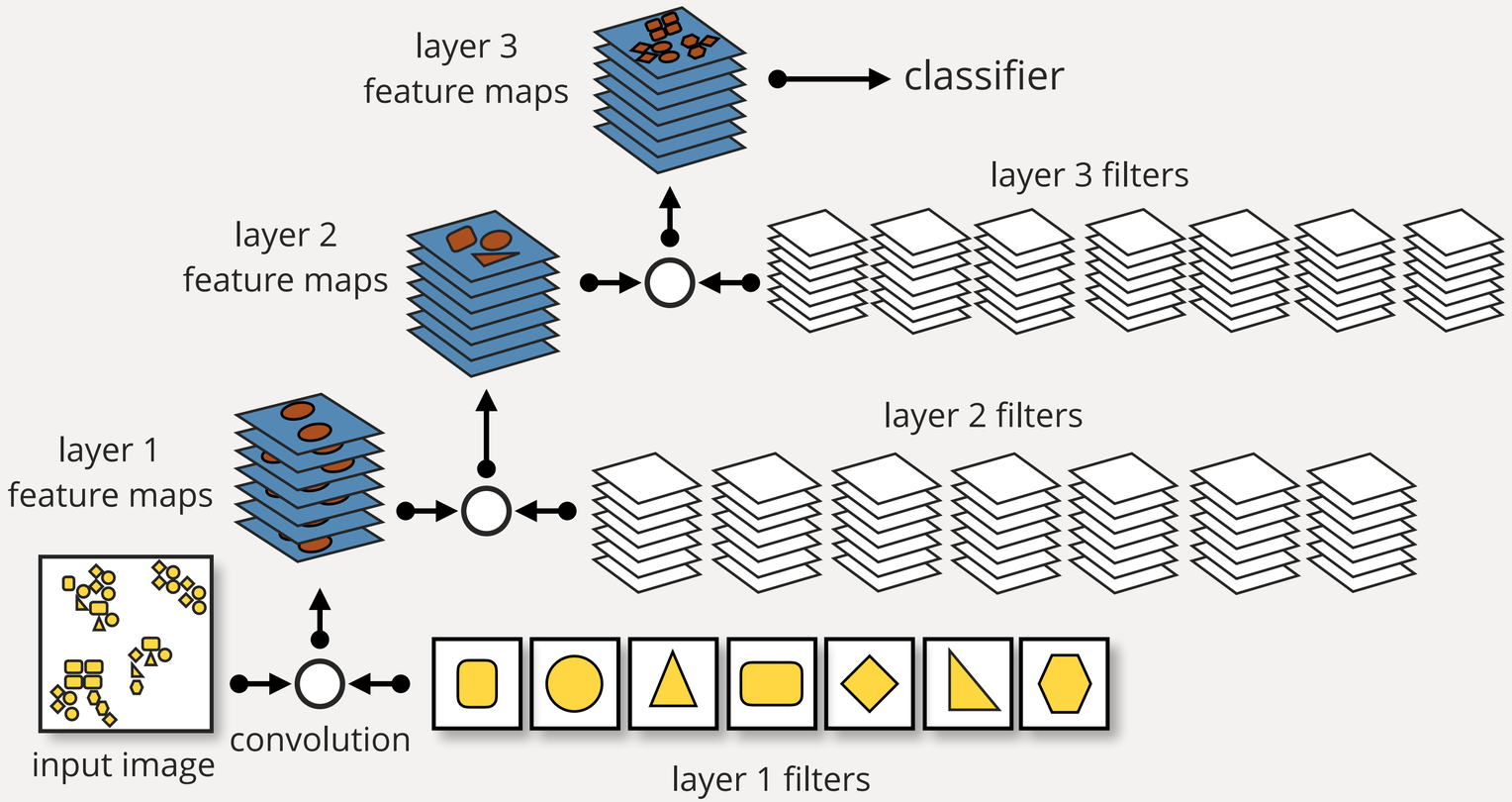
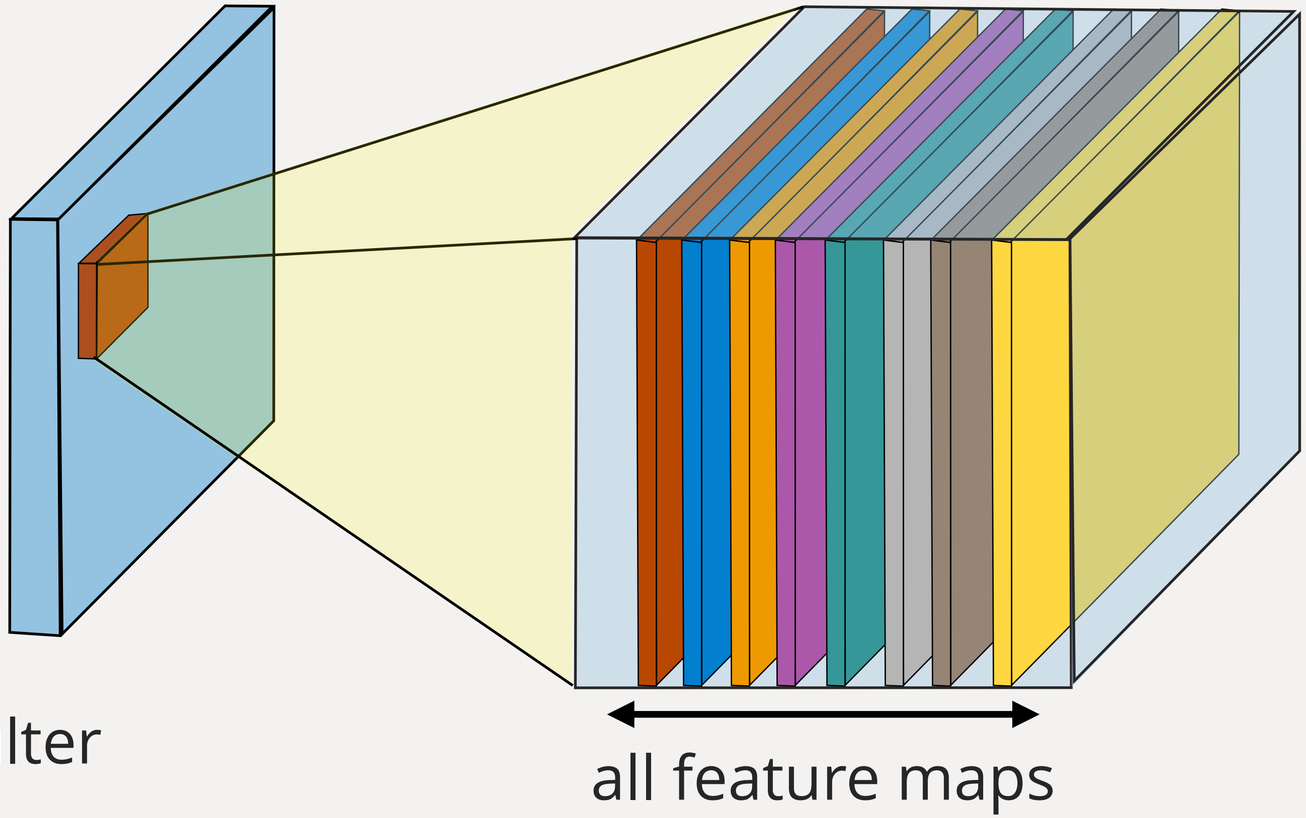
Core Components of the Convolutional Layer

Core Elements of the Convolutional Neural Network



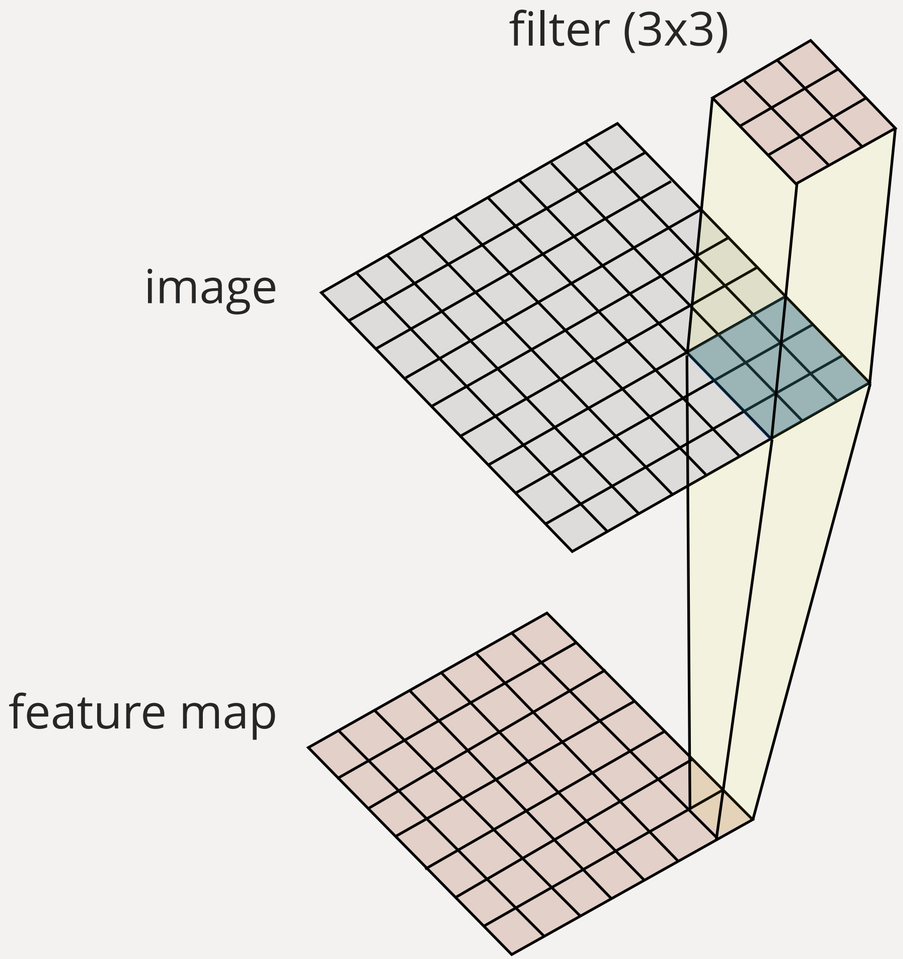
- Convolutional layers
- Activation functions
- Pooling layers
- Fully connected layers

