

Edge Detection

Image Processing

CSE 166

Lecture 16

Announcements

- Assignment 5 is due May 29, 11:59 PM
- Reading
 - Chapter 10: Image segmentation I: edge detection, thresholding, and region detection
 - Sections 10.1, 10.2, and 10.3

Image segmentation

- General approach
 1. Spatial filtering
 2. Additional processing
 3. Thresholding
- Global thresholding (simplest)

$$g(x, y) = \begin{cases} 1 & \text{if } f(x, y) > T \\ 0 & \text{otherwise} \end{cases}$$

where

T is threshold value

Image segmentation

Input

Edges

Segmentation



Edge-based



Region-based

Derivatives in 1D

- Forward difference

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

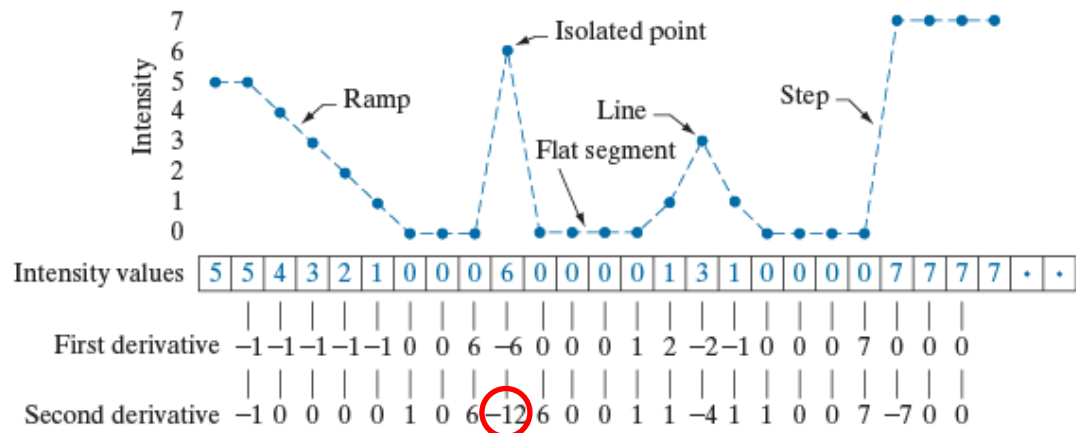
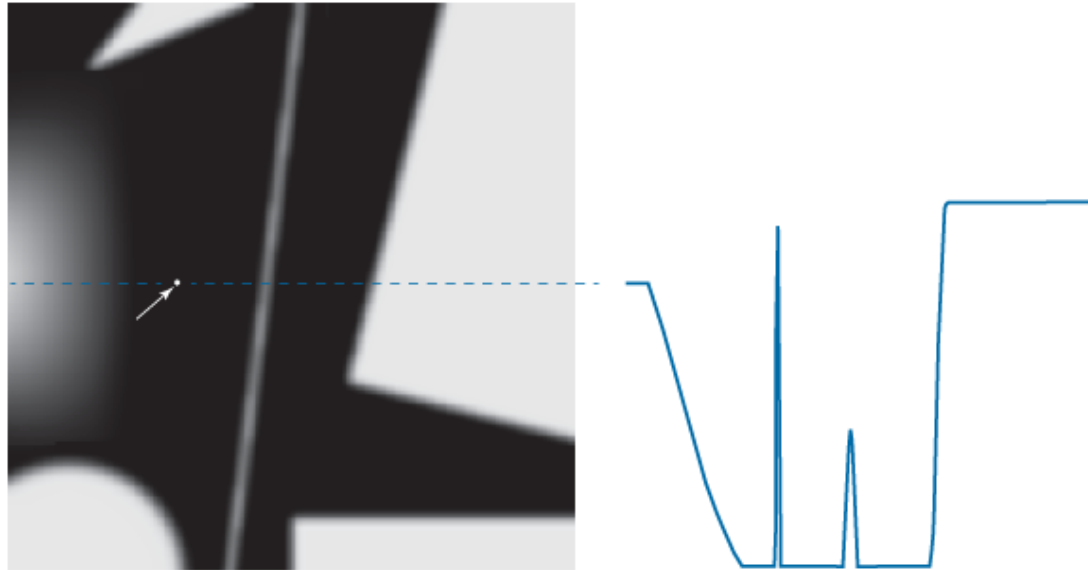
- Backward difference

