DLP ASSIGNMENT #01

Date ____ 20__
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20K-0477

Question #01.

1. Tensor flow : popular due to flexibility, extensive community support and wide range of application
2. PyTorch : popular due to dynamic computational graph.
3. Keras : popular due to user friendly API, popular among beginners
4. MXNet : popular due to efficiency and scalability
5. Caffe : popular due to efficiency and speed in computer vision task.

Question # 02 :

Binary cross entropy loss :

→ Binary classification problem

Formula : $-\frac{1}{N} \sum_{i=1}^{N} [y_i \log(p_i) + (1-y_i) \log(1-p_i)]$

derivative : $\frac{\partial L}{\partial p_i} = \frac{y_i}{p_i} + \frac{1-y_i}{1-p_i}$

~~Multiclass~~ Categorical Cross Entropy loss :

→ Multiclass classification problem.

Formula : $-\frac{1}{N} \sum_{i=1}^{N} \sum_{j=1}^{C} y_{ij} \log(p_{ij})$.

Derivative : $\frac{\partial L}{\partial p_{ij}} = \frac{y_{ij}}{p_{ij}}$

Mean squared Error :

→ Regression problem

Formula : $\frac{1}{N} \sum_{i=1}^{N} (y_i - p_i)^2$

Derivative : $\frac{\partial L}{\partial p_i} = 2(p_i - y_i)$.

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Mean Absolute Error
→ Regression problem
Formula: $\frac{1}{N} \sum_{i=1}^{N} |y_i - p_i|$
Derivative: $\frac{\partial L}{\partial p_i} = sign(y_i - p_i)$

Huber Loss:
→ combined MSE & MSA, less sensitive to error.
Formula: $\frac{1}{N} \sum_{i=1}^{N} huber(y_i - p_i)$ where $huber(x) = \frac{1}{2} x^2$ for $|x| \leq \delta$

Question #03:
① Sigmoid:
$\sigma(x) = 1/1+e^{-x}$
$\sigma'(x) = \sigma(x)(1 - \sigma(x))$

② Hyperbolic Tanh:
$\tanh(x) = \frac{e^{2x}-1}{e^{x}+1}$
$\tanh'(x) = 1 - \tanh^2(x)$

③ ReLU:
$ReLU(x) = \max(0, x)$
$ReLU'(x) = \begin{cases} 0 & \text{if } x < 0 \\ 1 & \text{if } x \geq 0 \end{cases}$

④ Leaky ReLU:
$\text{Leaky ReLU}(x) = \begin{cases} x & \text{if } x \geq 0 \\ \alpha x & \text{if } x < 0 \end{cases}$
$\text{Leaky ReLU}'(x) = \begin{cases} 1 & \text{if } x \geq 0 \\ \alpha & \text{if } x < 0 \end{cases}$

⑤ SELU:
$SELU(x) = \lambda \cdot \begin{cases} x & x \geq 0 \\ \alpha \cdot (e^{x}-1) & x < 0 \end{cases}$

$SELU'(x) = \lambda \cdot \begin{cases} 1 & x \geq 0 \\ \alpha \cdot e^{x} & x < 0 \end{cases}$

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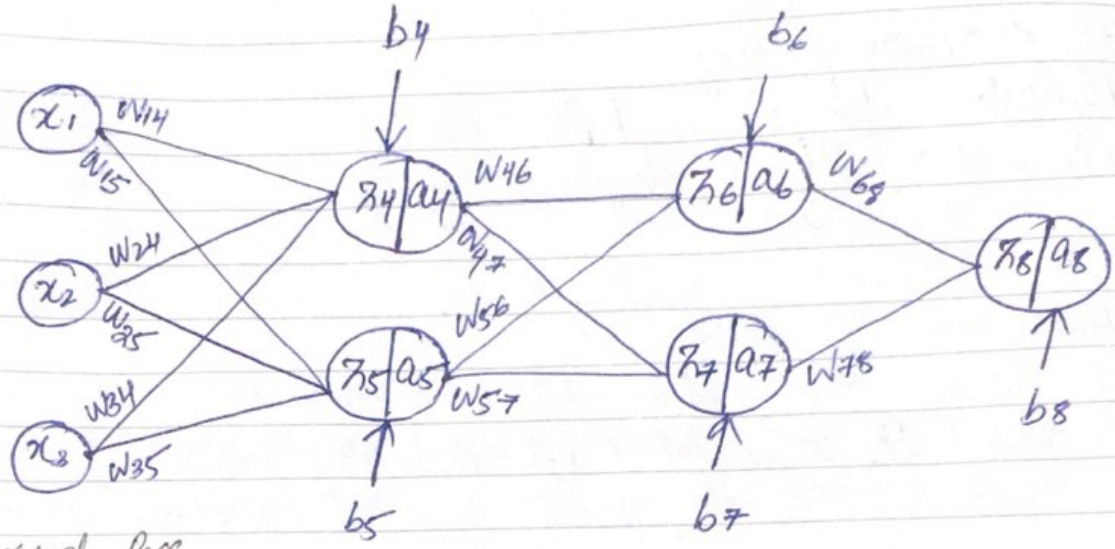
Question # 04



Forward Pass.

$z_4 = w_{14} x_1 + w_{24} x_2 + w_{34} x_3 + b_4$

$z_5 = w_{15} x_1 + w_{25} x_2 + w_{35} x_3 + b_5$

$z_6 = w_{46} a_4 + w_{56} a_5 + b_6$

$z_7 = w_{47} a_4 + w_{57} a_5 + b_7$

$z_8 = w_{68} a_6 + w_{78} a_7 + b_8$

i) Squared Loss.

$$L = \frac{1}{2}(y - a_8)^2$$

$$\frac{\partial L}{\partial a_8} = -(y - a_8).$$

Output Layer

$$\frac{\partial L}{\partial w_{68}} = \frac{\partial L}{\partial a_8} \cdot \frac{\partial a_8}{\partial z_8} \cdot \frac{\partial z_8}{\partial w_{68}}$$

$$\boxed{\frac{\partial L}{\partial w_{68}} = -(y - a_8)\, a_8 (1 - a_8)\, a_6}$$

$$\frac{\partial L}{\partial w_{78}} = \frac{\partial L}{\partial a_8} \cdot \frac{\partial a_8}{\partial z_8} \cdot \frac{\partial z_8}{\partial w_{78}}$$

$$\boxed{\frac{\partial L}{\partial w_{78}} = -(y-a_8)\ a_8(1-a_8)\ a_7}$$

$$\frac{\partial L}{\partial b_8} = \frac{\partial L}{\partial a_8} \cdot \frac{\partial a_8}{\partial z_8} \cdot \frac{\partial z_8}{\partial b_8}$$

$$\boxed{\frac{\partial L}{\partial b_8} = -(y-a_8)\ a_8(1-a_8)}$$

Hidden layer - 2.

$$\frac{\partial L}{\partial w_{46}} = \frac{\partial L}{\partial a_6} \cdot \frac{\partial a_6}{\partial z_6} \cdot \frac{\partial z_6}{\partial w_{46}} \quad — ①$$

$$\frac{\partial L}{\partial a_6} = \frac{\partial L}{\partial a_8} \cdot \frac{\partial a_8}{\partial z_8} \cdot \frac{\partial z_8}{\partial a_6}$$

$$\frac{\partial L}{\partial a_6} = -(y-a_8)\ a_8(1-a_8)\ w_{68}$$

putting in eq ①

$$\boxed{\frac{\partial L}{\partial w_{46}} = -(y-a_8)\ a_8\ (1-a_8)\ w_{68}\ a_6(1-a_6)\ a_4}$$

$$\frac{\partial L}{\partial w_{56}} = \frac{\partial L}{\partial a_6} \cdot \frac{\partial a_6}{\partial z_6} \cdot \frac{\partial z_6}{\partial w_{56}}$$

$$\boxed{\frac{\partial L}{\partial w_{56}} = -(y-a_8)\ a_8(1-a_8)\ w_{68}\ a_6(1-a_6)\ a_5}$$

