UNIVERSITÀ
DEGLI STUDI
DI PADOVA

Your first edge detection algorithm

Stefano Ghidoni

DIPARTIMENTO
DI INGEGNERIA
DELL'INFORMAZIONE

INTELLIGENT AUTONOMOUS SYSTEMS LAB

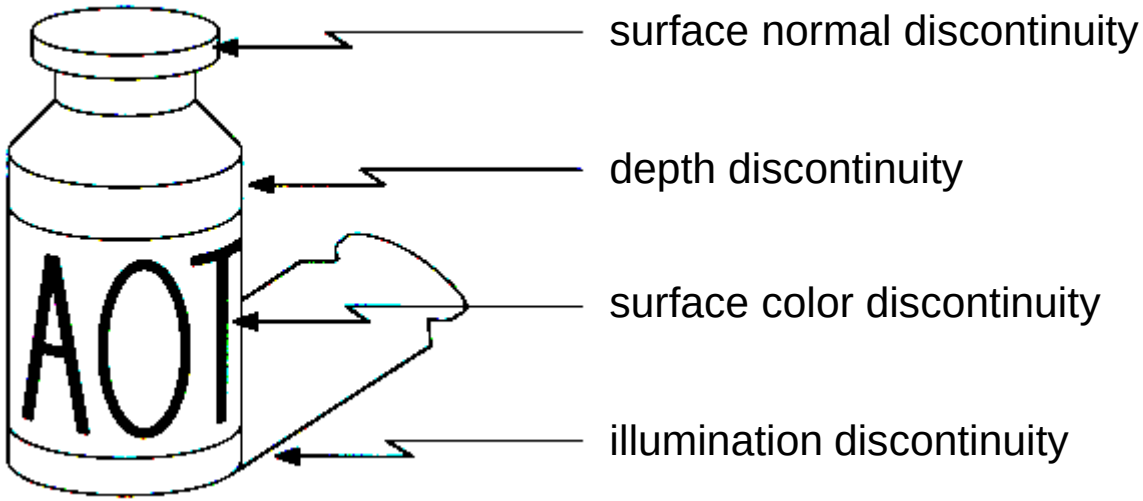
Agenda

- How to find edges?
- Interactive activity: combine filters to create an edge detection algorithm

Edge detection: problem formulation

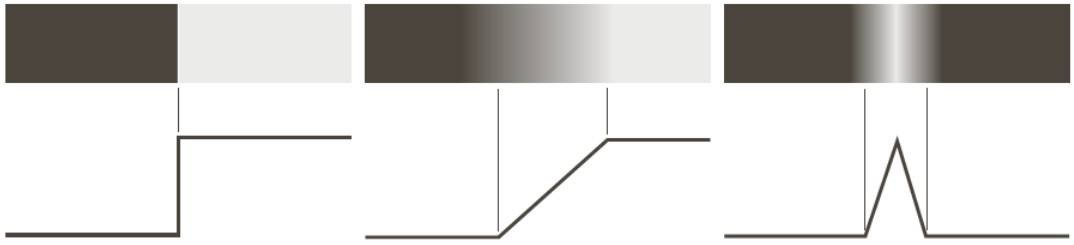
Edges in images

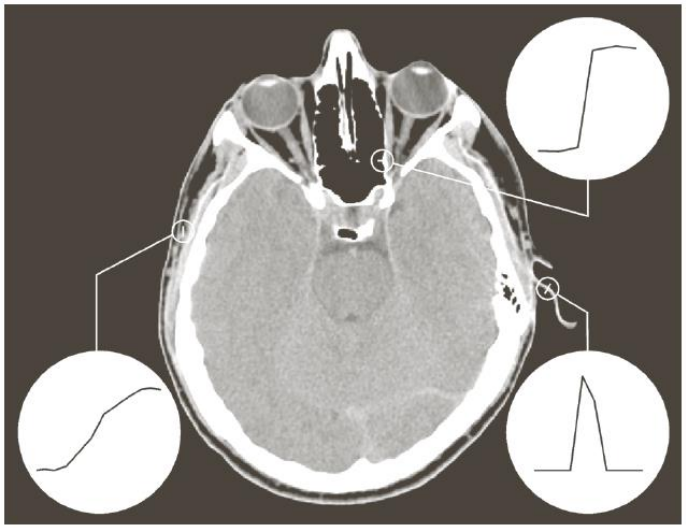
- Edges are caused by a variety of factors



