MANU2480

AUTONOMOUS SYSTEM

Week 3 – PERCEPTION – Image Processing – Part 3

School of Science and Technology, RMIT Vietnam

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Review on Image Filtering

- We have been introduced to the spatial filter (also called mask or kernel) and introduced to the operation between mask and input image to change its pixel's value individually (the convolution operation).

Reference for the visualization of convolution operation:

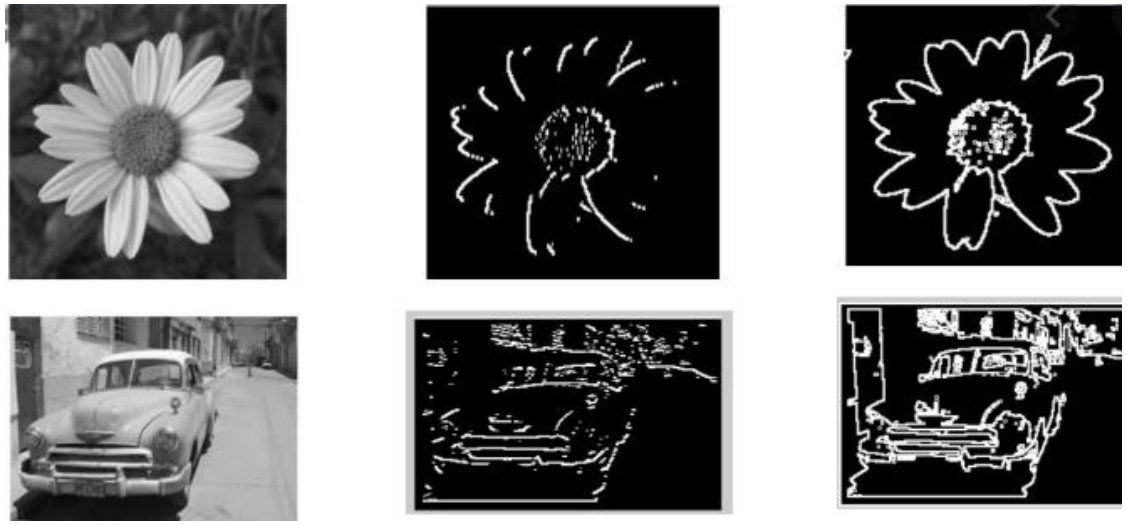
https://towardsdatascience.com/intuitively-understanding-convolutions-for-deep-learning-1f6f42faee1

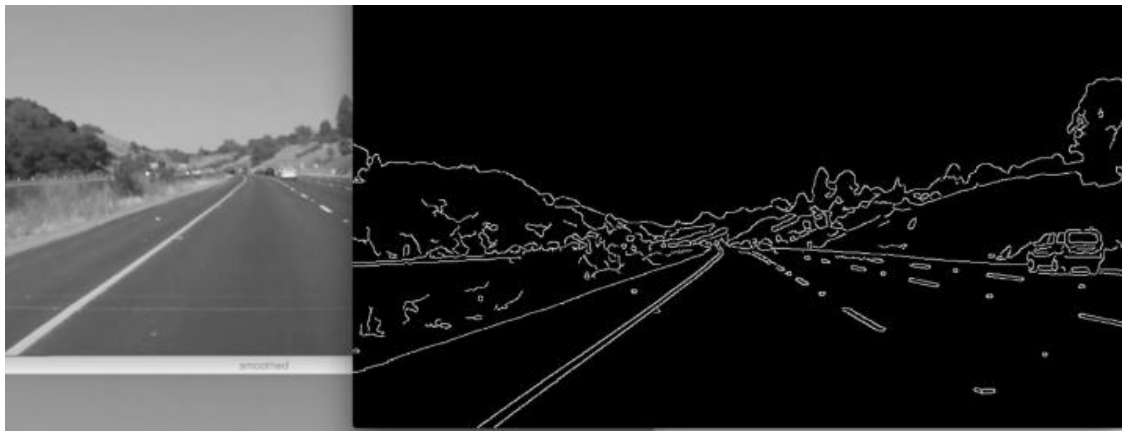
- The application of spatial filter previously discussed is on the problems of image filtering (blurring and sharpening) using low-pass filter and high-pass filter (depending on the nature of the mask's matrix),

Edge Detection

The mask and its operation used in the filtering technique is also applied on the problem of edge detection in an image.