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

- Central difference

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

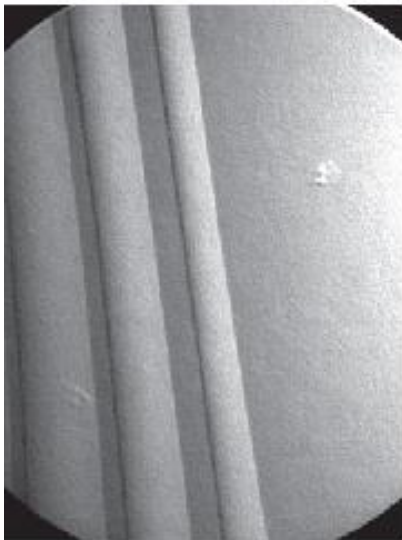
Image derivatives



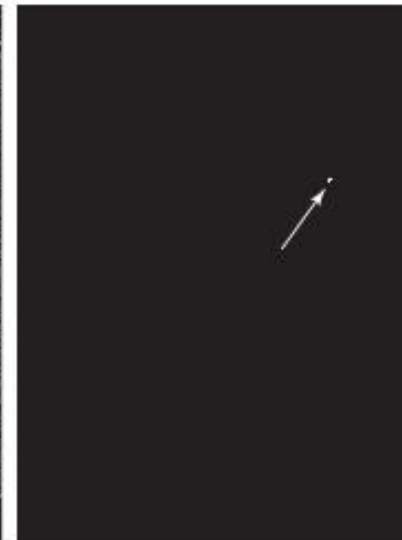
Detection of isolated points

1	1	1
1	-8	1
1	1	1

Laplacian
(second derivative)



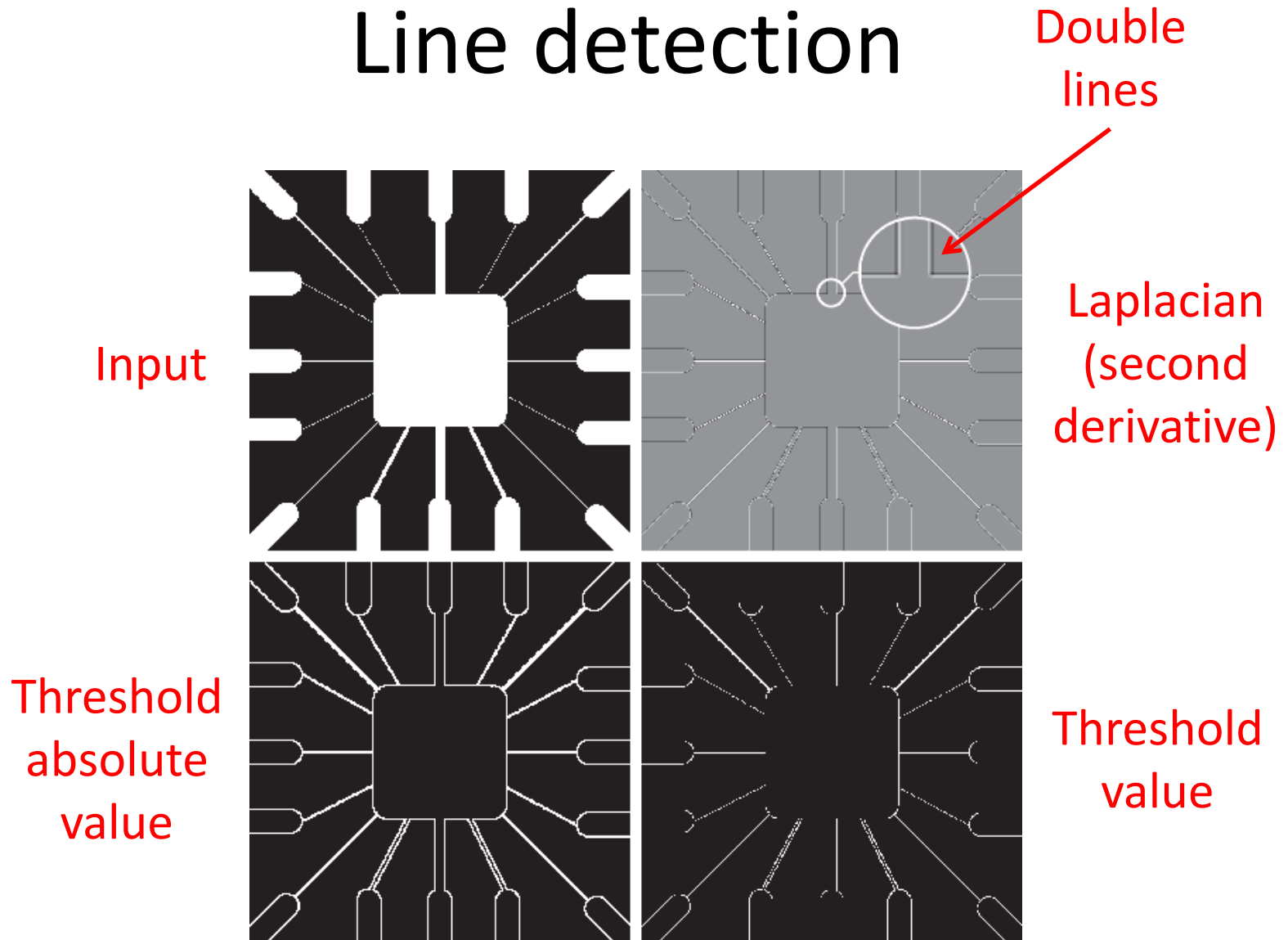
Input



Threshold
absolute
value

Segmentation

Line detection



Line detection, specific directions

-1	-1	-1	2	-1	-1	-1	2	-1	-1	-1	2
2	2	2	-1	2	-1	-1	2	-1	-1	2	-1
-1	-1	-1	-1	-1	2	-1	2	-1	2	-1	-1

