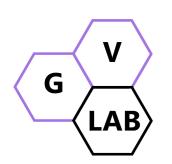
# Pooling

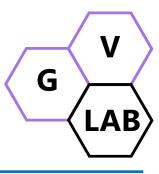
Dr. Thanh-Sach LE LTSACH@hcmut.edu.vn



**GVLab: Graphics and Vision Laboratory** 

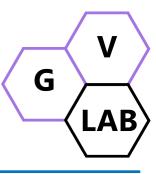
Faculty of Computer Science and Engineering, **HCMUT** 

# **Contents**

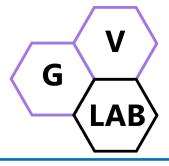


- Goal of pooling
- Max-pooling
- Other types of pooling

# Goal of pooling layer



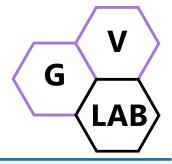
- Sampling feature spaces to remove redundant features
- Reducing size of feature maps
- Avoid overfitting (minor)



### Pooling's hyper-parameters

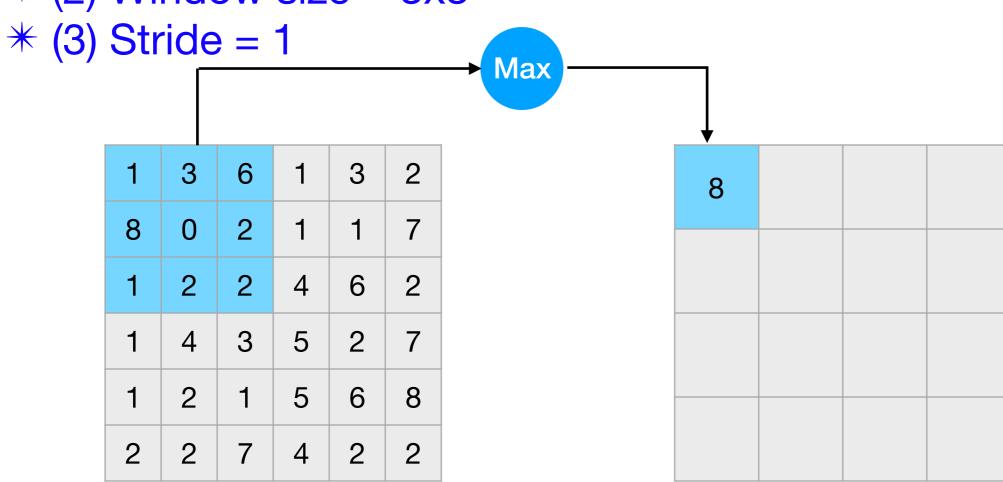
- \* (1) Type of pooling
- \* (2) Window size
- \* (3) Stride

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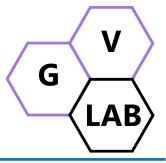