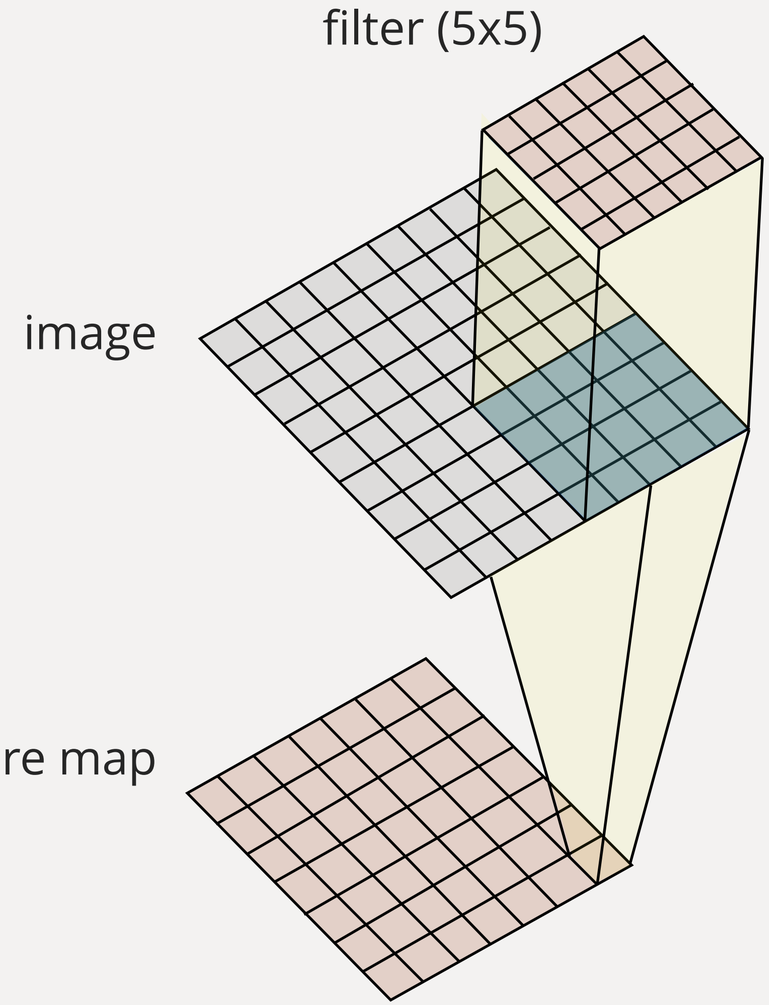


Convolutional Layer

- Filter size
- Filter stride
- Filter (feature) number

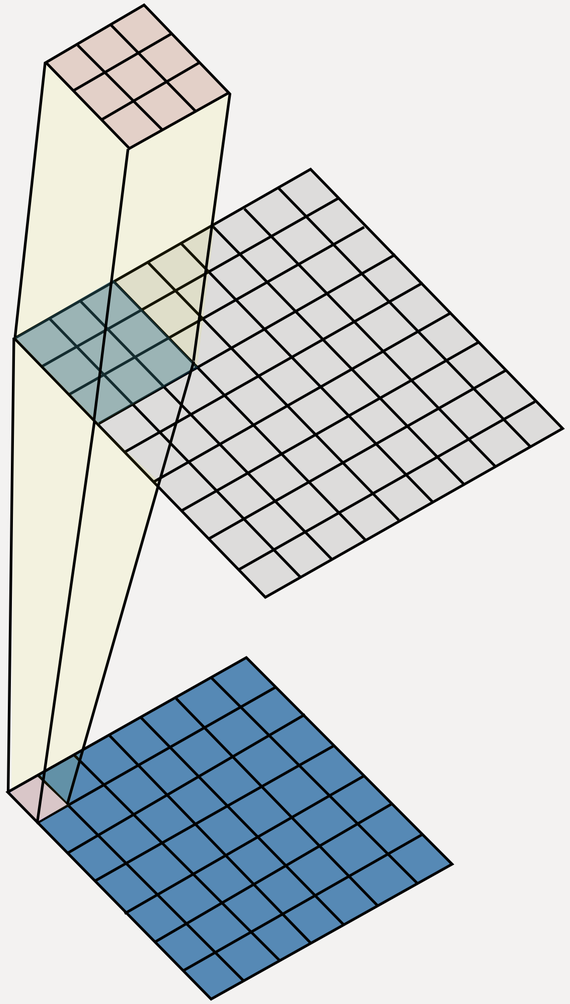
Convolutional Layer: Filter Size



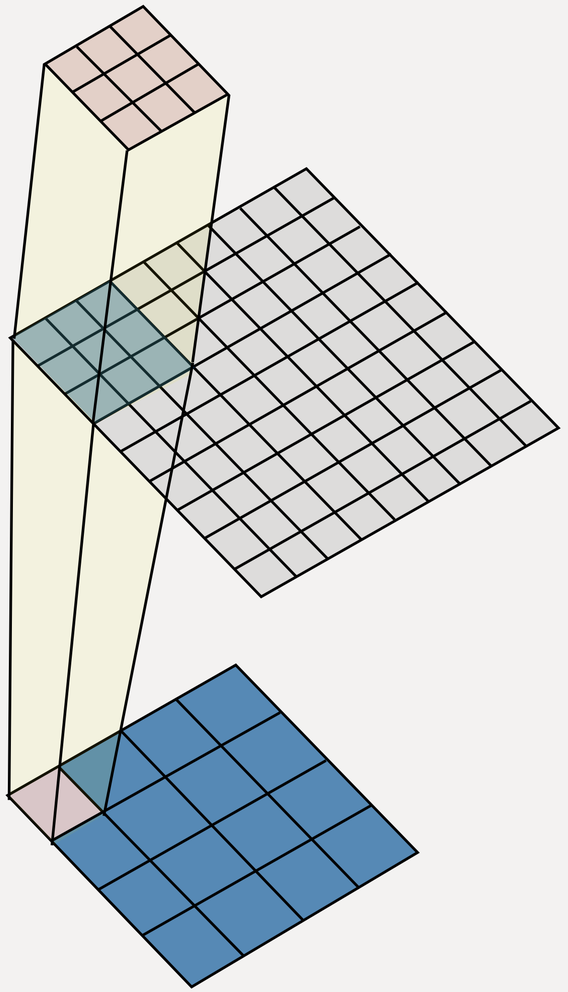


Convolutional Layer: Filter Stride

stride = 1

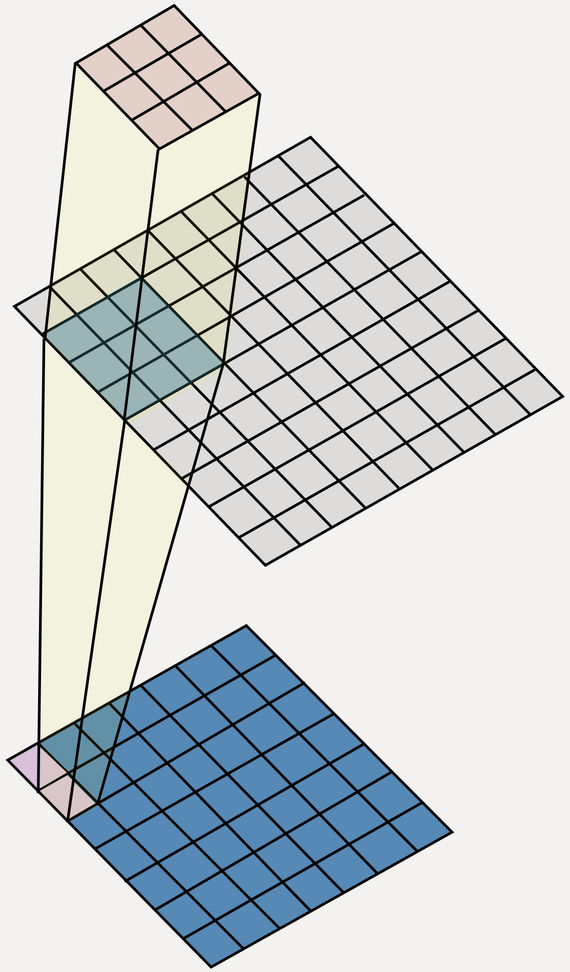


stride = 2

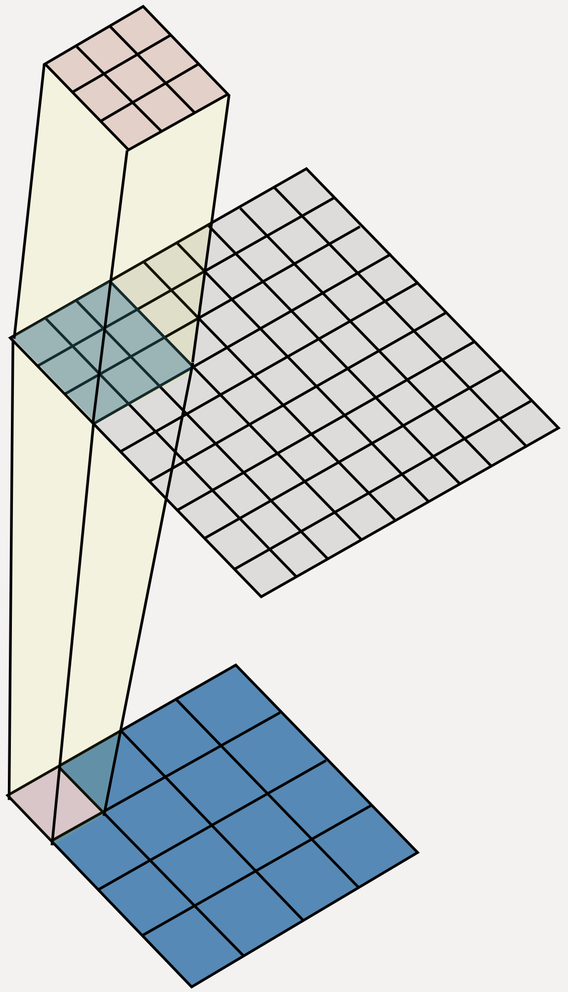


Convolutional Layer: Filter Stride

stride = 1

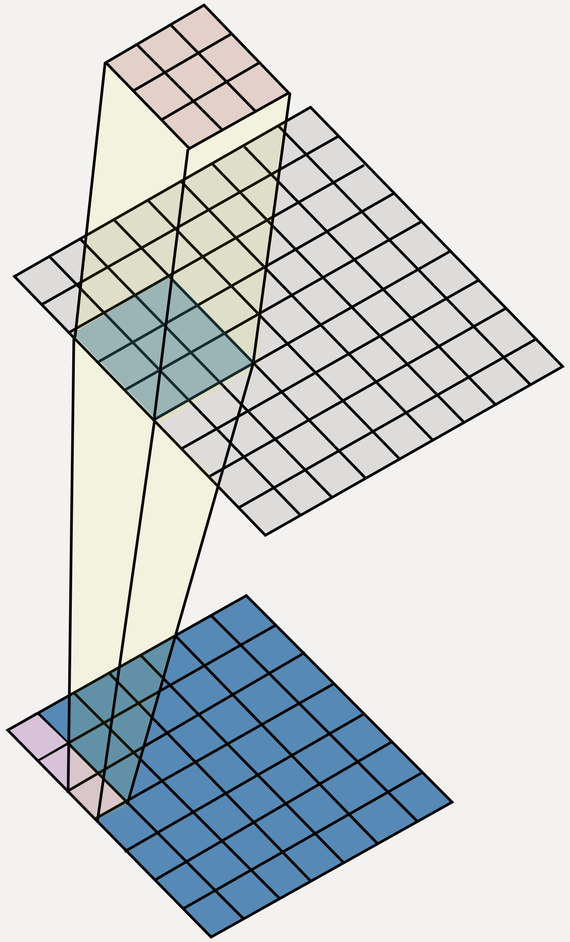


stride = 2

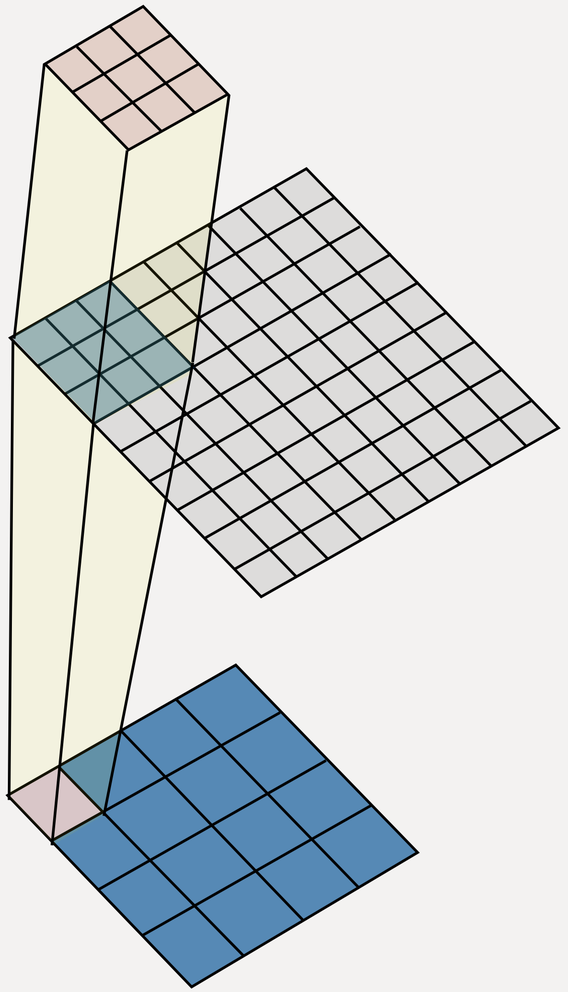


Convolutional Layer: Filter Stride

stride = 1

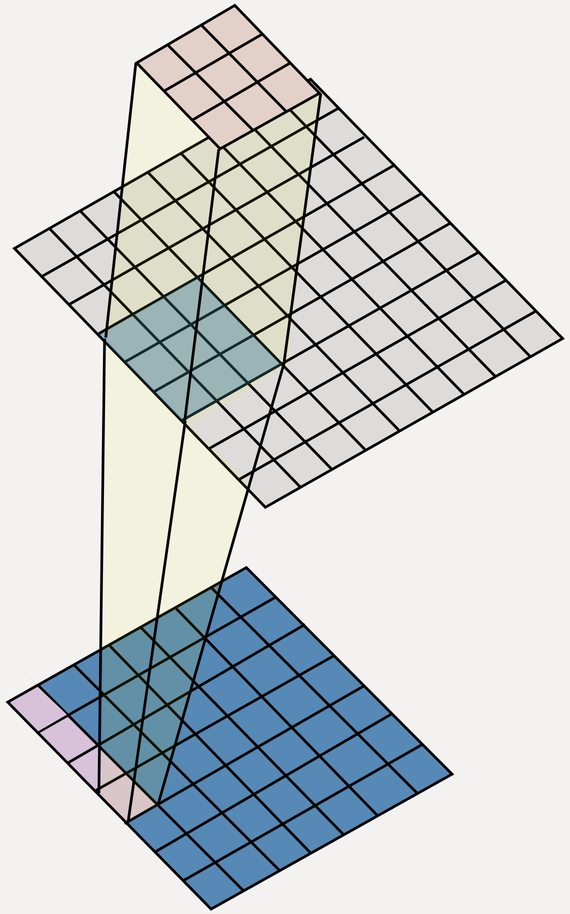


stride = 2

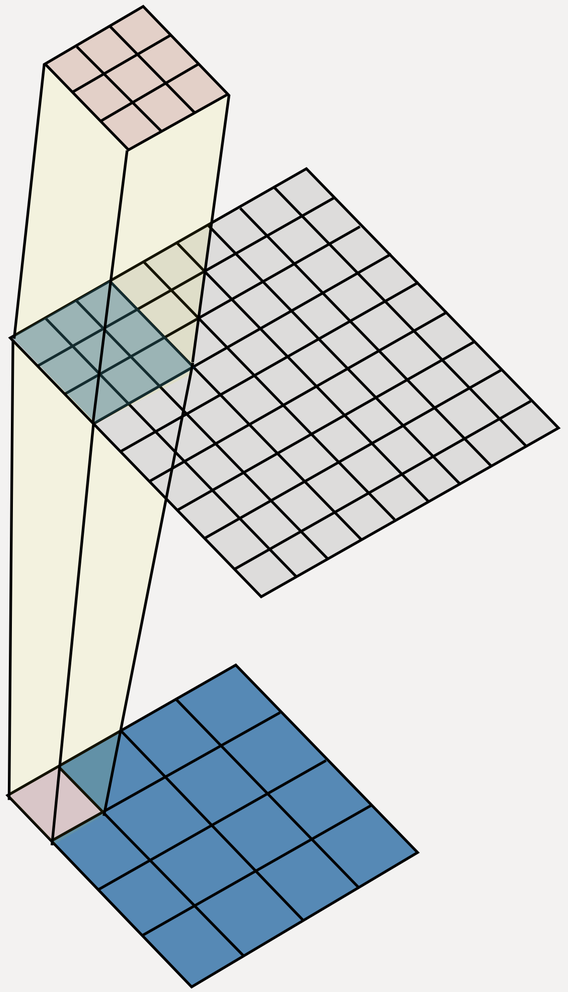


Convolutional Layer: Filter Stride

stride = 1

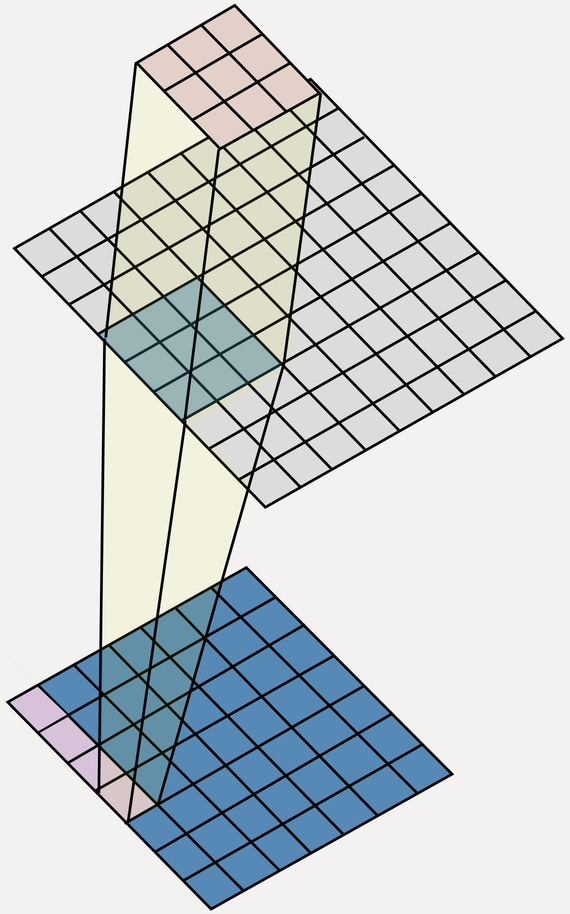


stride = 2

