Lecture *6*. Convolutional neural network

AI in Genetics

ZOO6927 / BOT6935 / ZOO4926

1. CNN intuitions

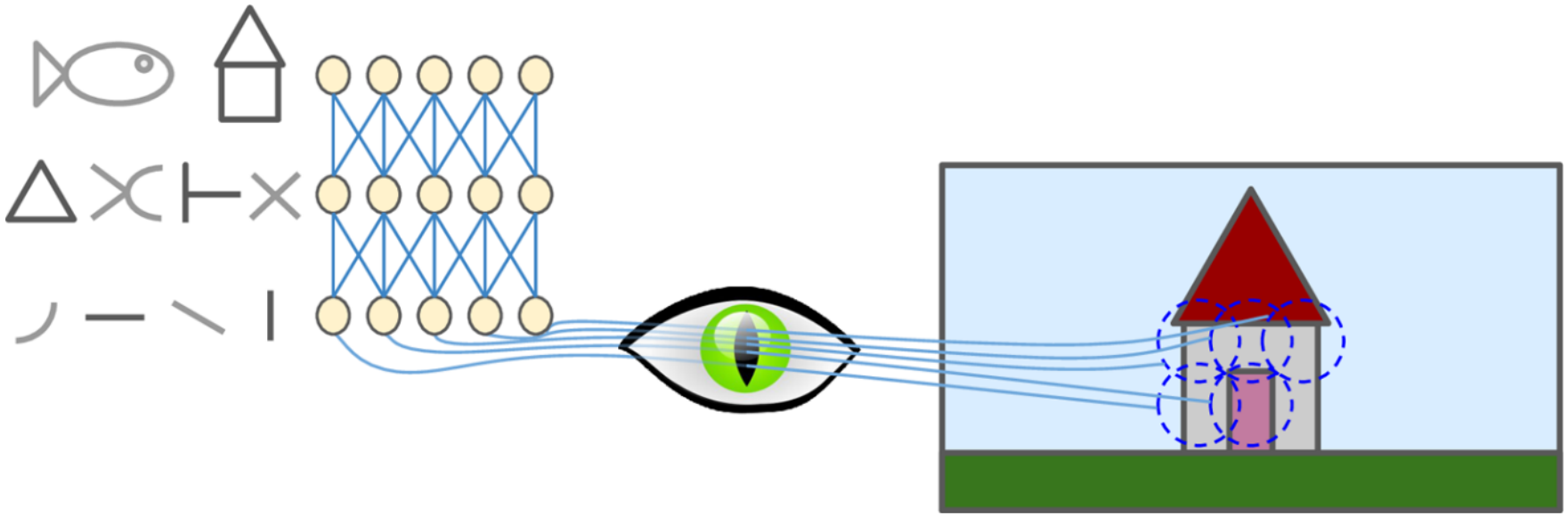
Lesson Overview

- Biology of Vision
- Image Basics
- Vocabulary

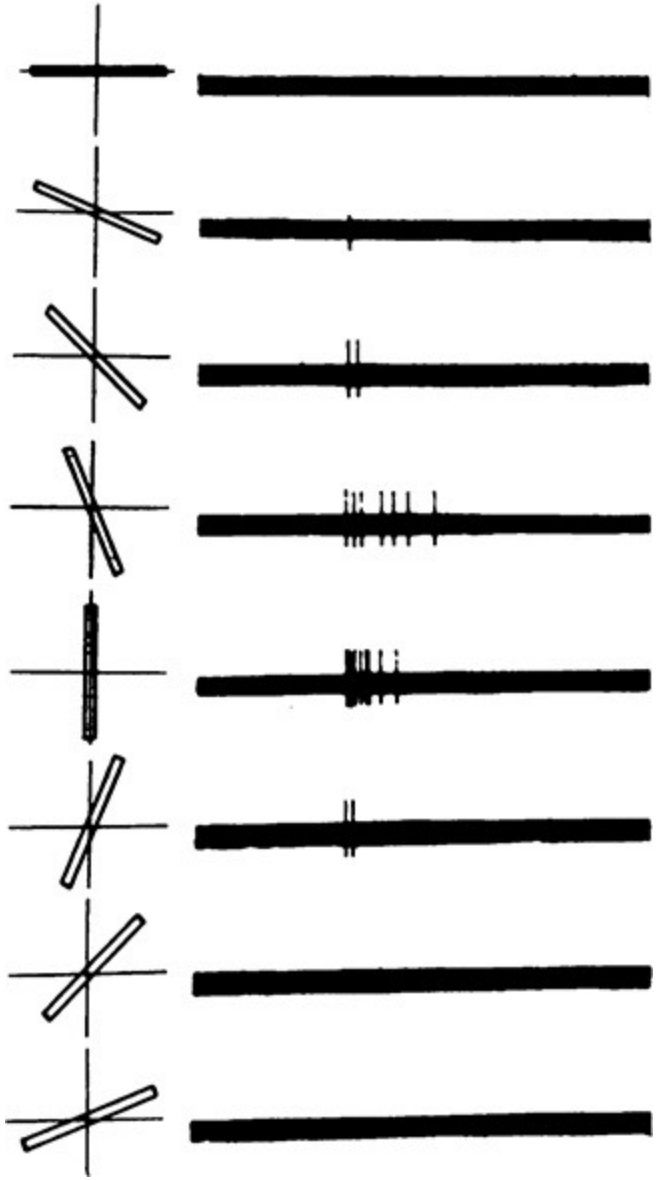
Torsten Wiesel

David Hubel

Source: Krohn, J. (2020). *Deep Learning Illustrated.* New York, NY: Addison-Wesley. (Chapter 1)



Source: Geron, A. (2019). *Hands-on machine learning with Sci-Kit learn, Keras, & Tensorflow.* Sebastopol, CA: O'Reilly Media. (Chapter 14)

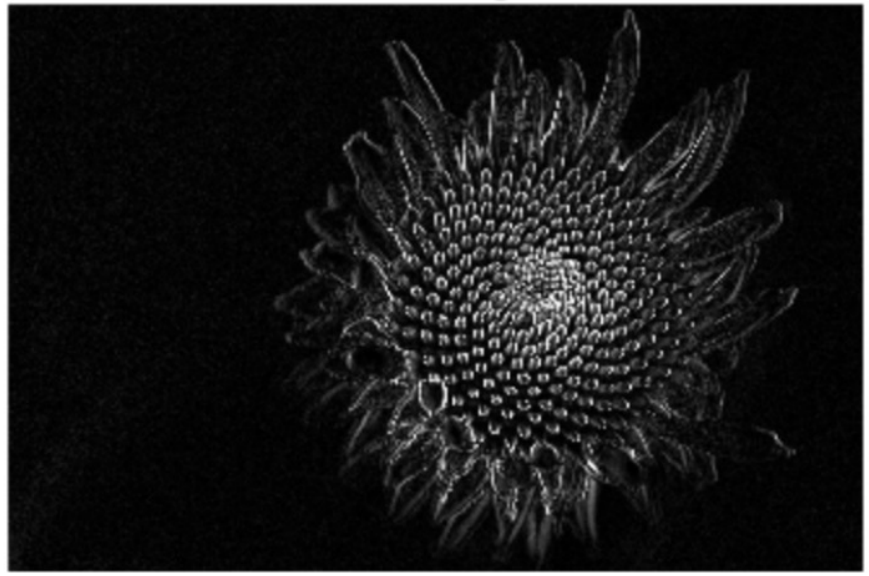


Source: Krohn, J. (2020). *Deep Learning Illustrated.* New York, NY: Addison-Wesley. (Chapter 1)

Original Image

Filter for Vertical Edge

Vertical Edge Detection



Source: Mirza, R.B. et al. (2021). *The deep learning workshop*. Birmingham, UK: Packt Publishing. (Chapter 3)

Why do we need Convolutional Neural Networks?

