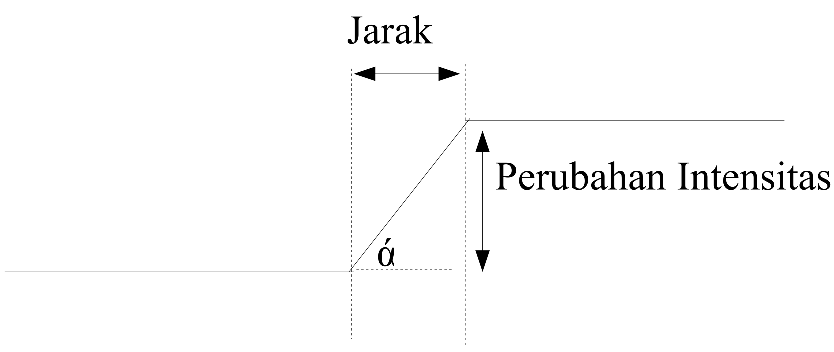
Pendeteksian Tepi (Edge Detection)

Eri Prasetyo

Pertemuan ke 6

Definisi Tepi

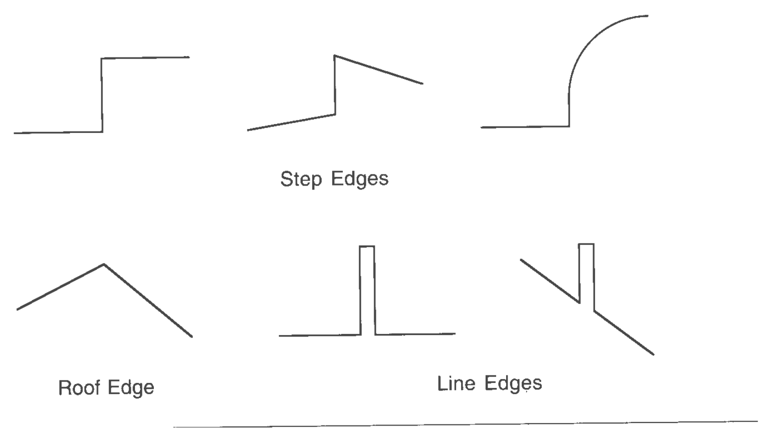
- Tepi (edge) adalah perubahan nilai intensitas derajat keabuan yang cepat/tiba-tiba (besar) dalam jarak yang singkat



ά = arah tepi

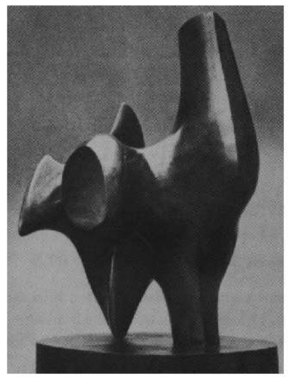
Profiles of image intensity edges

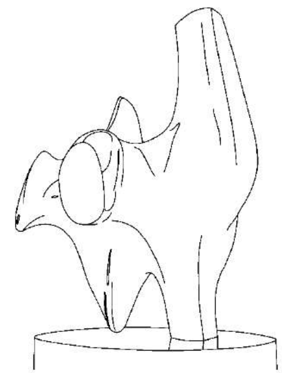
- Step
- Roof
- Line



Tujuan Pendeteksian tepi

- Untuk meningkatkan penampakan garis batas suatu daerah atau obyek di dalam citra.





Teknik yang digunakan untuk pendeteksian tepi antara lain :

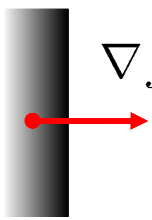
- Operator gradien pertama (*differential gradient*)
- Operator turunan kedua (*Laplacian*)
- Operator kompas (*compass operator*)

Image gradient

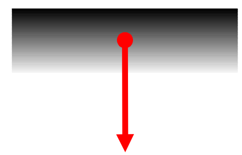
- The gradient of an image:

$$\nabla f = \left[\frac{\partial f}{\partial x}, \frac{\partial f}{\partial y}\right]$$

