Edge Detection

Image Processing

CSE 166

Lecture 16

Announcements

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

Image segmentation

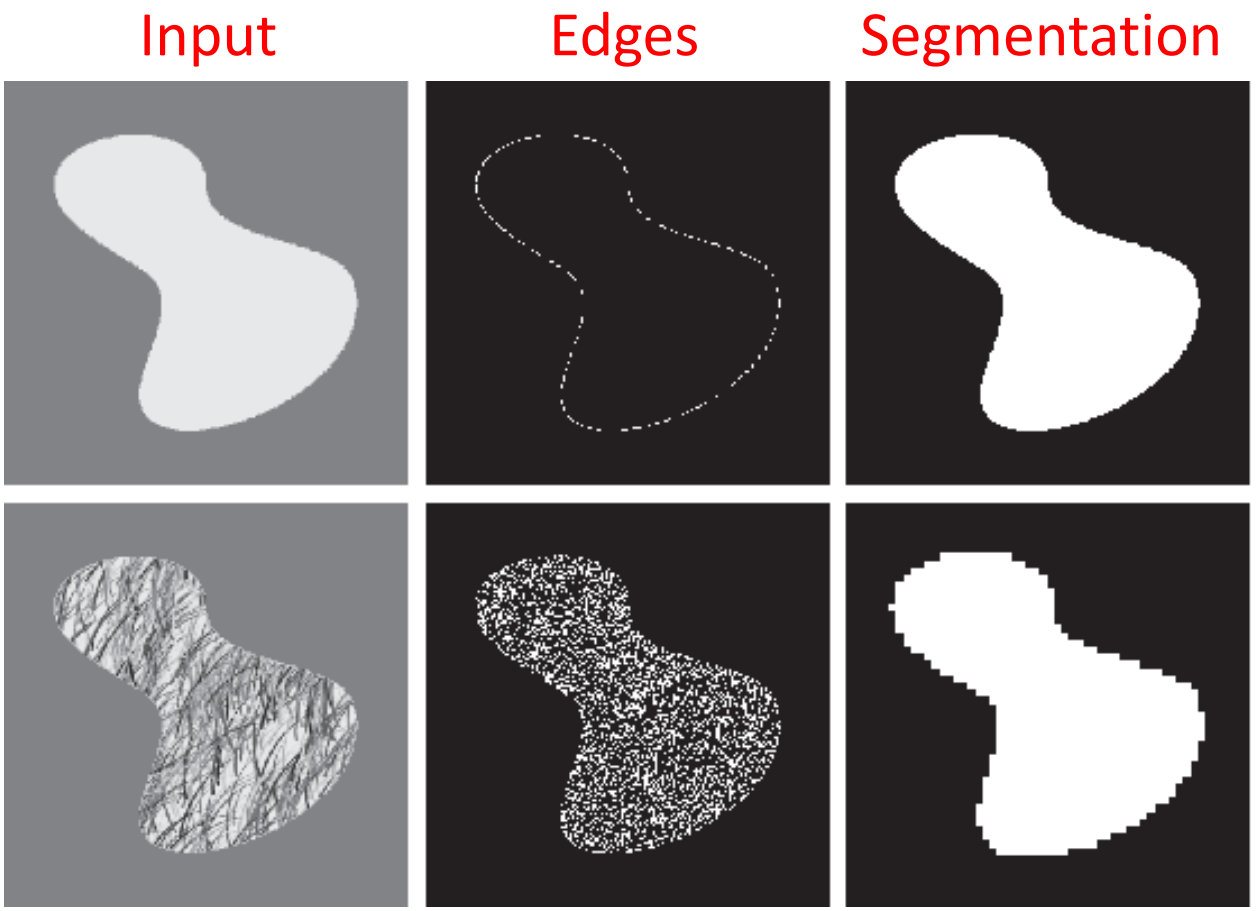
- General approach
  1. Spatial filtering
  2. Additional processing
  3. Thresholding
- Global thresholding (simplest)