Horizontal

+45°

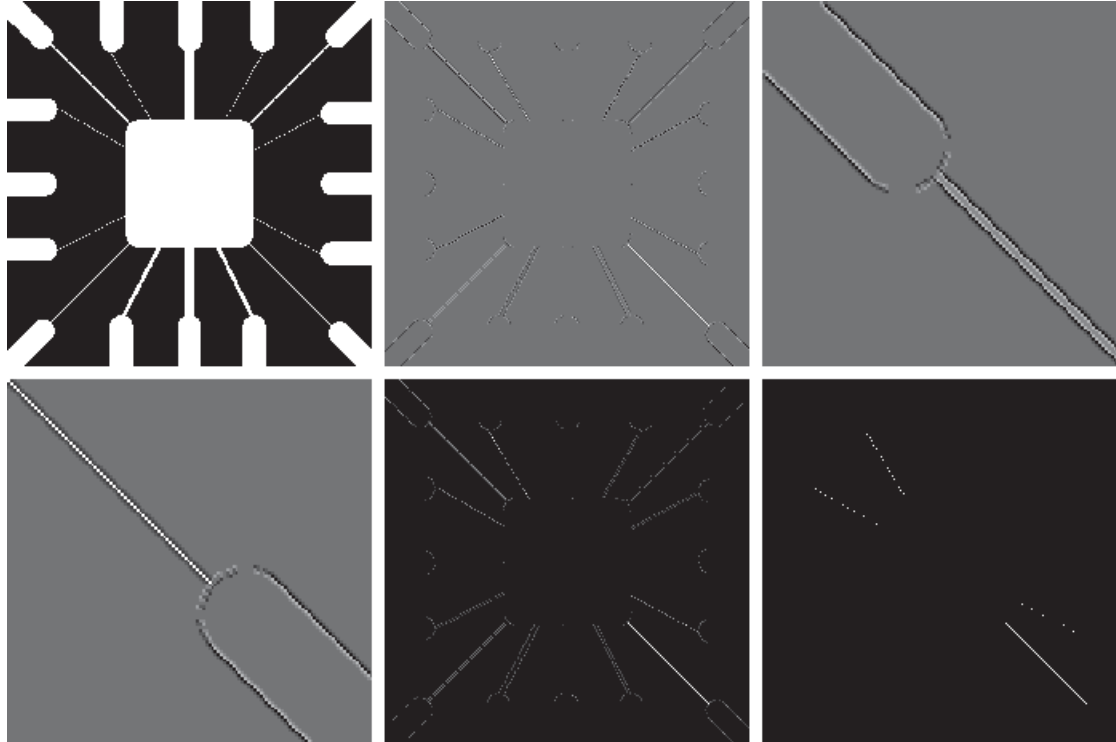
Vertical

-45°

Spatial filters

Line detection, specific directions

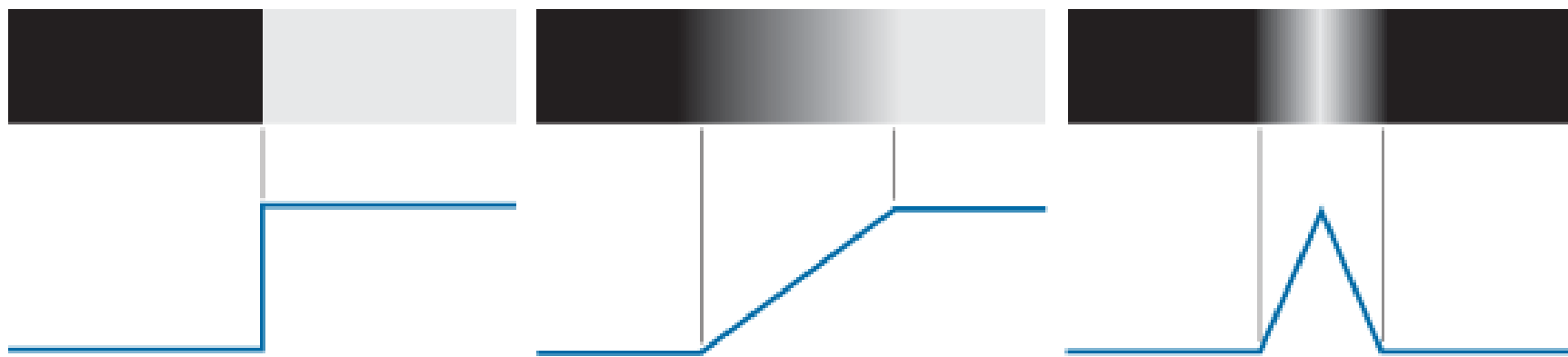