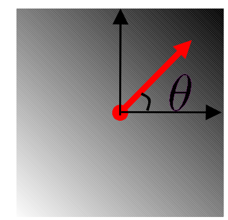
- The gradient points in the direction of most rapid change in intensity



$$\nabla f = \left[\frac{\partial f}{\partial x}, 0\right]$$



$$\nabla f = \left[0, \frac{\partial f}{\partial y}\right]$$



$$\nabla f = \left[\frac{\partial f}{\partial x}, \frac{\partial f}{\partial y}\right]$$

The gradient direction is given by:

$$\theta = \tan^{-1}\left(\frac{\partial f}{\partial y} / \frac{\partial f}{\partial x}\right)$$

- how does this relate to the direction of the edge?

The *edge strength* is given by the gradient magnitude

$$\|\nabla f\| = \sqrt{\left(\frac{\partial f}{\partial x}\right)^2 + \left(\frac{\partial f}{\partial y}\right)^2}$$

Magnitude of gradient vector

- *Rumus 1:* $\| \nabla f \| = \sqrt{\Delta x^2 + \Delta y^2}$
- *Rumus 2:* $\| \nabla f \| = \max(abs(\Delta x), abs(\Delta y))$
- *Rumus 3:* $\| \nabla f \| = abs(\Delta x) + abs(\Delta y)$

The discrete gradient

- How can we differentiate a *digital* image f[x,y]?
  - Option 1: reconstruct a continuous image, then take gradient
  - Option 2: take discrete derivative (finite difference)

$$\frac{\partial f}{\partial x}[x, y] \approx f[x+1, y] - f[x, y]$$

- Digunakan operator sobel

Tinjau pengaturan pixel disekitar pixel (x,y)

$$\begin{bmatrix} A0 & a1 & a2 \\ a7 & (x,y) & a3 \\ a6 & a5 & a4 \end{bmatrix}$$

Operator sobel adalah magnitude dari gradien yang dihitung dengan

$$M = \sqrt{sx^2 + sy^2}$$ Atau M = |sx| + |sy|

Turunan parsial dihitung dengan :

Sx = (a2+ca3+a4) – (a0+ca7+a6) ; sy = (a0+ca1+a2) – (a6+ca5+a4)

Dengan konstanta c=2 dalam bentuk mask, sx dan sy dinyatakan sebagai

$$Sx = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \qquad Sy = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}$$

- Contoh citra yang akan dilakukan pendeteksian tepi dengan operator sobel,

3	4	2	5	7
2	1	6	4	2
3	5	7	2	4
4	2	5	7	1
2	5	1	6	9

citra awal

*	*	*	*	*
*	18			*

citra hasil konvolusi

sx = 3x(-1)+2x(-1)+ 3x(-1)+2x(1)+6x(2)+7x(1) = 11

sy = 3x(1)+4x(2)+2x(1)+3x(-1)+5x(-2)+7x(-1) = -7

maka M = 18

- Operator lain adalah prewitt, dengan c = 1

px=

-1	0	1
-1	0	1
-1	0	1

py =

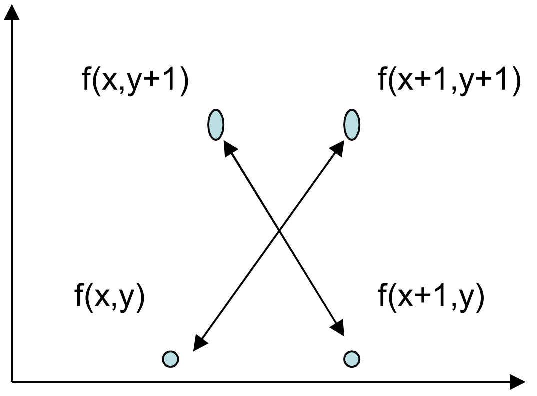
1	1	1
0	0	0
-1	-1	-1

- Operator Robert

  disebut operator silang, gradien robert dalam arah x dan y dapat dihitung :

  $R+(x,y) = f(x+1, y+1) – f(x,y)$

  $R-(x,y) = f(x,y+1) – f(x+1,y)$



operator R+ adalah turunan berarah dalam arah 45 derajat, dan R- turunan berarah dalam arah 135 derajat