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$$\frac{\partial L}{\partial W_{47}} = \frac{\partial L}{\partial a_7} \cdot \frac{\partial a_7}{\partial z_7} \cdot \frac{\partial z_7}{\partial W_{47}} \quad \text{— (2)}$$

$$\frac{\partial L}{\partial a_7} = \frac{\partial L}{\partial a_8} \cdot \frac{\partial a_8}{\partial z_8} \cdot \frac{\partial z_8}{\partial a_7}$$

$$\frac{\partial L}{\partial a_7} = -(y-a_8)\, a_8(1-a_8)\, W_{78}$$

putting in (2)

$$\boxed{\frac{\partial L}{\partial W_{47}} = -(y-a_8)\, a_8(1-a_8)\, W_{78}\, a_7(1-a_7)\, a_4}$$

$$\frac{\partial L}{\partial W_{57}} = \frac{\partial L}{\partial a_7} \cdot \frac{\partial a_7}{\partial z_7} \cdot \frac{\partial z_7}{\partial W_{57}}$$

$$\boxed{\frac{\partial L}{\partial W_{57}} = -(y-a_8)\, a_8(1-a_8)\, W_{78}\, a_7(1-a_7)\, a_5}$$

$$\frac{\partial L}{\partial b_6} = \frac{\partial L}{\partial a_6} \cdot \frac{\partial a_6}{\partial z_6} \cdot \frac{\partial z_6}{\partial b_6}$$

$$\boxed{\frac{\partial L}{\partial b_6} = -(y-a_8)\, a_8(1-a_8)\, W_{68}\, a_6(1-a_6)}$$

$$\frac{\partial L}{\partial b_7} = \frac{\partial L}{\partial a_7} \cdot \frac{\partial a_7}{\partial z_7} \cdot \frac{\partial z_7}{\partial b_7}$$

$$\boxed{\frac{\partial L}{\partial b_7} = -(y-a_8)\, a_8(1-a_8)\, W_{78}\, a_7(1-a_7)}$$

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Hidden Layer - 1

$$\frac{\partial L}{\partial W_{14}} = \frac{\partial L}{\partial a_4} \cdot \frac{\partial a_4}{\partial z_4} \cdot \frac{\partial z_4}{\partial W_{14}} \quad \text{— (3)}$$

$$\frac{\partial L}{\partial a_4} = \left[\frac{\partial L}{\partial a_6} \cdot \frac{\partial a_6}{\partial z_6} \cdot \frac{\partial z_6}{\partial a_4}\right] + \left[\frac{\partial L}{\partial a_7} \cdot \frac{\partial a_7}{\partial z_7} \cdot \frac{\partial z_7}{\partial a_4}\right]$$

$$\frac{\partial L}{\partial a_4} = \left[-(y-a_8)\, a_8(1-a_8)\, W_{68}\, a_6(1-a_6)\, W_{46}\right] + \left[-(y-a_8)\, a_8(1-a_8)\, W_{78}\, a_7(1-a_7)\, W_{47}\right].$$

putting in (3)

$$\boxed{\frac{\partial L}{\partial W_{14}} = \left[-(y-a_8)\, a_8(1-a_8)\, W_{68}\, a_6(1-a_6)\, W_{46} + -(y-a_8)\, a_8(1-a_8)\, W_{78}\, a_7(1-a_7)\, W_{47}\right] \cdot a_4(1-a_4) \cdot x_1}$$

$$\frac{\partial L}{\partial W_{24}} = \frac{\partial L}{\partial a_4} \cdot \frac{\partial a_4}{\partial z_4} \cdot \frac{\partial z_4}{\partial W_{24}}.$$

$$\boxed{\frac{\partial L}{\partial W_{24}} = \left[-(y-a_8)\, a_8(1-a_8)\, W_{68}\, a_6(1-a_6)\, W_{46} + -(y-a_8)\, a_8(1-a_8)\, W_{78}\, a_7(1-a_7)\, W_{47}\right] \cdot a_4(1-a_4)\, x_2.}$$

$$\frac{\partial L}{\partial W_{34}} = \frac{\partial L}{\partial a_4} \cdot \frac{\partial a_4}{\partial z_4} \cdot \frac{\partial z_4}{\partial W_{34}}$$

$$\boxed{\frac{\partial L}{\partial W_{34}} = \left[-(y-a_8)\, a_8(1-a_8)\, W_{68}\, a_6(1-a_6)\, W_{46} + -(y-a_8)\, a_8(1-a_8)\, W_{78}\, a_7(1-a_7)\, W_{47}\right] \cdot a_4(1-a_4) \cdot x_3.}$$

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$$\frac{\partial L}{\partial W_{15}} = \frac{\partial L}{\partial a_5} \cdot \frac{\partial a_5}{\partial z_5} \cdot \frac{\partial z_5}{\partial W_{15}} \quad — (4)$$

$$\frac{\partial L}{\partial a_5} = \left[\frac{\partial L}{\partial a_6} \cdot \frac{\partial a_6}{\partial z_6} \cdot \frac{\partial z_6}{\partial a_5}\right] + \left[\frac{\partial L}{\partial a_7} \cdot \frac{\partial a_7}{\partial z_7} \cdot \frac{\partial z_7}{\partial a_5}\right]$$

$$\frac{\partial L}{\partial a_5} = \left[-(y - a_8)\, a_8(1-a_8)\, W_{68}\; a_6(1-a_6)\, W_{56}\right] + \left[-(y - a_8)\, a_8(1-a_8)\, W_{78}\; a_7(1-a_7)\, W_{57}\right]$$

putting in (4)

$$\boxed{\frac{\partial L}{\partial W_{15}} = \left[-(y-a_8)\, a_8(1-a_8)\, W_{68}\; a_6(1-a_6)\, W_{56} + -(y-a_8)\, a_8(1-a_8)\, W_{78}\; a_7(1-a_7)\, W_{57}\right] \cdot a_5(1-a_5) \cdot x_1}$$

$$\frac{\partial L}{\partial W_{25}} = \frac{\partial L}{\partial a_5} \cdot \frac{\partial a_5}{\partial z_5} \cdot \frac{\partial z_5}{\partial W_{25}}$$

$$\boxed{\frac{\partial L}{\partial W_{25}} = \left[-(y-a_8)\, a_8(1-a_8)\, W_{68}\; a_6(1-a_6)\, W_{56} + -(y-a_8)\, a_8(1-a_8)\, W_{78}\; a_7(1-a_7)\, W_{57}\right] \cdot a_5(1-a_5) \cdot x_2}$$

$$\frac{\partial L}{\partial W_{35}} = \frac{\partial L}{\partial a_5} \cdot \frac{\partial a_5}{\partial z_5} \cdot \frac{\partial z_5}{\partial W_{35}}$$

$$\boxed{\frac{\partial L}{\partial W_{25}} = \left[-(y-a_8)\, a_8(1-a_8)\, W_{68}\; a_6(1-a_6)\, W_{56} + -(y-a_8)\, a_8(1-a_8)\, W_{78}\; a_7(1-a_7)\, W_{57}\right] \cdot a_5(1-a_5) \cdot x_3}$$

$$\frac{\partial L}{\partial b_4} = \frac{\partial L}{\partial a_4} \cdot \frac{\partial a_4}{\partial z_4} \cdot \frac{\partial z_4}{\partial b_4}$$

$$\boxed{\frac{\partial L}{\partial b_4} = \left[-(y-a_8)\, a_8(1-a_8)\, W_{68}\; a_6(1-a_6)\, W_{46} + -(y-a_8)\, a_8(1-a_8)\, W_{78}\; a_7(1-a_7)\, W_{47}\right] \cdot a_4(1-a_4) \cdot (1)}$$