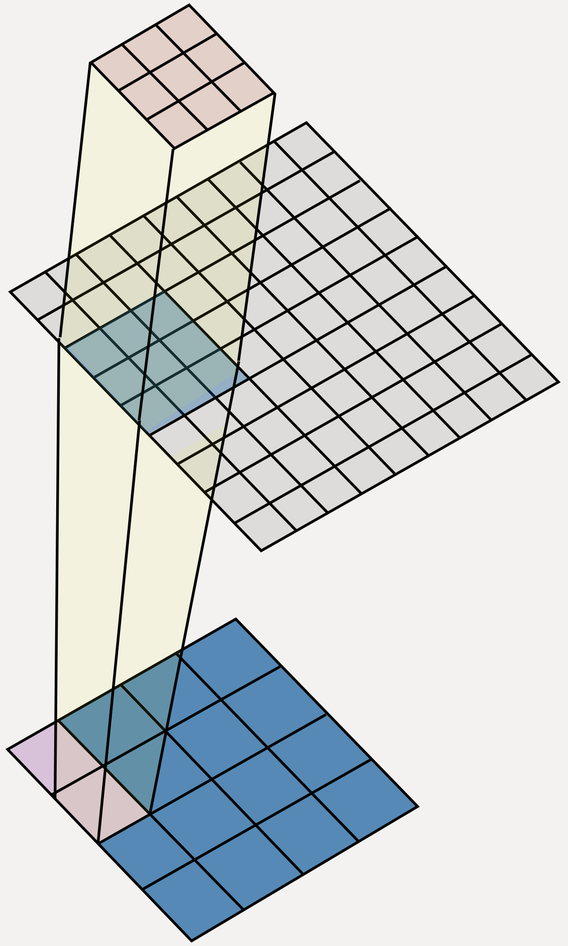


Convolutional Layer: Filter Stride

stride = 1

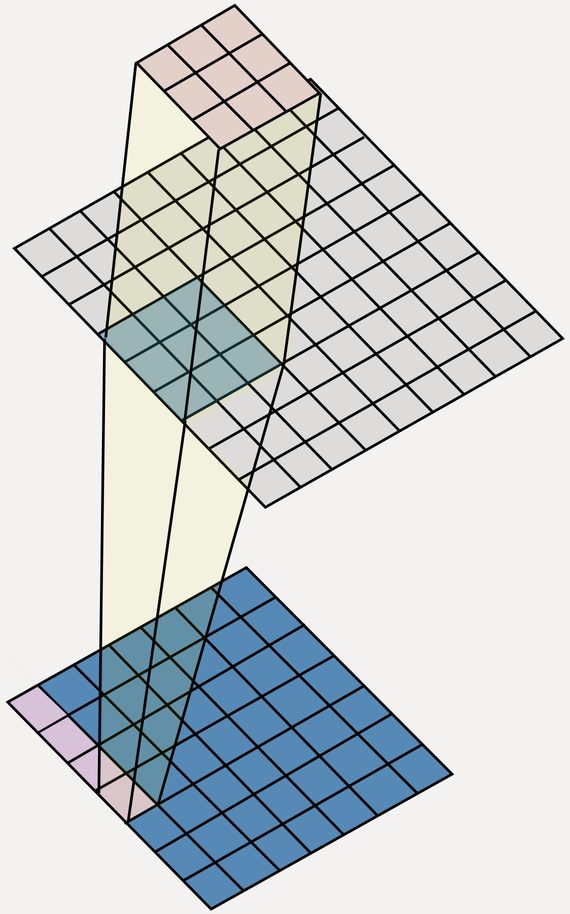


stride = 2

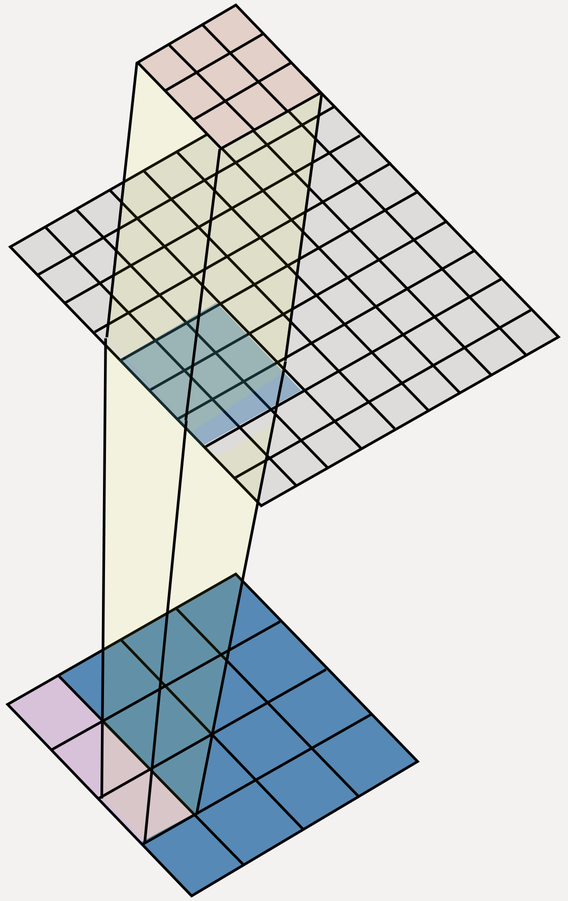


Convolutional Layer: Filter Stride

stride = 1

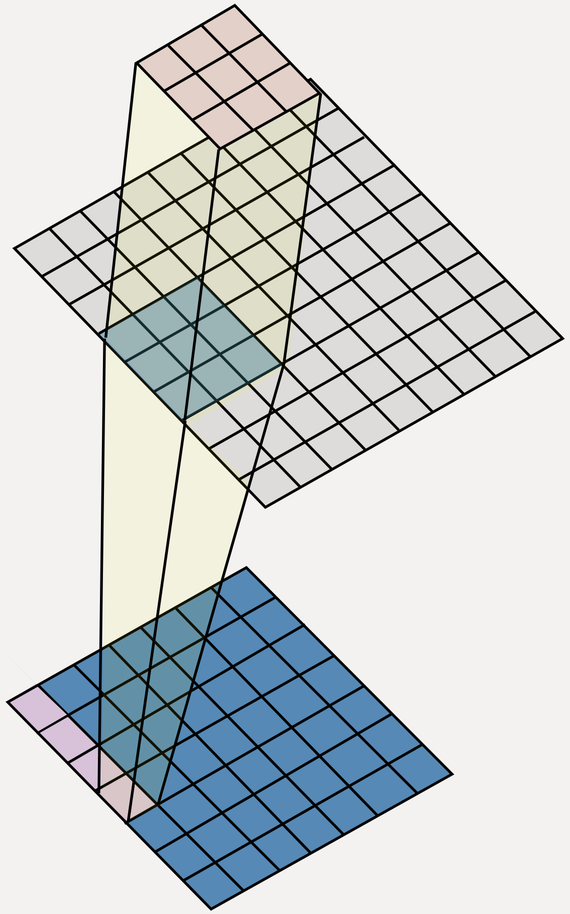


stride = 2

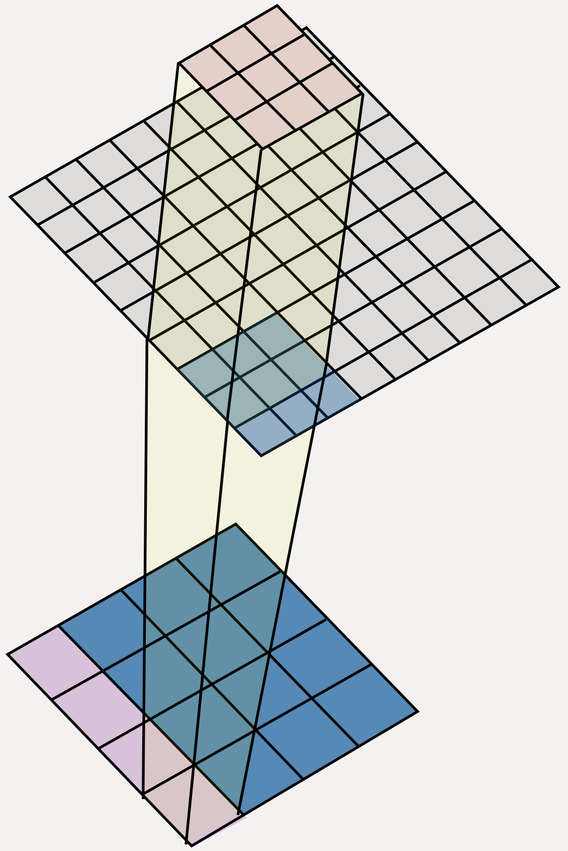


Convolutional Layer: Filter Stride

stride = 1

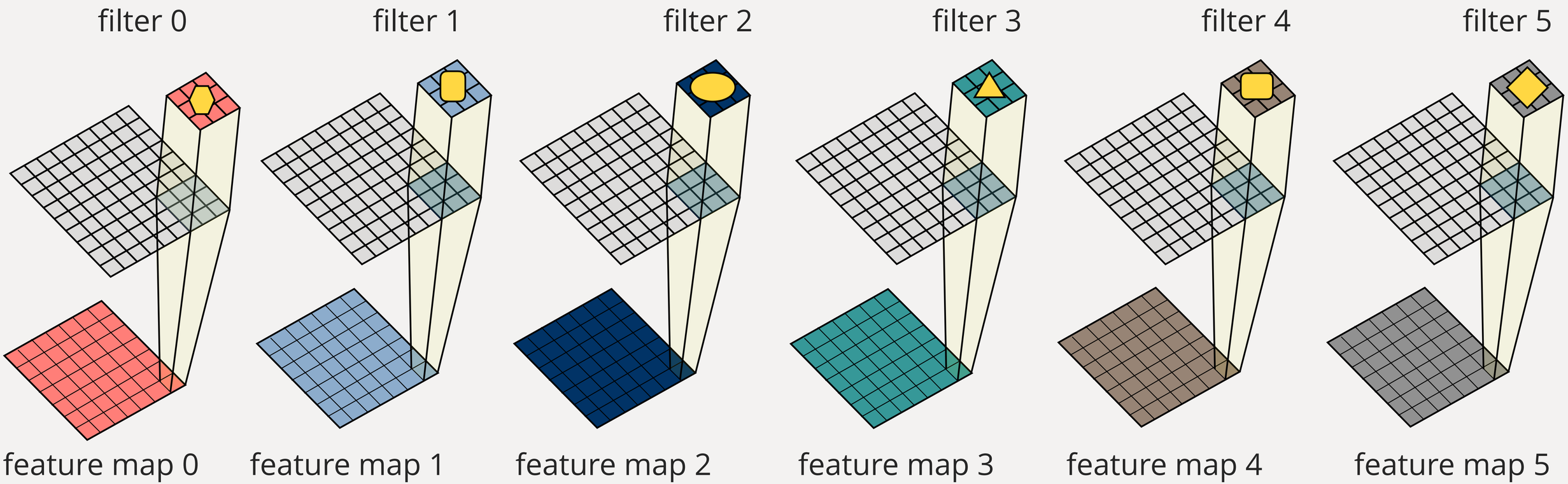


stride = 2

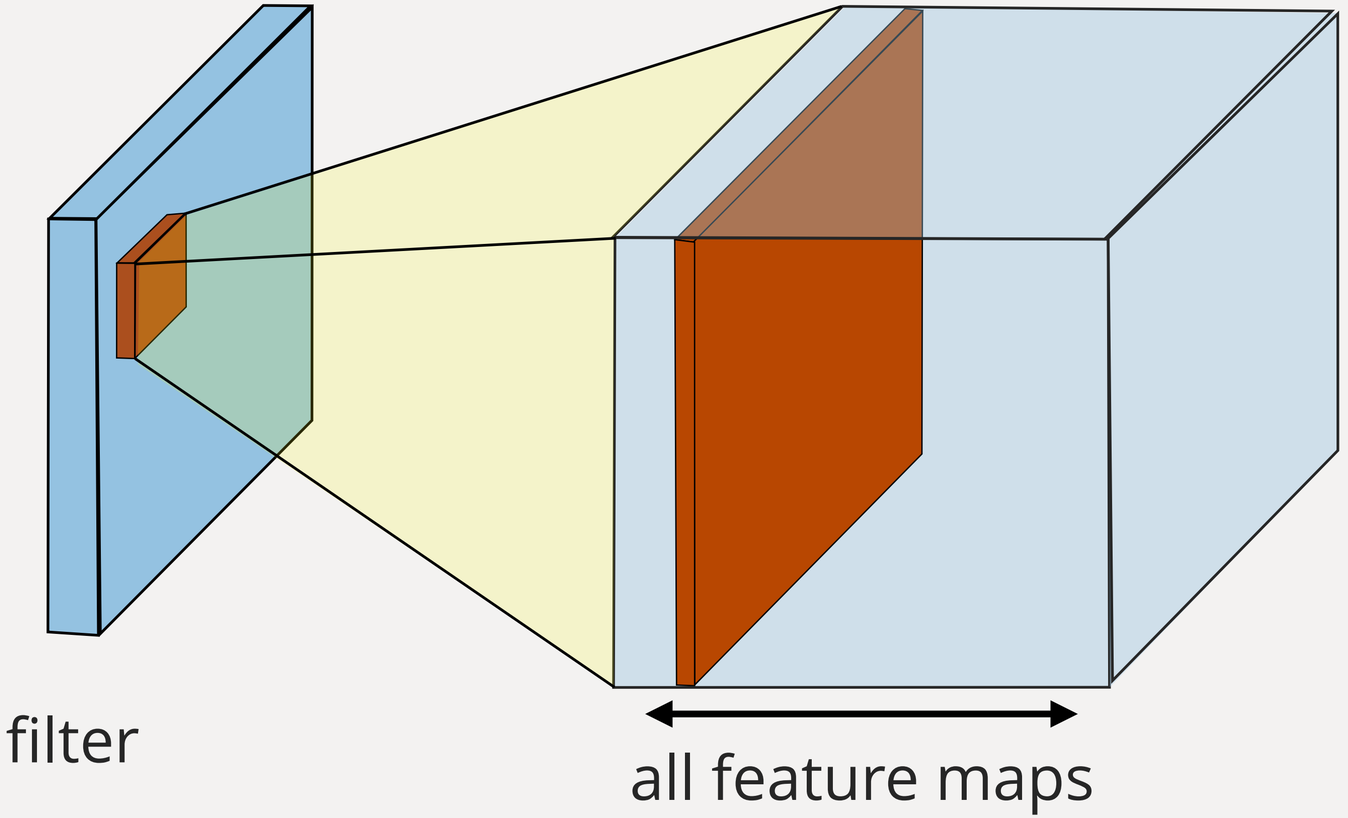


The stride helps reduce the computational load by downsampling the input

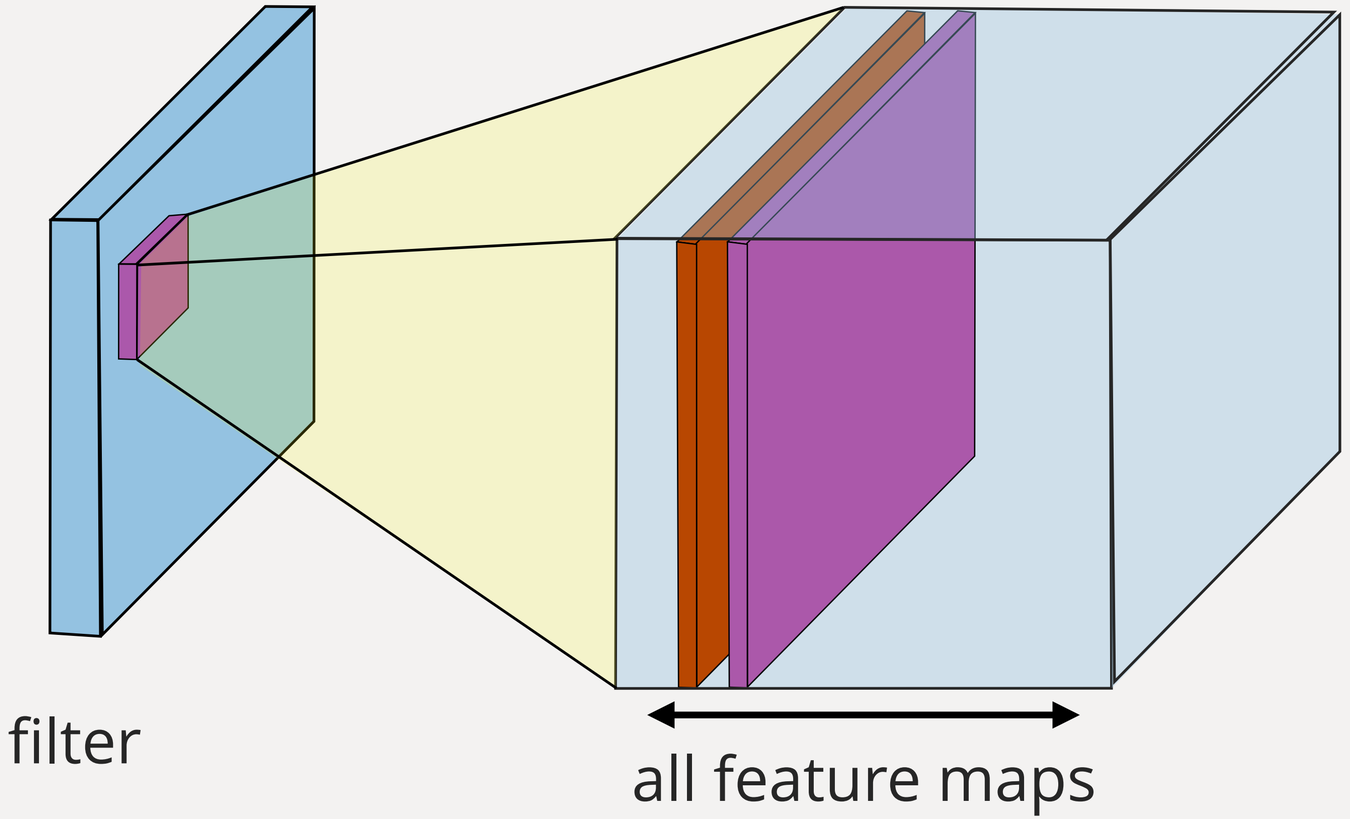
Convolutional Layer: Filter Number



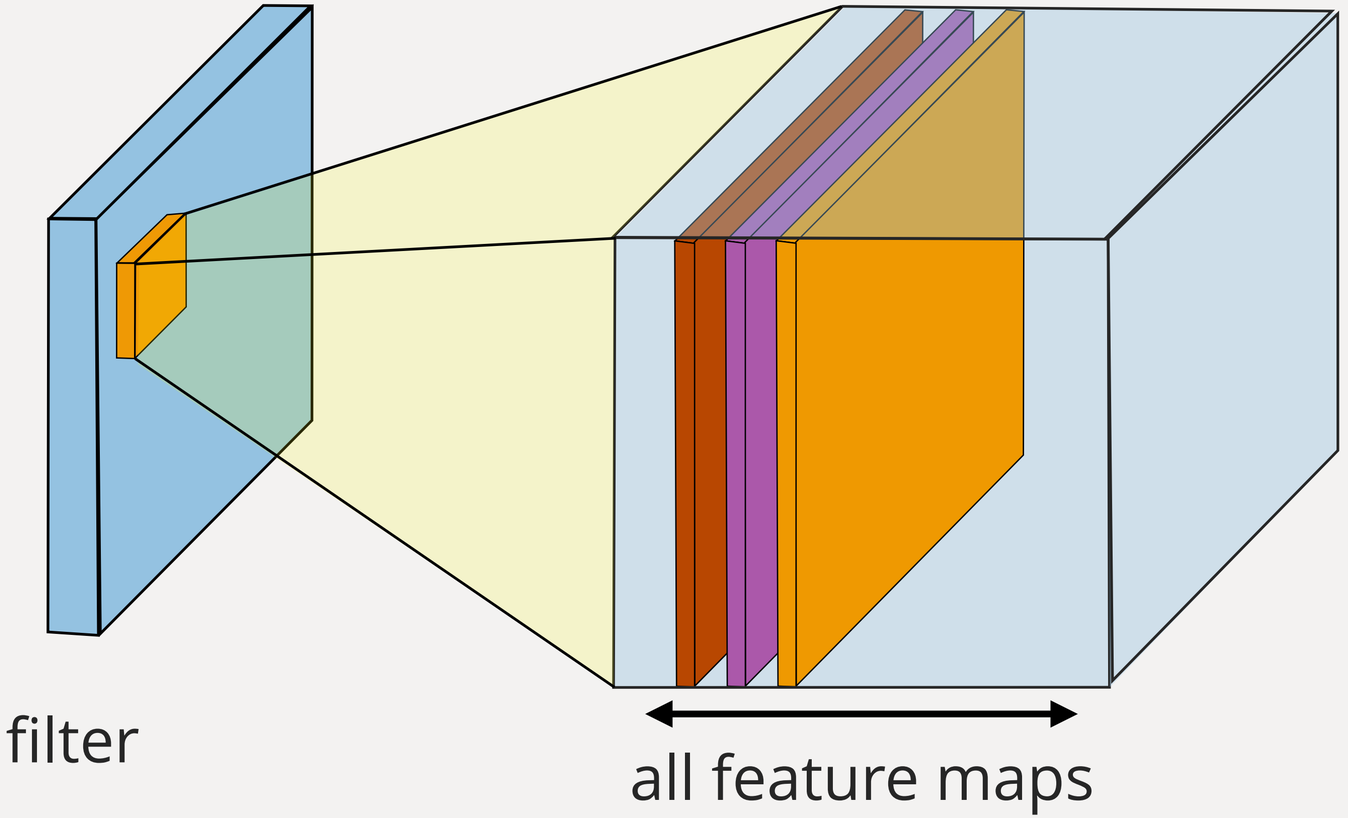
Convolutional Layer: Filter Number



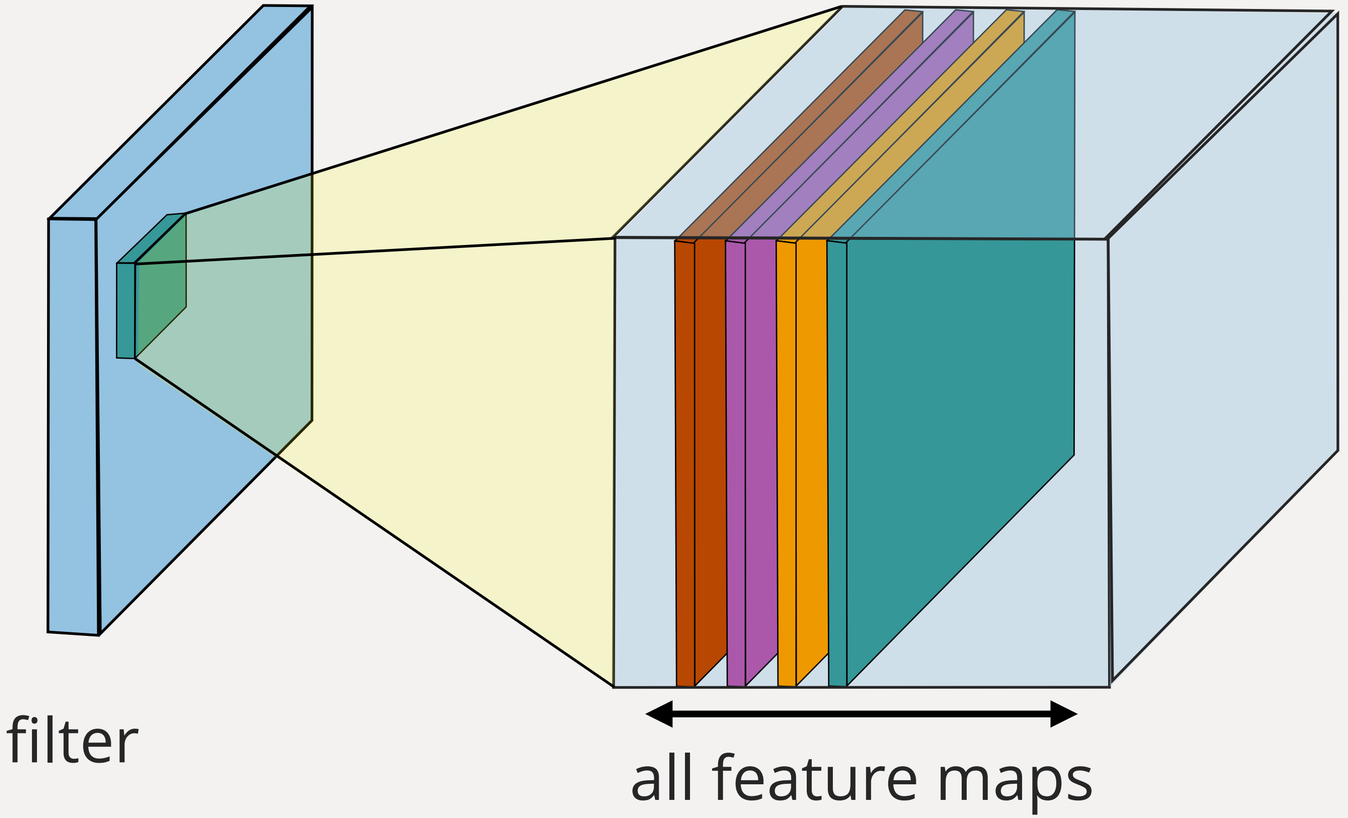
Convolutional Layer: Filter Number



