subject:
Page(   )

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الف)

x_{11}	x_{12}	x_{13}
x_{21}	x_{22}	x_{23}
x_{31}	x_{32}	x_{33}

input

w_{11}	w_{12}
w_{21}	w_{22}

Kernel

h_{11}	h_{12}
h_{21}	h_{22}

output

forward(x, w, b) :

$$h_{11} = w_{11}x_{11} + w_{12}x_{12} + w_{21}x_{21} + w_{22}x_{22} + b$$

$$h_{12} = w_{11}x_{12} + w_{12}x_{13} + w_{21}x_{22} + w_{22}x_{23} + b$$

$$h_{21} = w_{11}x_{21} + w_{12}x_{22} + w_{21}x_{31} + w_{22}x_{32} + b$$

$$h_{22} = w_{11}x_{22} + w_{12}x_{23} + w_{21}x_{32} + w_{22}x_{33} + b$$

return h

ب)

$$p = \frac{1}{4}(h_{11} + h_{12} + h_{21} + h_{22})$$

↑ Average pooling

subject:

Page( )

$$\frac{\partial p}{\partial w_{11}} = \frac{1}{4}\left(x_{11} + x_{12} + x_{21} + x_{22}\right) = a_1$$

$$\frac{\partial p}{\partial w_{12}} = \frac{1}{4}\left(x_{12} + x_{13} + x_{22} + x_{23}\right) = a_2$$

$$\frac{\partial p}{\partial w_{21}} = \frac{1}{4}\left(x_{21} + x_{22} + x_{31} + x_{32}\right) = a_3$$

$$\frac{\partial p}{\partial w_{22}} = \frac{1}{4}\left(x_{22} + x_{23} + x_{32} + x_{33}\right) = a_4$$

$$\frac{\partial p}{\partial b} = \frac{1}{4}(1 + 1 + 1 + 1) = 1 \qquad \frac{\partial p}{\partial w} = \begin{bmatrix} a_1 & a_2 \\ a_3 & a_4 \end{bmatrix}$$

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x_{11}	x_{12}	x_{13}
x_{21}	x_{22}	x_{23}
x_{31}	x_{32}	x_{33}

input

v

v_{11}	v_{12}
v_{21}	v_{22}

w

w_{11}	w_{12}
w_{21}	w_{22}

y

y_{11}	y_{12}
y_{21}	y_{22}

z

z_{11}	z_{12}
z_{21}	z_{22}

kernels

$(*_c)$

h_{11}	h_{12}
h_{21}	h_{22}

output

subject:
Page( )

input — kernels — biases

forward $(x, v, w, y, z, b_1, b_2, b_3, b_4)$

$$h_{11} = v_{11}x_{11} + v_{12}x_{12} + v_{21}x_{21} + v_{22}x_{22} + b_1$$

$$h_{12} = w_{11}x_{12} + w_{12}x_{13} + w_{21}x_{23} + w_{22}x_{23} + b_2$$

$$h_{21} = y_{11}x_{21} + y_{12}x_{22} + y_{21}x_{31} + y_{22}x_{32} + b_3$$

$$h_{22} = z_{11}x_{22} + z_{12}x_{23} + z_{21}x_{32} + z_{22}x_{33} + b_4$$

return h

$$p = \frac{1}{4}(h_{11} + h_{12} + h_{21} + h_{22})$$

همه ضریب $\frac{1}{4}$ دارند

$$\frac{\partial p}{\partial v_{11}} = x_{11}, \quad \frac{\partial p}{\partial v_{12}} = x_{12}, \quad \frac{\partial p}{\partial v_{21}} = x_{21}, \quad \frac{\partial p}{\partial v_{22}} = x_{22}$$

$$\frac{\partial p}{\partial w_{11}} = x_{12}, \quad \frac{\partial p}{\partial w_{12}} = x_{13}, \quad \frac{\partial p}{\partial w_{21}} = x_{23}, \quad \frac{\partial p}{\partial w_{22}} = x_{23}$$

$$\frac{\partial p}{\partial y_{11}} = x_{21}, \quad \frac{\partial p}{\partial y_{12}} = x_{22}, \quad \frac{\partial p}{\partial y_{21}} = x_{31}, \quad \frac{\partial p}{\partial y_{22}} = x_{32}$$

$$\frac{\partial p}{\partial z_{11}} = x_{22}, \quad \frac{\partial p}{\partial z_{12}} = x_{23}, \quad \frac{\partial p}{\partial z_{21}} = x_{32}, \quad \frac{\partial p}{\partial z_{22}} = x_{33}$$

subject:

Page( )

$$\frac{\partial p}{\partial b_1} = \frac{1}{4}, \quad \frac{\partial p}{\partial b_2} = \frac{1}{4}, \quad \frac{\partial p}{\partial b_3} = \frac{1}{4}, \quad \frac{\partial p}{\partial b_4} = \frac{1}{4}$$

$$\Rightarrow \frac{\partial p}{\partial v} = \frac{1}{4} \begin{bmatrix} u_{11} & u_{12} \\ u_{21} & u_{22} \end{bmatrix}$$

$$\frac{\partial p}{\partial w} = \frac{1}{4} \begin{bmatrix} u_{12} & u_{13} \\ u_{22} & u_{23} \end{bmatrix}$$

$$\frac{\partial p}{\partial y} = \frac{1}{4} \begin{bmatrix} u_{21} & u_{22} \\ u_{31} & u_{32} \end{bmatrix}$$

$$\frac{\partial p}{\partial z} = \frac{1}{4} \begin{bmatrix} u_{22} & u_{23} \\ u_{32} & u_{33} \end{bmatrix}$$