



正向传播

$$K_1 \begin{pmatrix} K_{11} & K_{12} & K_{13} \\ 0.1 & 0.2 & 0.3 \end{pmatrix} = 0$$

$$K_2 \begin{pmatrix} K_{21} & K_{22} & K_{23} \\ 0.3 & 0.2 & 0.1 \end{pmatrix} = 0$$

$$\bar{in}_{C1} = \bar{i}_1 * K_{12} + \bar{i}_2 * K_{11} + b_1$$

$$\bar{in}_{C2} = \bar{i}_1 * K_{23} + \bar{i}_2 * K_{22} + \bar{i}_3 * K_{21} + b_1$$

$$\bar{in}_{C3} = \bar{i}_2 * K_{13} + \bar{i}_3 * K_{12} + b_1$$

$$\bar{in}_{C4} = \bar{i}_1 * K_{21} + \bar{i}_2 * K_{22} + b_2$$

$$\bar{in}_{C5} = \bar{i}_1 * K_{23} + \bar{i}_2 * K_{22} + \bar{i}_3 * K_{21} + b_2$$

$$\bar{in}_{C6} = \bar{i}_2 * K_{23} + \bar{i}_3 * K_{21} + b_2$$

$$\bar{in}_{p1} = \frac{1}{3} (\bar{in}_{C1} + \bar{in}_{C2} + \bar{in}_{C3})$$

$$\bar{in}_{p2} = \frac{1}{3} (\bar{in}_{C4} + \bar{in}_{C5} + \bar{in}_{C6})$$

$$\bar{in}_{o1} = \text{out}_{p1} * w_1 + \text{out}_{p2} * w_2 + b_1$$

$$\bar{in}_{o2} = \text{out}_{p1} * w_3 + \text{out}_{p2} * w_4 + b_2$$

反向传播

$$\text{coef}_{o1} = \frac{\partial E_{\text{total}}}{\partial \bar{in}_{o1}} = \text{out}_{o1} - o_1 = 0.659 - 1 = -0.341$$

$$\text{coef}_{o2} = \frac{\partial E_{\text{total}}}{\partial \bar{in}_{o2}} = \text{out}_{o2} - o_2 = 0.341 - 0 = 0.341$$

$$w_1 = w_1 - \alpha \frac{\partial E_{\text{total}}}{\partial w_1} = w_1 - \alpha \cdot \frac{\partial E_{\text{total}}}{\partial \bar{in}_{o1}} \cdot \frac{\partial \bar{in}_{o1}}{\partial w_1} = w_1 - \alpha \text{coef}_{o1} \cdot \text{out}_{p1}$$

$$= 0.1 - 0.5 \cdot (-0.341) * 0.087 = 0.115$$

$$w_2 = w_2 - \alpha \frac{\partial E_{\text{total}}}{\partial w_2} = w_2 - \alpha \frac{\partial E_{\text{total}}}{\partial \bar{in}_{o2}} \cdot \frac{\partial \bar{in}_{o2}}{\partial w_2} = w_2 - \alpha \text{coef}_{o2} \cdot \text{out}_{p2}$$

$$= 0.2 - 0.5 \cdot (0.341) * 0.1 = 0.217$$

$$w_3 = w_3 - \alpha \frac{\partial E_{\text{total}}}{\partial w_3} = w_3 - \alpha \frac{\partial E_{\text{total}}}{\partial \bar{in}_{o1}} \cdot \frac{\partial \bar{in}_{o1}}{\partial w_3} = w_3 - \alpha \text{coef}_{o1} \cdot \text{out}_{p1}$$

$$= -0.1 - 0.5 \cdot 0.341 * 0.087 = -0.415$$

$$w_4 = w_4 - \alpha \frac{\partial E_{\text{total}}}{\partial w_4} = w_4 - \alpha \frac{\partial E_{\text{total}}}{\partial \bar{in}_{o2}} \cdot \frac{\partial \bar{in}_{o2}}{\partial w_4} = w_4 - \alpha \text{coef}_{o2} \cdot \text{out}_{p2}$$

