

2018.10.13

NEURAL NETWORK (1)

3기 천용희

CONTENTS

1. 이미지 분류
2. 뉴럴 네트워크
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4. 역전파
5. 간단한 뉴럴 네트워크 아키텍쳐

Chapter 1

이미지 분류

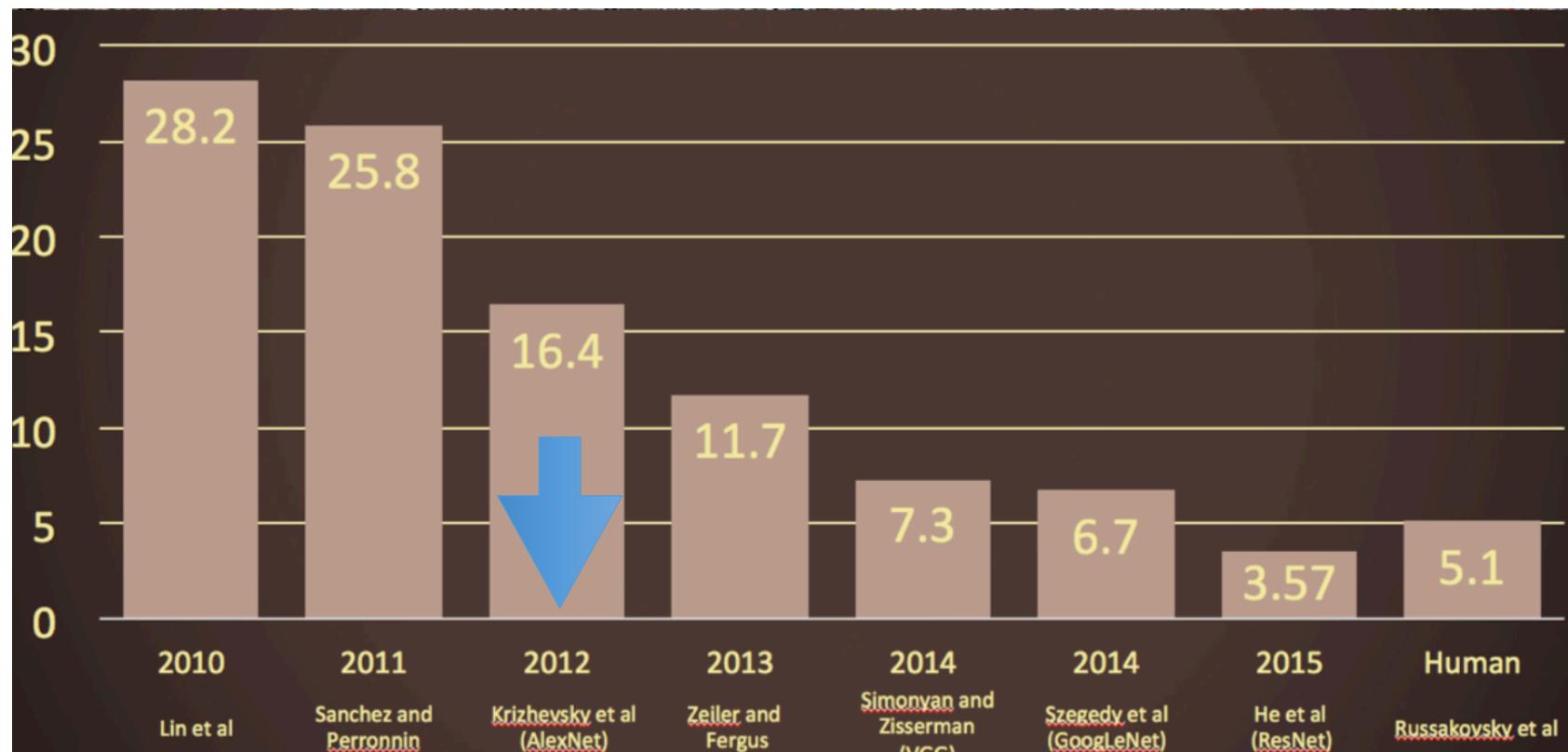
Chapter 1.1.1 | 왜 이미지 분류인가?

■ 이미지넷 챌린지 : 1,000 Objects, 1,431,167 Images



Chapter 1.1.1 | 왜 이미지 분류인가?

NN 기법(딥러닝)의 세계적 인기를 불러온 것이 이미지 분류 콘테스트에서 높은 성적을 보였기 때문



이제부터
고양이를
찾아보자



Chapter 1.1.2 | 여러 class를 주고, 고양이를 찾아내기



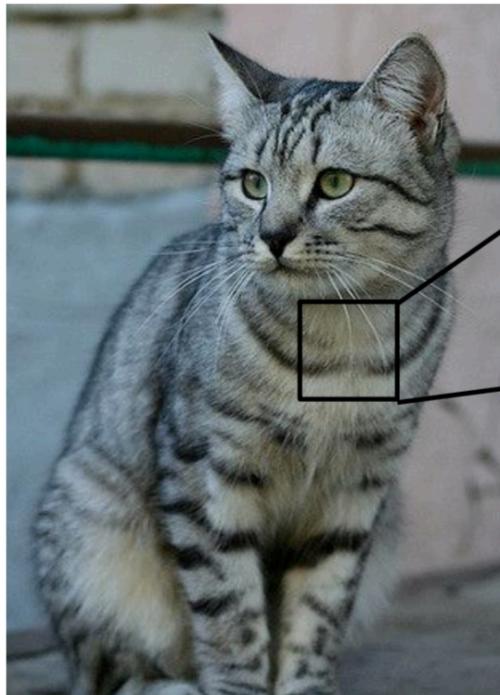
This image by [Nikita](#) is

(assume given set of discrete labels)
{dog, cat, truck, plane, ...}



cat

Chapter 1.1.2 | 컴퓨터가 보는 것



This image by [Nikita](#) is
licensed under [CC-BY 2.0](#)

```
[[105 112 108 111 104 99 106 99 96 103 112 119 104 97 93 87]
 [ 91 98 102 106 104 79 98 103 99 105 123 136 110 105 94 85]
 [ 76 85 90 105 128 105 87 96 95 99 115 112 106 103 99 85]
 [ 99 81 81 93 120 131 127 100 95 98 102 99 96 93 101 94]
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 [ 89 93 90 97 108 147 131 118 113 114 113 109 106 95 77 80]
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 [ 63 65 75 88 89 71 62 81 120 138 135 105 81 98 110 118]
 [ 87 65 71 87 106 95 69 45 76 130 126 107 92 94 105 112]
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 [128 112 96 117 150 144 120 115 104 107 102 93 87 81 72 79]
 [123 107 96 86 83 112 153 149 122 109 104 75 80 107 112 99]
 [122 121 102 80 82 86 94 117 145 148 153 102 58 78 92 107]
 [122 164 148 103 71 56 78 83 93 103 119 139 102 61 69 84]]
```

What the computer sees

An image is just a big grid of numbers between [0, 255]:

e.g. 800 x 600 x 3
(3 channels RGB)

Chapter 1.1.2 | 극복 요소 (1) : 카메라 시점이 변하면?

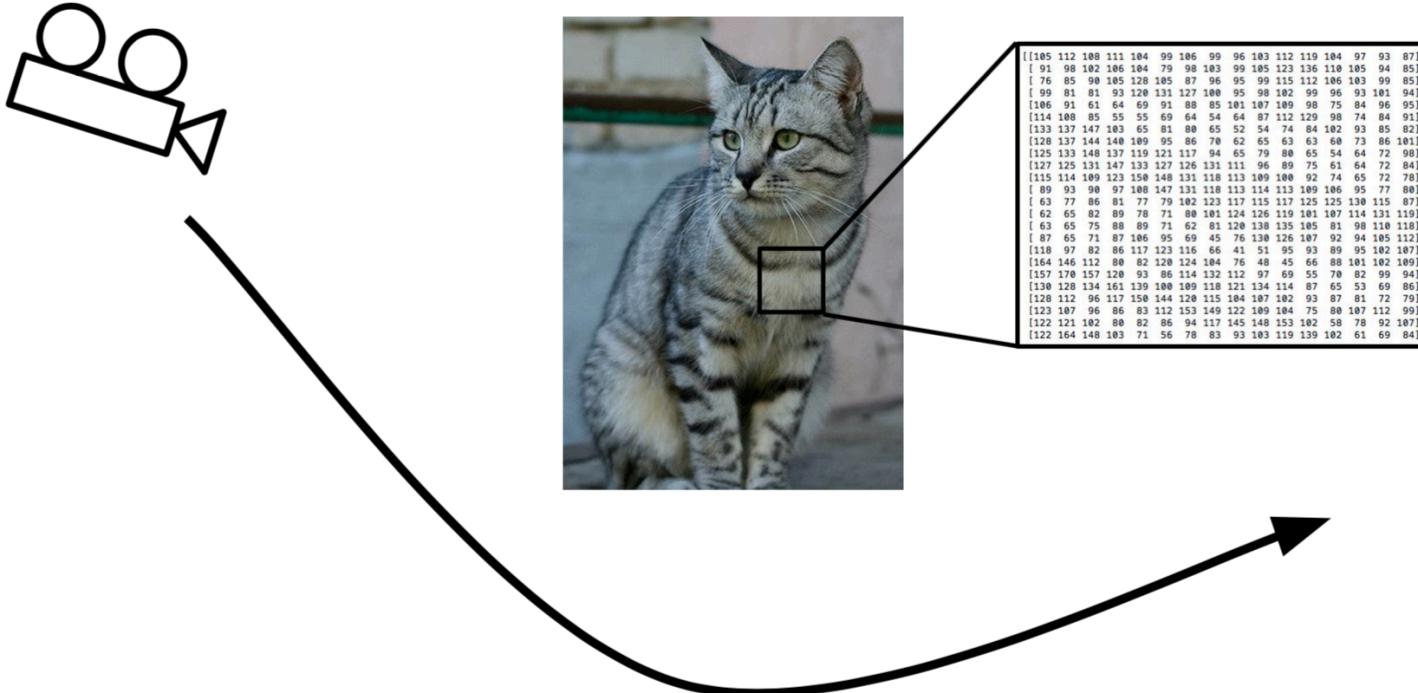


image by Nikita ie

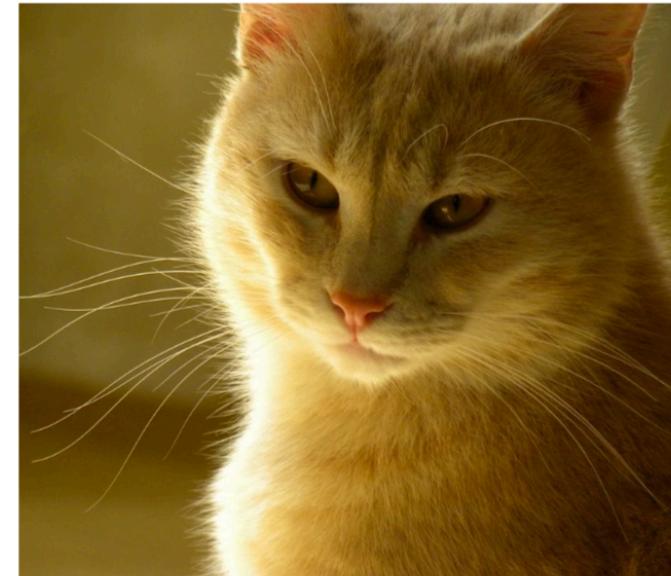
Chapter 1.1.2 | 극복 요소 (2) : 빛의 세기, 위치가 다르면?



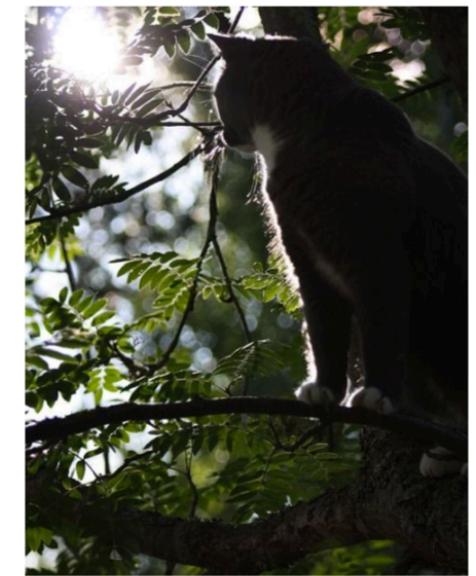
[This image is CC0 1.0 public domain](#)



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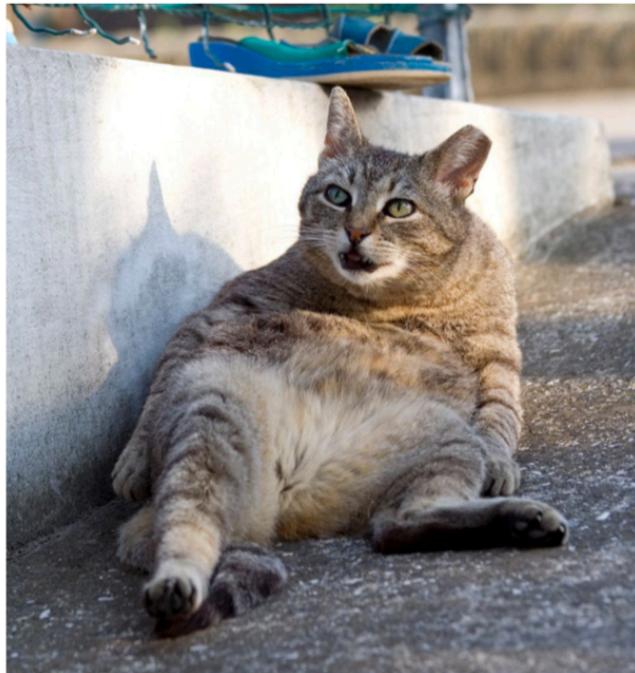


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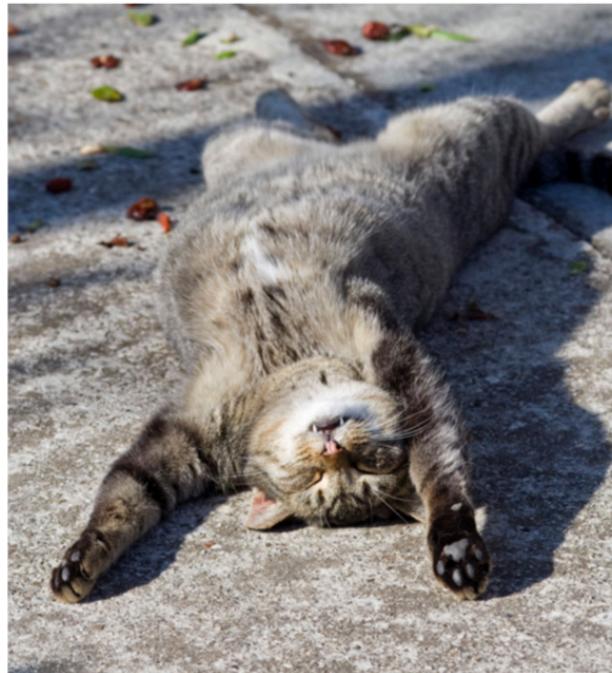


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Chapter 1.1.2 | 극복 요소 (3) : 고양이가 자세를 바꾸면?



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[This image by Tom Thai is](#)
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Chapter 1.1.2 | 극복 요소 (4) : 고양이가 숨으면?



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Chapter 1.1.2 | 극복 요소 (5) : 배경에 가려지면?