#### Pooling's hyper-parameters

- \* (1) Type = max-poling
- \* (2) Window size = 3x3



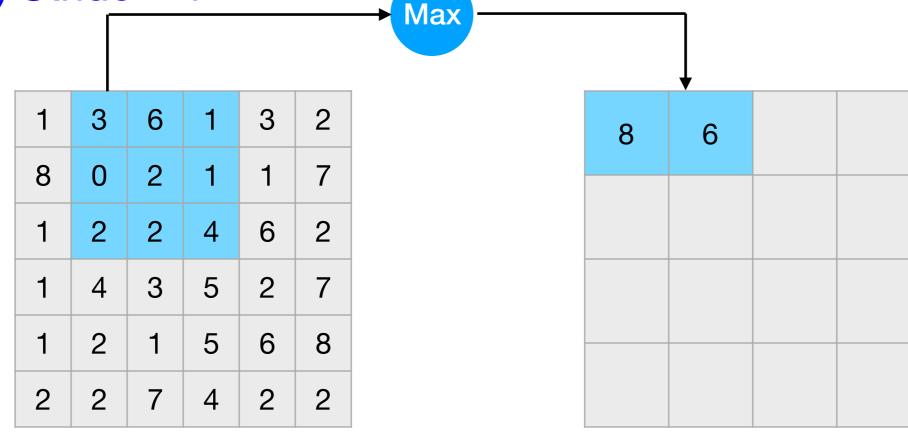
**Input feature map** 



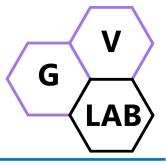
#### Pooling's hyper-parameters

- \* (1) Type = max-poling
- \* (2) Window size = 3x3





**Input feature map** 



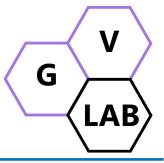
#### Pooling's hyper-parameters

- \* (1) Type = max-poling
- \* (2) Window size = 3x3

\* (3) Stride = 1

1	3	6	1	3	2
8	0	2	1	1	7
1	2	2	4	6	2
1	4	3	5	2	7
1	2	1	5	6	8
2	2	7	4	2	2

**Input feature map** 

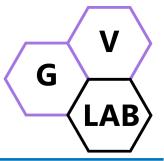


#### Pooling's hyper-parameters

- \* (1) Type = max-poling
- \* (2) Window size = 3x3

\* (3) Stride = 1

						→ Max		,	,	
1	3	6	1	3	2		8	6	6	
8	0	2	1	1	7					
1	2	2	4	6	2					
1	4	3	5	2	7					
1	2	1	5	6	8					
2	2	7	4	2	2					
Input feature map					Out	put fe	eature			

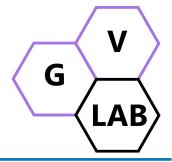


#### Pooling's hyper-parameters

- \* (1) Type = max-poling
- \* (2) Window size = 3x3
- \* (3) Stride = 1

1	3	6	1	3	2
8	0	2	1	1	7
1	2	2	4	6	2
1	4	3	5	2	7
1	2	1	5	6	8
2	2	7	4	2	2

**Input feature map** 

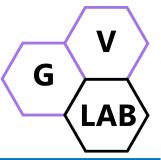


#### Pooling's hyper-parameters

- \* (1) Type = max-poling
- \* (2) Window size = 3x3
- \* (3) Stride = 1

1	3	6	1	3	2	8	6	6	
8	0	2	1	1	7				
1	2	2	4	6	2	8	5	6	
1	4	3	5	2	7	4	5	6	
1	2	1	5	6	8				
2	2	7	4	2	2	7	7	7	

**Input feature map** 



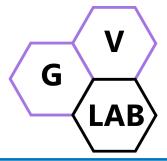
- \* (1) Type = max-poling
- \* (2) Window size = 3x3
- \* (3) Stride = 1

дb	$i_1$									
4		1	3	6	1	3	2			
		8	0	2	1	1	7			
<b>i</b>		1	2	2	4	6	2			
$i_2$		1	4	3	5	2	7			
		1	2	1	5	6	8			
•	,	2	2	7	4	2	2			

