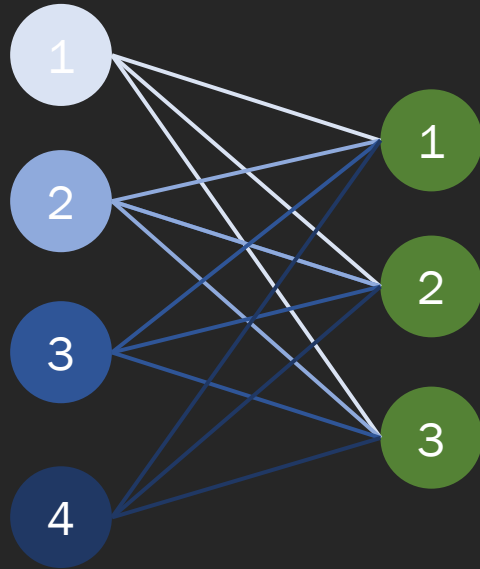


Deep Learning

Or why you should just ask a computer to figure it out.

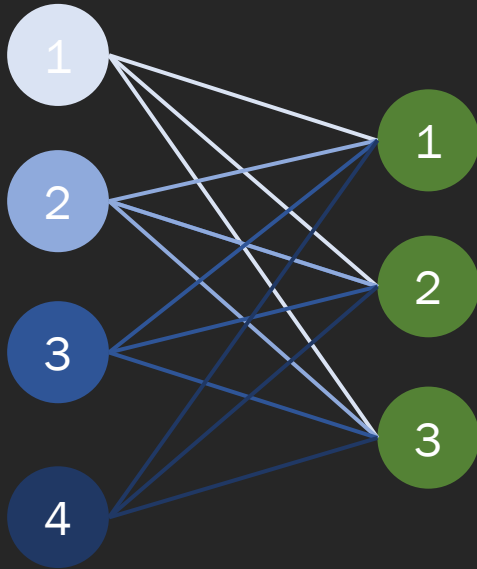
Convolutions

Linear Layers

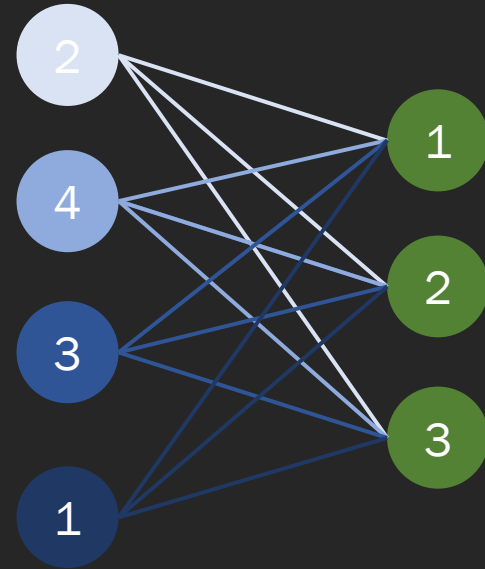


Convolutions

Linear Layers



Does changing
the order matter?