Different types of edge

- Several types of edges
  - Different *gradients*





The tools

Tools for edge detection

- We have already analyzed several tools that can be useful to solve our problem
  - Gradient
  - Laplacian
  - Smoothing filters

Tools for edge detection

- We have already analyzed several tools that can be useful to solve our problem
  - **Gradient**
  - Laplacian
  - Smoothing filters

Tools for edge detection

- We have already analyzed several tools that can be useful to solve our problem
- Discrete gradient: formulation

$$g_x = f(x+1, y) - f(x, y)$$
$$g_y = f(x, y+1) - f(x, y)$$

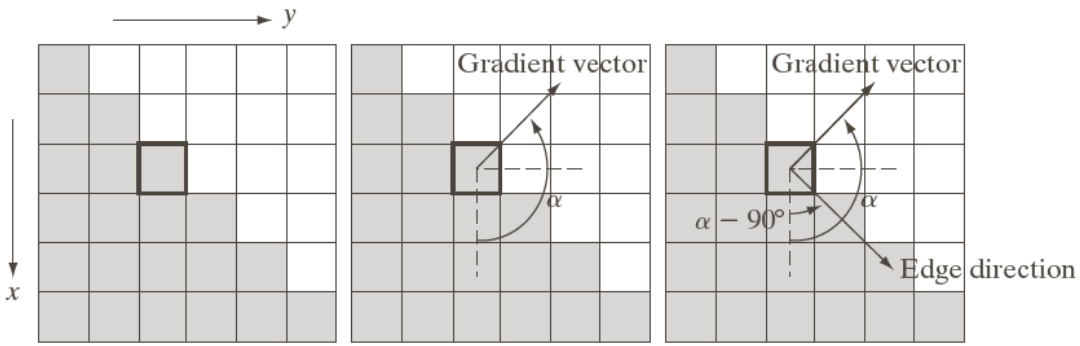
Recall: gradient edge detector

- The gradient is a vector pointing towards the fastest varying direction
- We get information about edge features considering:
  - Magnitude (edge strength)

$$\|\nabla f(x,y)\| = \sqrt{g_x^2 + g_y^2}$$

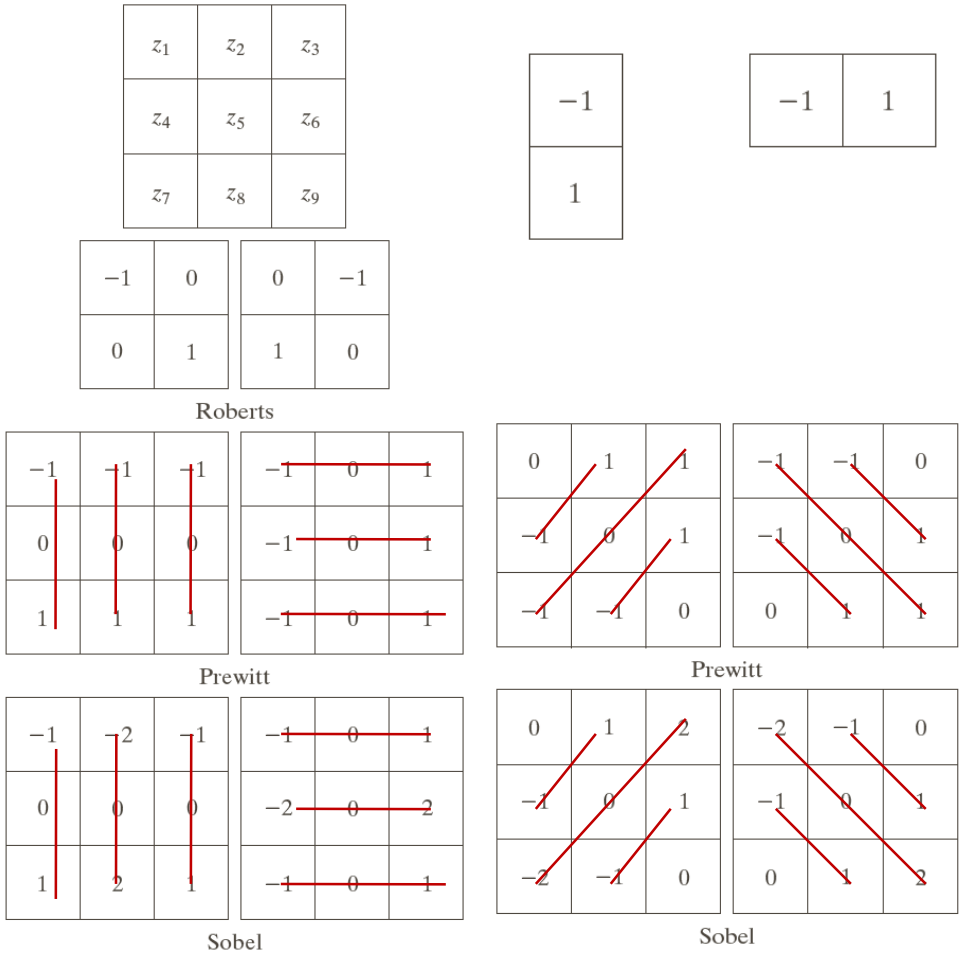
  - Phase (fastest varying direction)

