

Filtreler

4	1	0	2	3
3	2	4	2	1
5	5	2	0	4
4	3	1	2	0
1	1	2	3	5

5 x 5 Resim

*



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

3 x 3 Filtre

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Sonuç

Konvolüsyon
(Evrişim)
(Convolution)

Filtreler

4	1	0	2	3
3	2	4	2	1
5	5	2	0	4
4	3	1	2	0
1	1	2	3	5

*

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

=

6		

$$\begin{aligned} &4 \times 1 + 3 \times 1 + 5 \times 1 + \\ &1 \times 0 + 2 \times 0 + 5 \times 0 + \\ &0 \times -1 + 4 \times -1 + 2 \times -1 \\ &= 12 \end{aligned}$$

Filtreler

4	1	0	2	3
3	2	4	2	1
5	5	2	0	4
4	3	1	2	0
1	1	2	3	5

*

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

=

6	4	

$$\begin{aligned} &1 \times 1 + 1 \times 1 + 5 \times 1 + \\ &0 \times 0 + 4 \times 0 + 2 \times 0 + \\ &2 \times -1 + 2 \times -1 + 0 \times -1 \\ &= 4 \end{aligned}$$

Filtreler

4	1	0	2	3
3	2	4	2	1
5	5	2	0	4
4	3	1	2	0
1	1	2	3	5

 $*$

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

 $=$

6	4	-2

$$\begin{aligned} &0 \times 1 + 4 \times 1 + 2 \times 1 + \\ &2 \times 0 + 2 \times 0 + 0 \times 0 + \\ &3 \times -1 + 1 \times -1 + 4 \times -1 \\ &= -2 \end{aligned}$$

Filtreler

4	1	0	2	3
3	2	4	2	1
5	5	2	0	4
4	3	1	2	0
1	1	2	3	5

*

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

=

6	4	-2
5		

$$\begin{aligned} & 3 \times 1 + 5 \times 1 + 4 \times 1 + \\ & 2 \times 0 + 5 \times 0 + 3 \times 0 + \\ & 4 \times -1 + 2 \times -1 + 1 \times -1 \\ & = 5 \end{aligned}$$

Filtreler

4	1	0	2	3
3	2	4	2	1
5	5	2	0	4
4	3	1	2	0
1	1	2	3	5

*

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

=

6	4	-2
5	6	

$$\begin{aligned} &2 \times 1 + 5 \times 1 + 3 \times 1 + \\ &4 \times 0 + 2 \times 0 + 1 \times 0 + \\ &2 \times -1 + 0 \times -1 + 2 \times -1 \\ &= 6 \end{aligned}$$

Filtreler

4	1	0	2	3
3	2	4	2	1
5	5	2	0	4
4	3	1	2	0
1	1	2	3	5

 $*$

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

 $=$

6	4	-2
5	6	2

$$\begin{aligned} &4 \times 1 + 2 \times 1 + 1 \times 1 + \\ &2 \times 0 + 0 \times 0 + 2 \times 0 + \\ &1 \times -1 + 4 \times -1 + 0 \times -1 \\ &= 2 \end{aligned}$$

Filtreler

4	1	0	2	3
3	2	4	2	1
5	5	2	0	4
4	3	1	2	0
1	1	2	3	5

 $*$

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

 $=$

6	4	-2
5	6	2
5		

$$\begin{aligned} &5 \times 1 + 4 \times 1 + 1 \times 1 + \\ &5 \times 0 + 3 \times 0 + 1 \times 0 + \\ &1 \times -1 + 1 \times -1 + 2 \times -1 \\ &= 5 \end{aligned}$$

Filtreler

4	1	0	2	3
3	2	4	2	1
5	5	2	0	4
4	3	1	2	0
1	1	2	3	5

 $*$

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

 $=$

6	4	-2
5	6	2
5	4	

$$\begin{aligned} &5 \times 1 + 3 \times 1 + 1 \times 1 + \\ &2 \times 0 + 1 \times 0 + 2 \times 0 + \\ &0 \times -1 + 2 \times -1 + 3 \times -1 \\ &= 12 \end{aligned}$$

Filtreler

4	1	0	2	3
3	2	4	2	1
5	5	2	0	4
4	3	1	2	0
1	1	2	3	5

 $*$

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

 $=$

6	4	-2
5	6	2
5	4	-4

$$\begin{aligned} &2 \times 1 + 1 \times 1 + 2 \times 1 + \\ &0 \times 0 + 2 \times 0 + 3 \times 0 + \\ &4 \times -1 + 0 \times -1 + 5 \times -1 \\ &= -4 \end{aligned}$$

Padding

$$(5 \times 5) * (3 \times 3) \Rightarrow (3 \times 3)$$

$$(3 \times 3) * (3 \times 3) \Rightarrow (1 \times 1)$$

$$(4 \times 4) * (3 \times 3) \Rightarrow (2 \times 2)$$

$$(5 \times 4) * (3 \times 3) \Rightarrow (3 \times 2)$$

$$(r_h \times r_w) * (k_h \times k_w) \Rightarrow \\ ((r_h - k_h + 1) \times (r_w - k_w + 1))$$

Padding

4	1	0	2	3
3	2	4	2	1
5	5	2	0	4
4	3	1	2	0
1	1	2	3	5

5 x 5 Resim

*

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

3 x 3 Filtre

=

a	b	c	d	e
f	g	...		