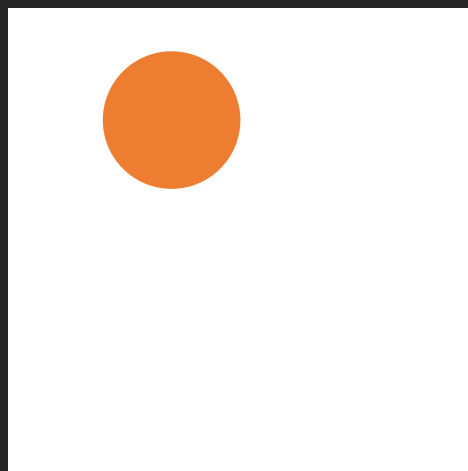
Convolutions

Translation
invariance

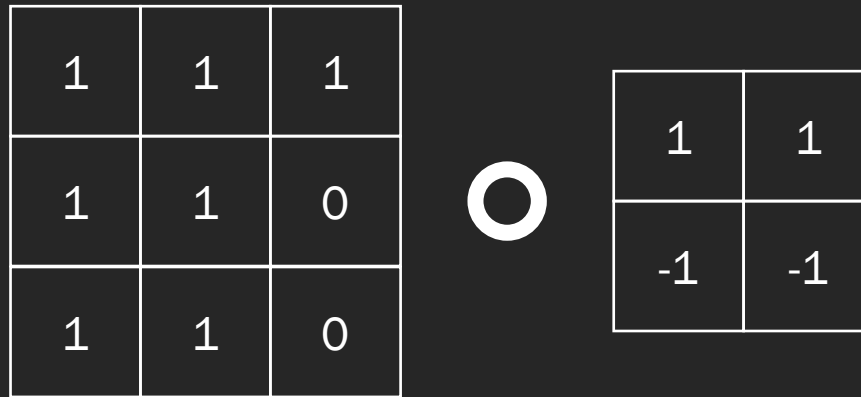


Convolutions

Locality

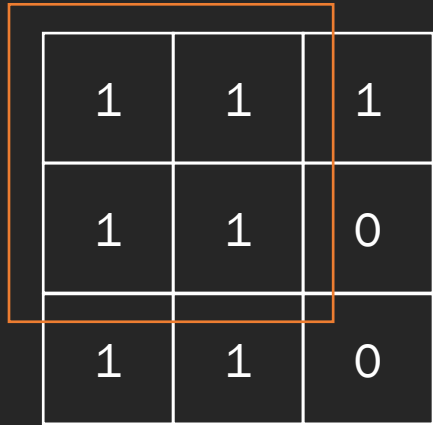


Convolutions



Elementwise multiplication and then summation

Convolutions



1	1	1
1	1	0
1	1	0

⊗

1	1
-1	-1

=

1	

Convolutions

1	1	1
1	0	0
1	1	0

 \odot

1	1
-1	-1

 $=$

0	1

The diagram illustrates a 2D convolution operation. A 3x3 input matrix is convolved with a 2x2 kernel matrix to produce a 2x2 output matrix. The input matrix is:

$$\begin{bmatrix} 1 & 1 & 1 \\ 1 & 0 & 0 \\ 1 & 1 & 0 \end{bmatrix}$$

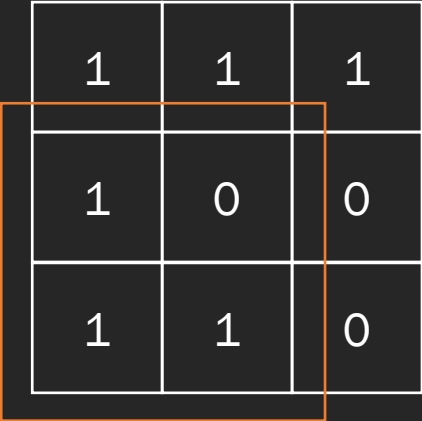
The kernel matrix is:

$$\begin{bmatrix} 1 & 1 \\ -1 & -1 \end{bmatrix}$$

The output matrix is:

$$\begin{bmatrix} 0 & 1 \\ & \end{bmatrix}$$

Convolutions



1	1	1
1	0	0
1	1	0

⊗

1	1
-1	-1

=

0	1
-1	

Convolutions

1	1	1
1	0	0
1	1	0

1	0	0
1	1	0

 \odot

1	1
-1	-1

 $=$

0	1
-1	-1

The diagram illustrates a 2D convolution operation. A 3x3 input matrix is convolved with a 2x2 kernel matrix to produce a 2x2 output matrix. The input matrix is:

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The kernel matrix is:

$$\begin{bmatrix} 1 & 1 \\ -1 & -1 \end{bmatrix}$$

The output matrix is:

$$\begin{bmatrix} 0 & 1 \\ -1 & -1 \end{bmatrix}$$

Padding

1	1	1
1	0	0
1	1	0



0	0	0	0
0	1	1	1
0	1	0	0
0	1	1	0

Padding

1	1	1
1	0	0
1	1	0



1	1	1	0
1	0	0	0
1	1	0	0
0	0	0	0

Padding

1	1	1
1	0	0
1	1	0



0	0	0	0	0
0	1	1	1	0
0	1	0	0	0
0	1	1	0	0
0	0	0	0	0

Padding

0	0	0	0	0
0	1	1	1	0
0	1	0	0	0
0	1	1	0	0
0	0	0	0	0

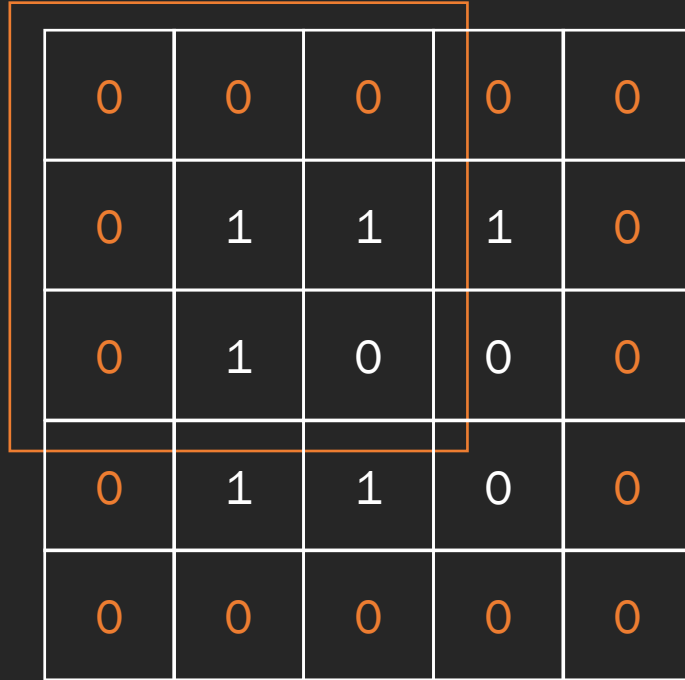
⊙

1	1	1
-1	-1	-1
0	0	0

=

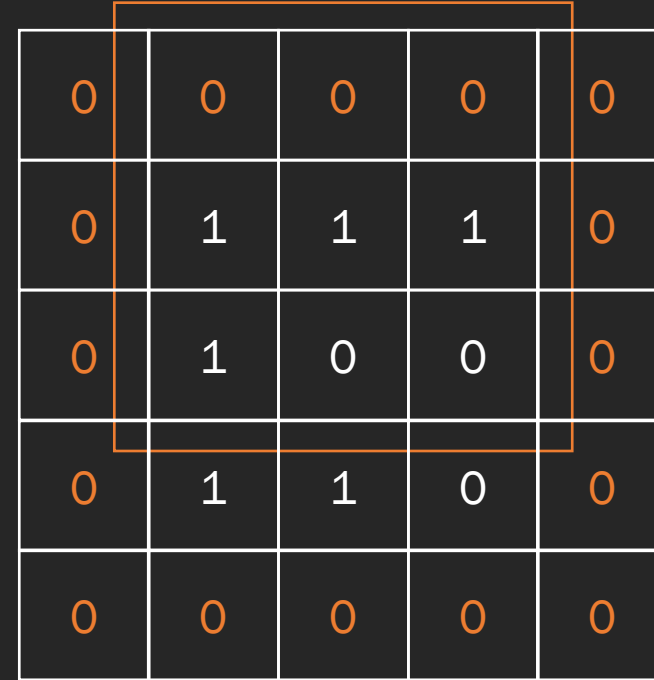
Stride

How much to move the kernel?



0	0	0	0	0
0	1	1	1	0
0	1	0	0	0
0	1	1	0	0
0	0	0	0	0

Step 1



0	0	0	0	0
0	1	1	1	0
0	1	0	0	0
0	1	1	0	0
0	0	0	0	0

Step 2

Stride 1

Stride

How much to move the kernel?

0	0	0	0	0
0	1	1	1	0
0	1	0	0	0
0	1	1	0	0
0	0	0	0	0

Step 3

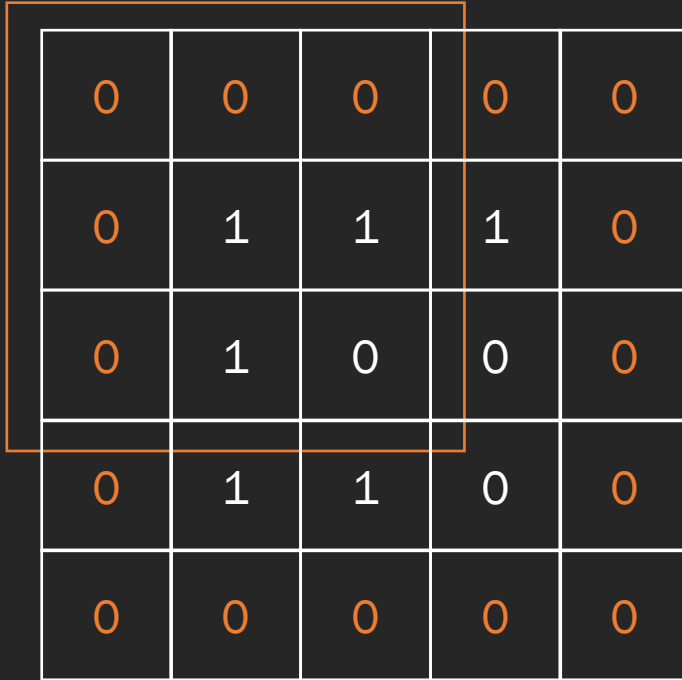
0	0	0	0	0
0	1	1	1	0
0	1	0	0	0
0	1	1	0	0
0	0	0	0	0

