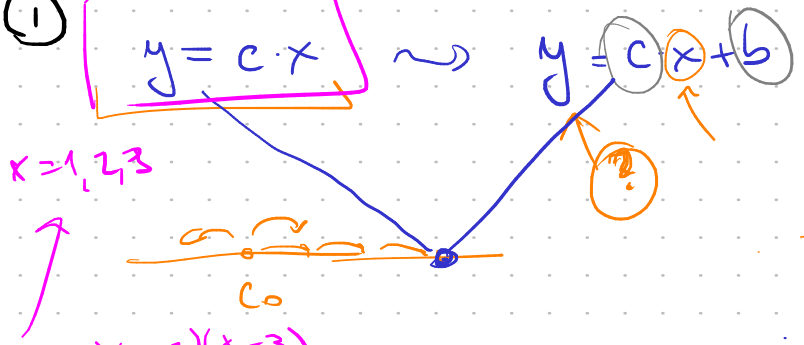
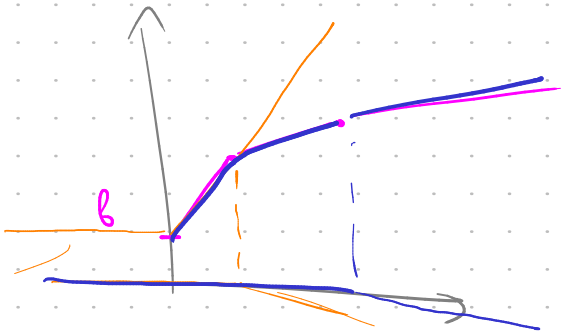
① $y = c \cdot x \rightsquigarrow y = c \cdot x + b$

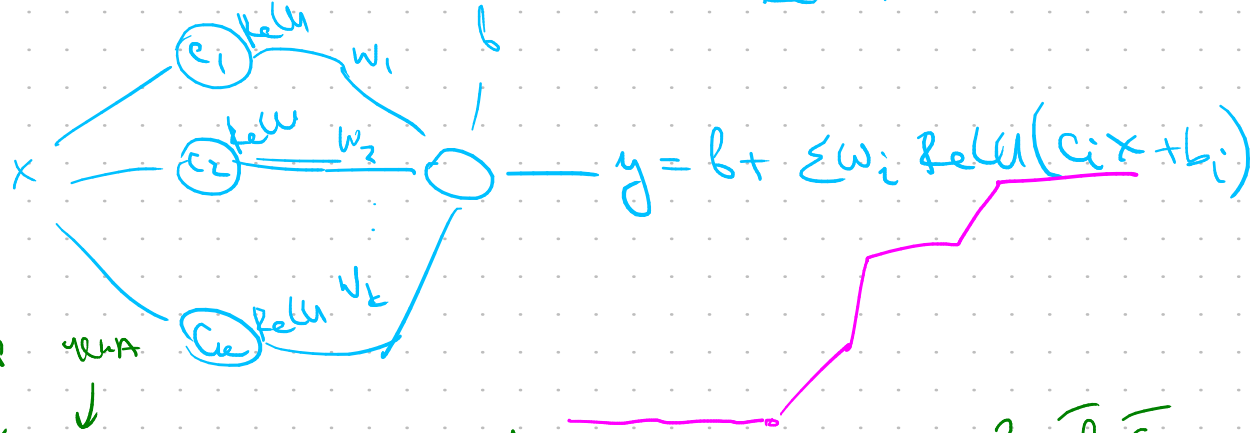




$a(x-1)(x-2)(x-3)$

$b + w_1 \cdot \max(0, c_1 x + b_1) + w_2 \max(0, c_2 x + b_2) + \ldots = \hat{y}$

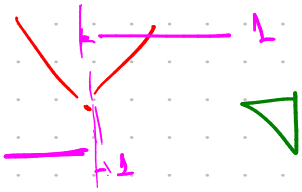
ReLU ReLU



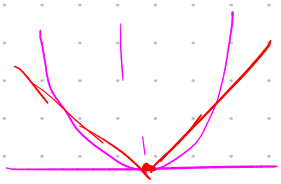
#стр рост

$D = \{(x_n, y_n)\}$

$L = \sum_{n=1}^{N} (y_n - \hat{y}_n(x_n))^2 \xrightarrow{\bar{b}, \bar{c}} \min$



$\nabla L = \left(\frac{\partial L}{\partial b_1}, \frac{\partial L}{\partial c_1}, \ldots \frac{\partial L}{\partial b_k}, \frac{\partial L}{\partial c_k} \right)$

