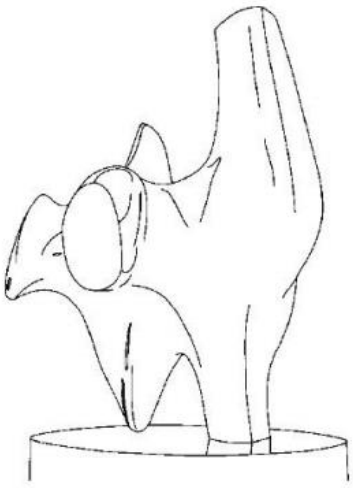
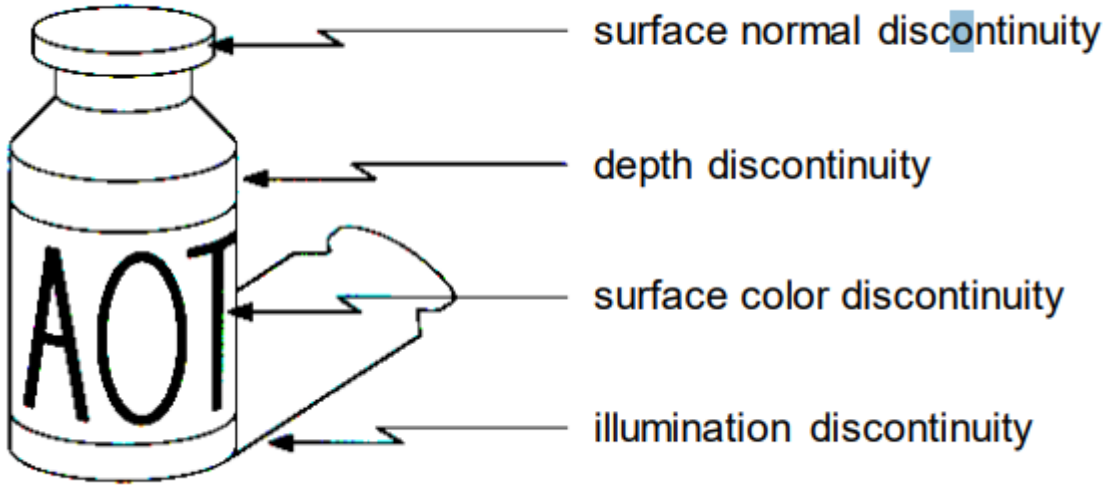
Canny Edge Detection

Edge detection

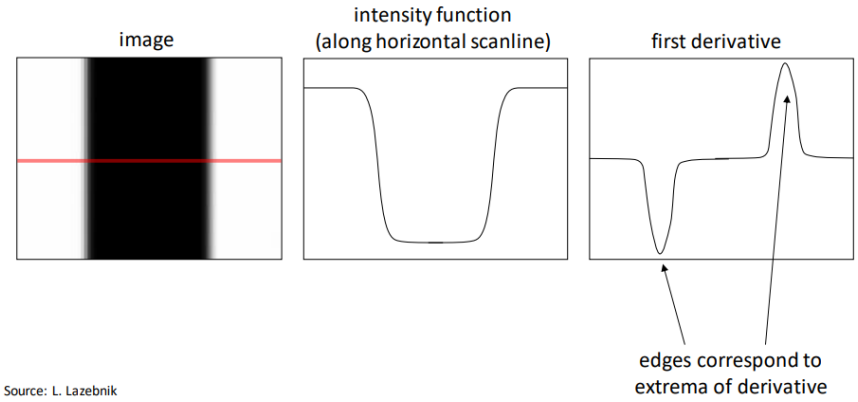


Edge가 왜 중요?

ex) 색깔이 다른 자동차. 같은 자동차인 것을 알아내기 위해서 edge를 이용.



이런 Edge..

