

Feature map.

Calculate receptive field of a neural network.

Given: Layer 1 kernel size $k_1 = 4$, stride $s_1 = 1$.

Receptive Field calc formula:

Layer 2 kernel size $k_2 = 4$, stride $s_2 = 2$.

Layer 3 kernel size $k_3 = 4$, stride $s_3 = 2$.

$$RF_n = RF_{n-1} + (k_n - 1) \times \prod_{i=1}^{n-1} s_i$$

Layer 1: $RF_1 = k_1 = 4$

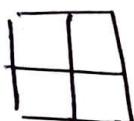
Layer 2: $RF_2 = RF_1 + (k_2 - 1) \times s_1 = 4 + (4 - 1) \times 1 = 4 + 3 = 7$

Layer 3 $RF_3 = RF_2 + (k_3 - 1) \times (s_1 \times s_2) = 7 + (4 - 1) \times (1 \times 2) = 7 + 3 \times 2 = 7 + 6 = 13$

Ans.



$\times 3$ channels



$\times 3$ channels.

Kernel.

No padding.

$$k_1 = \begin{pmatrix} 3 & 0 \\ 1 & -2 \end{pmatrix} \quad k_2 = \begin{pmatrix} -2 & 2 \\ -1 & -1 \end{pmatrix} \quad k_3 = \begin{pmatrix} 1 & -2 \\ -3 & -2 \end{pmatrix}$$

$$B_1 = \begin{pmatrix} 4 & 3 & 1 \\ 1 & 2 & 1 \\ 3 & 3 & 4 \end{pmatrix} \quad B_2 = \begin{pmatrix} 4 & 3 & 2 \\ 2 & 5 & 1 \\ 2 & 3 & 3 \end{pmatrix} \quad B_3 = \begin{pmatrix} 4 & 4 & 1 \\ 1 & 3 & 3 \\ 5 & 3 & 1 \end{pmatrix}$$

$$k_1 \oplus B_1 \Rightarrow$$

$$3 \cdot 4 + 0 \cdot 3 + 1 \cdot 1 + (-2) \cdot 2 = 12 + 0 + 1 - 4 = 9$$

$$3 \cdot 3 + 0 \cdot 1 + 1 \cdot 2 + (-2) \cdot 1 = 9 + 0 + 2 - 2 = 9$$

$$3 \cdot 1 + 0 \cdot 2 + 1 \cdot 2 + (-2) \cdot 3 = 3 + 0 + 3 - 6 = 0$$

$$3 \cdot 2 + 0 \cdot 1 + 1 \cdot 3 + (-2) \cdot 4 = 6 + 0 + 3 - 8 = 1$$

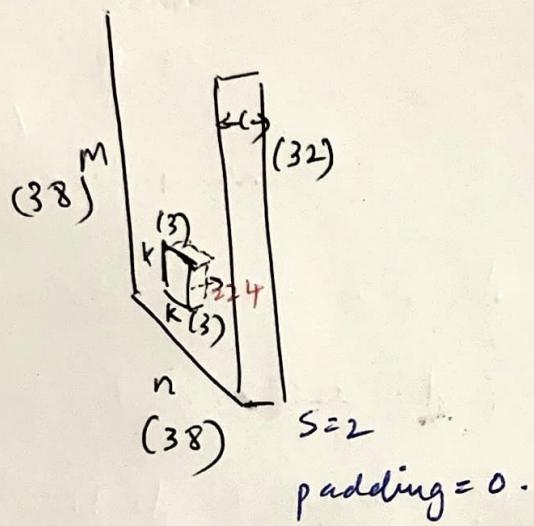
Kernel.

$$k_1 \oplus B_1 = \begin{pmatrix} 9 & 9 \\ 0 & 1 \end{pmatrix}$$

Likewise output for channel 2 and channel 3 are
 $\begin{pmatrix} -9 & -8 \\ 1 & -14 \end{pmatrix}$ and $\begin{pmatrix} -13 & -13 \\ -26 & -14 \end{pmatrix}$ respectively

Slicing the outputs, we get $\boxed{\begin{pmatrix} -13 & -12 \\ -25 & -27 \end{pmatrix}}$

