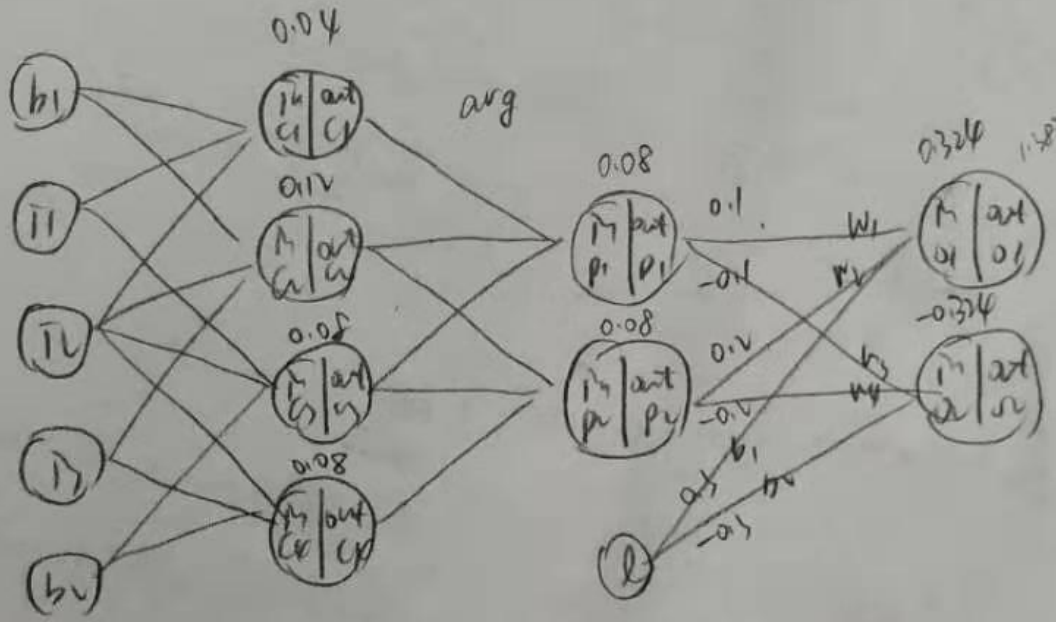
k_{13} $coef_{c1} \cdot i_1 + coef_{c2} \cdot i_2$

$0.3 \quad -0.5(-0.026 * 0.2)$

$0.2 - 0.5(-0.026 \times 0.1 + (-0.146) * 0.3)$

$0.1 - 0.5(-0.146 \times 0.2)$

$coef_{p1}$ $coef_{p2}$



k_{11} $coef_{c1} \cdot i_2 + coef_{c1} \cdot 0$

k_{12} $coef_{c1} \cdot i_1 + coef_{c1} \cdot i_3$

k_{13} $coef_{c1} \cdot 0 + coef_{c1} \cdot i_2$

length

size + stride $\longrightarrow$ length

$(n-1)$

w_{11} w_{12} w_{13}

w_{21} w_{22} w_{23}

w_{31} w_{32} w_{33}

$\frac{n - size}{stride} + 1$ $\quad \frac{length - size}{stride} + 1$

$(n-1)\,stride = length + n - 1 - size$

$00 \;\; 01 \;\; 02 \;\; [k] \;\; [j-k]$

$10 \;\; 11$

$00 \;\; 01 \;\; 02$

$10 \;\; 11 \;\; 12$

$20 \;\; 21 \;\; 23$

$n - 1 = \frac{length - size}{stride}$

$4-3/1$

$1+1$

正向传播

$$in_{C1} = i_1 * k_{12} + i_2 * k_{11} + b_1$$
$$in_{C2} = i_2 * k_{11} + i_3 * k_{12} + b_1$$
$$in_{C3} = i_1 * k_{11} + i_2 * k_{21} + b_1$$
$$in_{C4} = i_2 * k_{13} + i_3 * k_{22} + b_2$$

$$in_{P1} = \frac{1}{3}(out_{C1} + out_{C2} + out_{C3})$$
$$in_{P2} = \frac{1}{3}(out_{C1} + out_{C3} + out_{C4})$$

$$in_{O1} = w_1 out_{P1} + w_2 out_{P2} + b_1$$
$$in_{O2} = w_3 out_{P1} + w_4 out_{P2} + b_1$$