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[This image is CC0 1.0 public domain](#)

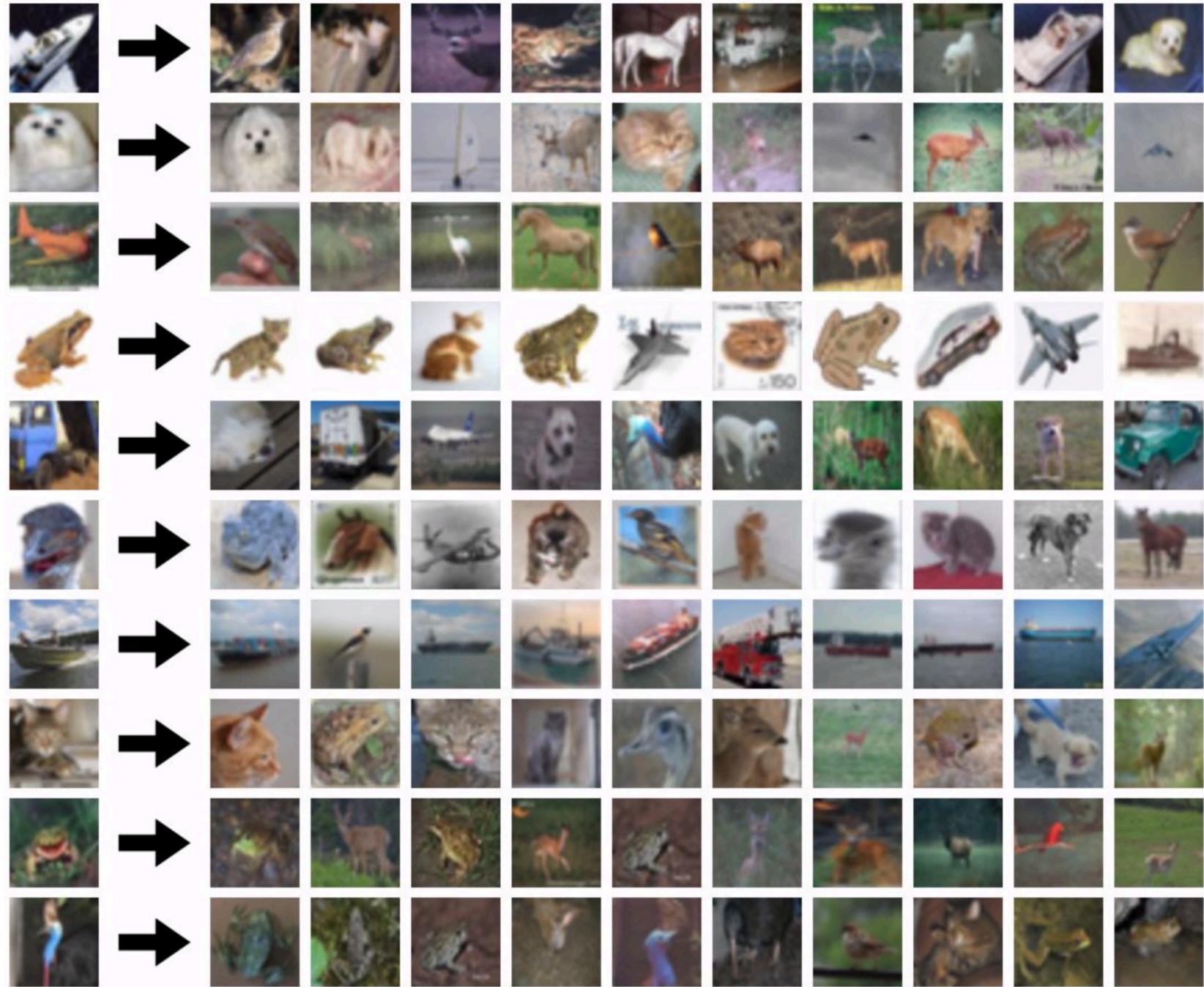
Chapter 1.1.2 | 극복 요소 (6) : 얘들이 모두 고양이다



This image is CC0 1.0 public domain

Chapter 1.1.3 | KNN을 쓴다면?





Chapter 1.1.3 | KNN의 문제

- Fast at training, and slow at testing
- Pixel matrix itself is not informative

Original



Boxed



Shifted



Tinted



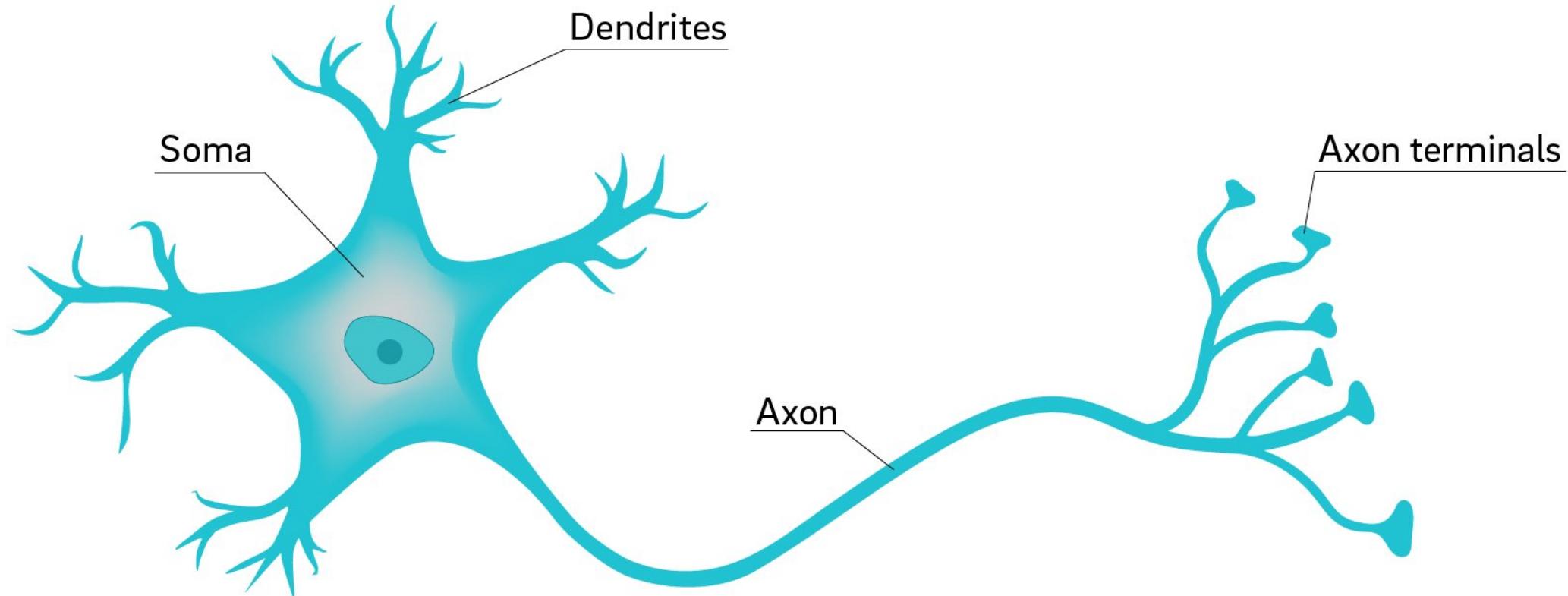
(all 3 images have same L2 distance to the one on the left)

[Original image is
CC0 public domain](#)

Chapter 2

뉴럴 네트워크

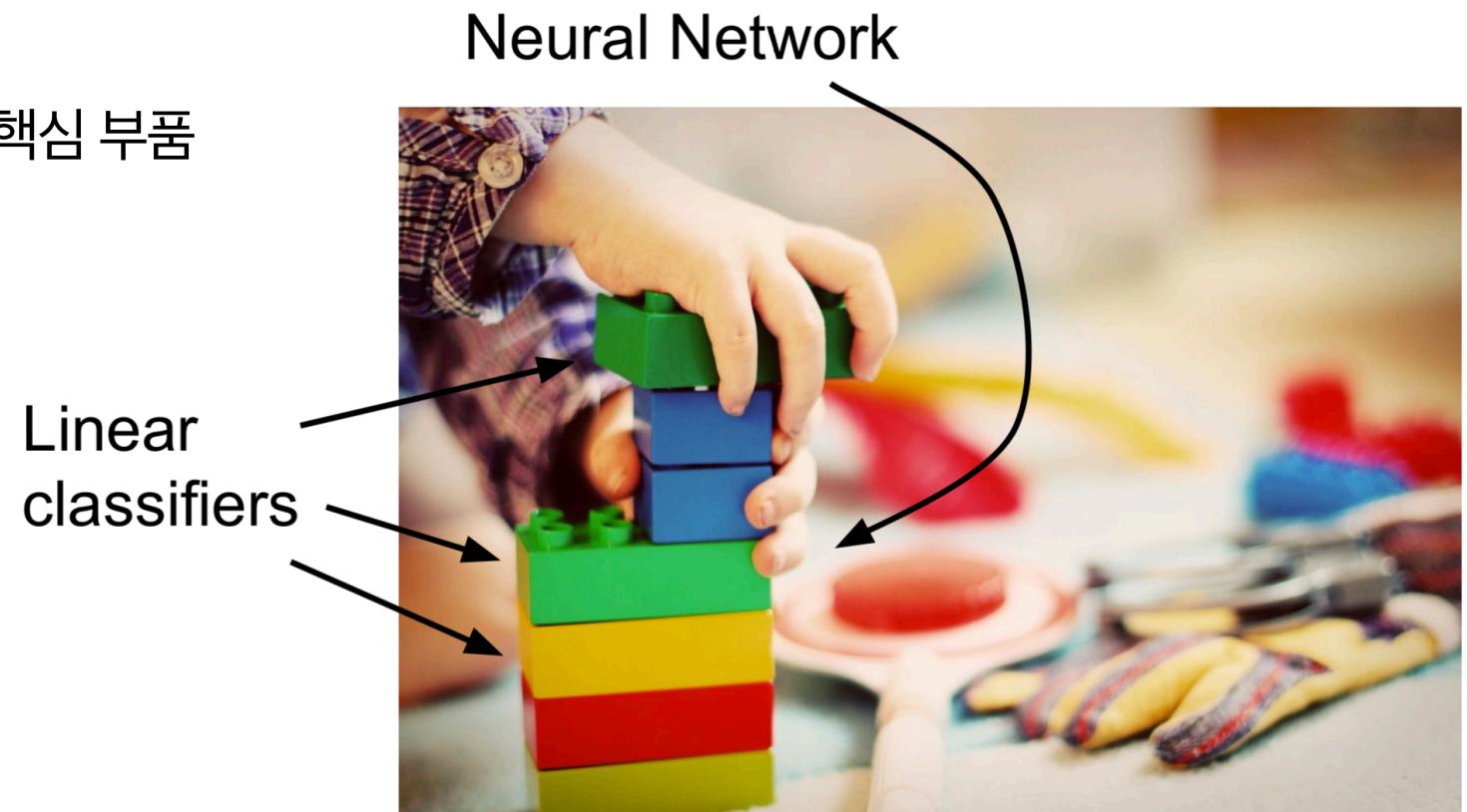
Chapter 2.1 | 뉴런



1. 무수히 많은 다른 뉴런들과 연결
2. 입력값이 임계치를 넘겨야 출력

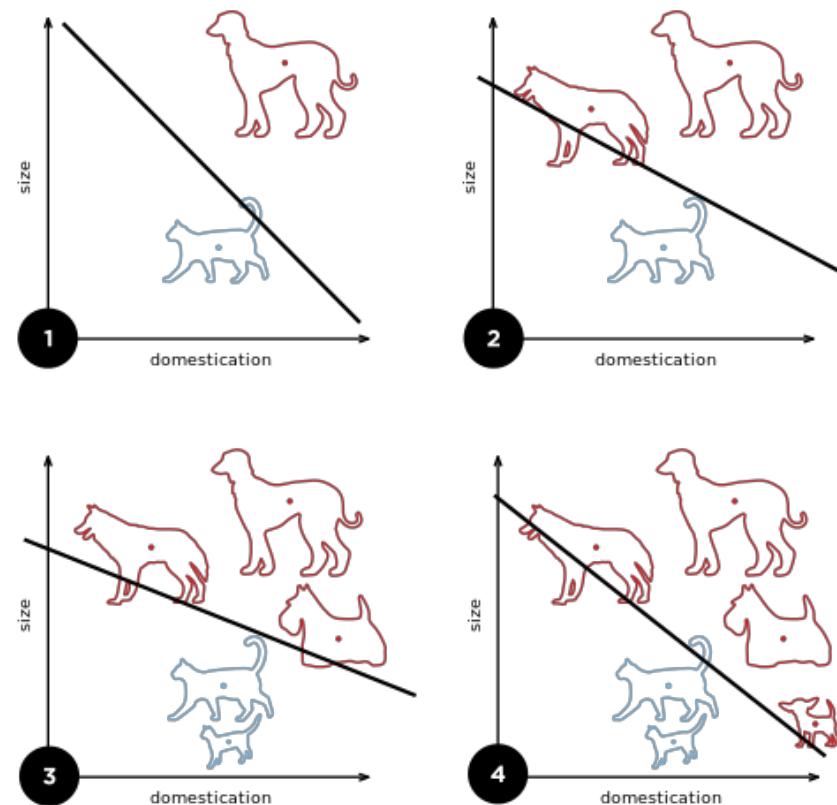
Chapter 2.2 | Linear Classifier의 일종인 인공 뉴런

- Linear Classifier는 NN을 구성하는 핵심 부품
- 퍼셉트론이라고도 함



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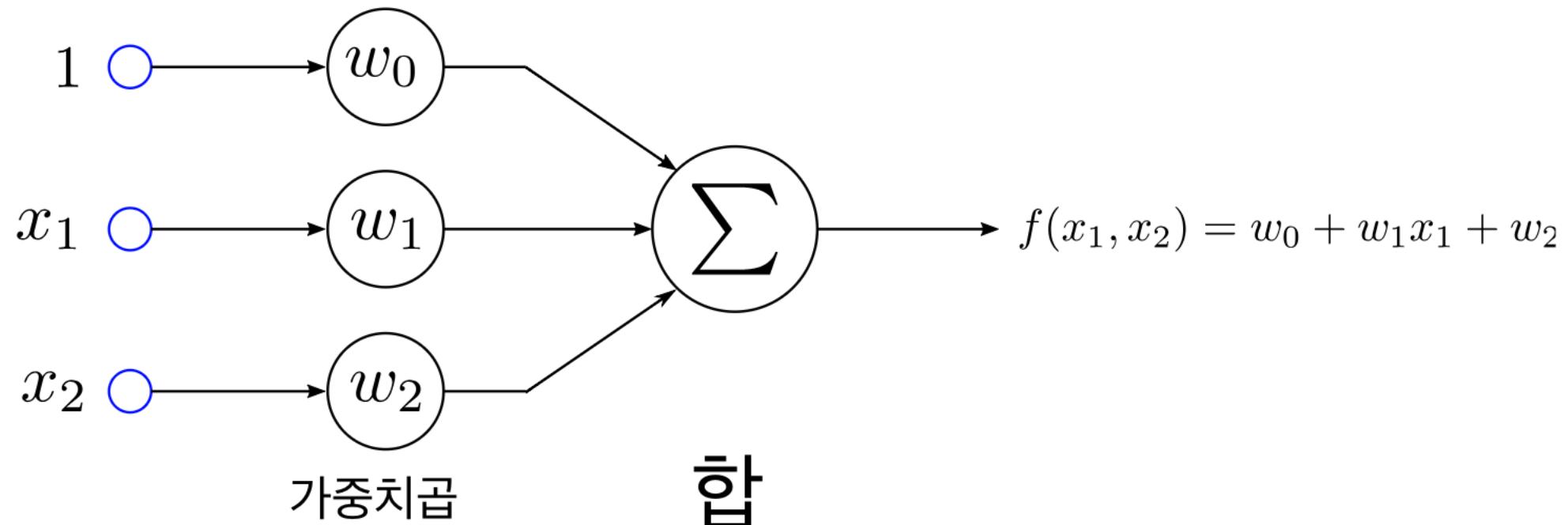
Chapter 2.2 | Linear Classifier의 일종인 인공 뉴런



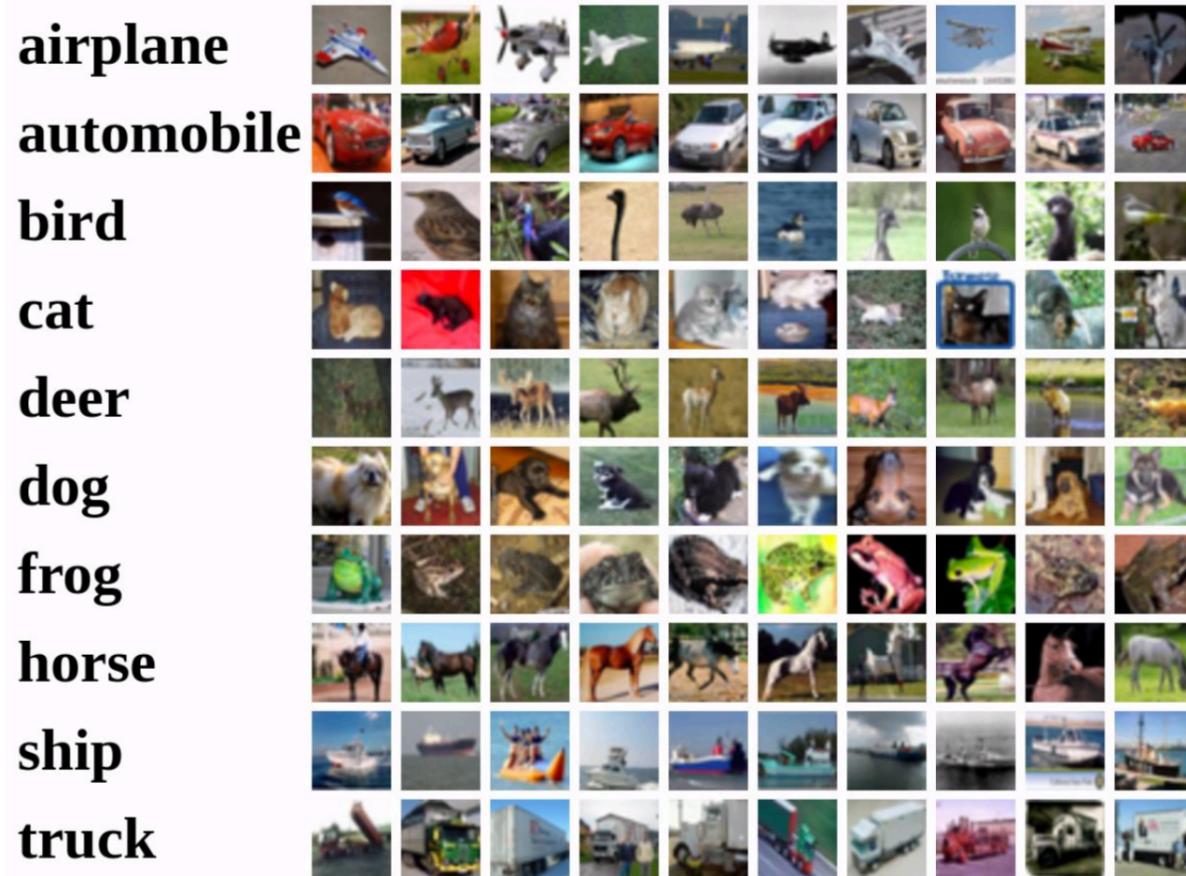
$$w_1x_1 + w_2x_2 + \dots + w_nx_n > \theta \quad \xrightarrow{\text{Output}} 1$$

$$w_1x_1 + w_2x_2 + \dots + w_nx_n \leq \theta \quad \xrightarrow{\text{Output}} 0$$