$$\alpha \triangleq \theta = \tan^{-1}\left(\frac{g_y}{g_x}\right)$$



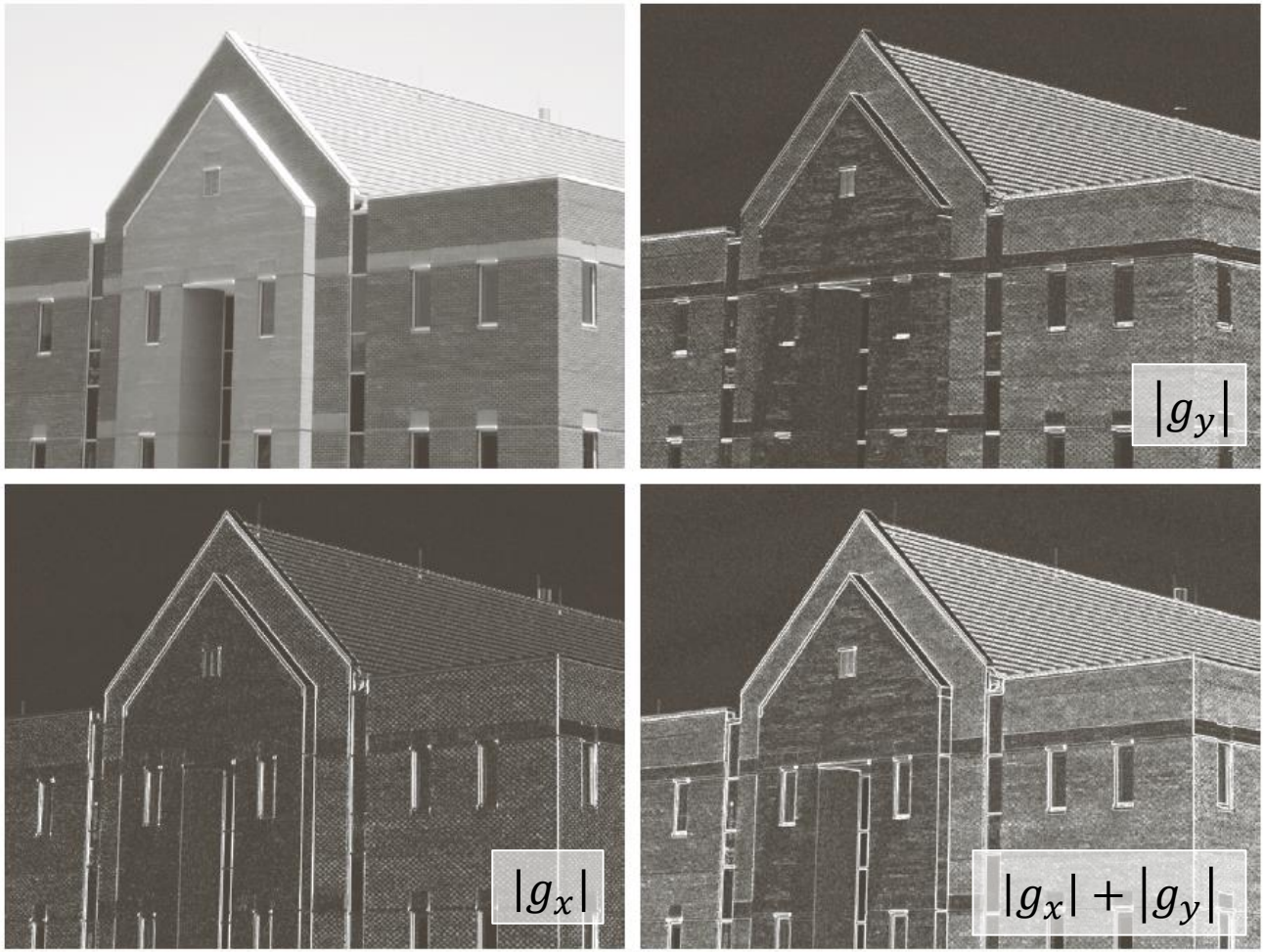
Recall: gradient masks

- We already introduced the masks for edge detection
  - The Sobel operator is the most widely used
  - Evaluated in four directions



