DIP Homework Assignment #2

Problem 1: EDGE DETECTION

(a)

sample1.png, result1.png and result2.png

Approach

1. Use Guassion filter (H) to perform low-pass filtering

$$H = \frac{1}{9} * \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

2. Use two matrix G_r, G_c to compute G for each pixels, obtaining the gradient image (`result1.png`)

$$G_r = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}, G_c = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}$$

$$G = \sqrt{G_R^2 + G_R^2}$$

3. Select the threshold to generate edge map. Here I choose pixel value > 95 in gradient image

Discussion

Here are images in different threshold:

threshold = 95, threshold = 50 and threshold = 120

It shows that if threshold is too small, the image will look dazzled. I tried different threshold, finding threshold = 95 obtain the best result, especially the texture of the woman's hand. If threshold is bigger than 95 (here I take 120 for example), some details will disappear.

(b)

sample1.png and result3.png

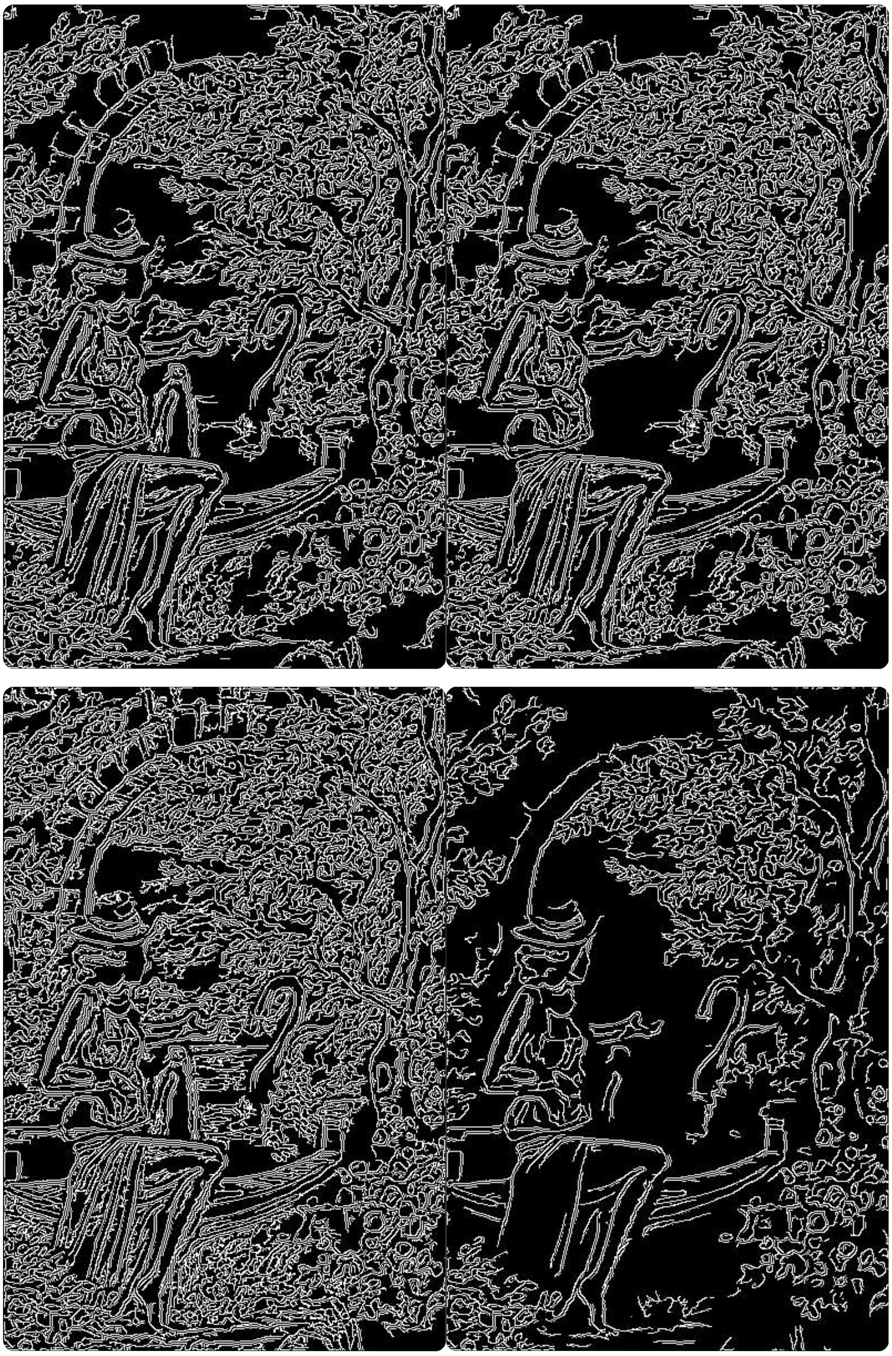
Approach

1. Use Guassion filter H to perform low-pass filtering
2. Compute gradient magnitude and orientation