反向传播

$$coef_{O1} = \frac{\partial E_{total}}{\partial in_{O1}} = out_1 - o_1 = 0.657 - 1 = -0.343$$
$$coef_{O2} = \frac{\partial E_{total}}{\partial in_{O2}} = out_2 - o_2 = 0.343 - 0 = 0.343$$

$$w_1 = w_1 - \alpha \frac{\partial E_{total}}{\partial w_1} = w_1 - \alpha \frac{\partial E_{total}}{\partial in_{O1}} \cdot \frac{\partial in_{O1}}{\partial w_1} = w_1 - \alpha \cdot coef_{O1} \cdot out_{P1}$$
$$= 0.1 - 0.5 * (-0.343) * 0.08 = 0.114$$

$$w_2 = w_2 - \alpha \frac{\partial E_{total}}{\partial w_2} = w_2 - \alpha \frac{\partial E_{total}}{\partial in_{O1}} \cdot \frac{\partial in_{O1}}{\partial w_2} = w_2 - \alpha \cdot coef_{O1} \cdot out_{P2}$$
$$= 0.2 - 0.5 * (-0.343) * 0.08 = 0.214$$

$$w_3 = w_3 - \alpha \frac{\partial E_{total}}{\partial w_3} = w_3 - \alpha \frac{\partial E_{total}}{\partial in_{O2}} \cdot \frac{\partial in_{O2}}{\partial w_3} = w_3 - \alpha \cdot coef_{O2} \cdot out_{P1}$$
$$= -0.1 - 0.5 * 0.343 * 0.08 = -0.114$$

$$w_4 = w_4 - \alpha \frac{\partial E_{total}}{\partial w_4} = w_4 - \alpha \frac{\partial E_{total}}{\partial in_{O2}} \cdot \frac{\partial in_{O2}}{\partial w_4} = w_4 - \alpha \cdot coef_{O2} \cdot out_{P2}$$
$$= -0.2 - 0.5 * 0.343 * 0.08 = -0.214$$

$$b_1 = b_1 - \alpha \frac{\partial E_{total}}{\partial b_1} = b_1 - \alpha \cdot \frac{\partial E_{total}}{\partial in_{O1}} \cdot \frac{\partial in_{O1}}{\partial b_1} = b_1 - \alpha \cdot coef_{O1} \cdot 1 = 0.3 - 0.5 * (-0.2$$
$$= 0.472$$

$$b_2 = b_2 - \alpha \frac{\partial E_{total}}{\partial b_2} = b_2 - \alpha \frac{\partial E_{total}}{\partial in_{O2}} \cdot \frac{\partial in_{O2}}{\partial b_2} = b_2 - \alpha \cdot coef_{O2} \cdot 1 = -0.3 - 0.5 * 0.343$$
$$= -0.472$$

$$coef_{P1} = \frac{\partial E_{total}}{\partial in_{P1}} = \left(\frac{\partial E_{total}}{\partial in_{O1}} \cdot \frac{\partial in_{O1}}{\partial out_{P1}} + \frac{\partial E_{total}}{\partial in_{O2}} \cdot \frac{\partial in_{O2}}{\partial out_{P1}}\right) \cdot \frac{\partial out_{P1}}{\partial in_{P1}}$$
$$= (coef_{O1} \cdot w_1 + coef_{O2} \cdot w_3) \cdot 1 = -0.343 * 0.114 + 0.343 * (-0.114) = -$$

