Ex 4-1

$G = \sqrt{G_x^2 + G_y^2}$

$\Delta f = \nabla^2 f = \nabla(\nabla f)$

$= \sum_{i=1}^{n} \frac{\partial^2 f}{\partial x_i^2}$

5	5	2	5	5
5	5	2	5	5
7	7	5	7	7
5	5	2	5	5
5	5	2	5	5

Filters: Sobel

1	0	-1
2	0	-2
1	0	-1

1	2	1
0	0	0
-1	-2	-1

Laplace ↓

0	1	0
1	-4	1
0	1	0

Detect vertical / horizontal, gradient ~~increasing~~ intensity

(a) $Y_{0,0} = 5\times1 + 5\times0 + 2\times(-1) + 5\times2 + 5\times0 + 2\times(-2)$

$+ 7\times1 + 5\times0 + 5\times(-1)$

$= 5 + 0 - 2 + 10 + 0 - 4 + 7 + 0 - 5$

$= 3 + 6 + 2 = 11$

⋮

- Filter
- Kernel
- Feature map
- Convolutional operator

11	0	-11	-9	-10	-9
10	0	-10	0	0	0
11	0	-11	9	10	9

-1	9	-1
-6	-2	-6
-1	9	-1

see note book

Ex 4-2

$Y = W * X$. $Y_{i,j} = (K * X)_{i,j} = \sum_{m=0}^{k} \sum_{n=0}^{k} W_{m,n} X_{i+m, j+n}$

$$\frac{\partial Y_{ij}}{\partial W_{u,v}} = \frac{\partial \sum_{m=0}^{k} \sum_{n=0}^{k} W_{m,n} X_{i+m, j+n}}{\partial W_{u,v}}$$

$= X_{i+u, j+v}$

$u, v = 0, 1, \cdots, k$

$Y \in \mathbb{R}^{(d-k+1)\times(d-k+1)}$

- caffee net benchmark
- cross correlation in tensorflow
- how to read source of tf

Ex 4-3

$$(T_{x,y}\, X * K)_{i,j} = \sum_m \sum_n T_{xy}\, X_{i-m,\, j-n}\, K_{m,n}$$

$$= \sum_m \sum_n X_{i-m-x,\, j-n-y}\, K_{m,n}$$

$$= \sum_m \sum_n X_{(i-x)-m,\, (j-y)-n}\, K_{m,n}$$

$$= (X * K)_{i-x,\, j-y}$$

$$= T_{x,y}(X * K)_{i,j}. \qquad \#$$