Application of Edge Detection



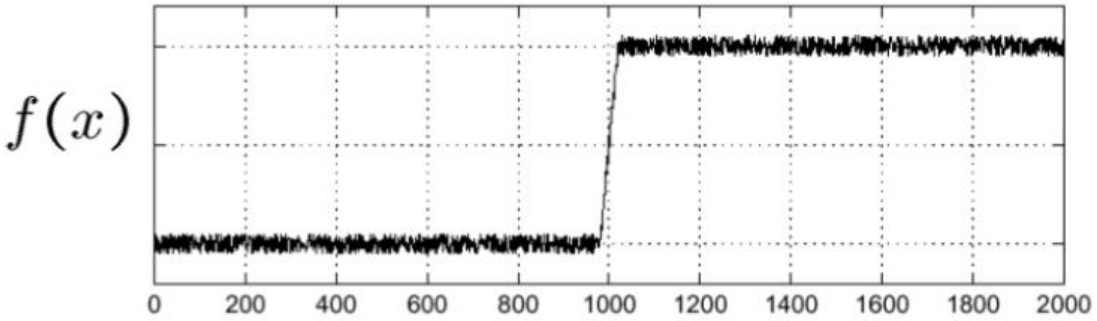


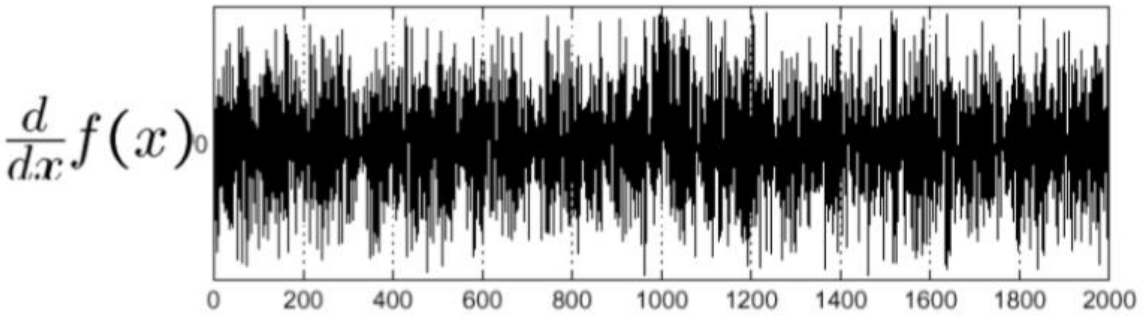
Edge Detection Fundamentals

- Objects and the background in an image have different intensities.
- The edges of objects are the areas in which abrupt intensity changes occur in an image.
- The change of intensity is measured by 1st derivative in 1D.
- If we consider about the biggest change, it is the case that the 1st derivative has the maximum magnitude, or the 2nd derivative is zero.

Edge Detection Fundamentals

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





- Where is the edge?

