derivative of $f(x)$, $$\frac{\partial^2 f}{\partial x^2} = f(x+1) + f(x-1) - 2f(x)$$

Image derivatives

a b
c

FIGURE 3.38 (a) A simple image. (b) 1-D horizontal gray-level profile along the center of the image and including the isolated noise point. (c) Simplified profile (the points are joined by dashed lines to simplify interpretation).



Derivatives

- First Order
  - Thicker edges
  - Stronger response to gray-level step
- Second Order
  - Thin lines and isolated points
  - A double (pos/neg) response at step changes – (step, line and a point)

Derivatives

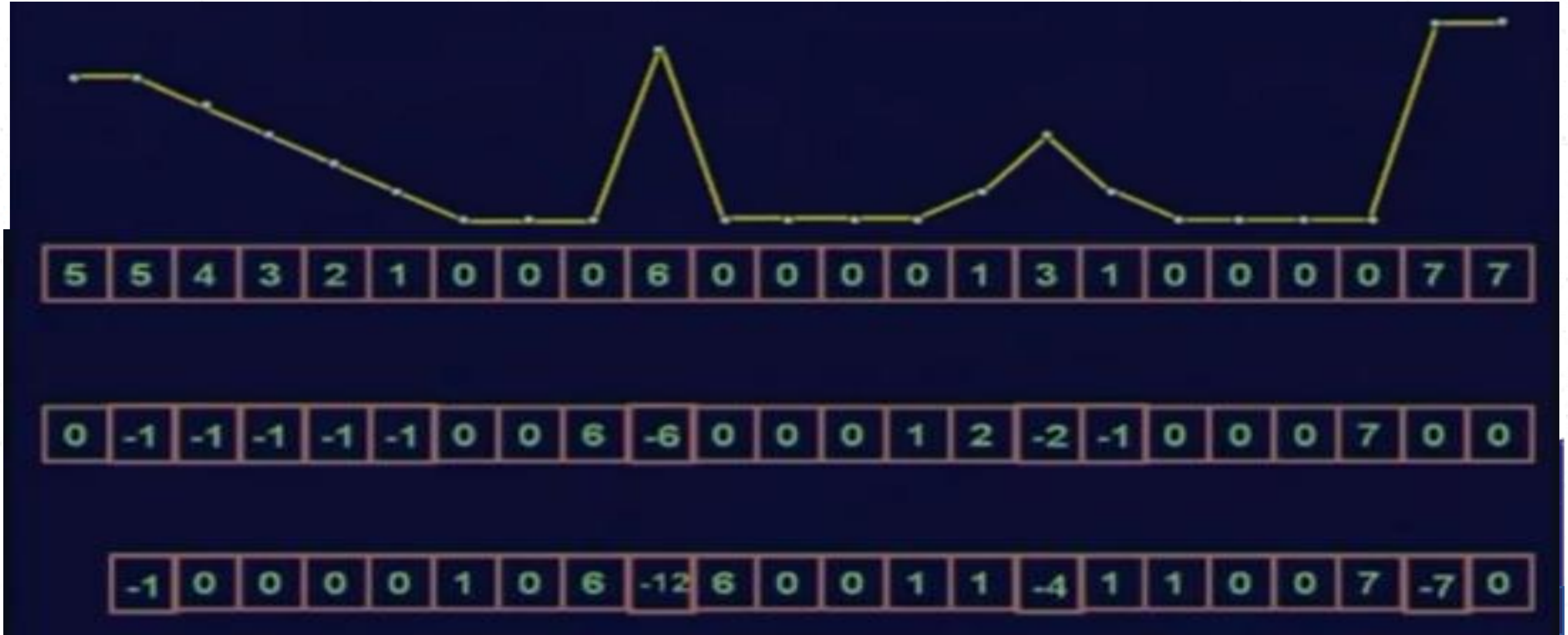
First Order Derivative Filter:

- Must be zero in areas of constant gray level
- Non zero at the onset/start of a gray level step or ramp
- Non zero along ramps