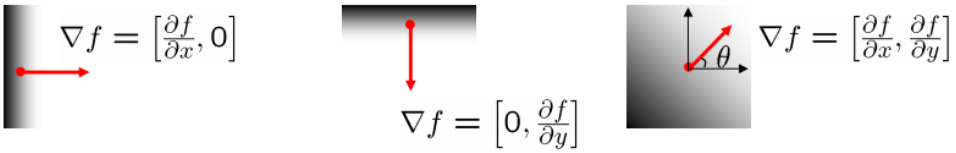


미분을 이용해서 Edge를 찾는다.

Image gradient

- The *gradient* of an image: $\nabla f = \left[\frac{\partial f}{\partial x}, \frac{\partial f}{\partial y}\right]$

The gradient points in the direction of most rapid increase in intensity



The *edge strength* is given by the gradient magnitude:

$$\|\nabla f\| = \sqrt{\left(\frac{\partial f}{\partial x}\right)^2 + \left(\frac{\partial f}{\partial y}\right)^2}$$

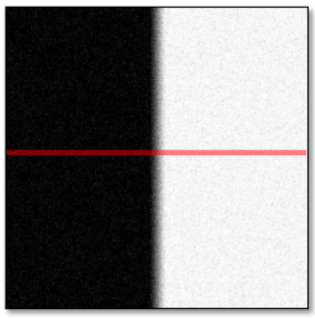
The gradient direction is given by:

$$\theta = \tan^{-1}\left(\frac{\partial f}{\partial y} / \frac{\partial f}{\partial x}\right)$$

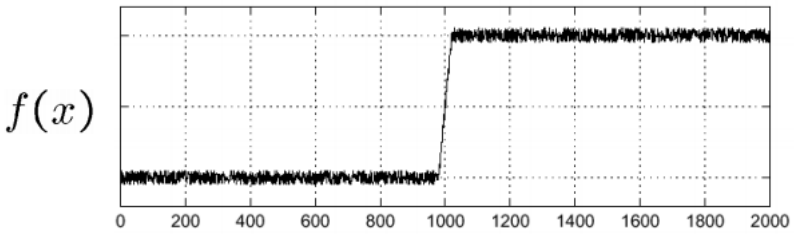
- how does this relate to the direction of the edge?

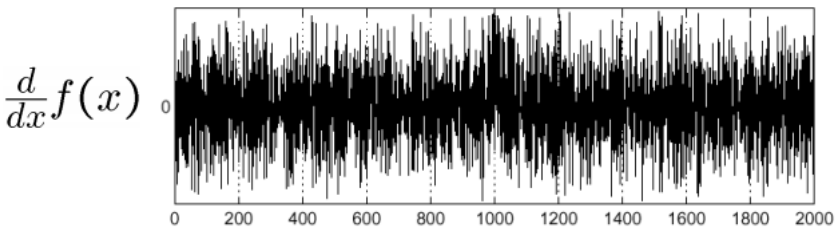
Source: Steve Seitz

Gradient.