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Edge Detection Fundamentals

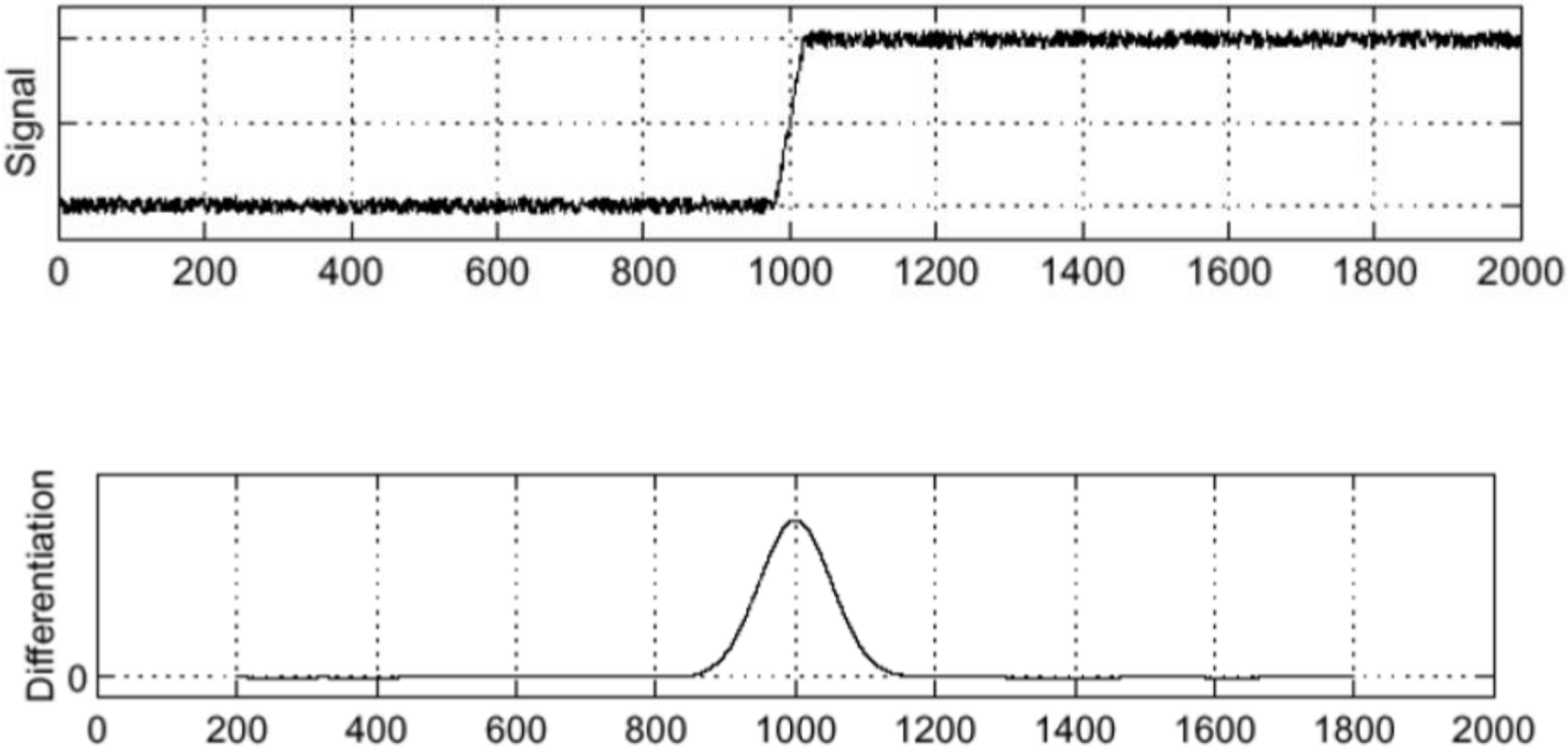
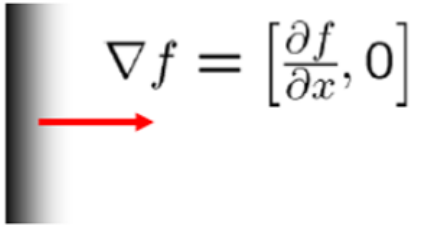


Image Gradient

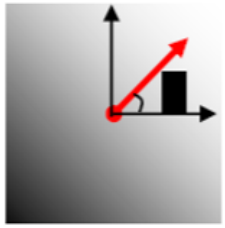
In the edge detection algorithm, the assumption is that the edges are the pixels with a high gradient.

- The gradient of an image: $\nabla f = \begin{bmatrix} \frac{\partial f}{\partial x} & \frac{\partial f}{\partial y} \end{bmatrix}$
- The gradient points in the direction of most rapid change in intensity



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

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



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

- Gradient direction: $\theta = \text{atan}\left(\frac{\partial f}{\partial y} / \frac{\partial f}{\partial x}\right)$
- Gradient magnitude: $\|\nabla f\| = \sqrt{\left(\frac{\partial f}{\partial x}\right)^2 + \left(\frac{\partial f}{\partial y}\right)^2}$

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Image Gradient

- How can we differentiate a digital image $I(x, y)$?
  - Option 1: reconstruct a continuous image, then take gradient;
  - Option 2: take discrete derivative (finite difference):

$$\frac{\partial I}{\partial x}(x, y) \approx (+1) \times I(x+1, y) + (-1) \times I(x, y)$$

$$\frac{\partial I}{\partial y}(x, y) \approx (+1) \times I(x, y+1) + (-1) \times I(x, y)$$

- How would you implement this as a spatial filter?