Second Order Derivative Filter:

- Zero in flat areas
- Non zero at onset/start and end of a gray level step or ramp
- Zero along ramps of constant slope

1st and 2nd order derivatives

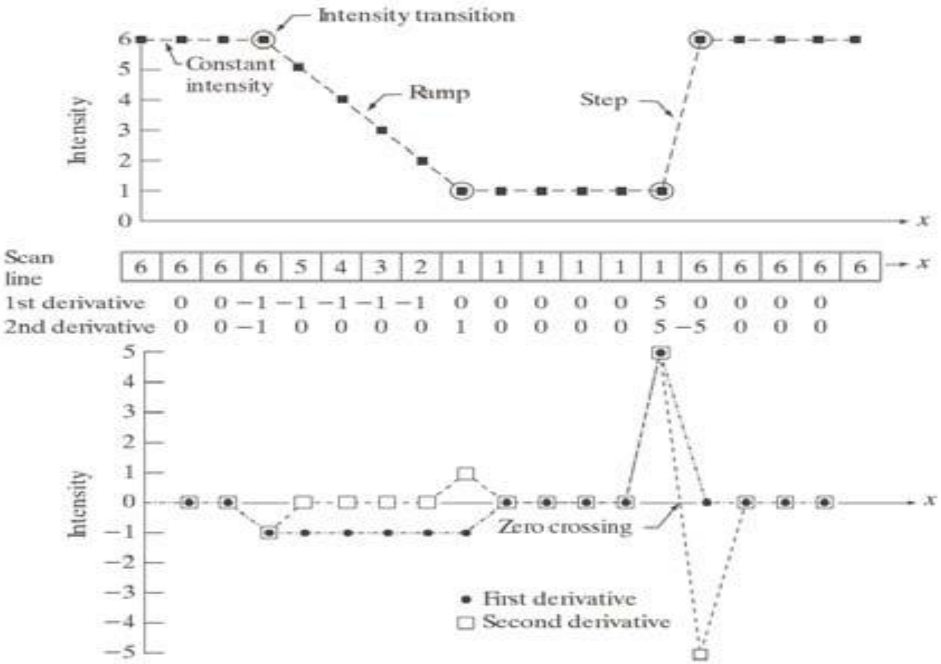


Observations

- First order derivative generally produce thicker edges in an image
- Second order derivatives give stronger response to the fine details such as thin lines and isolated points
- First order derivatives have stronger response to gray level step
- Second order derivatives produce a double response at step edges

  \- Second order derivatives are better suited for image enhancement

1st and 2nd order derivatives



a
b
c

FIGURE 3.36 Illustration of the first and second derivatives of a 1-D digital function representing a section of a horizontal intensity profile from an image. In (a) and (c) data points are joined by dashed lines as a visualization aid.

The Laplacian

- Derivation
  - Define two dimensional (2D) isotropic Laplaciain operator
  - write 2D second – order derivative in x direction
  - write 2D second – order derivative in y direction
  - Draw the simple Laplacian mask
  - Apply to diagonals
- Applying
  - Based on the sign of the center value
    - <0 – subtract
    - >0 – add
  - Derive the composite Laplacian