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

where

T is threshold value

Image segmentation



Derivatives in 1D

- Forward difference

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

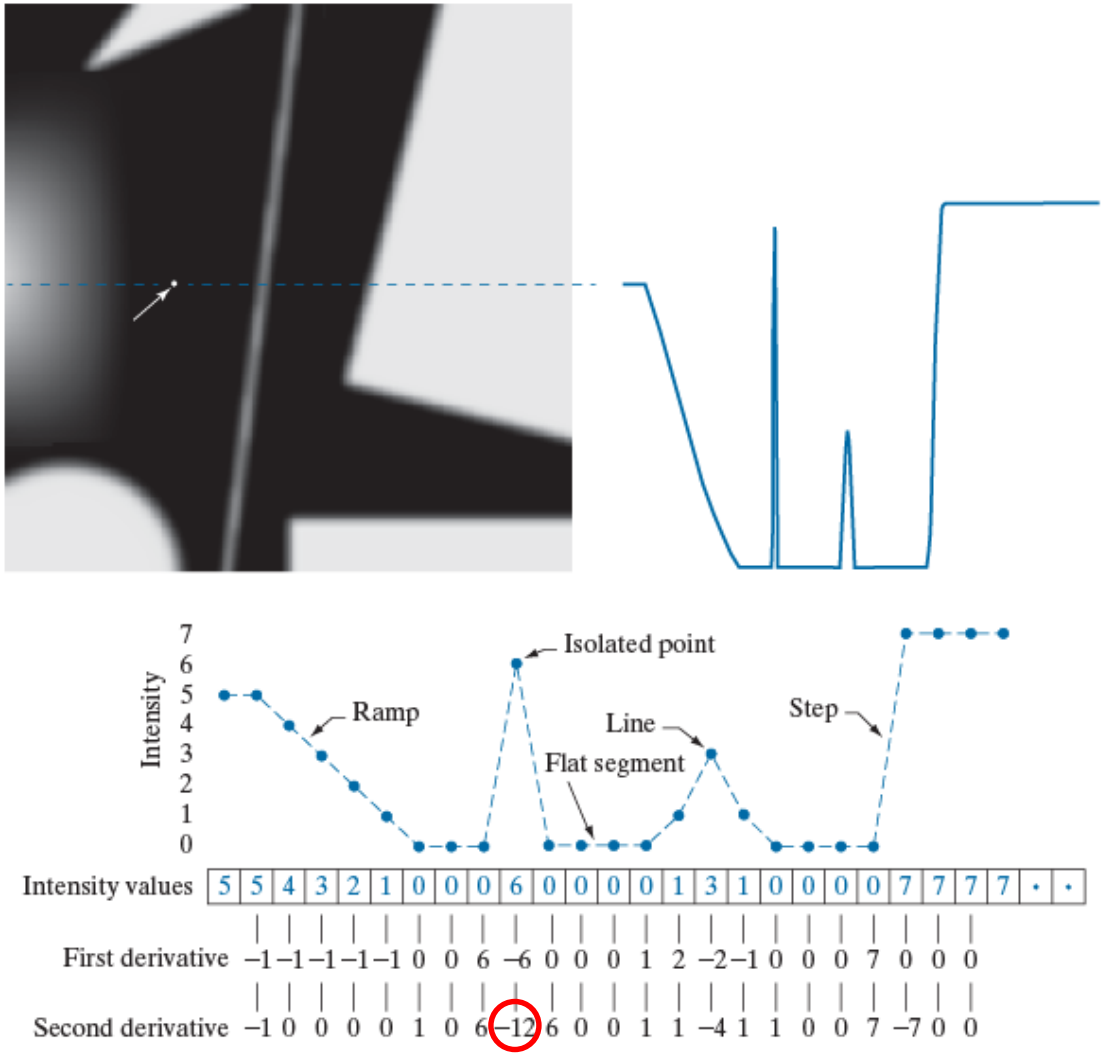
- Backward difference

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

- Central difference

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

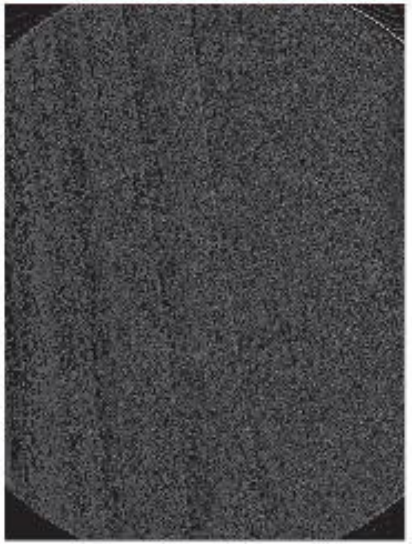
Image derivatives



Detection of isolated points

1	1	1
1	−8	1
1	1	1

Laplacian
(second derivative)

