SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

19ECE301 – IMAGE PROCESSING AND COMPUTER VISION

III B.E. ECE / V SEMESTER

UNIT 2 – IMAGE ENHANCEMENT AND RESTORATION

TOPIC – SHARPENING AND SMOOTHENING

SMOOTHING LINEAR FILTERS

- Smoothing is often used to reduce noise within an image.

- Image smoothing is a key technology of image enhancement, which can remove noise in images. So, it is a necessary functional module in various image-processing software.

- Image smoothing is a method of improving the quality of images.

- Smoothing is performed by spatial and frequency filters

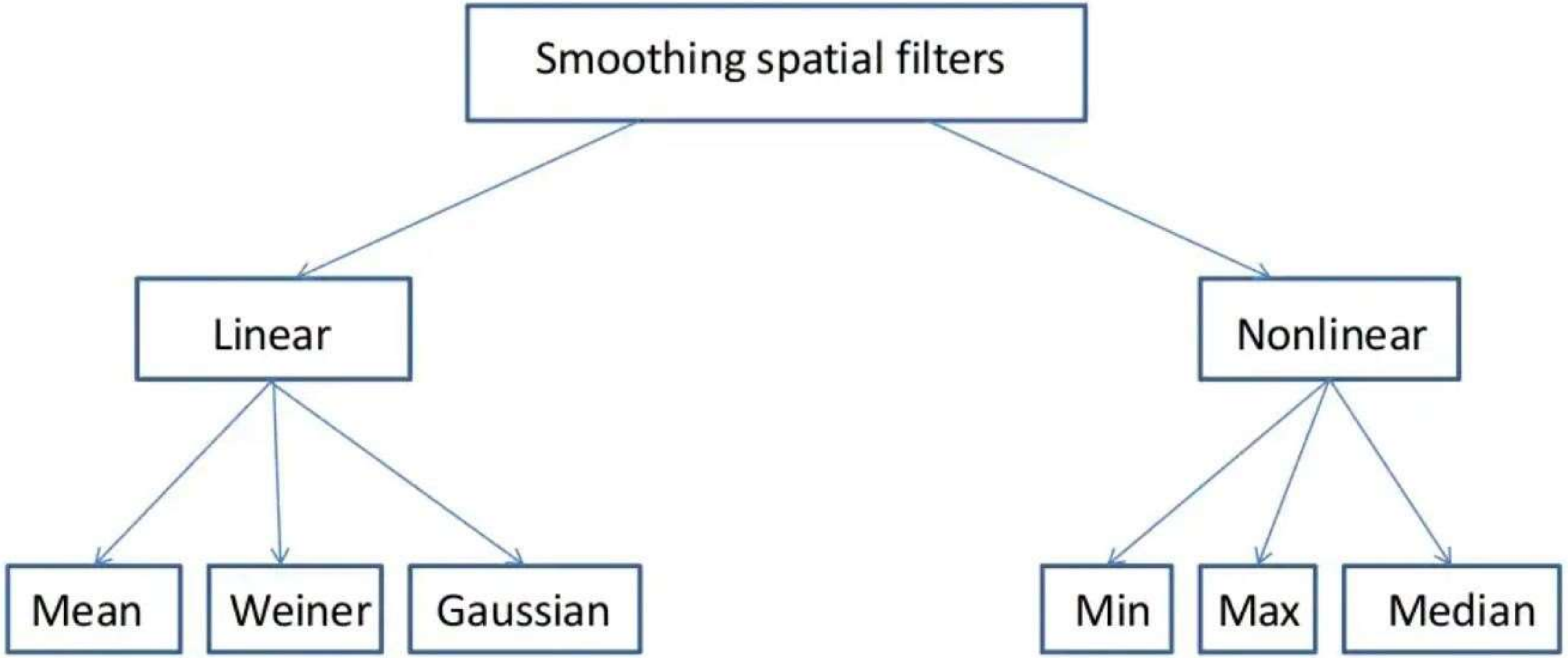
SPATIAL FILTERING

- Spatial filtering term is the filtering operations that are performed directly on the pixels of an image. The process consists simply of moving the filter mask from point to point in an image.
  - Smoothing spatial filters
  - Sharpening spatial filters

SMOOTHING SPATIAL FILTERS

- Smoothing filters are used for noise reduction and blurring operations.
- It takes into account the pixels surrounding it in order to make a determination of a more accurate version of this pixel.
- By taking neighboring pixels into consideration, extreme “noisy” pixels can be filtered out.
- Unfortunately, extreme pixels can also represent original fine details, which can also be lost due to the smoothing process

SMOOTHING SPATIAL FILTERS



SMOOTHING LINEAR FILTERS

- Smoothing linear spatial filter is the average of the pixels contained in the neighborhood of the filter mask.