Laplace operator

0	1	0
1	−4	1
0	1	0

1	1	1
1	−8	1
1	1	1

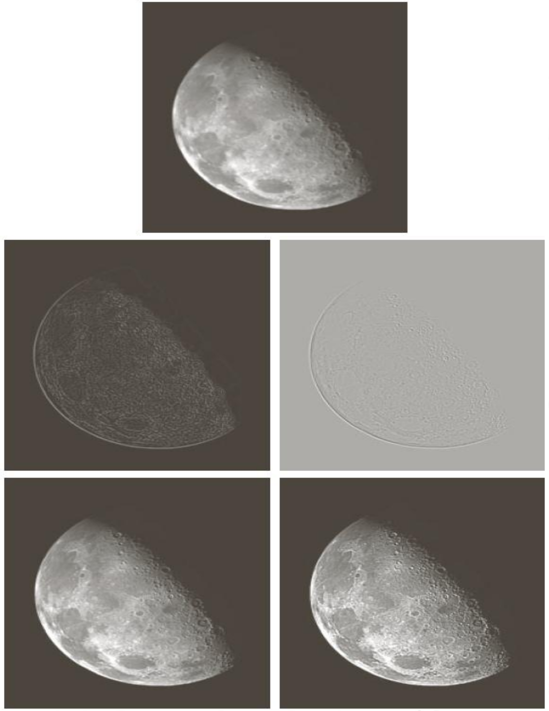
0	−1	0
−1	4	−1
0	−1	0

−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.

Example - Laplace operator



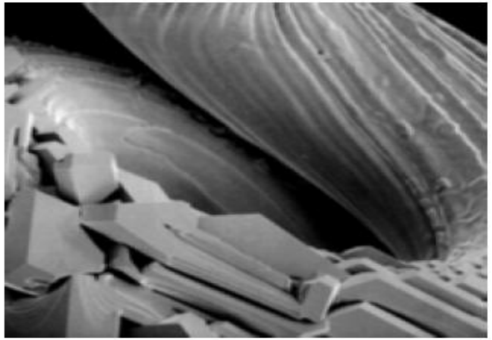
a	
b	c
d	e

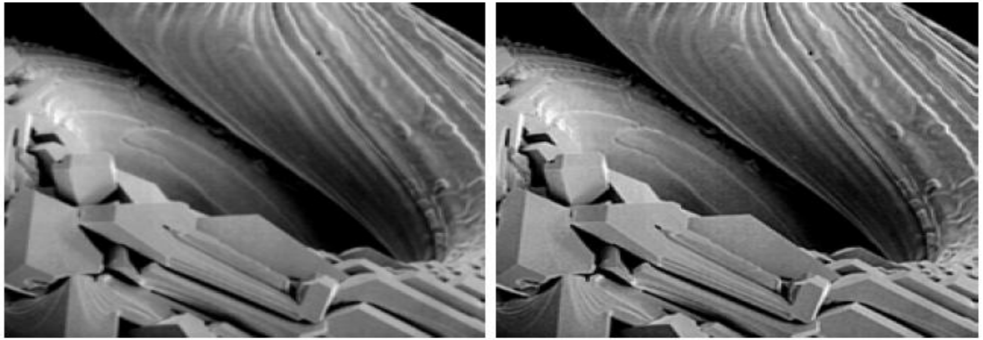
FIGURE 3.38 (a) Blurred image of the North Pole of the moon. (b) Laplacian without scaling. (c) Laplacian with scaling. (d) Image sharpened using the mask in Fig. 3.37(a). (e) Result of using the mask in Fig. 3.37(b). (Original image courtesy of NASA.)

Basic and composite Laplacian

0	−1	0
−1	5	−1
0	−1	0

−1	−1	−1
−1	9	−1
−1	−1	−1





a b c
d e

FIGURE 3.41 (a) Composite Laplacian mask. (b) A second composite mask. (c) Scanning electron microscope image. (d) and (e) Results of filtering with the masks in (a) and (b), respectively. Note how much sharper (e) is than (d). (Original image courtesy of Mr. Michael Shaffer, Department of Geological Sciences, University of Oregon, Eugene.)