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$$\frac{\partial L}{\partial b_5} = \frac{\partial L}{\partial a_5} \cdot \frac{\partial a_5}{\partial z_5} \cdot \frac{\partial z_5}{\partial b_5}$$

$$\boxed{\frac{\partial L}{\partial b_5} = \left[-(y-a_8)\, a_8(1-a_8)\, w_{68}\, a_6(1-a_6)\, w_{56} + -(y-a_8)\, a_8(1-a_8)\, w_{68}\, a_6(1-a_6)\, w_{57}\right] a_5(1-a_5) \cdot (1)}$$

ii) Cross Entropy.

$$2 = -\left[y \log(a_8) + (1-y)\log(1-a_8)\right].$$

$$\frac{\partial L}{\partial a_8} = -\frac{y}{a_8} - \frac{(1-y)(-1)}{1-a_8}$$

$$\frac{\partial L}{\partial a_8} = -\frac{y}{a_8} + \frac{(1-y)}{(1-a_8)}$$

Output layer

$$\frac{\partial L}{\partial w_{68}} = \frac{\partial L}{\partial a_8} \cdot \frac{\partial a_8}{\partial z_8} \cdot \frac{\partial z_8}{\partial w_{68}}$$

$$\frac{\partial L}{\partial w_{68}} = \left(\frac{-y}{a_8} + \frac{1-y}{1-a_8}\right) \cdot a_8(1-a_8) \cdot a_6.$$

$$\frac{\partial L}{\partial w_{68}} = \left(\frac{-y(1-a_8) + (1-y)a_8}{\cancel{a_8(1-a_8)}}\right) \cdot \cancel{a_8(1-a_8)} \cdot a_6$$

$$\frac{\partial L}{\partial w_{68}} = \left(-y + \cancel{a_8 y} + a_8 - \cancel{a_8 y}\right) \cdot a_6$$

$$\boxed{\frac{\partial L}{\partial w_{68}} = (-y + a_8) \cdot a_6}$$

$$\frac{\partial L}{\partial b_8} = \frac{\partial L}{\partial a_8} \cdot \frac{\partial a_8}{\partial z_8} \cdot \frac{\partial z_8}{\partial b_8}$$

$$\frac{\partial L}{\partial w_{78}} = \frac{\partial L}{\partial a_8} \cdot \frac{\partial a_8}{\partial z_8} \cdot \frac{\partial z_8}{\partial w_{78}}$$

$$\boxed{\frac{\partial L}{\partial w_{78}} = (-y + a_8) \cdot a_7}$$

$$\boxed{\frac{\partial L}{\partial b_8} = (-y + a_8) \times (1)}$$

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Hidden layer - 2

$$\frac{\partial L}{\partial w_{46}} = \frac{\partial L}{a_6} \cdot \frac{\partial a_6}{\partial z_6} \cdot \frac{\partial z_6}{\partial w_{46}} \quad — \quad (5)$$

$$\frac{\partial L}{\partial a_6} = \frac{\partial L}{a_8} \cdot \frac{\partial a_8}{\partial z_8} \cdot \frac{\partial z_8}{\partial a_6}.$$

$$\frac{\partial L}{\partial a_6} = (-y + a_8)\, w_{68}$$

putting in (5)

$$\boxed{\frac{\partial L}{\partial w_{46}} = (-y + a_8)\, w_{68} \cdot a_6(1 - a_6) \cdot a_4.}$$

$$\frac{\partial L}{\partial w_{56}} = \frac{\partial L}{\partial a_6} \cdot \frac{\partial a_6}{\partial z_6} \cdot \frac{\partial z_6}{\partial w_{56}}.$$

$$\boxed{\frac{\partial L}{\partial w_{56}} = (-y + a_8)\, w_{68} \cdot a_6(1 - a_6) \cdot a_5}$$

$$\frac{\partial L}{\partial b_6} = \frac{\partial L}{\partial a_6} \cdot \frac{\partial a_6}{\partial z_6} \cdot \frac{\partial z_6}{\partial b_6}$$

$$\boxed{\frac{\partial L}{\partial b_6} = (-y + a_8)\, w_{68} \cdot a_6(1 - a_6) \cdot x(1)}$$

$$\frac{\partial L}{\partial w_{47}} = \frac{\partial L}{\partial a_7} \cdot \frac{\partial a_7}{\partial z_7} \cdot \frac{\partial z_7}{w_{47}} \quad — \quad (6)$$

$$\frac{\partial L}{\partial a_7} = \frac{\partial L}{\partial a_8} \cdot \frac{\partial a_8}{\partial z_8} \cdot \frac{\partial z_8}{\partial a_7}$$

$$\frac{\partial L}{\partial a_7} = (-y + a_8)\, w_{78}.$$

putting in (6)

$$\boxed{\frac{\partial L}{\partial w_{47}} = (-y + a_8)\, w_{78} \cdot a_7(1 - a_7) \cdot a_4}$$

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$$\frac{\partial L}{\partial w_{57}} = \frac{\partial L}{\partial a_7} \cdot \frac{\partial a_7}{\partial z_7} \cdot \frac{\partial z_7}{\partial w_{57}}$$

$$\boxed{\frac{\partial L}{\partial w_{57}} = (-y+a_8)\, w_{78} \cdot a_7(1-a_7) \cdot a_5}$$

$$\frac{\partial L}{\partial b_7} = \frac{\partial L}{\partial a_7} \cdot \frac{\partial a_7}{\partial z_7} \cdot \frac{\partial z_7}{\partial b_7}$$

$$\boxed{\frac{\partial L}{\partial b_7} = (-y+a_8)\, w_{78} \cdot a_7(1-a_7) \cdot (1)}$$

Hidden layer - 1.

$$\frac{\partial L}{\partial w_{14}} = \frac{\partial L}{\partial a_4} \cdot \frac{\partial a_4}{\partial z_4} \cdot \frac{\partial z_4}{\partial w_{14}} \quad — \quad (7)$$

$$\frac{\partial L}{\partial a_4} = \left[\frac{\partial L}{\partial a_6} \cdot \frac{\partial a_6}{\partial z_6} \cdot \frac{\partial z_6}{\partial a_4}\right] + \left[\frac{\partial L}{a_7} \cdot \frac{\partial a_7}{\partial z_7} \cdot \frac{\partial z_7}{\partial a_4}\right]$$

$$\frac{\partial L}{\partial a_4} = \left[(-y+a_8)\, w_{68}\; a_6(1-a_6)\, w_{46}\right] + \left[(-y+a_8)\, w_{78}\; a_7(1-a_7)\, w_{47}\right].$$

putting in (7)

$$\boxed{\frac{\partial L}{\partial w_{14}} = \left[(-y+a_8)\, w_{68} \cdot a_6(1-a_6)\, w_{46} + (-y+a_8)\, w_{78}\; a_7(1-a_7)\, w_{47}\right] \cdot a_4(1-a_4) \cdot x_1}$$

$$\frac{\partial L}{\partial w_{24}} = \frac{\partial L}{\partial a_4} \cdot \frac{\partial a_4}{\partial z_4} \cdot \frac{\partial z_4}{\partial w_{24}}$$

$$\boxed{\frac{\partial L}{\partial w_{24}} = \left[(-y+a_8)\, w_{68} \cdot a_6(1-a_6)\, w_{46} + (-y+a_8)\, w_{78}\; a_7(1-a_7)\, w_{47}\right] \cdot a_4(1-a_4) \cdot x_2}$$

$$\frac{\partial L}{\partial W_{34}} = \frac{\partial L}{\partial a_4} \cdot \frac{\partial a_4}{\partial z_4} \cdot \frac{\partial z_4}{\partial W_{34}}$$

