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FACULTY OF EGINEERING

Digital Image Processing
LECTURE-21

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OUTLINE

- ❖Spatial Filtering for Image Sharpening
- ❖Derivatives
- ❖First and Second Order Derivatives
- ❖Example for Discrete Derivatives
- ❖Comparison between f'' and f´
- ❖Laplacian for Image Enhancement
- ❖MCQ
- ❖References

Spatial Filtering for Image Sharpening

- **Background:** to highlight fine detail in an image or to enhance blurred detail
- **Applications:** electronic printing, medical imaging, industrial inspection, autonomous target detection (smart weapons)......
- **Foundation (Blurring vs Sharpening):**
- **Blurring/smoothing is performed by spatial averaging** (equivalent to integration)
- **Sharpening is performed by noting only the gray level** changes in the image that is the differentiation

Spatial Filtering for Image Sharpening

Operation of Image Differentiation

- Enhance edges and discontinuities (magnitude of output gray level >>0)
- De-emphasize areas with slowly varying gray-level values (output gray level: 0)

Mathematical Basis of Filtering for Image Sharpening

- First-order and second-order derivatives
- Gradients
- Implementation by mask filtering

First Order Derivative

- A basic definition of the first-order derivative of a one-dimensional function f(x) is the difference

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

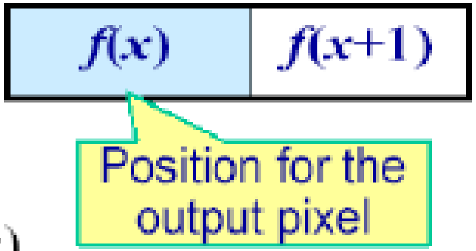
Second Order Derivative

- Similarly, we define the second-order derivative of a one-dimensional function f(x) is the difference

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

First and Second Order Derivatives

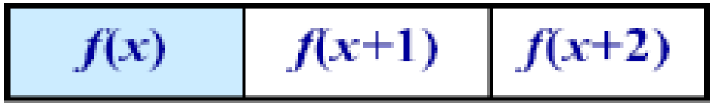
$$\frac{\partial f}{\partial x} = f(x+1) - f(x)$$



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

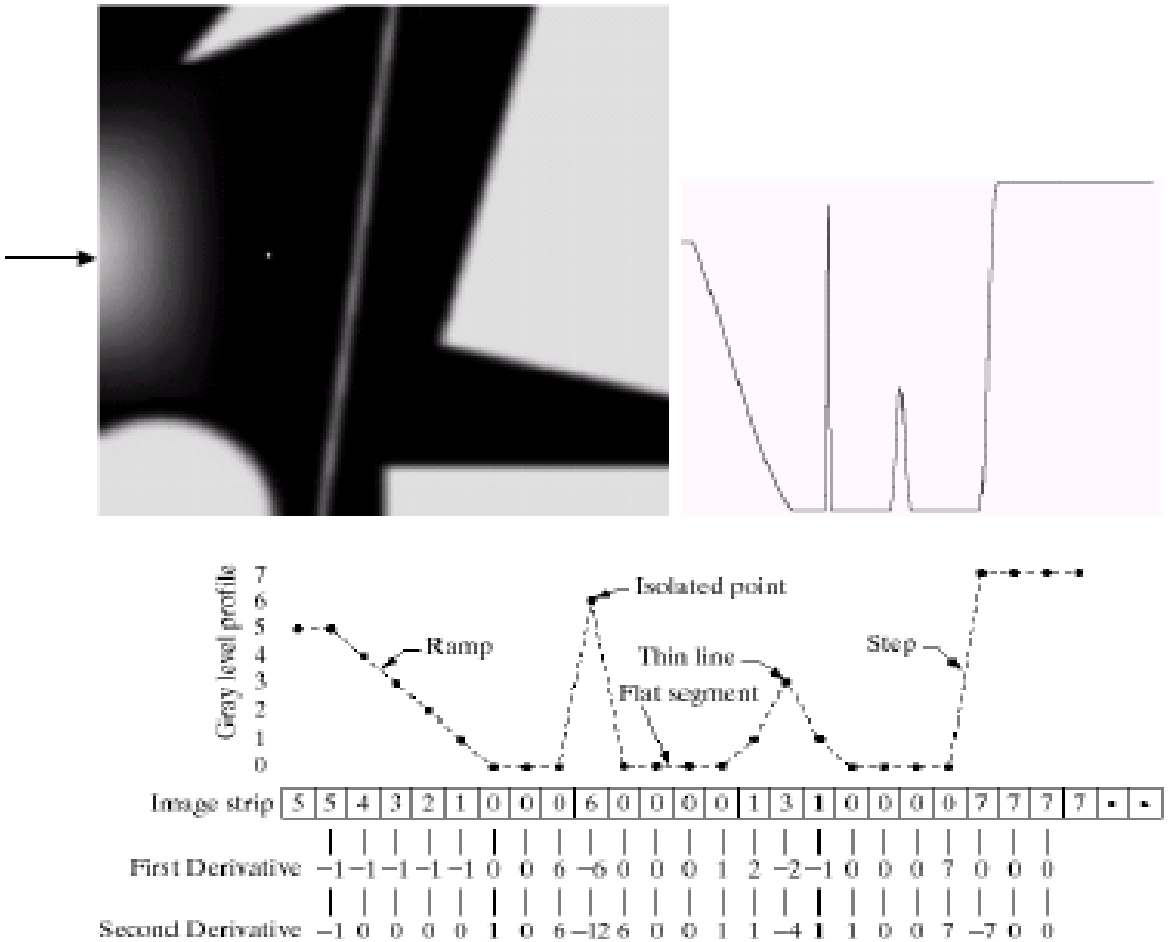
$$= [f(x+2) - f(x+1)] - [f(x+1) - f(x)]$$

