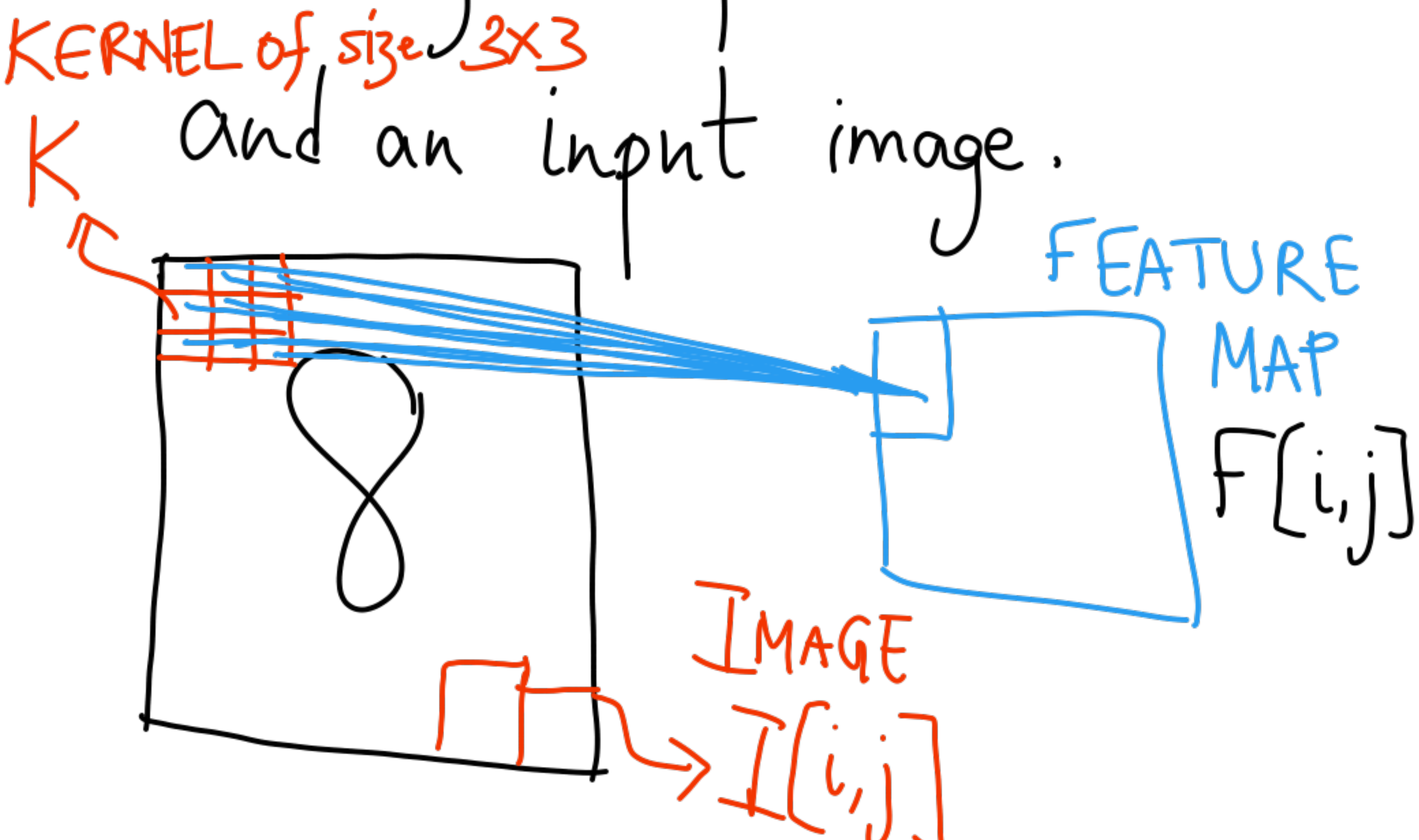
CS725

Recap:

Property	FFNs	CNNs
1 Locality	✗	✓
2 Translation Invariance	✗	✓
3 Parameter-efficient	✗	✓

<u>CONVOLUTION</u> is an operation that involves a sliding dot-product between a <u>Kernel</u> or a <u>filter</u> and an input image.



$$F[i,j] = \sum_{u=-k}^{k} \sum_{v=-k}^{k} K[u,v]\, I[i+u, j+v]$$

A

Say you have a 3×3 kernel:

$$K = \begin{bmatrix} \overset{1}{-1,-1} & \overset{2}{-1,0} & \overset{3}{-1,1} \\ \overset{4}{0,-1} & \overset{5}{0,0} & \overset{6}{0,1} \\ \overset{7}{1,-1} & \overset{8}{1,0} & \overset{9}{1,1} \end{bmatrix} \qquad I = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$$

Technically, equation (A) is called <u>CROSS-CORRELATION</u>

With convolution, flip the kernel both horizontally and vertically

-1,-1 9	-1,0 8	-1,1 7
0,-1 6	0,0 5	0,1 4
1,-1 3	1,0 2	1,1 1

1	2	3
4	5	6
7	8	9

Convolution gives $F[i,j] = \sum_{u=-k}^{k} \sum_{v=-k}^{k} K[u,v]\, I[i-u][j-v]$ B

In deep learning with convolutions, operation A [cross-correlation] is used.

