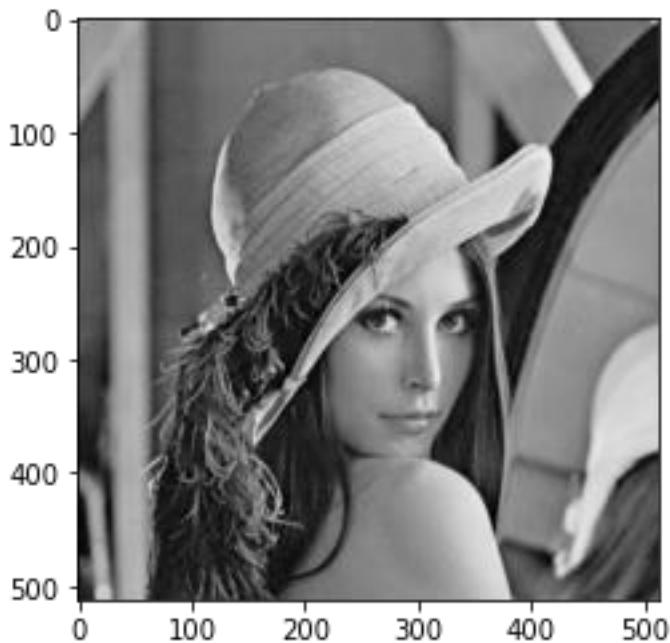


Python 版本 3.6.12

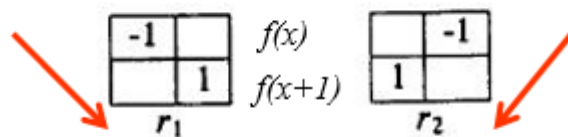
使用套件 cv2, numpy, matplotlib

Original Image:



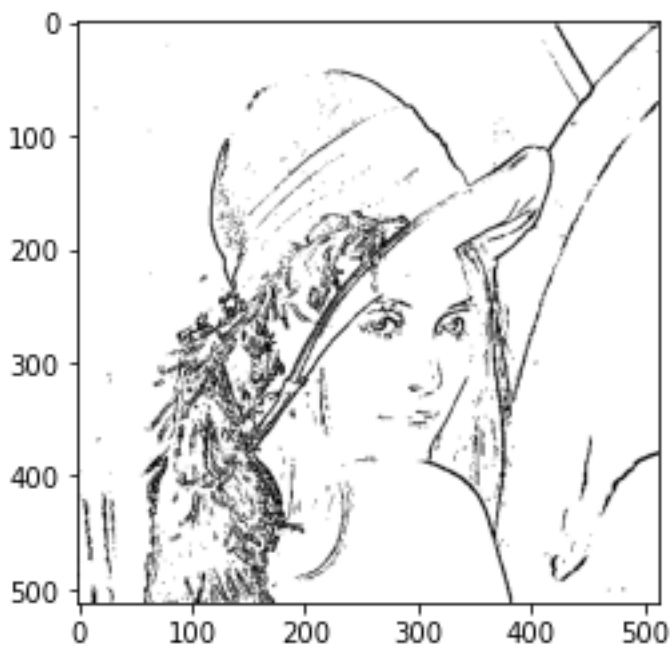
(a) Robert's Operator: 12

$$f'(x) \approx f(x+1) - f(x)$$



$$\text{gradient magnitude: } \sqrt{r_1^2 + r_2^2}$$

對原圖每個 pixel 算出卷積，求出 r_1 r_2 ，算出 $\text{gradient magnitude} \geq \text{threshold}$ 設為 0