Sobel – example

- Gradient magnitude



−1	−2	−1	−1	0	1
0	0	0	−2	0	2
1	2	1	−1	0	1

Sobel

Sobel – example

- Gradient angle

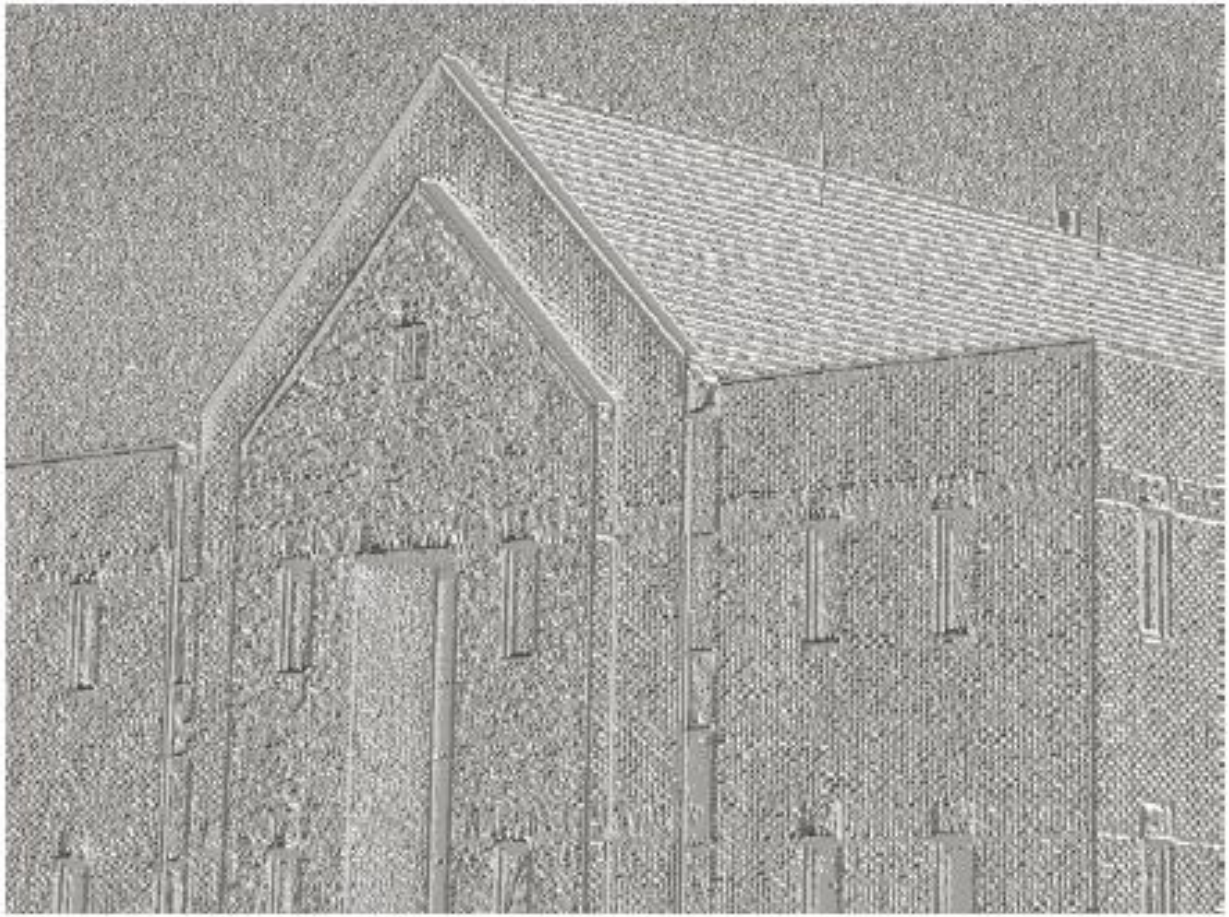


FIGURE 10.17 Gradient angle image computed using Eq. (10.2-11). Areas of constant intensity in this image indicate that the direction of the gradient vector is the same at all the pixel locations in those regions.

Tools for edge detection

- We have already analyzed several tools that can be useful to solve our problem
  - **Gradient**
  - Laplacian
  - Smoothing filters

Tools for edge detection

- We have already analyzed several tools that can be useful to solve our problem
  - Gradient
  - **Laplacian**
  - Smoothing filters