**Input feature map** 

8	6	6	6
8	5	6	7
4	5	6	8
7	7	7	7

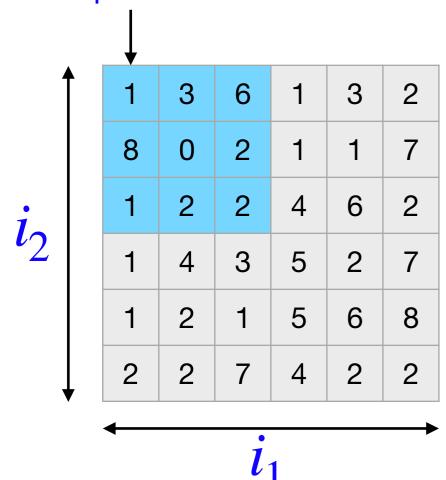
**Output feature map** 

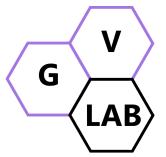


#### Pooling's hyper-parameters

- \* (1) Type = max-poling
- \* (2) Window size = 3x3
- \* (3) Stride = 1

#### 1st valid position





#### Pooling's hyper-parameters

- \* (1) Type = max-poling
- \* (2) Window size = 3x3
- \* (3) Stride = 1

1st valid position last valid position

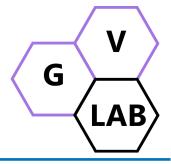
$$i_2 - k_2 + 1$$

$$= 6 - 3 + 1$$

$$= 4$$

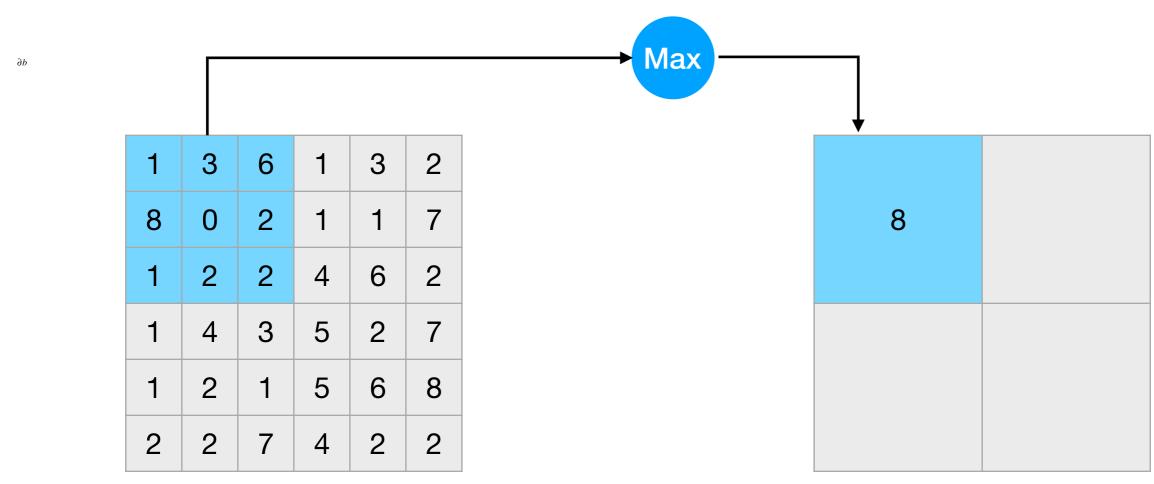
	$i_1 - k_1 + 1$ $= 6 - 3 + 1$ $= 4$									
8	6	6	6							
8	5	6	7							
4	5	6	8							
7	7	7	7							