3. Do **non-maximal suppression**: For gradient of each pixels, check whether two neighbors along the orientation are both smaller than it. If so, verify it as a part of edge.
4. Label each pixels according to two threshold T_H, T_L, verify they are edge, candidate or non-edge pixels. Here I choose $T_H = 90, T_L = 10$

5. For each pixels that are verified with edge pixels, label its candidate neighbors with to be edges. Then label continuously with **dfs** method, obtaining the edge map (`result3.png`)

Discussion

Here are the images with different threshold T_H, T_L



(10, 90), (10, 120), (5, 90) and (30, 60)

I find that if T_H is too high , some details will disappear (like woman's left leg). If T_L is too low, the edge map show too much unimportant things. If we choose $T_L = 30, T_H = 90$, the image is pretty clear, but it lose some details. So I think (10, 90) is the most beautiful edge map after trying multiple thresholds

(c)

sample1.png and result4.png

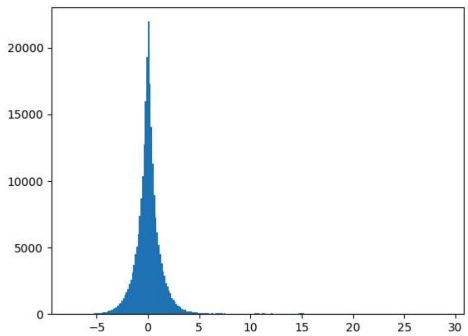
Approach

1. Use Guassion filter H to perform low-pass filtering by two times

2. Use Laplacian filter H' to enhence edge

$$H' = \frac{1}{4} * \begin{bmatrix} 0 & -1 & 0 \\ -1 & 4 & -1 \\ 0 & -1 & 0 \end{bmatrix}$$