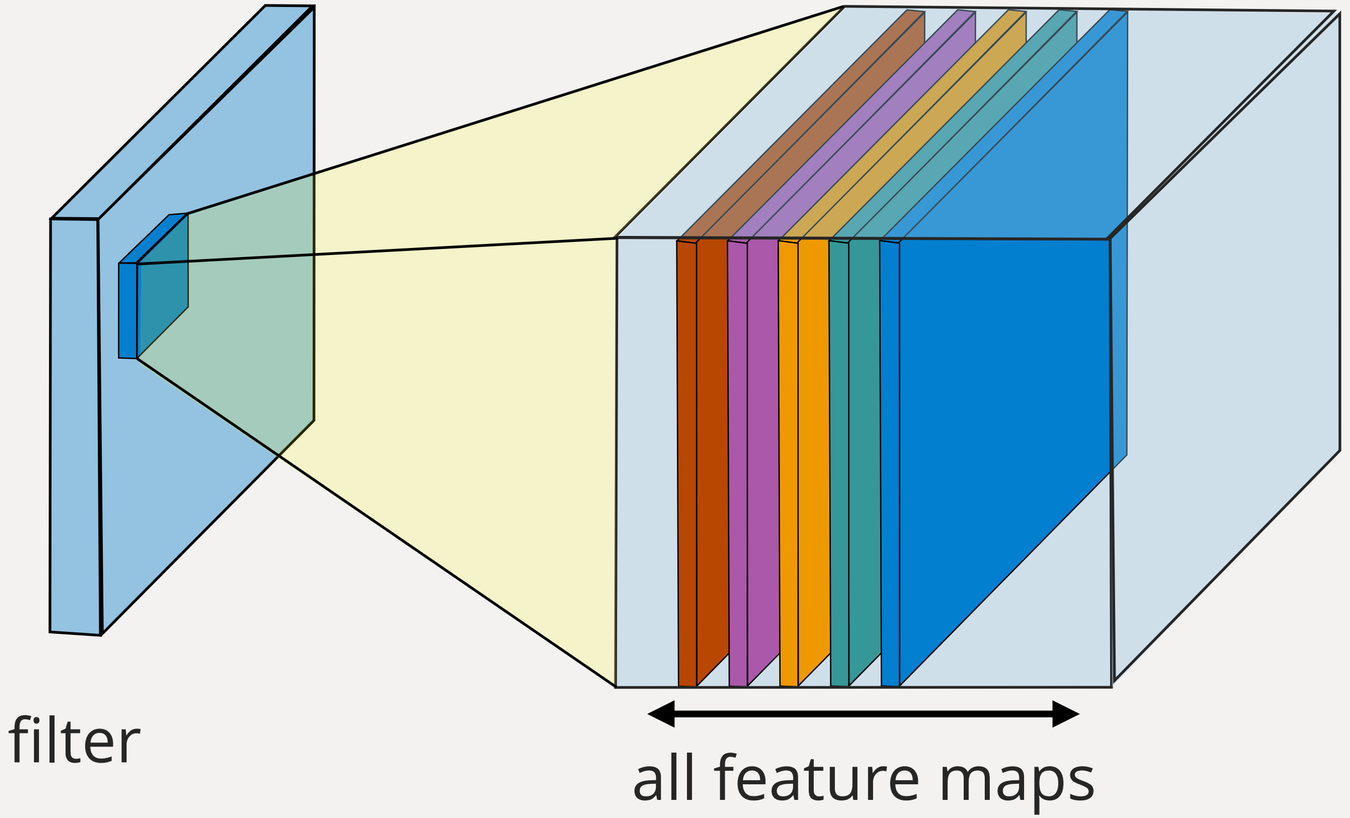
Convolutional Layer: Filter Number



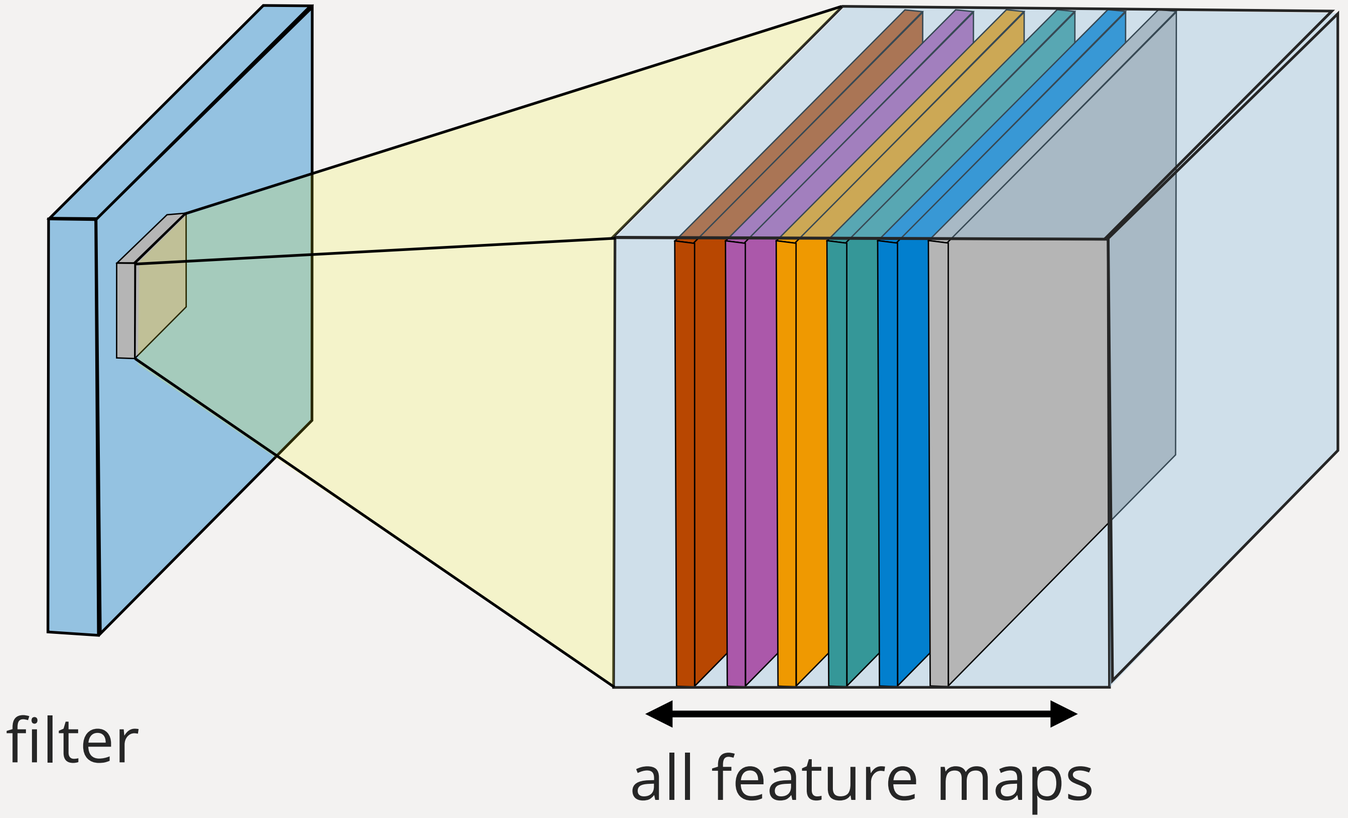
Convolutional Layer: Filter Number



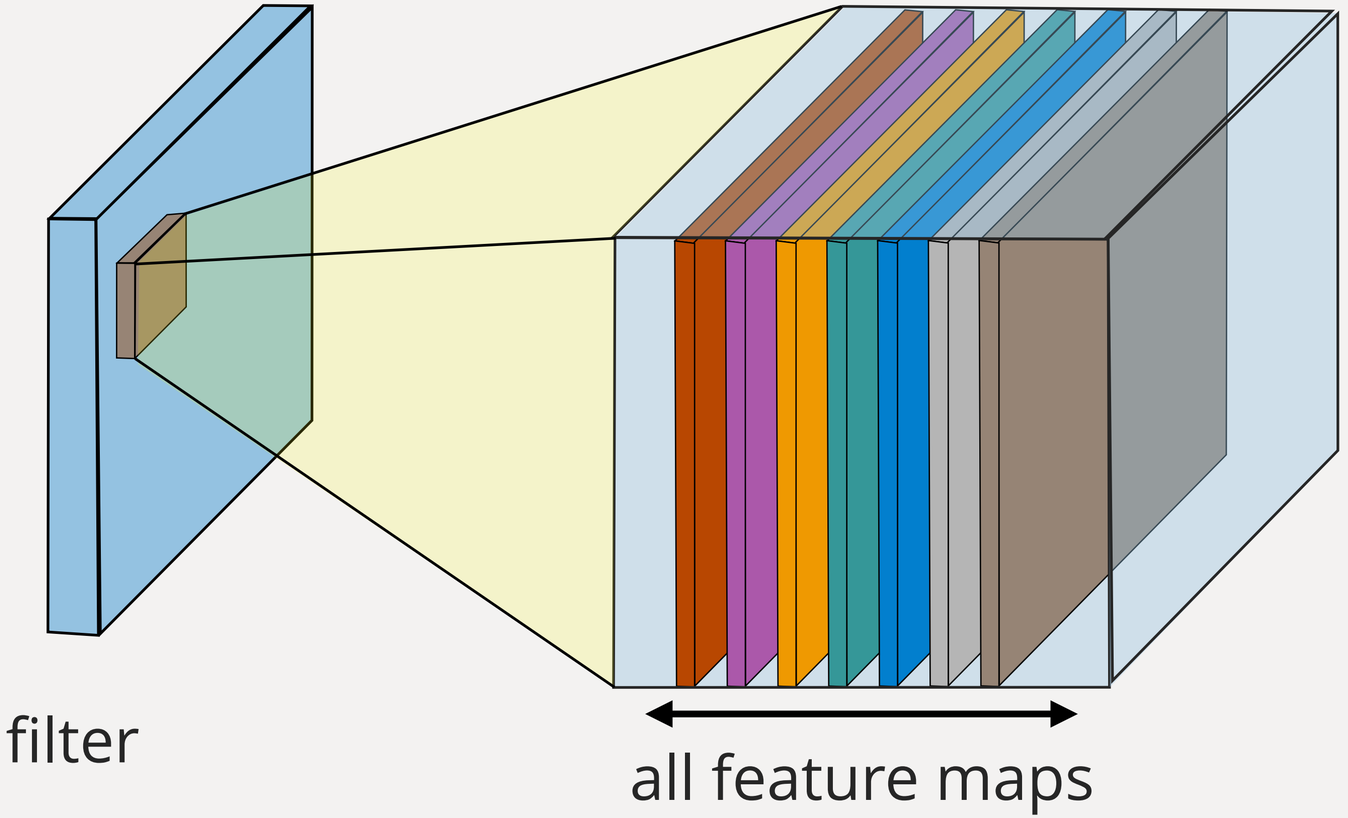
Convolutional Layer: Filter Number



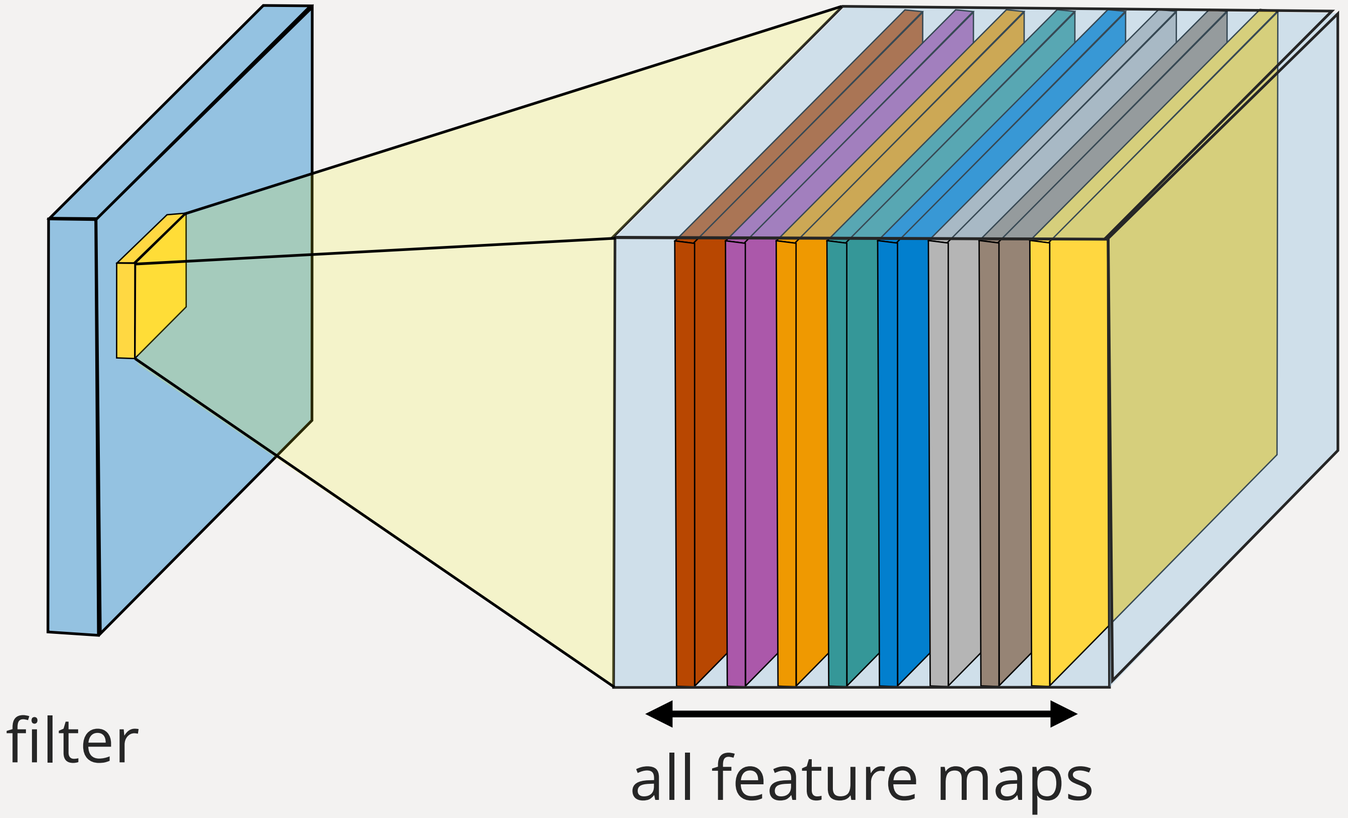
Convolutional Layer: Filter Number



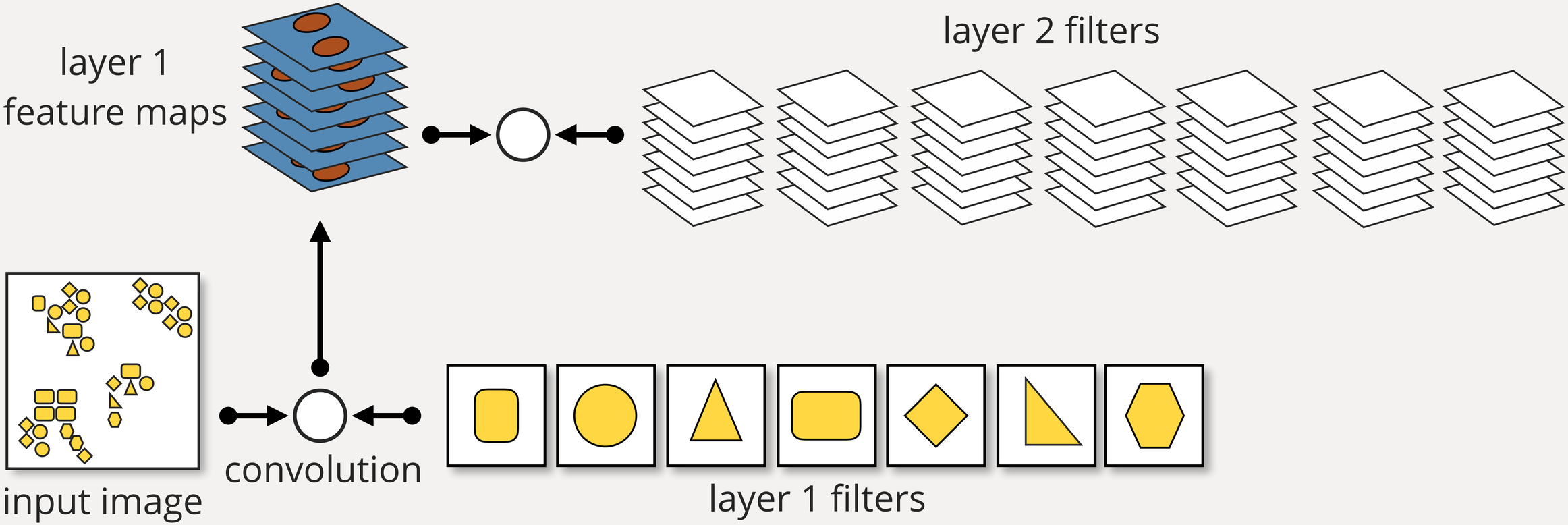
Convolutional Layer: Filter Number



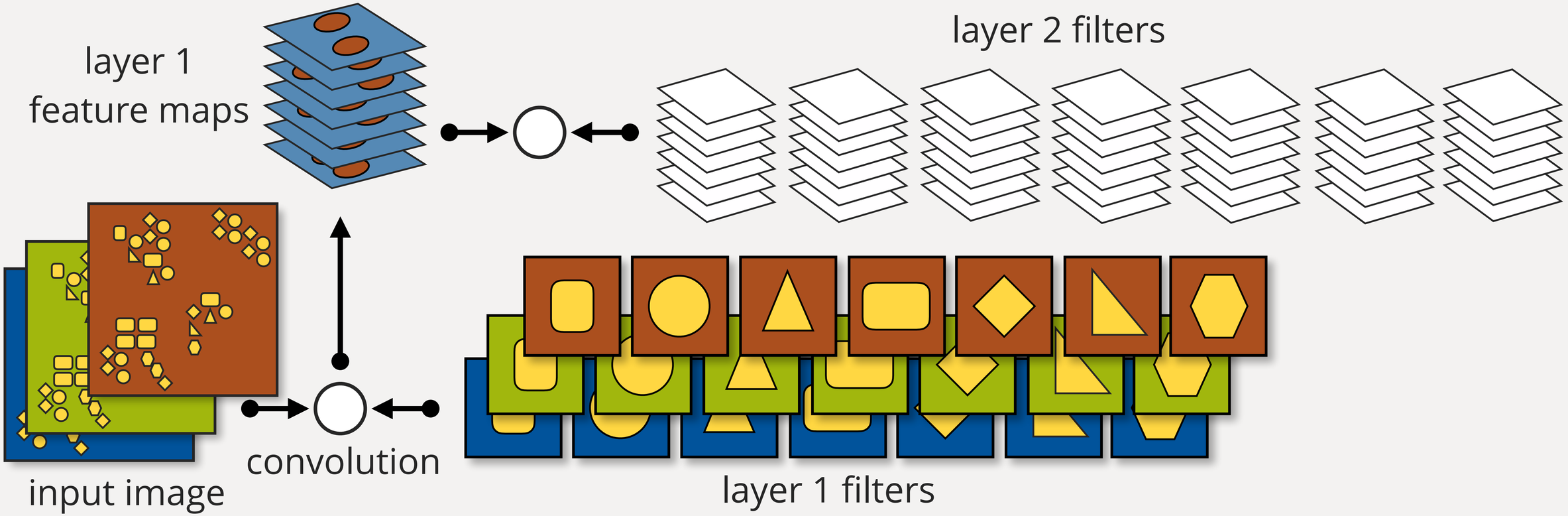
Convolutional Layer: Filter Number



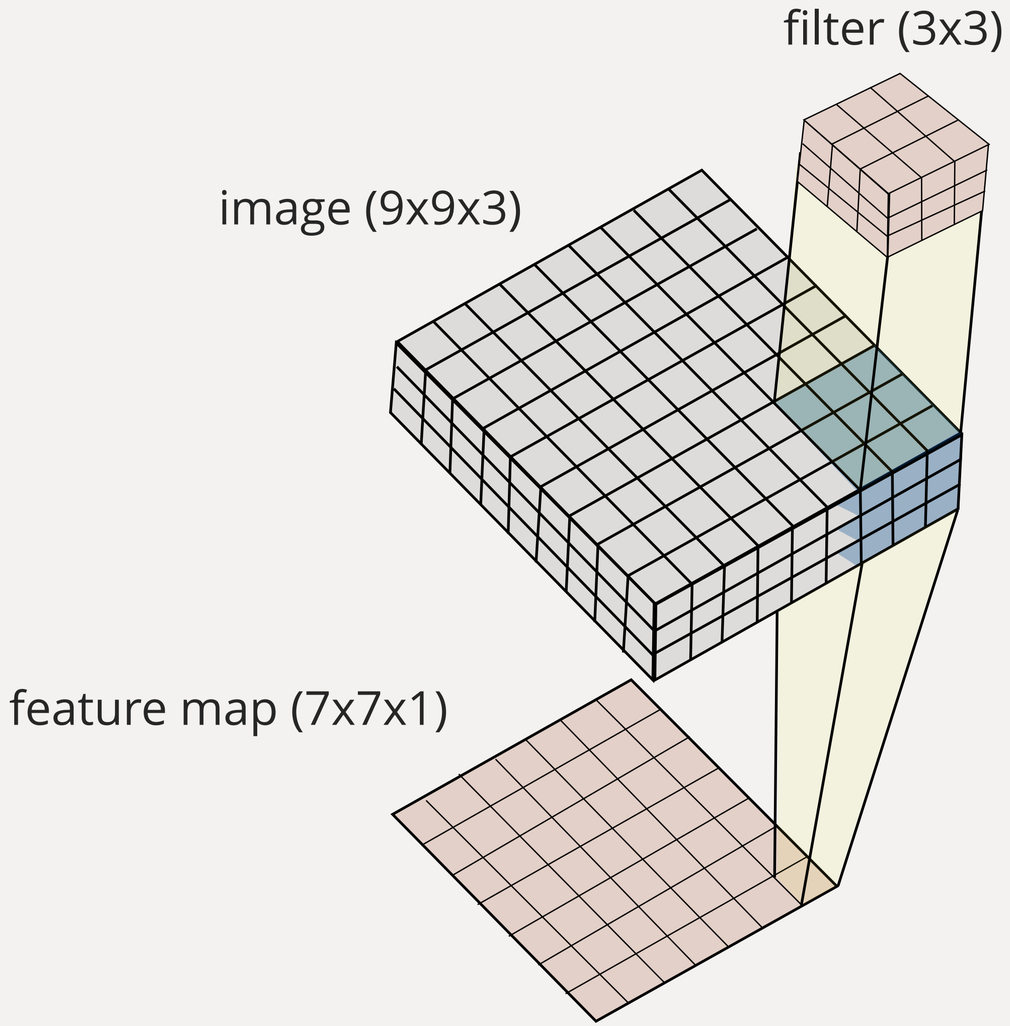
Filters Operate Over Input Volumes

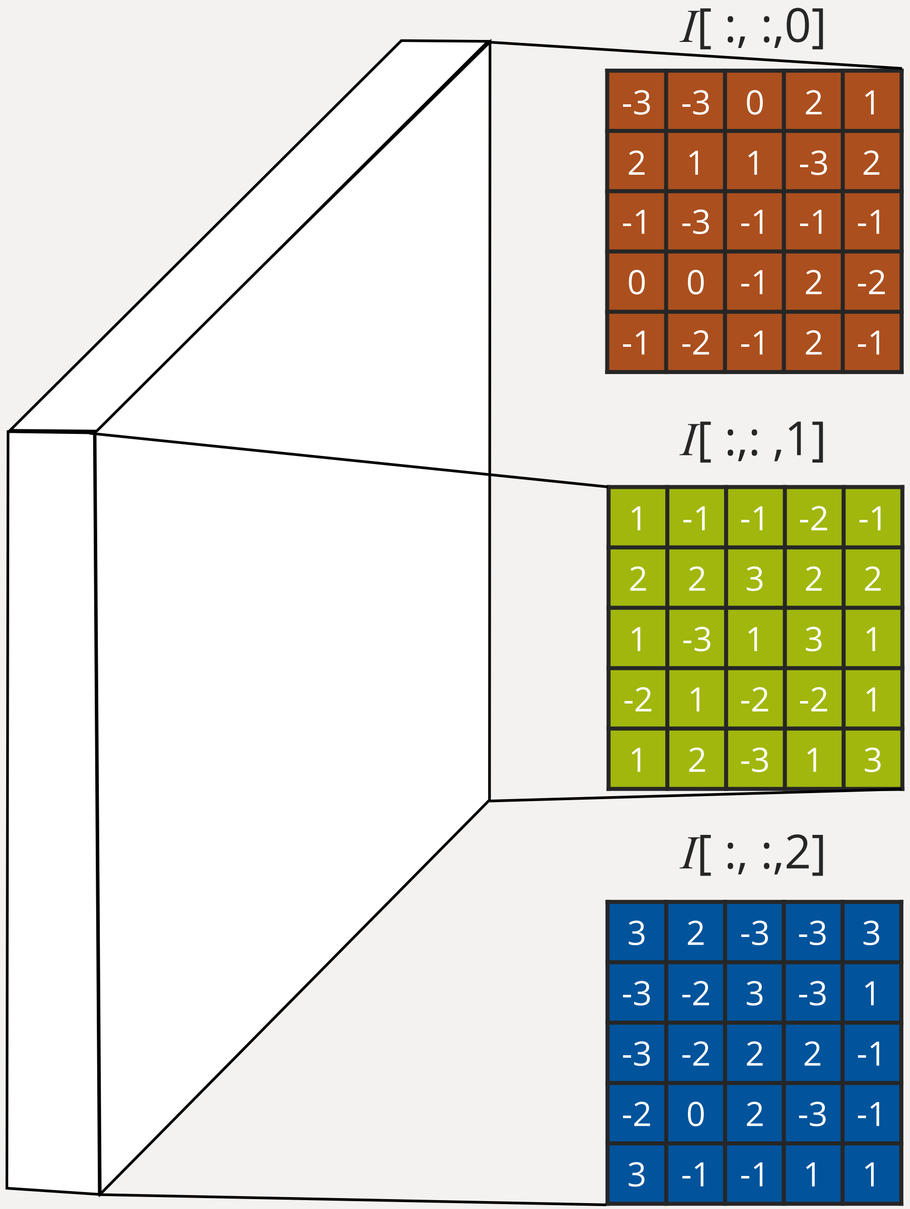


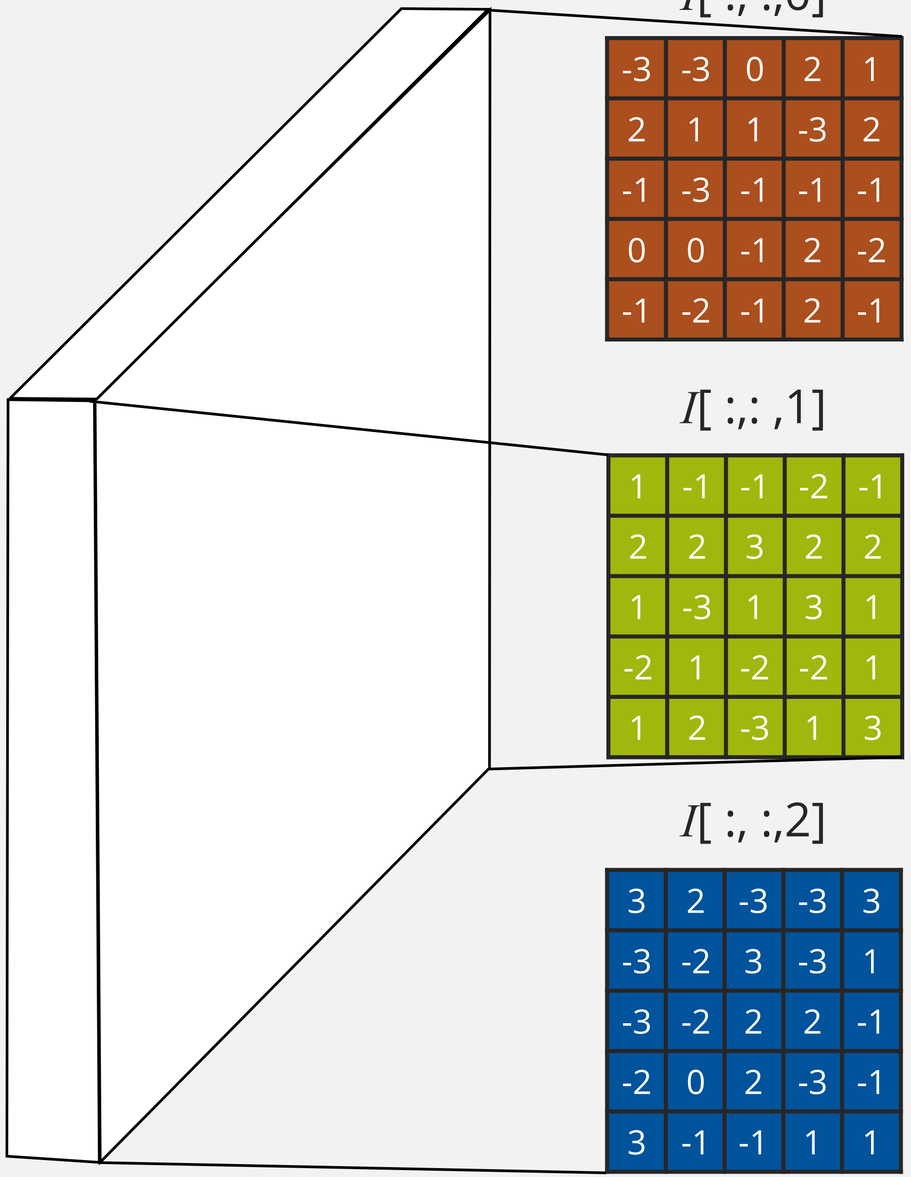
Filters Operate Over Input Volumes



Filters Operate Over Input Volumes




I[:, :,0]
-3 -3 0 2 1
2 1 1 -3 2
-1 -3 -1 -1 -1
0 0 -1 2 -2
-1 -2 -1 2 -1
I[:,: ,1]