#### **Non-unit strides**



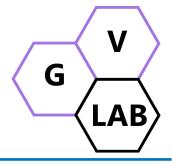
#### Pooling's hyper-parameters

- \* (1) Type = max-poling
- \* (2) Window size = 3x3
- \* (3) Stride = 2

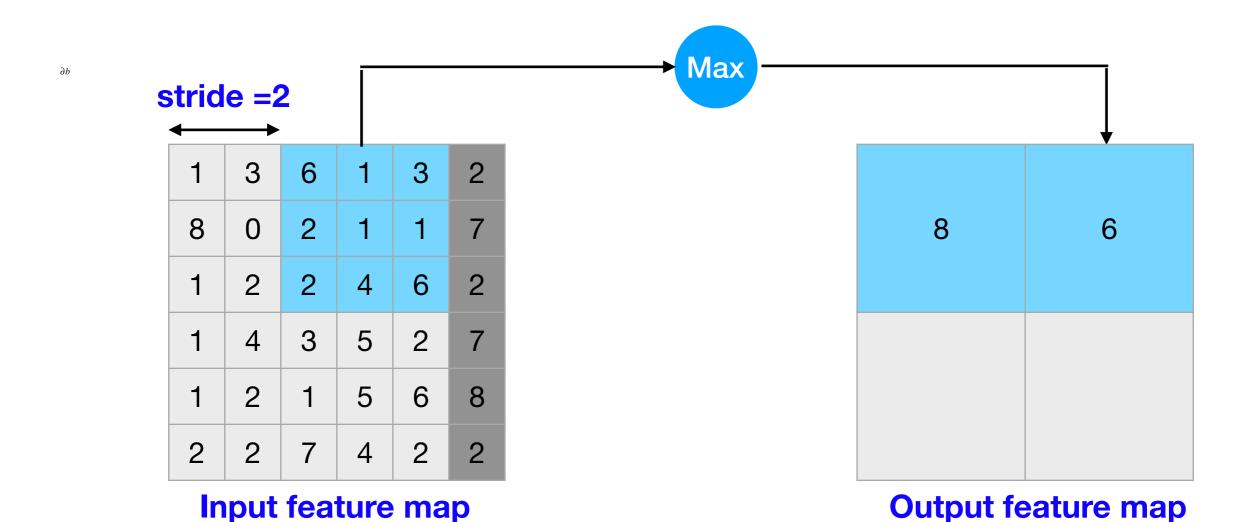


**Input feature map** 

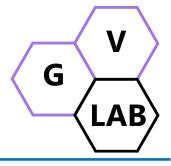
#### **Non-unit strides**



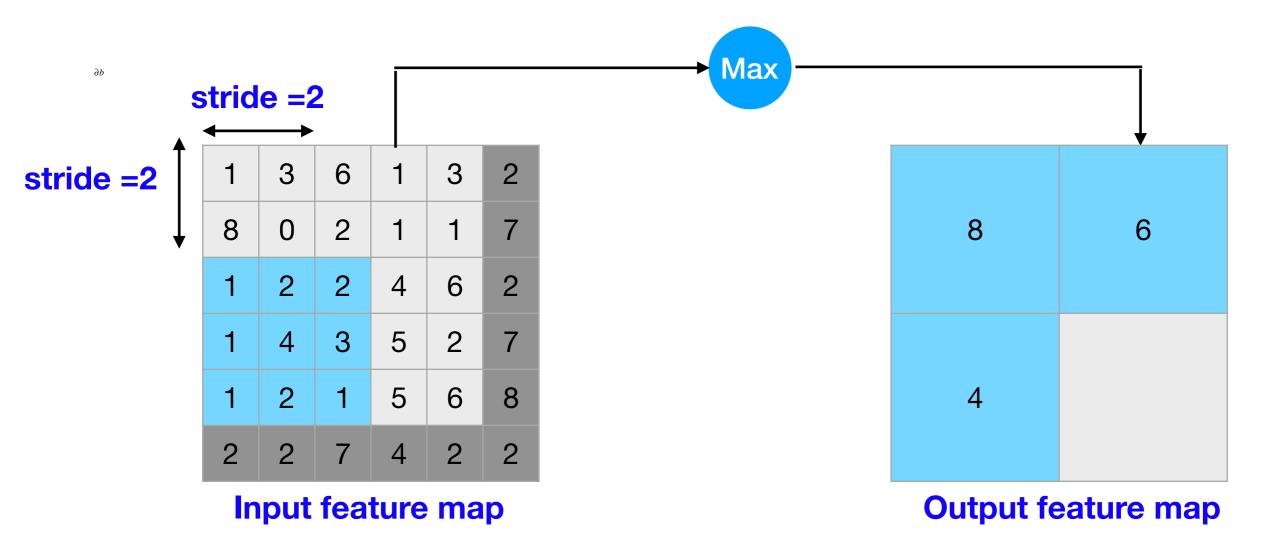
- \* (1) Type = max-poling
- \* (2) Window size = 3x3
- \* (3) Stride = 2



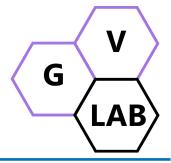
#### **Non-unit strides**



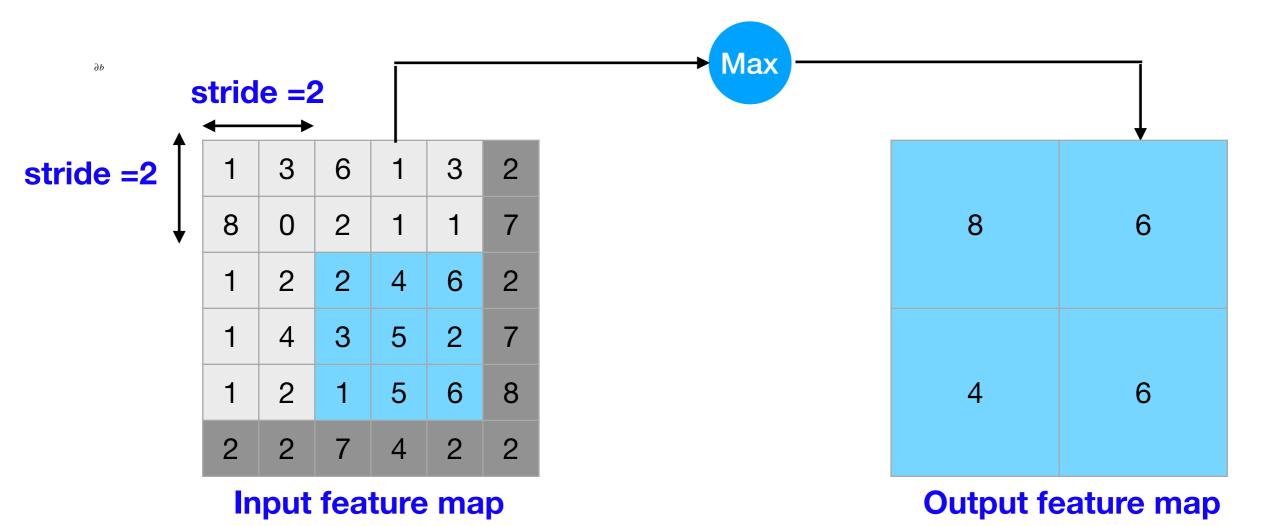
- \* (1) Type = max-poling
- \* (2) Window size = 3x3
- \* (3) Stride = 2