3. Generate the histogram to choose the threshold.

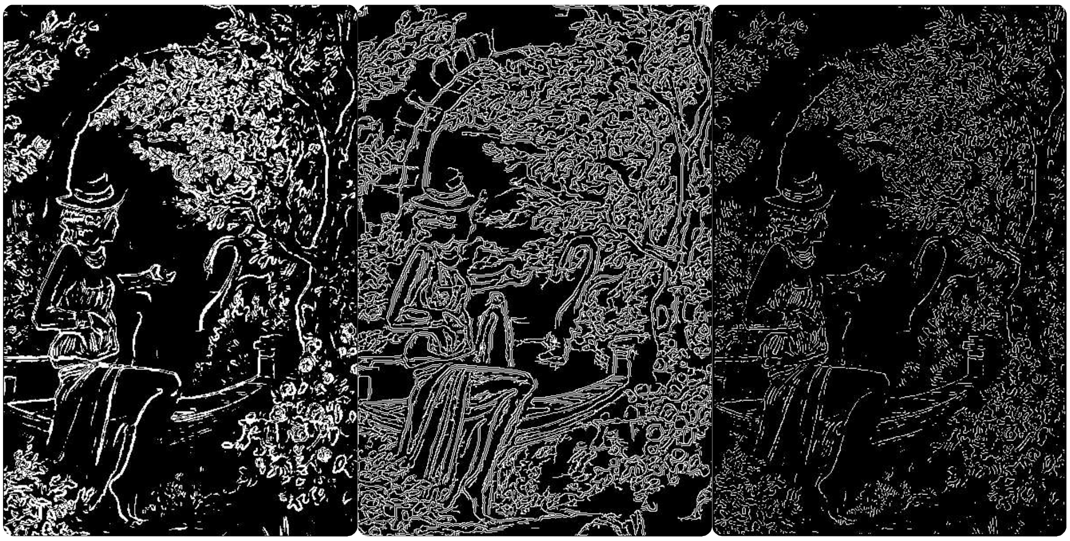


4. Choose a threshold to separate zero and non-zero. Here I choose threshold = 0.8

5. For each pixels that value = 0, check whether there are two oppsite neighbors being one postive and one negative. If so, verify it as an edge. Obtain the edge map (`result4.png`)

Disussion

Compare these three images:

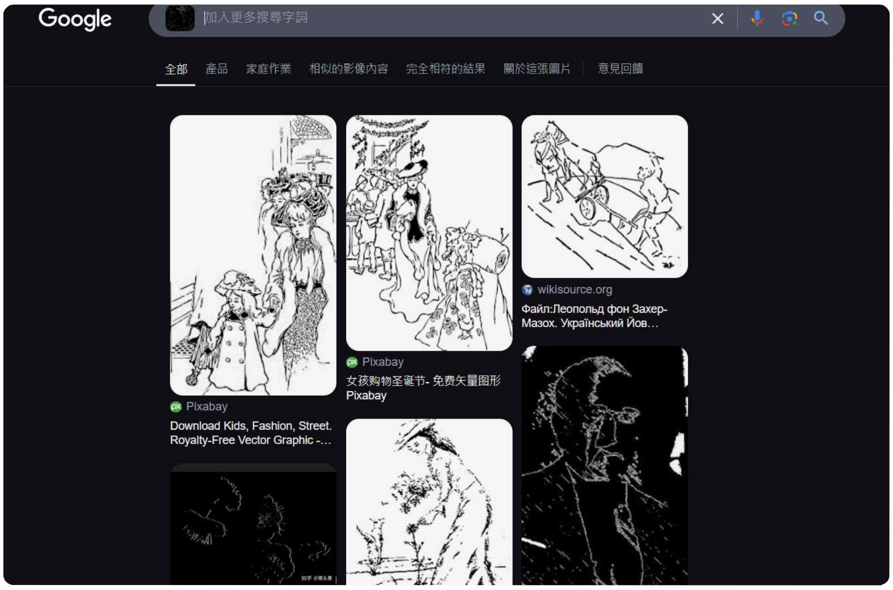


result2.png, result3.png and resul4.png

1. I find that `result2.png` has thicker edges, and it can generate a good edge map with simple way.
2. It's surprising that canny method gereate such a beautiful image, `result3.png` has very clear lines, while retaining good details. The stone arched door can only be seen clearly in `result3.png` I think it's the most beautiful edge map of the three.
3. Take a look at these three images, `result4.png` seem to be the worst edge map. But compare to `result2.png` in detail, it generate the most import edge in the image. It rarely contains unnecessary lines after performing Guassian filter.

(d)