Chapter 2.2 | Linear Classifier의 일종인 인공 뉴런



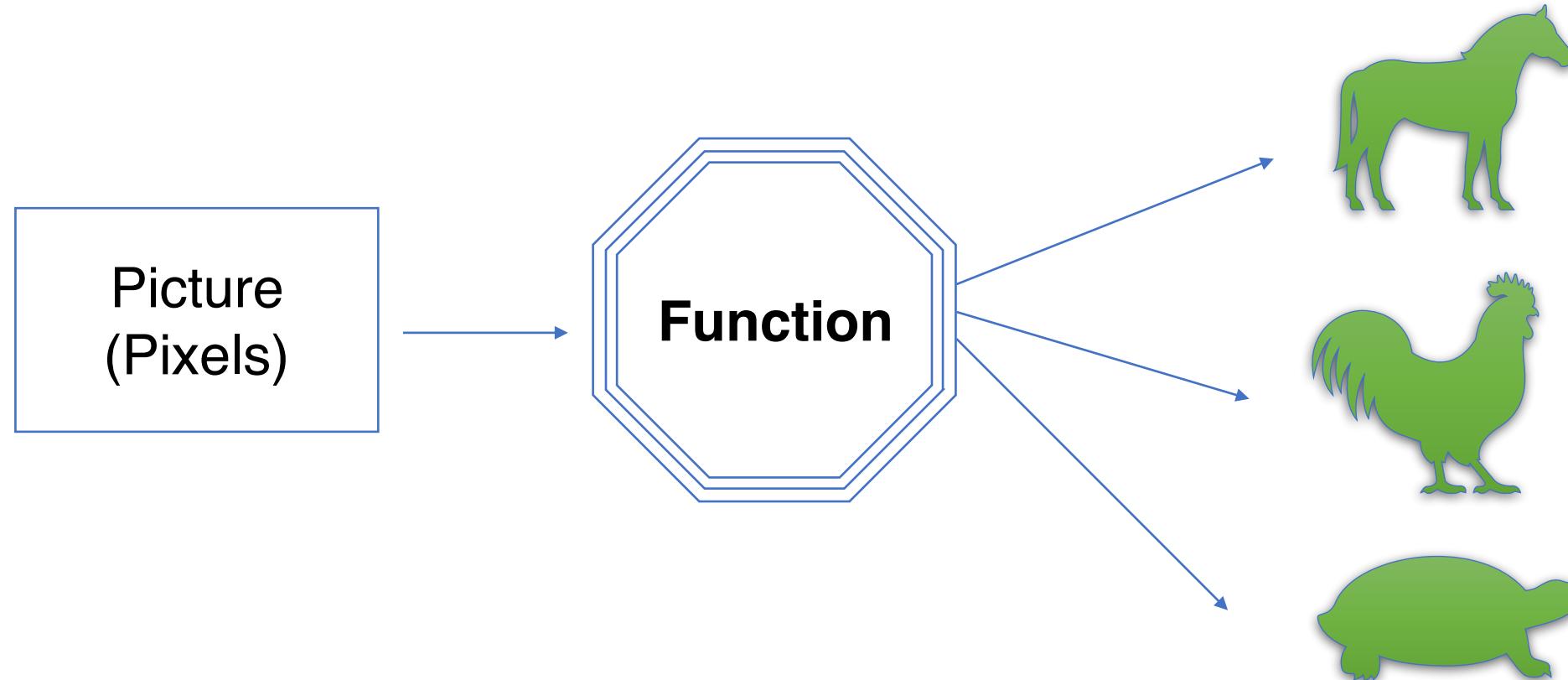
Chapter 2.3 | CIFAR 10을 분류해보자



50,000 training images
each image is **32x32x3**

10,000 test images.

Chapter 2.4 | 퍼셉트론 활용

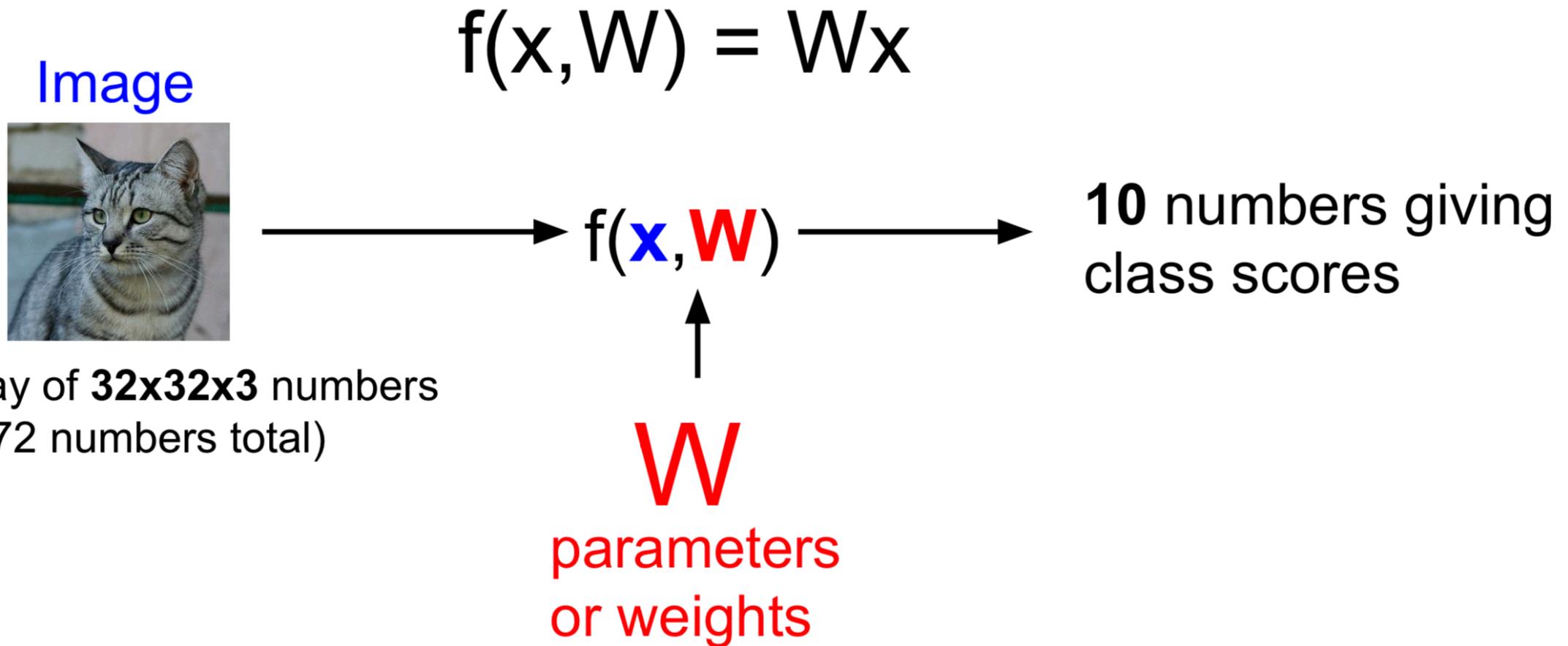


Chapter 2.5 | 결과물이 이렇게 나오면 좋겠다!

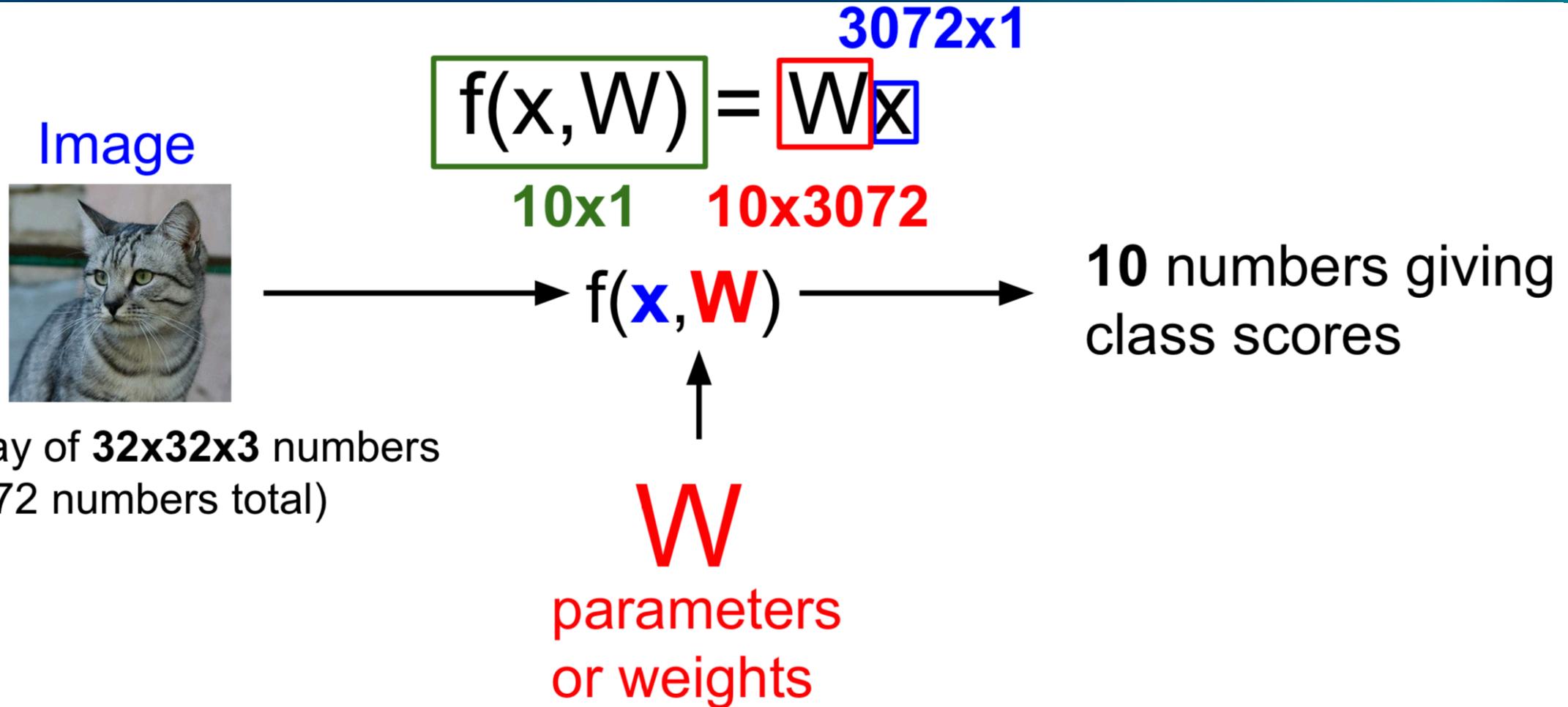


airplane	-3.45	-0.51	3.42
automobile	-8.87	6.04	4.64
bird	0.09	5.31	2.65
cat	2.9	-4.22	5.1
deer	4.48	-4.19	2.64
dog	8.02	3.58	5.55
frog	3.78	4.49	-4.34
horse	1.06	-4.37	-1.5
ship	-0.36	-2.09	-4.79
truck	-0.72	-2.93	6.14

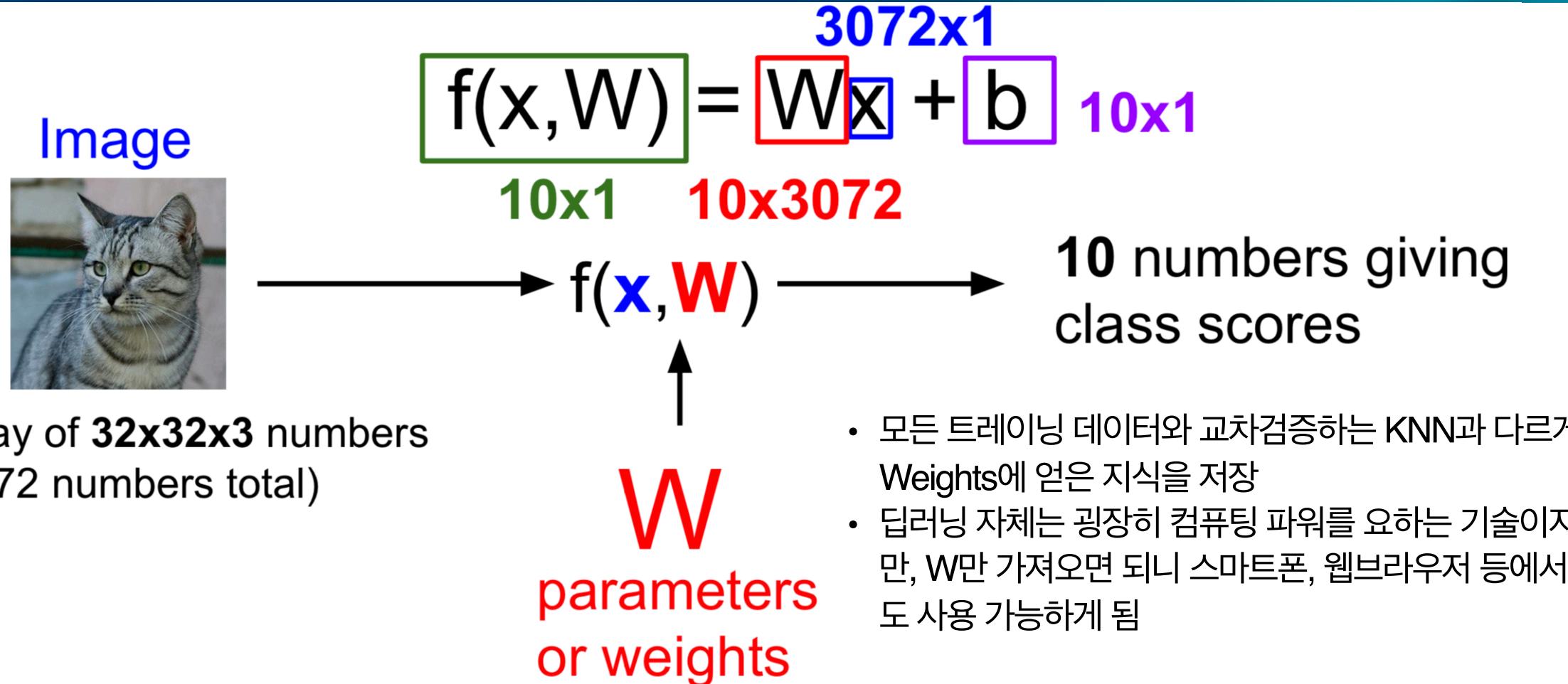
Chapter 2.6 | Parametric Approach (1)



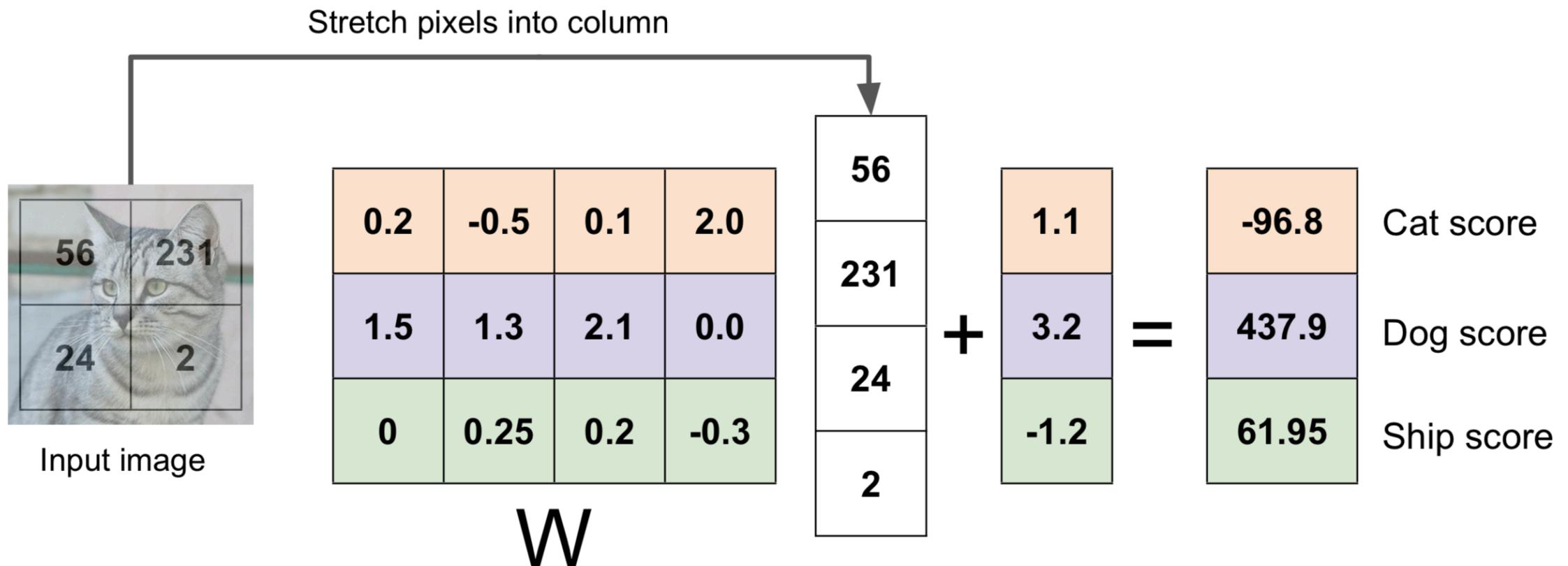
Chapter 2.6 | Parametric Approach (2)