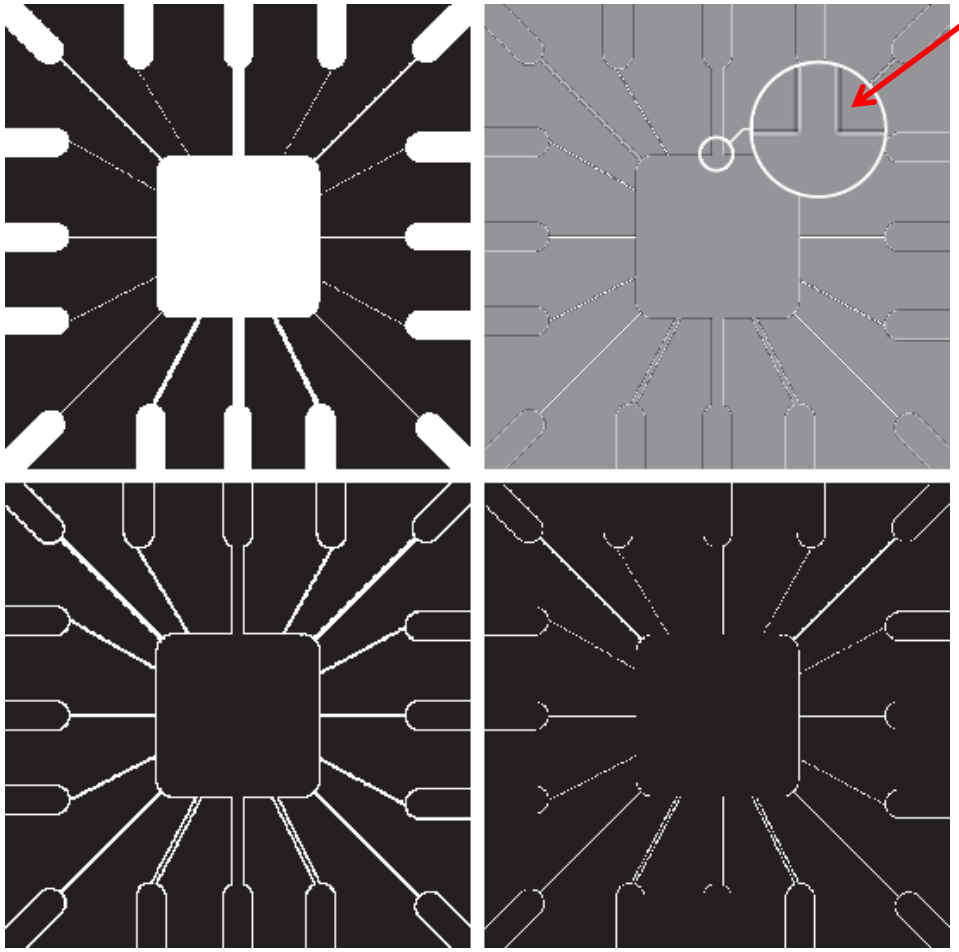


Threshold
absolute
value

Input

Segmentation

Line detection



Line detection, specific directions

−1	−1	−1
2	2	2
−1	−1	−1

Horizontal

2	−1	−1
−1	2	−1
−1	−1	2

+45°