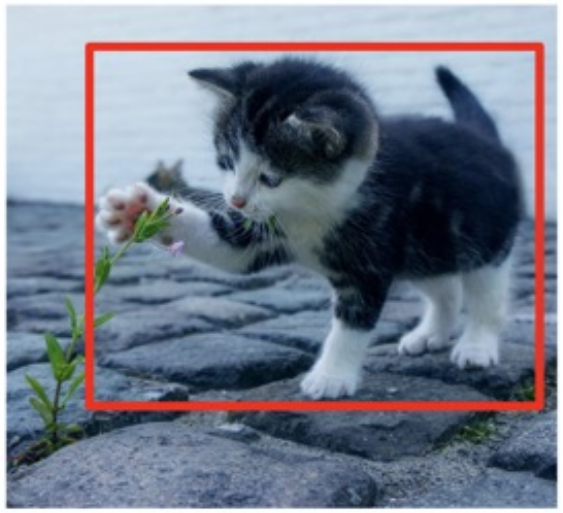
Source: Geron, A. (2019). *Hands-on machine learning with Sci-Kit learn, Keras, & Tensorflow.* Sebastopol, CA: O'Reilly Media. (Chapter 14)

CNN Domains

Classification

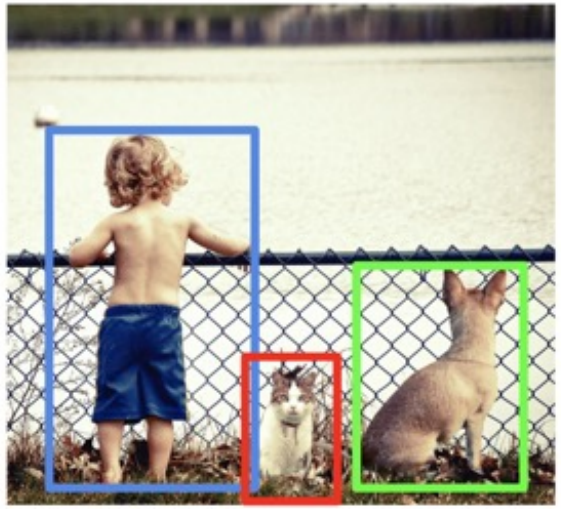
Cat

Classification and Localization



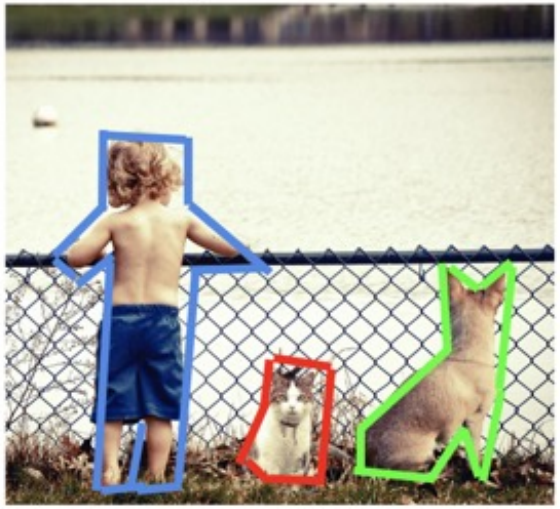
Cat

Object Detection



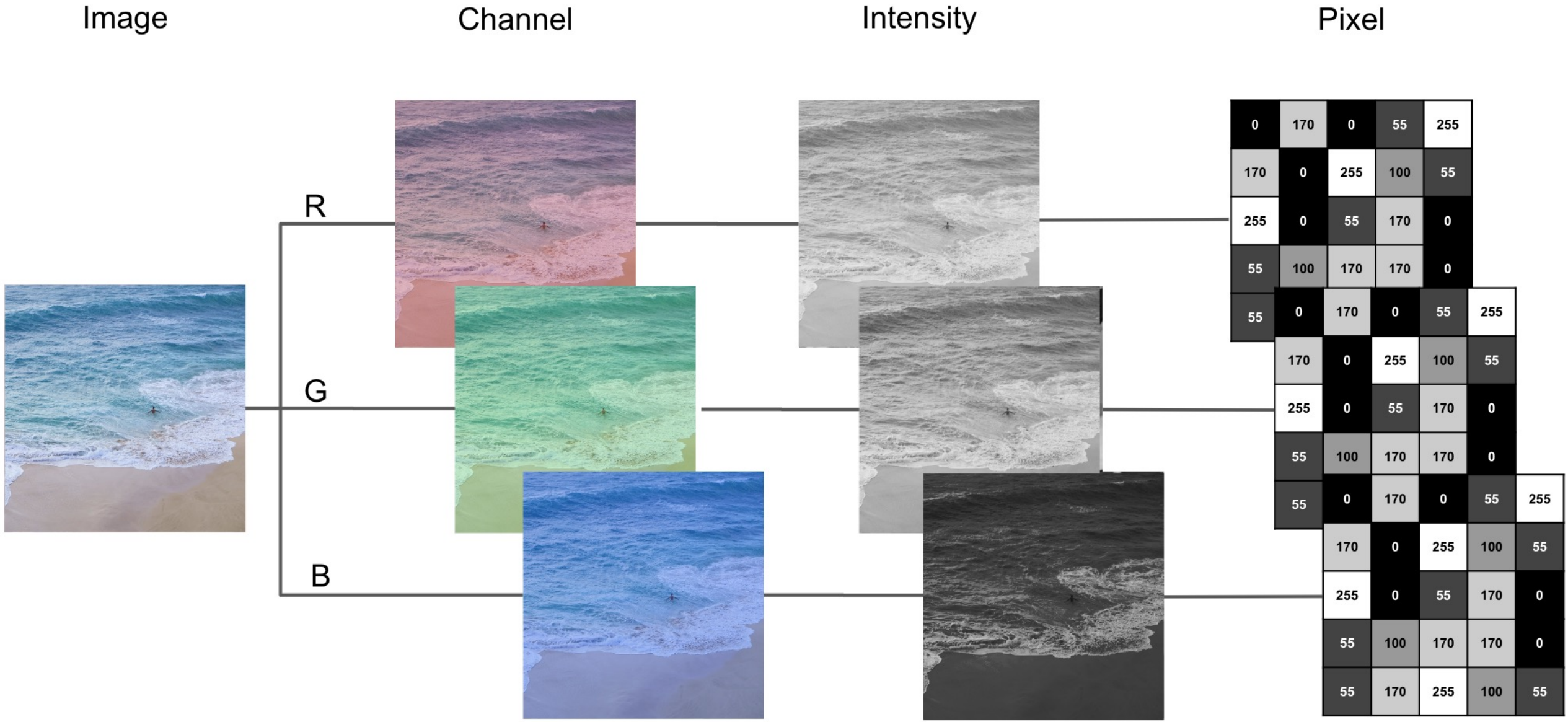
Kid, cat, dog

Instance Segmentation



Kid, cat, dog

Source: Mirza, R.B. et al. (2021). *The deep learning workshop*. Birmingham, UK: Packt Publishing. (Chapter 3)



