Canny Edge Detection

What is the purpose of edge detection?

The purpose of edge detection in general is to significantly reduce the amount of data in an image, while preserving the structural properties to be used for further image processing

Canny Edge Detection Algorithm

- The algorithm runs in five separate steps:

1. Smoothing: Blurring of the image to remove noise.

2. Finding gradients: The edge should be marked where the gradients of the image has large magnitude.

3. Non-maximum suppression: Only local maxima should be marked as edge.

4. Double thresholding: Potential edges are determined by thresholding.

5. Edge tracking by hysteresis: Final edges are determined by suppressing all edges that are not connected to a very certain (strong) edge.

Smoothing

- All image taken from a camera will contain some amount of noise.
- To prevent that noise is mistaken for edges, noise must be reduced.
- Therefore the image is first smoothed by applying a Gaussian filter.

Finding Gradients

- The Canny algorithm finds edges where the gray-scale intensity of the image changes the most.
- Gradients at each pixel in the smoothed image are determined by applying the *Sobel operator.*

Finding Gradients

(a) Smoothed

(b) Gradient magnitudes

Non-maximum Suppression

- The purpose of this step is to convert the “blurred” edges in the image of the gradient magnitudes to “sharp” edges.
- This is done by preserving all local maxima in the gradient image, and deleting everything else.

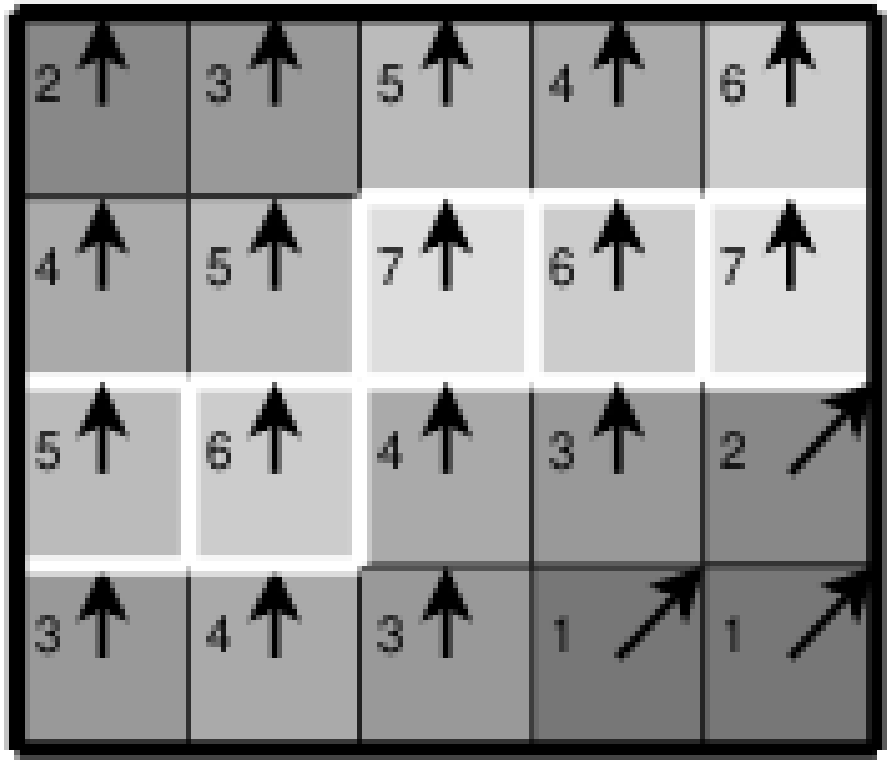
Non-maximum Suppression

The algorithm is for each pixel in the gradient image:

1. Compare the edge strength of the current pixel with the edge strength of the pixel in the positive and negative direction. i.e if the gradient direction is north (theta = 90 degree), compare with pixel to the north and south.

2. If the edge strength of the current pixel is largest; preserve the value of the edge strength. If not, suppress the value.