−1	2	−1
−1	2	−1
−1	2	−1

Vertical

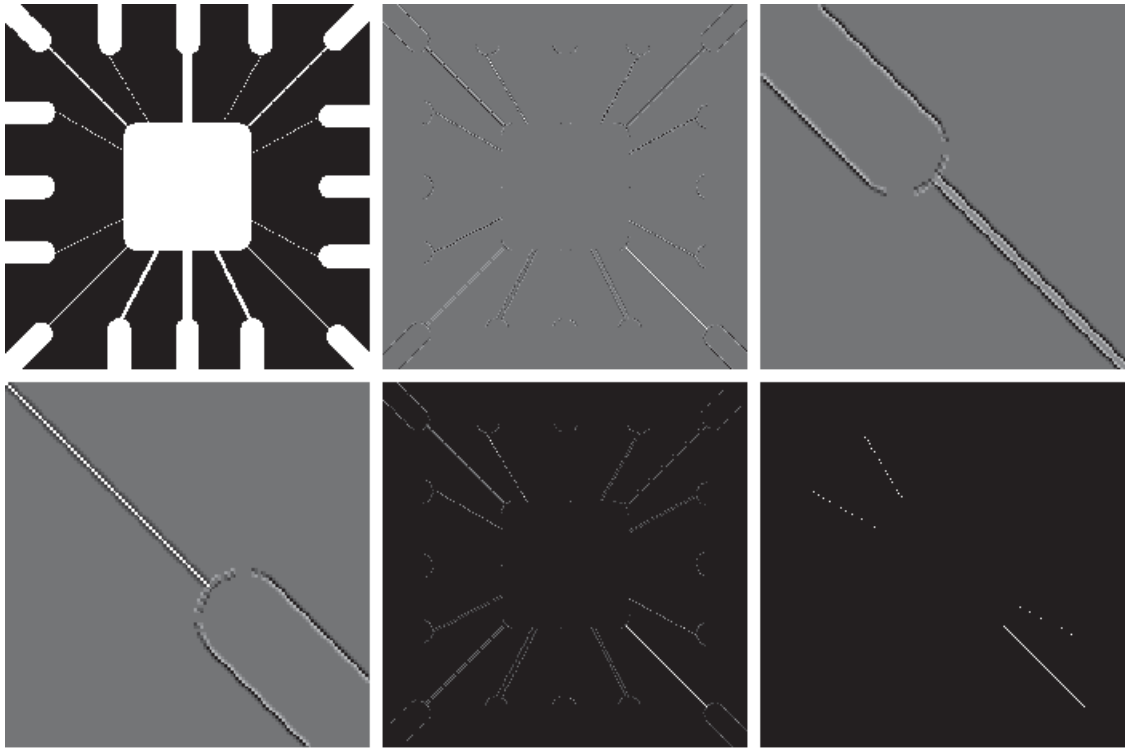
−1	−1	2
−1	2	−1
2	−1	−1

−45°

Spatial filters

Line detection, specific directions

+45°

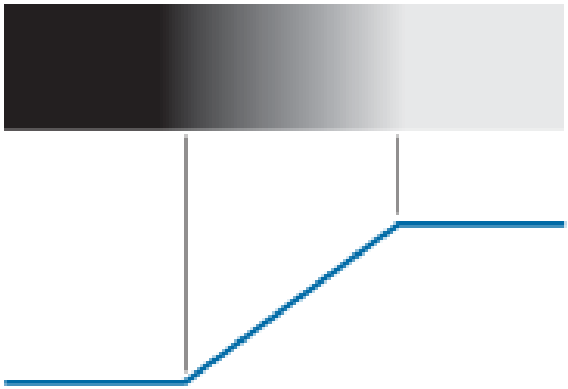