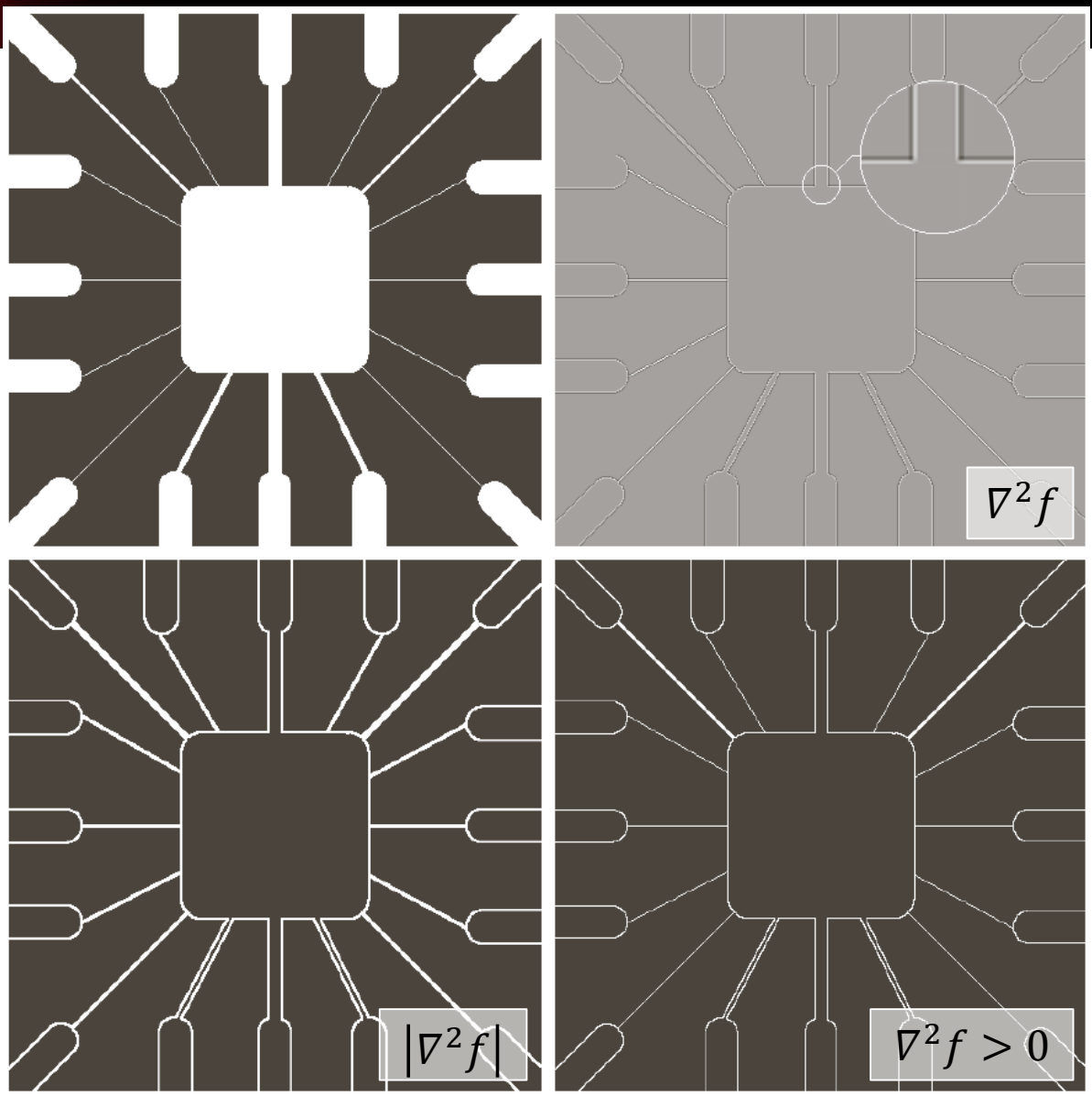
Laplacian

- Recall: Laplacian in discrete domain

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

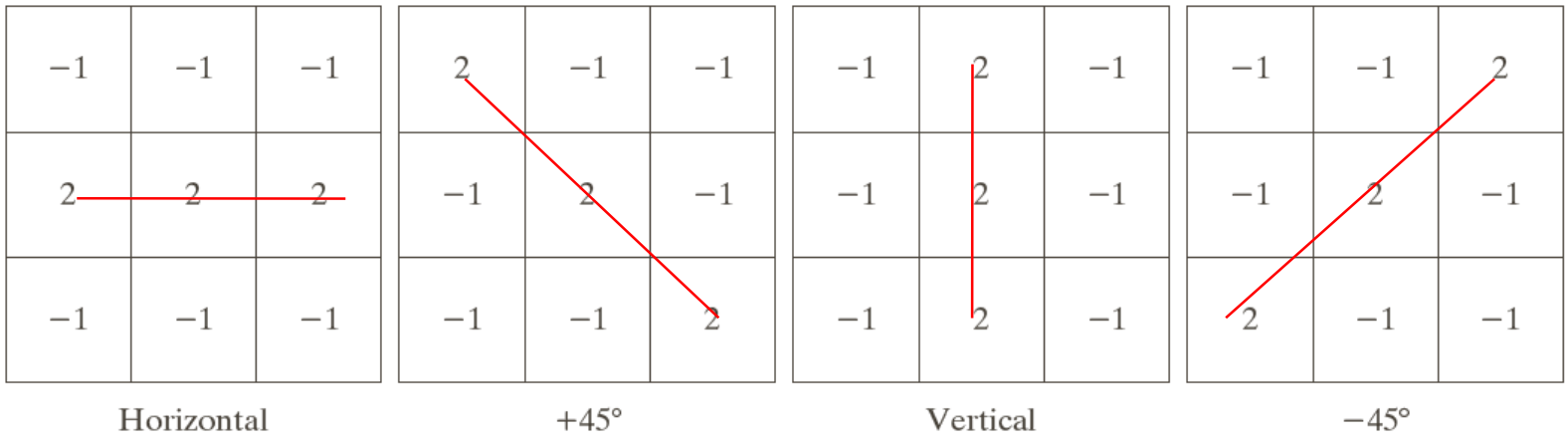
Laplacian

- Recall:
  - Isotropic detector
  - Double-line effect



Laplacian: oriented masks

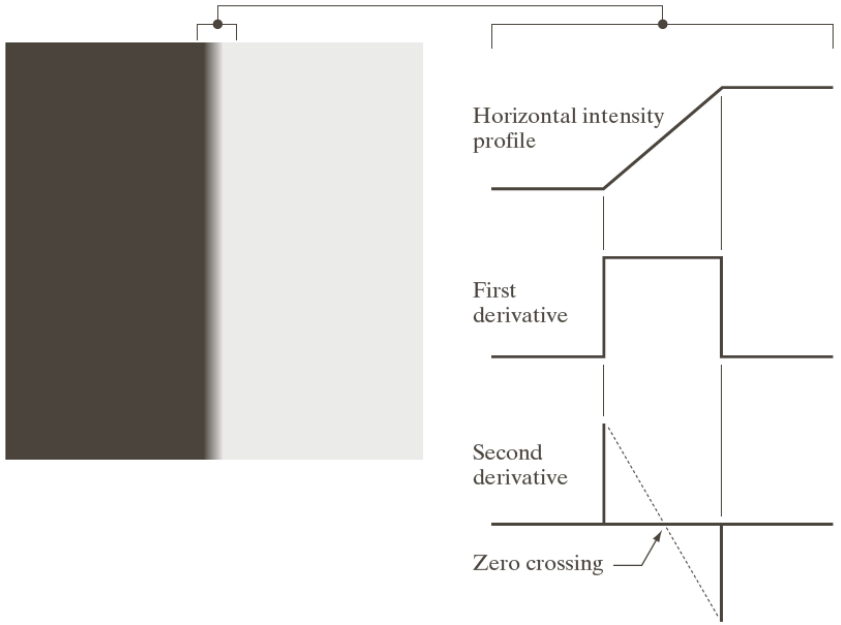
- Recall: anisotropic detectors **derived from** the laplacian
  - Anisotropic: four directions available