Dalam bentuk mask operator adalah :

$$R+ = \begin{vmatrix} 1 & 0 \\ 0 & -1 \end{vmatrix} \qquad R- = \begin{vmatrix} 0 & 1 \\ -1 & 0 \end{vmatrix}$$

Nilai kekuatan tepi :

$$G[f(x,y)] = |R+| + |R-|$$

- Contoh deteksi tepi dengan robert :

4	5	7	5	1
2	1	3	4	5
4	3	2	6	9
4	2	5	7	1
2	4	8	6	3

citra awal

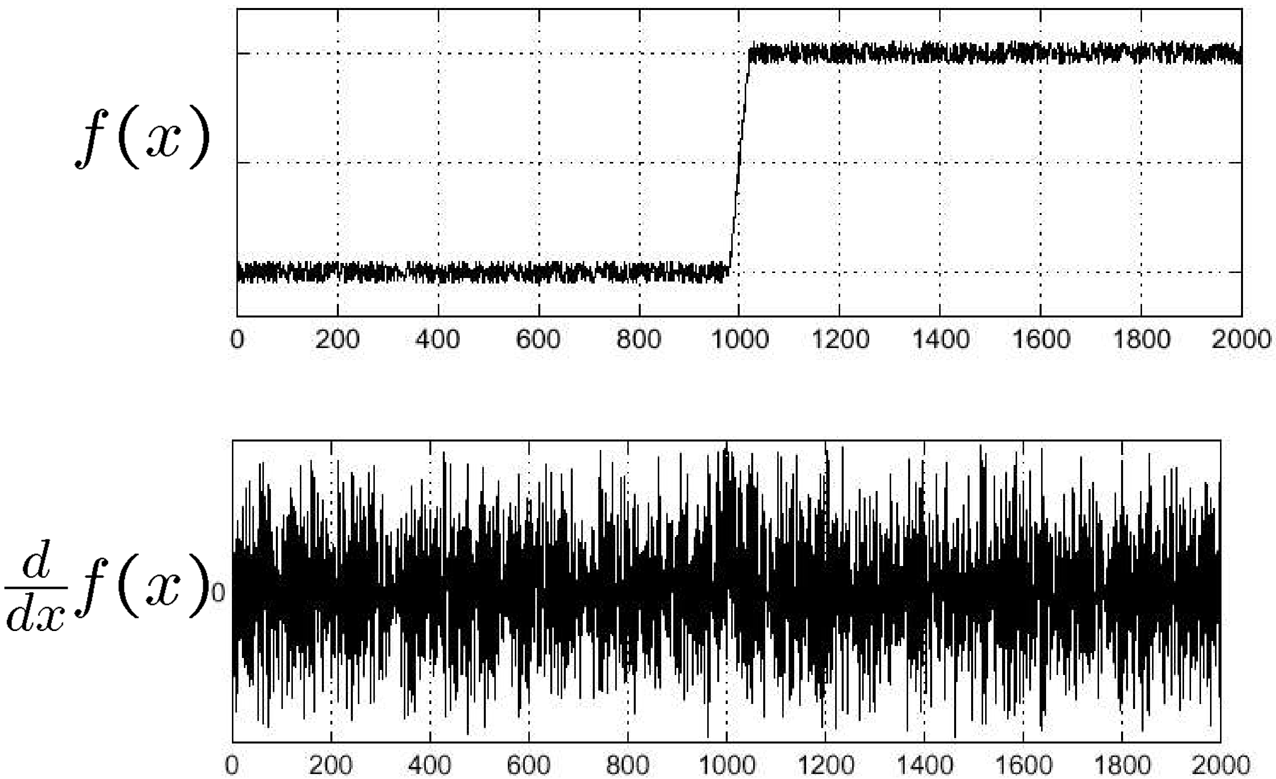
6	8	5	3	1
4	1	5	6	5
3	2	6	7	9
0	7	2	5	1
2	4	8	6	3