Negative values set to zero

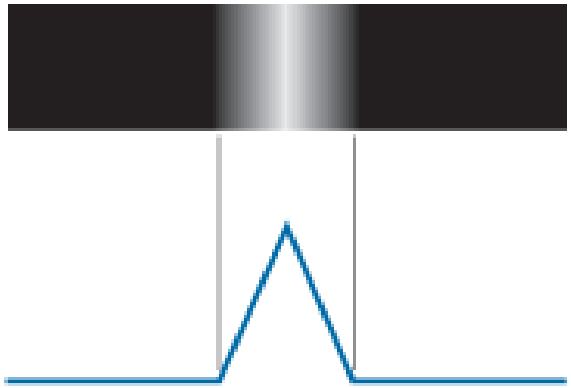
Threshold

Edge models

Step

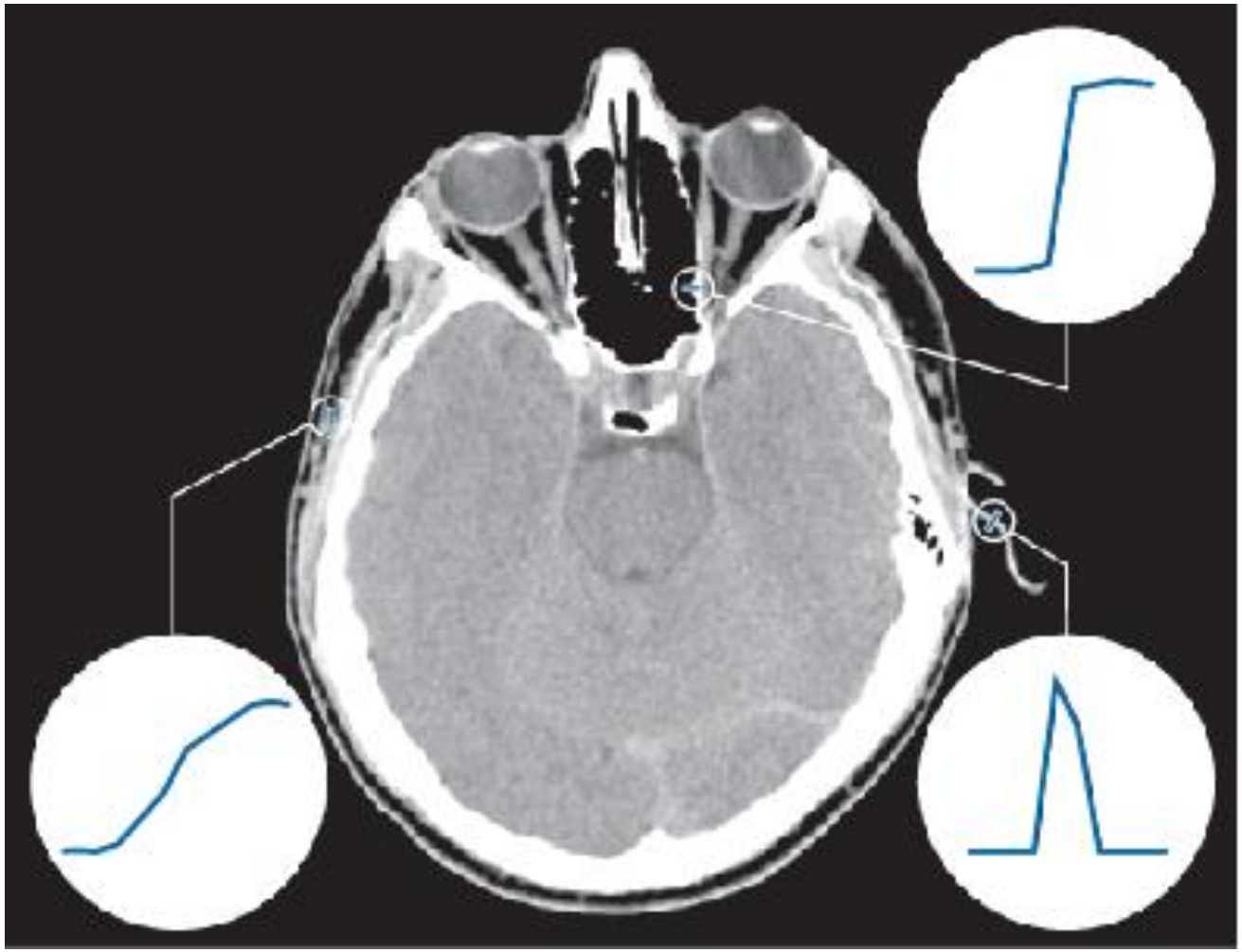


Ramp



Roof edge

Edge models

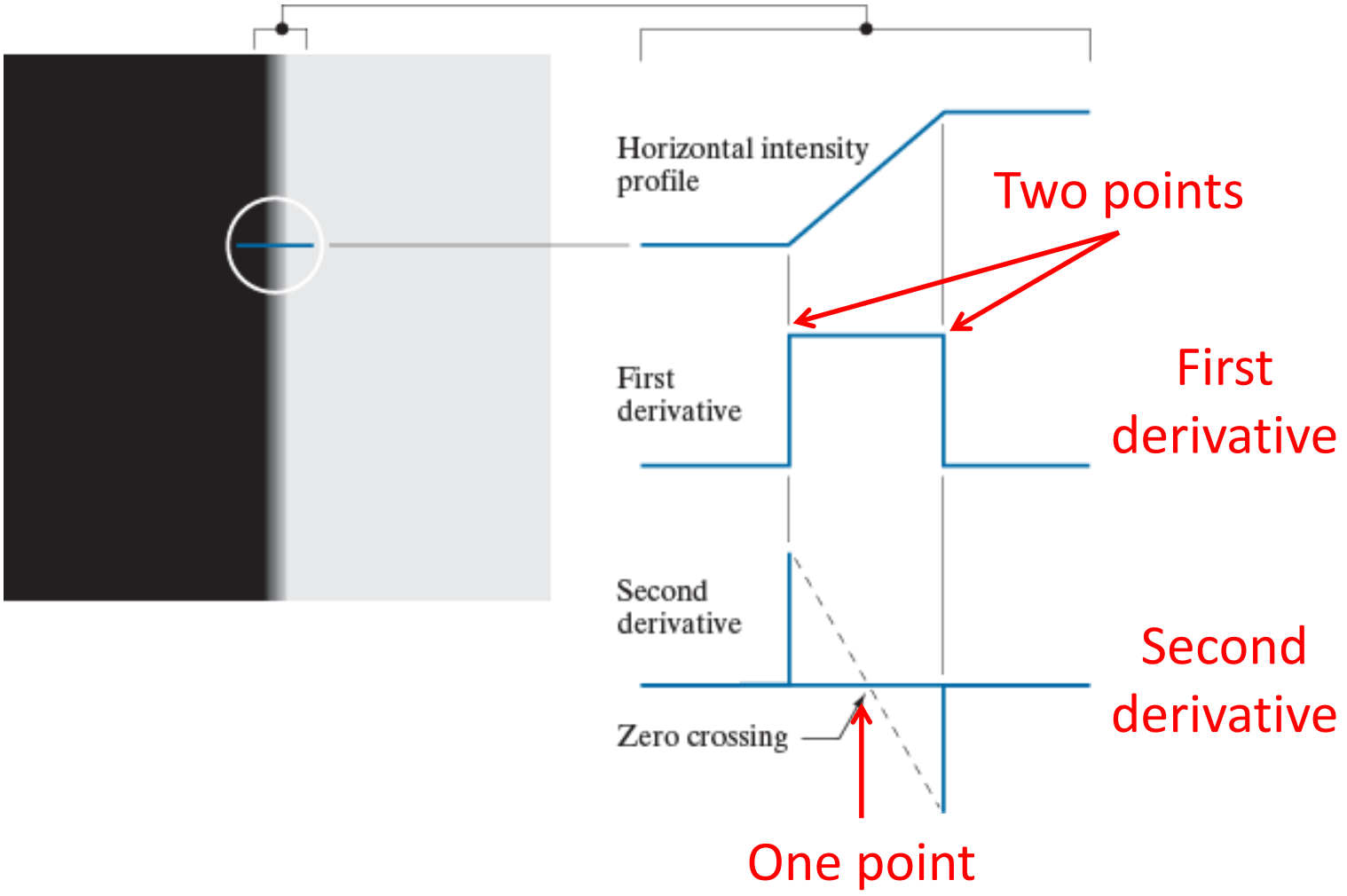