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$$coefp_2 = \frac{\partial E_{total}}{\partial inp_2} = \left(\frac{\partial E_{total}}{\partial inO_1} \cdot \frac{\partial inO_1}{\partial outp_2} + \frac{\partial E_{total}}{\partial inO_2} \cdot \frac{\partial inO_2}{\partial outp_2}\right) \frac{\partial outp_2}{\partial inp_2}$$

$$= (coef_{O_1} \cdot w_3 + coef_{O_2} \cdot w_4) \quad (= -0.345 * 0.214 + 0.143 * (-0.114) = -0.104)$$

$$coefc_1 = \frac{\partial E_{total}}{\partial inc_1} = \frac{\partial E_{total}}{\partial inp_1} \cdot \frac{\partial inp_1}{\partial outc_1} \cdot \frac{\partial outc_1}{\partial inc_1} = coefp_1 * w_{11} * 1 = -0.078 * \frac{1}{1} * 1 = -0.026$$

$$coefc_2 = \frac{\partial E_{total}}{\partial inc_2} = \left(\frac{\partial E_{total}}{\partial inp_1} \cdot \frac{\partial inp_1}{\partial outc_2} + \frac{\partial E_{total}}{\partial inp_2} \cdot \frac{\partial inp_2}{\partial outc_2}\right) \frac{\partial outc_2}{\partial inc_2} = coefp_1 * w_{12} + coefp_2 * w_{11}$$

$$= -0.078 * \frac{1}{3} + (-0.114) * \frac{1}{3} = -0.075$$

$$coefc_3 = \frac{\partial E_{total}}{\partial inc_3} = \left(\frac{\partial E_{total}}{\partial inp_1} \cdot \frac{\partial inp_1}{\partial outc_3} + \frac{\partial E_{total}}{\partial inp_2} \cdot \frac{\partial inp_2}{\partial outc_3}\right) \cdot \frac{\partial outc_3}{\partial inc_3} = coefp_1 * w_{13} + coefp_2 * w_{12}$$

$$= -0.078 * \frac{1}{3} + (-0.114) * \frac{1}{3} = -0.075$$

$$coefc_4 = \frac{\partial E_{total}}{\partial inc_4} = \frac{\partial E_{total}}{\partial inp_2} \cdot \frac{\partial inp_2}{\partial outc_4} \cdot \frac{\partial outc_4}{\partial inc_4} = coefp_2 * w_{13} * 1 = -0.147 * \frac{1}{3} * 1 = -0.049$$

w_{11} w_{12} w_{13}
$coefp_1$
$coefp_2$ w_{21} w_{22} w_{23}

$$k_{11} = k_{11} - \alpha \frac{\partial E_{total}}{\partial k_{11}} = k_{11} - \left(\frac{\partial E_{total}}{\partial inc_1} \cdot \frac{\partial inc_1}{\partial k_{11}} + \frac{\partial E_{total}}{\partial inc_2} \cdot \frac{\partial inc_2}{\partial k_{11}}\right) * \alpha$$

$$= k_{11} - (coef_{c_1} \cdot i_2 + coef_{c_2} \cdot 0) * 0.5 = 0.1 - 0.5 * (-0.026 * 0.2 + (-0.075) * 0)$$

$$= 0.103$$

$$k_{12} = k_{12} - \alpha \frac{\partial E_{total}}{\partial k_{12}} = k_{12} - \left(\frac{\partial E_{total}}{\partial inc_1} \cdot \frac{\partial inc_1}{\partial k_{12}} + \frac{\partial E_{total}}{\partial inc_2} \cdot \frac{\partial inc_2}{\partial k_{12}}\right) * \alpha$$

$$= k_{12} - \alpha (coef_{c_1} \cdot i_1 + coef_{c_2} * i_2) = 0.2 - 0.5 * (-0.026 * 0.1 + (-0.075) * 0.1)$$