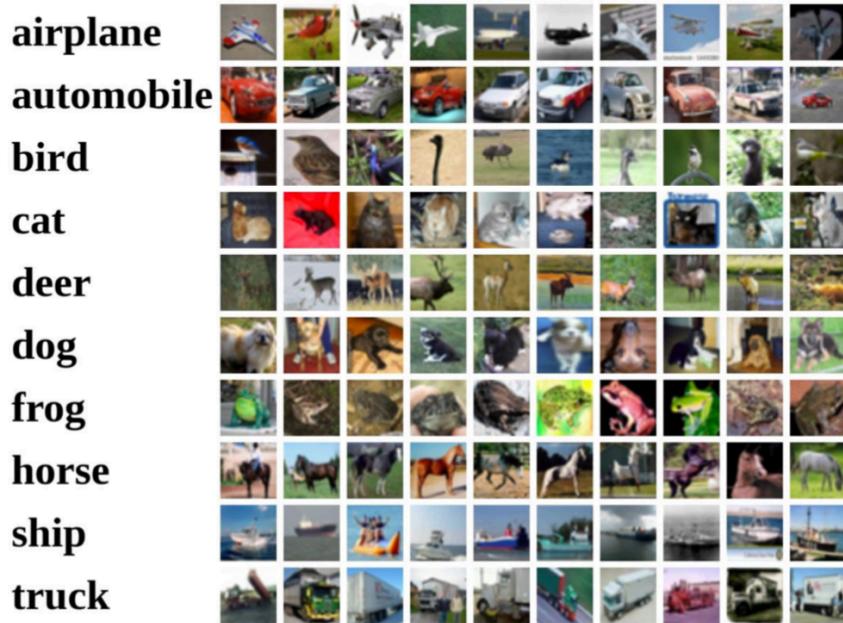
Chapter 2.6 | Parametric Approach (3)



Chapter 2.7 | 픽셀은 4, 카테고리는 3으로 단순화해보자



Chapter 2.8 | Weights는 한 가지 템플릿을 넣은 것과 같다



$$f(x, W) = Wx + b$$

Example trained weights
of a linear classifier
trained on CIFAR-10:



Chapter 3

뉴럴 네트워크의 손실 함수

Chapter 3.1 | Loss Function

$$L = \frac{1}{N} \sum_i L_i(f(x_i, W), y_i)$$

$$\begin{aligned} L_i &= \sum_{j \neq y_i} \begin{cases} 0 & \text{if } s_{y_i} \geq s_j + 1 \\ s_j - s_{y_i} + 1 & \text{otherwise} \end{cases} \\ &= \sum_{j \neq y_i} \max(0, s_j - s_{y_i} + 1) \end{aligned}$$

Chapter 3.2 | Toy Example에서 본 Loss Function



cat	3.2	1.3	2.2
car	5.1	4.9	2.5
frog	-1.7	2.0	-3.1
Losses:	2.9		

$$L_i = \sum_{j \neq y_i} \max(0, s_j - s_{y_i} + 1)$$

$$= \max(0, 5.1 - 3.2 + 1)$$

$$+ \max(0, -1.7 - 3.2 + 1)$$

$$= \max(0, 2.9) + \max(0, -3.9)$$

$$= 2.9 + 0$$

$$= 2.9$$

Chapter 3.2 | Toy Example에서 본 Loss Function

			
cat	3.2	1.3	2.2
car	5.1	4.9	2.5
frog	-1.7	2.0	-3.1
Losses:	2.9	0	

$$L_i = \sum_{j \neq y_i} \max(0, s_j - s_{y_i} + 1)$$

$$= \max(0, 1.3 - 4.9 + 1)$$

$$+ \max(0, 2.0 - 4.9 + 1)$$

$$= \max(0, -2.6) + \max(0, -1.9)$$

$$= 0 + 0$$

$$= 0$$

Chapter 3.2 | Toy Example에서 본 Loss Function

			
cat	3.2	1.3	2.2
car	5.1	4.9	2.5
frog	-1.7	2.0	-3.1
Losses:	2.9	0	12.9

$$L_i = \sum_{j \neq y_i} \max(0, s_j - s_{y_i} + 1)$$

$$= \max(0, 2.2 - (-3.1) + 1)$$

$$+ \max(0, 2.5 - (-3.1) + 1)$$

$$= \max(0, 6.3) + \max(0, 6.6)$$

$$= 6.3 + 6.6$$

$$= 12.9$$

Chapter 3.2 | Toy Example에서 본 Loss Function

			
cat	3.2	1.3	2.2
car	5.1	4.9	2.5
frog	-1.7	2.0	-3.1
Losses:	2.9	0	12.9

$$L_i = \sum_{j \neq y_i} \max(0, s_j - s_{y_i} + 1)$$

Loss over full dataset is average:

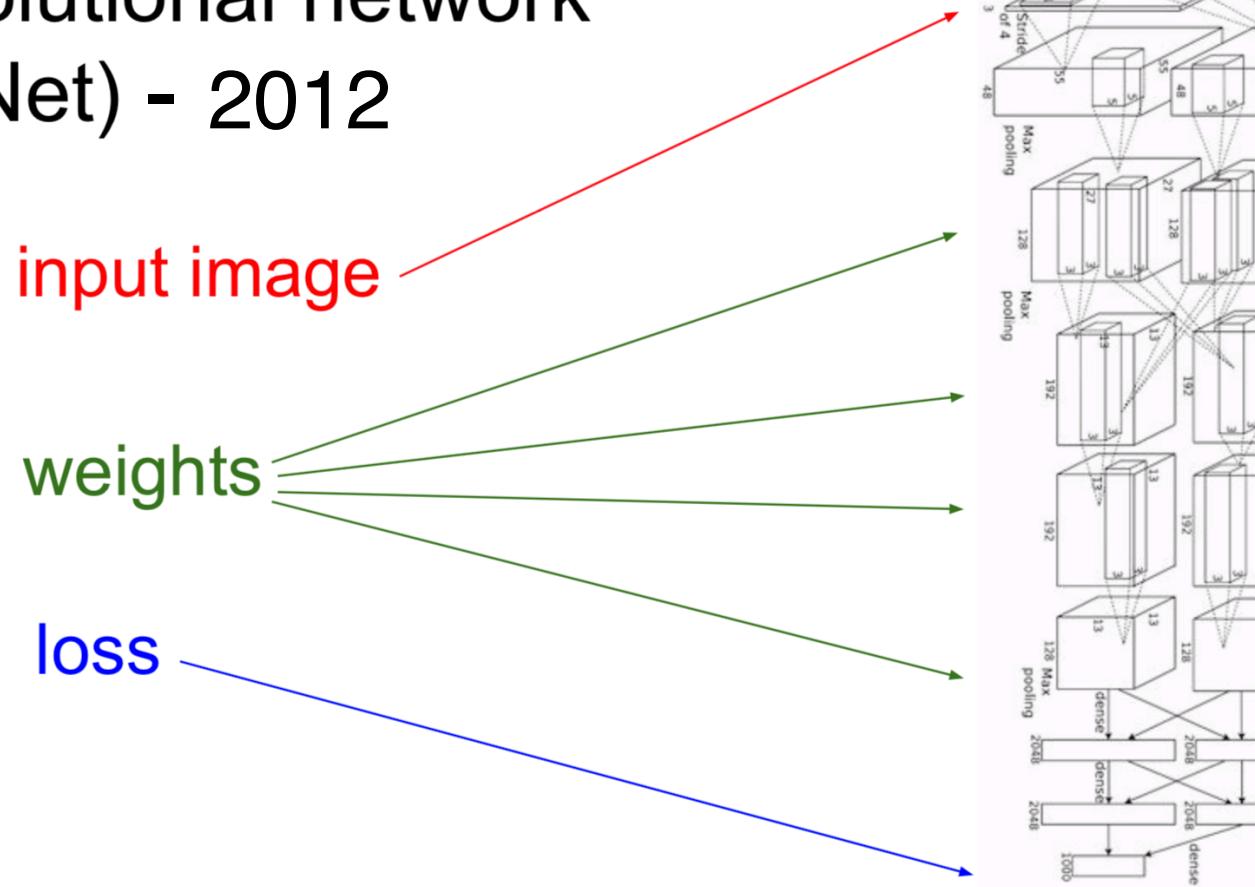
$$\begin{aligned} L &= \frac{1}{N} \sum_{i=1}^N L_i \\ L &= (2.9 + 0 + 12.9)/3 \\ &= \mathbf{5.27} \end{aligned}$$

Chapter 4

역전파

Chapter 4.1 | 점점 복잡해지는 네트워크

Convolutional network (AlexNet) - 2012



Chapter 4.1 | 점점 복잡해지는 네트워크

요즘 NN

input image

loss

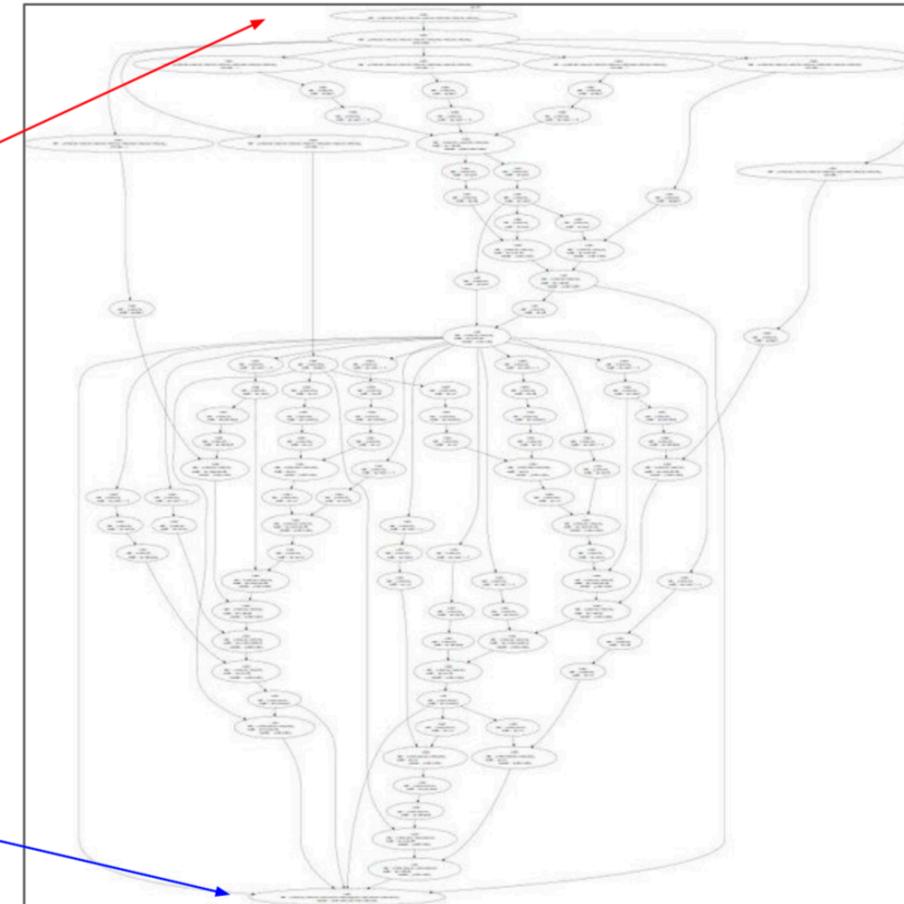
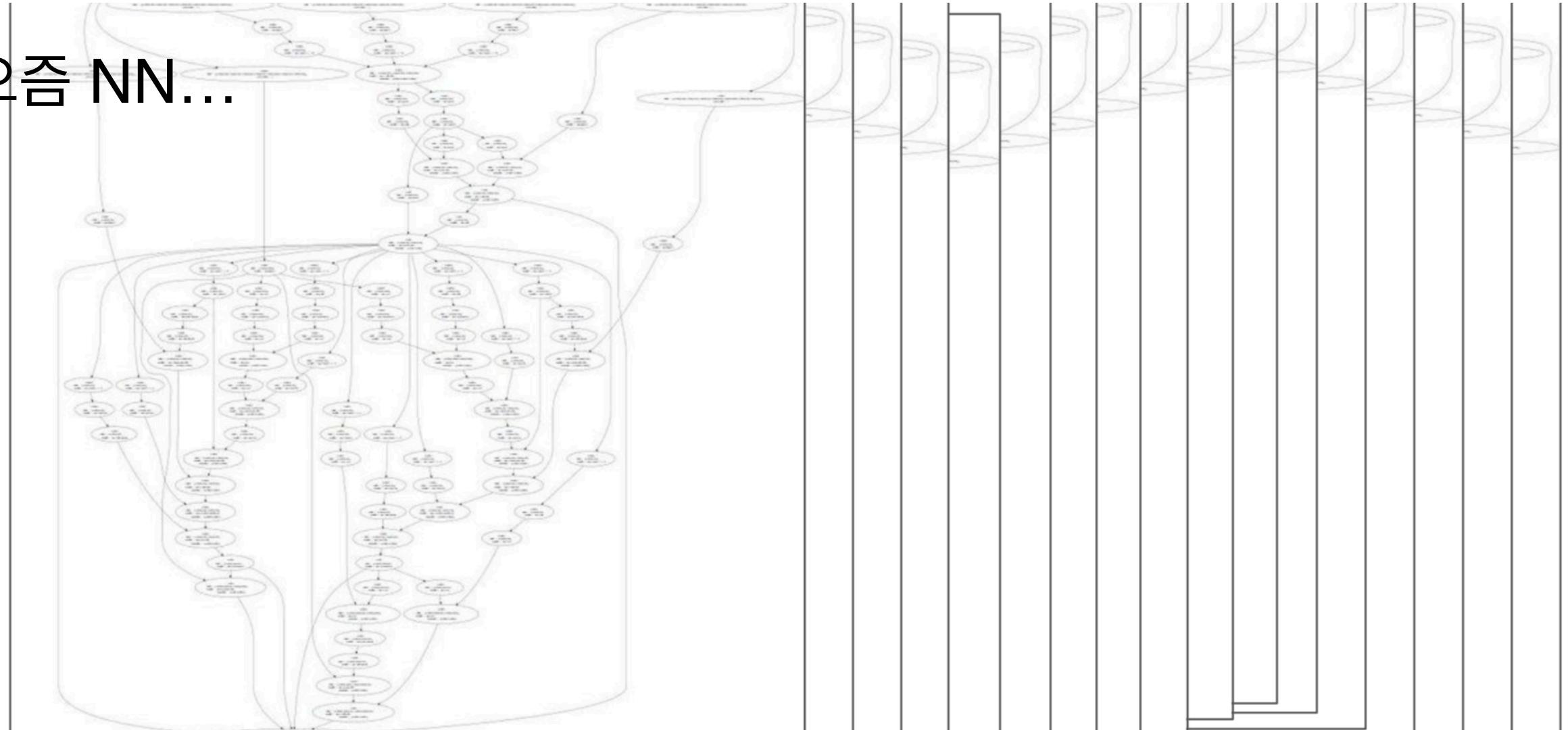


Figure reproduced with permission from a [Twitter post](#) by Andrej Karpathy.

Chapter 4.1 | 점점 복잡해지는 네트워크

요오즘 NN...