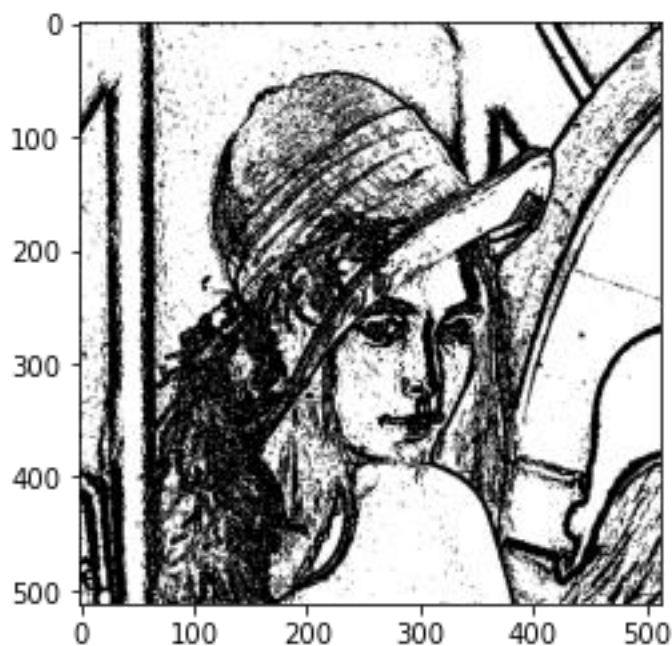


(b) Prewitt's Edge Detector: 24

$$f'(x) \approx f(x+1) - f(x-1) \quad \text{Threshold}=24$$

-1	-1	-1	$f(x-1)$	-1		1
				-1		1
1	1	1	$f(x+1)$	-1		1
p_1				p_2		

對原圖每個 pixel 算出卷積, 求出 p_1 p_2 , 算出 gradient magnitude \geq threshold 設為 0



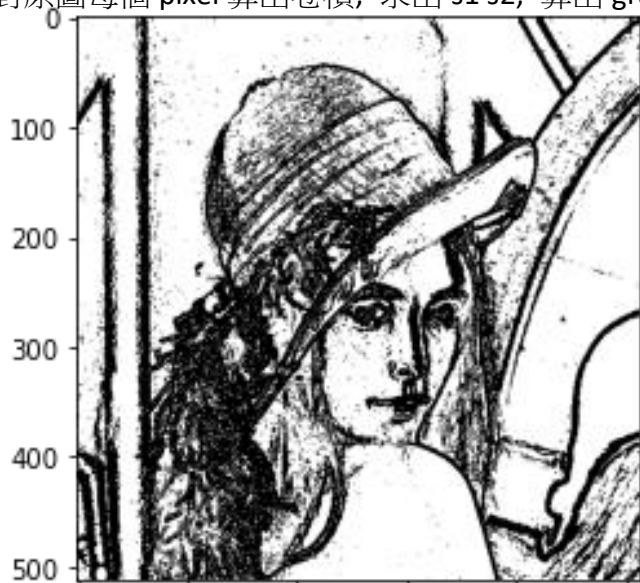
(c) Sobel's Edge Detector: 38

$$f'(x) \approx f(x+1) - f(x-1) \quad \text{Threshold}=38$$

-1	-2	-1	$f(x-1)$	-1		1
				-2		2
1	2	1	$f(x+1)$	-1		1
s_1				s_2		

$$\text{gradient magnitude: } \sqrt{s_1^2 + s_2^2}$$

對原圖每個 pixel 算出卷積, 求出 s_1 s_2 , 算出 gradient magnitude \geq threshold 設為 0

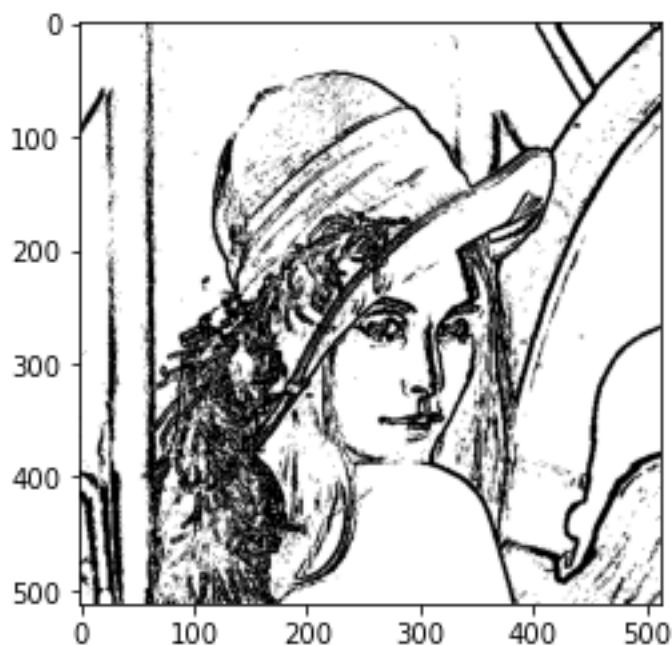


(d) Frei and Chen's Gradient Operator: 30

$$f(x-1) \begin{bmatrix} -1 & -\sqrt{2} & -1 \\ & & \\ 1 & \sqrt{2} & 1 \end{bmatrix} \quad f_1 \quad \begin{bmatrix} -1 & & 1 \\ -\sqrt{2} & & \sqrt{2} \\ -1 & & 1 \end{bmatrix} \quad f_2$$

