Canny Edge and Harris Interest Point Detection

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1 Canny Edge Detection

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1. Apply Gaussian blur after converting to gray-
    scale.
2. Get Gradient magnitude and direction.
3. Apply Non-Maximal Suppression
4. Use double threshold
5. Edge tracking by hysteresis
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Listing 1: Canny Edge Detection

- For Gaussian blur sigma = sqrt(2) and size 5x5 is used.

$$B = \begin{pmatrix} 0.0125 & 0.0264 & 0.0339 & 0.0264 & 0.0125 \\ 0.0264 & 0.0559 & 0.0718 & 0.0559 & 0.0264 \\ 0.0339 & 0.0718 & 0.0922 & 0.0718 & 0.0339 \\ 0.0264 & 0.0559 & 0.0718 & 0.0559 & 0.0264 \\ 0.0125 & 0.0264 & 0.0339 & 0.0264 & 0.0125 \end{pmatrix} \quad (1)$$

- For Gradient convolution is done using matrix

$$Gx = \begin{pmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{pmatrix} \quad (2)$$

$$Gy = \begin{pmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{pmatrix} \quad (3)$$

- For Non-Maximal Suppression angle is first rounded to 0°, 45°, 90°, 135° which maybe negative
  - if the rounded gradient angle is 0° (i.e. the edge is in the northâĂŞsouth direction) the point will be considered to be on the edge if its gradient magnitude is greater than the magnitudes at pixels in the east and west directions
  - if the rounded gradient angle is 90° (i.e. the edge is in the eastâĂŞwest direction) the point will be considered to be on the edge if its gradient magnitude is greater than the magnitudes at pixels in the north and south directions
  - if the rounded gradient angle is 135° (i.e. the edge is in the northeastâĂŞsouthwest direction) the point will be considered to be on the edge if its gradient magnitude is greater than the magnitudes at pixels in the north west and south east directions
  - if the rounded gradient angle is 45° (i.e. the edge is in the north westâĂŞsouth east direction) the point will be considered to be on the edge if its gradient magnitude is greater than the magnitudes at pixels in the north east and south west directions.
- For edge tracking a queue of strong edges is maintained. The front of queue is popped and all neighbouring weak edges are added to queue as strong edge. It is done while queue is not empty.

1.1 Observation

The Output of MyCannyEdgeDetector closely matches Matlab version. See the example figure.

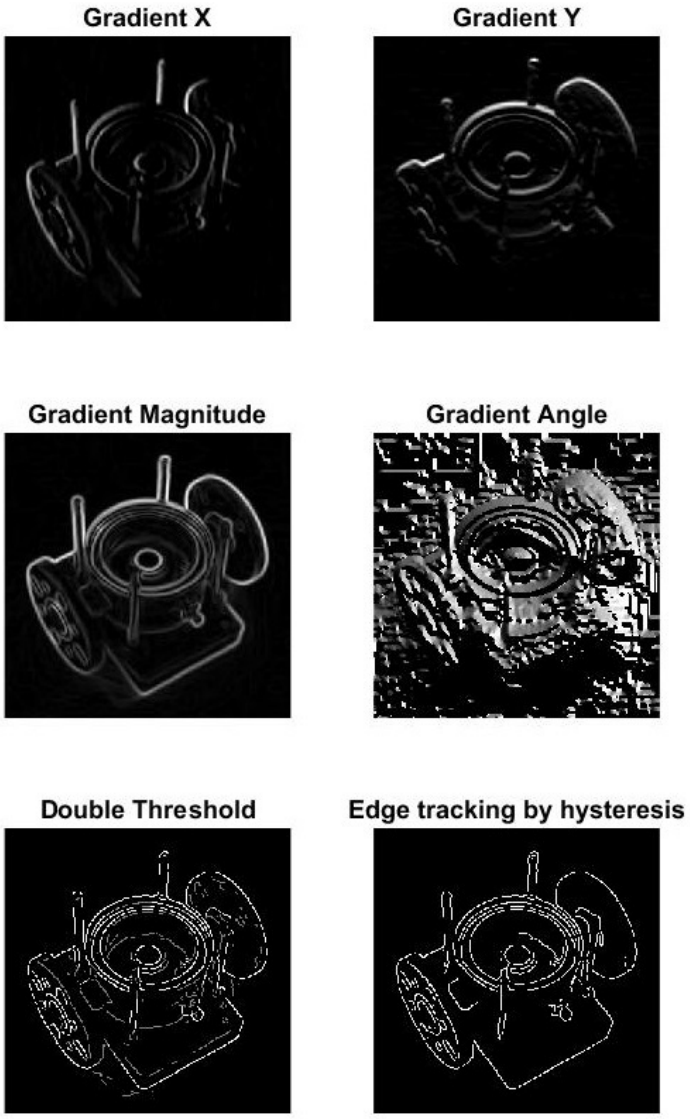

Figure 1: Stages of Canny Edge Detection for test.jpg with Threshold = [0.08 0.2]

2 MSE and PSNR Value

The MSE and PSNR Value are calculated using following formulas, where, MAX_I is the maximum possible pixel value of the image i.e 256 for 8 bit image

Mean-Squared Error (MSE):

$$\text{MSE} = \frac{\sum_{j=1}^{N}\left(\sum_{i=1}^{M}(X_{i,j} - Y_{i,j})^2\right)}{MN}$$

Peak Signal-to-Noise Ratio (PSNR):

$$\text{PSNR} = 10\log\frac{255^2}{\text{MSE}}$$

2.1 Observation

Since the Output of MyCannyEdgeDetector closely matches Matlab version, MSE is mostly zero and PSNR is mostly Infinite.