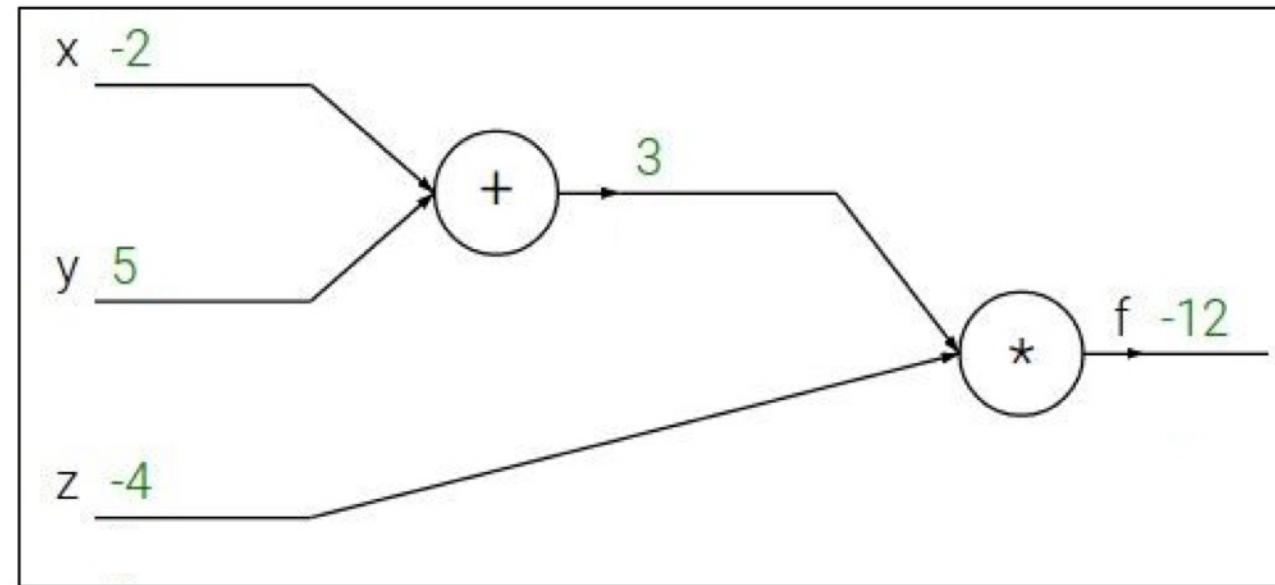


Chapter 4.2 | 간단한 역전파 설명

Backpropagation: a simple example

$$f(x, y, z) = (x + y)z$$

e.g. $x = -2$, $y = 5$, $z = -4$



Chapter 4.2 | 간단한 역전파 설명

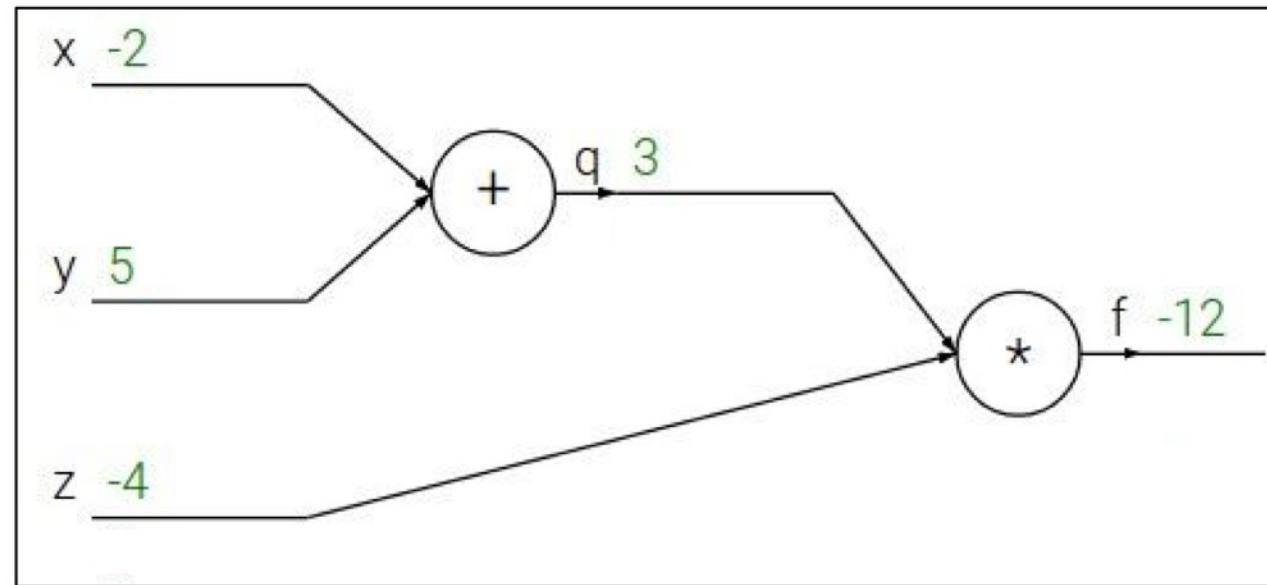
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$$q = x + y \quad \frac{\partial q}{\partial x} = 1, \frac{\partial q}{\partial y} = 1$$

$$f = qz \quad \frac{\partial f}{\partial q} = z, \frac{\partial f}{\partial z} = q$$



Want: $\frac{\partial f}{\partial x}, \frac{\partial f}{\partial y}, \frac{\partial f}{\partial z}$

Chapter 4.2 | 간단한 역전파 설명

Backpropagation: a simple example

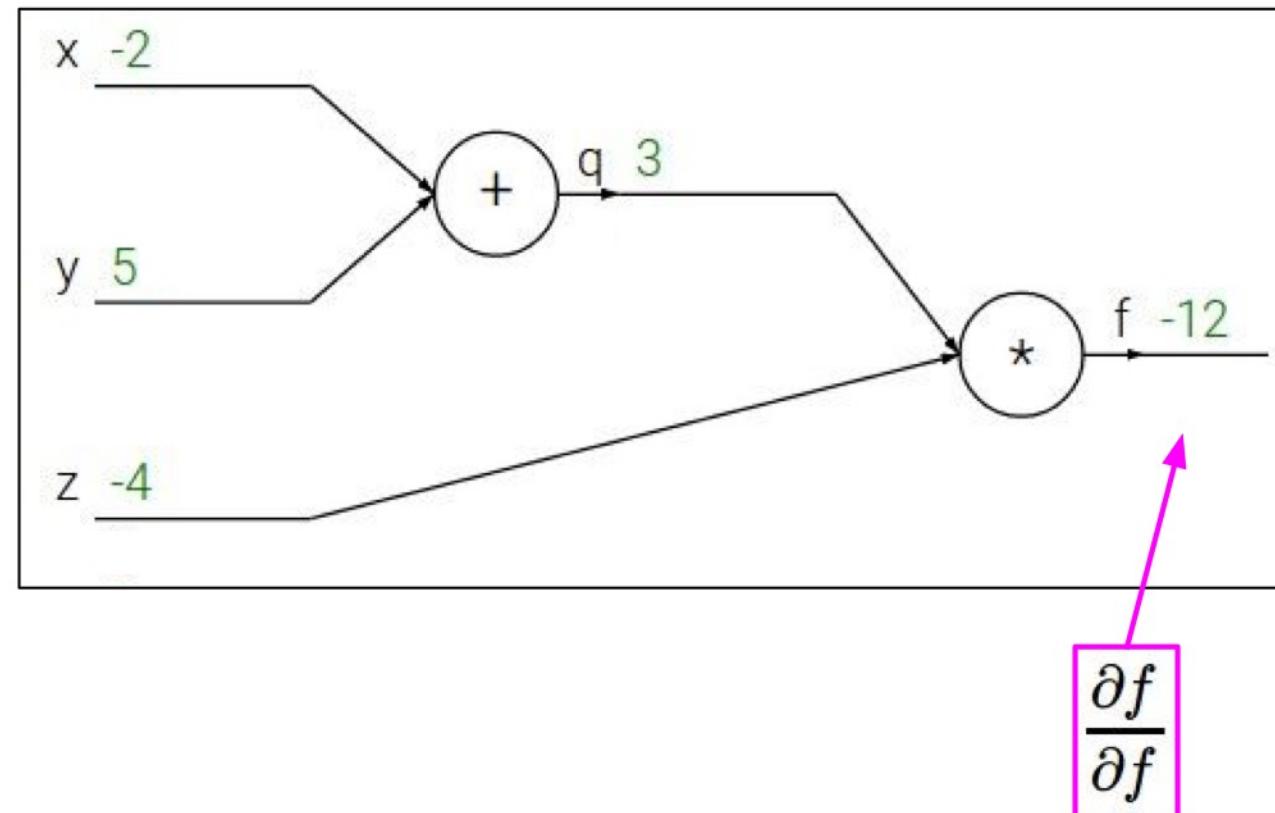
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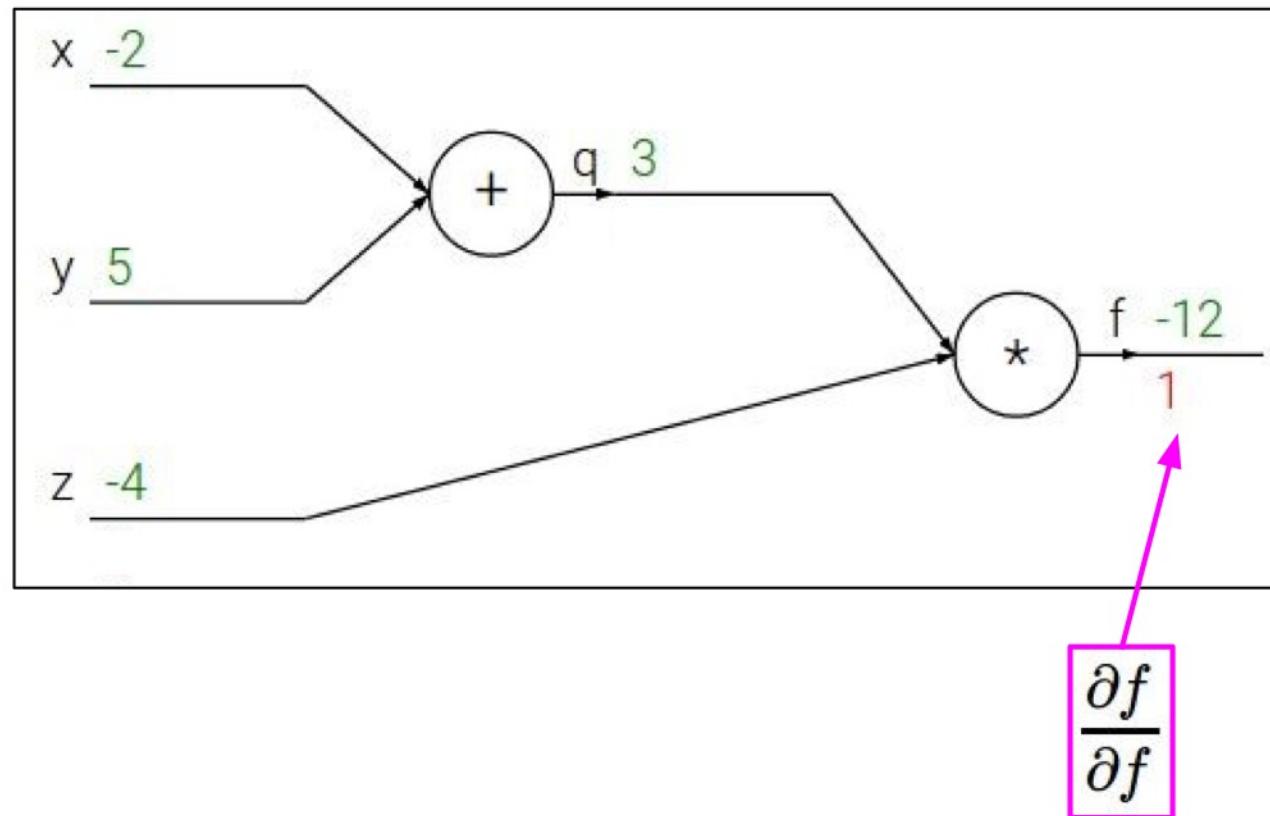
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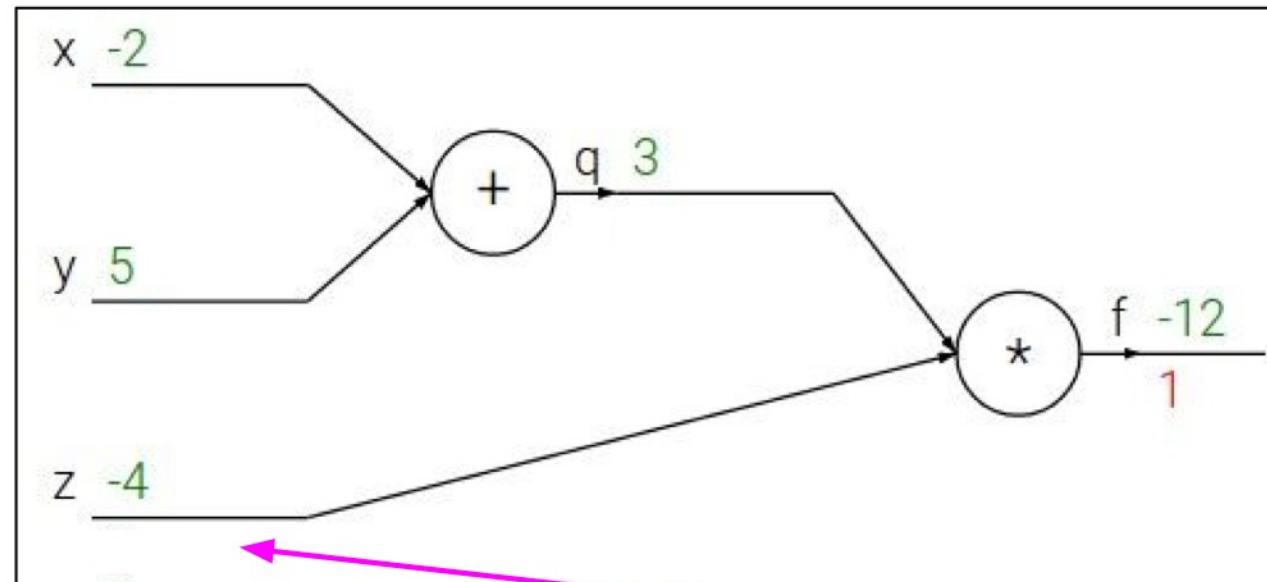
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Chapter 4.2 | 간단한 역전파 설명

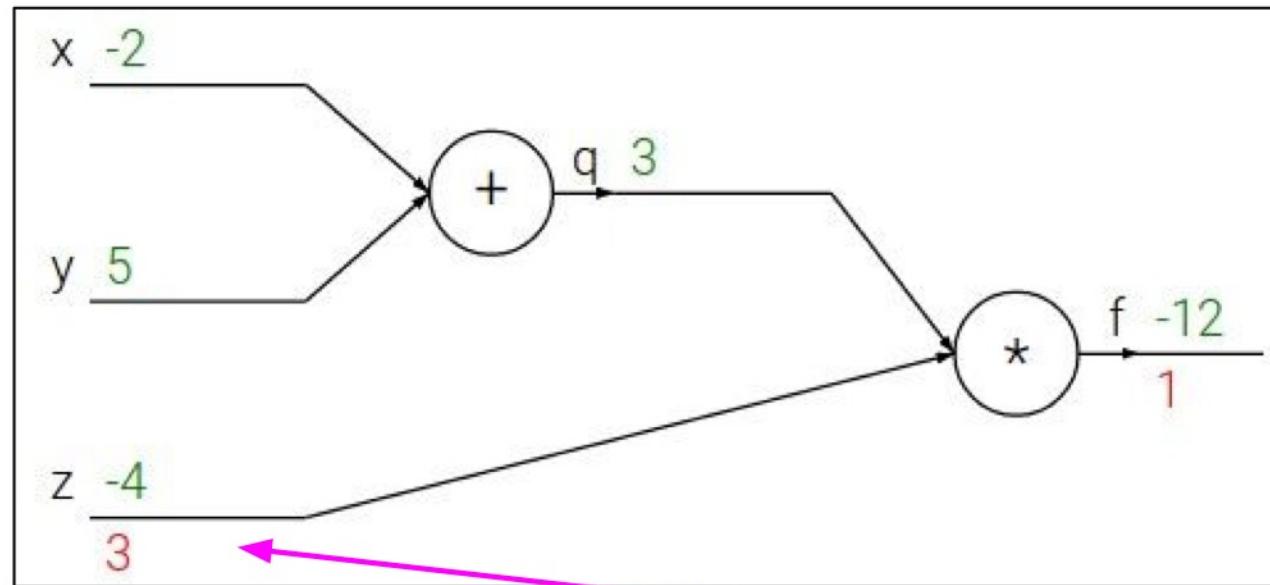
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Want: $\frac{\partial f}{\partial x}, \frac{\partial f}{\partial y}, \frac{\partial f}{\partial z}$

$$\frac{\partial f}{\partial z}$$

Chapter 4.2 | 간단한 역전파 설명

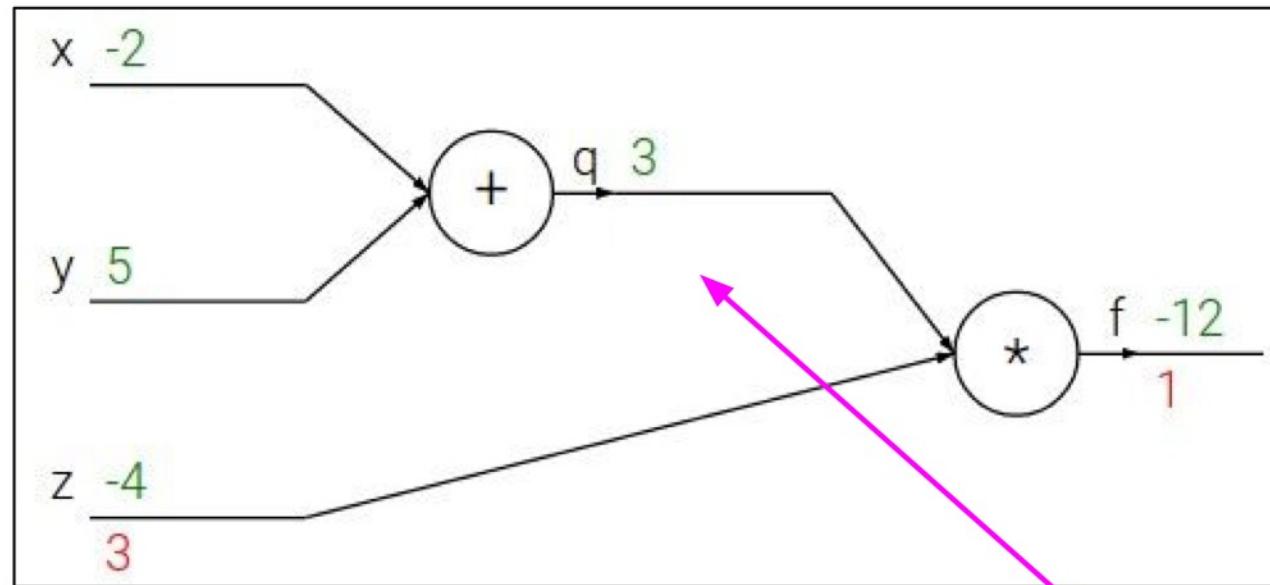
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$$\frac{\partial f}{\partial q}$$