$$\boxed{\frac{\partial L}{\partial W_{34}} = \left[(-y+a_8)\, W_{68} \cdot a_6(1-a_6)\, W_{46} + (-y+a_8)\, W_{78}\, a_7(1-a_7)\, W_{47}\right] \cdot a_4(1-a_4)\, x_3.}$$

$$\frac{\partial L}{\partial b_4} = \frac{\partial L}{\partial a_4} \cdot \frac{\partial a_4}{\partial z_4} \cdot \frac{\partial z_4}{\partial b_4}$$

$$\boxed{\frac{\partial L}{\partial b_4} = \left[(-y+a_8)\, W_{68} \cdot a_6(1-a_6)\, W_{46} + (-y+a_8)\, W_{78}\, a_7(1-a_7)\, W_{47}\right] \cdot a_4(1-a_4)\, \cancel{x}(1)}$$

$$\frac{\partial L}{\partial W_{15}} = \frac{\partial L}{\partial a_5} \cdot \frac{\partial a_5}{\partial z_5} \cdot \frac{\partial z_5}{\partial W_{15}} \quad \text{— (8)}$$

$$\frac{\partial L}{\partial a_5} = \left[\frac{\partial L}{\partial a_6} \cdot \frac{\partial a_6}{\partial z_6} \cdot \frac{\partial z_6}{\partial a_5}\right] + \left[\frac{\partial L}{\partial a_7} \cdot \frac{\partial a_7}{\partial z_7} \cdot \frac{\partial z_7}{\partial a_5}\right]$$

$$\frac{\partial L}{\partial a_5} = \left[(-y+a_8)\, W_{68} \cdot a_6(1-a_6)\, W_{56}\right] + \left[(-y+a_8)\, W_{78} \cdot a_7(1-a_7)\, W_{57}\right].$$

putting in (8)

$$\boxed{\frac{\partial L}{\partial W_{15}} = \left[(-y+a_8)\, W_{68} \cdot a_6(1-a_6)\, W_{56} + (-y+a_8)\, W_{78}\, a_7(1-a_7)\, W_{57}\right] \cdot a_5(1-a_5)\, x_1}$$

$$\frac{\partial L}{\partial W_{25}} = \frac{\partial L}{\partial a_5} \cdot \frac{\partial a_5}{\partial z_5} \cdot \frac{\partial z_5}{\partial W_{25}}$$

$$\boxed{\frac{\partial L}{\partial W_{25}} = \left[(-y+a_8)\, W_{68} \cdot a_6(1-a_6)\, W_{56} + (-y+a_8)\, W_{78}\, a_7(1-a_7)\, W_{57}\right] \cdot a_5(1-a_5) \cdot x_2.}$$

$$\frac{\partial L}{\partial W_{35}} = \frac{\partial L}{\partial a_5} \cdot \frac{\partial a_5}{\partial z_5} \cdot \frac{\partial z_5}{\partial W_{35}}$$

$$\boxed{\frac{\partial L}{\partial W_{35}} = \left[(-y+a_8)\, W_{68} \cdot a_6(1-a_6)\, W_{56} + (-y+a_8)\, W_{78}\, a_7(1-a_7)\, W_{57}\right] \cdot a_5(1-a_5) \cdot x_3.}$$

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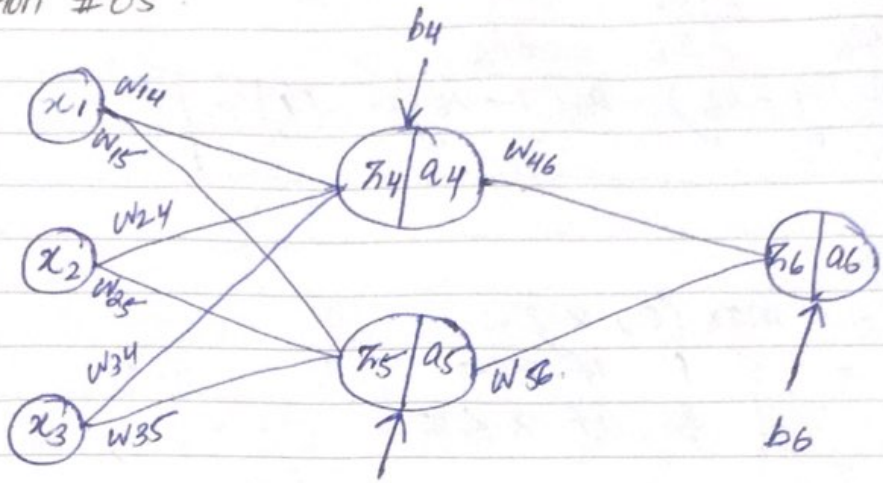
$$\frac{\partial L}{\partial b_5} = \frac{\partial L}{\partial a_5} \cdot \frac{\partial a_5}{\partial z_5} \cdot \frac{\partial z_5}{\partial b_5}$$

$$\boxed{\frac{\partial L}{\partial b_5} = \left[(-y + a_8) w_{68} \cdot a_6(1-a_6) w_{56} + (-y + a_8) w_{78} a_7 (1-a_7) w_{57}\right] \cdot a_5 (1-a_5) \times (1)}$$

Question #05



Forward Pass.

$z_4 = w_{14} x_1 + w_{24} x_2 + w_{34} x_3 + b_4$

$z_5 = w_{15} x_1 + w_{25} x_2 + w_{35} x_3 + b_5$

$z_6 = w_{46} a_4 + w_{56} a_5 + b_6.$

i) Squared Loss.

$$L = \frac{1}{2}(y - a_6)^2$$

$$\frac{\partial L}{\partial a_6} = -(y - a_6).$$

Output layer

$$\frac{\partial L}{\partial w_{46}} = \frac{\partial L}{\partial a_6} \cdot \frac{\partial a_6}{\partial z_6} \cdot \frac{\partial z_6}{\partial w_{46}}$$

$$\boxed{\frac{\partial L}{\partial w_{46}} = -(y - a_6) \cdot a_6(1 - a_6) \cdot a_4.}$$

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$$\frac{\partial L}{\partial w_{56}} = \frac{\partial L}{\partial a_6} \cdot \frac{\partial a_6}{\partial z_6} \cdot \frac{\partial z_6}{\partial w_{56}}$$

$$\boxed{\frac{\partial L}{\partial w_{56}} = -(y - a_6) \cdot a_6(1 - a_6) \cdot a_5}$$

$$\frac{\partial L}{\partial b_6} = \frac{\partial L}{\partial a_6} \cdot \frac{\partial a_6}{\partial z_6} \cdot \frac{\partial z_6}{\partial b_6}$$

$$\boxed{\frac{\partial L}{\partial b_6} = -(y - a_6) \cdot a_6(1 - a_6) \cdot (1)}$$

