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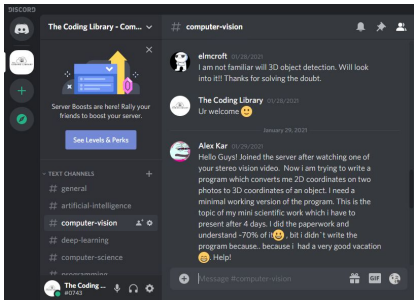
Computer Vision

Edge Detection



Discord Link in Description

Edges

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- Segment objects and information in images
- Edges is the analysis of discontinuities in images

Edge Detection

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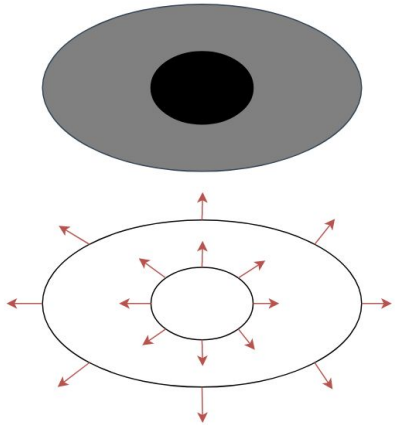
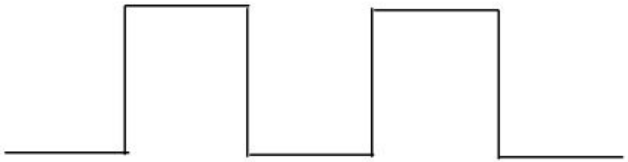
- Where brightness changes abruptly
- Changes can be found by using derivatives
- Edges have gradients and orientation
  - They are found by applying convolution masks in both x and y direction
- Edge Profiles
  - Step
  - Real
  - Noisy





Edge Detection - First Derivative

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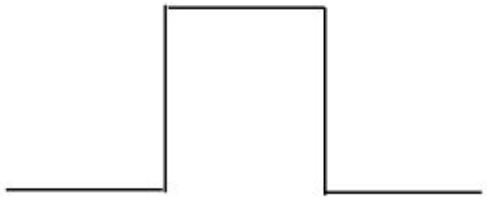
- Rate of change in two directions
- Detecting edges can be performed by locating pixel locations where the gradient is higher than its neighbors
  - Higher than some threshold
- Peak or jump when we differentiate the image intensity function

$$\nabla f(i,j) = \sqrt{\left(\frac{\delta f(i,j)}{\delta i}\right)^2 + \left(\frac{\delta f(i,j)}{\delta j}\right)^2}$$

$$\phi(i,j) = \arctan\left(\frac{\delta f(i,j)}{\delta j}, \frac{\delta f(i,j)}{\delta i}\right)$$



Edge Detection Methods - First Derivative

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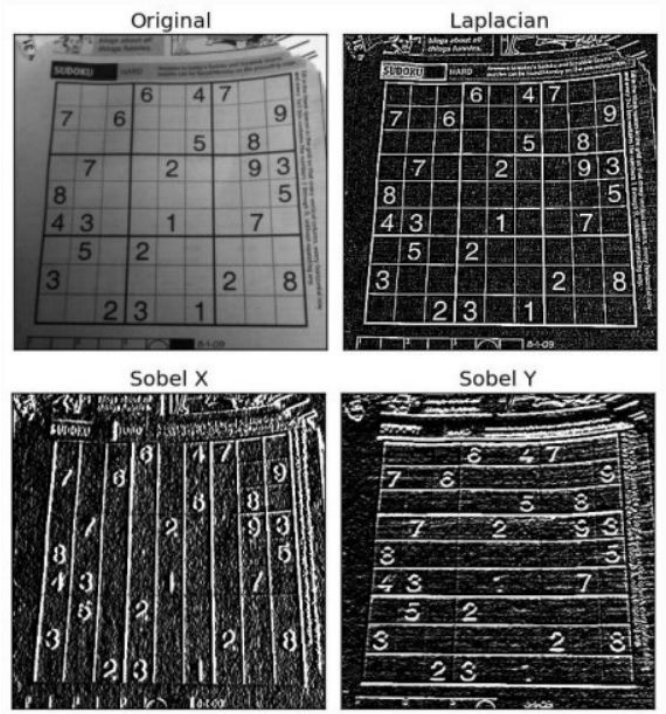
- Roberts
- Compass
- Sobel Filter
- Thresholding



Convolution

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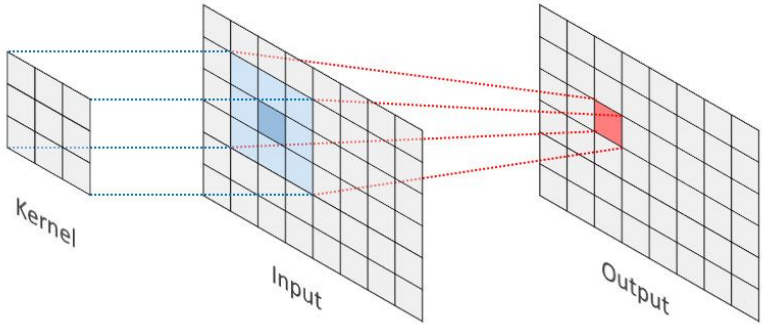
- Convolution in images
  - Applying a filter/kernel on an image
- Used in edge detectors
  - Apply conv mask in x and y direction