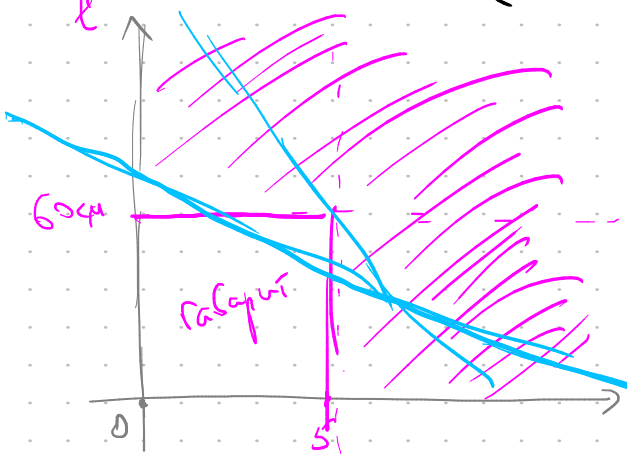


$(\bar{b}, \bar{c}) := (\bar{b}, \bar{c}) - \alpha \cdot \nabla L$

набла / nabla

② Oversize – посылки

негабарит = $(m > 5\text{кг})$ ИЛИ $(l > 60\text{см})$



$D = \{(\bar{x}_n, y_n)\}_{n=1}^{N}$

(m, l) — classification

$\{0, 1\}$

Model: $w_0 + w_1 m + w_2 l > 0$ ⇒ несбудется

Что мы улучшаем? Точность классификации

$$Acc = \frac{\#\text{прав. ответов}}{N}$$

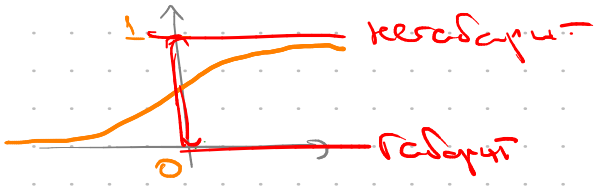
$Acc(\bar{w}) \to \max_{\bar{w}}$

$\bar{w} + \Delta\bar{w}$

$\nabla_{\bar{w}} Acc(\bar{w})$

$w_0 + w_1 m + w_2 l \to \sigma \rightsquigarrow \sigma(w_0 + w_1 m + w_2 l) \in (0,1)$

$= p$



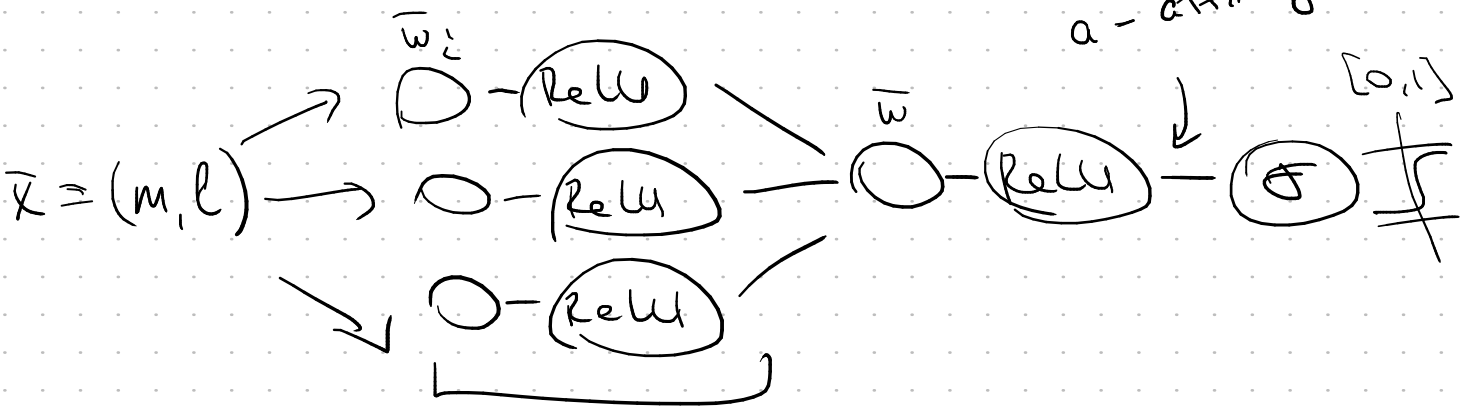
$y \in \{0,1\}$

$$l(\bar{w}) = -y \cdot \log p - (1-y) \cdot \log(1-p) = \begin{cases} -\log p, & y=1 \\ -\log(1-p), & y=0 \end{cases}$$

$$L(\bar{w}) = \sum_{n=1}^{N} \left(-y_n \log \sigma(w_0 + w_1 m_n + w_2 l_n) - (1-y_n) \log\left(1 - \sigma(w_0 + w_1 m_n + w_2 l_n)\right)\right)$$