Hidden layer

$$\text{Relu}(x) = \max(0, x)$$

$$\frac{d\,\text{Relu}(x)}{dx} = \begin{cases} 1 & \text{if } x > 0 \\ 0 & \text{if } x \leq 0 \end{cases}$$

$$\frac{\partial L}{\partial w_{14}} = \frac{\partial L}{\partial a_4} \cdot \frac{\partial a_4}{\partial z_4} \cdot \frac{\partial z_4}{\partial w_{14}} \quad \text{— (1)}$$

$$\frac{\partial L}{\partial a_4} = \frac{\partial L}{\partial a_6} \cdot \frac{\partial a_6}{\partial z_6} \cdot \frac{\partial z_6}{\partial a_4}$$

$$\frac{\partial L}{\partial a_4} = -(y - a_6) \cdot a_6(1 - a_6) \cdot w_{46}$$

putting in (1)

$$\boxed{\frac{\partial L}{\partial w_{14}} = -(y - a_6) \cdot a_6(1 - a_6) \cdot w_{46} \cdot \begin{cases} 1 & \text{if } z_4 > 0 \\ 0 & \text{if } z_4 \leq 0 \end{cases} \cdot x_1}$$

$$\frac{\partial L}{\partial w_{24}} = \frac{\partial L}{\partial a_4} \cdot \frac{\partial a_4}{\partial z_4} \cdot \frac{\partial z_4}{\partial w_{24}}$$

$$\boxed{\frac{\partial L}{\partial W_{24}} = -(y-a_6)\cdot a_6(1-a_6)\cdot W_{46}\cdot \begin{cases} 1 & \text{if } z_4 > 0 \\ 0 & \text{if } z_4 \le 0 \end{cases} \cdot x_2}$$

$$\frac{\partial L}{\partial W_{34}} = \frac{\partial L}{\partial a_4}\cdot\frac{\partial a_4}{\partial z_4}\cdot\frac{\partial z_4}{\partial W_{34}}$$

$$\boxed{\frac{\partial L}{\partial W_{34}} = -(y-a_6)\cdot a_6(1-a_6)\cdot W_{46}\cdot \begin{cases} 1 & \text{if } z_4 > 0 \\ 0 & \text{if } z_4 \le 0 \end{cases} \cdot x_3}$$

$$\frac{\partial L}{\partial b_4} = \frac{\partial L}{\partial a_4}\cdot\frac{\partial a_4}{\partial z_4}\cdot\frac{\partial z_4}{\partial b_4}$$

$$\boxed{\frac{\partial L}{\partial b_4} = -(y-a_6)\cdot a_6(1-a_6)\cdot W_{46}\cdot \begin{cases} 1 & \text{if } z_4 > 0 \\ 0 & \text{if } z_4 \le 0 \end{cases} \cdot (1)}$$

$$\frac{\partial L}{\partial W_{15}} = \frac{\partial L}{\partial a_5}\cdot\frac{\partial a_5}{\partial z_5}\cdot\frac{\partial z_5}{\partial W_{15}} \quad \text{— (2)}$$

$$\frac{\partial L}{\partial a_5} = \frac{\partial L}{\partial a_6}\cdot\frac{\partial a_6}{\partial z_6}\cdot\frac{\partial z_6}{\partial a_5}$$

$$\frac{\partial L}{\partial a_5} = -(y-a_6)\cdot a_6(1-a_6)\cdot W_{56}$$

putting in (1).

$$\boxed{\frac{\partial L}{\partial W_{15}} = -(y-a_6)\cdot a_6(1-a_6)\cdot W_{56}\cdot \begin{cases} 1 & \text{if } z_5 > 0 \\ 0 & \text{if } z_5 \le 0 \end{cases} \cdot x_1}$$

$$\frac{\partial L}{\partial W_{25}} = \frac{\partial L}{\partial a_5}\cdot\frac{\partial a_5}{\partial z_5}\cdot\frac{\partial z_5}{\partial W_{25}}$$

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$$\boxed{\frac{\partial L}{\partial W_{25}} = -(y-a_6) \cdot a_6(1-a_6) \cdot W_{56} \cdot \begin{cases} 1 \text{ if } z_5 > 0 \\ 0 \text{ if } z_5 \le 0 \end{cases} \cdot x_2}$$

$$\frac{\partial L}{\partial W_{35}} = \frac{\partial L}{\partial a_5} \cdot \frac{\partial a_5}{\partial z_5} \cdot \frac{\partial z_5}{\partial W_{35}}$$

$$\boxed{\frac{\partial L}{\partial W_{35}} = -(y-a_6) \cdot a_6(1-a_6) \cdot W_{56} \cdot \begin{cases} 1 \text{ if } z_5 > 0 \\ 0 \text{ if } z_5 \le 0 \end{cases} \cdot x_3}$$

$$\frac{\partial L}{\partial b_5} = \frac{\partial L}{\partial a_5} \cdot \frac{\partial a_5}{\partial z_5} \cdot \frac{\partial z_5}{\partial b_5}$$

$$\boxed{\frac{\partial L}{\partial b_5} = -(y-a_6) \cdot a_6(1-a_6) \cdot W_{56} \cdot \begin{cases} 1 \text{ if } z_5 > 0 \\ 0 \text{ if } z_5 \le 0 \end{cases} \cdot (1).}$$

ii) Cross Entropy loss

$$L = -[y \log(a_6) + (1-y) \log(1-a_6)]$$

$$\frac{\partial L}{\partial a_6} = \frac{-y}{a_6} - \frac{(1-y)(-1)}{1-a_6}$$

$$\frac{\partial L}{\partial a_6} = \frac{-y}{a_6} + \frac{1-y}{1-a_6}$$

Output layer

$$\frac{\partial L}{\partial W_{46}} = \frac{\partial L}{\partial a_6} \cdot \frac{\partial a_6}{\partial z_6} \cdot \frac{\partial z_6}{\partial W_{46}}$$

$$\frac{\partial L}{\partial W_{46}} = \left(\frac{-y}{a_6} + \frac{1-y}{1-a_6}\right) \cdot a_6(1-a_6) \cdot a_4$$

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$$\frac{\partial L}{\partial W_{46}} = \left\{ \frac{-y + \cancel{y a_6} + a_6 - \cancel{a_6 y}}{\cancel{a_6(1-a_6)}} \right\} \cdot \cancel{a_6(1-a_6)} \cdot a_4 .$$

$$\boxed{\frac{\partial L}{\partial W_{46}} = (-y + a_6) \cdot a_4}$$

$$\frac{\partial L}{\partial W_{56}} = \frac{\partial L}{\partial a_6} \cdot \frac{\partial a_6}{\partial z_6} \cdot \frac{\partial z_6}{\partial W_{56}} .$$

$$\boxed{\frac{\partial L}{\partial W_{56}} = (-y + a_6) \cdot a_5 .}$$

$$\frac{\partial L}{\partial b_6} = \frac{\partial L}{\partial a_6} \cdot \frac{\partial a_6}{\partial z_6} \cdot \frac{\partial z_6}{\partial b_6} .$$

$$\boxed{\frac{\partial L}{\partial b_6} = (-y + a_6) \cdot (1)}$$

Hidden layer

$$\frac{\partial L}{\partial W_{14}} = \frac{\partial L}{\partial a_4} \cdot \frac{\partial a_4}{\partial z_4} \cdot \frac{\partial z_4}{\partial W_{14}} . \quad \text{— } ①$$

$$\frac{\partial L}{\partial a_4} = \frac{\partial L}{\partial a_6} \cdot \frac{\partial a_6}{\partial z_6} \cdot \frac{\partial z_6}{\partial a_4} .$$

$$\frac{\partial L}{\partial a_4} = (-y + a_6) \cdot W_{46} .$$

putting in ①

$$\boxed{\frac{\partial L}{\partial W_{14}} = (-y + a_6) \cdot W_{46} \cdot \begin{cases} 1 \text{ if } z_4 > 0 \\ 0 \text{ if } z_4 \leq 0 \end{cases} \cdot x_1}$$

$$\frac{\partial L}{\partial W_{24}} = \frac{\partial L}{\partial a_4} \cdot \frac{\partial a_4}{\partial z_4} \cdot \frac{\partial z_4}{\partial W_{24}}$$

$$\boxed{\frac{\partial L}{\partial W_{24}} = (-y + a_6) \cdot W_{46} \cdot \begin{cases} 1 \text{ if } z_4 > 0 \\ 0 \text{ if } z_4 \leq 0 \end{cases} \cdot x_2}$$