gradient magnitude: $\sqrt{f_1^2 + f_2^2}$ $f'(x) \approx f(x+1) - f(x-1)$

對原圖每個 pixel 算出卷積，求出 f1 f2，算出 gradient magnitude \geq threshold 設為 0

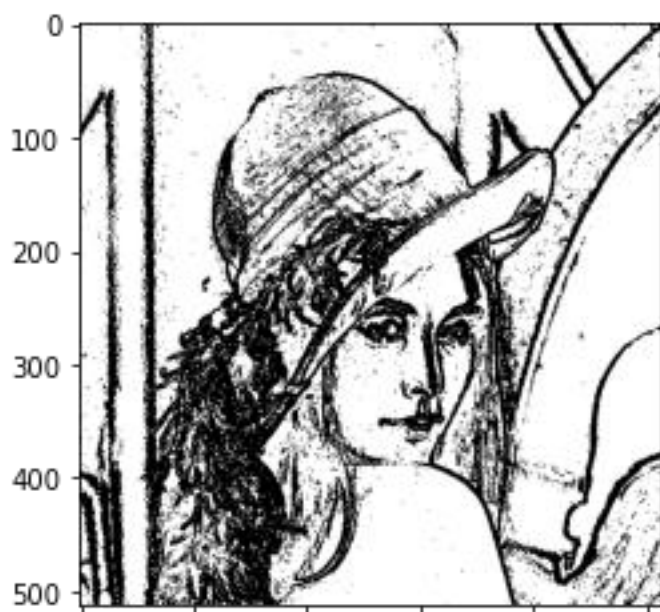


(e) Kirsch's Compass Operator: 135

$$\begin{matrix} \begin{bmatrix} -3 & -3 & 5 \\ -3 & & 5 \\ -3 & -3 & 5 \end{bmatrix} & \begin{bmatrix} -3 & 5 & 5 \\ -3 & & 5 \\ -3 & -3 & -3 \end{bmatrix} & \begin{bmatrix} 5 & 5 & 5 \\ -3 & & -3 \\ -3 & -3 & -3 \end{bmatrix} & \begin{bmatrix} 5 & 5 & -3 \\ 5 & & -3 \\ -3 & -3 & -3 \end{bmatrix} \\ k_0 & k_1 & k_2 & k_3 \\ \begin{bmatrix} 5 & -3 & -3 \\ 5 & & -3 \\ 5 & -3 & -3 \end{bmatrix} & \begin{bmatrix} -3 & -3 & -3 \\ 5 & & -3 \\ 5 & 5 & -3 \end{bmatrix} & \begin{bmatrix} -3 & -3 & -3 \\ -3 & & -3 \\ 5 & 5 & 5 \end{bmatrix} & \begin{bmatrix} -3 & -3 & -3 \\ -3 & & 5 \\ -3 & 5 & 5 \end{bmatrix} \\ k_4 & k_5 & k_6 & k_7 \end{matrix}$$