3.1



Calculating output dimensions. ($m' \times n' \times w$)

$$m' = \left\lfloor \frac{m - k + 2p}{s} \right\rfloor + 1 = \left\lfloor \frac{38 - 3 + 0}{2} \right\rfloor + 1 = 18.$$

$$n' = \left\lfloor \frac{n - k + 2p}{s} \right\rfloor + 1 = \left\lfloor \frac{38 - 3 + 0}{2} \right\rfloor + 1 = 18.$$

$$N = k = 224$$

Answer $\Rightarrow \boxed{[18 \ 18 \ 224]}$

3.2 No. of Parameters.

Each kernel has

$$k \times k \times c = 3 \times 3 \times 22 = 198 \text{ parameters}$$

For 224 such kernels:

$$198 \times 224 = \boxed{44,352}$$

3.3 Number of Multiplications.

For one o/p position and 1 kernel

$$k \times k \times c = 3 \times 3 \times 22 = 198 \text{ multiplications.}$$

Total o/p positions:

$$\frac{m' \times n'}{k} = 18 \times 18 = 324 \times \cancel{6}^3 = \cancel{72576} \cdot 972.$$

Total multiplications.

$$198 \times \cancel{324}^{\cancel{72576}} \times 224 = \cancel{14382872} \cancel{321887072} \cdot 43110144$$

$$\cancel{14382872} \times \cancel{1} =$$

^{3.3} The o/p of each activation is computed by performing $k \times k \times c$ multiplications per filter.

\therefore we have $m' \times n'$ positions in the output feat. map and k filters, the total no. of multiplication is.

$$m' \times n' \times k \times (k \times k \times c)$$

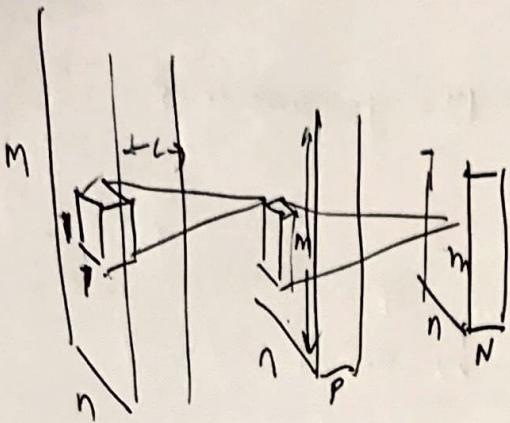
Substituting these values.

$$18 \times 18 \times 224 \times (3 \times 3 \times 22)$$

$$= 18 \times 18 \times 224 \times 198$$

$$= 1437 \times 224 \times 198$$

$$= 635299392$$



$$M \times n \times l = 54 \times 54 \times 250$$

$$N = 48$$

4.1
original conv.

Kernels: Directly map $1/p$ $C = 250$ to output $N = 48$. ✓

Multiplications per o/p position: $7 \times 7 \times 250 = 12250$. ✓

Total o/p positions: $54 \times 54 = 2916$. ✓

$$\underbrace{12250 \times 2916 \times 48}_{\text{Total multiplications.}} = 17147658000.$$

4.2
Bottleneck conv.

~~Stage 1~~ Reduce channels from $C = 250$ to $P = 12$

Kernels $\Rightarrow 1 \times 1 \times \underbrace{250}_{\text{inputs}} \Rightarrow \underbrace{12}_{\text{outputs}}$

positions $54 \times 54 = 2916$.

Total multiplications: $250 \times 2916 \times 12 = 8748000$.

Stage 2 7×7 Conv. ($12 \rightarrow 48$)

SK, 7

$$7 \times 7 \times 12 = \underline{\underline{588}} \text{ multiplications}$$

positions: $54 \times 54 = \underline{\underline{2916}}$

Total multiplications: $\underline{\underline{588}} \times 2916 \times \underline{\underline{48}} = 82,301,184$ ✓

Total Bottleneck Multiplication: $87,48,000 + 83,301,184$
= 91049184

Reduction in calculation.

$$\left(\frac{1714608000 - 91049184}{1714608000} \right) \times 100 = 94.69\%$$

The bottleneck reduces multiplications by 1623558816.