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1.

(i) $h(x) = f_1(x)$

- cumple para (b) porque son datos linealmente separables, no cumple para los demás casos.

(ii) $h(x) = f_2(f_1(x))$

- Como f_1 y f_2 son funciones lineales, su composición también lo será. Igual que el item anterior, solo cumple (b).

(iii) $h(x) = f_2(g(f_1(x)))$

- puede suceder que f_2 sea la función identidad, lo que conduce a $f_2(g(f_1(x))) = g(f_1(x))$, y esta función 'g' al ser NO LINEAL podría modelar regiones curvas. Para este caso cumple 'a', 'b' y 'c'.

(iv) $h(x) = f_4(f_3(f_2(f_1(x))))$

- De forma similar a (i), la composición de funciones lineales sigue siendo lineal, esto solo resolvería 'a'.

(v) $h(x) = g_2(g_1(x))$

- La composición de dos funciones no lineales, es no lineal. Puede resolver 'a', 'b' y 'c'.

2.

(a) $\frac{\partial z}{\partial h_1} = \frac{\partial (f_1(x) \cdot f_2(x))}{\partial h_1} = \frac{\partial h_1}{\partial h_1} h_2 + \cancel{h_1 \frac{\partial h_2}{\partial h_1}} = h_2$

(b) $\frac{\partial z}{\partial h_2} = \frac{\partial (f_1(x) \cdot f_2(x))}{\partial h_2} = \cancel{\frac{\partial h_1}{\partial h_2} h_2} + h_1 \frac{\partial h_2}{\partial h_2} = h_1$

(c) $\frac{\partial z}{\partial x} = \frac{\partial (f_1(x) \cdot f_2(x))}{\partial x} = \frac{\partial f_1(x)}{\partial x} f_2(x) + f_1(x) \frac{\partial f_2(x)}{\partial x}$

$= \frac{\partial f_1(x)}{\partial x} h_2 + h_1 \frac{\partial f_2(x)}{\partial x}$

(a)

h_1	h_2	h_3	r_1	r_2	r_3	s	y_1	y_2	z
2	-10	3	2	0	3	3	0.27	0.73	1

(b) y_1 y z se aproximan a 0.27 y 1 respectivamente.

(c) Sea $g(x)$ la función sigmoide, su derivada $\frac{dg}{dx} = g(x)(1 - g(x))$

- $\frac{\partial h_1}{\partial w_{12}} = \frac{\partial (w_{11} x_1 + w_{12} x_2)}{\partial w_{12}} = x_2$

- $\frac{\partial h_1}{\partial x_1} = \frac{\partial (w_{11} x_1 + w_{12} x_2)}{\partial x_1} = w_{11} = 6$

- $\frac{\partial r_1}{\partial h_1} = \frac{\partial (\max(h_1, 0))}{\partial h_1} = \max\left(\frac{\partial h_1}{\partial h_1}, \frac{\partial 0}{\partial h_1}\right) = \max(1, 0) = 1$

- $\frac{\partial y_1}{\partial r_1} = \frac{\partial \, \mathrm{Sofmax}(r_1)}{\partial r_1}$

Sea $p_j = \frac{e^{o_j}}{\sum_k e^{o_k}}$ 　 $\frac{\partial p_j}{\partial o_i} = p_i (1 - p_i)$ si $i = j$

$\frac{\partial p_i}{\partial o_i} = -p_i p_j$ si $i \neq j$

Usando esa fórmulas:

$\frac{dy_1}{dr_1} = y_1 (1 - y_1) = 0.1971$

- $\frac{\partial y_1}{\partial s_1} = -y_1 y_2$ (de acuerdo a la ecuación anterior)

$= 0.1971$

- $\frac{\partial z}{\partial y_1} = \frac{\partial (y_1 + y_2)}{\partial y_1} = \frac{\partial y_1}{\partial y_1} + \cancel{\frac{\partial y_2}{\partial y_1}} = 1$

- $\frac{\partial z}{x_1} = \frac{\partial (y_1 + y_2)}{\partial x_1} = \frac{\partial y_1}{\partial x_1} + \frac{\partial y_2}{\partial x_1} = 2.1681$ (ver α)

$y_1 = \text{Softmax}\left(\max(x_1 w_{11} + x_2 w_{12}, 0)\right)$
$y_2 = \text{Softmax}\left(\max(\max(x_1 w_{21} + x_2 w_{22}, 0), \max(x_1 w_{31} + x_2 w_{32}, 0))\right)$

- $\frac{\partial s_1}{\partial r_2} = \frac{\partial(\max(r_2, r_3))}{\partial r_2} = \max\left(\frac{\partial r_2}{\partial r_2}, \frac{\partial r_3}{\partial r_2}\right) = \max(1, 0)$

$= 1$

α :

Sea $O_1 = \max(x_1 w_{11} + x_2 w_{12}, 0)$

$\frac{\partial O_1}{\partial x_1} = \frac{\partial \max(x_1 w_{11} + \cancel{x_2} w_{12}, 0)}{\partial x_1}$

$\frac{\partial O_1}{\partial x_1} = \max(w_{11}, 0)$

$\Rightarrow \frac{\partial y_1}{\partial x_1} = \frac{\partial y_1}{\partial O_1} \frac{\partial O_1}{\partial x_1} = y_1(1 - y_1)\max(w_{11}, 0)$

$\frac{\partial y_1}{\partial x_1} = 1.1826$

Sea $O_2 = \max(\max(x_1 w_{21} + x_2 w_{22}, 0), \max(x_1 w_{31} + w_{32}, 0))$

$\frac{\partial O_2}{\partial x_1} = \max(\underbrace{\max(w_{21}, 0)}_{4}, \underbrace{\max(w_{31}, 0)}_{5})$

$\Rightarrow \frac{\partial y_2}{\partial x_1} = \frac{\partial y_2}{\partial O_2} \frac{\partial O_2}{\partial x_1} = y_2(1 - y_2) \frac{\partial O_2}{\partial x_1} = 0.9855$