citra hasil pendeteksian tepi

f'[0,0] = |4-1| + |5-2| = 6

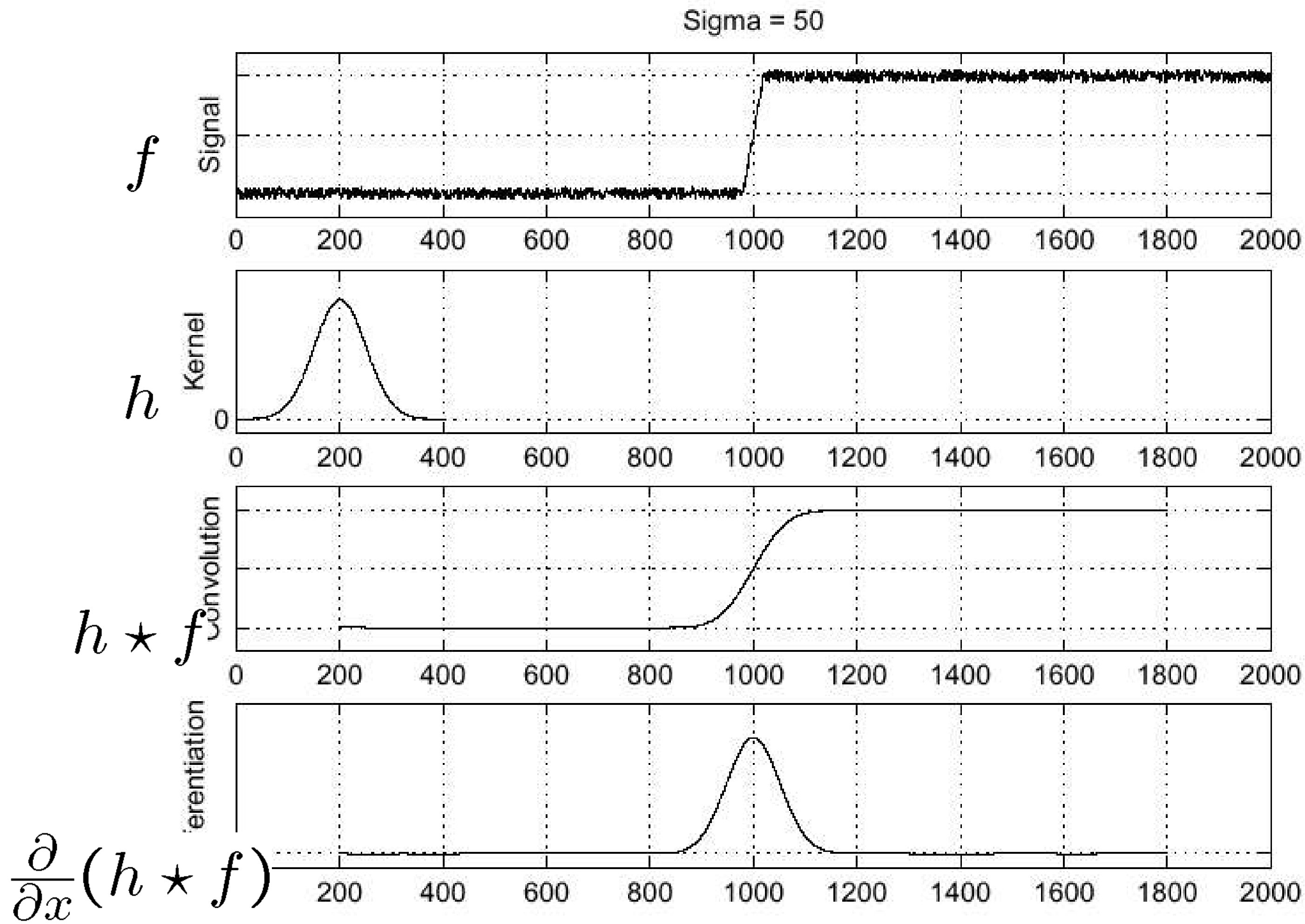
Effects of noise

- Consider a single row or column of the image
  - Plotting intensity as a function of position gives a signal



Where is the edge?