Chapter 4.2 | 간단한 역전파 설명

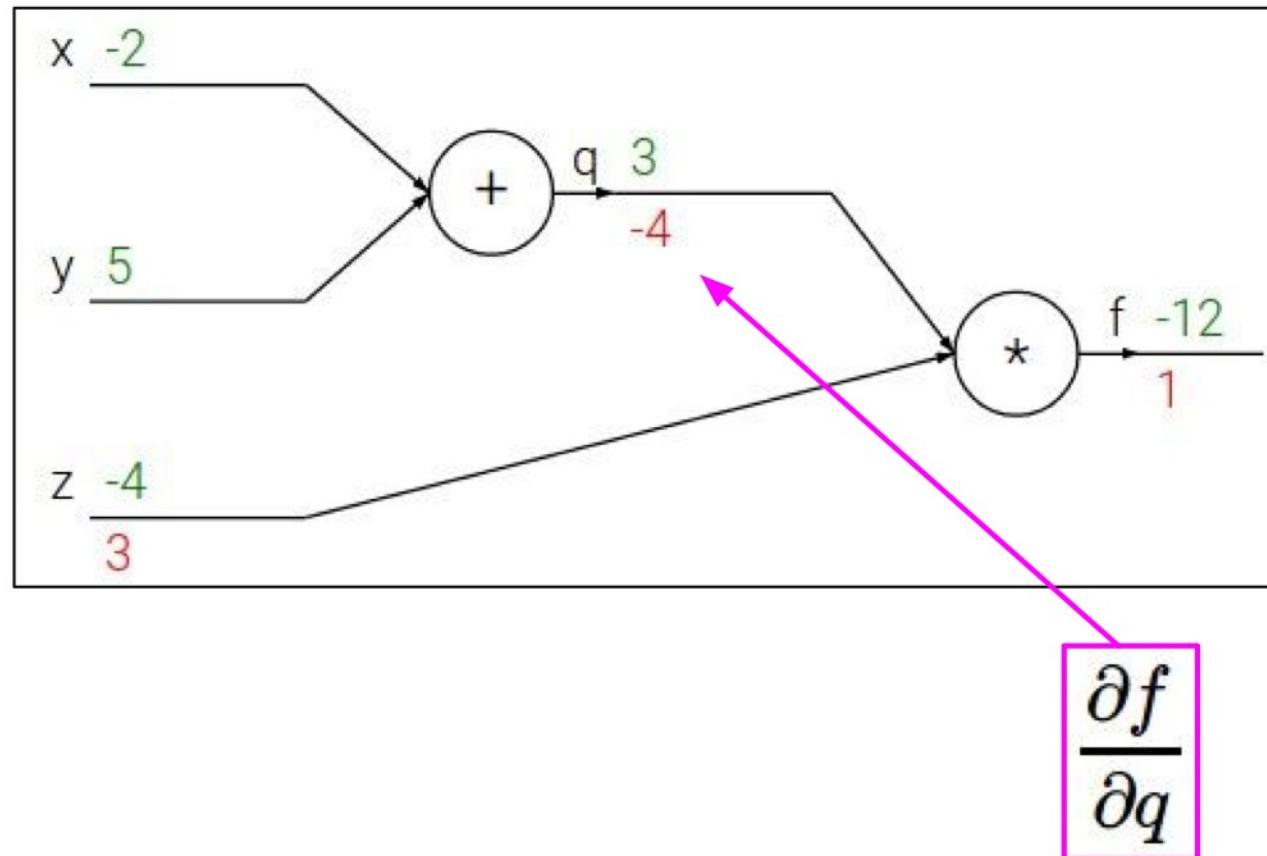
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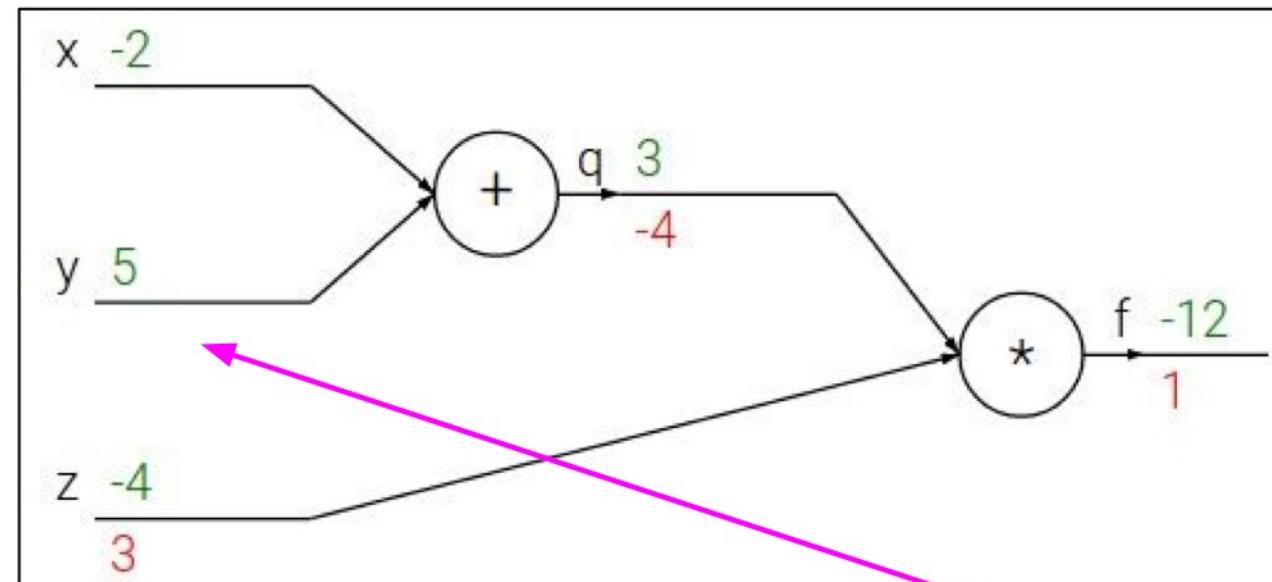
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Chapter 4.2 | 간단한 역전파 설명

Backpropagation: a simple example

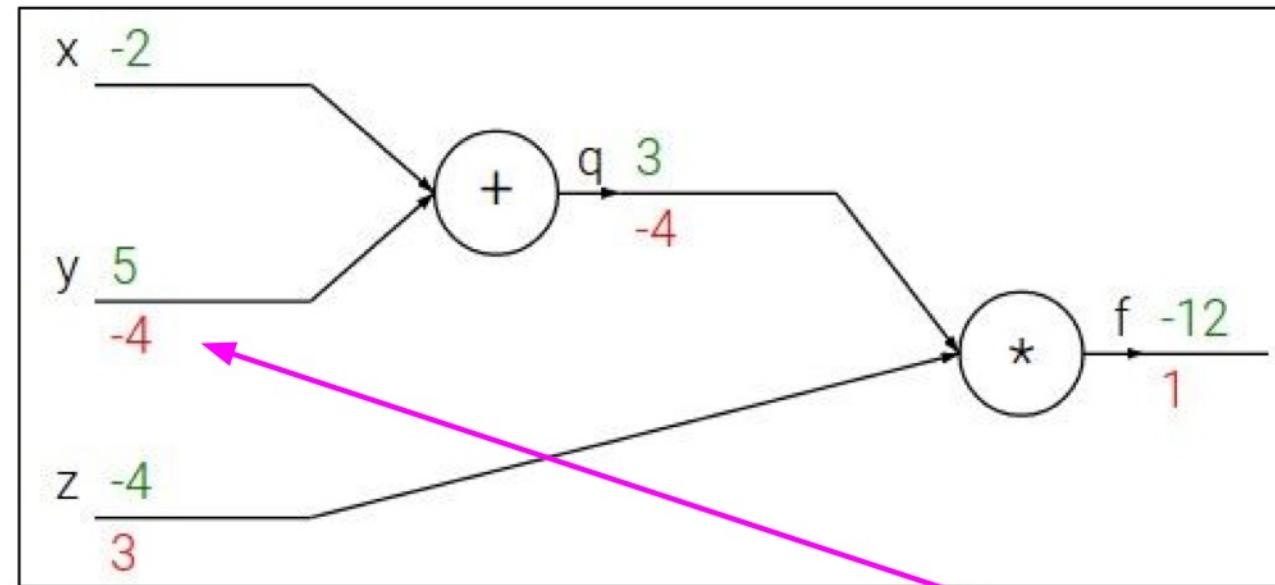
$$f(x, y, z) = (x + y)z$$

e.g. $x = -2$, $y = 5$, $z = -4$

$$q = x + y \quad \frac{\partial q}{\partial x} = 1, \frac{\partial q}{\partial y} = 1$$

$$f = qz \quad \frac{\partial f}{\partial q} = z, \frac{\partial f}{\partial z} = q$$

Want: $\frac{\partial f}{\partial x}, \frac{\partial f}{\partial y}, \frac{\partial f}{\partial z}$



Chain rule:

$$\frac{\partial f}{\partial y} = \frac{\partial f}{\partial q} \frac{\partial q}{\partial y}$$

$$\frac{\partial f}{\partial y}$$

Chapter 4.2 | 간단한 역전파 설명

Backpropagation: a simple example

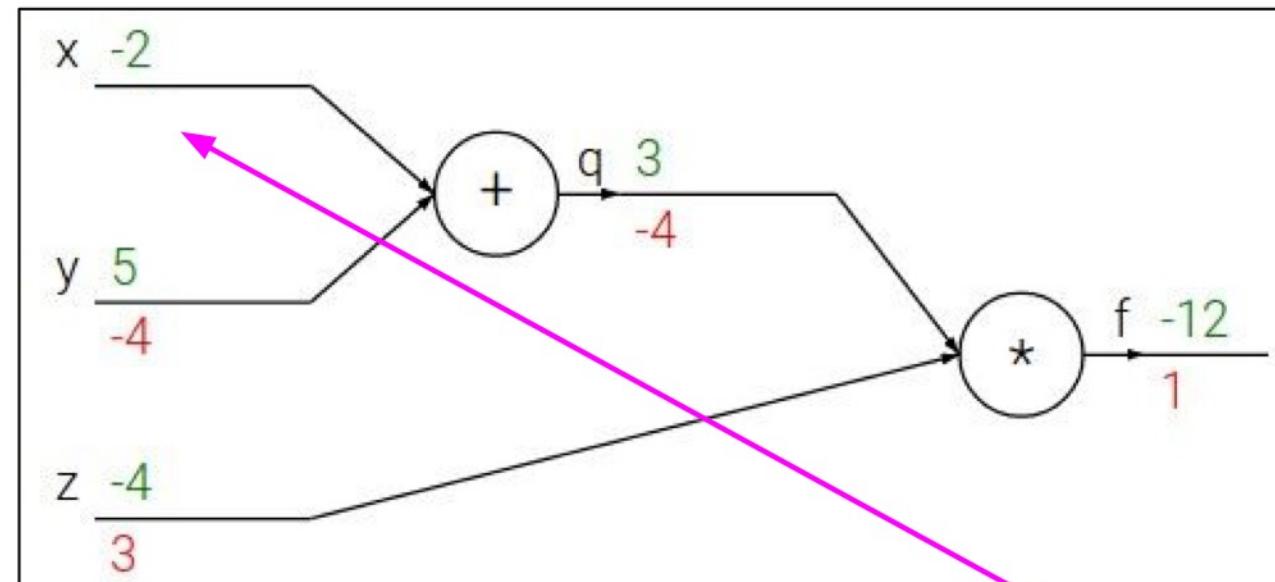
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Want: $\frac{\partial f}{\partial x}, \frac{\partial f}{\partial y}, \frac{\partial f}{\partial z}$



$$\frac{\partial f}{\partial x}$$

Chapter 4.2 | 간단한 역전파 설명

Backpropagation: a simple example

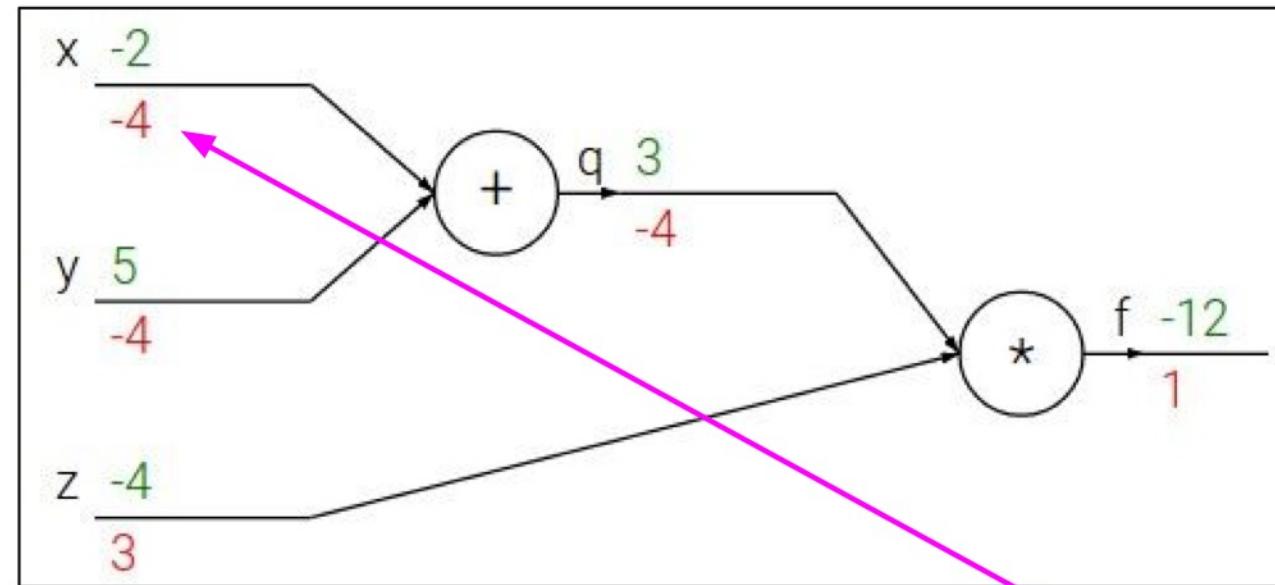
$$f(x, y, z) = (x + y)z$$

e.g. $x = -2$, $y = 5$, $z = -4$

$$q = x + y \quad \frac{\partial q}{\partial x} = 1, \frac{\partial q}{\partial y} = 1$$

$$f = qz \quad \frac{\partial f}{\partial q} = z, \frac{\partial f}{\partial z} = q$$

Want: $\frac{\partial f}{\partial x}, \frac{\partial f}{\partial y}, \frac{\partial f}{\partial z}$