1 -1 -1 -2 -1
2 2 3 2 2
1 -3 1 3 1
-2 1 -2 -2 1
1 2 -3 1 3
I[:, :,2]
3 2 -3 -3 3
-3 -2 3 -3 1
-3 -2 2 2 -1
-2 0 2 -3 -1
3 -1 -1 1 1



I[:, :,0]

-3	-3	0	2	1
2	1	1	-3	2
-1	-3	-1	-1	-1
0	0	-1	2	-2
-1	-2	-1	2	-1

I[:,: ,1]

1	-1	-1	-2	-1
2	2	3	2	2
1	-3	1	3	1
-2	1	-2	-2	1
1	2	-3	1	3

I[:, :,2]

3	2	-3	-3	3
-3	-2	3	-3	1
-3	-2	2	2	-1
-2	0	2	-3	-1
3	-1	-1	1	1

W_0[:, :,0]

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

W_0[:, :,1]

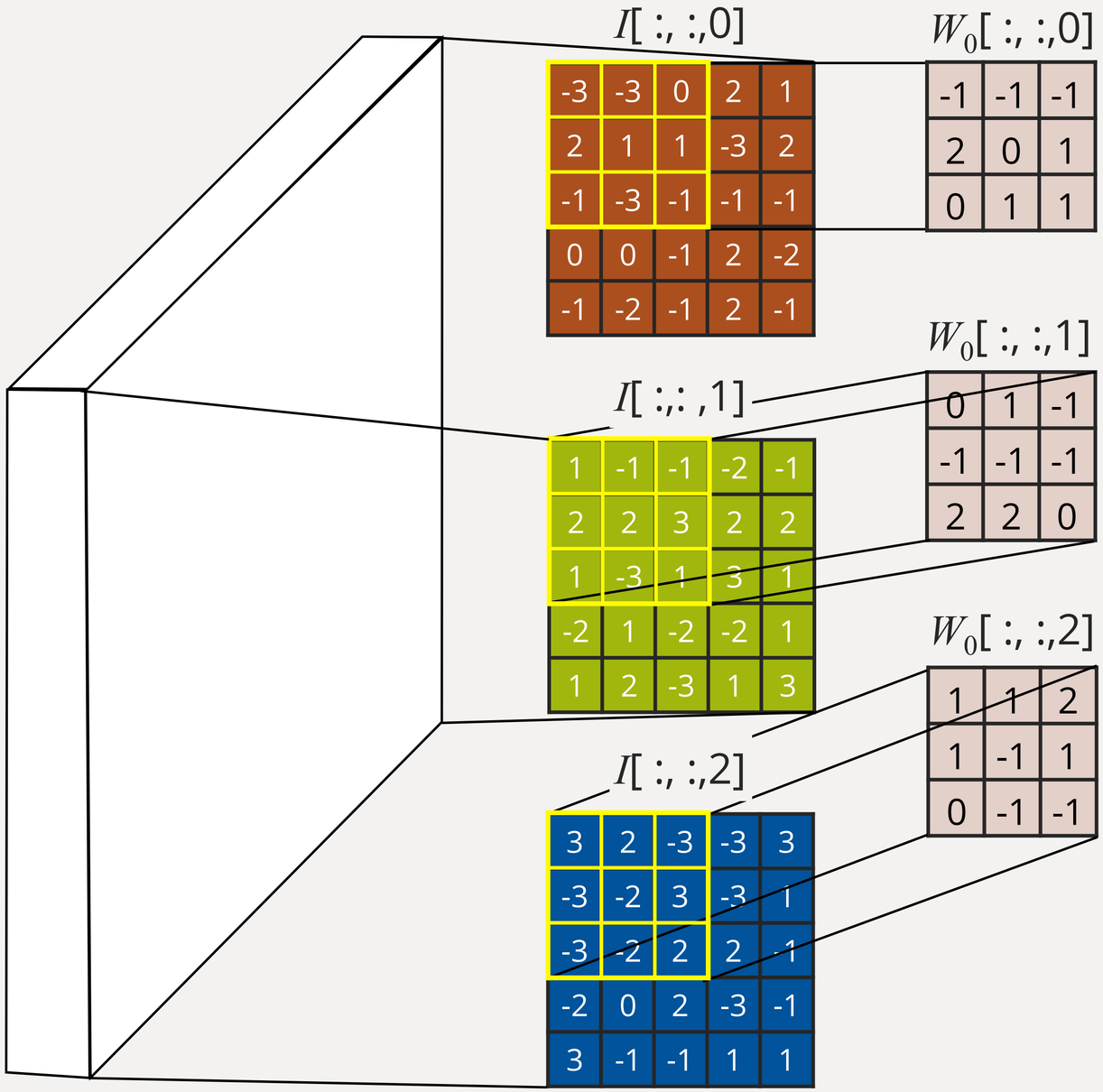
0	1	-1
-1	-1	-1
2	2	0

W_0[:, :,2]

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

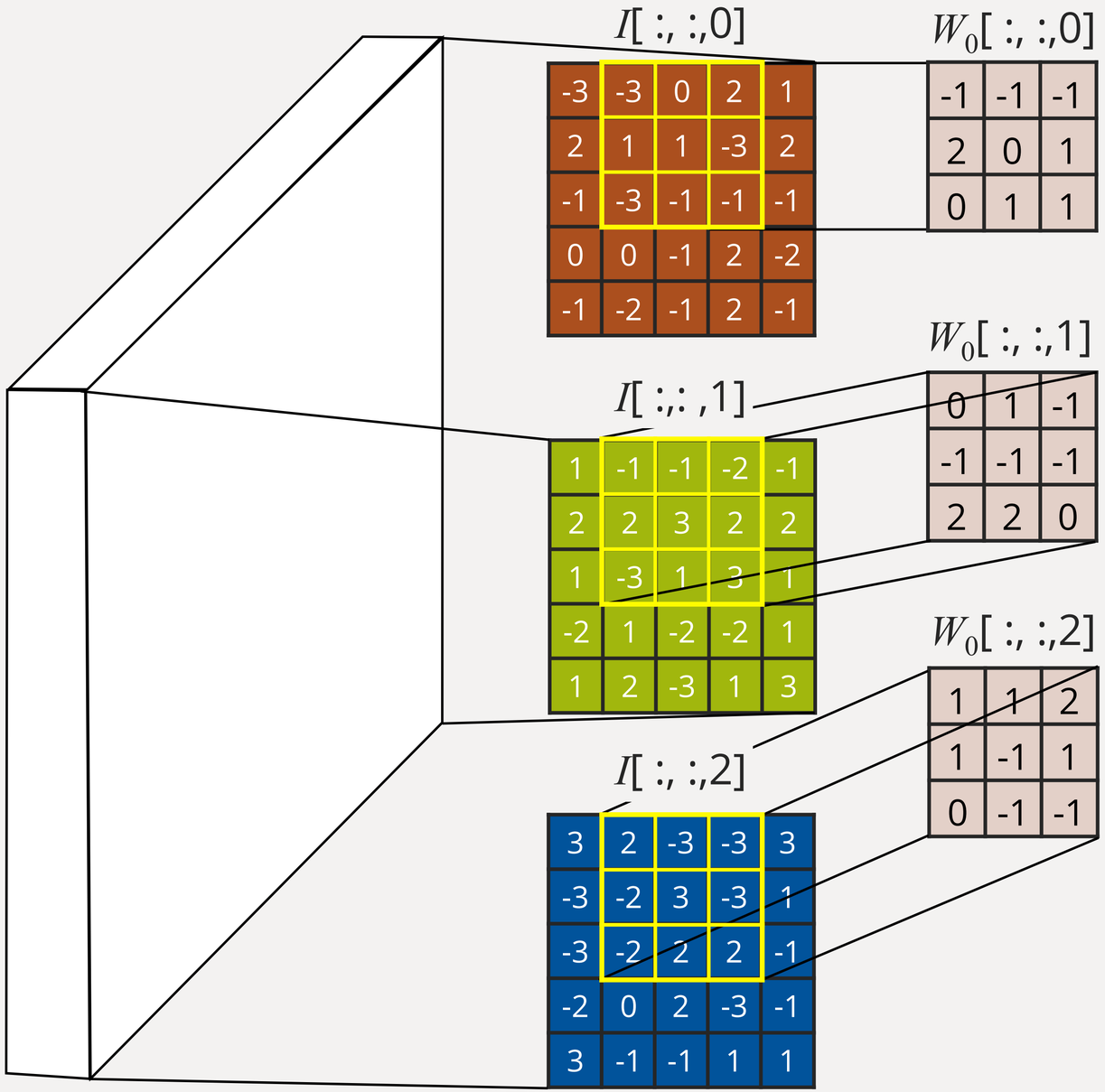
O[:, :,0]

-1	27	11
-14	-17	-15
13	3	-2



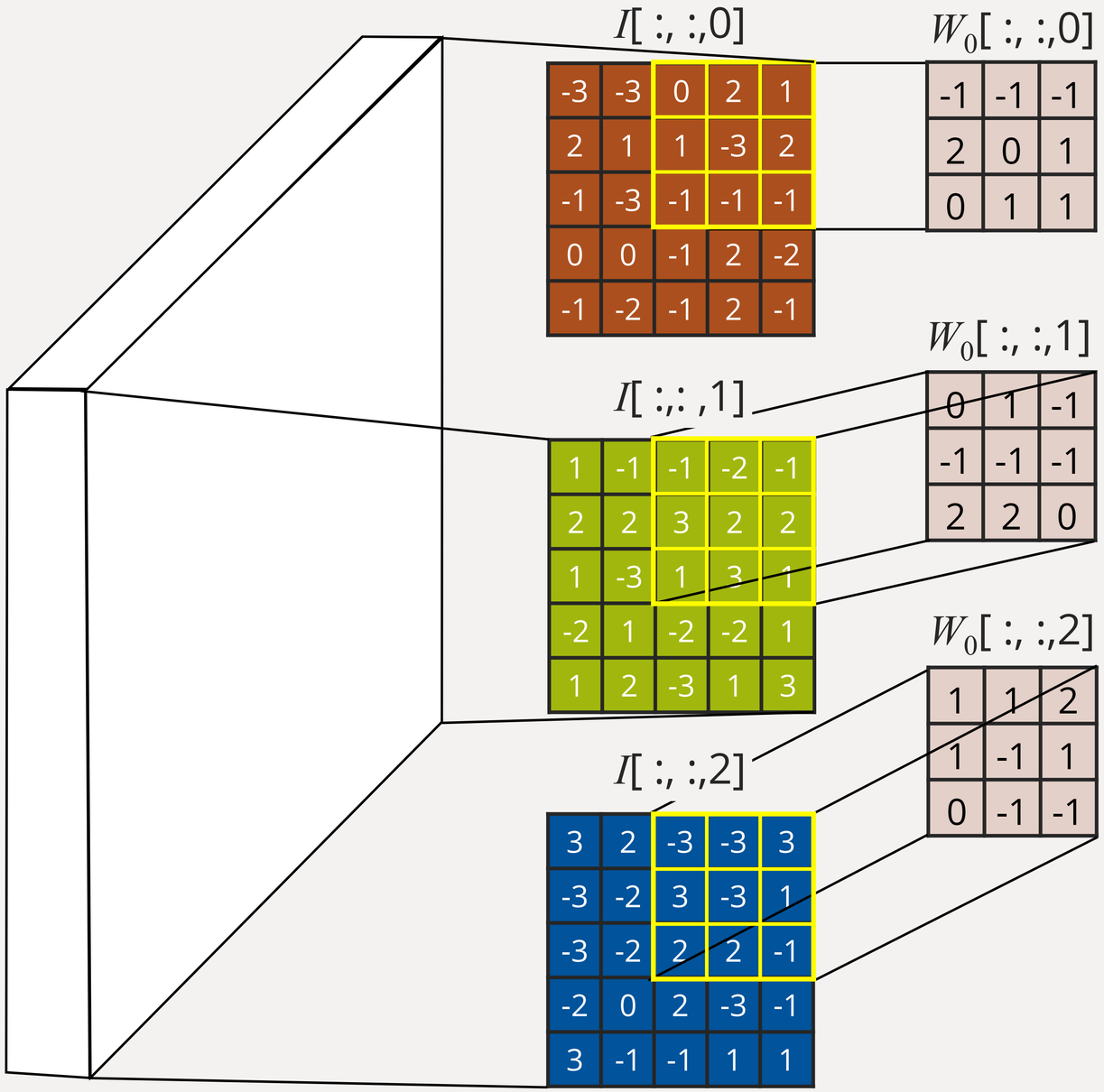
O[:, :,0]

-1	27	11
-14	-17	-15
13	3	-2



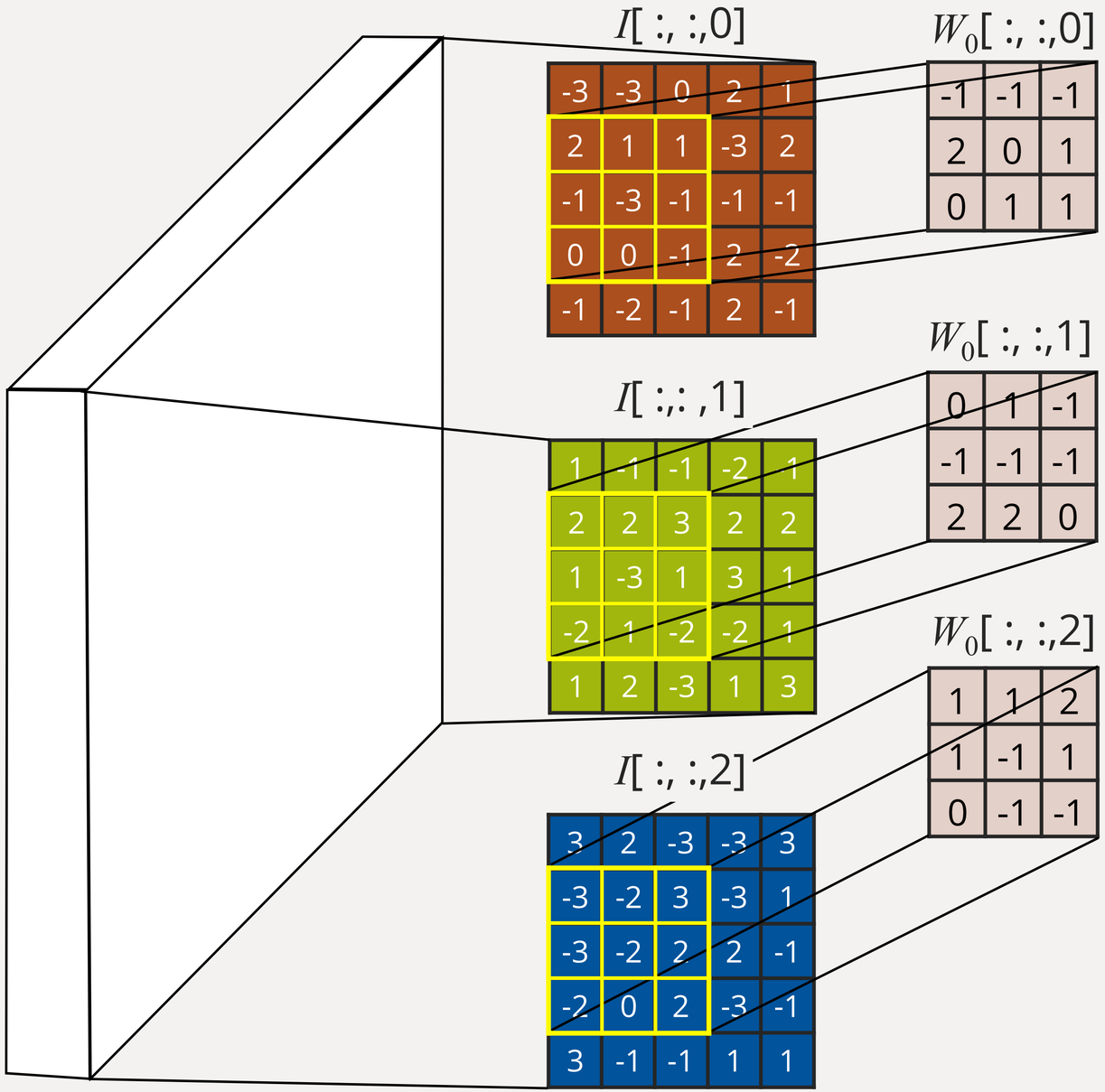
O[:, :,0]