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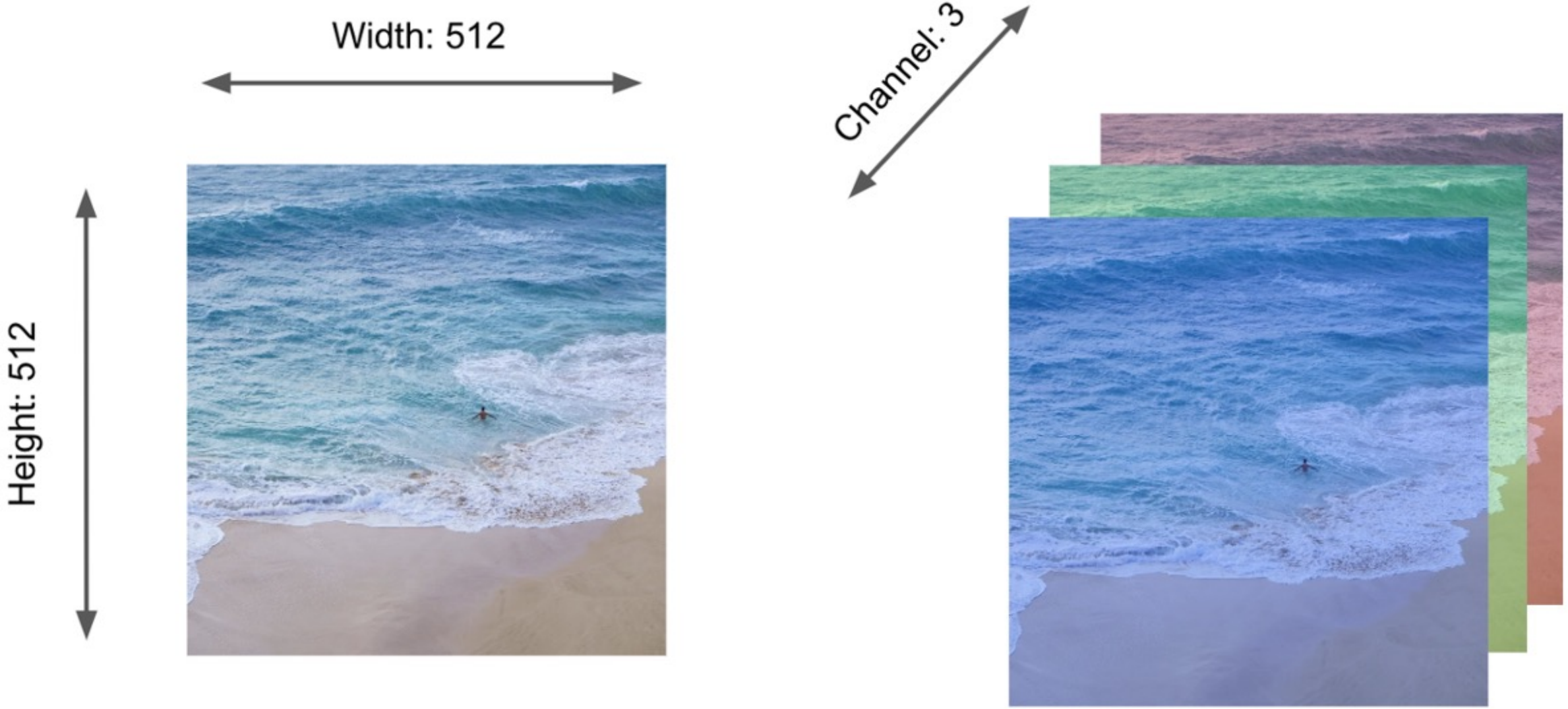

Source: Mirza, R.B. et al. (2021). *The deep learning workshop*. Birmingham, UK: Packt Publishing. (Chapter 3)