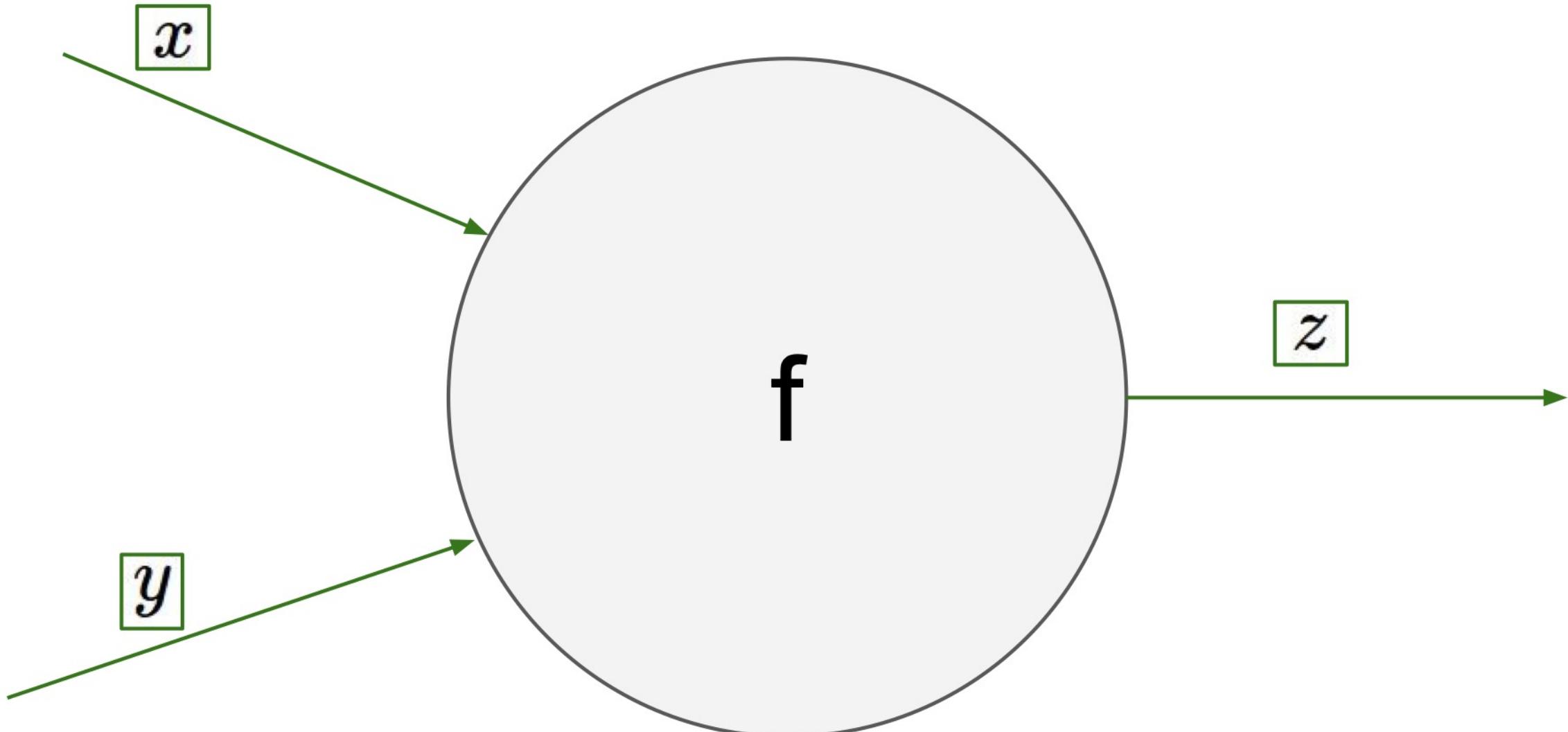


Chain rule:

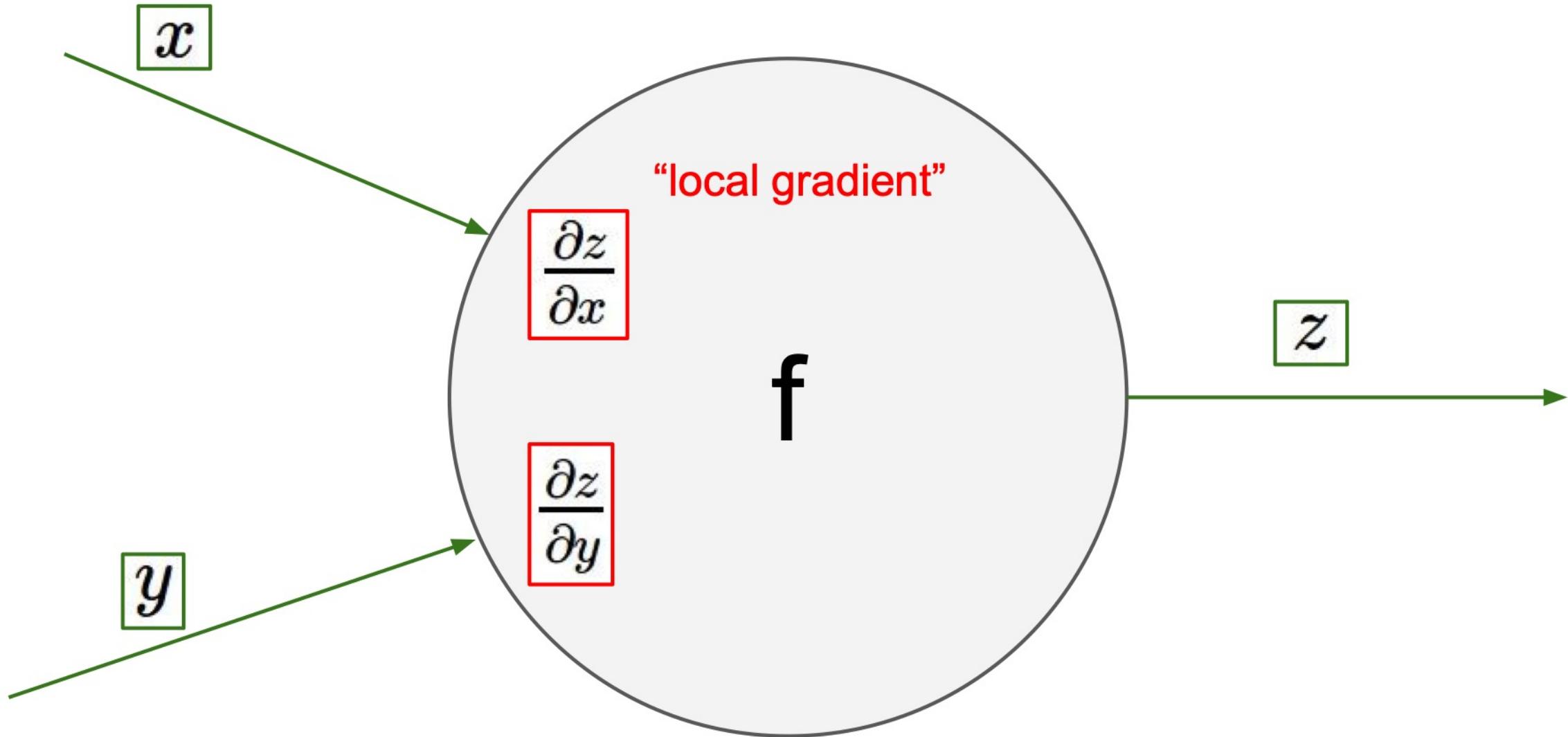
$$\frac{\partial f}{\partial x} = \frac{\partial f}{\partial q} \frac{\partial q}{\partial x}$$