Highpass filters

- The shape of the impulse response needed to implement a highpass (sharpening) filter indicates the filter should have positive coefficients near its center and negative coefficients in the outer periphery
- For a 3x3 mask, the simplest arrangement is to have the center coefficient positive and all others negative
  - Note the sum of the coefficients is zero
- Reducing the average gray-level value to zero implies some negative gray levels
  - The output should be scaled back into an appropriate range [0, L-1]

Unsharp Masking and high-boost filtering

- Unsharp masking => $f_{um} = f - f_{blurred}$
- high-boost filtering
    - $f_{hb} = A * f - f_{blurred}$
    - $f_{hb} = (A-1) * f - f_{sharpened}$
    - when $f_{sharpened}$ is Basic Laplacian
        - $f_{hb} = A * f - \partial^2 f_,$ centre coefficient <0

Different Examples of High-Boost

0	-1	0
-1	A+4	-1
0	-1	0

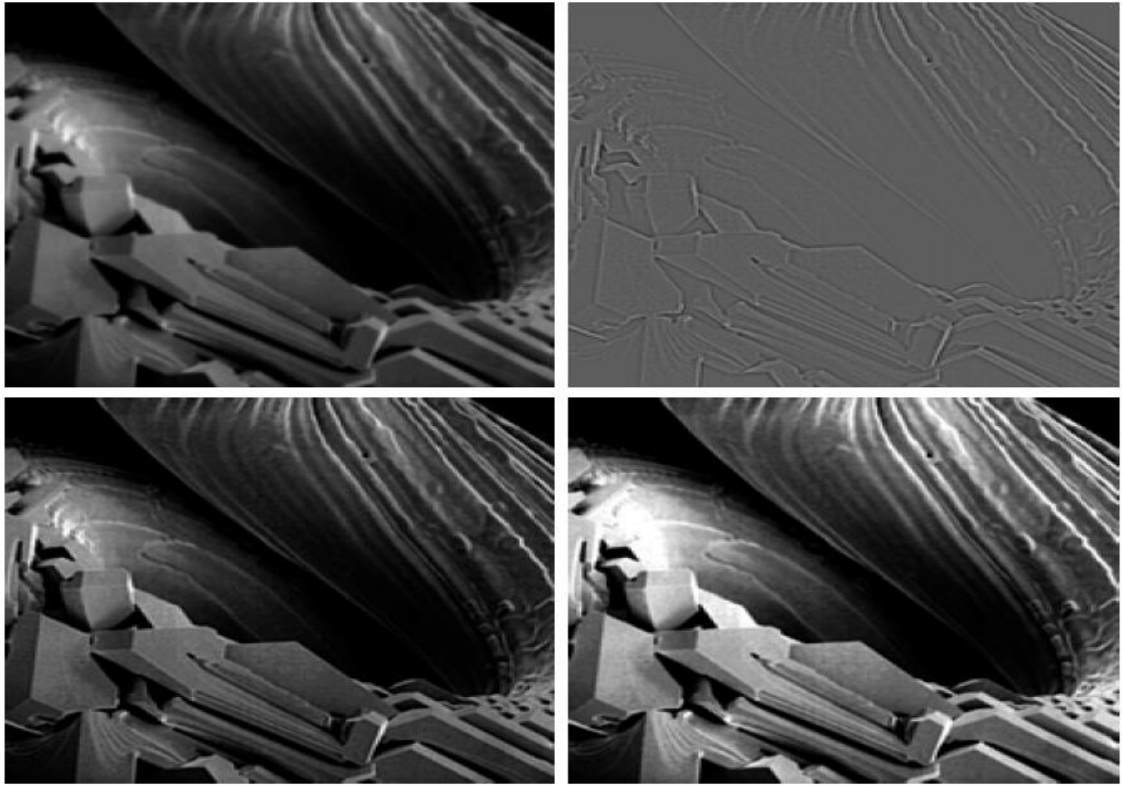
a

0	-1	0
-1	A+8	-1
0	-1	0

b

a	b
c	d

FIGURE 3.43
(a) Same as Fig. 3.41(c), but darker.
(a) Laplacian of (a) computed with the mask in Fig. 3.42(b) using $A = 0$.
(c) Laplacian enhanced image using the mask in Fig. 3.42(b) with $A = 1$. (d) Same as (c), but using $A = 1.7$.



SLIIT FACULTY OF COMPUTING

- In practice, multiple filters are combined to enhance images
- We will learn the use of more masks under edge detection.