-1	27	11
-14	-17	-15
13	3	-2



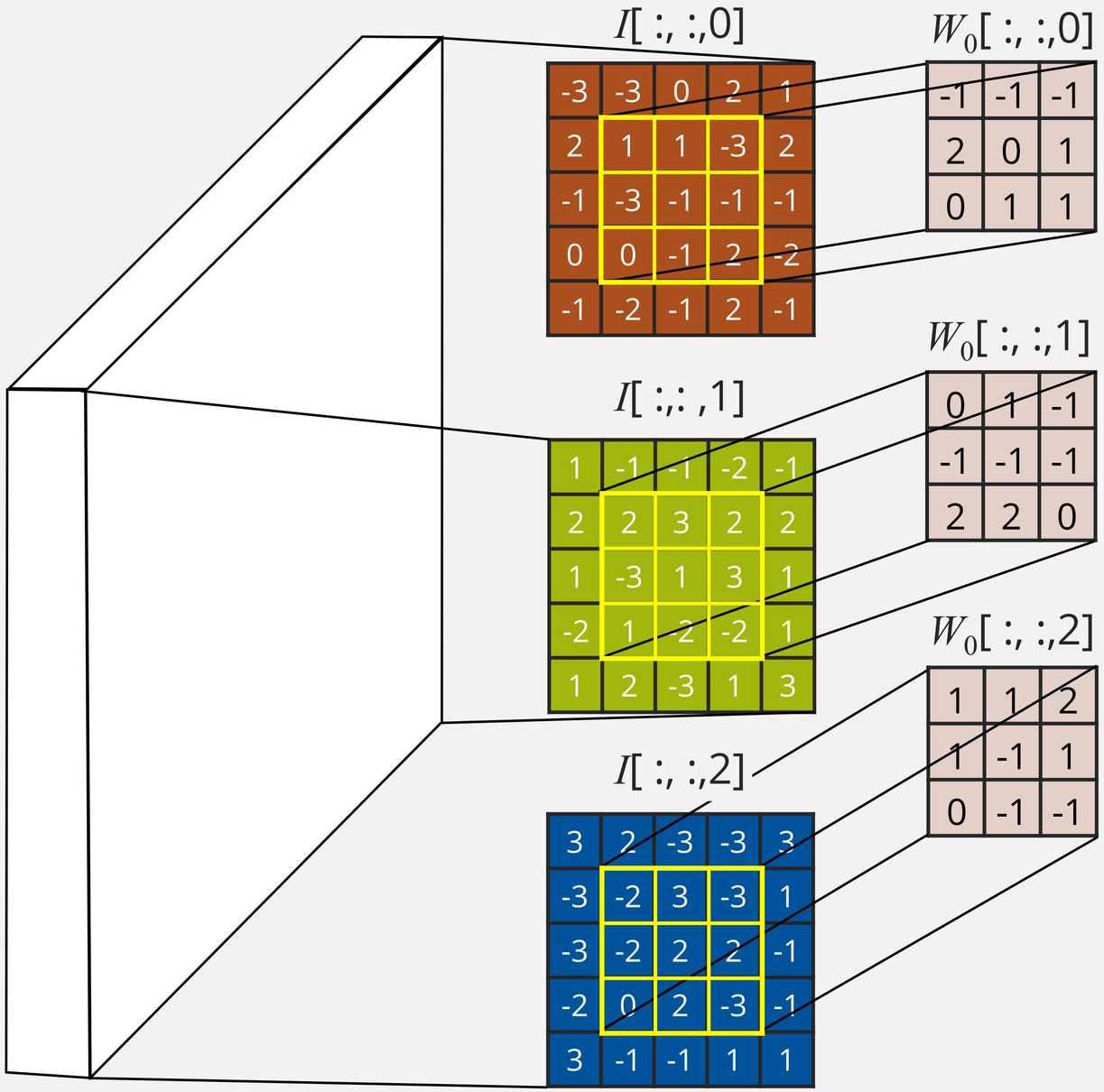
O[:, :,0]

-1	27	11
-14	-17	-15
13	3	-2



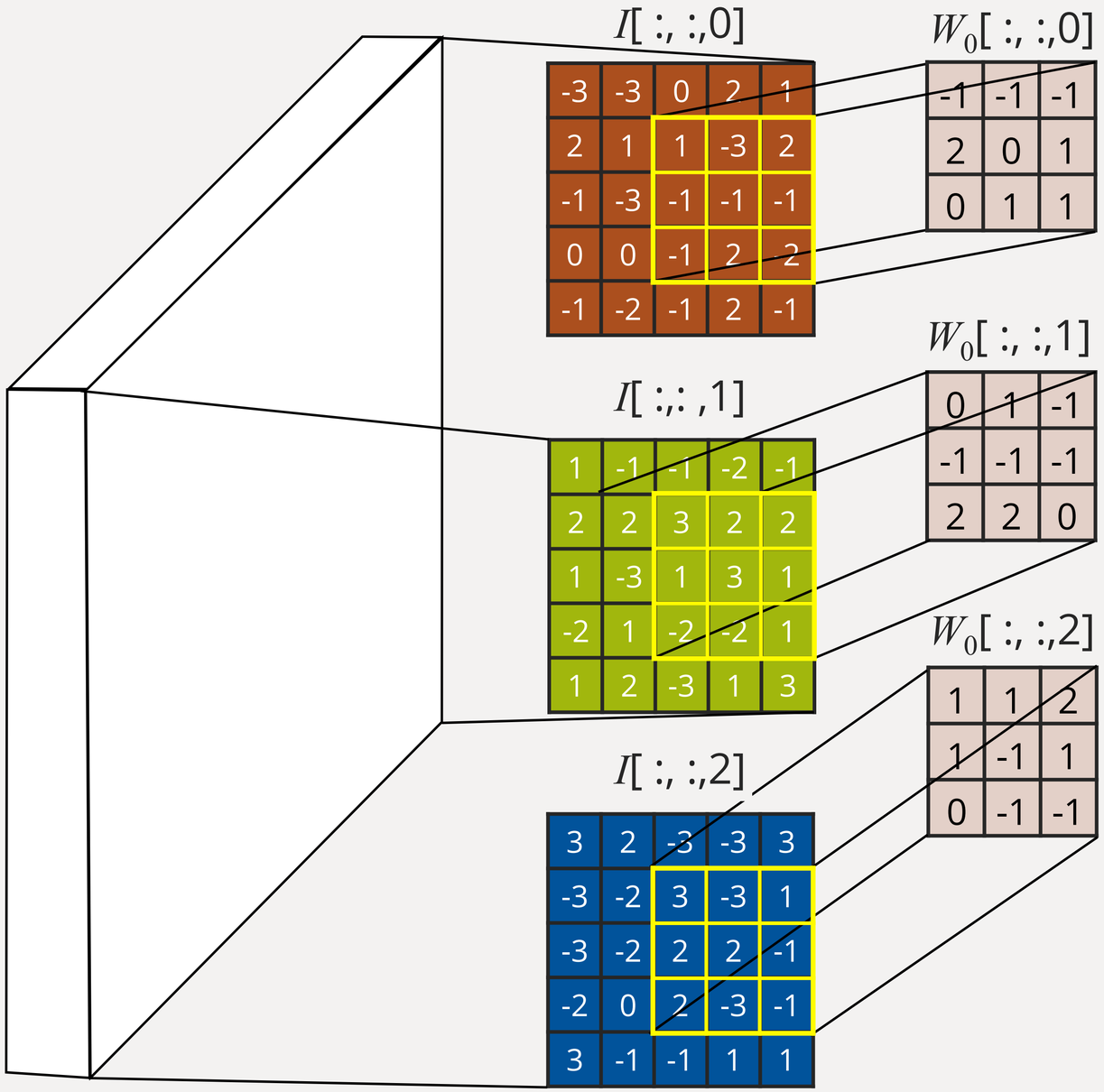
O[:, :,0]

-1	27	11
-14	-17	-15
13	3	-2



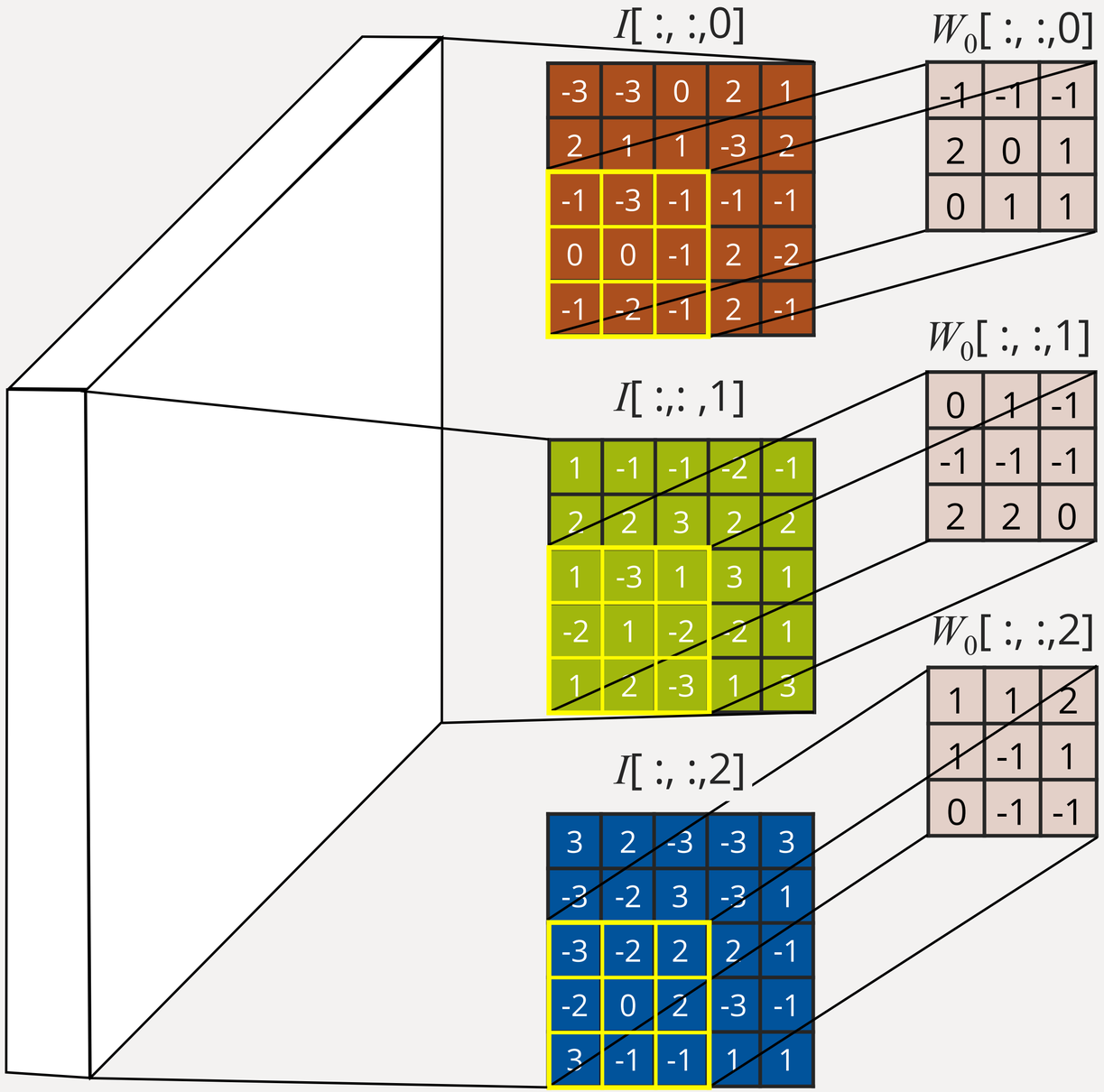
O[:, :,0]

-1	27	11
-14	-17	-15
13	3	-2



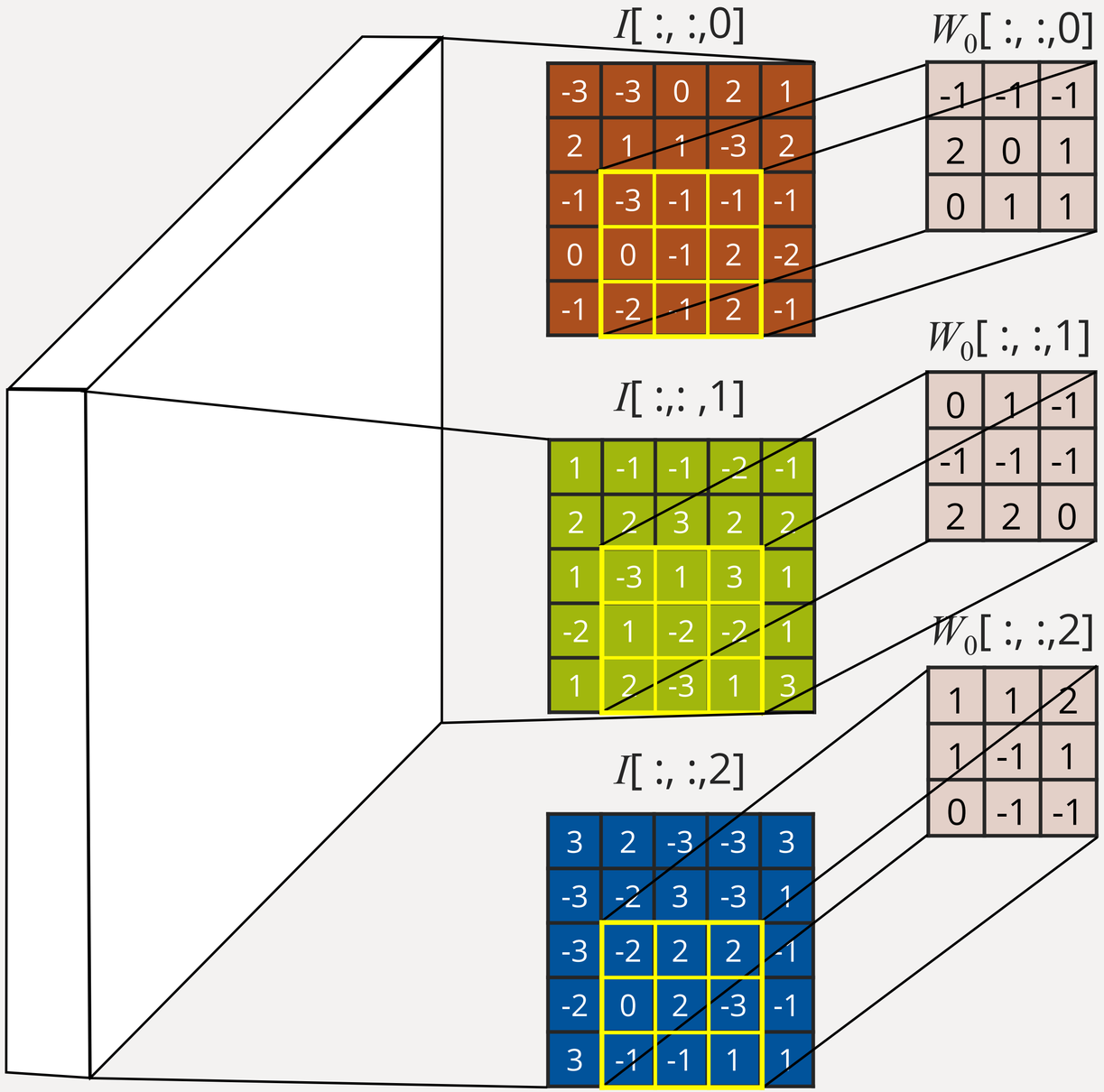
O[:, :,0]

-1	27	11
-14	-17	-15
13	3	-2



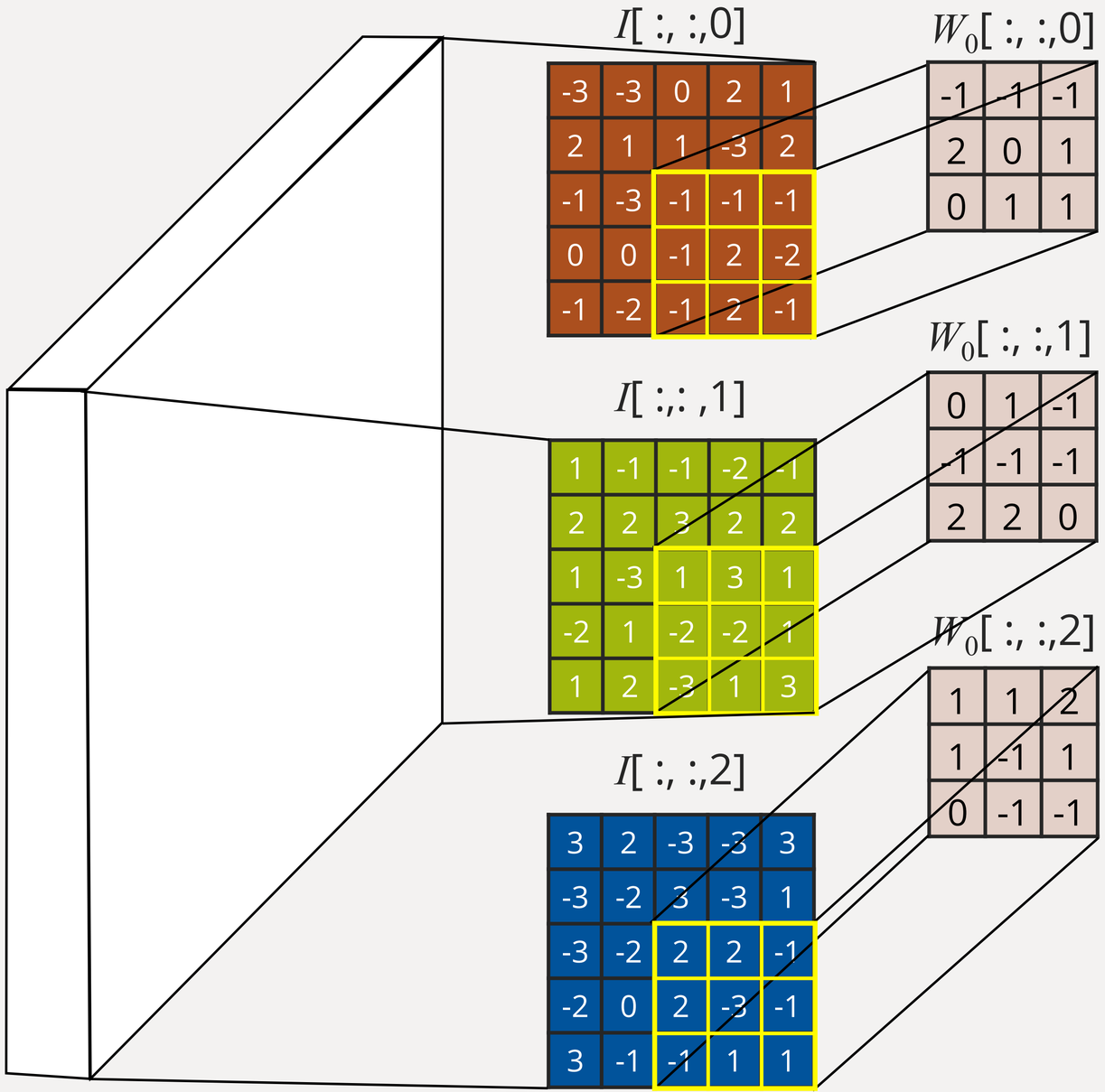
O[:, :,0]

-1	27	11
-14	-17	-15
13	3	-2



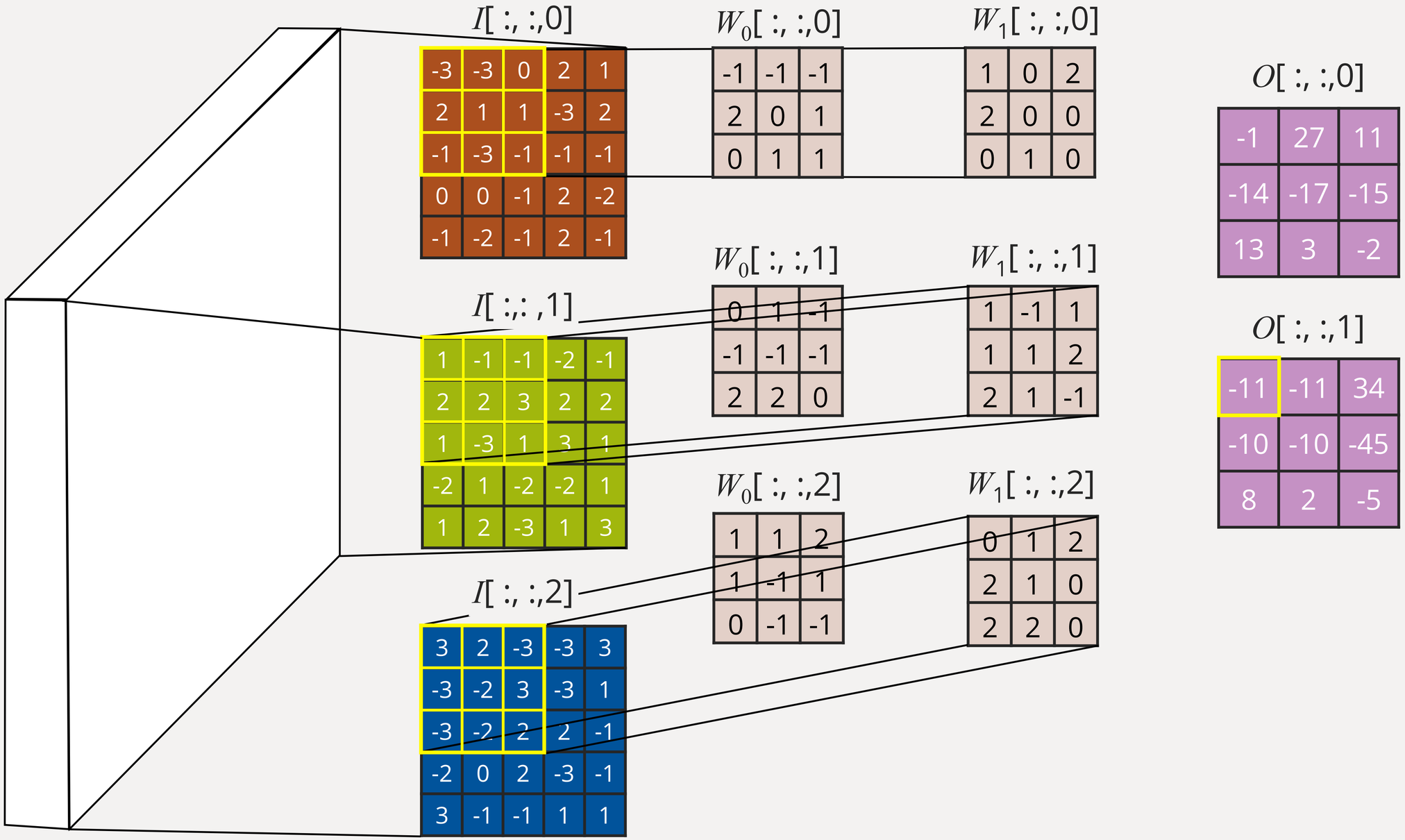
O[:, :,0]