+45°



Negative
values set
to zero

Threshold

Edge models

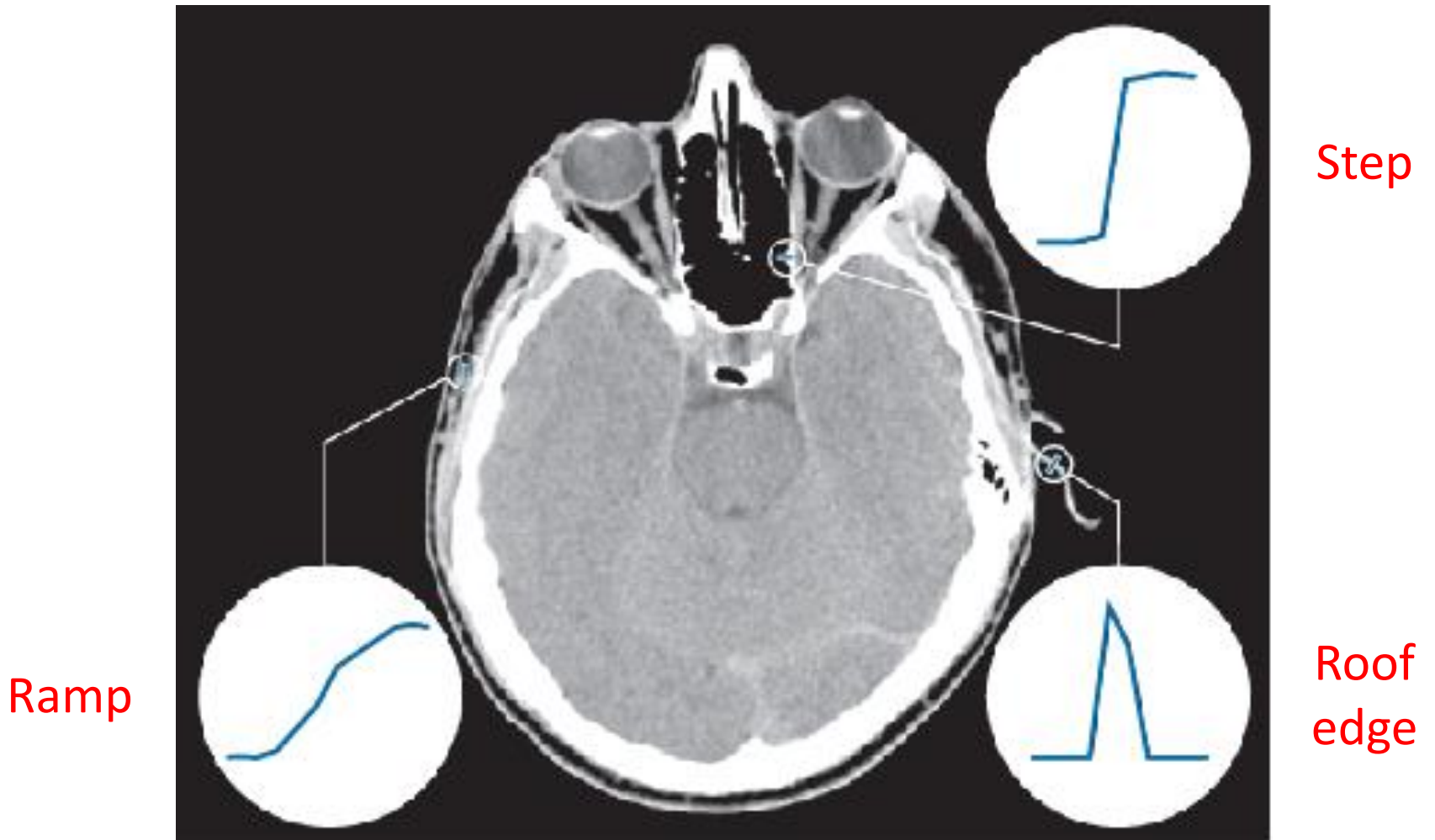


Step

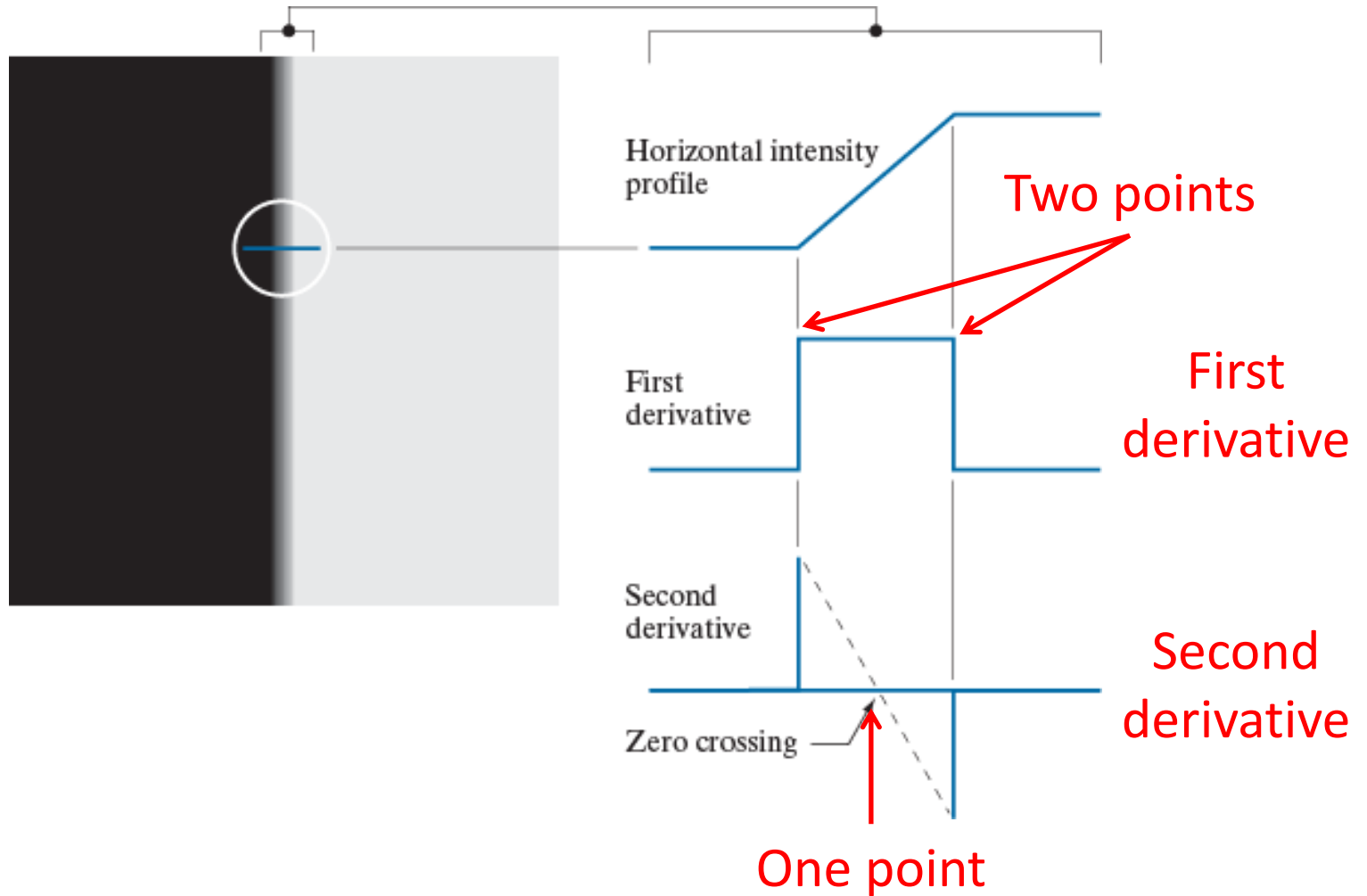
Ramp