$$= -0.2 - 0.5 * 0.341 * 0.1 = -0.217$$

$$b_1 = b_1 - \alpha \frac{\partial E_{\text{Total}}}{\partial b_1} = b_1 - \alpha \cdot \frac{\partial E_{\text{Total}}}{\partial b_{11}} \cdot \frac{\partial b_{11}}{\partial b_1} = b_1 - \alpha \cdot \text{coef}_{b1} = 0.3 - 0.5 \cdot (-0.341) = 0.471$$

$$b_2 = b_2 - \alpha \frac{\partial E_{\text{Total}}}{\partial b_2} = b_2 - \alpha \frac{\partial E_{\text{Total}}}{\partial b_{12}} \cdot \frac{\partial b_{12}}{\partial b_2} = b_2 - \alpha \cdot \text{coef}_{b2} = -0.1 - 0.5 \cdot 0.341 = -0.471$$

$$\text{coef}_{p1} = \frac{\partial E_{\text{Total}}}{\partial b_{1p1}} = \left(\frac{\partial E_{\text{Total}}}{\partial b_{11p1}} \cdot \frac{\partial b_{11p1}}{\partial b_{1p1}} + \frac{\partial E_{\text{Total}}}{\partial b_{12p1}} \cdot \frac{\partial b_{12p1}}{\partial b_{1p1}} \right) \cdot \frac{\partial \text{out}_{p1}}{\partial b_{1p1}}$$

$$= (\text{coef}_{b1} \cdot w_1 + \text{coef}_{b2} \cdot w_3) * 1 = (0.341 * 0.115 + 0.341 * (-0.115)) = -0.078$$

$$\text{coef}_{p2} = \frac{\partial E_{\text{Total}}}{\partial b_{1p2}} = \left(\frac{\partial E_{\text{Total}}}{\partial b_{11p2}} \cdot \frac{\partial b_{11p2}}{\partial b_{1p2}} + \frac{\partial E_{\text{Total}}}{\partial b_{12p2}} \cdot \frac{\partial b_{12p2}}{\partial b_{1p2}} \right) \frac{\partial \text{out}_{p2}}{\partial b_{1p2}}$$

$$= (\text{coef}_{b1} \cdot w_2 + \text{coef}_{b2} \cdot w_4) * 1 = (-0.341 * 0.217 + 0.341 * (-0.217)) = -0.148$$

$$\text{coef}_{c1} = \frac{\partial E_{\text{Total}}}{\partial b_{1c1}} = \frac{\partial E_{\text{Total}}}{\partial b_{1p1}} \cdot \frac{\partial b_{1p1}}{\partial \text{out}_{c1}} \cdot \frac{\partial \text{out}_{c1}}{\partial b_{1c1}} = \text{coef}_{p1} \cdot w_{11} * 1 = -0.078 * \frac{1}{3} * 1 = -0.026$$

$$\text{coef}_{c2} = \frac{\partial E_{\text{Total}}}{\partial b_{1c2}} = \frac{\partial E_{\text{Total}}}{\partial b_{1p1}} \cdot \frac{\partial b_{1p1}}{\partial \text{out}_{c2}} \cdot \frac{\partial \text{out}_{c2}}{\partial b_{1c2}} = \text{coef}_{p1} \cdot w_{12} * 1 = -0.078 * \frac{1}{3} * 1 = -0.026$$

$$\text{coef}_{c3} = \frac{\partial E_{\text{Total}}}{\partial b_{1c3}} = \frac{\partial E_{\text{Total}}}{\partial b_{1p1}} \cdot \frac{\partial b_{1p1}}{\partial \text{out}_{c3}} \cdot \frac{\partial \text{out}_{c3}}{\partial b_{1c3}} = \text{coef}_{p1} \cdot w_{13} * 1 = -0.078 * \frac{1}{3} * 1 = -0.026$$

$$\text{coef}_{c4} = \frac{\partial E_{\text{Total}}}{\partial b_{1c4}} = \frac{\partial E_{\text{Total}}}{\partial b_{1p2}} \cdot \frac{\partial b_{1p2}}{\partial \text{out}_{c4}} \cdot \frac{\partial \text{out}_{c4}}{\partial b_{1c4}} = \text{coef}_{p2} \cdot w_{21} * 1 = -0.148 * \frac{1}{3} * 1 = -0.049$$