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$$\frac{\partial L}{\partial w_{34}} = \frac{\partial L}{\partial a_4} \cdot \frac{\partial a_4}{\partial z_4} \cdot \frac{\partial z_4}{\partial w_{34}}$$

$$\boxed{\frac{\partial L}{\partial w_{34}} = (-y + a_6) \cdot w_{46} \cdot \begin{cases} 1 \text{ if } z_4 > 0 \\ 0 \text{ if } z_4 \leq 0 \end{cases} \cdot x_3}$$

$$\frac{\partial L}{\partial b_4} = \frac{\partial L}{\partial a_4} \cdot \frac{\partial a_4}{\partial z_4} \cdot \frac{\partial z_4}{\partial b_4}$$

$$\boxed{\frac{\partial L}{\partial b_4} = (-y + a_6) \cdot w_{46} \cdot \begin{cases} 1 \text{ if } z_4 > 0 \\ 0 \text{ if } z_4 \leq 0 \end{cases} \cdot (1)}$$

$$\frac{\partial L}{\partial w_{15}} = \frac{\partial L}{\partial a_5} \cdot \frac{\partial a_5}{\partial z_5} \cdot \frac{\partial z_5}{\partial w_{15}} \quad — \quad (2)$$

$$\frac{\partial L}{\partial a_5} = \frac{\partial L}{\partial a_6} \cdot \frac{\partial a_6}{\partial z_6} \cdot \frac{\partial z_6}{\partial a_5}$$

$$\frac{\partial L}{\partial a_5} = (-y + a_6) \cdot w_{56}.$$

putting in (2)

$$\boxed{\frac{\partial L}{\partial w_{15}} = (-y + a_6) \cdot w_{56} \cdot \begin{cases} 1 \text{ if } z_5 > 0 \\ 0 \text{ if } z_5 \leq 0 \end{cases} \cdot x_1}$$

$$\frac{\partial L}{\partial w_{25}} = \frac{\partial L}{\partial a_5} \cdot \frac{\partial a_5}{\partial z_5} \cdot \frac{\partial z_5}{\partial w_{25}}$$

$$\boxed{\frac{\partial L}{\partial w_{25}} = (-y + a_6) \cdot w_{56} \cdot \begin{cases} 1 \text{ if } z_5 > 0 \\ 0 \text{ if } z_5 \leq 0 \end{cases} \cdot x_2}$$

$$\frac{\partial L}{\partial w_{35}} = \frac{\partial L}{\partial a_5} \cdot \frac{\partial a_5}{\partial z_5} \cdot \frac{\partial z_5}{\partial w_{35}}$$

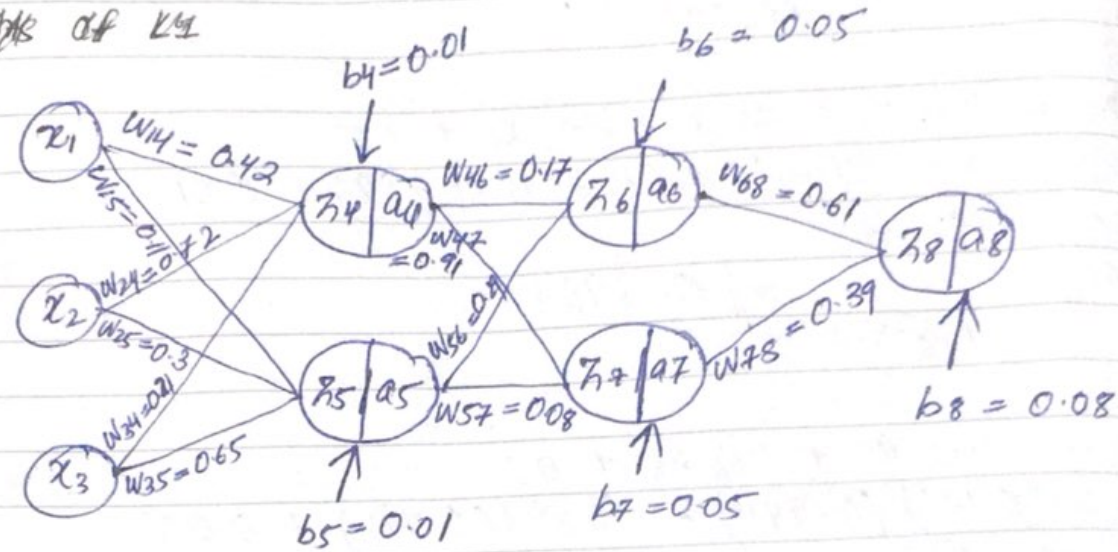
$$\boxed{\frac{\partial L}{\partial w_{35}} = (-y + a_6) \cdot w_{56} \cdot \begin{cases} 1 \text{ if } z_5 > 0 \\ 0 \text{ if } z_5 \leq 0 \end{cases} \cdot x_3}$$

$$\frac{\partial L}{\partial b_5} = \frac{\partial L}{\partial a_4} \cdot \frac{\partial a_5}{\partial z_5} \cdot \frac{\partial z_5}{\partial b_5}$$

$$\boxed{\frac{\partial L}{\partial b_5} = (-y + a_6) \cdot w_{56} \cdot \begin{cases} 1 \text{ if } z_5 > 0 \\ 0 \text{ if } z_5 \leq 0 \end{cases} \cdot (1)}$$

Question # 06.

Weights of K4



Student ID = 01K200477

F_1	F_2	F_3	Class
1	1	8	A
6	5	7	A
2	4	8	B
8	1	2	B

$w_{14} = 0.42$ $\quad w_{15} = 0.11$ $\quad w_{46} = 0.17$ $\quad w_{47} = 0.91$

$w_{24} = 0.72$ $\quad w_{25} = 0.3$ $\quad w_{56} = 0.29$ $\quad w_{57} = 0.0$

$w_{34} = 0.21$ $\quad w_{35} = 0.65$

$w_{68} = 0.61$ $\quad A = 1$ $\quad b_4 = 0.01$ $\quad b_6 = 0.05$

$w_{78} = 0.39$ $\quad B = 0$ $\quad b_5 = 0.01$ $\quad b_7 = 0.05$

$b_8 = 0.08$

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$x_1 = 1$, $x_2 = 1$, $x_3 = 8$, $A = 1$

$z_4 = w_{14} x_1 + w_{24} x_2 + w_{34} x_3 + b_4$

$z_4 = (0.42)(1) + (0.72)(1) + (0.21)(8) + 0.01$

$z_4 = 2.83$

$a_4 = \frac{1}{1+e^{-2.83}} = \boxed{0.944}$

$z_5 = w_{15} x_1 + w_{25} x_2 + w_{35} x_3 + b_5$

$z_5 = (0.11)(1) + (0.3)(1) + (0.65)(8) + 0.01$

$z_5 = 5.62$

$a_5 = \frac{1}{1+e^{-5.62}} = \boxed{0.996}$

$z_6 = w_{46} a_4 + w_{56} a_5 + b_6$

$z_6 = (0.17)(0.944) + (0.29)(0.996) + 0.05$

$z_6 = 0.49932$

$a_6 = \frac{1}{1+e^{-0.49932}} = \boxed{0.622}$

$z_7 = w_{47} a_4 + w_{57} a_5 + b_7$

$z_7 = (0.91)(0.944) + (0.08)(0.996) + 0.05$

$z_7 = 0.988$

$a_7 = \frac{1}{1+e^{-0.988}} = \boxed{0.728}$

$z_8 = w_{68} a_6 + w_{78} a_7 + b_8$

$z_8 = (0.61)(0.622) + (0.39)(0.728) + 0.08$

$z_8 = 0.743$

$a_8 = \frac{1}{1+e^{-0.743}} = \boxed{0.677}$

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$$\frac{\partial L}{\partial W_{68}} = -(y - a_8)\, a_8 (1 - a_8)\, a_6.$$