Google AI Glossary

https://developers.google.com/machine-learning/glossary

2. CNN anatomy

Lesson Overview

- Quick Review
- Filters and Images
- Convolution
- Stride, Padding, Pooling

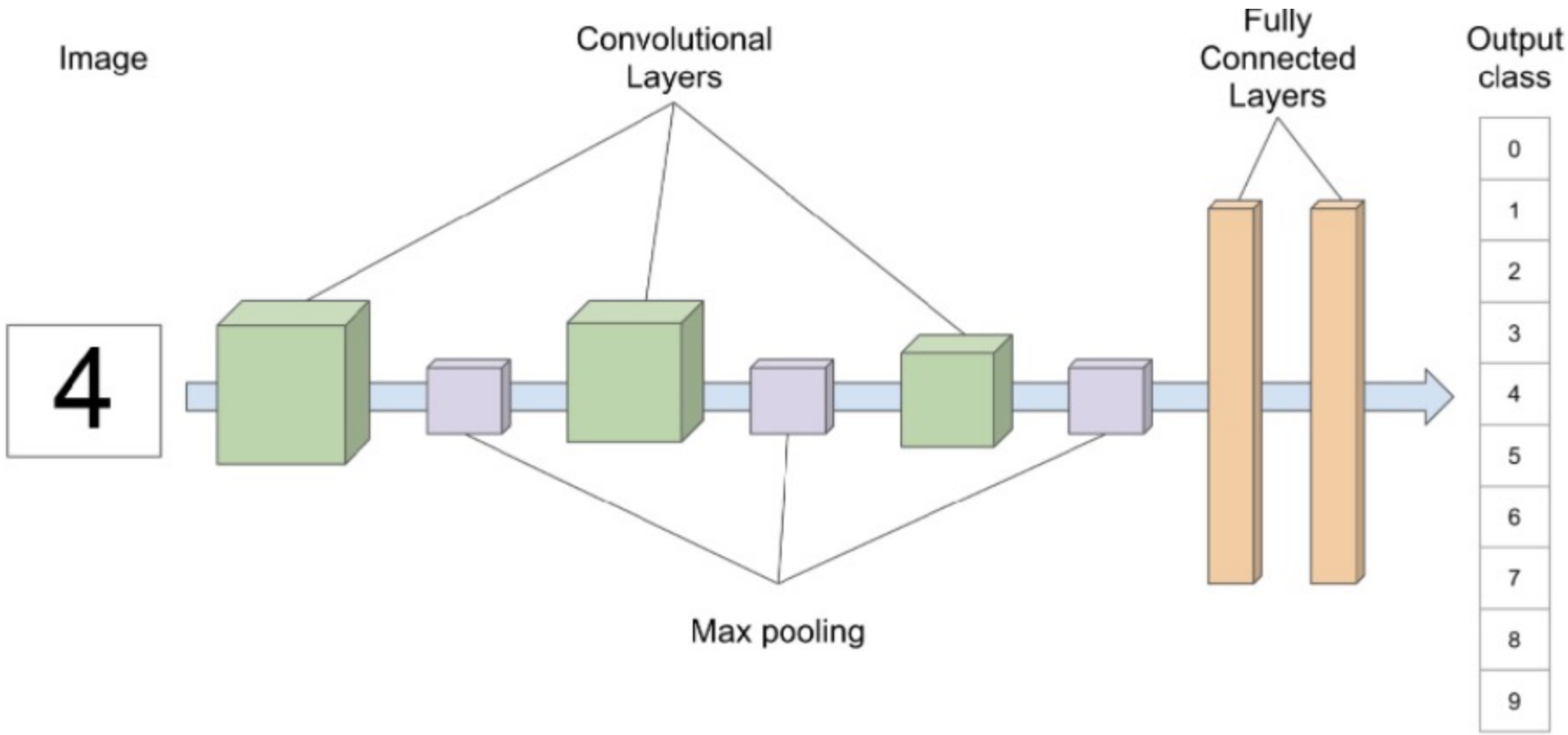
Image
Convolutional Layers
Fully Connected Layers
Output class
4
Max pooling
0
1
2
3
4
5
6
7
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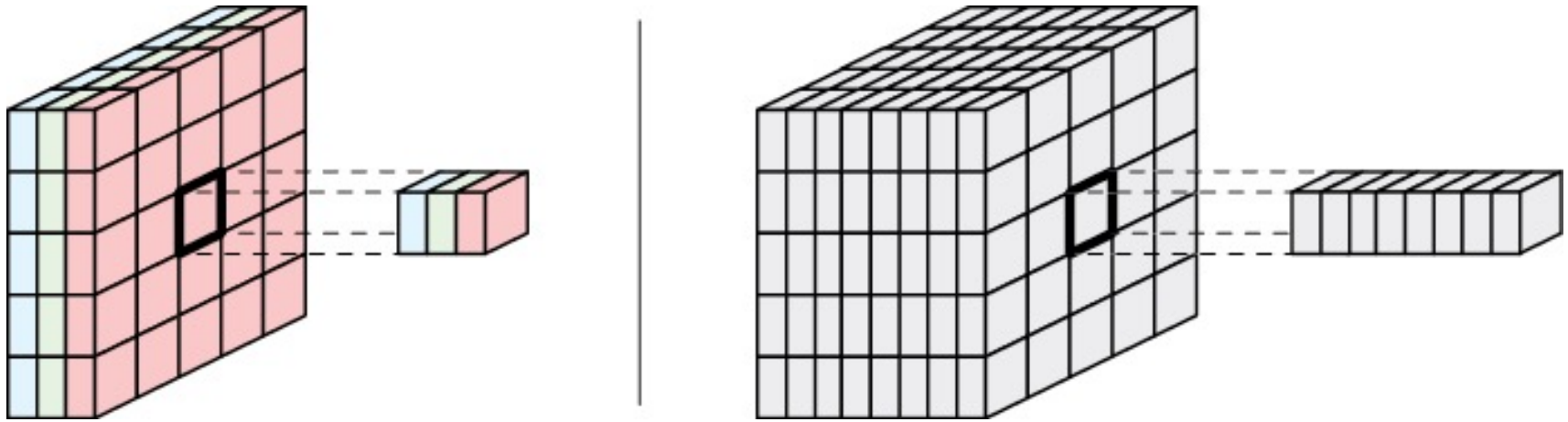
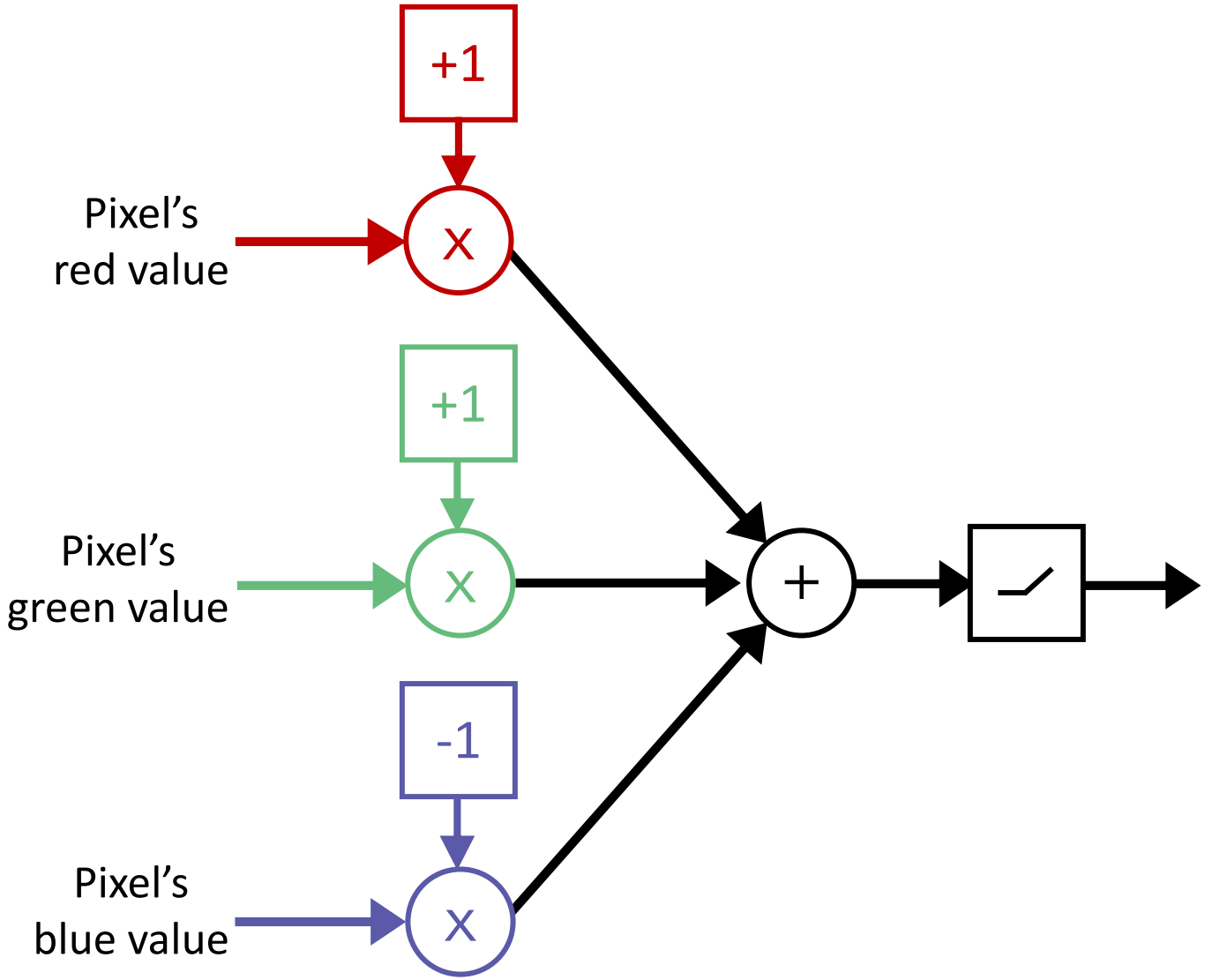
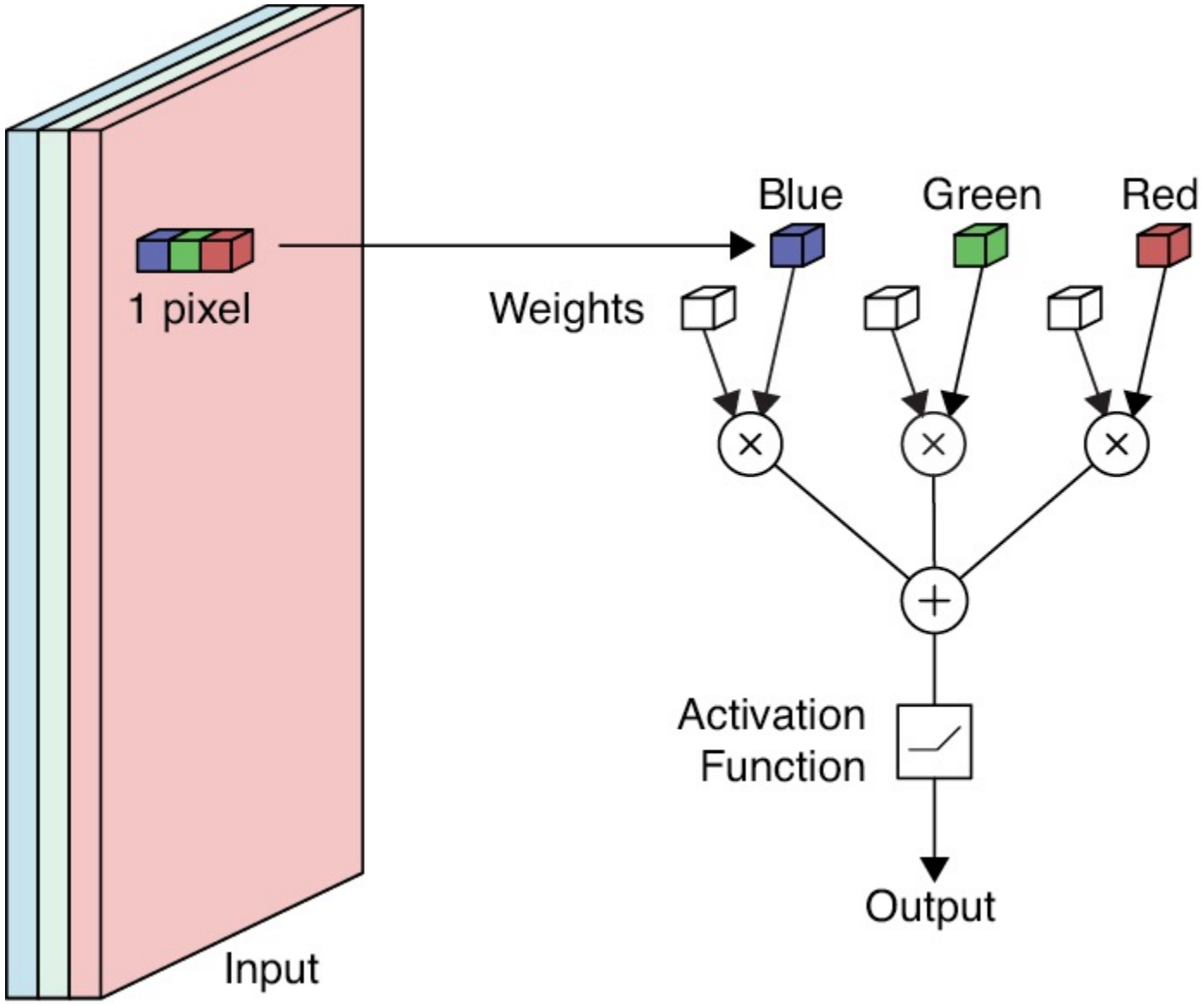