$$\text{coef}_{c5} = \frac{\partial E_{\text{Total}}}{\partial b_{1c5}} = \frac{\partial E_{\text{Total}}}{\partial b_{1p2}} \cdot \frac{\partial b_{1p2}}{\partial \text{out}_{c5}} \cdot \frac{\partial \text{out}_{c5}}{\partial b_{1c5}} = \text{coef}_{p2} \cdot w_{22} * 1 = -0.148 * \frac{1}{3} * 1 = -0.049$$

$$\text{coef}_{c6} = \frac{\partial E_{\text{Total}}}{\partial b_{1c6}} = \frac{\partial E_{\text{Total}}}{\partial b_{1p2}} \cdot \frac{\partial b_{1p2}}{\partial \text{out}_{c6}} \cdot \frac{\partial \text{out}_{c6}}{\partial b_{1c6}} = \text{coef}_{p2} \cdot w_{23} * 1 = -0.148 * \frac{1}{3} * 1 = -0.049$$

$$k_{11} = k_{11} - \alpha \frac{\partial E_{\text{Total}}}{\partial k_{11}} = k_{11} - \alpha \left(\frac{\partial E_{\text{Total}}}{\partial b_{1c1}} \cdot \frac{\partial b_{1c1}}{\partial k_{11}} + \frac{\partial E_{\text{Total}}}{\partial b_{1c2}} \cdot \frac{\partial b_{1c2}}{\partial k_{11}} + \frac{\partial E_{\text{Total}}}{\partial b_{1c3}} \cdot \frac{\partial b_{1c3}}{\partial k_{11}} \right)$$

$$= k_{11} - \alpha (\text{coef}_{c1} \cdot i_2 + \text{coef}_{c2} \cdot i_3 + \text{coef}_{c3} \cdot 0)$$

$$= 0.1 - 0.5 (-0.026 * 0.1 + (-0.026) * 0.1 + (-0.026) * 0) = 0.107$$

$$k_{12} = k_{12} - \alpha \frac{\partial E_{\text{Total}}}{\partial k_{12}} = k_{12} - \alpha \left(\frac{\partial E_{\text{Total}}}{\partial b_{1c1}} \cdot \frac{\partial b_{1c1}}{\partial k_{12}} + \frac{\partial E_{\text{Total}}}{\partial b_{1c2}} \cdot \frac{\partial b_{1c2}}{\partial k_{12}} + \frac{\partial E_{\text{Total}}}{\partial b_{1c3}} \cdot \frac{\partial b_{1c3}}{\partial k_{12}} \right)$$

$$= k_{12} - \alpha (\text{coef}_{c1} \cdot i_1 + \text{coef}_{c2} \cdot i_2 + \text{coef}_{c3} \cdot i_3)$$

$$= 0.2 - 0.5 (-0.026 * 0.1 + (-0.026) * 0.1 + (-0.026) * 0.1) = 0.208$$

$$k_{13} = k_{13} - \alpha \frac{\partial E_{\text{Total}}}{\partial k_{13}} = k_{13} - \alpha \left(\frac{\partial E_{\text{Total}}}{\partial b_{1c1}} \cdot \frac{\partial b_{1c1}}{\partial k_{13}} + \frac{\partial E_{\text{Total}}}{\partial b_{1c2}} \cdot \frac{\partial b_{1c2}}{\partial k_{13}} + \frac{\partial E_{\text{Total}}}{\partial b_{1c3}} \cdot \frac{\partial b_{1c3}}{\partial k_{13}} \right)$$

$$= k_{13} - \alpha (\text{coef}_{c1} \cdot 0 + \text{coef}_{c2} \cdot i_1 + \text{coef}_{c3} \cdot i_2)$$

$$= 0.3 - 0.5 (-0.026 * 0 + (-0.026) * 0.1 + (-0.026) * 0.1) = 0.304$$

0	i_1	i_2	i_3	0
			coef_{c23}	
			k_{11}	
				k_{12}
				k_{13}

$$k_{21} = k_{21} - \alpha \frac{\partial E_{\text{total}}}{\partial k_{21}} = k_{21} - \alpha \left(\frac{\partial E_{\text{total}}}{\partial \ln C_4} \cdot \frac{\partial \ln C_4}{\partial k_{21}} + \frac{\partial E_{\text{total}}}{\partial \ln C_5} \cdot \frac{\partial \ln C_5}{\partial k_{21}} + \frac{\partial E_{\text{total}}}{\partial \ln C_6} \cdot \frac{\partial \ln C_6}{\partial k_{21}} \right)$$