$$\frac{\partial L}{\partial W_{68}} = -(1 - 0.677)(0.677)(1 - 0.677)(0.622).$$

$$\boxed{\frac{\partial L}{\partial W_{68}} = -0.043}$$

$$\frac{\partial L}{\partial W_{78}} = -(y - a_8)\, a_8 (1 - a_8)\, a_7$$

$$\frac{\partial L}{\partial W_{78}} = -(1 - 0.677)(0.677)(1 - 0.677)(0.728)$$

$$\boxed{\frac{\partial L}{\partial W_{78}} = -0.051}$$

$$\frac{\partial L}{\partial W_{46}} = -(y - a_8)\, a_8 (1 - a_8)\, W_{68}\, a_6 (1 - a_6)\, a_4$$

$$\frac{\partial L}{\partial W_{46}} = -(1 - 0.677)(0.677)(1 - 0.677)(\cancel{-0.043})\,0.61\,(0.622)(1 - 0.622)(0.944)$$

$$\boxed{\frac{\partial L}{\partial W_{46}} = -0.0095}$$

$$\frac{\partial L}{\partial W_{56}} = -(y - a_8)\, a_8 (1 - a_8)\, W_{68}\, a_6 (1 - a_6)\, a_5$$

$$\frac{\partial L}{\partial W_{56}} = -(1 - 0.677)(0.677)(1 - 0.677)(0.61)(0.622)(1 - 0.622)(0.996).$$

$$\boxed{\frac{\partial L}{\partial W_{56}} = -0.01}$$

$$\frac{\partial L}{\partial b_6} = -(1 - 0.677)(0.677)(1 - 0.677)(0.61)(0.622)(1 - 0.622)$$

$$\boxed{\frac{\partial L}{\partial b_6} = -0.01}.$$

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$$\frac{\partial L}{\partial W_{47}} = -(y - a_8)\, a_8 (1 - a_8)\, W_{78}\, a_7 (1 - a_7)\, a_4 .$$

$$\frac{\partial L}{\partial W_{47}} = -(1 - 0.677)(0.677)(1 - 0.677)(0.39)(0.728)(1 - 0.728)(0.944)$$

$$\boxed{\frac{\partial L}{\partial W_{47}} = -0.005}$$

$$\frac{\partial L}{\partial W_{57}} = -(1 - 0.677)(0.677)(1 - 0.677)(0.39)(0.728)(1 - 0.728)(0.996)$$

$$\boxed{\frac{\partial L}{\partial W_{57}} = -0.005}$$

$$\frac{\partial L}{\partial b_7} = -(1 - 0.677)(0.677)(1 - 0.677)(0.39)(0.728)(1 - 0.728) \times 1$$

$$\boxed{\frac{\partial L}{\partial b_7} = -0.00545}$$

$$\frac{\partial L}{\partial b_8} = -(y - a_8)\, a_8 (1 - a_8)$$

$$\frac{\partial L}{\partial b_8} = -(1 - 0.677)(0.677)(1 - 0.677)$$

$$\boxed{\frac{\partial L}{\partial b_8} = -0.07063}$$

$$\frac{\partial L}{\partial W_{14}} = \Big[-(y - a_8)\, a_8 (1 - a_8)\, W_{68}\, a_6 (1 - a_6)\, W_{46} + -(y - a_8)\, a_8 (1 - a_8)\, W_{78}\, a_7 (1 - a_7)\, W_{47} \Big] \times a_4 (1 - a_4)\, x_1$$

$$\boxed{\frac{\partial L}{\partial W_{14}} = -0.00035}$$

$$\frac{\partial L}{\partial W_{24}} = \left[-(y - a_8)\, a_8 (1 - a_8)\, W_{68}\, a_6 (1 - a_6)\, W_{46} + -(y - a_8)\, a_8 (1 - a_8)\, W_{78}\, a_7 (1 - a_7)\, W_{46} \right] \times a_4 (1 - a_4)\, x_2$$

$$\boxed{\frac{\partial L}{\partial W_{24}} = -0.00035}$$

$$\frac{\partial L}{\partial W_{34}} = \left[-0.00172 + (-0.00496) \right] (0.944)(0.944) \cdot (1)$$

$$\boxed{\frac{\partial L}{\partial W_{34}} = -0.00035}$$

$$\boxed{\frac{\partial L}{\partial b_4} = = -0.00035}$$

$$\frac{\partial L}{\partial W_{15}} = \left(-(y - a_8)\, a_8 (1 - a_8)\, W_{68}\, a_6 (1 - a_6)\, W_{56} + -(y - a_8)\, a_8 (1 - a_8)\, W_{78}\, a_7 (1 - a_7)\, W_{57} \right] \times a_5 (1 - a_5)\, x_1$$

$$\frac{\partial L}{\partial W_{15}} = -(1 - 0.677)(0.677)(0.61)$$

$$\frac{\partial L}{\partial W_{15}} = (-0.00294 - 0.00052) \times (0.00398)(1)$$

$$\boxed{\frac{\partial L}{\partial W_{15}} = -0.00001}$$

$$\boxed{\frac{\partial L}{\partial W_{25}} = -0.00001}$$

$$\boxed{\frac{\partial L}{\partial W_{35}} = -0.00011}$$

$$\boxed{\frac{\partial L}{\partial b_5} = -0.00001}$$

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$x_1 = 6$, $x_2 = 5$, $x_3 = 7$, $A = 1$

$z_4 = (0.42)(6) + (0.72)(5) + (0.21)(7) + 0.01$

$z_4 = 7.6$ $\boxed{a_4 = 0.9995}$

$z_5 = (0.11)(6) + (0.3)(5) + (0.65)(7) + 0.01$

$z_5 = 6.72$ $\boxed{a_5 = 0.99879}$

$z_6 = (0.17)(0.9995) + (0.29)(0.99879) + 0.05$

$z_6 = 0.50956$ $\boxed{a_6 = 0.62470}$

$z_7 = (0.91)(0.9995) + (0.08)(0.99879) + 0.05$

$z_7 = 1.03945$ $\boxed{a_7 = 0.73874}$

$z_8 = (0.61)(0.62470) + (0.08)(0.73874)$

$\boxed{z_8 = 0.494918}$ $\boxed{a_8 = 0.679}$

$\boxed{\frac{\partial L}{\partial w_{68}} = -0.04371}$

$\frac{\partial L}{\partial w_{78}} = -(1-0.679)(0.679)(1-0.679)(0.73874)$

$\boxed{\frac{\partial L}{\partial w_{78}} = -0.05169}$

$\frac{\partial L}{\partial w_{46}} = -(1-0.679)(0.679)(1-0.679)(0.61)(0.62470)(1-0.62470)(0.9995)$

$\boxed{\frac{\partial L}{\partial w_{46}} = -0.01000}$

$\frac{\partial L}{\partial w_{46}} = -(1-0.679)(0.679)(1-0.679)(0.61)(0.62470)(1-0.62470)(0.99879)$