Source: Glassner, A. (2021). *Deep learning: A visual approach*. San Francisco, CA: No Starch Press. (Chapter 16)

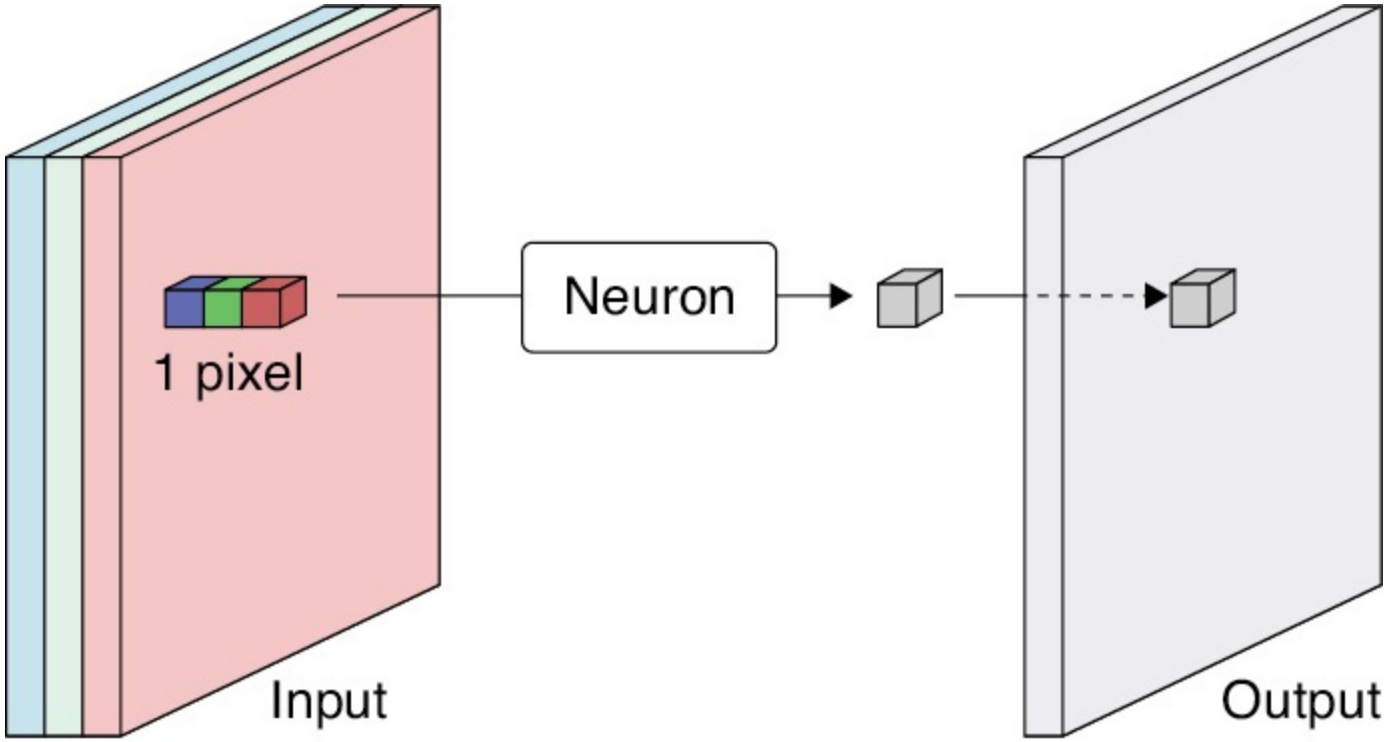
Simple filter for deteriming the yellowness of a pixel



Source: Glassner, A. (2021). *Deep learning: A visual approach*. San Francisco, CA: No Starch Press. (Chapter 16)



Source: Glassner, A. (2021). *Deep learning: A visual approach*. San Francisco, CA: No Starch Press. (Chapter 16)