Padding

	4	1	0	2	3	
	3	2	4	2	1	
	5	5	2	0	4	
	4	3	1	2	0	
	1	1	2	3	5	

*

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

3 x 3 Filtre

=

a	b	c	d	e
f	g	...		

Padding

- Valid Convolution:
 - $(n \times n) * (f \times f) \Rightarrow (n - f + 1) \times (n - f + 1)$
- Same Convolution:
 - $(n \times n) * (f \times f) \Rightarrow (n \times n)$
 - $n + 2p - f + 1 = n, p = (f - 1) / 2$

Stride (Adım Boyu)

1	3	2	0	0	5	3
4	4	1	0	2	3	1
2	3	2	4	2	1	2
0	5	5	2	0	4	2
1	4	3	1	2	0	1
4	1	1	2	3	5	4
4	1	3	3	0	1	2

7 x 7 Resim

*

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

3 x 3 Filtre

=

2		

Sonuç

Adım Boyu (Stride = 2)

Stride (Adım Boyu)

1	3	2	0	0	5	3
4	4	1	0	2	3	1
2	3	2	4	2	1	2
0	5	5	2	0	4	2
1	4	3	1	2	0	1
4	1	1	2	3	5	4
4	1	3	3	0	1	2

7 x 7 Resim

*

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

3 x 3 Filtre

=

2	1	

Sonuç

Adım Boyu (Stride = 2)

Stride (Adım Boyu)

1	3	2	0	0	5	3
4	4	1	0	2	3	1
2	3	2	4	2	1	2
0	5	5	2	0	4	2
1	4	3	1	2	0	1
4	1	1	2	3	5	4
4	1	3	3	0	1	2

7 x 7 Resim

*

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

3 x 3 Filtre

=

2	1	-3

Sonuç

Adım Boyu (Stride = 2)

Stride (Adım Boyu)

1	3	2	0	0	5	3
4	4	1	0	2	3	1
2	3	2	4	2	1	2
0	5	5	2	0	4	2
1	4	3	1	2	0	1
4	1	1	2	3	5	4
4	1	3	3	0	1	2

7 x 7 Resim

*

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

3 x 3 Filtre

=

2	1	-3
-7		

Sonuç

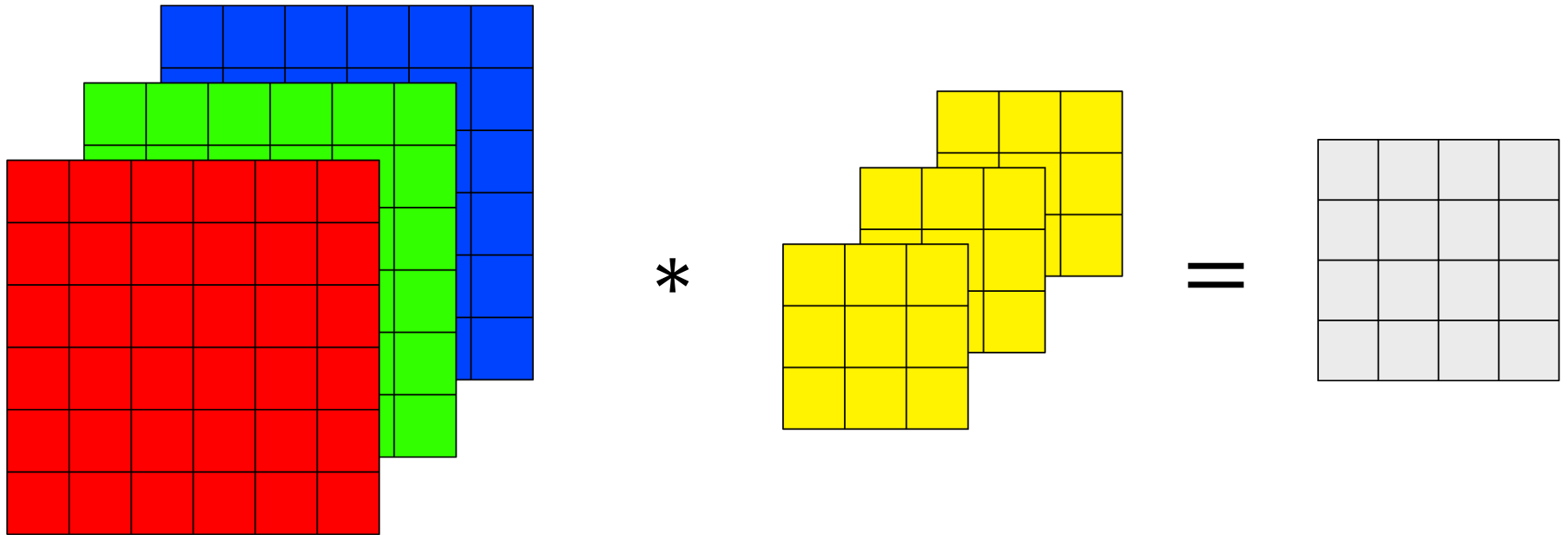
Adım Boyu (Stride = 2)