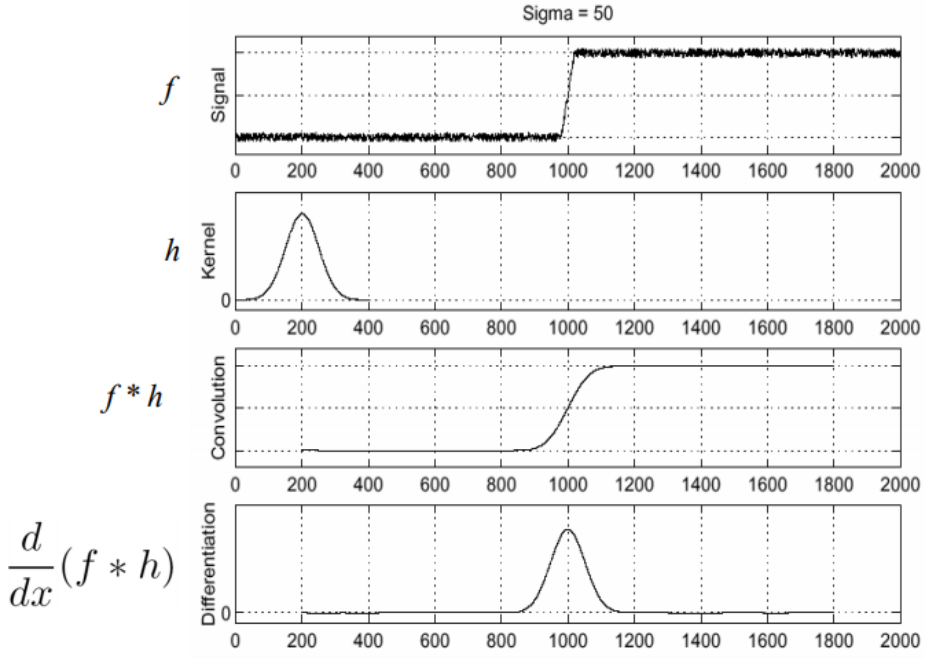
Noisy input image





Where is the edge?

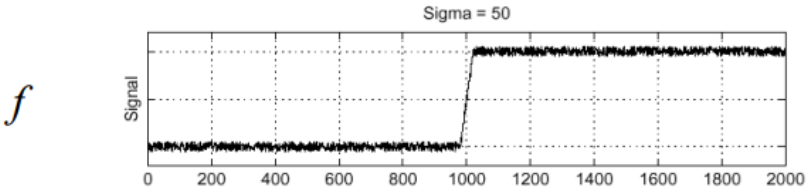
Source: S. Seitz

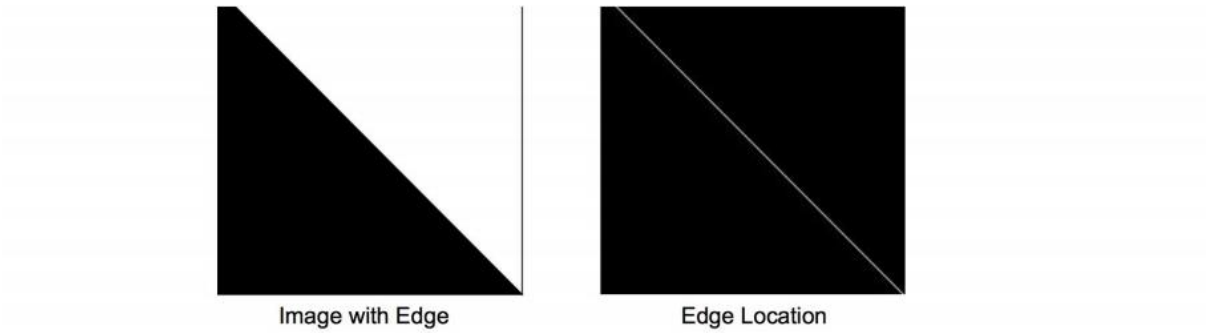


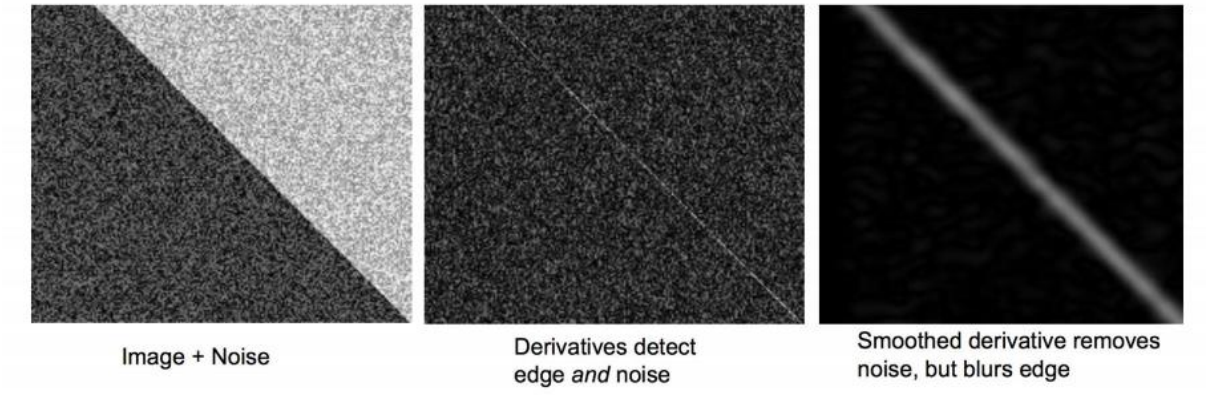
To find edges, look for peaks in $\frac{d}{dx}(f * h)$