Roof edge

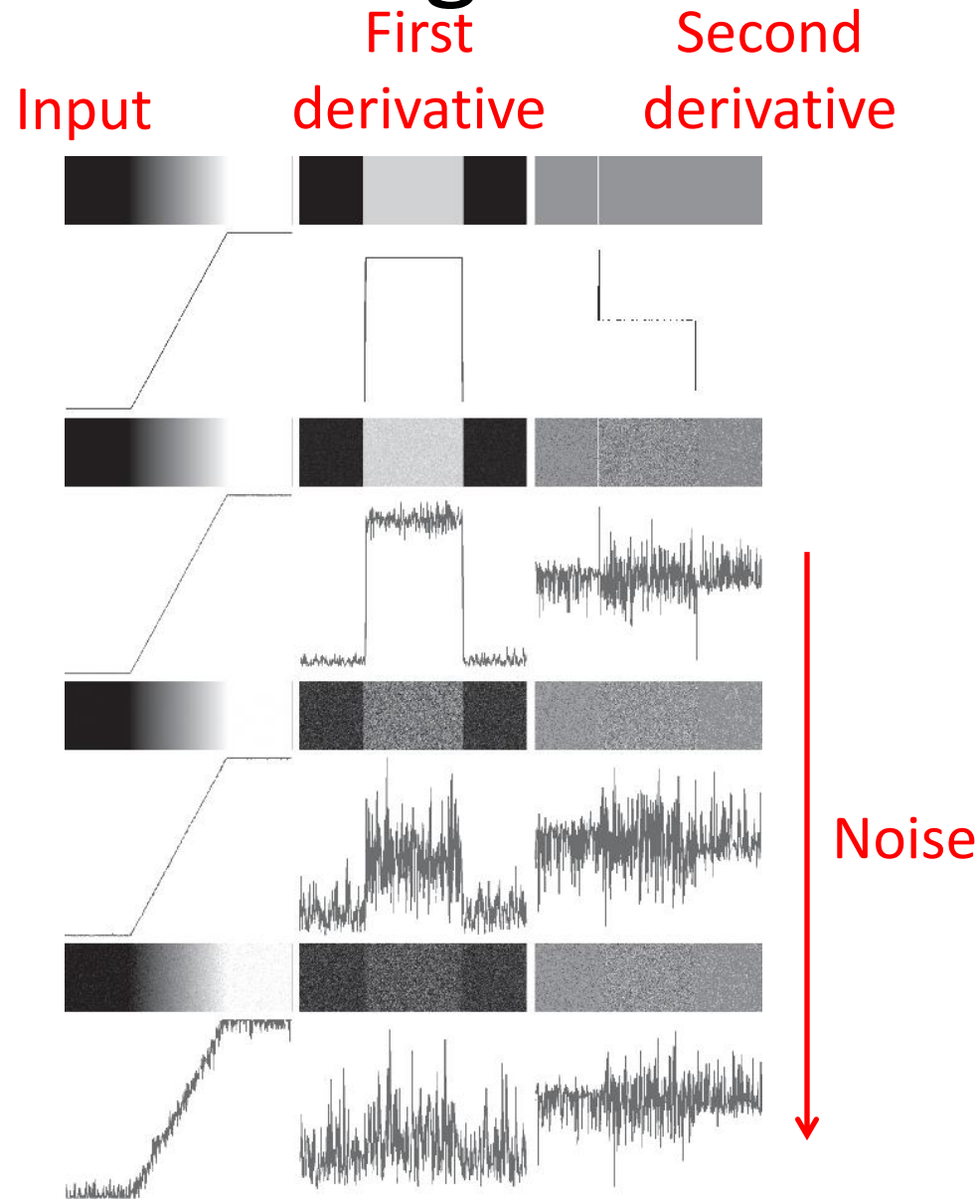
Edge models



Ramp edge



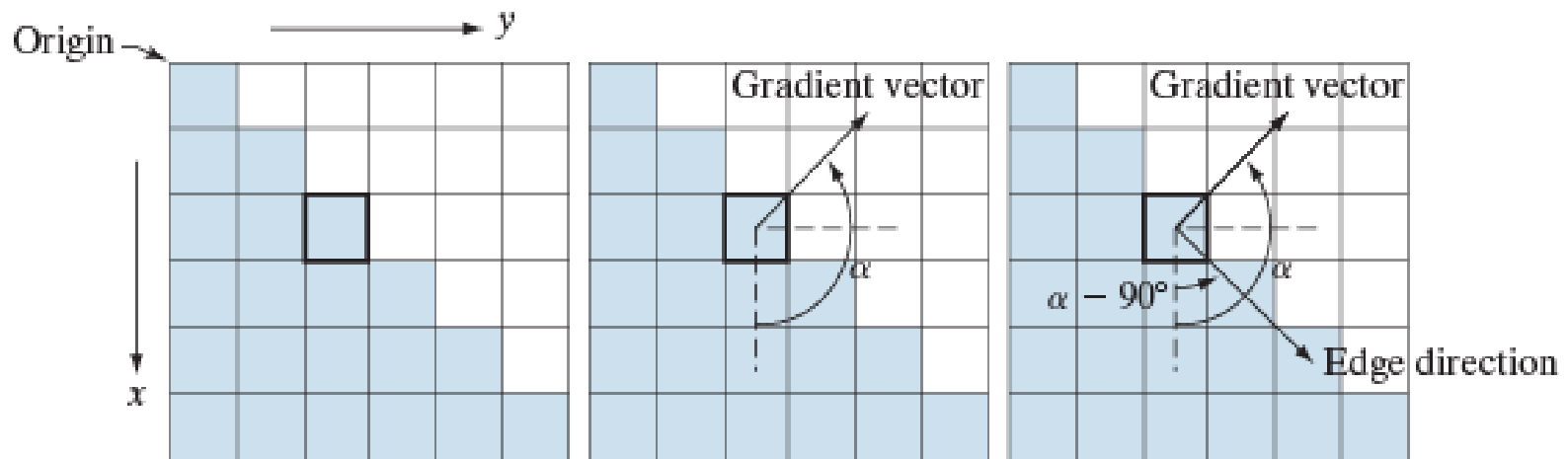
Noise and image derivatives



Edge detection

1. Image smoothing for noise reduction
2. Detection of image points (edge point candidates)
3. Edge localization (select from candidates, set of edge points)