$$\frac{\partial f}{\partial x}$$

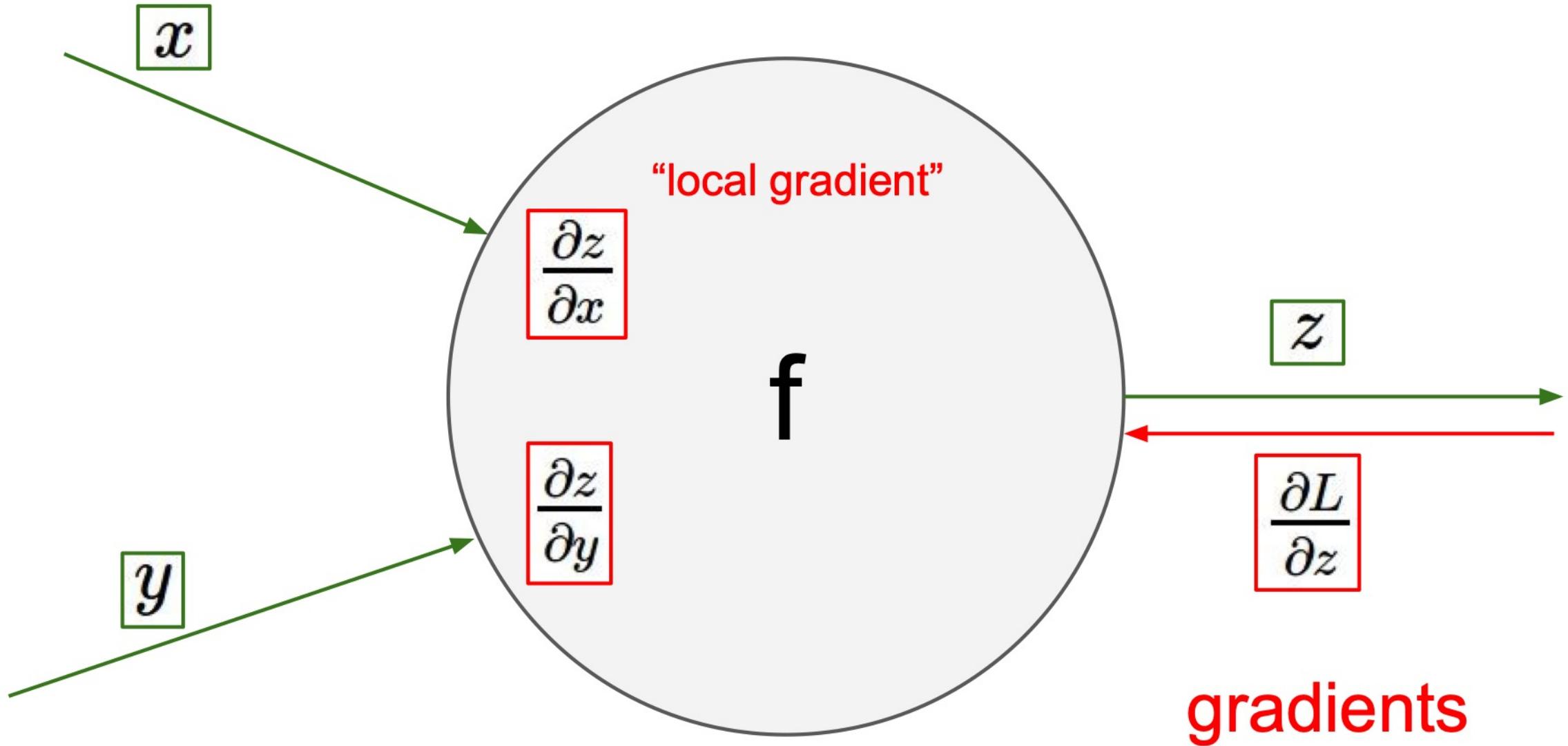
Chapter 4.2 | 간단한 역전파 설명



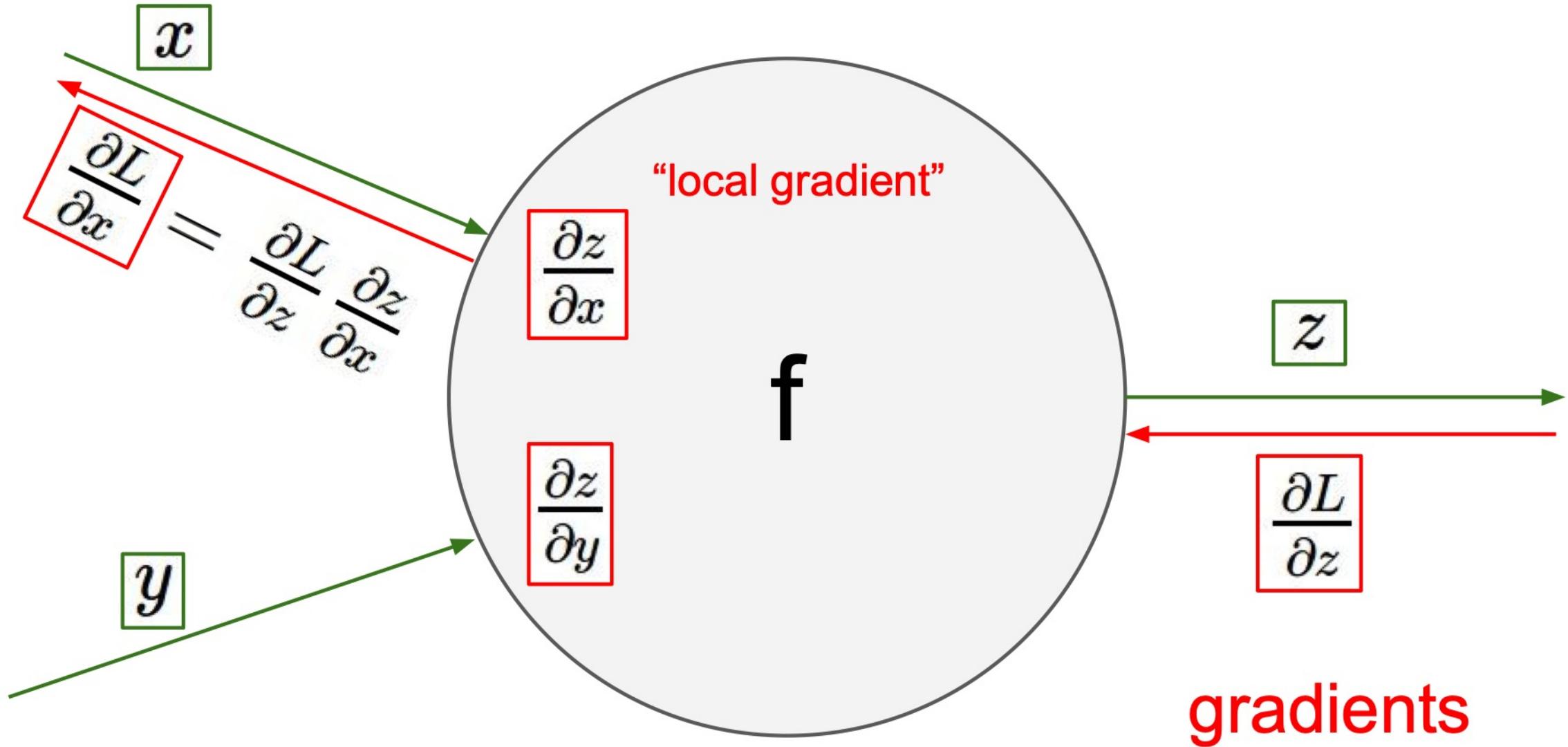
Chapter 4.2 | 간단한 역전파 설명



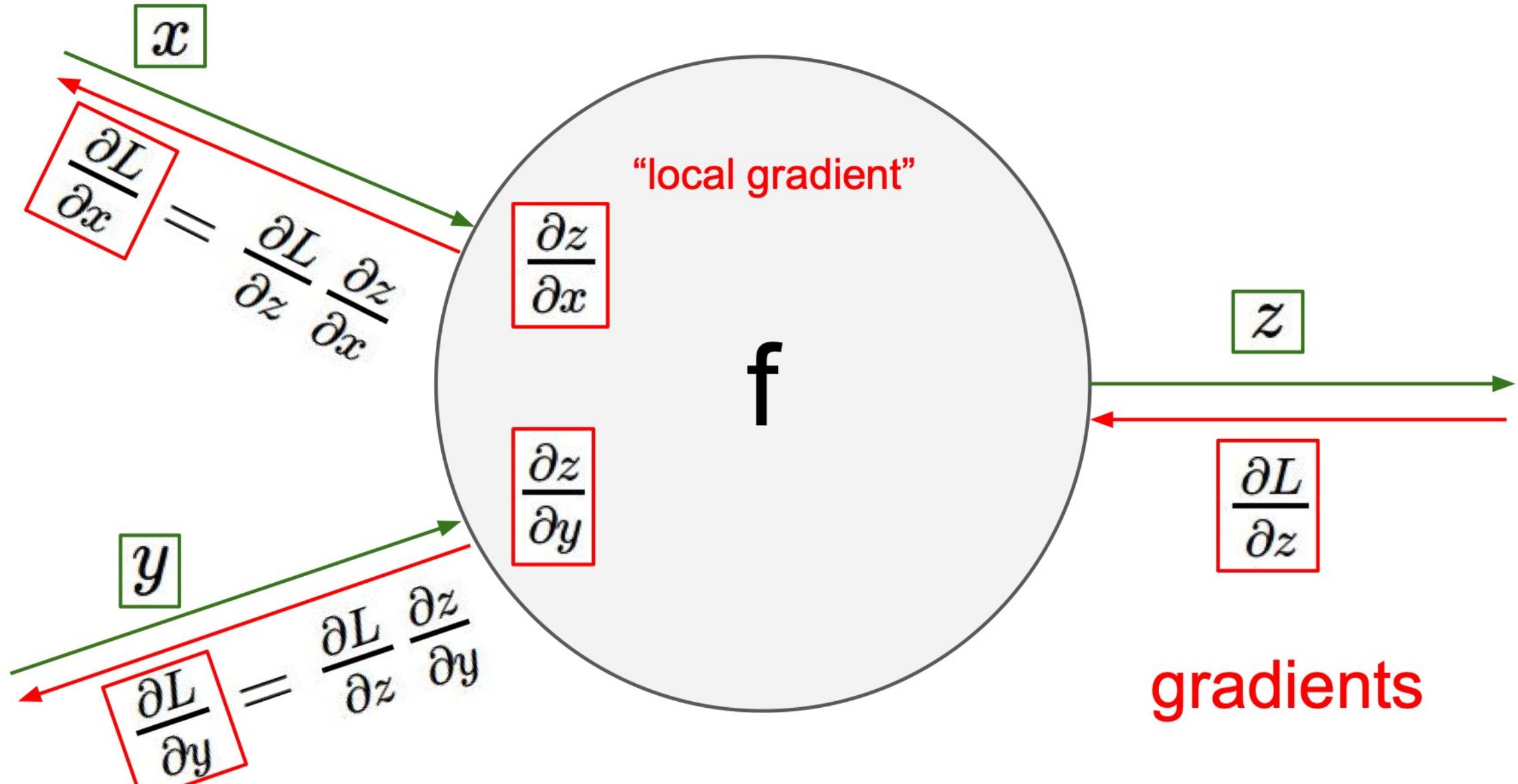
Chapter 4.2 | 간단한 역전파 설명



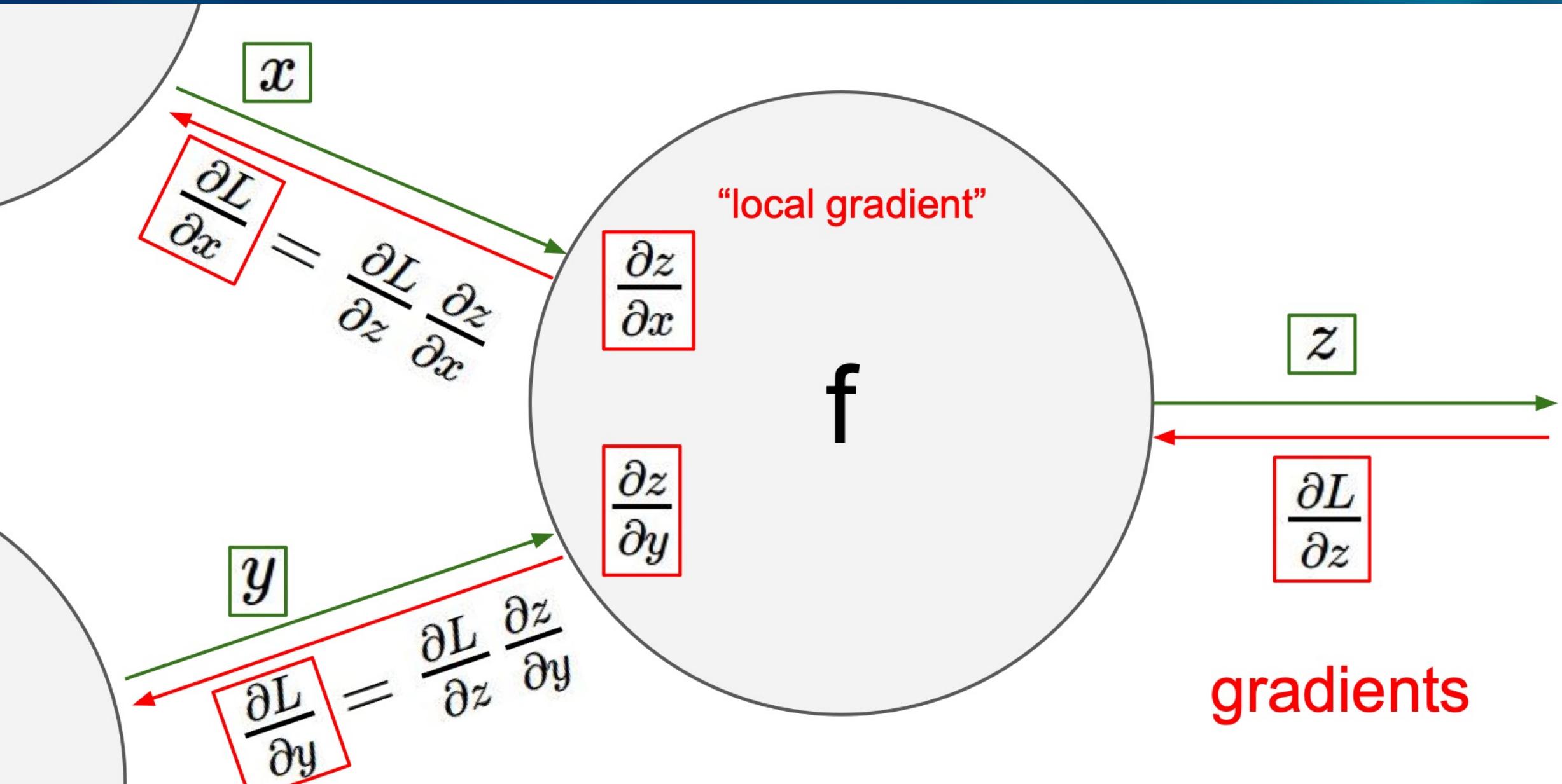
Chapter 4.2 | 간단한 역전파 설명



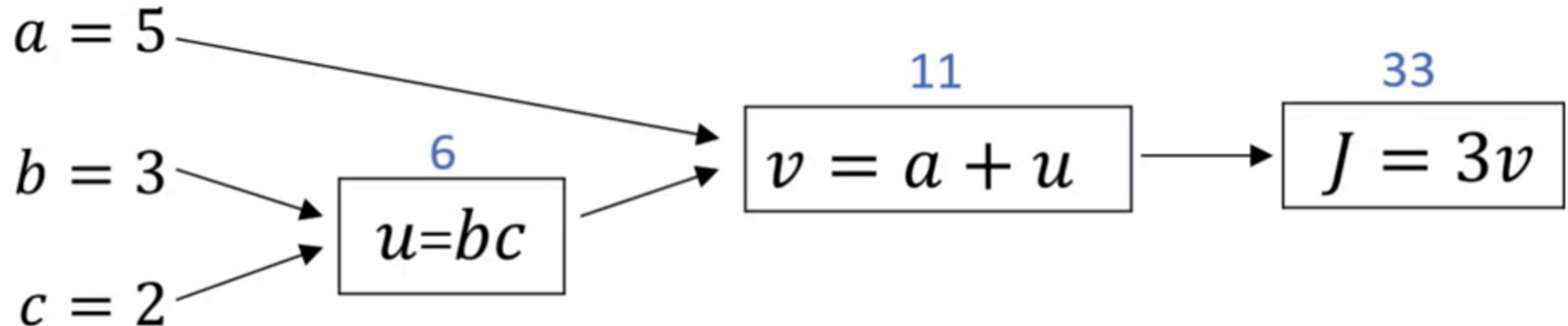
Chapter 4.2 | 간단한 역전파 설명



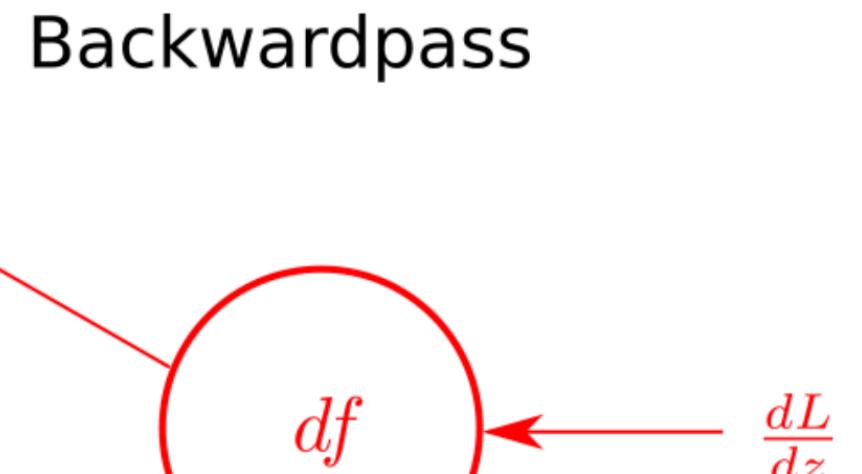
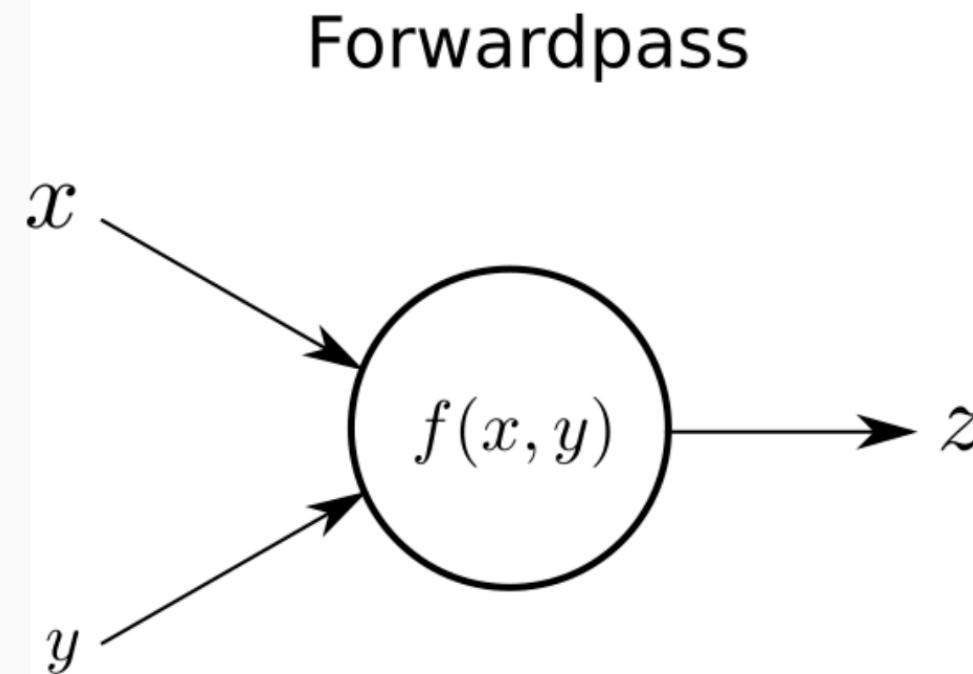
Chapter 4.2 | 간단한 역전파 설명



Chapter 4.3 | Example (직접 해보기)



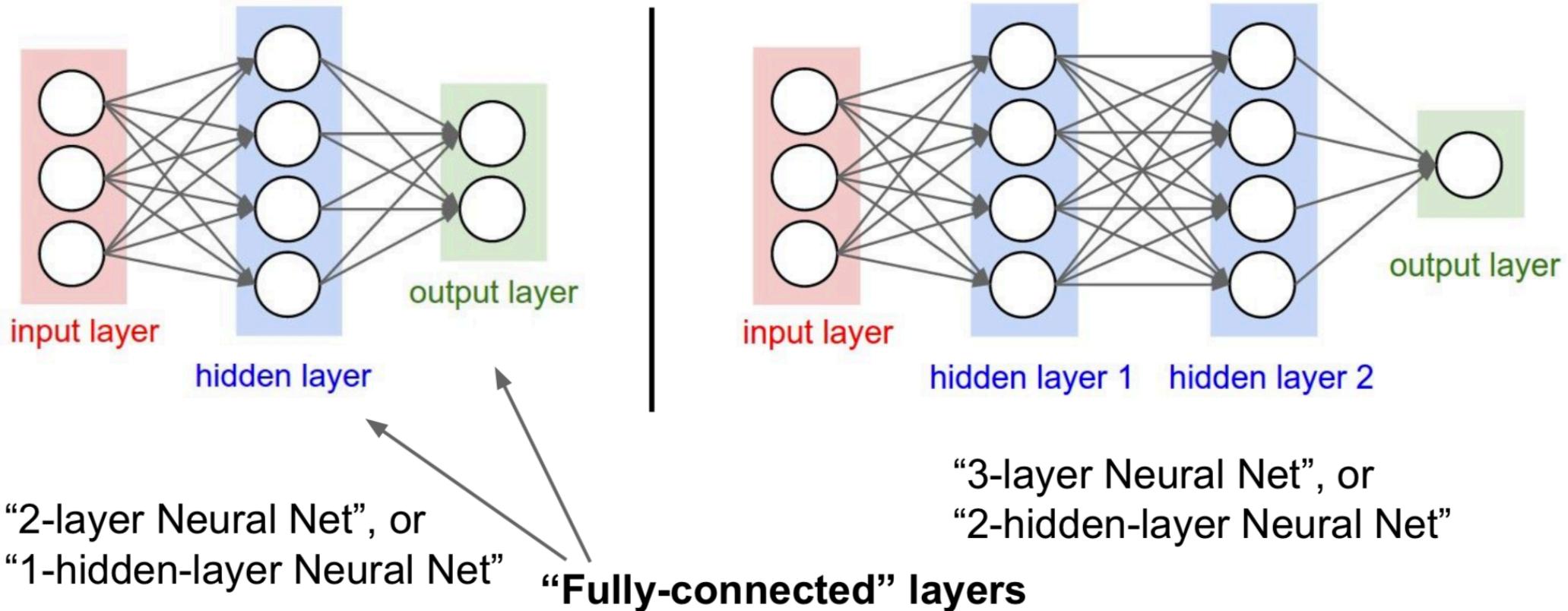
Chapter 4.4 | Forward Pass vs Backward Pass



Chapter 5

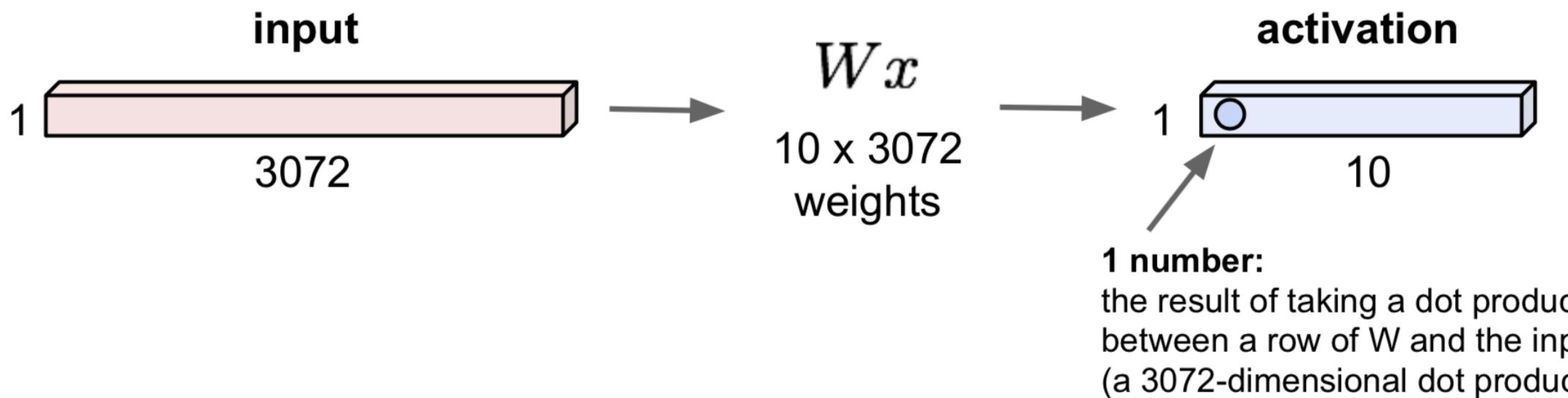
간단한 뉴럴 네트워크 아키텍쳐

Chapter 5.1 | Simple NN 아키텍쳐

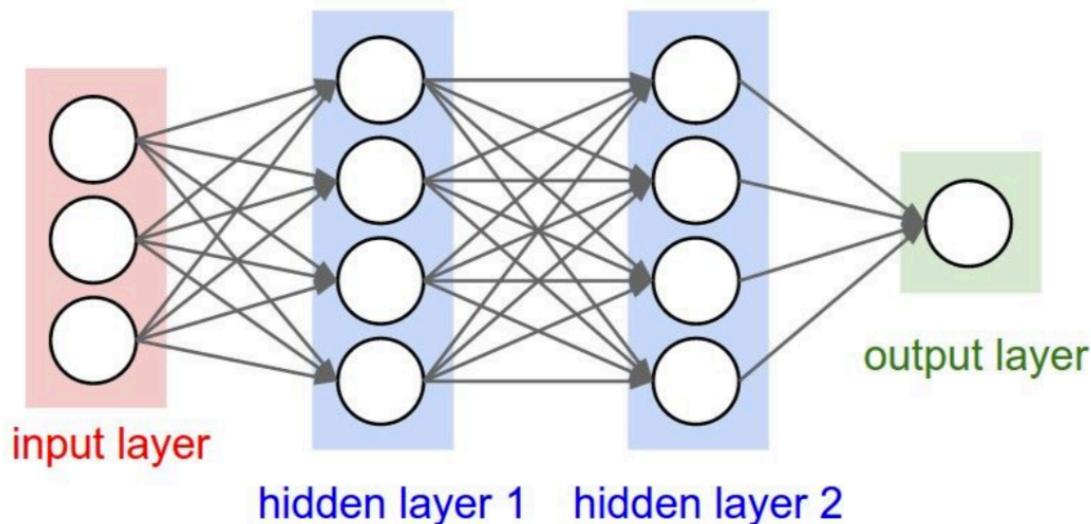


Chapter 5.2 | Fully Connected Layer

32x32x3 image -> stretch to 3072 x 1



Chapter 5.3 | Simple NN 아키텍쳐



```
# forward-pass of a 3-layer neural network:  
f = lambda x: 1.0/(1.0 + np.exp(-x)) # activation function (use sigmoid)  
x = np.random.randn(3, 1) # random input vector of three numbers (3x1)  
h1 = f(np.dot(W1, x) + b1) # calculate first hidden layer activations (4x1)  
h2 = f(np.dot(W2, h1) + b2) # calculate second hidden layer activations (4x1)  
out = np.dot(W3, h2) + b3 # output neuron (1x1)
```



E.O.D