$\bar{w}$ — $\min$

$\bar{w}_0, \bar{w}_1 = \bar{w}_0 - \alpha \cdot \nabla_{\bar{w}} L(\bar{w}_0), \bar{w}_2, \bar{w}_3, \ldots$

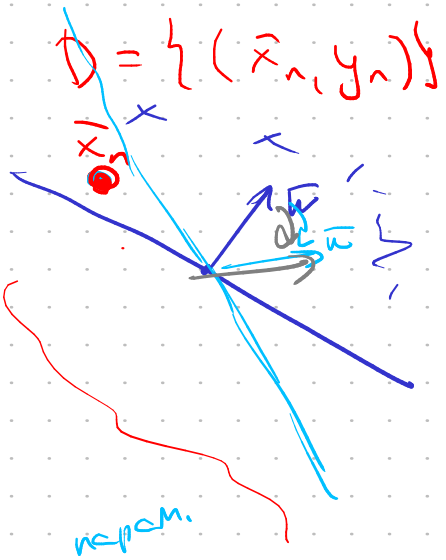


$\max(0, w_0 + w_1 m + w_2 l)$

(3) Ф-ция ошибки на подсчитать

$$L(\bar{w}) = \sum_{n=1}^{N} l(\bar{w}, \bar{x}_n, y_n)$$

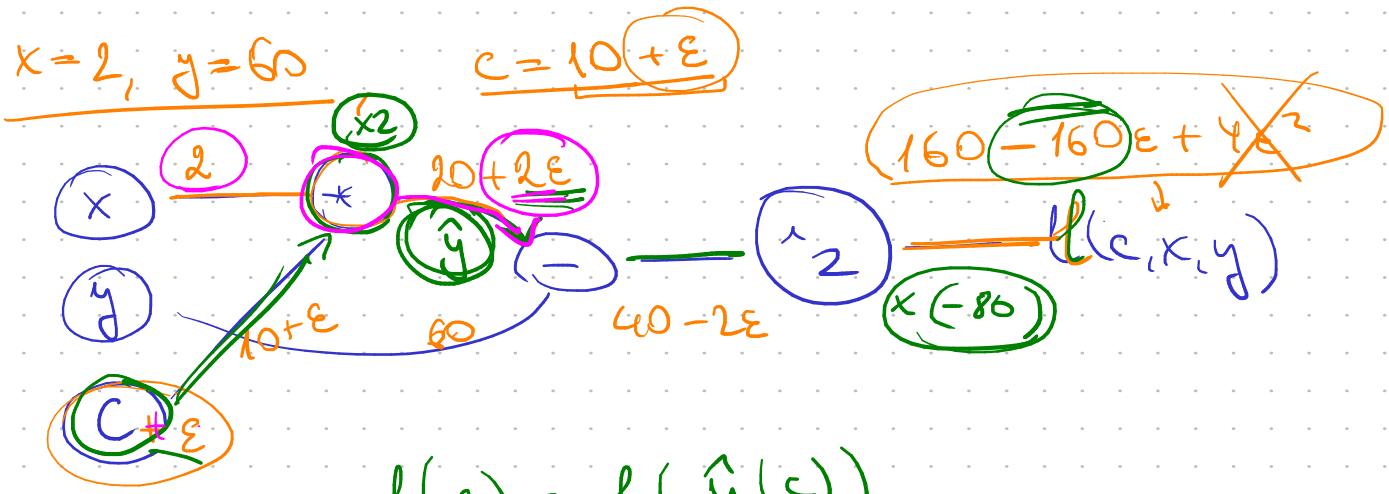
$$\nabla_{\bar{w}} L(\bar{w}) = \sum_{n=1}^{N} \nabla_{\bar{w}} l(\bar{w}, \bar{x}_n, y_n)$$



(4) Backpropagation

Forward propagation

$\hat{y} = c \cdot x$, $l(c, x, y) = (\hat{y} - y)^2 = (y - c \cdot x)^2$ — параметр, данные



$$l(c) = l(\hat{y}(c))$$

$$\frac{\partial l}{\partial c} = \frac{\partial l}{\partial \hat{y}} \cdot \frac{\partial \hat{y}}{\partial c} = (-2y + 2\hat{y}) \cdot x$$