$$= k_{21} - \alpha (\text{coef}_{C4} \cdot i_2 + \text{coef}_{C5} \cdot i_3 + \text{coef}_{C6} \cdot 0)$$

$$= 0.3 - 0.5 (-0.049 \times 0.2 + (-0.049) \times 0.1 + (-0.049) \times 0) = 0.312$$

$$k_{12} = k_{12} - \alpha \frac{\partial E_{\text{total}}}{\partial k_{12}} = k_{12} - \alpha \left(\frac{\partial E_{\text{total}}}{\partial \ln C_4} \cdot \frac{\partial \ln C_4}{\partial k_{12}} + \frac{\partial E_{\text{total}}}{\partial \ln C_5} \cdot \frac{\partial \ln C_5}{\partial k_{12}} + \frac{\partial E_{\text{total}}}{\partial \ln C_6} \cdot \frac{\partial \ln C_6}{\partial k_{12}} \right)$$

$$= k_{12} - \alpha (\text{coef}_{C4} \cdot i_1 + \text{coef}_{C5} \cdot i_2 + \text{coef}_{C6} \cdot i_3)$$

$$= 0.2 - 0.5 (-0.049 \times 0.1 + (-0.049) \times 0.1 + (-0.049) \times 0.3) = 0.215$$

$$k_{13} = k_{13} - \alpha \frac{\partial E_{\text{total}}}{\partial k_{13}} = k_{13} - \alpha \left(\frac{\partial E_{\text{total}}}{\partial \ln C_4} \cdot \frac{\partial \ln C_4}{\partial k_{13}} + \frac{\partial E_{\text{total}}}{\partial \ln C_5} \cdot \frac{\partial \ln C_5}{\partial k_{13}} + \frac{\partial E_{\text{total}}}{\partial \ln C_6} \cdot \frac{\partial \ln C_6}{\partial k_{13}} \right)$$

$$= k_{13} - \alpha (\text{coef}_{C4} \cdot 0 + \text{coef}_{C5} \cdot i_1 + \text{coef}_{C6} \cdot i_1)$$

$$= 0.1 - 0.5 (-0.049 \times 0 + (-0.049) \times 0.1 + (-0.049) \times 0.1) = 0.107$$

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$$b_1 = b_1 - \alpha \frac{\partial E_{\text{total}}}{\partial b_1} = b_1 - \alpha \left(\frac{\partial E_{\text{total}}}{\partial \ln C_1} \cdot \frac{\partial \ln C_1}{\partial b_1} + \frac{\partial E_{\text{total}}}{\partial \ln C_2} \cdot \frac{\partial \ln C_2}{\partial b_1} + \frac{\partial E_{\text{total}}}{\partial \ln C_3} \cdot \frac{\partial \ln C_3}{\partial b_1} \right)$$

$$= b_1 - \alpha (\text{coef}_{C1} \cdot 1 + \text{coef}_{C2} \cdot 1 + \text{coef}_{C3} \cdot 1)$$

$$= 0.1 - 0.5 ((-0.026) \times 1 + (-0.026) \times 1 + (-0.026) \times 1) = 0.039$$

$$b_L = b_L - \alpha \frac{\partial E_{\text{total}}}{\partial b_L} = b_L - \alpha \left(\frac{\partial E_{\text{total}}}{\partial \ln C_4} \cdot \frac{\partial \ln C_4}{\partial b_L} + \frac{\partial E_{\text{total}}}{\partial \ln C_5} \cdot \frac{\partial \ln C_5}{\partial b_L} + \frac{\partial E_{\text{total}}}{\partial \ln C_6} \cdot \frac{\partial \ln C_6}{\partial b_L} \right)$$

$$= b_L - \alpha (\text{coef}_{C4} \cdot 1 + \text{coef}_{C5} \cdot 1 + \text{coef}_{C6} \cdot 1)$$

$$= 0.1 - 0.5 ((-0.049) \times 1 + (-0.049) \times 1 + (-0.049) \times 1) = 0.070$$