0	0	0
0	-1	0
0	+1	0

w for $\partial I / \partial y$

$$w_{\partial I/\partial y} = \begin{bmatrix} -1 \\ 1 \end{bmatrix}$$

0	0	0
0	-1	+1
0	0	0

w for $\partial I / \partial x$

$$w_{\partial I/\partial x} = \begin{bmatrix} -1 & 1 \end{bmatrix}$$

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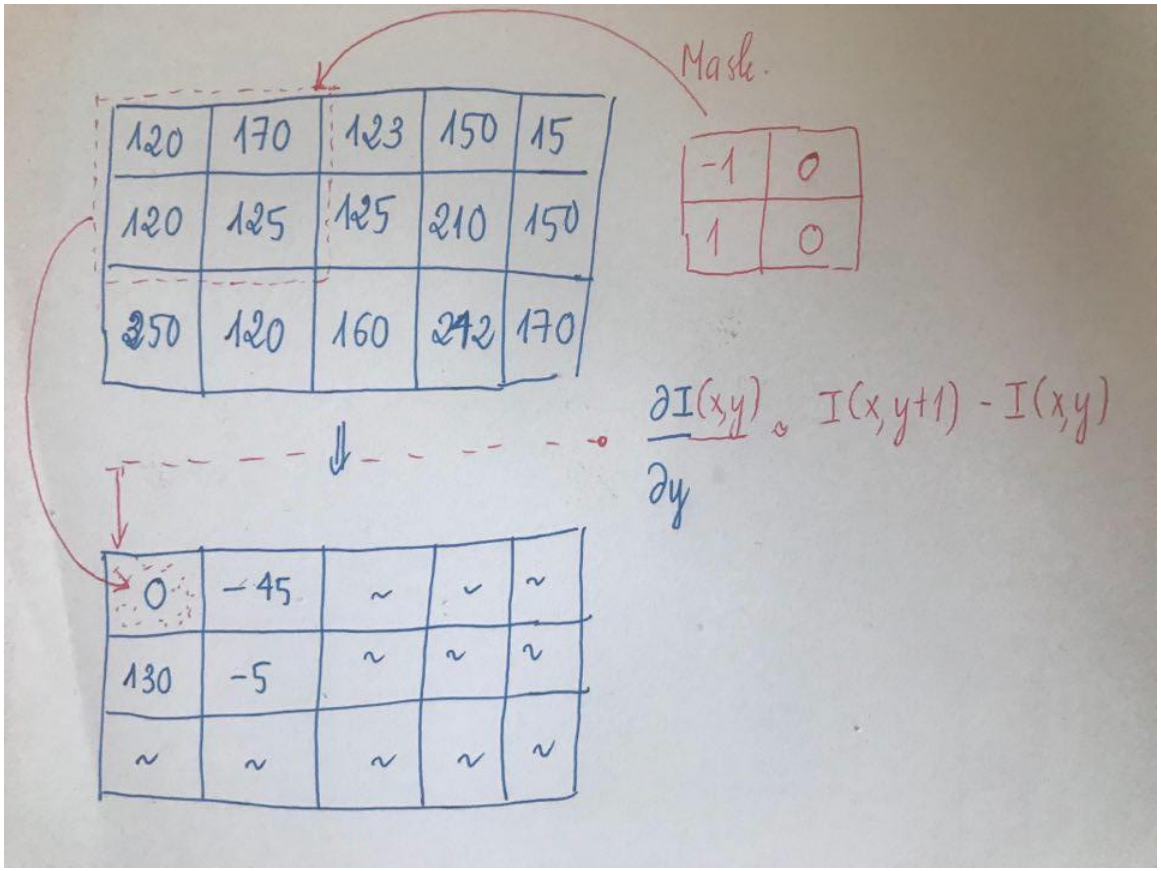
Image Gradient



Robert Edge Detection

- The Roberts edge detector is the simplest edge detector algorithm which was proposed and implemented by Lawrence Roberts in 1963.
- This edge detector uses the masks shown below to approximate the first derivatives Gx (df/dx) and Gy (df/dy). This edge detector detects edges in horizontal, vertical, or both directions in the image.

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 0 \end{bmatrix} \text{ and } \begin{bmatrix} 0 & 1 & 0 \\ -1 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

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Robert Edge Detection

- Filter the image using the first mask should give an image with pixels values equal to partial derivatives in the horizontal direction (Phase 1).
- Filter the image using the second mask should give an image with pixels values equal to partial derivatives in the vertical direction (Phase 2).
- Adding two image filtered from phase 1 and phase 2 we get the image “filtered” with the edge “highlighted”.
- https://drive.google.com/open?id=1wetmsXu6x8RB3rwUWKgiMSa1jAVyE7Yo

Sobel Edge Detection

- The Sobel edge detector uses the masks shown to approximate the first derivatives Gx (df/dx) and Gy (df/dy). This edge detector detects edges in horizontal, vertical, or both directions in the image.
- There are many other edge detection algorithm!

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

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

Reference

- *MATHWORKS official tutorial.*
- *Lecture slides from RMIT Melbourne Autonomous System course, delivered by Prof Reza Hoseinnezhad.*
- *Wheeled Mobile Robotics. From Fundamentals Towards Autonomous Systems.*
- *Digital Image Processing using Scilab.*

Thank you for your attendance :D

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