Step 4

Stride 1

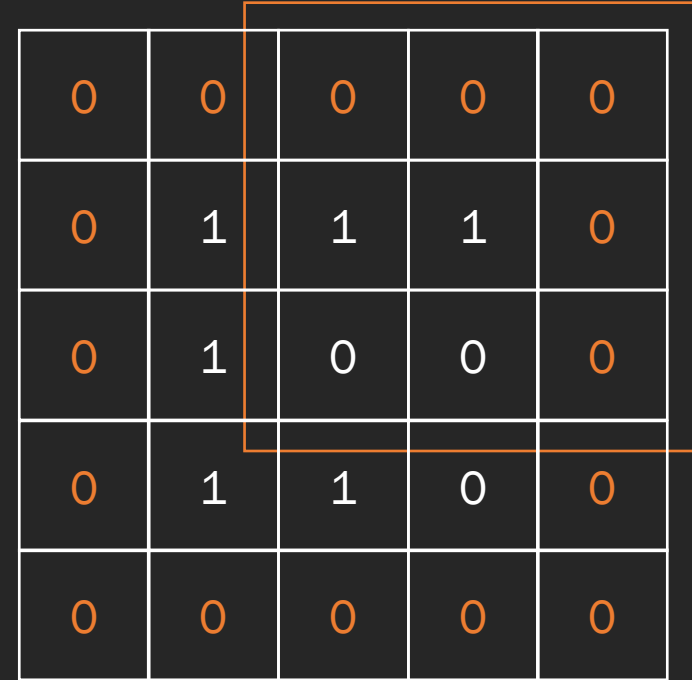
Stride

How much to move the kernel?



0	0	0	0	0
0	1	1	1	0
0	1	0	0	0
0	1	1	0	0
0	0	0	0	0

Step 1



0	0	0	0	0
0	1	1	1	0
0	1	0	0	0
0	1	1	0	0
0	0	0	0	0

Step 2

Stride 2

Stride

How much to move the kernel?