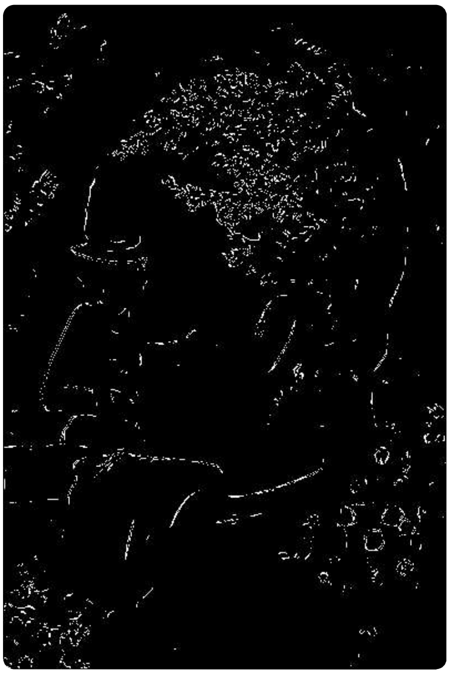
sampl1.png and portait

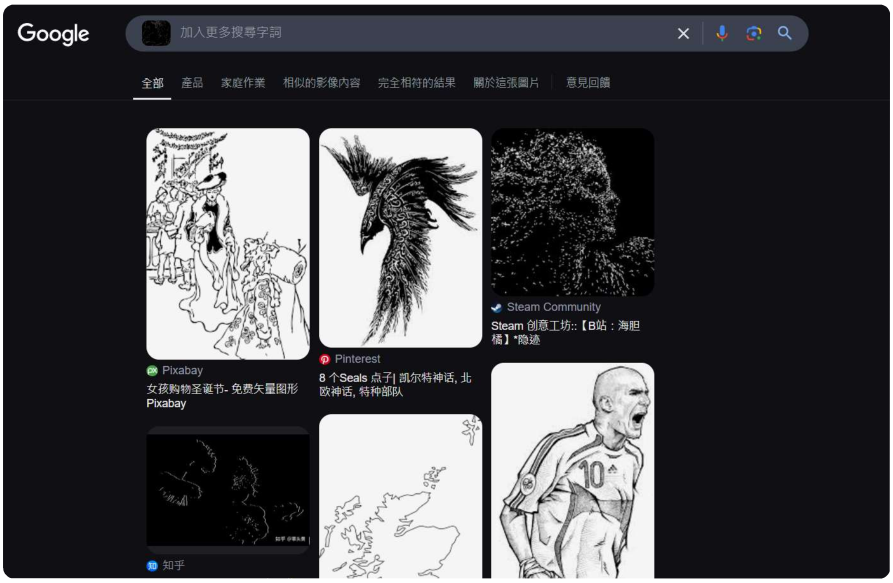


search result

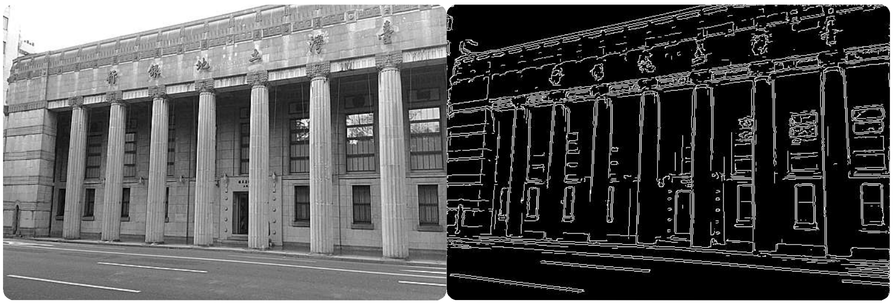
Approach

1. I observe that Sobel method can easily show different edge map with different thresholds, so I choose to use it.
2. I tried threshold = 180 and 200, they both work.

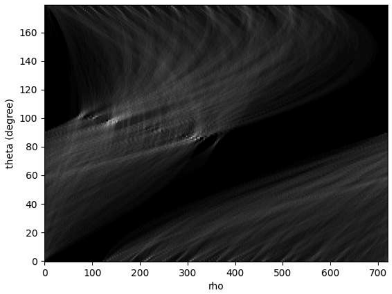


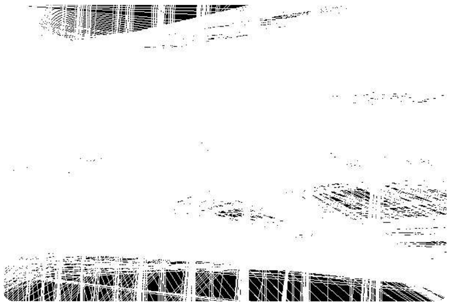


(e)



sample.png and result5.png





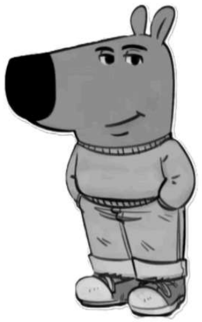
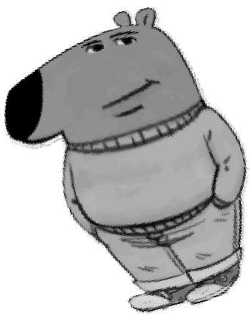
result6.png and result7.png

