

Deep Learning Assignment 1

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1 PROBLEM 1

1.1

Let $f(x_{in}) = \frac{1}{1+\exp^{-x_{in}}}$

$$\begin{aligned}\frac{\partial E}{\partial x_{in}} &= \frac{\partial E}{\partial f(x_{in})} \frac{\partial f(x_{in})}{\partial x_{in}} \\ &= \frac{\partial E}{\partial x_{out}} \frac{\partial f(x_{in})}{\partial x_{in}} \\ \frac{\partial f(x_{in})}{\partial x_{in}} &= \frac{\partial}{\partial x_{in}} \frac{1}{1 + \exp^{-x_{in}}} \\ &= \frac{\exp^{-x_{in}}}{(1 + \exp^{-x_{in}})^2} \\ \Rightarrow \frac{\partial E}{\partial x_{in}} &= \frac{\partial E}{\partial x_{out}} \frac{\exp^{-x_{in}}}{(1 + \exp^{-x_{in}})^2}\end{aligned}\tag{1.1}$$

1.2

For $i = j$

$$\begin{aligned}
\frac{\partial(x_{out})_i}{\partial(x_{in})_j} &= \frac{\partial}{\partial(x_{in})_i} \frac{\exp^{-\beta(x_{in})_i}}{\sum_k \exp^{-\beta(x_{in})_k}} \\
&= \left(\frac{\partial}{\partial(x_{in})_i} \exp^{-\beta(x_{in})_i} \right) \times \frac{1}{\sum_k \exp^{-\beta(x_{in})_k}} + \left(\frac{\partial}{\partial(x_{in})_i} \frac{1}{\sum_k \exp^{-\beta(x_{in})_k}} \right) \times \exp^{-\beta(x_{in})_i} \\
&= (-\beta) \exp^{-\beta(x_{in})_i} \frac{1}{\sum_k \exp^{-\beta(x_{in})_k}} - \exp^{-\beta(x_{in})_i} \frac{1}{(\sum_k \exp^{-\beta(x_{in})_k})^2} (-\beta) \exp^{-\beta(x_{in})_i} \\
&= -\beta \frac{\exp^{-\beta(x_{in})_i}}{\sum_k \exp^{-\beta(x_{in})_k}} \left(1 - \frac{\exp^{-\beta(x_{in})_i}}{\sum_k \exp^{-\beta(x_{in})_k}} \right)
\end{aligned} \tag{1.2}$$

2 TORCH (MNIST HANDWRITTEN DIGIT RECOGNITION)