Non-maximum Suppression

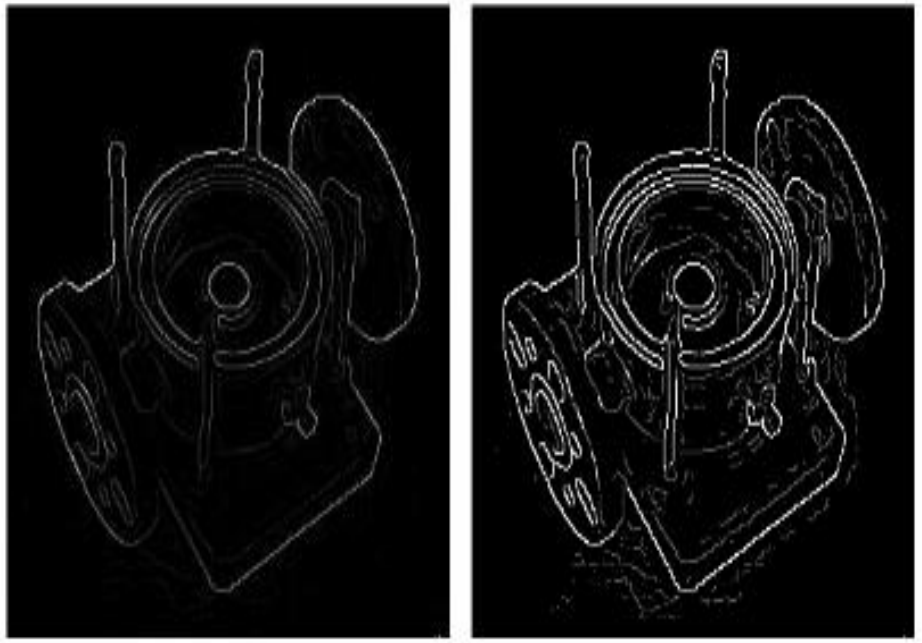


- An example of non-maximum suppression is shown in figure. Almost all pixel have gradient directions pointing north. They are compared with pixels above and below.
- The pixel that turn out to be maximal is this comparison are marked with white border.

Double Thresholding

- The edge-pixels after the non-maximum suppression are marked with their strength pixel-by-pixel.
- Many of these will probably be true edges in the image, but some may be caused by noise.
- The Canny edge detection algorithm uses double threshold value.
- Edge pixels stronger than the high threshold are marked as strong; edge pixels weaker than the low threshold are suppressed and edge pixels between the two thresholds are marked as weak.

Double Thresholding



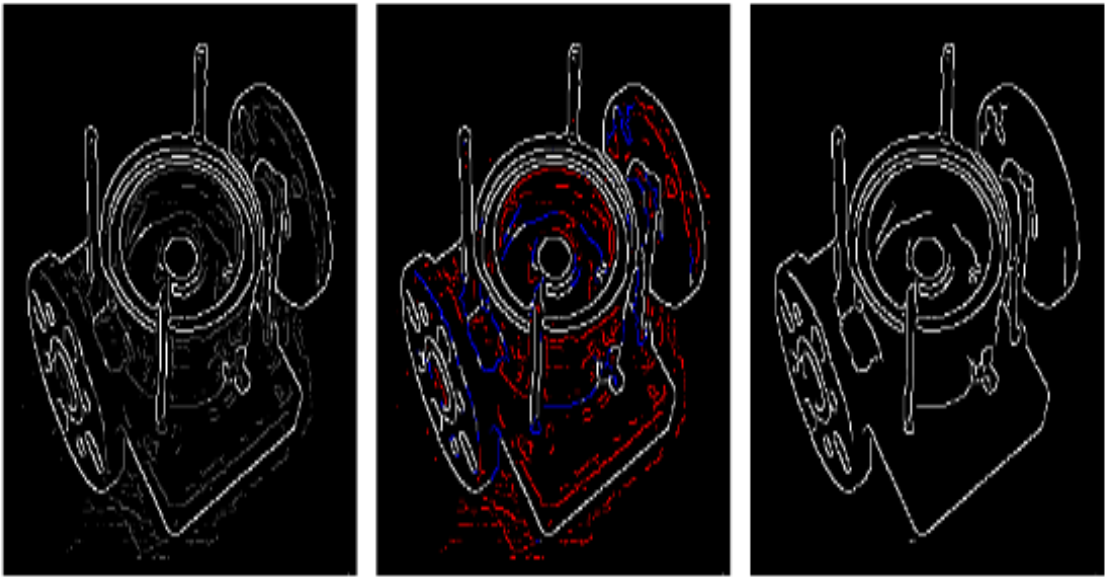
(a) Edges after non-maximum suppression (b) Double thresholding

- The effect on the test image with thresholds 20 and 80 is shown in figure.
- In the second image the strong edges are white and weak edges are gray

Edge Tracking by Hysteresis

- Strong edges are interpreted as “certain edges”, and can be included in the final edge image.
- Weak edges are included if and only if they are connected to strong edges.

Edge Tracking by Hysteresis



(a) Double thresholding (b) Edge tracking by hysteresis (c) Final output

- The middle image shows strong edges in white, weak edges connected to strong edges in blue and other weak edges in red.