gradient magnitude: $\max_{n, n=0, \dots, 7} k_n$

對原圖每個 pixel 算出卷積，求出 k0~k7，算出 gradient magnitude(=max(ki)) \geq threshold 設為 0

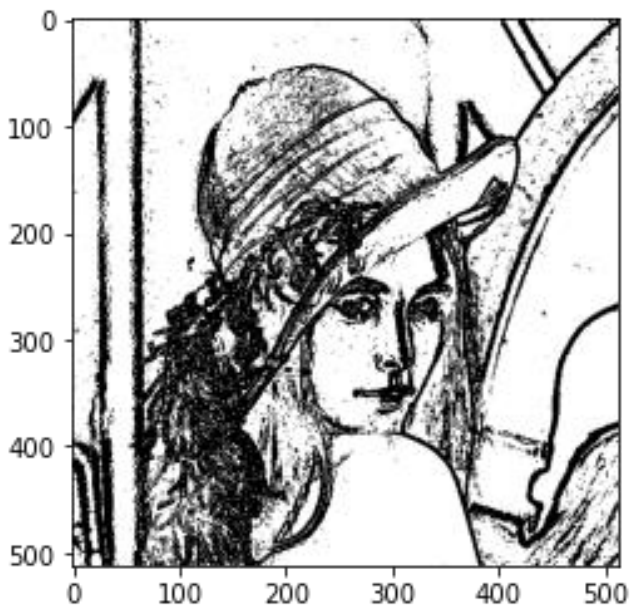


(f) Robinson's Compass Operator: 43

r_0	r_1	r_2	r_3
$\begin{bmatrix} -1 & & 1 \\ -2 & & 2 \\ -1 & & 1 \end{bmatrix}$	$\begin{bmatrix} & 1 & 2 \\ -1 & & 1 \\ -2 & -1 & \end{bmatrix}$	$\begin{bmatrix} 1 & 2 & 1 \\ & & \\ -1 & -2 & -1 \end{bmatrix}$	$\begin{bmatrix} 2 & 1 & \\ 1 & & -1 \\ & -1 & -2 \end{bmatrix}$
r_4	r_5	r_6	r_7
$\begin{bmatrix} 1 & & -1 \\ 2 & & -2 \\ 1 & & -1 \end{bmatrix}$	$\begin{bmatrix} & -1 & -2 \\ 1 & & -1 \\ 2 & 1 & \end{bmatrix}$	$\begin{bmatrix} -1 & -2 & -1 \\ & & \\ 1 & 2 & 1 \end{bmatrix}$	$\begin{bmatrix} -2 & -1 & \\ -1 & & 1 \\ & 1 & 2 \end{bmatrix}$

gradient magnitude: $\max_{n, n=0, \dots, 7} r_n$

對原圖每個 pixel 算出卷積，求出 $r_0 \sim r_7$ ，算出 gradient magnitude(=max(ri)) >= threshold 設為 0



(g) Nevatia-Babu 5x5 Operator: 12500

0°	30°
$\begin{bmatrix} 100 & 100 & 100 & 100 & 100 \\ 100 & 100 & 100 & 100 & 100 \\ 0 & 0 & 0 & 0 & 0 \\ -100 & -100 & -100 & -100 & -100 \\ -100 & -100 & -100 & -100 & -100 \end{bmatrix}$	$\begin{bmatrix} 100 & 100 & 100 & 100 & 100 \\ 100 & 100 & 100 & 100 & 78 \\ 100 & 92 & 0 & -92 & -100 \\ 32 & -78 & -100 & -100 & -100 \\ -100 & -100 & -100 & -100 & -100 \end{bmatrix}$
60°	-90°
$\begin{bmatrix} 100 & 100 & 100 & 32 & -100 \\ 100 & 100 & 92 & -78 & -100 \\ 100 & 100 & 0 & -100 & -100 \\ 100 & 78 & -92 & -100 & -100 \\ 100 & -32 & -100 & -100 & -100 \end{bmatrix}$	$\begin{bmatrix} -100 & -100 & 0 & 100 & 100 \\ -100 & -100 & 0 & 100 & 100 \\ -100 & -100 & 0 & 100 & 100 \\ -100 & -100 & 0 & 100 & 100 \\ -100 & -100 & 0 & 100 & 100 \end{bmatrix}$
-60°	-30°
$\begin{bmatrix} -100 & 32 & 100 & 100 & 100 \\ -100 & -78 & 92 & 100 & 100 \\ -100 & -100 & 0 & 100 & 100 \\ -100 & -100 & -92 & 78 & 100 \\ -100 & -100 & -100 & -32 & 100 \end{bmatrix}$	$\begin{bmatrix} 100 & 100 & 100 & 100 & 100 \\ -32 & 78 & 100 & 100 & 100 \\ -100 & -92 & 0 & 92 & 100 \\ -100 & -100 & -100 & -78 & 32 \\ -100 & -100 & -100 & -100 & -100 \end{bmatrix}$

gradient magnitude: $\max_{n, n=0, \dots, 5} N_n$

169	169	169	1
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對原圖每個 pixel 算出卷積，求出 $N_0 \sim N_5$ ，算出 gradient magnitude(=max(Ni)) >= threshold 設為 0