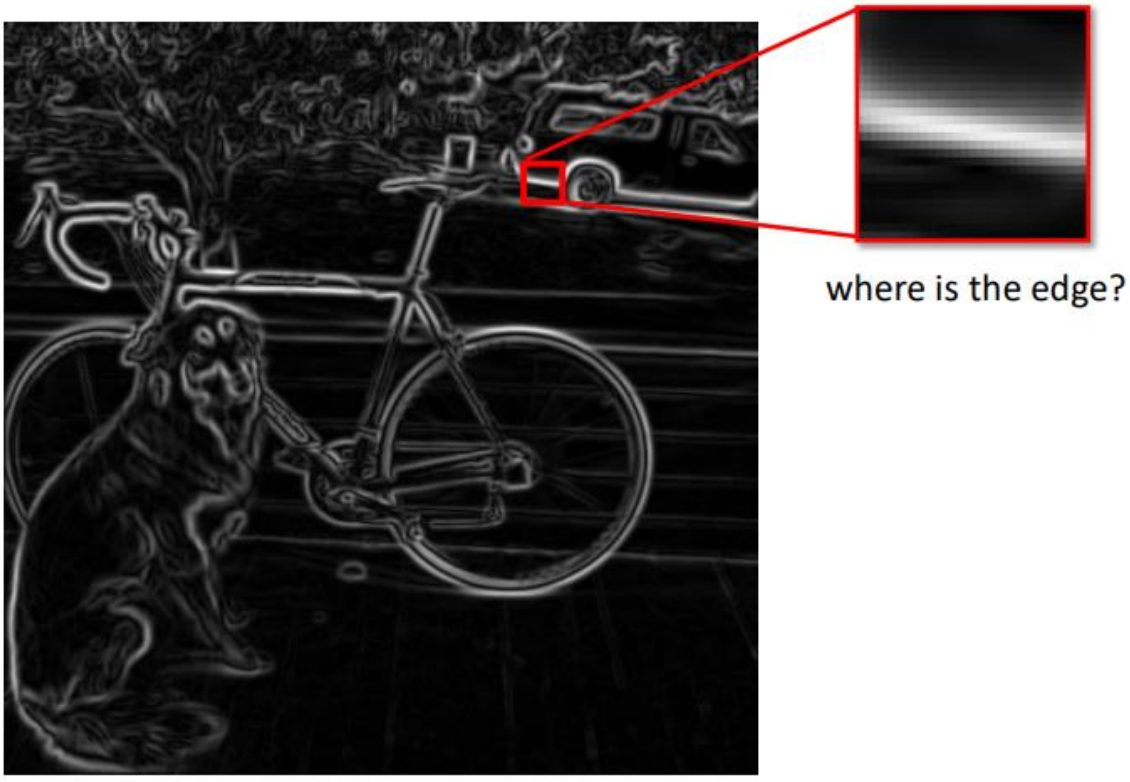
Source: S. Seitz

- Differentiation is convolution, and convolution is associative: $\frac{d}{dx}(f * h) = f * \frac{d}{dx}h$
- This saves us one operation:





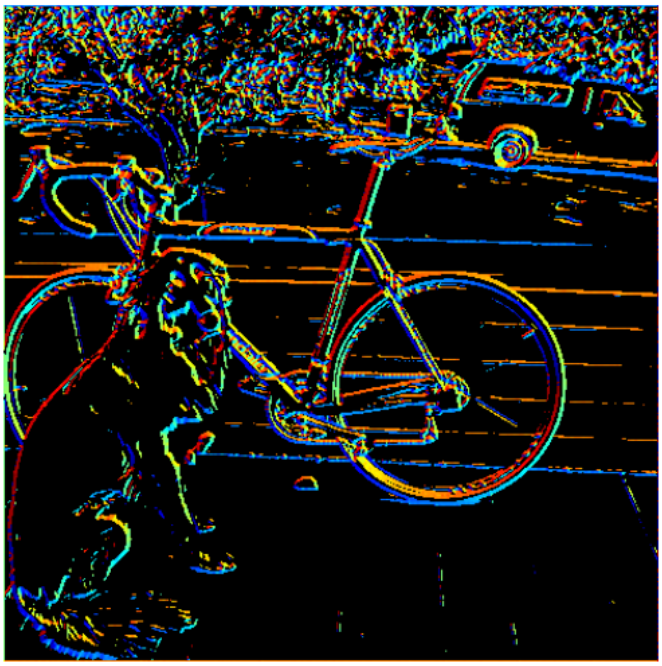




thresholding

저 굵은 부분을 Edge라고 판단하기 어렵다. 최대한 edge를 가늘게 해줘야 할 필요가 있다.

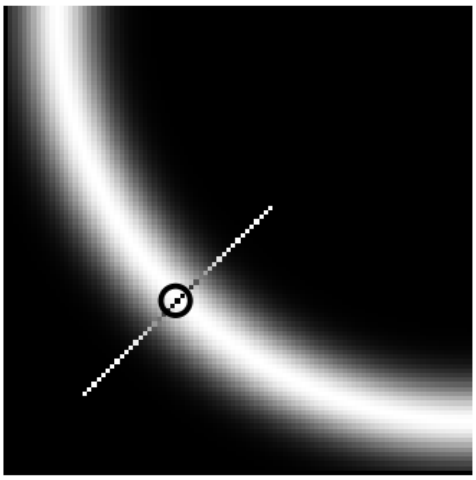
- Get orientation (below, threshold at minimum gradient magnitude)

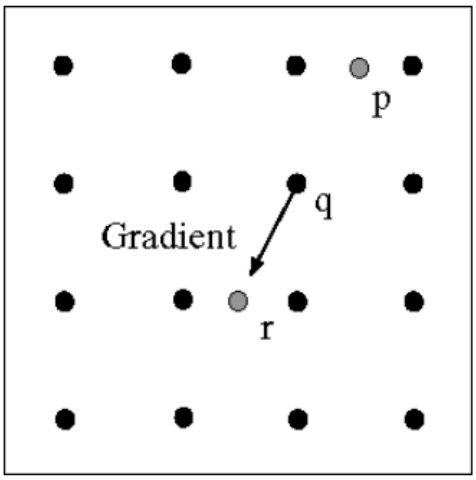


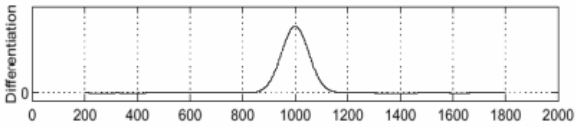
theta = numpy.arctan2(gy, gx)

Gradient orientation angle

Non-maximum supression







- Check if pixel is local maximum along gradient direction
  - requires *interpolating* pixels p and r

Before Non-max Suppression

After Non-max Suppression

Non-max suppression을 적용함으로써 가늘어진 Edge를 볼 수 있다.

- Still some noise
- Only want strong edges
- 2 thresholds, 3 cases
  - R > T: strong edge
  - R < T but R > t: weak edge
  - R < t: no edge
- Why two thresholds?

Canny edge detector

1. Filter image with derivative of Gaussian
2. Find magnitude and orientation of gradient
3. Non-maximum suppression
4. Thresholding and linking (hysteresis):
   - Define two thresholds: low and high
   - Use the high threshold to start edge curves and the low threshold to continue them

Source: D. Lowe, L. Fei-Fei, J. Redmon

Canny edge detector

original | Canny with $\sigma = 1$ | Canny with $\sigma = 2$