Solution: smooth first



Where is the edge? Look for peaks in $\frac{\partial}{\partial x}(h \star f)$

Derivative theorem of convolution

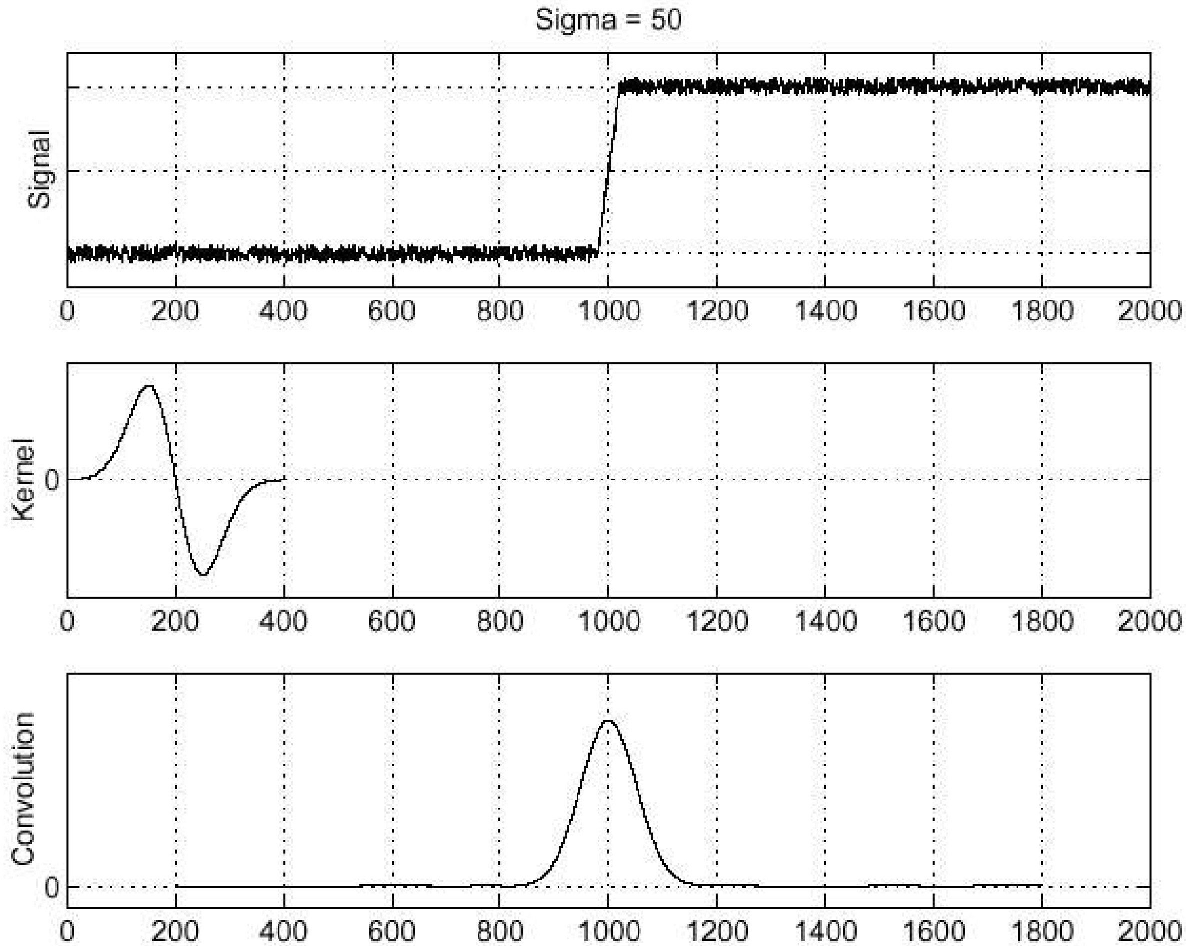
$$\frac{\partial}{\partial x}(h \star f) = (\frac{\partial}{\partial x}h) \star f$$