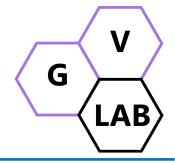
#### **Non-unit strides**



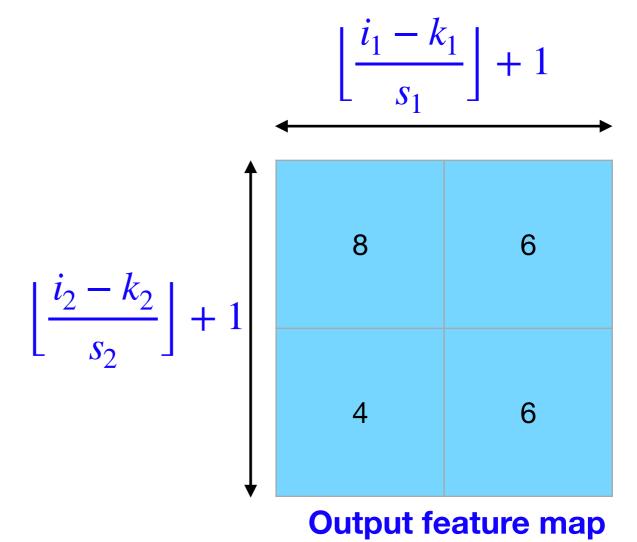
- \* (1) Type = max-poling
- \* (2) Window size = 3x3
- \* (3) Stride = 2

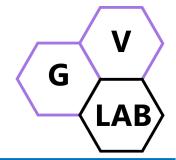


# Max-pooling Non-unit strides



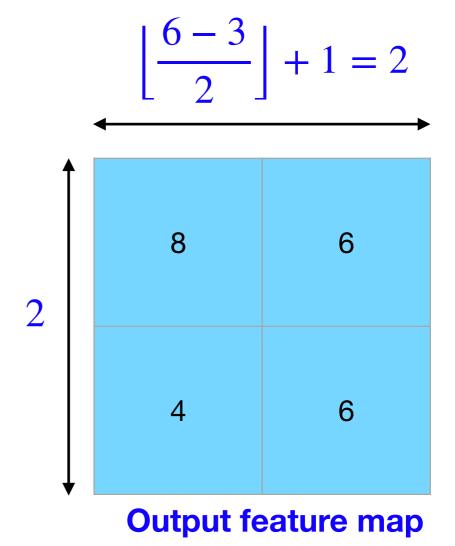
$(i_1-k_1)$										
S	1		$\leftarrow$ $k_1$							
1	3	6	1	3	2					
8	0	2	1	1	7					
1	2	2	4	6	2					
1	4	3	5	2	7					
1	2	1	5	6	8					
2	2	7	4	4 2						
_										



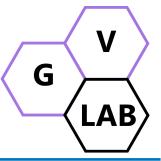


N	on	I-UI	nit	str	<b>Id</b>	es

$(i_1-k_1)$										
S	1		•	$\stackrel{k_1}{\longleftarrow}$						
1	3	6	1	3	2					
8	0	2	1	1	7					
1	2	2	4	6	2					
1	4	3	5	2	7					
1	2	1	5	6	8					
2	2	7	4	4 2						