10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

6 x 6

*

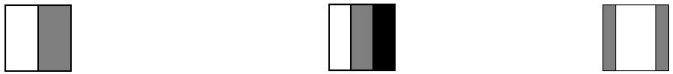
1	0	-1
1	0	-1
1	0	-1

3 x 3

=

-0	30	30	0
0	30	30	0
0	30	30	0
0	30	30	0

4 x 4



Edge Detection - Roberts

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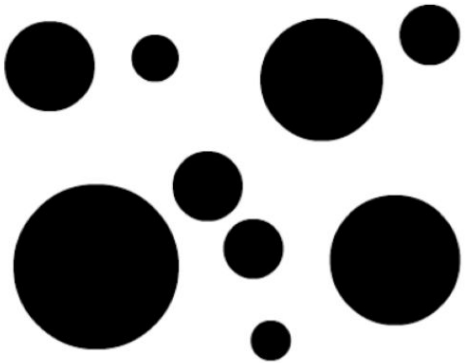
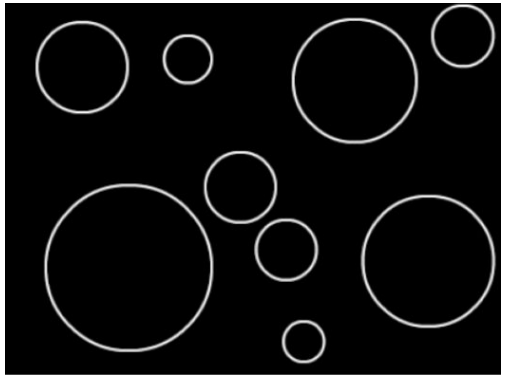
- Good for binary images
- Very sensitive to noise in the image

$$h_1(i,j) = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} \quad h_2(i,j) = \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}$$





Edge Detection - Sobel

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- Discrete differentiation operator
- It computes an approximation of the gradient of an image intensity function
- Combines Gaussian smoothing and differentiation
- Vertical and Horizontal changes

$$G_y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ +1 & +2 & +1 \end{bmatrix} * I \qquad G_x = \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix} * I$$

$$G = \sqrt{G_x^2 + G_y^2}$$

Edge Detection - Thresholding

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Edge Detection Methods - Second Derivative

- Laplacian of Gaussian
- Canny

- What is the differences between the detectors and which one to use?

Edge Detection - Laplace Operator

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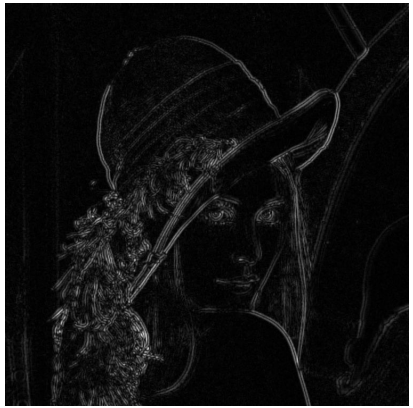
- Second derivative is zero
  - Edges in an image
- Laplacian operator to take the derivative in both dimensions $Laplace(f) = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}$
- Laplacian uses Sobel internally

$$h(i,j) = \begin{bmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{bmatrix} \quad h(i,j) = \begin{bmatrix} 2 & -1 & 2 \\ -1 & -4 & -1 \\ 2 & -1 & 2 \end{bmatrix}$$



Edge Detection - Canny

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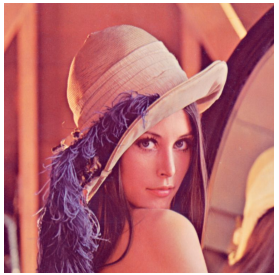

- Known as the optimal edge detector
- The Canny Algorithm computes both
  - Orientation, location and gradient
- Steps
  - Filter out any noise with Gaussian filter
  - Find the intensity gradient of the image, method similar to Sobel
  - Non-maximum suppression is applied. Removes pixels that are not considered to be part of an edge
  - Hysteresis. Using thresholds to filter pixels

a. If a pixel gradient is higher than the *upper* threshold, the pixel is accepted as an edge

b. If a pixel gradient value is below the *lower* threshold, then it is rejected.

c. If the pixel gradient is between the two thresholds, then it will be accepted only if it is connected to a pixel that is above the *upper* threshold.

Canny recommended a *upper:lower* ratio between 2:1 and 3:1.

Edge Detection in OpenCV

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```
GaussianBlur(gray,
    blurred,
    cv::Size(3, 3),  // smoothing window width and height in pixels
    3);              // how much the image will be blurred

Canny(blurred,
    edge,
    lowerThreshold, // lower threshold
    50);           // higher threshold
```

Canny vs Sobel

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Contour Segmentation

- Representation of edge data
- Detection of borders
- Line segment extraction
- Extract information/objects from images

Contour Segmentation

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- Find contours - edges