Step

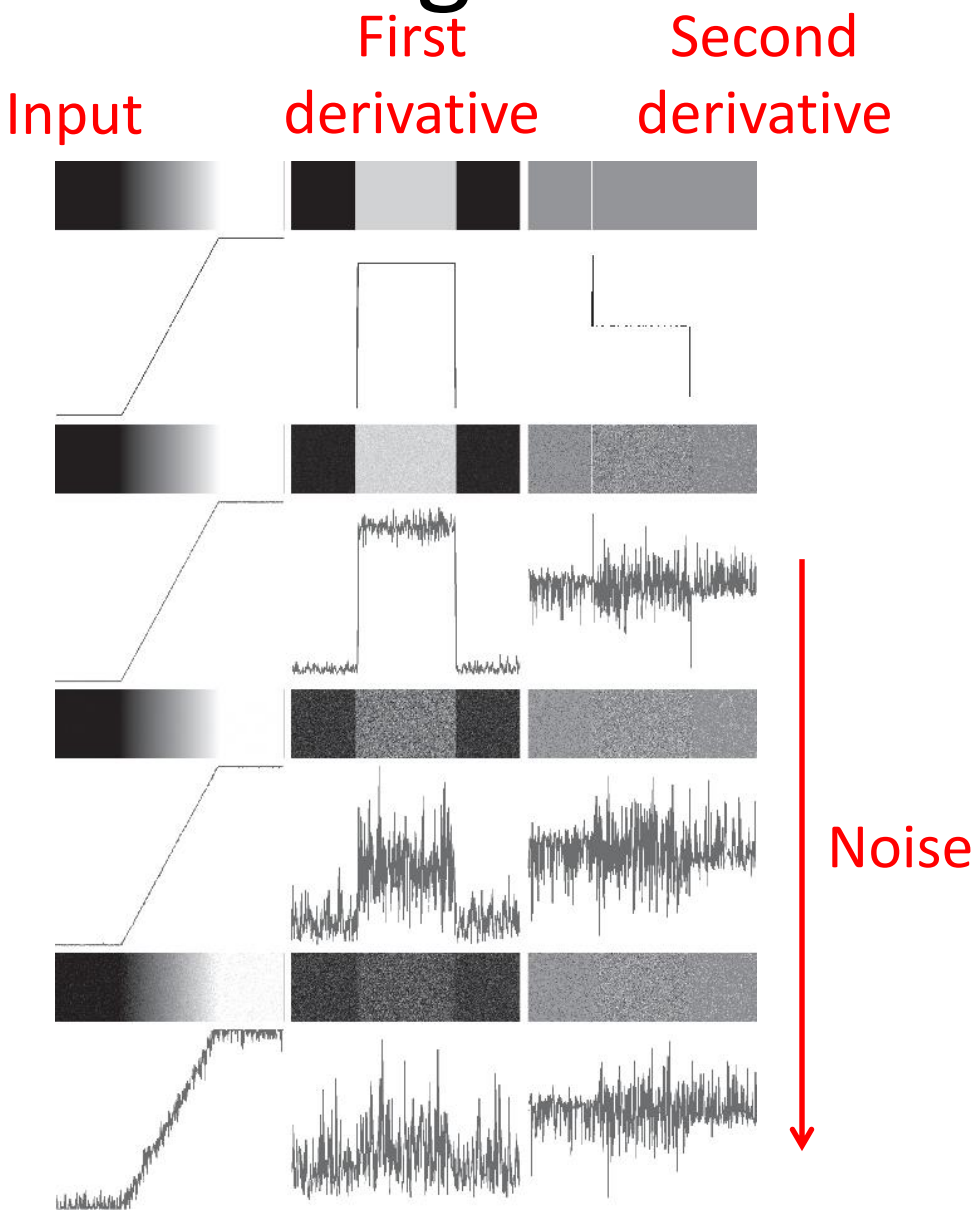
Ramp

Roof edge

Ramp edge


Horizontal intensity profile
Two points
First derivative
First derivative
Second derivative
Second derivative
Zero crossing
One point