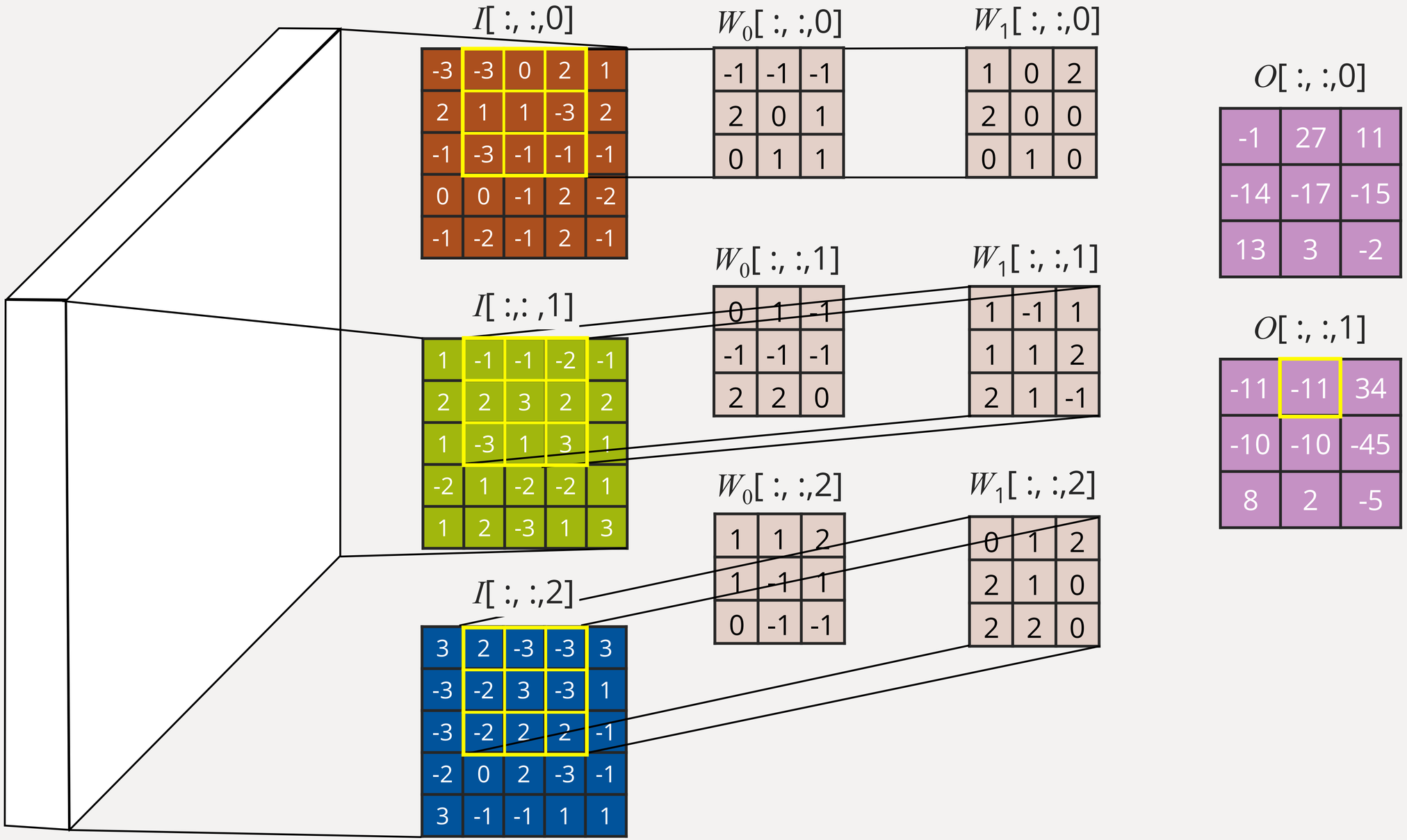
-1	27	11
-14	-17	-15
13	3	-2



O[:, :,0]

-1	27	11
-14	-17	-15
13	3	-2


I[:, :,0]
-3 -3 0 2 1
2 1 1 -3 2
-1 -3 -1 -1 -1
0 0 -1 2 -2
-1 -2 -1 2 -1
W0[:, :,0]
-1 -1 -1
2 0 1
0 1 1
W1[:, :,0]
1 0 2
2 0 0
0 1 0
W0[:, :,1]
0 1 -1
-1 -1 -1
2 2 0
W1[:, :,1]
1 -1 1
1 1 2
2 1 -1
I[:,: ,1]
1 -1 -1 -2 -1
2 2 3 2 2
1 -3 1 3 1
-2 1 -2 -2 1
1 2 -3 1 3
W0[:, :,2]
1 1 2
1 -1 1
0 -1 -1
W1[:, :,2]
0 1 2
2 1 0
2 2 0
I[:, :,2]
3 2 -3 -3 3
-3 -2 3 -3 1
-3 -2 2 2 -1
-2 0 2 -3 -1
3 -1 -1 1 1
O[:, :,0]
-1 27 11
-14 -17 -15
13 3 -2
O[:, :,1]
-11 -11 34
-10 -10 -45
8 2 -5

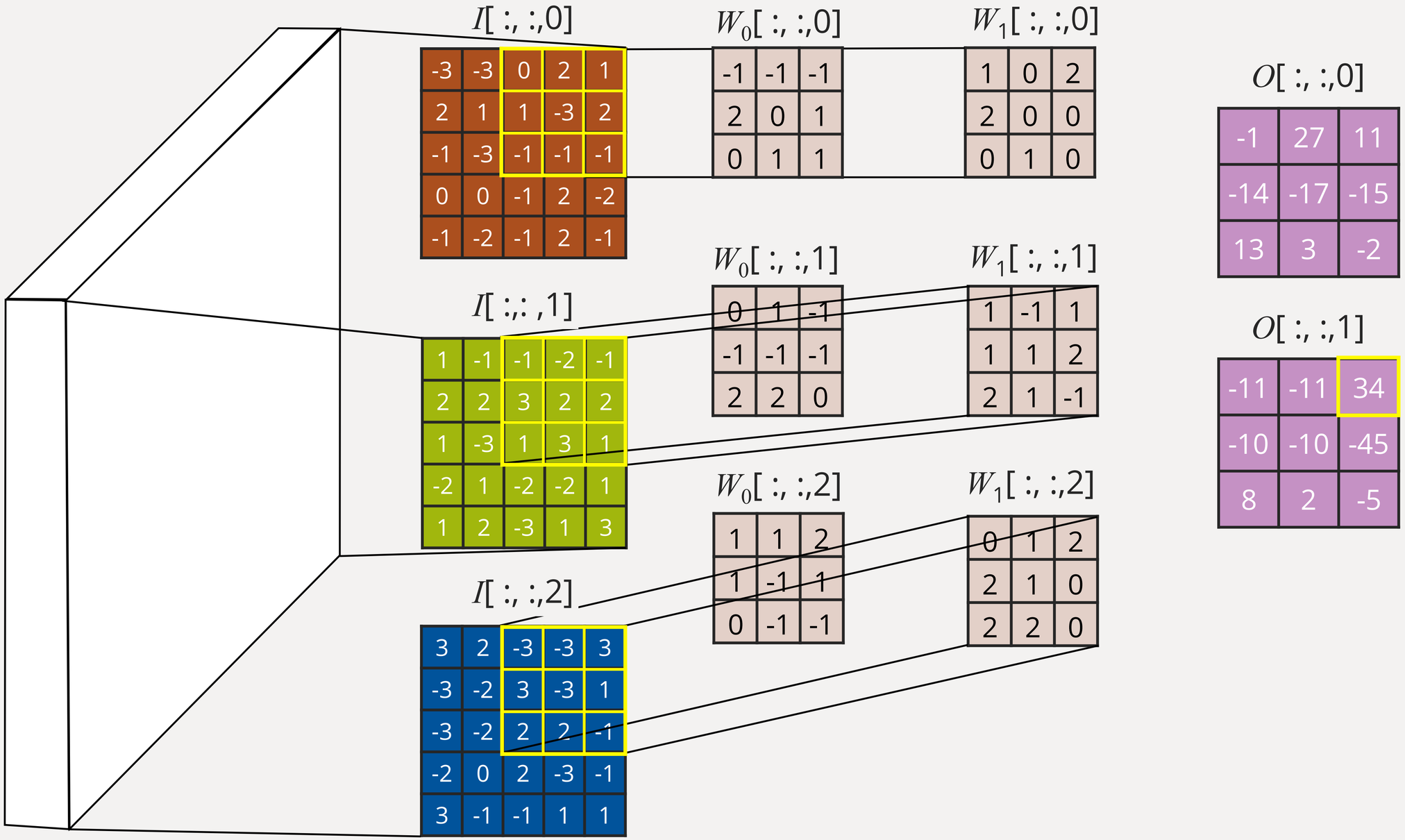


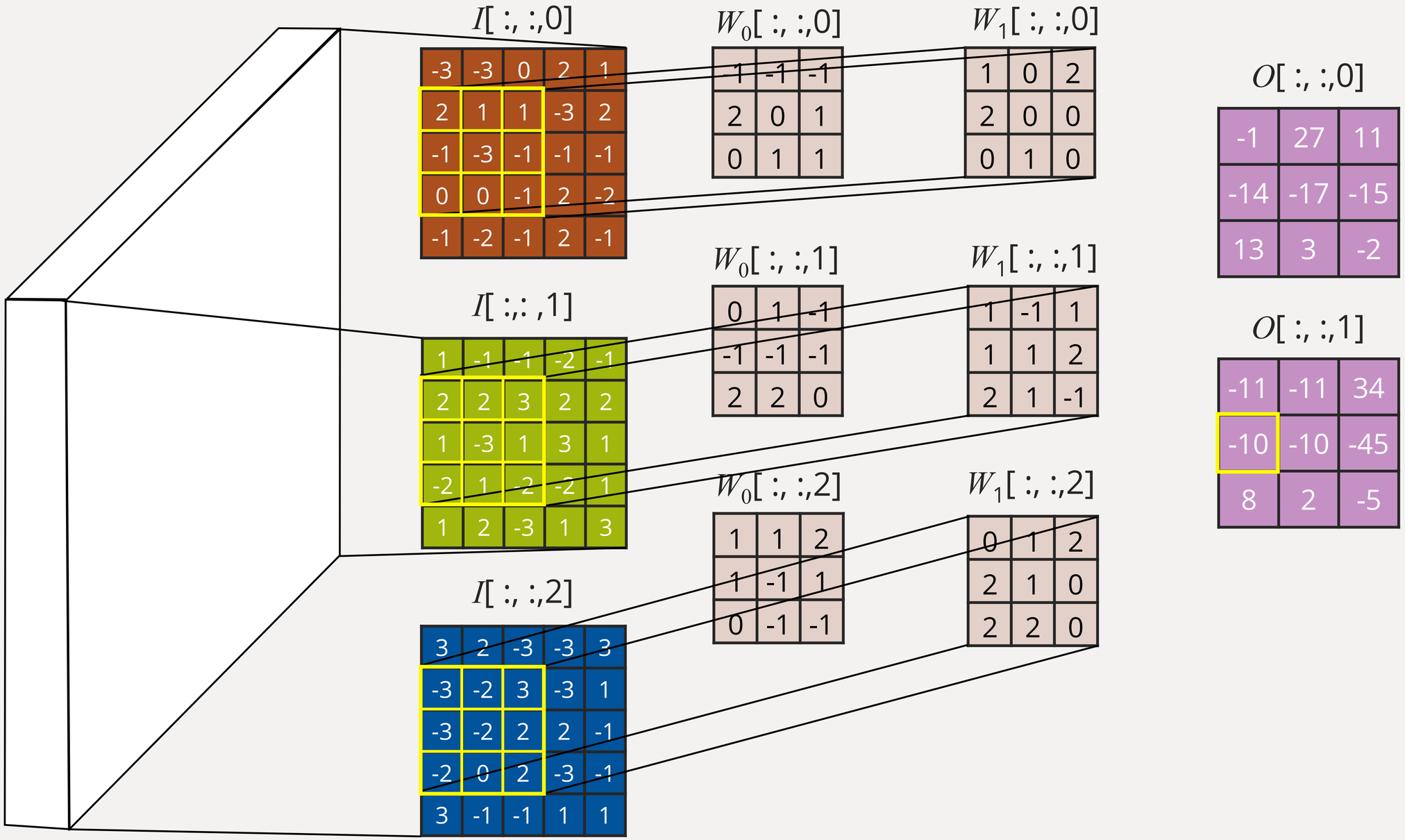
O[:, :,0]

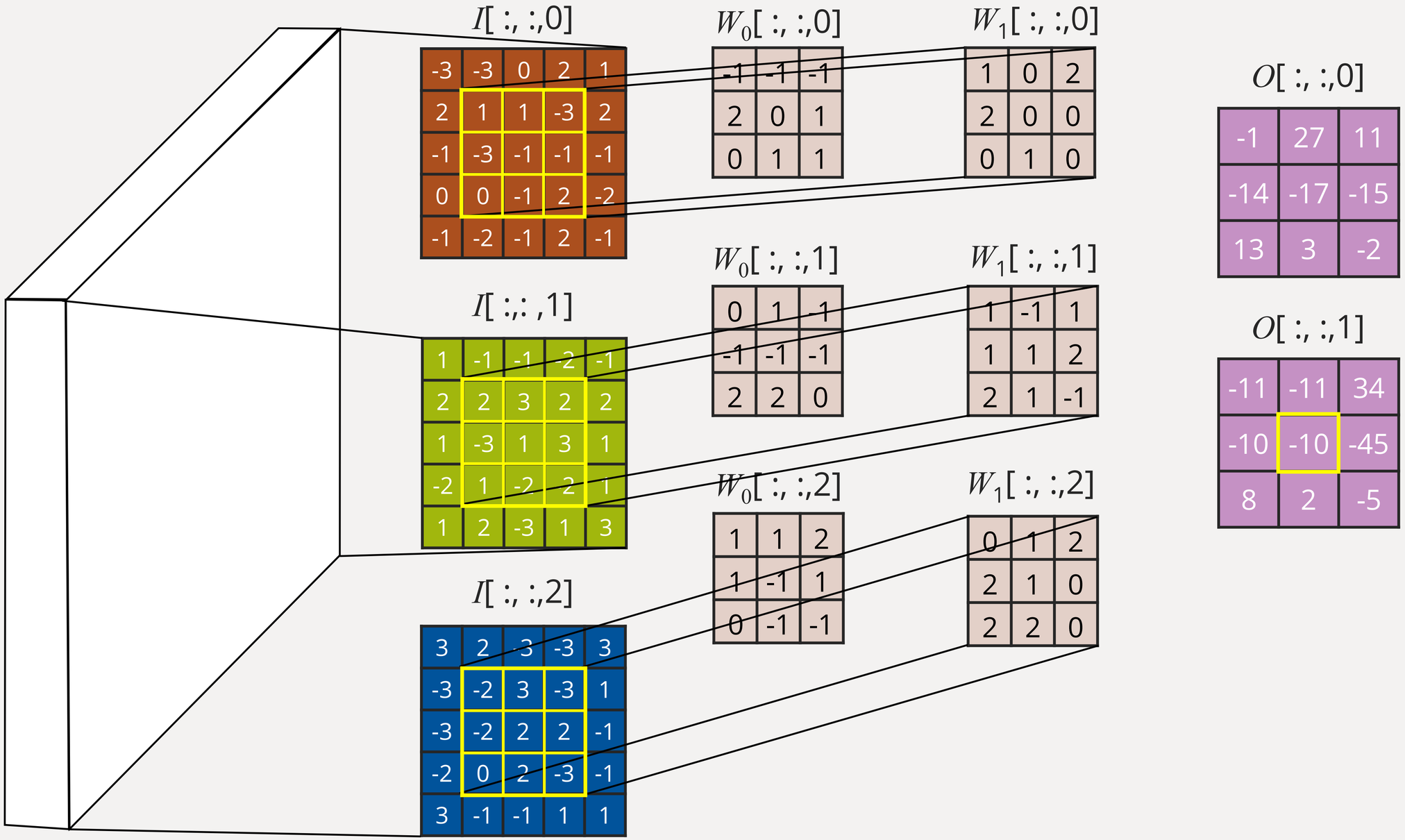
-1	27	11
-14	-17	-15
13	3	-2

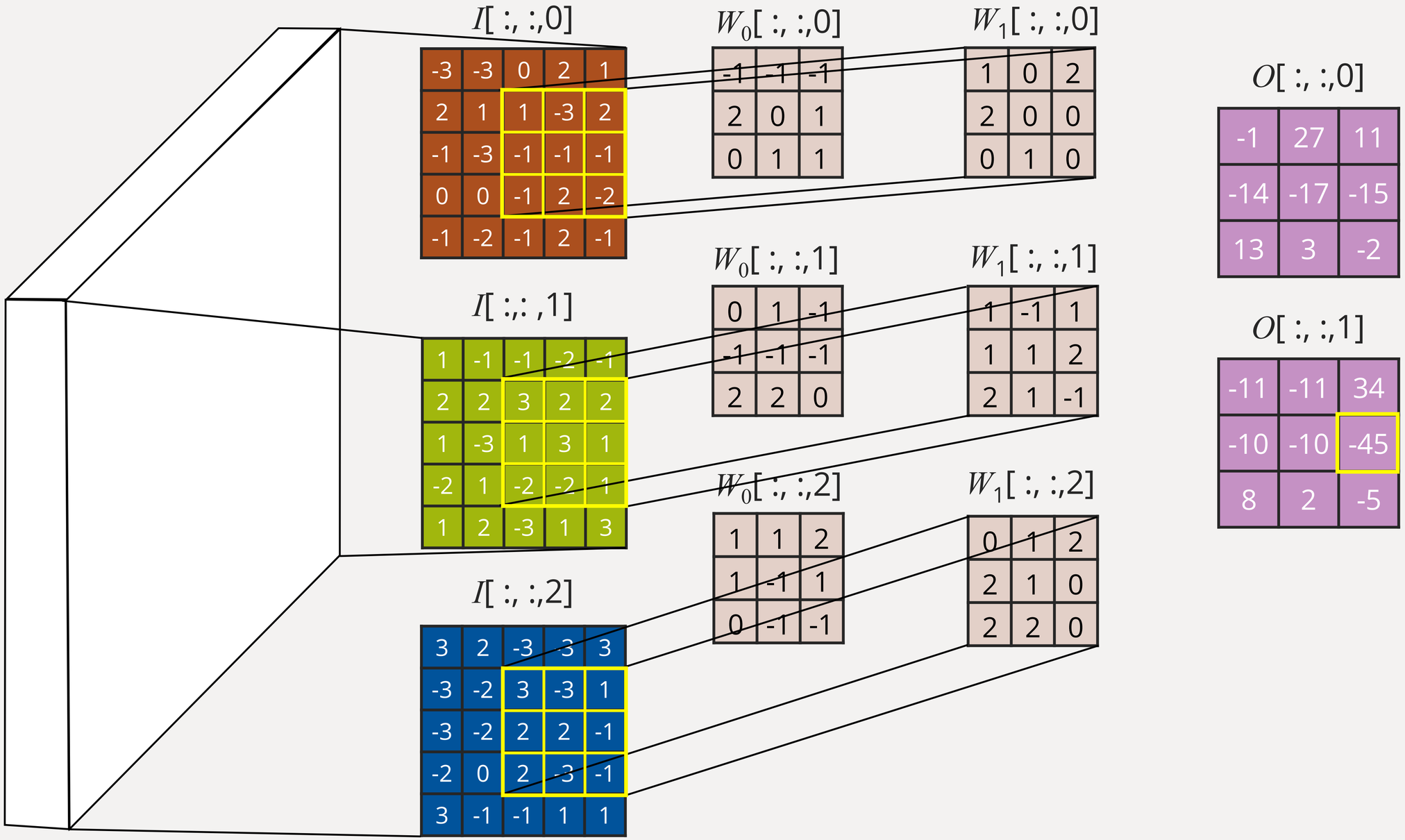
O[:, :,1]