- This saves us one operation:

f

$\frac{\partial}{\partial x}h$

$(\frac{\partial}{\partial x}h) \star f$



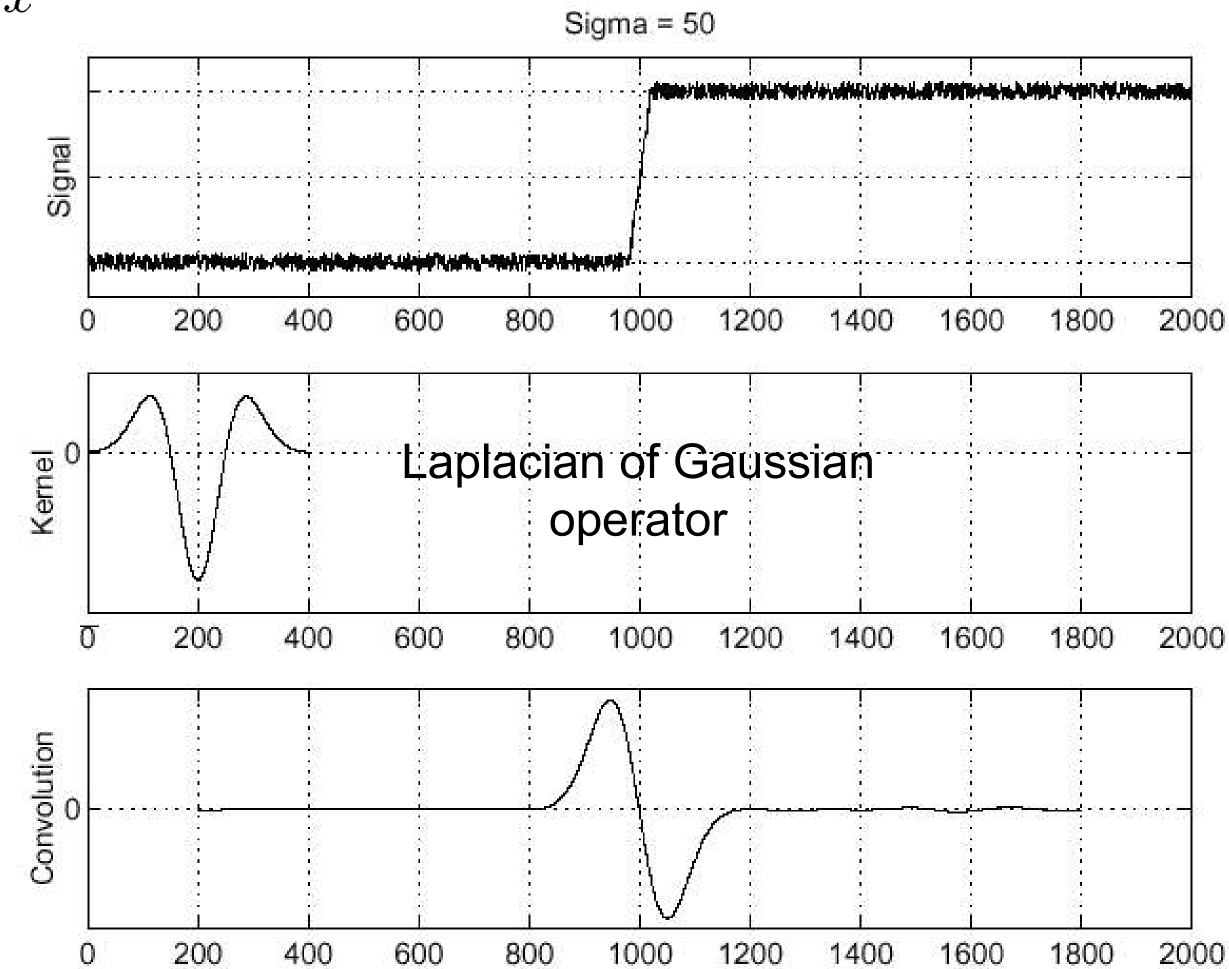
Laplacian of Gaussian

- Consider $\frac{\partial^2}{\partial x^2}(h \star f)$

f

$\frac{\partial^2}{\partial x^2}h$

$(\frac{\partial^2}{\partial x^2}h) \star f$



Where is the edge? Zero-crossings of bottom graph