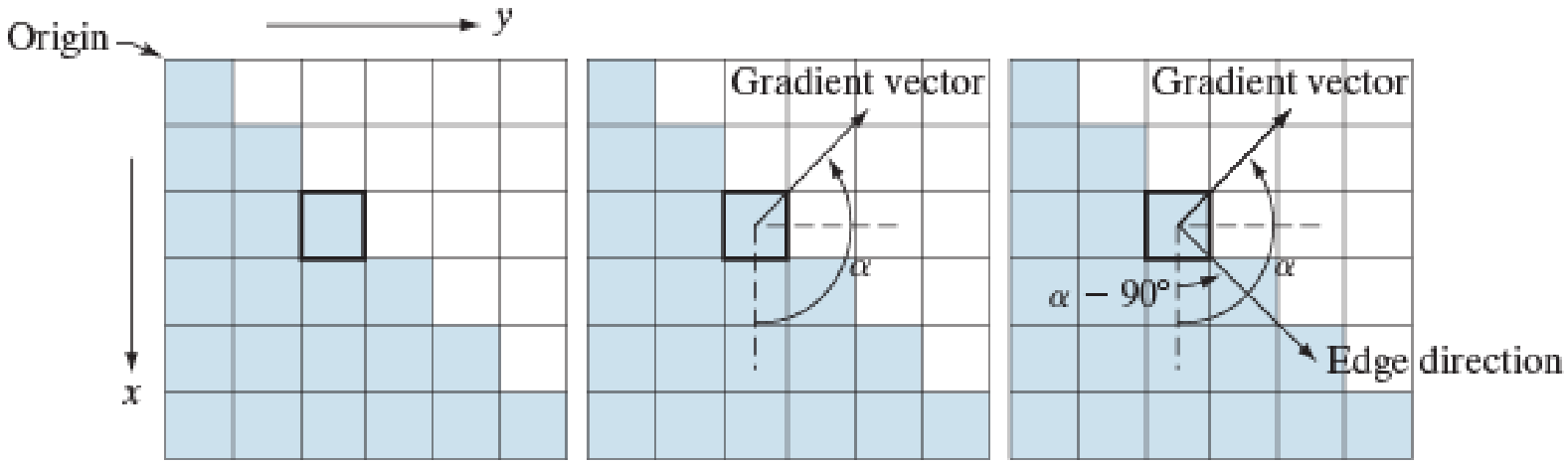
Noise and image derivatives



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

Forward difference

−1	0
0	1

0	−1
1	0

Roberts

−1	−1	−1
0	0	0
1	1	1

−1	0	1
−1	0	1
−1	0	1

Prewitt

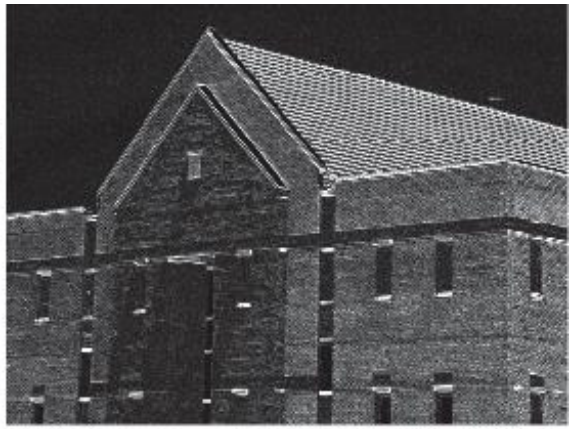
−1	−2	−1
0	0	0
1	2	1

−1	0	1
−2	0	2
−1	0	1

Sobel

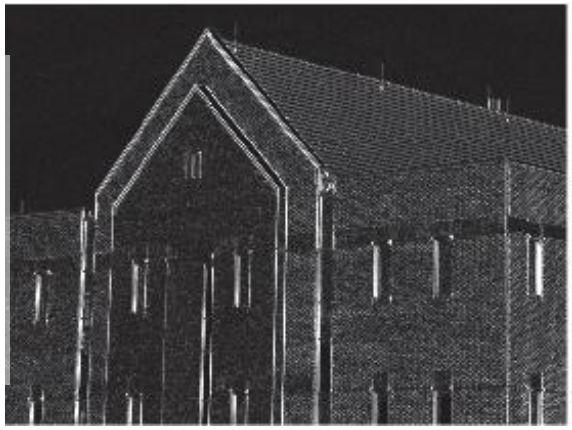
Gradients

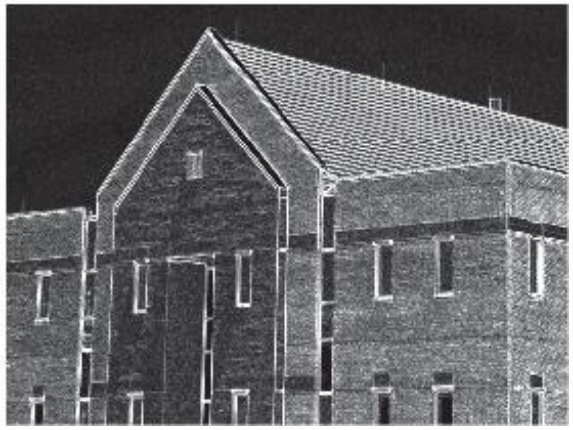
Input



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

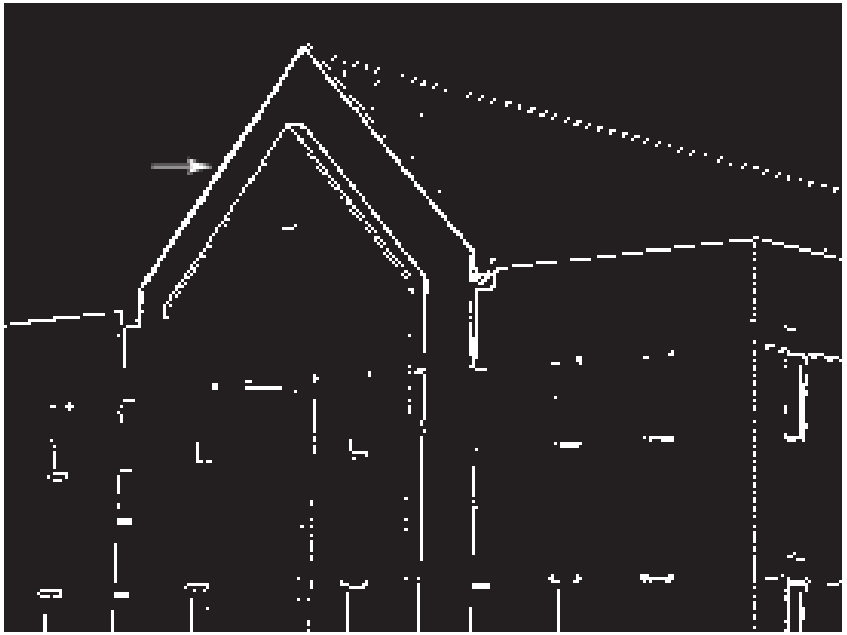
Edge detection

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

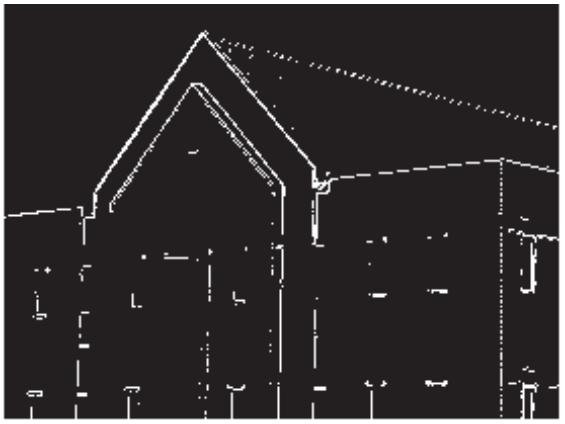
Without smoothing



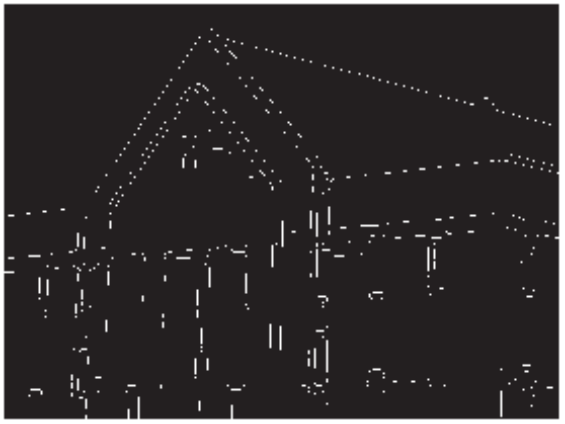
With smoothing

Advanced edge detection

Input



Magnitude of gradient vector (with smoothing)