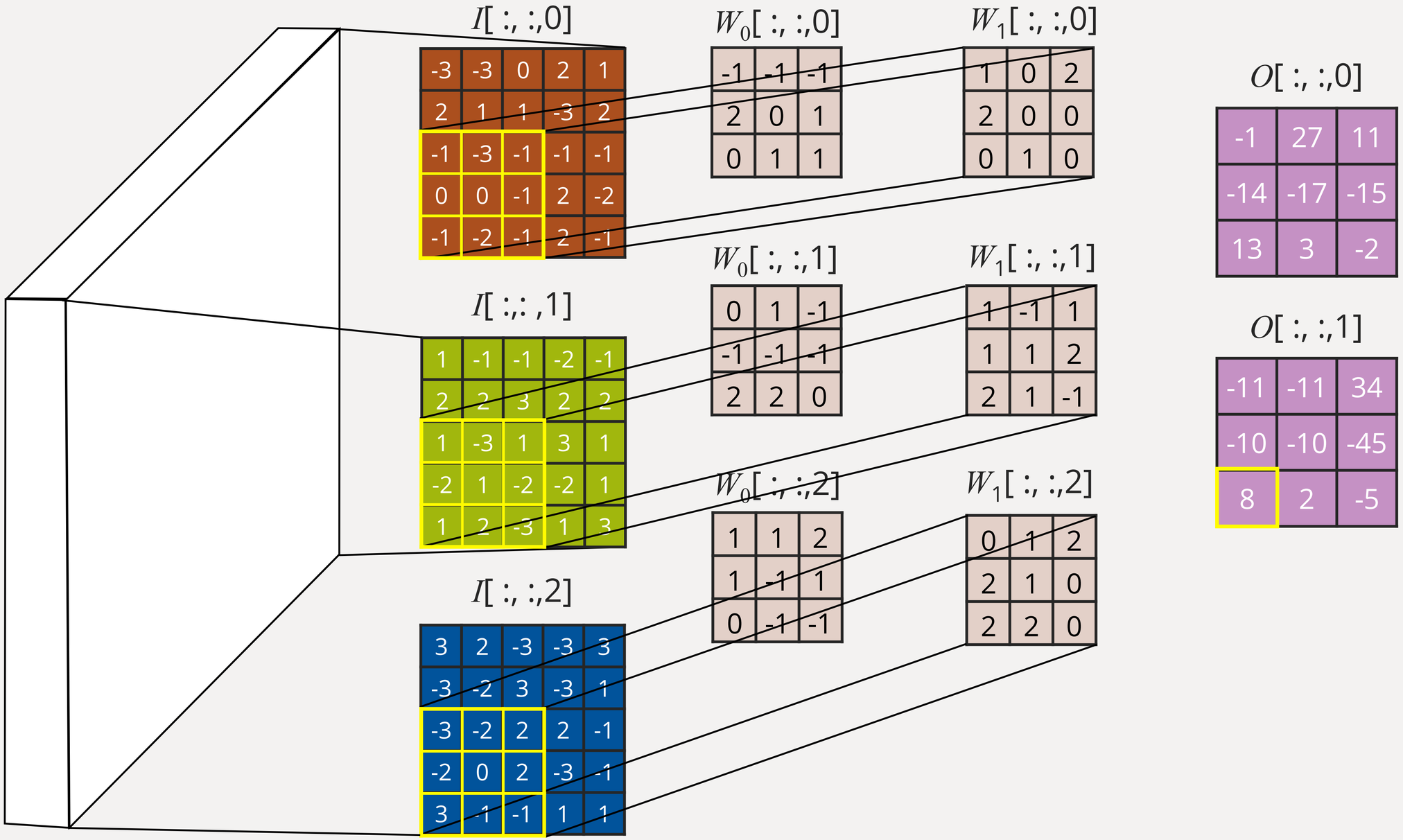
-11	-11	34
-10	-10	-45
8	2	-5

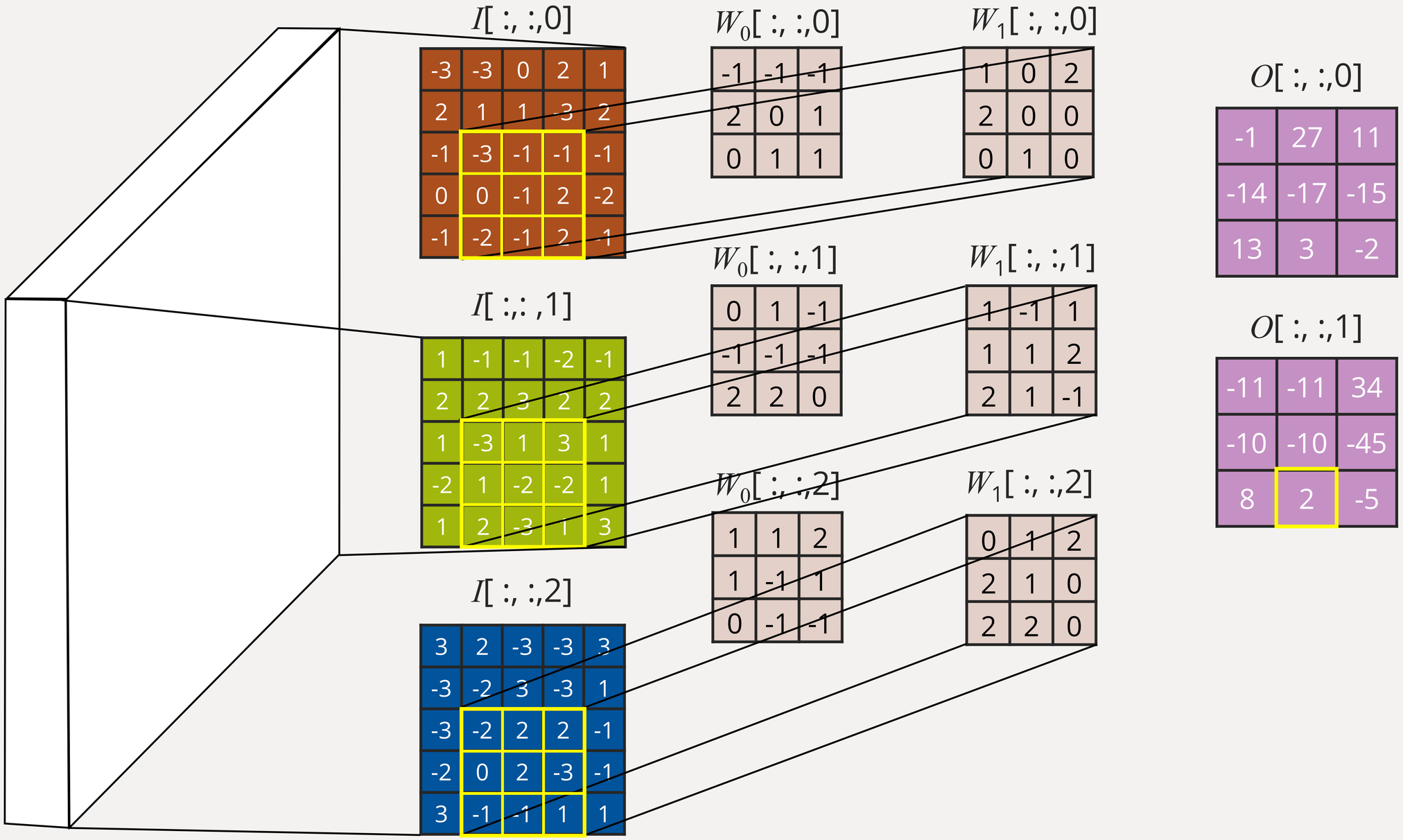

I[:, :,0]
-3 -3 0 2 1
2 1 1 -3 2
-1 -3 -1 -1 -1
0 0 -1 2 -2
-1 -2 -1 2 -1
W0[:, :,0]
-1 -1 -1
2 0 1
0 1 1
W1[:, :,0]
1 0 2
2 0 0
0 1 0
I[:,: ,1]
1 -1 -1 -2 -1
2 2 3 2 2
1 -3 1 3 1
-2 1 -2 -2 1
1 2 -3 1 3
W0[:, :,1]
0 1 -1
-1 -1 -1
2 2 0
W1[:, :,1]
1 -1 1
1 1 2
2 1 -1
I[:, :,2]
3 2 -3 -3 3
-3 -2 3 -3 1
-3 -2 2 2 -1
-2 0 2 -3 -1
3 -1 -1 1 1
W0[:, :,2]
1 1 2
1 -1 1
0 -1 -1
W1[:, :,2]
0 1 2
2 1 0
2 2 0
O[:, :,0]
-1 27 11
-14 -17 -15
13 3 -2
O[:, :,1]
-11 -11 34
-10 -10 -45
8 2 -5

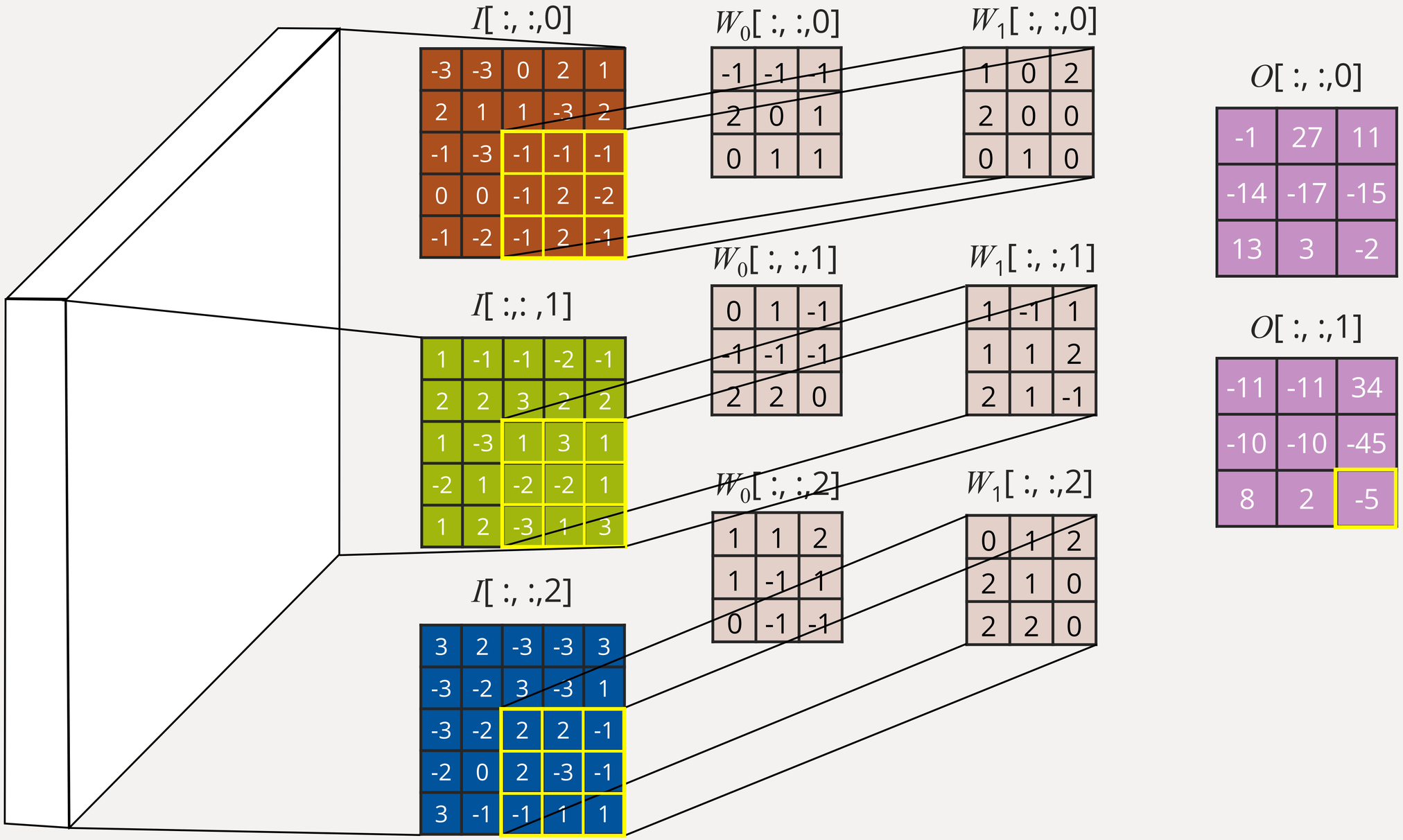

I[:, :,0]
-3 -3 0 2 1
2 1 1 -3 2
-1 -3 -1 -1 -1
0 0 -1 2 -2
-1 -2 -1 2 -1
W_0[:, :,0]
-1 -1 -1
2 0 1
0 1 1
W_1[:, :,0]
1 0 2
2 0 0
0 1 0
I[:,: ,1]
1 -1 -1 -2 -1
2 2 3 2 2
1 -3 1 3 1
-2 1 -2 -2 1
1 2 -3 1 3
W_0[:, :,1]
0 1 -1
-1 -1 -1
2 2 0
W_1[:, :,1]
1 -1 1
1 1 2
2 1 -1
I[:, :,2]
3 2 -3 -3 3
-3 -2 3 -3 1
-3 -2 2 2 -1
-2 0 2 -3 -1
3 -1 -1 1 1
W_0[:, :,2]
1 1 2
1 -1 1
0 -1 -1
W_1[:, :,2]
0 1 2
2 1 0
2 2 0
O[:, :,0]
-1 27 11
-14 -17 -15
13 3 -2
O[:, :,1]
-11 -11 34
-10 -10 -45
8 2 -5


I[:, :,0]
-3 -3 0 2 1
2 1 1 -3 2
-1 -3 -1 -1 -1
0 0 -1 2 -2
-1 -2 -1 2 -1
I[:,: ,1]
1 -1 -1 -2 -1
2 2 3 2 2
1 -3 1 3 1
-2 1 -2 2 1
1 2 -3 1 3
I[:, :,2]
3 2 -3 -3 3
-3 -2 3 -3 1
-3 -2 2 2 -1
-2 0 2 -3 -1
3 -1 -1 1 1
W0[:, :,0]
-1 -1 -1
2 0 1
0 1 1
W0[:, :,1]
0 1 -1
-1 -1 -1
2 2 0
W0[:, :,2]
1 1 2
1 -1 1
0 -1 -1
W1[:, :,0]
1 0 2
2 0 0
0 1 0
W1[:, :,1]
1 -1 1
1 1 2
2 1 -1
W1[:, :,2]
0 1 2
2 1 0
2 2 0
O[:, :,0]
-1 27 11
-14 -17 -15
13 3 -2
O[:, :,1]
-11 -11 34
-10 -10 -45
8 2 -5


I[:, :,0]
-3 -3 0 2 1
2 1 1 -3 2
-1 -3 -1 -1 -1
0 0 -1 2 -2
-1 -2 -1 2 -1
W0[:, :,0]
-1 -1 -1
2 0 1
0 1 1
W1[:, :,0]
1 0 2
2 0 0
0 1 0
I[:,: ,1]
1 -1 -1 -2 -1
2 2 3 2 2
1 -3 1 3 1
-2 1 -2 -2 1
1 2 -3 1 3
W0[:, :,1]
0 1 -1
-1 -1 -1
2 2 0
W1[:, :,1]
1 -1 1
1 1 2
2 1 -1
I[:, :,2]
3 2 -3 -3 3
-3 -2 3 -3 1
-3 -2 2 2 -1
-2 0 2 -3 -1
3 -1 -1 1 1
W0[:, :,2]
1 1 2
1 -1 1
0 -1 -1
W1[:, :,2]
0 1 2
2 1 0
2 2 0
O[:, :,0]
-1 27 11
-14 -17 -15
13 3 -2
O[:, :,1]
-11 -11 34
-10 -10 -45
8 2 -5


I[:, :,0]
-3 -3 0 2 1
2 1 1 -3 2
-1 -3 -1 -1 -1
0 0 -1 2 -2
-1 -2 -1 2 -1
W_0[:, :,0]
-1 -1 -1
2 0 1
0 1 1
W_1[:, :,0]
1 0 2
2 0 0
0 1 0
I[:,: ,1]
1 -1 -1 -2 -1
2 2 3 2 2
1 -3 1 3 1
-2 1 -2 -2 1
1 2 -3 1 3
W_0[:, :,1]
0 1 -1
-1 -1 -1
2 2 0
W_1[:, :,1]
1 -1 1
1 1 2
2 1 -1
I[:, :,2]
3 2 -3 -3 3
-3 -2 3 -3 1
-3 -2 2 2 -1
-2 0 2 -3 -1
3 -1 -1 1 1
W_0[:, :,2]
1 1 2
1 -1 1
0 -1 -1
W_1[:, :,2]
0 1 2
2 1 0
2 2 0
O[:, :,0]
-1 27 11
-14 -17 -15
13 3 -2
O[:, :,1]
-11 -11 34
-10 -10 -45
8 2 -5


I[:, :,0]
-3 -3 0 2 1
2 1 1 -3 2
-1 -3 -1 -1 -1
0 0 -1 2 -2
-1 -2 -1 2 -1
W_0[:, :,0]
-1 -1 -1
2 0 1
0 1 1
W_1[:, :,0]
1 0 2
2 0 0
0 1 0
I[:,: ,1]
1 -1 -1 -2 -1
2 2 3 2 2
1 -3 1 3 1
-2 1 -2 -2 1
1 2 -3 1 3
W_0[:, :,1]
0 1 -1
-1 -1 -1
2 2 0
W_1[:, :,1]
1 -1 1
1 1 2
2 1 -1
I[:, :,2]
3 2 -3 -3 3
-3 -2 3 -3 1
-3 -2 2 2 -1
-2 0 2 -3 -1
3 -1 -1 1 1
W_0[:, :,2]
1 1 2
1 -1 1
0 -1 -1
W_1[:, :,2]
0 1 2
2 1 0
2 2 0
O[:, :,0]
-1 27 11
-14 -17 -15
13 3 -2
O[:, :,1]
-11 -11 34
-10 -10 -45
8 2 -5


I[:, :,0]
-3 -3 0 2 1
2 1 1 -3 2
-1 -3 -1 -1 -1
0 0 -1 2 -2
-1 -2 -1 2 -1
I[:,: ,1]
1 -1 -1 -2 -1
2 2 3 2 2
1 -3 1 3 1
-2 1 -2 -2 1
1 2 -3 1 3
I[:, :,2]
3 2 -3 -3 3
-3 -2 3 -3 1
-3 -2 2 2 -1
-2 0 2 -3 -1
3 -1 -1 1 1
W_0[:, :,0]
-1 -1 -1
2 0 1
0 1 1
W_1[:, :,0]
1 0 2
2 0 0
0 1 0
W_0[:, :,1]
0 1 -1
-1 -1 -1
2 2 0
W_1[:, :,1]
1 -1 1
1 1 2
2 1 -1
W_0[:, :,2]
1 1 2
1 -1 1
0 -1 -1
W_1[:, :,2]
0 1 2
2 1 0
2 2 0
O[:, :,0]
-1 27 11
-14 -17 -15
13 3 -2
O[:, :,1]
-11 -11 34
-10 -10 -45
8 2 -5