- Averaging filters or low pass filters.
  - Mean filter
  - Gaussian filter

MEAN FILTER/BOX FILTER

- Mean filtering is simply to replace each pixel value in an image with the mean (`average') value of its neighbors, including itself.

- 3×3 normalized box filter:

20	40	10
10	20	20
10	20	30

→

20	40	10
10	**20**	20
10	20	30

MEAN FILTER/BOX FILTER

- Image smoothed with 3×3, 5×5, 9×9 and 11 ×11 box filters

MEAN FILTER/BOX FILTER

- Often a 3×3 square matrix is used, although larger matrix (*e.g.* 5×5 squares) can be used for more severe smoothing.

- **Drawback:**
  – smoothing reduces fine image detail

GAUSSIAN FILTER

- A Gaussian filters smoothens an image by calculating weighted averages in a filter box.
- It is used to `blur' images and remove detail and noise.
- Gives more weight at the central pixels and less weights to the neighbors.
- The farther away the neighbors, the smaller the weight.
- Gaussian Blurs produce a very pure smoothing effect without side effects.

$$\frac{1}{2\pi\sigma^2}\exp\{-\frac{x^2+y^2}{2\sigma^2}\}$$

GAUSSIAN SMOOTHING EXAMPLE

Original

Sigma = 3

SHARPENING SPATIAL FILTERS

- The objective of sharpening is to highlight fine detail in an image or to enhance detail that has been blurred
- Image sharpening include applications ranging from electronic printing and medical imaging to industrial inspection and autonomous guidance in military systems
- Image blurring could be accomplished in the spatial domain by pixel averaging in a neighborhood. Hence, it is logical to conclude that sharpening could be accomplished by spatial differentiation

SHARPENING SPATIAL FILTERS

- Fundamentally, the strength of the response of a derivative operator is proportional to the degree of discontinuity of the image at the point at which the operator is applied
- Thus, image differentiation enhances edges and other discontinuities (such as noise) and deemphasizes areas with slowly varying gray-level values
- A basic definition of the first-order derivative of a one-dimensional function f(x) is the difference