Stride (Adım Boyu)

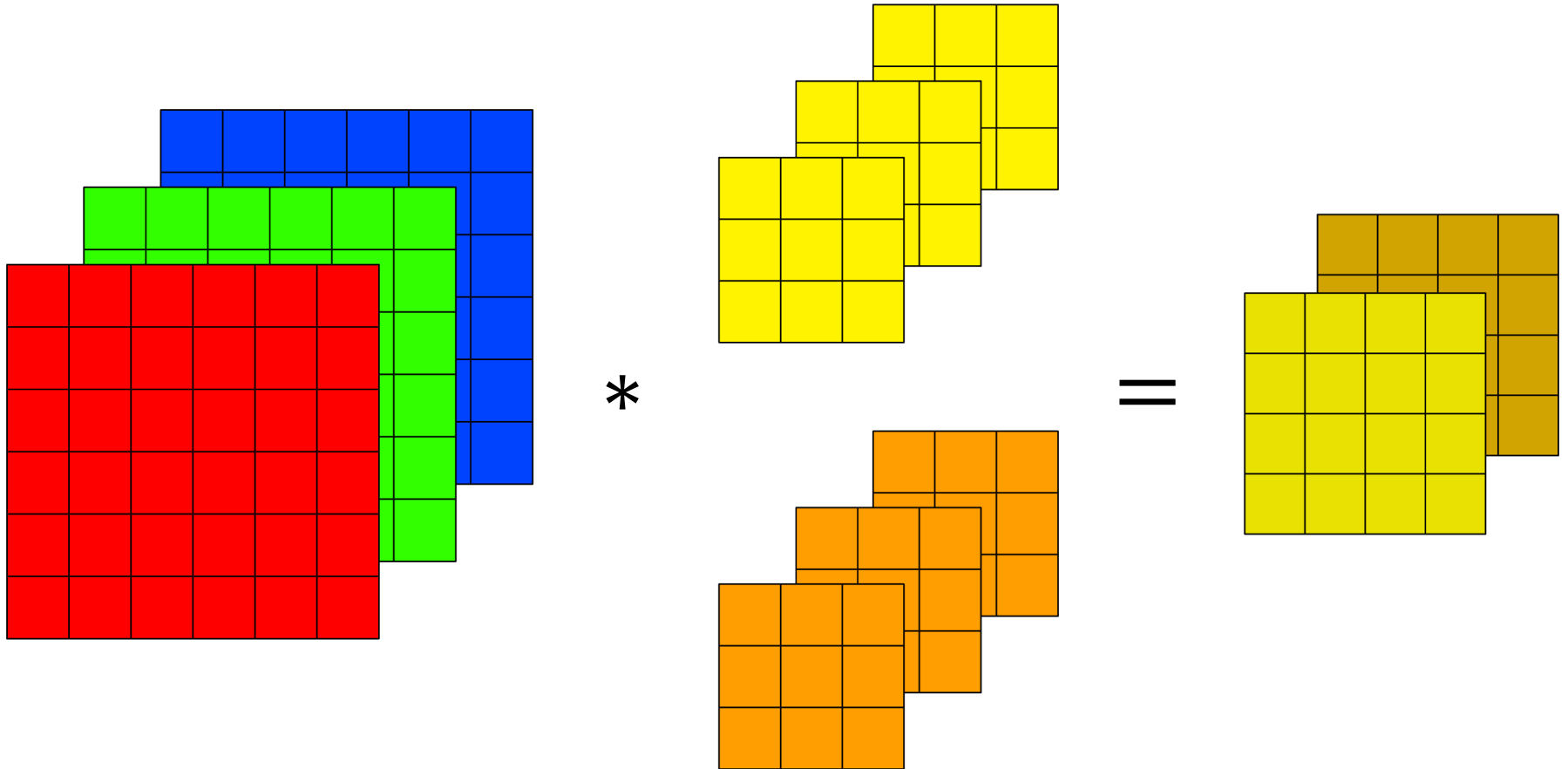
$$(n \times n) * (f \times f) \rightarrow (r \times r)$$

$$r = \frac{n + 2p - f}{s} + 1$$

Çok Boyutlu Convolution



Çok Boyutlu Convolution



Pooling: Max Pooling

4	1	0	2
3	2	6	2
5	5	2	0
4	3	1	3



$f = 2, s = 2$

4	6
5	3

Pooling: Average Pooling

4	1	0	2
3	2	6	2
5	5	2	0
4	3	1	3



$f = 2, s = 2$

2.5	2.5
4.25	1.5