Gradient and edge direction



Gradient direction is orthogonal to edge direction

Gradient operators

-1
1

-1	1
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Forward difference

-1	0	0	-1
0	1	1	0

Roberts

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

Prewitt

-1	-2	-1	-1	0	1
0	0	0	-2	0	2
1	2	1	-1	0	1

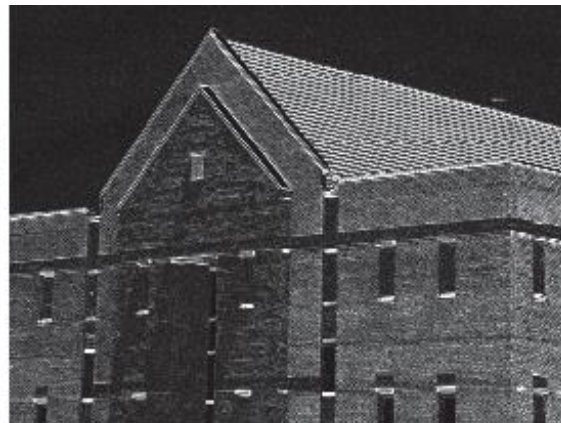
Sobel

Gradients

Input



Magnitude
of
vertical
gradient



Magnitude
of
horizontal
gradient



Magnitude
of
gradient
vector



Gradients

Smooth image prior to computing gradients.
Results in more selective edges

Input



Magnitude
of
vertical
gradient



Magnitude
of
horizontal
gradient



Magnitude
of
gradient
vector

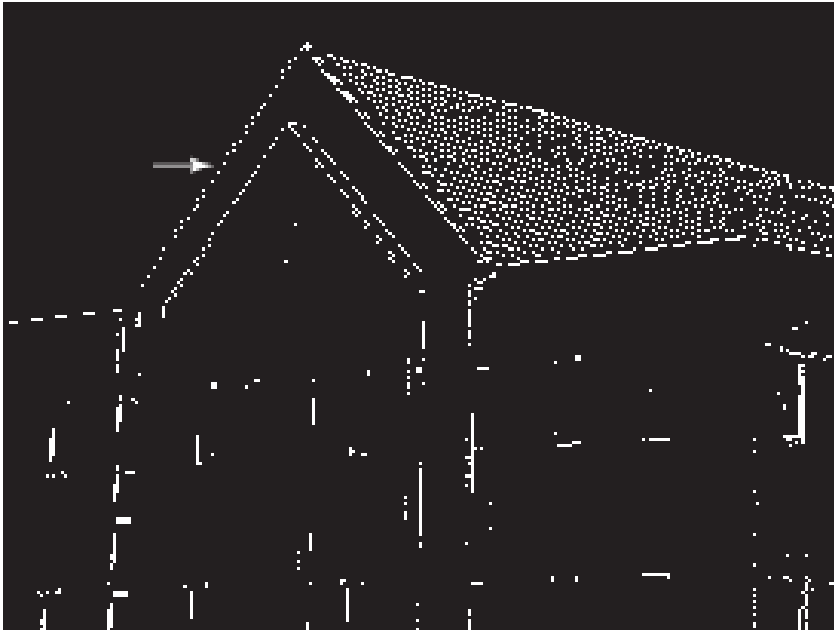


Edge detection

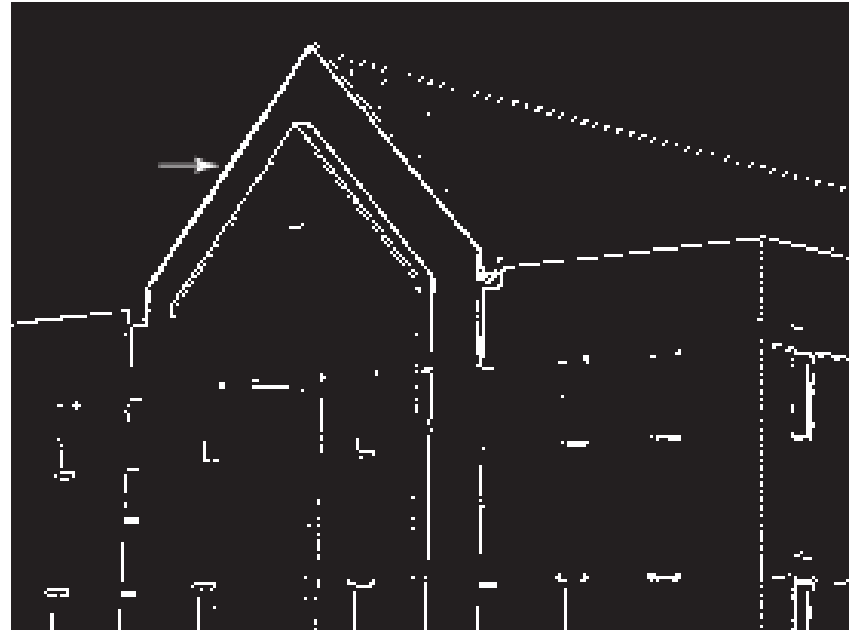
1. Smooth the input image
2. Compute the gradient magnitude image
3. Apply nonmaximal suppression to the gradient magnitude image
4. Threshold the resulting image

Edge detection

Threshold magnitude of gradient vector



Without smoothing



With smoothing

Advanced edge detection

Input



Magnitude of
gradient vector
(with smoothing)