$\boxed{\frac{\partial L}{\partial w_{46}} = -0.00999}$

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$$\boxed{\frac{\partial L}{\partial W_{46}} = -0.01001}$$

$$\frac{\partial L}{\partial W_{47}} = -(1-0.679)(0.679)(1-0.679)(0.39)(0.73874)(1-0.73874)(0.9995)$$

$$\boxed{\frac{\partial L}{\partial W_{47}} = -0.00526}$$

$$\boxed{\frac{\partial L}{\partial W_{57}} = -0.00520}$$

$$\boxed{\frac{\partial L}{\partial b_7} = -0.00527}$$

$$\frac{\partial L}{\partial W_{14}} = -(1-0.679)(0.679)(1-0.679)(0.61)(0.62470)(1-0.62470)(0.17) + \left[-(1-0.679)(0.679)(1-0.679)(0.39)(0.73874)(1-0.73874)(0.21)\right] \times (0.9995)(1-0.9995)(6).$$

$$\partial L / \partial W_{14} = -0.00001 \times 6$$

$$\boxed{\frac{\partial L}{\partial W_{15}} = -0.00007}$$

$$\frac{\partial L}{\partial W_{25}} = -0.00001 \times 5$$

$$\boxed{\frac{\partial L}{\partial b_4} = -0.00001}$$

$$\boxed{\frac{\partial L}{\partial W_{25}} = -0.00006}$$

$$\frac{\partial L}{\partial W_{35}} = -0.00001 \times 7$$

$$\boxed{\partial L / \partial W_{35} = -0.00008}$$

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$$\frac{\partial L}{\partial w_{15}} = -(1-0.679)(0.679)(1-0.679)(0.61)(0.62470)(1-0.62470)(0.29) + -(1-0.679)(0.679)(1-0.679)(0.39)(0.73784)(1-0.73784)(0.05)(0.99879)(1-0.99879)(8)$$

$$\frac{\partial L}{\partial w_{15}} = -0.00000402 \times 8$$

$$\boxed{\frac{\partial L}{\partial w_{15}} = -0.0000032411}$$

$$\frac{\partial L}{\partial w_{25}} = -0.00000402 \times 5$$

$$\boxed{\frac{\partial L}{\partial w_{25}} = -0.00002009}$$

$$\frac{\partial L}{\partial w_{35}} = -0.00000402 \times 7$$

$$\boxed{\frac{\partial L}{\partial w_{35}} = -0.00002812}$$

$$\boxed{\frac{\partial L}{\partial b_{35}} = -0.00000402}$$

$x_1 = 2$, $x_2 = 4$, $x_3 = 8$, $B = 0$.

$z_4 = (0.42)(2) + (0.72)(4) + (0.21)(8) + 0.01$

$z_4 = 5.35$ $\quad a_4 = 1/1+e^{-5.35}$

$\boxed{a_4 = 0.995}$

$z_5 = (0.11)(2) + (0.3)(4) + (0.65)(8) + 0.01$

$z_5 = 5.33$ $\quad a_4 = 1/1+e^{-5.33}$

$\boxed{a_5 = 0.995}$

$z_6 = (0.7)(0.995 + (0.29) \times 0.995) + 0.05$

$z_6 = 0.508$

$a_6 = 1/1+e^{-0.508} = \boxed{0.624}$

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$z_7 = (0.91)(0.994) + (0.39)(0.738) + 0.08$

$z_7 = 1.035$

$a_7 = \frac{1}{1+e^{-1.035}} = \boxed{0.738}$

$z_8 = (0.61)(0.624) + (0.39)(0.738) + 0.08$

$z_8 = 0.748$

$\boxed{a_8 = 0.679}$

$\frac{\partial L}{\partial w_{68}} = (0.148)(0.0624)$

$\boxed{\frac{\partial L}{\partial w_{68}} = -0.092}$

$\frac{\partial L}{\partial w_{78}} = (0.148)(0.738)$

$\boxed{\frac{\partial L}{\partial w_{78}} = -0.107}$

$\boxed{\frac{\partial L}{\partial w_{B8}} = -0.148}$

$\frac{\partial L}{\partial w_{46}} = 0.021 \times 0.995$

$\boxed{\frac{\partial L}{\partial w_{46}} = 0.021}$

$\frac{\partial L}{\partial w_{56}} = 0.021 \times 0.9952$

$\boxed{\frac{\partial L}{\partial w_{5}} = 0.021}$

$\boxed{\frac{\partial L}{\partial w_{6}} = 0.021}$

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$$\frac{\partial L}{\partial w_{47}} = 0.011 \times 0.995$$

$$\boxed{\frac{\partial L}{\partial w_{47}} = -0.0111}$$

$$\frac{\partial L}{\partial w_{57}} = -(0.011)(0.9952)$$

$$\boxed{\frac{\partial L}{\partial w_{57}} = -0.011}$$

$$\boxed{\frac{\partial L}{\partial b_7} = -0.011}$$

$$\boxed{\frac{\partial L}{\partial w_{14}} = -0.00013}$$

$$\boxed{\frac{\partial L}{\partial w_{24}} = -0.00027}$$

$$\boxed{\frac{\partial L}{\partial w_{34}} = -0.0000406}$$

$$\boxed{\frac{\partial L}{\partial b_4} = \cancel{-6.760}\ 0.00000676}$$

$$\boxed{\frac{\partial L}{\partial w_{15}} = -0.00069998}$$

$$\boxed{\frac{\partial L}{\partial w_{25}} = -0.000139}$$

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$$\boxed{\frac{\partial L}{\partial w_{35}} = 0.00021}$$

$$\boxed{\frac{\partial L}{\partial b_5} = 0.00003499}$$

$x_1 = 8$, $x_2 = 1$, $x_3 = 2$, $B = 0$

$z_4 = 4.5$
$\boxed{a_4 = 0.989}$

$z_6 = 0.486$
$\boxed{a_6 = 0.619}$

$z_5 = 2.49$
$\boxed{a_5 = 0.923}$

$z_7 = 3.404$
$\boxed{a_7 = 0.999}$

$z_8 = 0.847$
$\boxed{a_8 = 0.699}$

$$\frac{\partial L}{\partial w_{68}} = (0.147)(0.619)$$

$$\boxed{\frac{\partial L}{\partial w_{68}} = 0.091}$$

$$\frac{\partial L}{\partial w_{78}} = (0.147)(0.999)$$

$$\boxed{\frac{\partial L}{\partial w_{78}} = 0.147}$$

$$\boxed{\frac{\partial L}{\partial b_8} = 0.147}$$

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$$\frac{\partial L}{\partial w_{46}} = (0.0211)(0.989)$$

$$\boxed{\frac{\partial L}{\partial w_{46}} = 0.021}$$

$$\frac{\partial L}{\partial w_{56}} = 0.021 \times 0.9905$$

$$\boxed{\frac{\partial L}{\partial w_{56}} = 0.022}$$

$$\boxed{\frac{\partial L}{\partial w_{47}} = 0.012}$$

$$\boxed{\frac{\partial L}{\partial w_{57}} = 0.021}$$

$$\boxed{\frac{\partial L}{\partial b_7} = 0.011}$$

$$\boxed{\frac{\partial L}{\partial w_{14}} = 0.0014} \qquad \boxed{\frac{\partial L}{\partial w_{15}} = 0.0035}$$

$$\boxed{\frac{\partial L}{\partial w_{24}} = 0.0026} \qquad \boxed{\frac{\partial L}{\partial w_{25}} = 0.00087}$$

$$\boxed{\frac{\partial L}{\partial w_{34}} = 0.000406} \qquad \boxed{\frac{\partial L}{\partial w_{35}} = 0.0057}$$

$$\boxed{\frac{\partial L}{\partial b_4} = 0.0000676} \qquad \boxed{\frac{\partial L}{\partial b_5} = 0.0000486}$$

Date_____20__
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Batch Gradient Descent

$$W_{68}' = \frac{-0.048 - 0.04371 - 0.092 - 0.071}{4}$$

$W_{68}' = -0.05759$
$W_{78}' = -0.0896$
$W_{46}' = -0.00092$
$W_{56}' = -0.0201$
$W_{47}' = -0.0625$
$W_{57}' = -0.0062$
$W_{14}' = -0.00016$
$W_{24}' = -0.00052$
$W_{34}' = -0.00009$
$W_{15}' = -0.00024$
$W_{25}' = -0.00003$
$W_{35}' = -0.0004$
$b_8' = -0.07603$
$b_7' = -0.00545$
$b_6' = -0.001$
$b_5' = -0.00001$
$b_4' = -0.00035$

to get new weights.

We put all these in formuds below $\eta = 0.7$.

$W_{68} = W_{68} - \eta W_{68}'$
$W_{78} = W_{78} - \eta W_{78}'$
W :

ii) Cross Entropy Loss
Same for cross entropy loss.