$$\frac{\partial f}{\partial x} = f(x+1) - f(x).$$

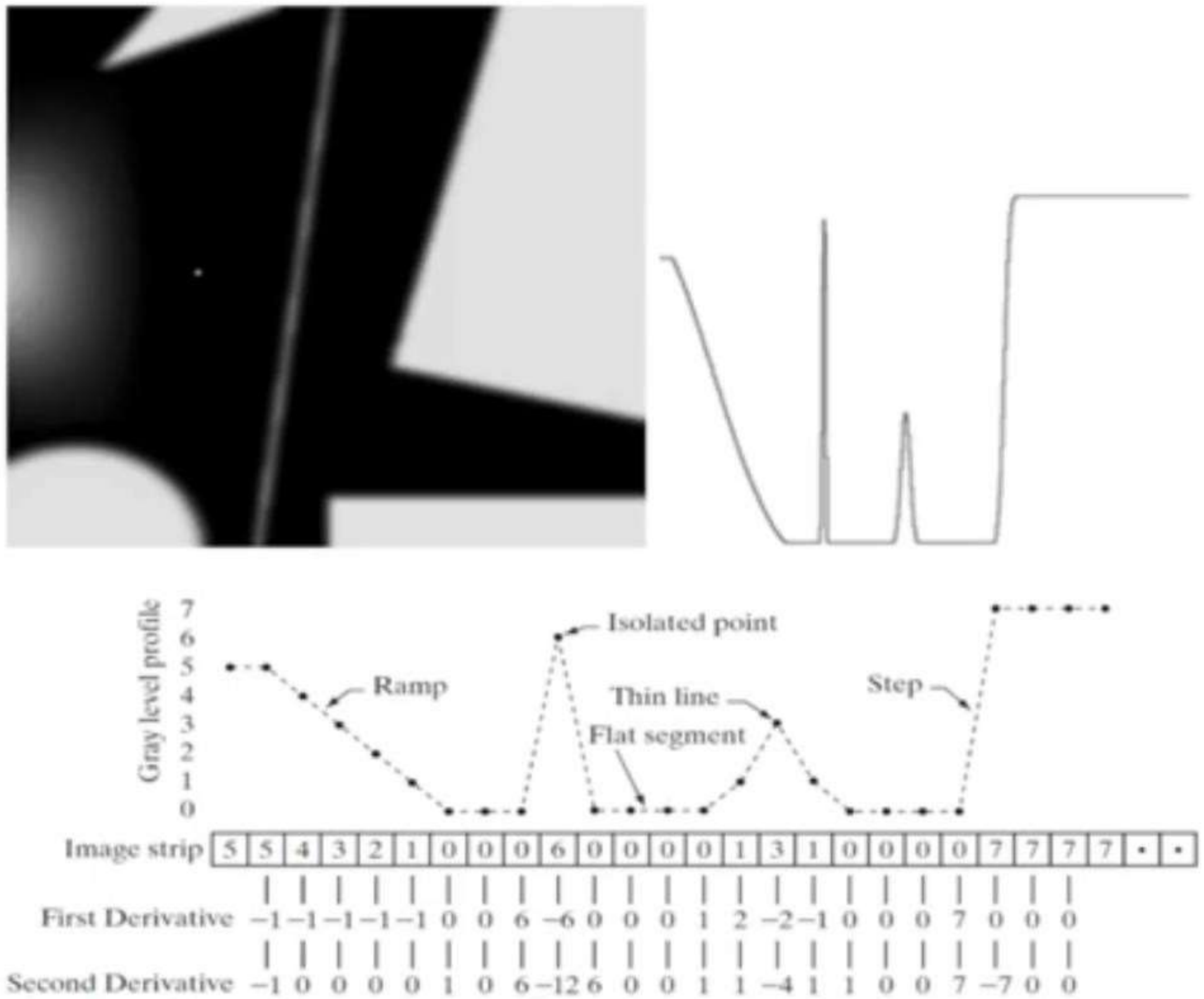
SHARPENING SPATIAL FILTERS

- Similarly, we define a second-order derivative as the difference

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

- We shall consider an image function of two variables f(x,y)
- Next figure (a) shows a simple image that contains various solid objects, a line, and a single noise point

SHARPENING SPATIAL FILTERS



(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)

SHARPENING SPATIAL FILTERS

- In simplified diagram the transition in the ramp spans four pixels, the noise point is a single pixel, the line is three pixels thick, and the transition into the gray-level step takes place between adjacent pixels
- The number of gray levels was simplified to only eight levels
- Consider the properties of the first and second derivatives as we traverse the profile from left to right
- First, we note that the first-order derivative is nonzero along the entire ramp, while the second-order derivative is nonzero only at the onset and end of the ramp

SHARPENING SPATIAL FILTERS

- Because edges in an image resemble this type of transition, we conclude that first-order derivatives produce "thick" edges and second-order derivatives, much finer ones
- Next we encounter the isolated noise point
- Here, the response at and around the point is much stronger for the second-order than for the first-order derivative
- A second-order derivative is much more aggressive than a first-order derivative in enhancing sharp changes
- Thus, we can expect a second-order derivative to enhance fine detail (including noise) much more than a first-order derivative

SHARPENING SPATIAL FILTERS

Use of Second Derivatives for Enhancement: The Laplacian

- The simplest isotropic derivative operator is the Laplacian, which, for a function (image) f(x,y) of two variables, is defined as