$$= f(x+2) - 2f(x+1) + f(x)$$



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

Example for Discrete Derivatives\



Comparison between f" and f´

•f´ generally produces thicker edges in an image

•f" has a stronger response to fine detail

•f´ generally has a stronger response to a gray-level step

•f" produces a double response at step changes in gray level

•For image enhancement, f" is generally better suited

• than f´

•Major application of f´ is for edge extraction; f´ used

together with f" results in impressive enhancement effect

Laplacian for Image Enhancement

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

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

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

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

y →, x ↓

$f(x-1, y-1)$	$f(x-1, y)$	$f(x-1, y+1)$
$f(x, y-1)$	$f(x, y)$	$f(x, y+1)$
$f(x+1, y-1)$	$f(x+1, y)$	$f(x+1, y+1)$

0	1	0
1	–4	1
0	1	0

Laplacian for Image Enhancement

(a)

0	1	0
1	−4	1
0	1	0

(b)

1	1	1
1	−8	1
1	1	1

(c)

0	−1	0
−1	4	−1
0	−1	0

(d)

−1	−1	−1
−1	8	−1
−1	−1	−1

a b
c d

FIGURE 3.39 (a) Filter mask used to implement the digital Laplacian, as defined in Eq. (3.7-4). (b) Mask used to implement an extension of this equation that includes the diagonal neighbors. (c) and (d) Two other implementations of the Laplacian.

MCQ

1. What is the thickness of the edges produced by first order derivatives when compared to that of second order derivatives?
   a) Finer
   b) Equal
   c) Thicker
   d) Independent

2. First order derivative can enhance the fine detail in the image compared to that of second order derivative.
   a) True
   b) False

3. Which of the following derivatives produce a double response at step changes in gray level?
   a) First order derivative
   b) Third order derivative
   c) Second order derivative
   d) First and second order derivatives

MCQ

4. Which of the following is the primary objective of sharpening of an image?

   a) Blurring the image

   b) Highlight fine details in the image

   c) Increase the brightness of the image

   d) Decrease the brightness of the image

5. Image sharpening process is used in electronic printing.

   a) True

   b) False

References

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- Digital Image Processing and Computer Vision, R.J. Schalkoff. Published by: JohnWiley and Sons, NY.
- Fundamentals of Digital Image Processing, A.K. Jain. Published by Prentice Hall,Upper Saddle River, NJ.