1 2 3 4

I

0	0	0	0	0	0
0	255	0	255	0	0
0	0	255	0	0	255
0	255	0	255	255	0
0	0	0	255	-255	0
0	-255	0	-255	0	255

F

1	2	1
0	4	0
1	2	1

1 → $0*1 + 2*0 + 1*0 + 0*0 + 255*4 + 0*0 + 0*1 + 0*2 + -255*1$ → 1020 − 255 → 765

2 → $0*1 + 0*2 + 0*1 + 255*0 + 0*4 + 255*0 + 0*1 + -255*2 + 0*1$ → −510

3 → $0*1 + 0*2 + 0*1 + 0*0 + 255*4 + 0*0 + -255*1 + 0*2 + 0*1$ → 1020 − 255 → 765

4 → $0*1 + 0*2 + 0*1 + 255*0 + 0*4 + 0*0 + 0*1 + 0*2 + 255*1$ → 255

5) $0\times1 + 255\times2 + 0\times1 + 0\times0 + 0\times4 + -255\times0 + 0\times1 + 255\times2 + 0\times1$ → 510 + 510 → 1020

6) $255\times1 + 0\times2 + 255\times1 + 0\times0 + 255\times4 + 0\times0 + 255\times1 + 0\times2 + 255\times1$ → 255+255+255+255 → 0 − 1020

7) $0\times1 + 255\times2 + 0\times1 + -255\times0 + 0\times4 + 0\times0 + 0\times1 + 255\times2 + 255\times1$ → 510+510+255 → 1275

8) $255\times1 + 0\times2 + 0\times1 + 0\times0 + 0\times4 + 255\times0 + 255\times1 + 255\times2 + 0\times1$ → 255+255+510 → 1020

9) $0\times1 + 0\times2 + -255\times1 + 0\times0 + 255\times4 + 0\times0 + 0\times1 + 0\times2 + 0\times1$ → −255+1020 → 765

C.C.:

Subject:

10 → $0*1 + -255*2 + 0*1$
$+255*0 + 0*4 + 255*0$
$+0*1 + 0*2 + 255*1$
→ $-510 + 255 \rightarrow -255$

11 → $-255*1 + 0*2 + 0*1$
$+0*0 + 255*4 + 255*0$
$+0*1 + 255*2 + -255*1$
→ $-255 + 1020 + 510 - 255 \rightarrow 1020$

12 → $0*1 + 0*2 + 255*1$
$+255*0 + 255*4 + 0*0$
$+255*1 + -255*2 + 0*1$
→ $255 + 1020 + 255 \rightarrow 1020$
-510

13 → $0*1 + 255*2 + 0*1$
$+0*0 + 0*4 + 0*0$
$+0*1 + -255*2 + 0*1$
→ $510 - 510 \rightarrow 0$

14 → $255*1 + 0*2 + 255*1$
$+0*0 + 0*4 + 255*0$
$-255*1 + 0*2 + -255*1$
→ $255 + 255 - 255 - 255 \rightarrow 0$

Subject:

15 →

0*1	+255*2	+255*1
0*0	+255*4	+255*0
0*1	+-255*2	+0*1

→ 510+255+1020 → 1275
-510

16 →

255*1	255*2	+0*1
+255*0	-255*4	+0*0
+255*1	0*2	+255*1

→ 255+510-1020-255 → -255
+255

After Conv2d

1

765	-510
1020	0

2

765	255
1275	1020

3

765	-255
0	0

4

1020	1020
1275	-255

1 → 1020
2 → 1275
3 → 765
4 → 1275

After Pooling

1020	1275
765	1275

Relu make the negative one a zero

After Relu = $\begin{bmatrix} 1020 & 1275 \\ 765 & 1275 \end{bmatrix}$

Flaten = [1020 | 1275 | 765 | 1275]

= 1020 * 0.01 + 1275 * 0.01 + 765 * -0.01 + 1275 * -0.1

= 10.2 + 12.75 - 7.65 - 12.75

= 2.55

After Sigmoid = $\frac{1}{1+e^{-(2.55)}}$

= 0.92757

Backpropagating through dense layer

$$\frac{\partial L}{\partial w} = \frac{dz}{dw}\frac{dy}{dz}\frac{dL}{dy}$$

$$\frac{dz}{dw} = x_i \qquad \therefore z = wx$$

$$\frac{dy}{dz} = \sigma(y_i)\,1-\sigma(y_i) \qquad y_i = \frac{1}{1+e^{-x}} = \frac{e^{-x}}{(1+e^{-x})^2}$$

$$= \frac{1+e^{-x}-1}{(1+e^{-x})^2} * \frac{1}{1+e^{-x}} = (1-\sigma(x))_\sigma$$

$$\frac{dL}{dy_i} = \frac{1}{(1-y_i)} \qquad \therefore = -\log(1-y_i) = \frac{1}{(1-y_i)}(-1)$$

$$= \frac{1}{(1-y_i)}$$

updated weights

$w^N = w - \alpha \, dL/dw$

$w_1 = w_1 - \alpha (1020 * 0.9275 * 0.0725 \times 13.793)$
$= -94.59$

$w_2 = 0.01 - 0.1 (1275 * 0.9274)$
$= -118.24$

$w_2 = 0.01 - 0.1 (1275 * 0.9274)$
$= -118.24$

$w_3 = 0.01 - 0.1 (765 * 0.9274)$
$= -70.956$

$w_4 = -0.01 - 0.1 (1275 \times 0.9274)$
$= -118.535$

Subject:

$\frac{dL}{dz}$ = will be the same

$$\begin{bmatrix} -94.59 \\ -118.2 \\ -70.95 \\ -118.25 \end{bmatrix} \rightarrow \begin{bmatrix} 94.6 & -118.25 \\ 70.95 & -118.25 \end{bmatrix}$$

Derivative of Relu

$$\frac{dL}{dRelu} = \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} \qquad h'(x) = \begin{cases} 1 & x \geq 0 \\ 0 & x < 0 \end{cases}$$

$\frac{dL}{dRelu}$ = max will be kept same
zero on all places in location

Pooling 2x2 matrix make 4x4 matrix

$$\begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} \rightarrow \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$