

## Κεφάλαιο 4

### Πρόβλημα 4

---

$$n^m = \beta^m \cdot [\mathbf{W}^m \mathbf{a}^{m-1} + \mathbf{b}^m] \quad (4.1)$$

Backpropagation

$$1. \quad \frac{\partial E}{\partial W_{ij}^m} = \frac{\partial E}{\partial a_i^m} \cdot \frac{\partial a_i^m}{\partial n_i^m} \cdot \frac{\partial n_i^m}{\partial W_{ij}^m} = -2(t - a^M) \cdot f'^m \cdot n^m \cdot a^{m-1} \cdot \beta^m \quad (4.2)$$

$$2. \quad \frac{\partial E}{\partial b_i^m} = \frac{\partial E}{\partial a_i^m} \cdot \frac{\partial a_i^m}{\partial n_i^m} \cdot \frac{\partial n_i^m}{\partial b_i^m} = -2(t - a^M) \cdot f'^m \cdot n^m \cdot \beta^m \quad (4.3)$$

$$3. \quad \frac{\partial E}{\partial \beta_i^m} = \frac{\partial E}{\partial a_i^m} \cdot \frac{\partial a_i^m}{\partial n_i^m} \cdot \frac{\partial n_i^m}{\partial \beta_i^m} = -2(t - a^M) \cdot f'^m \cdot n^m \cdot (\mathbf{W}^m \mathbf{a}^{m-1} + \mathbf{b}^m) \quad (4.4)$$

$$4. \quad a^0 = p \quad (4.5)$$

$$5. \quad a^m = \beta^m (\mathbf{W}^m \mathbf{a}^{m-1} + \mathbf{b}^m) \quad (4.6)$$

for  $m = 0, 1, \dots, M-1$ ,

$$6. \quad a = a^M \quad (4.7)$$

$$7. \quad s^M = -2F^M \cdot n^M \cdot (t - a) \quad (4.8)$$

$$8. \quad s^m = F^m \cdot n^m \cdot (W^{m+1})^T \cdot s^{m+1} \quad (4.9)$$

$$9. \quad W^m(k+1) = W^m(k) - a \cdot \frac{\partial E}{\partial W_{ij}^m} = \mathbf{W}^m(k) - a \cdot (-2(t - a^M) \cdot f'^m \cdot n^m \cdot a^{m-1} \cdot \beta^m) \quad (4.10)$$

10.

$$b^m(k+1) = b^m(k) - a \cdot \frac{\partial E}{\partial b_{ij}^m} = \mathbf{b}^m(k) - a \cdot (-2(t - a^M) \cdot f'^m \cdot n^m \cdot \beta^m) \quad (4.11)$$

11.

$$\beta^m(k+1) = \beta^m(k) - a \cdot \frac{\partial E}{\partial b_{ij}^m} = \mathbf{b}^m(k) - a \cdot (-2(t - a^M) \cdot f'^m \cdot n^m \cdot (\mathbf{W}^m(k) a^{m-1} + b^m)) \quad (4.12)$$

12.

$$\frac{\partial n^m}{\partial n_j^{m-1}} = \frac{\partial \beta^m(W^m a^{m-1} + b^m)}{\partial n_j^{m-1}} = \beta^m(W^m + b^m) \frac{\partial a^{m-1}}{\partial n_j^{m-1}} = \beta^m(W^m + b^m) F'^m(n^{m-1}) \quad (4.13)$$

13.

$$s^m = \frac{\partial F}{\partial n^m} = \frac{\partial n^m}{\partial n^{m-1}}^T \frac{\partial F}{\partial n^m} = \beta^m(W^m + b^m) F'^m(n^{m-1}) s^m \quad (4.14)$$