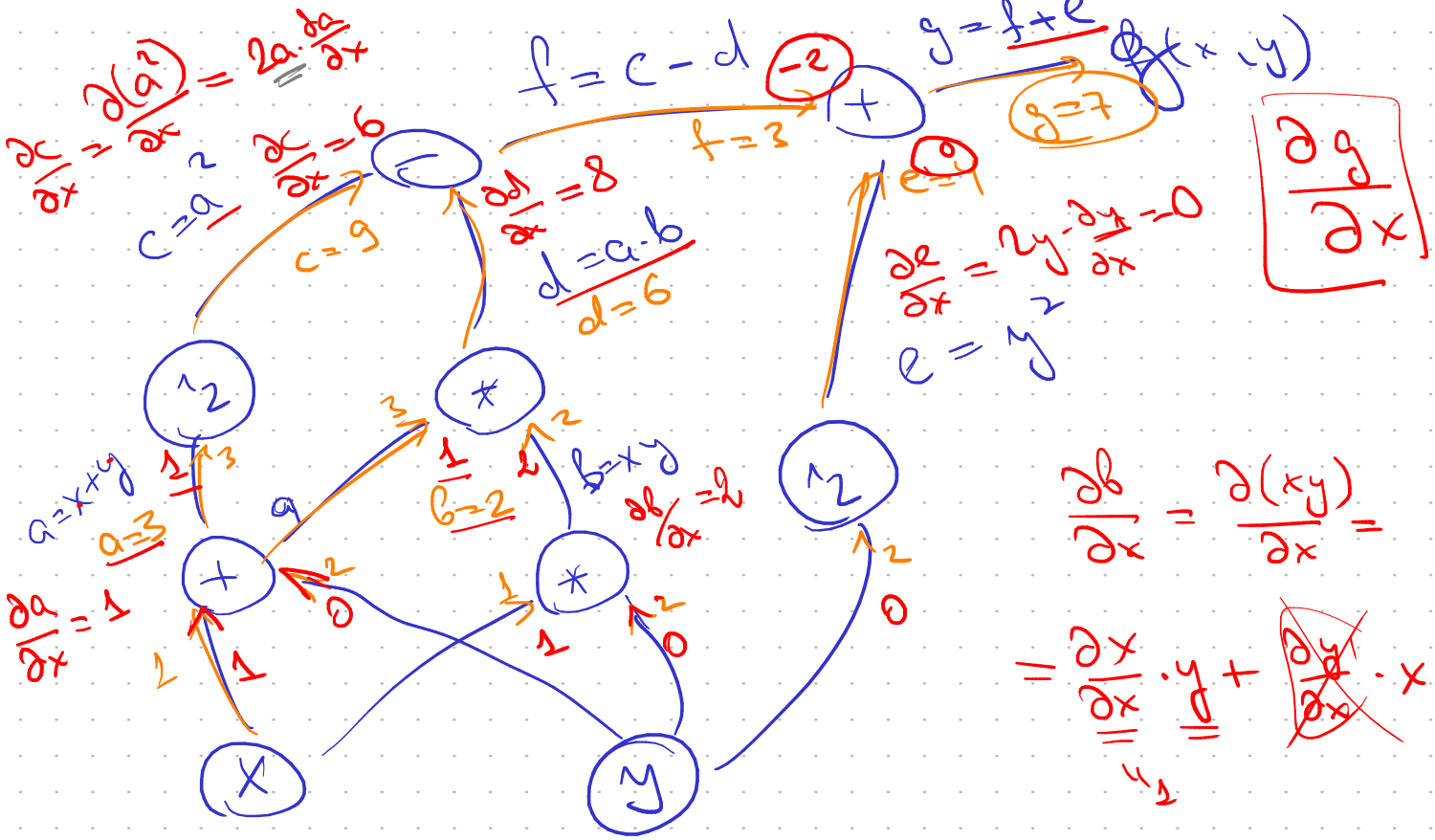
$$= (-2y + 2cx) \cdot x$$

$$\frac{\partial (cx)}{\partial c} = x$$

$$\frac{\partial (y - \hat{y})^2}{\partial \hat{y}} = \frac{\partial (y^2 - 2y\hat{y} + \hat{y}^2)}{\partial \hat{y}} = -2y + 2\hat{y}$$

$$\frac{\partial g}{\partial x} = \overset{=1}{2}(x+y) - \overset{=2}{y}(x+y) - xy = 6 - 6 - 2 = -2$$

$$g(x,y) = (x+y)^2 - xy(x+y) + y^2 \qquad \nabla f = \left(\frac{\partial f}{\partial x}, \frac{\partial f}{\partial y}\right)$$



$$\frac{\partial g}{\partial x}$$

$$\frac{\partial b}{\partial x} = \frac{\partial (xy)}{\partial x} = \frac{\partial x}{\partial x} \cdot y + \frac{\partial y}{\partial x} \cdot x = y$$

$$\frac{\partial d}{\partial x} = \frac{\partial a}{\partial x} \cdot b + \frac{\partial b}{\partial x} \cdot a = 2 + 2 \cdot 3$$

$$\frac{\partial f}{\partial x} = \frac{\partial c}{\partial x} - \frac{\partial d}{\partial x} = -2$$

$$\frac{\partial g}{\partial x} = \frac{\partial f}{\partial x} + \frac{\partial e}{\partial x} = -2$$