0	0	0	0	0
0	1	1	1	0
0	1	0	0	0
0	1	1	0	0
0	0	0	0	0

Step 3

0	0	0	0	0
0	1	1	1	0
0	1	0	0	0
0	1	1	0	0
0	0	0	0	0

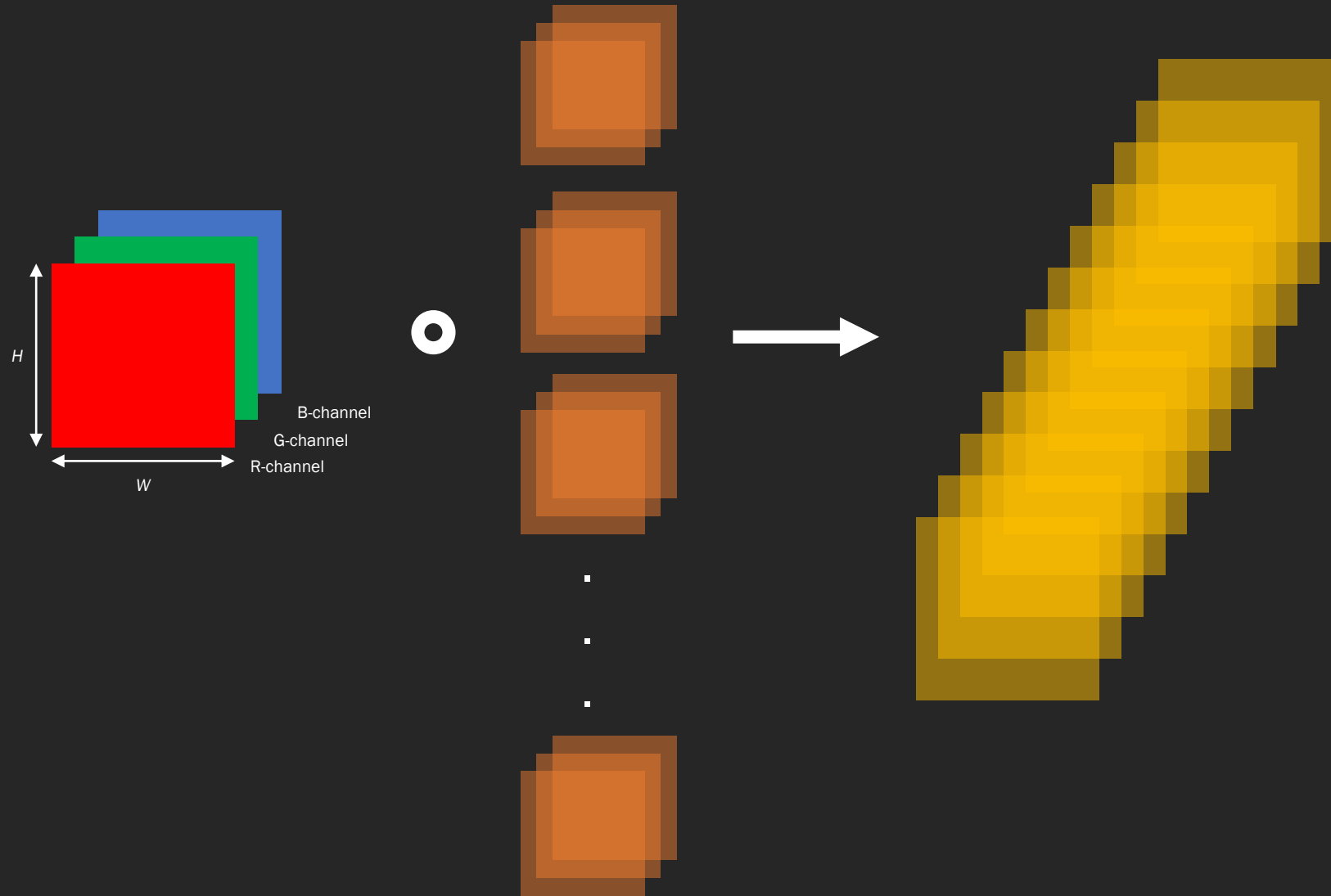
Step 4

Stride 2

Channels are the new nodes



Channels are the new nodes



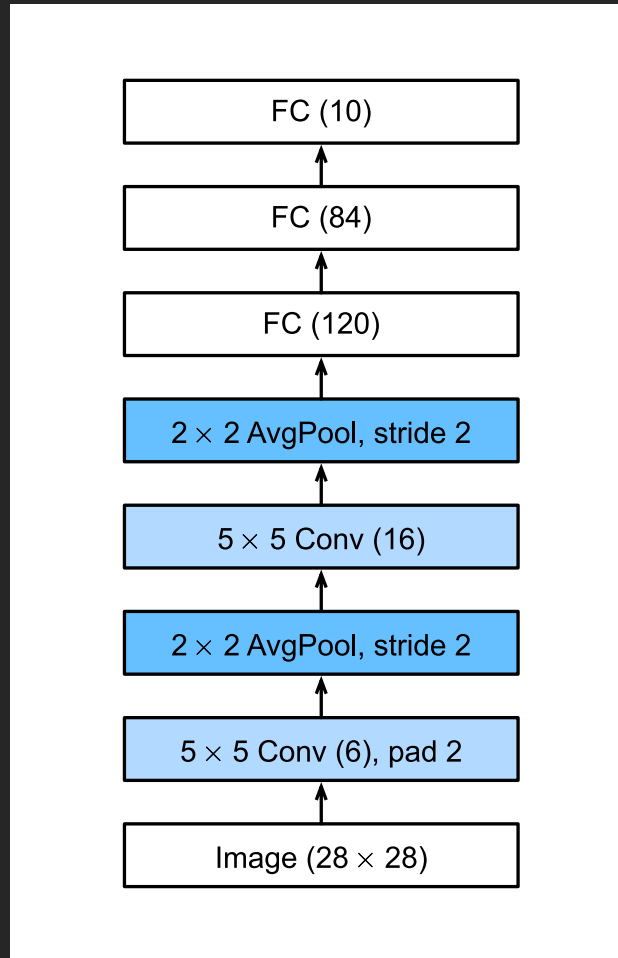
Pooling

1	1	2
-5	5	0
1	1	0

Average

Max

LeNet



Source: d2l.ai