$$= 0.213$$

$$k_{13} = k_{13} - \alpha \frac{\partial E_{total}}{\partial k_{13}} = k_{13} - \left(\frac{\partial E_{total}}{\partial inc_1} \cdot \frac{\partial inc_1}{\partial k_{13}} + \frac{\partial E_{total}}{\partial inc_2} \cdot \frac{\partial inc_2}{\partial k_{13}}\right) * \alpha$$

$$= k_{13} - \alpha (coef_{c_1} \cdot 0 + coef_{c_2} * i_1) = 0.3 - 0.5 * (-0.026 * 0 + (-0.075) * 0.1)$$

$$= 0.308$$

$$k_{21} = k_{21} - \alpha \frac{\partial E_{total}}{\partial k_{21}} = k_{21} - \left(\frac{\partial E_{total}}{\partial inc_3} \cdot \frac{\partial inc_3}{\partial k_{21}} + \frac{\partial E_{total}}{\partial inc_4} \cdot \frac{\partial inc_4}{\partial k_{21}}\right) * \alpha$$

$$= k_{21} - \alpha (coef_{c_3} \cdot i_2 + coef_{c_4} \cdot 0) = 0.3 - 0.5 * (-0.075 * 0.1 + (-0.049) * 0)$$

$$= 0.308$$

$$k_{22} = k_{22} - \alpha \frac{\partial E_{total}}{\partial k_{22}} = k_{22} - \left(\frac{\partial E_{total}}{\partial inc_3} \cdot \frac{\partial inc_3}{\partial k_{22}} + \frac{\partial E_{total}}{\partial inc_4} \cdot \frac{\partial inc_4}{\partial k_{22}}\right) * \alpha$$

$$= k_{22} - \alpha (coef_{c_3} \cdot i_1 + coef_{c_4} \cdot i_2) = 0.2 - 0.5 * (-0.075 * 0.1 + (-0.049) * 0.2)$$

$$= 0.211$$

$$k_{23} = k_{23} - \alpha \frac{\partial E_{total}}{\partial k_{23}} = k_{23} - \alpha \left(\frac{\partial E_{total}}{\partial inc_3} \cdot \frac{\partial inc_3}{\partial k_{23}} + \frac{\partial E_{total}}{\partial inc_4} \cdot \frac{\partial inc_4}{\partial k_{23}}\right)$$

$$= k_{23} - \alpha (coef_{c_3} \cdot 0 + coef_{c_4} \cdot i_1) = 0.3 - 0.5 * (-0.075 * 0 + (-0.049) * 0.1)$$

$$= 0.305$$

$$b_2 = b_2 - \alpha \frac{\partial E_{total}}{\partial b_2} = b_2 - \alpha\left(\frac{\partial E_{total}}{\partial inc_3} \cdot \frac{\partial inc_3}{\partial b_2} + \frac{\partial E_{total}}{\partial inc_4} \cdot \frac{\partial inc_4}{\partial b_2}\right)$$

$$b_1 = b_1 - \alpha \frac{\partial E_{total}}{\partial b_1} = b_1 - \alpha\left(\frac{\partial E_{total}}{\partial inc_1} \cdot \frac{\partial inc_1}{\partial b_1} + \frac{\partial E_{total}}{\partial inc_2} \cdot \frac{\partial inc_2}{\partial b_1}\right) = b_1 - \alpha(coef_{c_1} * 1 + coef_{c_2} * 1)$$

$$= 0 - 0.5(-0.046 * 1 + (-0.075) * 1) = 0.051$$

$$b_2 = b_2 - \alpha \frac{\partial E_{total}}{\partial b_2} = b_2 - \alpha\left(\frac{\partial E_{total}}{\partial inc_3} \cdot \frac{\partial inc_3}{\partial b_2} + \frac{\partial E_{total}}{\partial inc_4} \cdot \frac{\partial inc_4}{\partial b_2}\right) = b_2 - \alpha(coef_{c_3} * 1 + coef_{c_4} * 1)$$

$$= 0 - 0.5(-0.075 * 1 + (-0.049) * 1) = 0.062$$

0.1 0.2 0.3