Marr-Hildreth

Canny

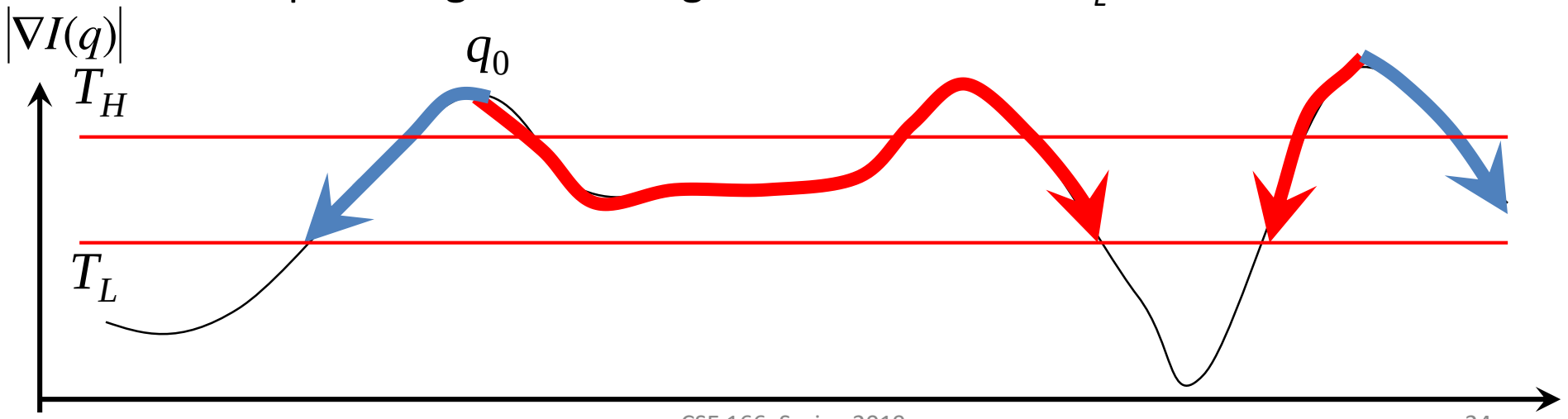
Figure 10.25 in textbook looks better

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

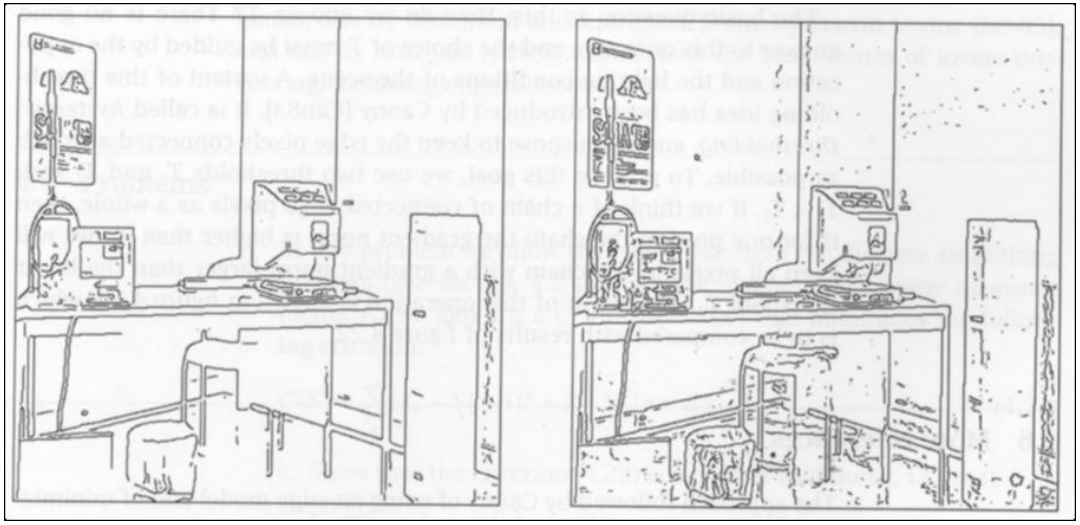
Double thresholding

- 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



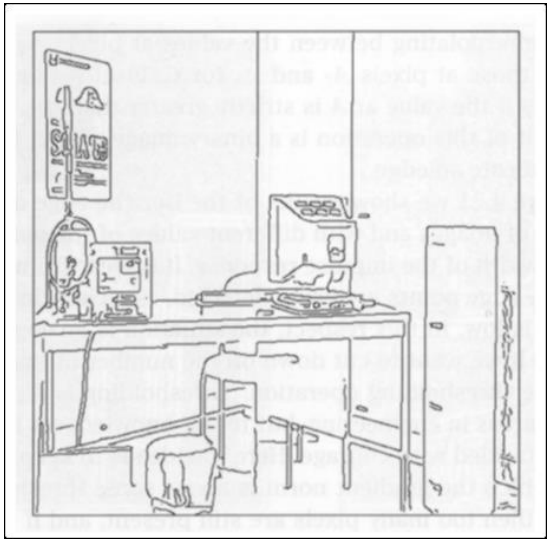
Double thresholding

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