Marr-Hildreth



Canny

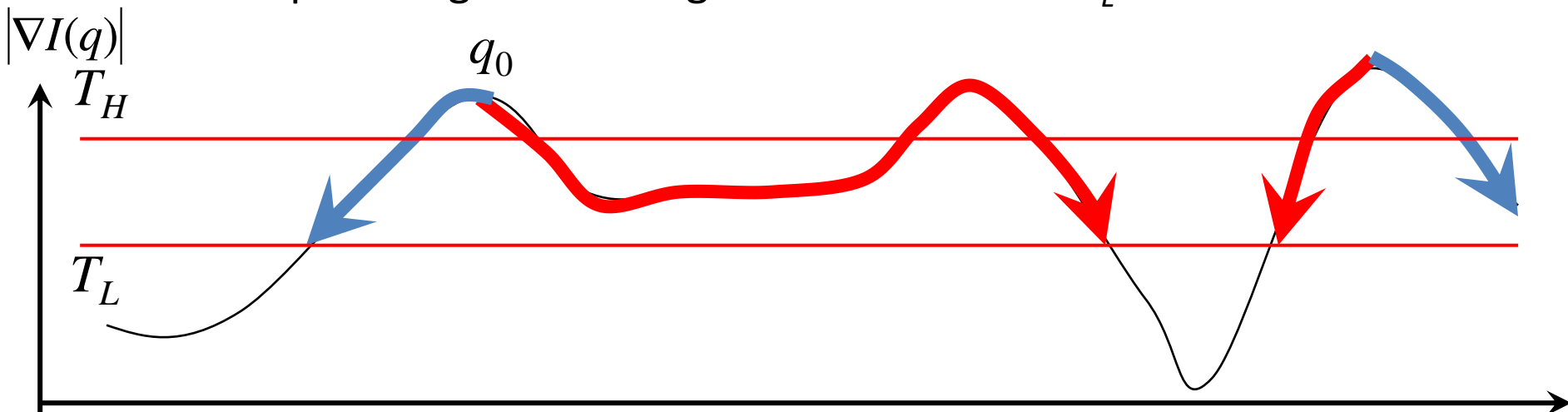
Figure 10.25 in textbook looks better

Canny edge detector

1. Smooth the input image with a Gaussian filter
2. Compute the gradient magnitude and angle images
3. Apply nonmaximal suppression to the gradient magnitude image
4. Use double thresholding and connectivity analysis to detect and link edges

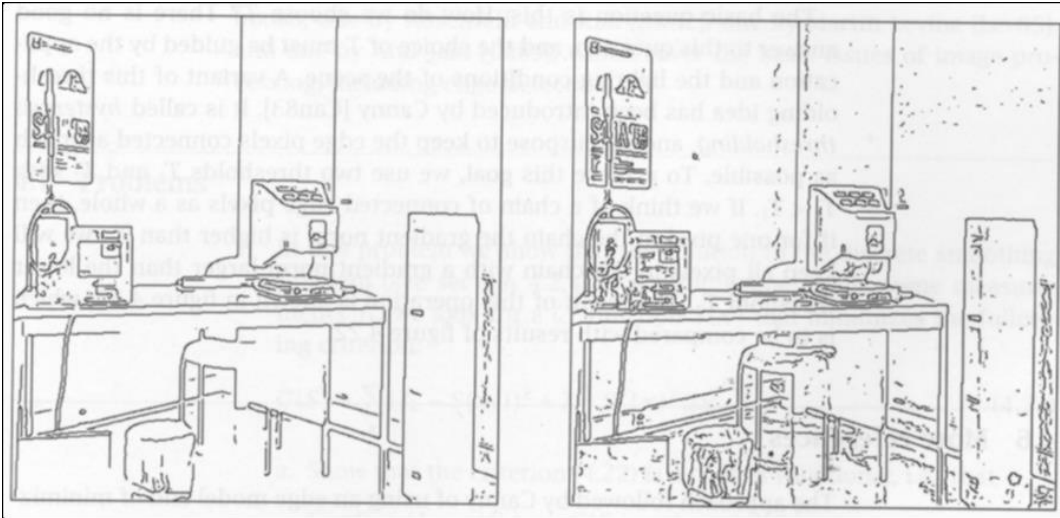
Double thresholding

- Use a high threshold to start edge curves and a low threshold to continue them
 - Define two thresholds T_H and T_L
 - Starting with output of nonmaximal suppression, find a point q_0 , which is a local maximum greater than T_H
 - Start tracking an edge chain at pixel location q_0 in one of the two directions
 - Stop when gradient magnitude is less than T_L



Double thresholding

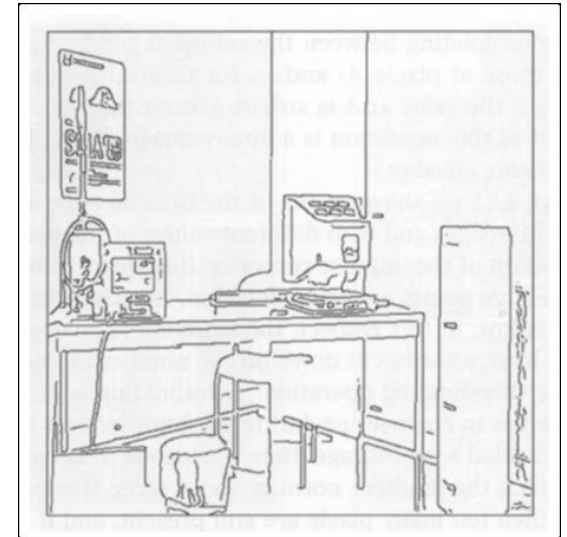
Single threshold



$T = 15$

$T = 5$

Double threshold



$T_H = 15$ and $T_L = 5$

Canny edge detector



Canny edge detector



Next Lecture

- Image segmentation
- Reading
 - Chapter 10: Image segmentation I: edge detection, thresholding, and region detection
 - Sections 10.3, 10.4, 10.5, and 10.6