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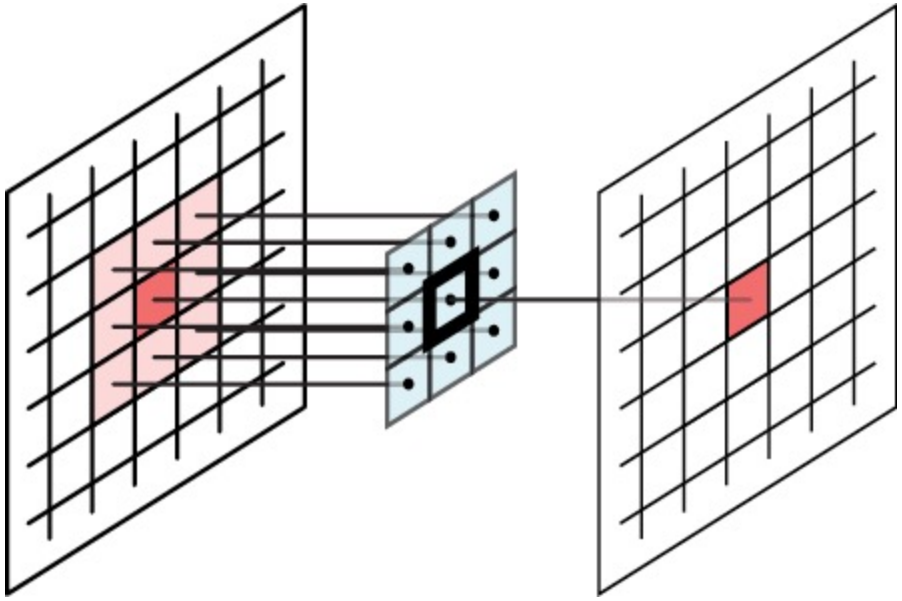
Using larger kernels



Source: Glassner, A. (2021). *Deep learning: A visual approach*. San Francisco, CA: No Starch Press. (Chapter 16)

Convolution

Input

3	0^{1}	1^{0}	2^{-1}	7	4
1	5^{1}	8^{0}	9^{-1}	3	1
2	7^{1}	2^{0}	5^{-1}	1	3
0	1	3	1	7	3
4	2	1	6	2	8
2	4	5	2	3	9

*

Filter or Kernel

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

=

Output

-5	-4		

0 x 1 + 5 x 1 + 7 x 1 + 1 x 0 + 8 x 0 + 2 x 0 + 2 x -1 + 8 x -1 + 5 x -1

Source: https://www.youtube.com/watch?v=XuD4C8vJzEQ

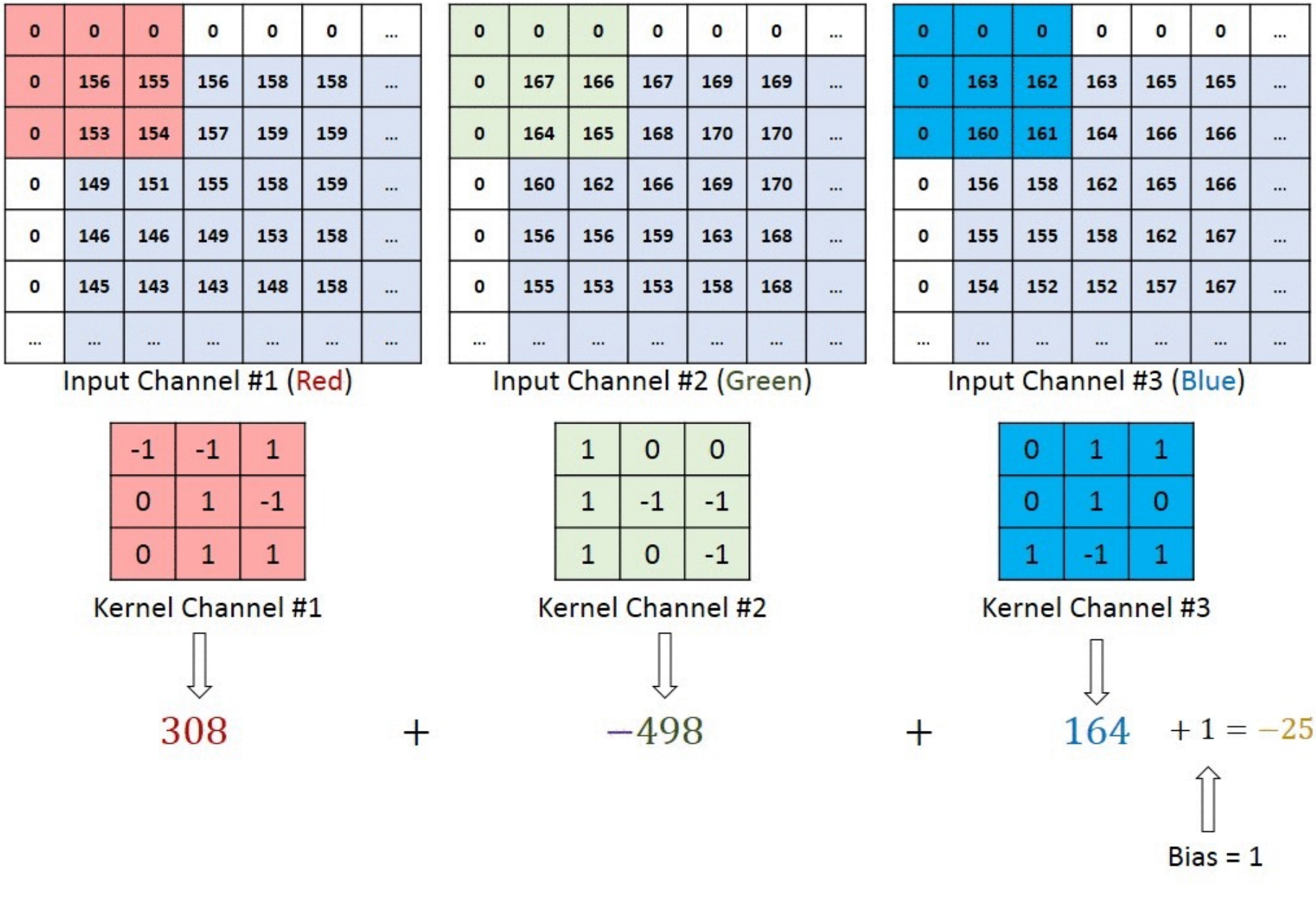
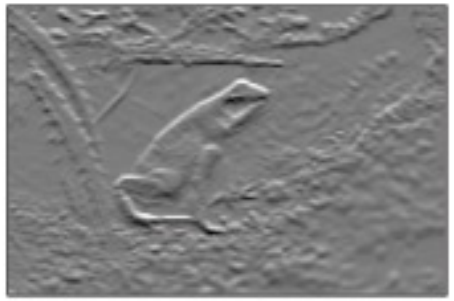


Image Credit: https://cognitivetruth.wordpress.com/2019/02/01/convolutional-neural-networks/

1	1	1
1	1	1
1	1	1

Blurring

1	1	1
0	0	0
–1	–1	–1



Horizontal Edges

–1	0	1
–1	0	1
–1	0	1

Vertical Edges

Source: Glassner, A. (2021). *Deep learning: A visual approach*. San Francisco, CA: No Starch Press. (Chapter 16)