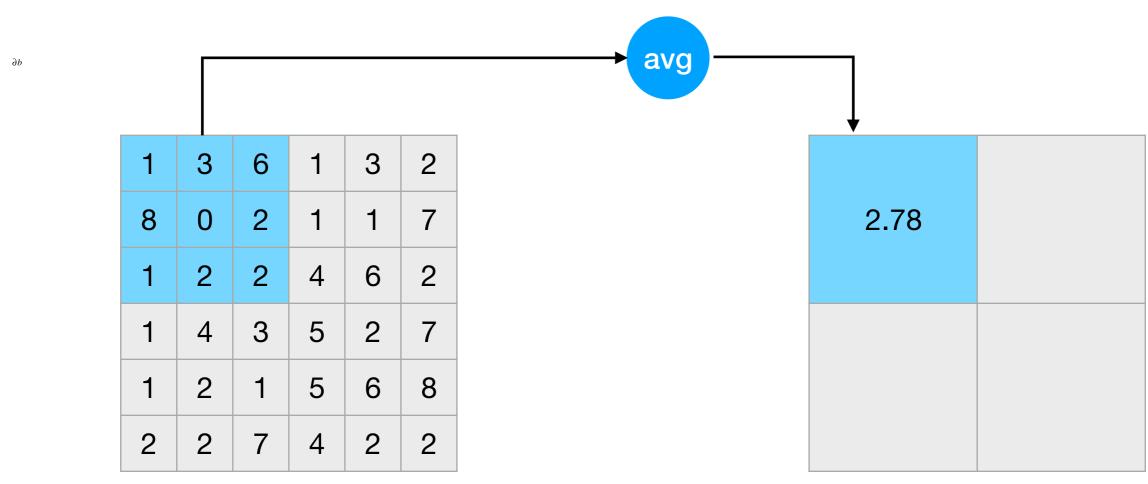


## Other types of pooling



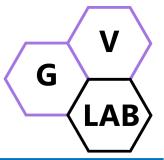
#### Pooling's hyper-parameters

- \* (1) Type = average
- \* (2) Window size = 3x3
- \* (3) Stride = 2



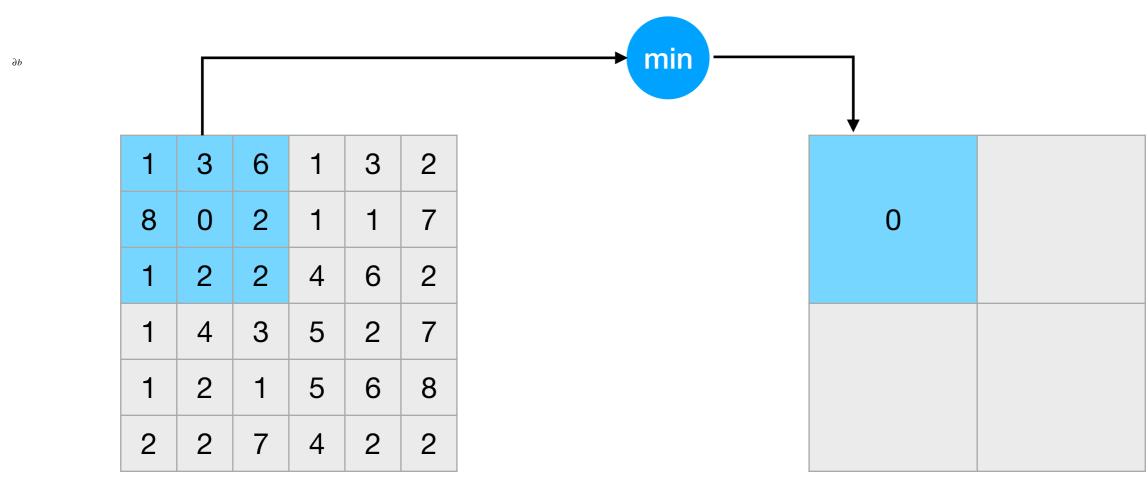
**Input feature map** 

### Other types of pooling



#### Pooling's hyper-parameters

- \* (1) Type = min
- \* (2) Window size = 3x3
- \* (3) Stride = 2



**Input feature map**