Approach

1. First perform Canny edge detection by using $threshold_{low} = 60, threshold_{high} = 70$, obtaining `result5.png`
2. Apply hough transform to `result5.png` and obtain Hough space `result6.png`
3. Find the point that its slope is close to vertical line in `result6.png` , then we can count how many vertical line it has and count the number of pillars

Problem 2: GEOMETRICAL MODIFICATION

(a)

sample3.png and result8.png

Approach

1. Using barrel distortion formula by using backward treatment. Here I let $k_1 = 0.001, k_2 = 0$

$$r_{new} = \sqrt{(x_{new} - x_{center})^2 + (y_{new} - y_{center})^2}$$

And then

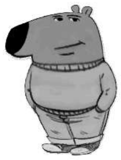
$$r_{old} = r(1 + k_1 r_{new}^2 + k_2 r_{new}^4)$$

We obtain x_{old}, y_{old}:

$$x_{old} = x_{center} + (x_{new} - x_{center})\frac{r_{old}}{r_{new}}$$

$$y_{old} = y_{center} + (y_{new} - y_{center})\frac{r_{old}}{r_{new}}$$

So, we obtain the image after barrel distortion.

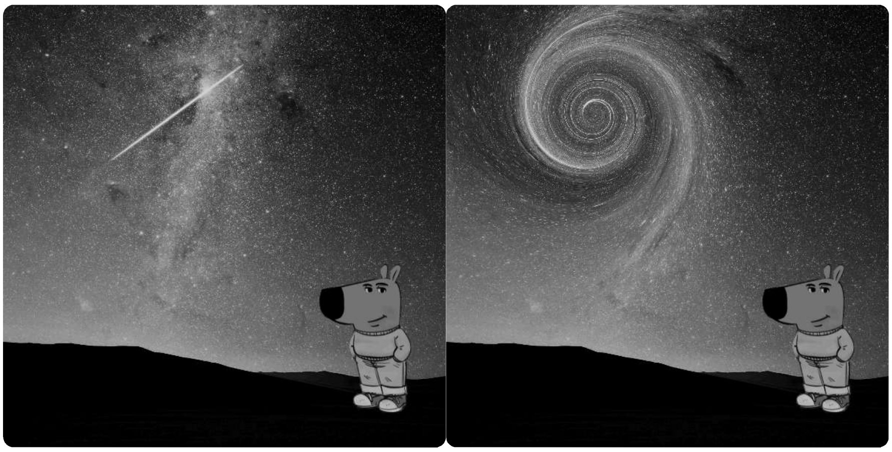


2. Then I use multiple matrixes to control its scale, position and angle. Here I move left 70 pixels and up 60 pixels, rotate 15 degrees counterclockwise, and scale 2 times both of x and y. Finally, we obtain the result image.

$$\begin{bmatrix} x_{new} \\ y_{new} \\ 1 \end{bmatrix} = T^{-1}S^{-1}R^{-1}\begin{bmatrix} x_{old} \\ y_{old} \\ 1 \end{bmatrix}$$

Note: I always use the center of image to be the pivot

(b)



sample5.png and result9.png

Approach

Using swirling formula by using backward treatment.
Here I let $center = (200, 450), radius = 300, strength = 20, rotation = 0$.

$$\theta_{new} = \arctan(\frac{y_{new} - y_{center}}{x_{new} - x_{center}})$$

$$\rho = \sqrt{(x_{new} - x_{center})^2 + (y_{new} - y_{center})^2}$$

Then transform them according to

$$r = \ln(2)\frac{radius}{5}$$

$$\phi = rotation$$

$$s = strength$$

$$\theta_{old} = \phi + se^{-\rho/r} + \theta$$

Here we obtain original points angle and distance, so we can compute their positions

$$x_{old} = x_{center} + \rho\cos(\theta_{old})$$

$$y_{old} = y_{center} + \rho\cos(\theta_{old})$$

Finally we obtain the new image through swirling.

Discussion

I think the most important part of this problem is **the center of the swirl**. `sample6.png` looks very smooth, and there is a perfect shape of its center. The arcs in `result9.png` look more clearly, but doesn't look such smooth as `sample6.png` overall. And I think it looks almost the same around the swirl.