Edges and derivatives

- Recap: first and second order derivatives

	1st order derivative	*2nd order derivative*
Large values	On all the edge	Start and end of the edge
Edge type	Single	Double
Edge thickness	Thick	Thin
Noise sensitivity	Moderate	High

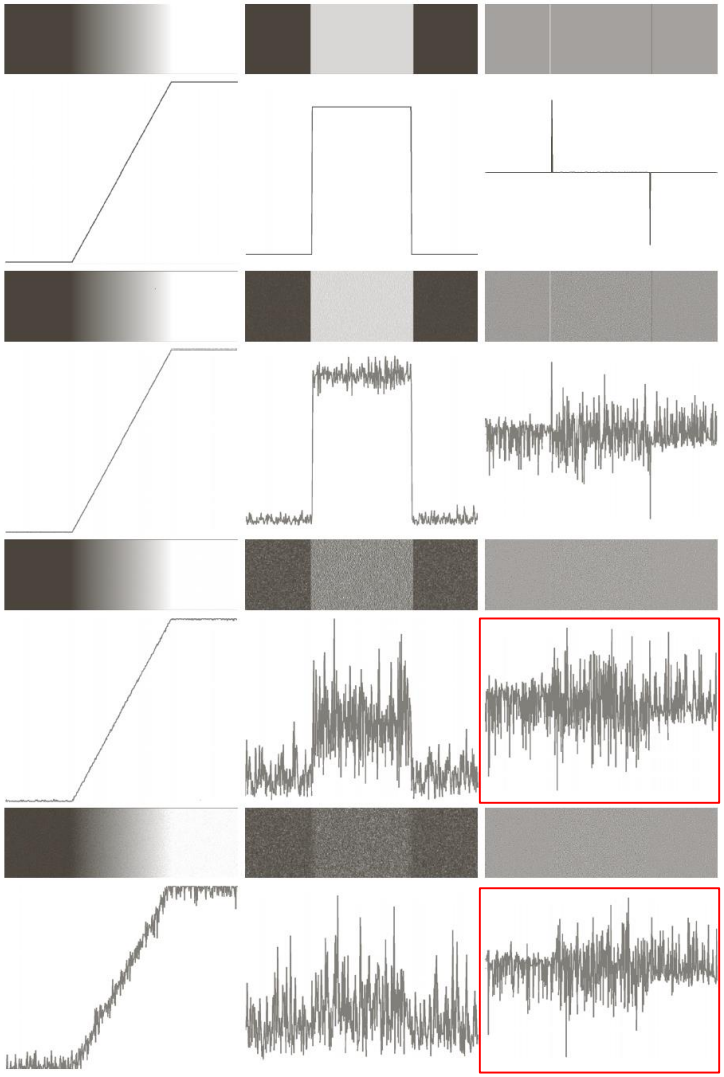


Derivatives and noise

- Are derivatives sensitive to noise?