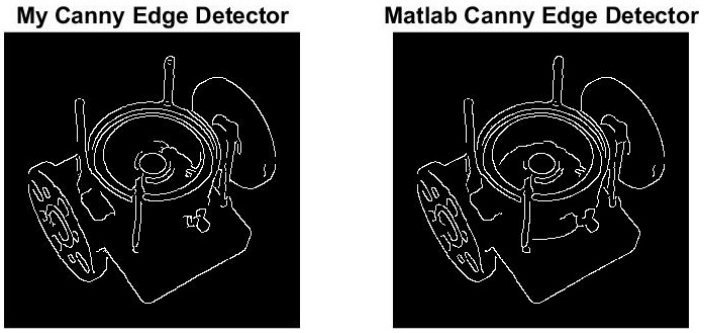

Figure 2: Comparison between MyCannyEdgeDetector and Matlab Canny Edge Detection for test.jpg with Threshold = [0.03 0.2]

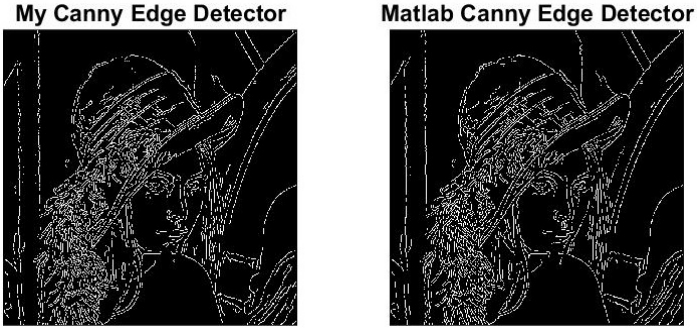

Figure 3: Comparison between MyCannyEdgeDetector and Matlab Canny Edge Detection for lenna.png with Threshold = [0.0375 0.0938]

3 Harris Interest Point Detection

1. Compute image gradient in x and y.
2. Compute I_x^2, I_y^2 and$I_x.I_y$.
3. Apply Gaussian blur.
4. Compute $R = det(M) - \alpha.trace(M)_2$ each
5. Choose points with R above threshold.
6. Compute Non-maximal suppression.

Listing 2: Harris Interest Points Detection

3.1 Observation

- The α can out to 0.4 through trial and error.
- As threshold is decreased the detected interest points falsely report edges as on an edge one of I_x^2 and I_y^2 is huge which makes it lie above small values of threshold.

[1] Canny Edge Detector *https://en.wikipedia.org/wiki/Canny$_e$dge$_d$etecto*
[2] Image : Test.jpg *www.cse.iitd.ernet.in/ pkalra/col783/canny.pdf*
[3] Image : Lenna.png *https://en.wikipedia.org/wiki/Lenna*

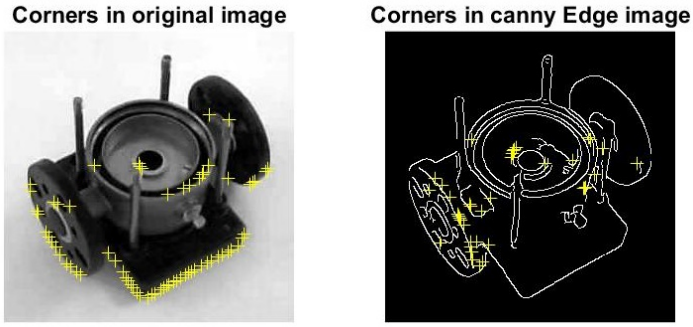

Figure 4: Harris Interest Point Detection with Threshold = [0.03 0.2 0.01] - Few edges appear as interest points

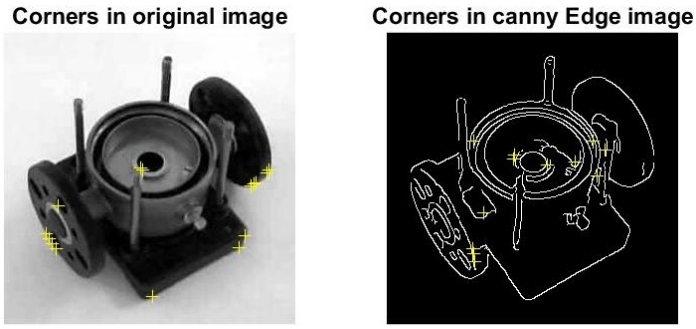

Figure 5: Harris Interest Point Detection with Threshold = [0.03 0.2 0.1]