Stride

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

Stride of 1

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

Stride of 2

Source: https://www.youtube.com/watch?v=tQYZaDn_kSg

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

6 x 6

-5			

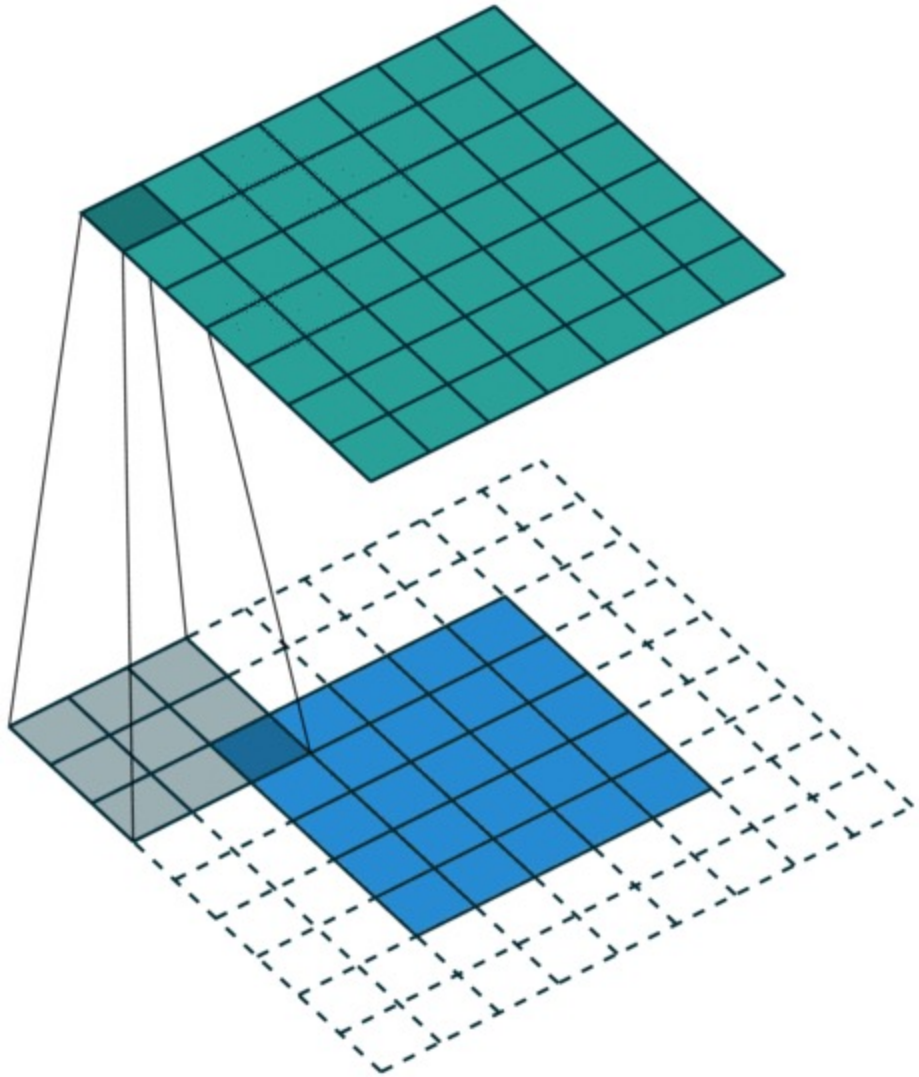
4 x 4

Source: https://www.youtube.com/watch?v=smHa2442Ah4&t=40s

Padding

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

Source: https://www.youtube.com/watch?v=smHa2442Ah4&t=40s



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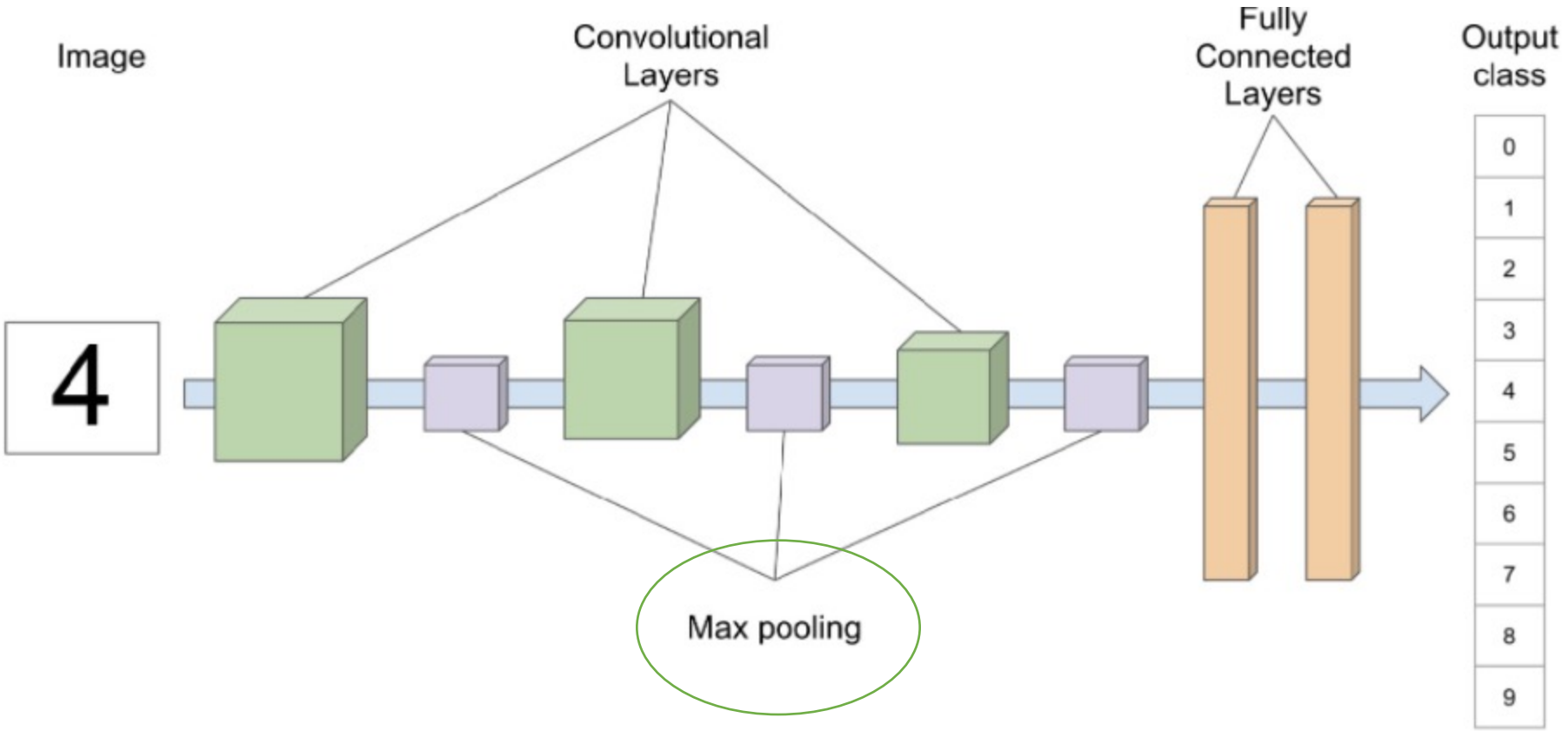


Image
Convolutional Layers
Fully Connected Layers
Output class
4
Max pooling
0
1
2
3
4
5
6
7
8
9