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

SHARPENING SPATIAL FILTERS

0	1	0
1	–4	1
0	1	0

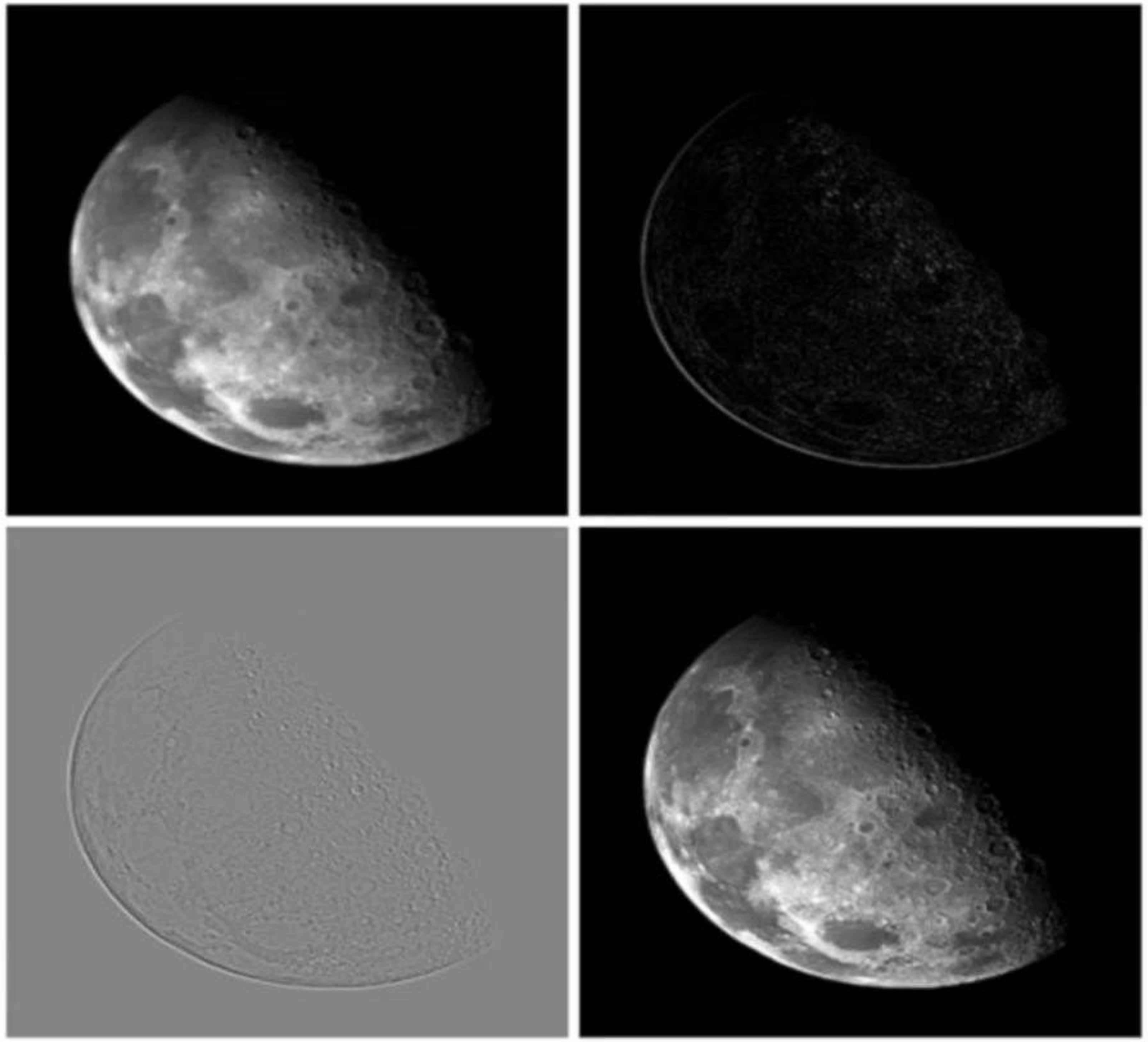
1	1	1
1	–8	1
1	1	1

0	–1	0
–1	4	–1
0	–1	0

–1	–1	–1
–1	8	–1
–1	–1	–1

(a) Filter mask used to implement the digital Laplacian
(b) Mask used to implement an extension that includes the diagonal neighbors
(c) and (d) Two other implementations of the Laplacian

SHARPENING SPATIAL FILTERS



(a) Image of the North Pole of the moon
(b) Laplacian filtered image
(c) Laplacian image scaled for display purposes
(d) Image enhanced

Thank you!