Consider the following kernels. What would be the effect of convolving these kernels with an input image

1. $K = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix}$

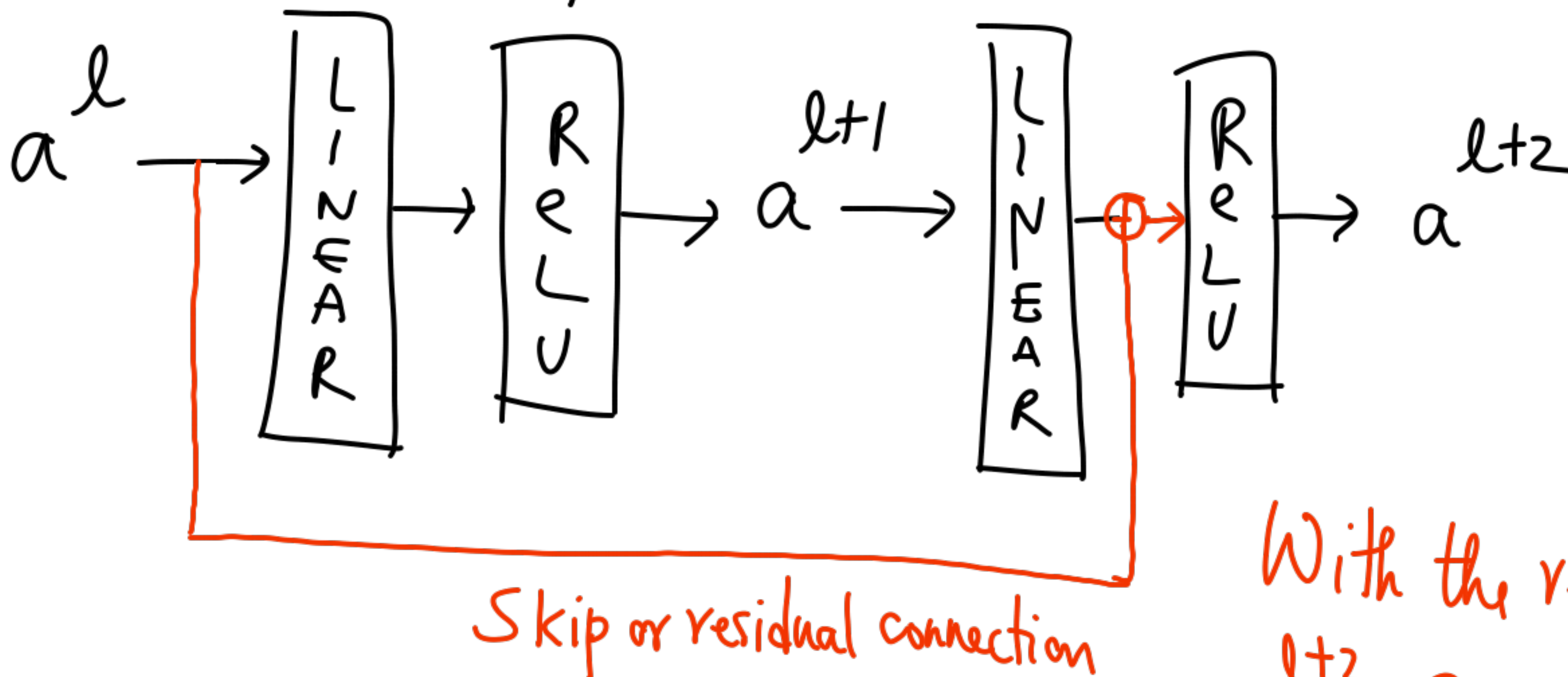
Identity kernel

2. $K = \begin{bmatrix} 1/9 & 1/9 & 1/9 \\ 1/9 & 1/9 & 1/9 \\ 1/9 & 1/9 & 1/9 \end{bmatrix}$ Blur filter or a mean filter "blurring effect"

(c) $K = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$

"SOBEL" filter which detects vertical edges

Resnet uses the idea of residual blocks or skip connections



Earlier,

$$a^{l+1} = \mathrm{ReLU}(W^{l+1}a^{l} + b^{l+1})$$

$$a^{l+2} = \mathrm{ReLU}(W^{l+2}a^{l+1} + b^{l+2})$$

With the residual connection,

$$a^{l+2} = \mathrm{ReLU}(W^{l+2}a^{l+1} + b^{l+2} + a^{l})$$

Adding the residual or skip connections makes it easier to learn the identity mapping from $a^{l+2} \to a^{l}$.

$$a^{l+2} = \mathrm{ReLU}\left(W^{l+2} a^{l+1} + b^{l+2} + a^{l}\right)$$

$\approx \mathrm{ReLU}(a^{l})$ if the weights and biases in W^{l+2}, b^{l+2} go to zero

$= a^{l}$