Max Pooling

Input Image

6	8	6	1
1	2	7	4
9	8	1	2
8	9	3	2

Max pooling with Stride 2

MAX

Result

8	7
9	3

Source: https://www.youtube.com/watch?v=8oOgPUO-TBY&t=6s

Max Pooling

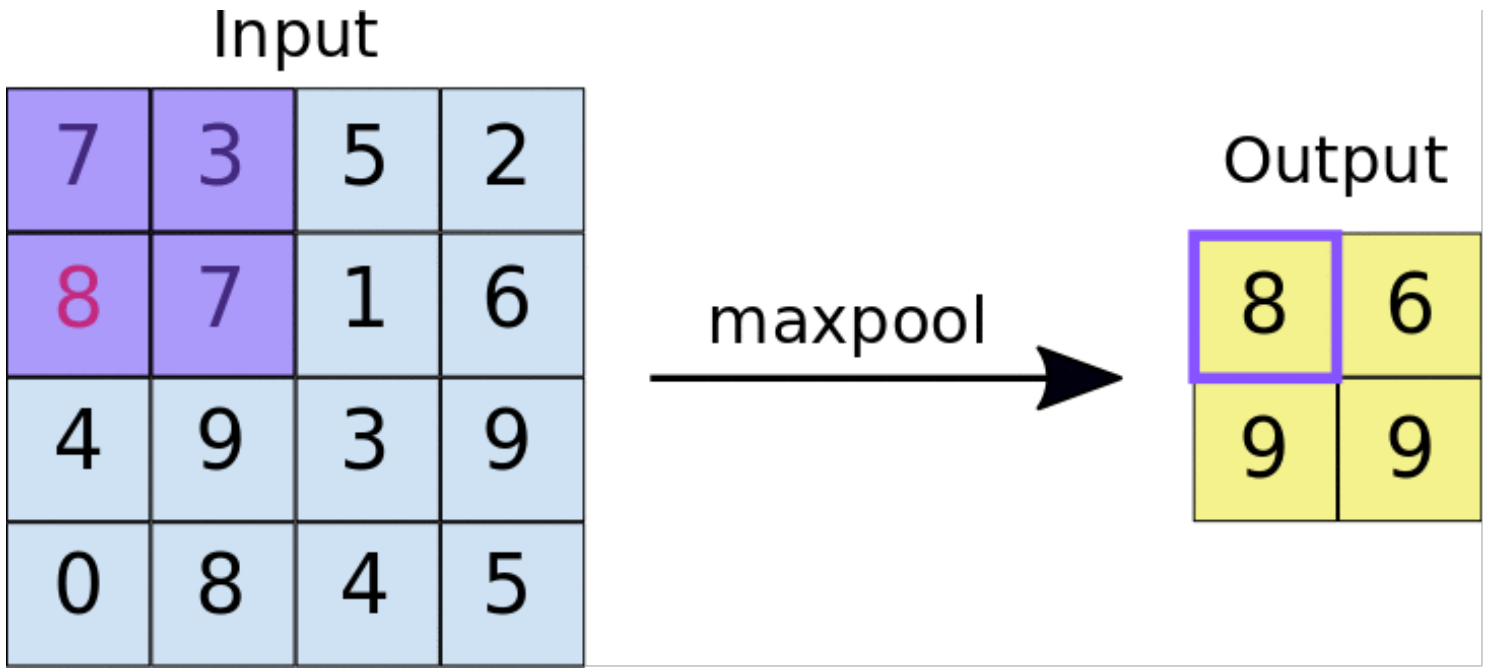


Image Credit: https://cognitivetruth.wordpress.com/2019/02/01/convolutional-neural-networks/

Average Pooling

Input Image

6	8	6	1
1	2	7	4
9	8	1	2
8	9	3	2

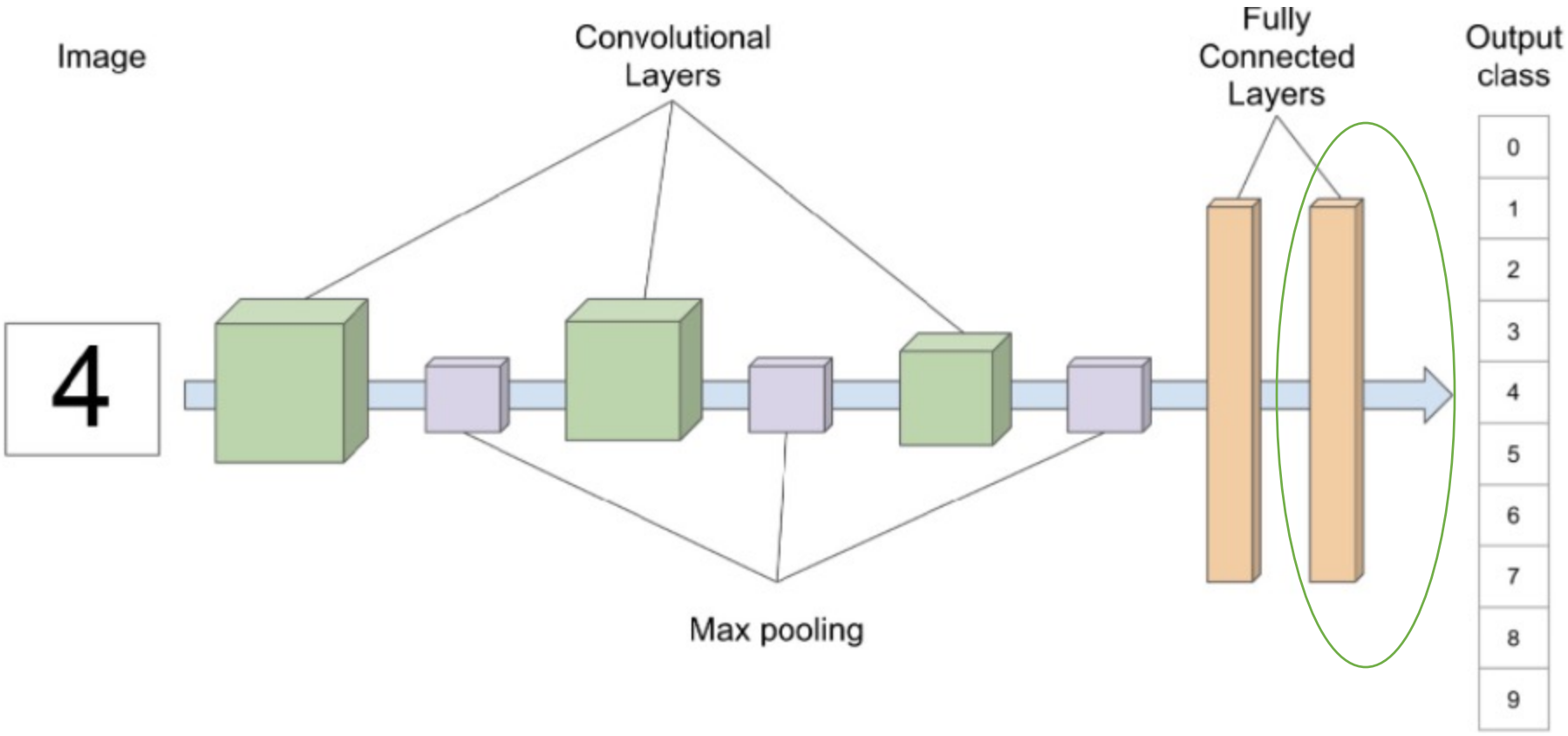
Max pooling with Stride 2

AVG

Result

4.25	4.50
8.50	2.67

Source: https://www.youtube.com/watch?v=8oOgPUO-TBY&t=6s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Problem Type	Activation Function for Last Layer	Output
Regression	None (or identity function)	A numerical number that can take any value
Binary classification	sigmoid	A numerical number ranging from 0 to 1 corresponding to the probability of the observation.
Multi-class classification	softmax	Multiple numerical numbers (depending on the number of classes) ranging from 0 to 1 corresponding to the probability of each class.