Derivatives and noise

- Are derivatives sensitive to noise?
- Derivatives amplify noise
  - 2nd derivative noisier than 1st



The approach

Your first edge detection algorithm

- Let's discuss a possible algorithm for detecting edges
  - Without looking at the next slides!
- Example: how to reduce the effect of noise on edge detection?
  - This shall be done combining some techniques we have discussed in the previous lectures

- Anti spoiler ☺

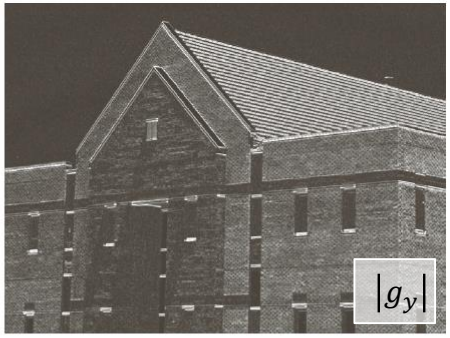
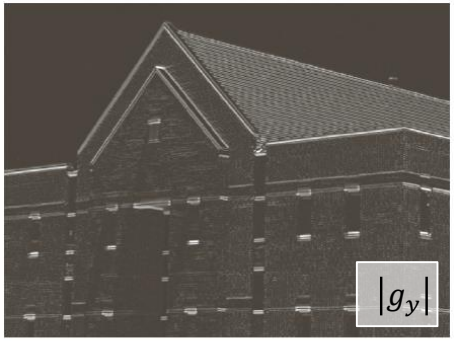
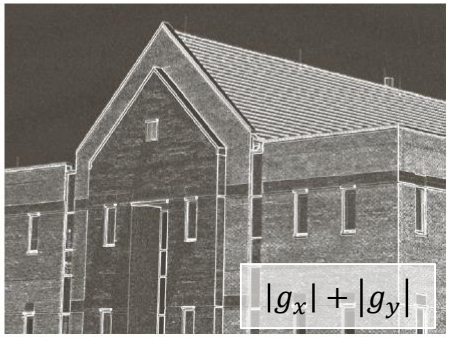
Your first edge detection algorithm

Steps of a possible approach:

1. Low-pass filter for noise removal
2. Gradient calculation
3. Gradient thresholding – $|\nabla f| > T$

Steps 1-2: Smoothing and gradient

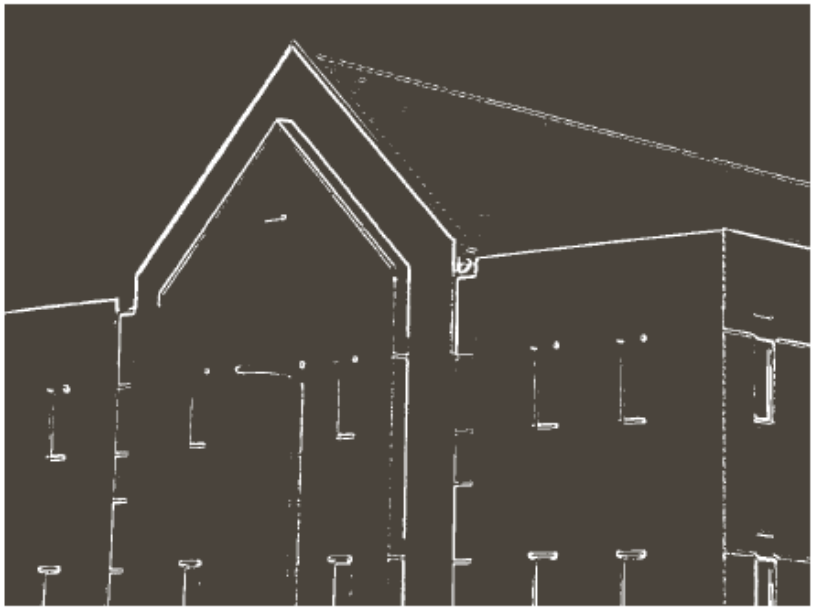
- Edge images are noisy
  - Smoothing (low-pass) often useful prior to calculation
  - In which part of the image can you observe the effect of noise reduction?

Without smoothing		With smoothing: 5×5 averaging filter	
			
			

Steps 3: Thresholding

- Thresholding selects only the strongest edges

Thresholded (33% of highest value)
no smoothing



Thresholded (33% of highest value)
5×5 smoothing filter

Diagonal edges

- Results of diagonal edges computation

0	1	2
−1	0	1
−2	−1	0

−2	−1	0
−1	0	1
0	1	2

Sobel

Well done!

- Good! You designed your first computer vision *algorithm*

UNIVERSITÀ
DEGLI STUDI
DI PADOVA

Your first edge detection algorithm

Stefano Ghidoni

DIPARTIMENTO
DI INGEGNERIA
DELL'INFORMAZIONE

INTELLIGENT AUTONOMOUS SYSTEMS LAB