Test

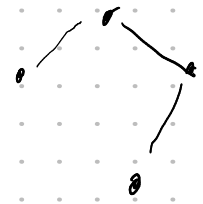
(1) **Úloha 1.** (1b.) Jaká je časová složitost (počet float operací sčítání/násobení) základní verze algoritmu K-means pro K clusterů, T iterací a data $X = \{x_j \in \mathbb{R}^d \mid j = 1, .., N\}$?

$\|x-y\|^2$

1/ label x_i: $N \cdot K\,(d + d^2 + (d-1))$

rozdíl ⋮ rozdíl

$O(NKd)$



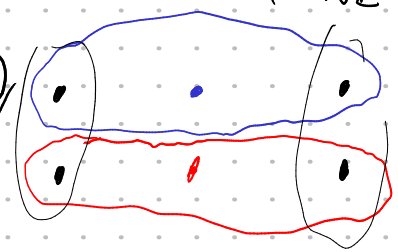
2/ update c_k: $(N-K)d + Kd$ $\quad O(Nd)$

$x_1 \quad x_2 \quad x_3$

A B A

$O(TNKd)$

(2)



(3) minimalizace upper-bound emp chyby

$$R_{emp}(H_T) \leq \prod_{t=1}^{T} Z_t$$

(4) $$D_{t+1}(i) = \frac{D_t(i) \cdot e^{-\alpha_t y_i h_t(x_i)}}{Z_t}$$

chybně klas: $y_i \cdot h_t(x_i) = -1$ $\quad D_t(i) \cdot e^{-} < 1$

správně klas: $y_i h_t(x_i) = 1$ $\quad D_t(i)\, e^{+} > 1$

$\alpha_t > 0$

CNN

$T = \{(x_1, y_1) \dots (x_N, y_N)\}$

Stochastic Grad. Descent $\arg\min_w L(y, f_w(x))$

1. x_i → Forward → $\hat{y}_i$
2. $Loss(\hat{y}_i, y_i)$ napr.: $(y_i - \hat{y}_i)^2$
3. Backward ← Loss
4. W update $W_{t+1} = W_t - \gamma \cdot \frac{\partial L}{\partial W}$

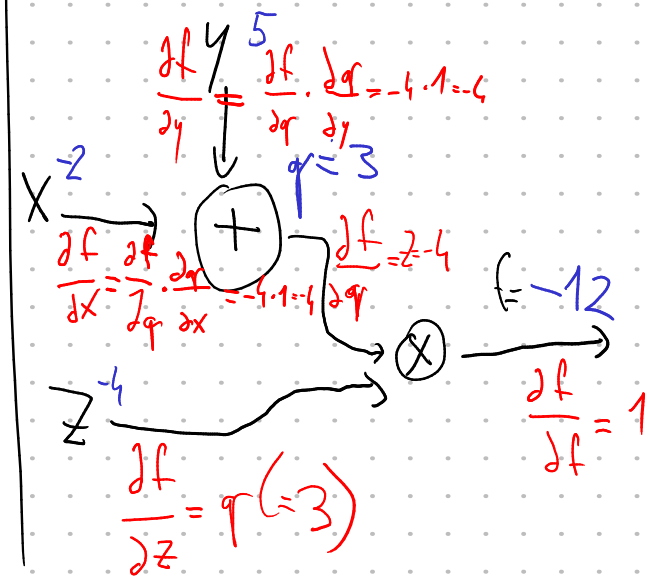
$f_y(x, z) = (x + y) \cdot z$ $\quad x, y, z \in \mathbb{R}$

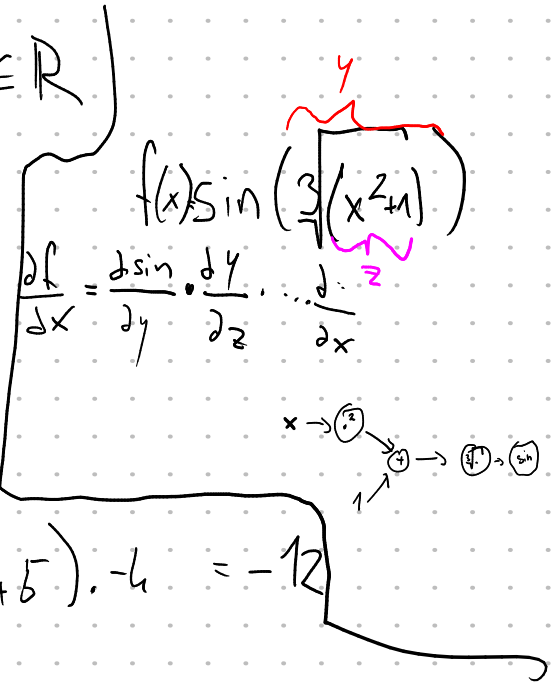
chceme se učit

$(x = -2, z = -4)$

$\arg\min_y f_y(x, z)$

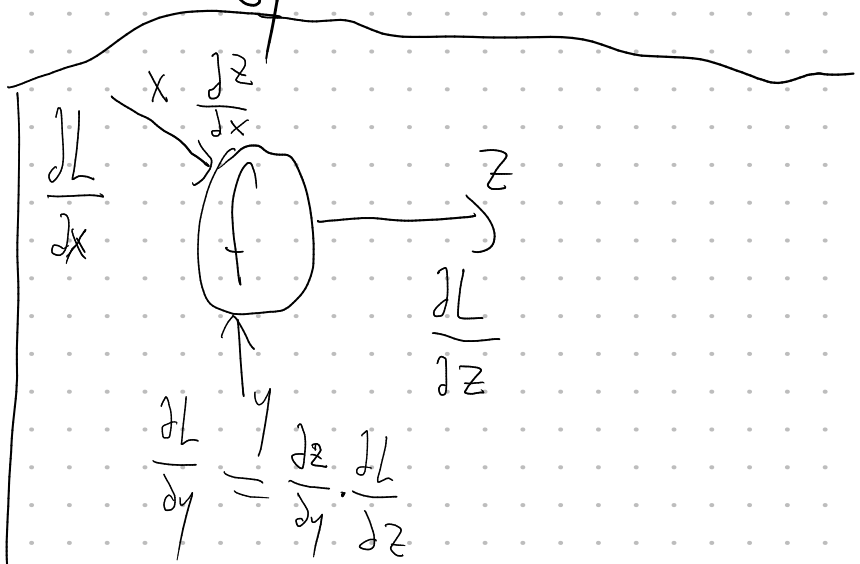
SGD $\quad y = 5$





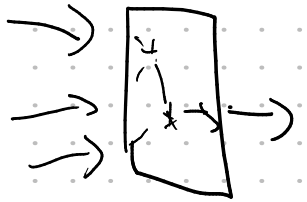
$f_y(x, z) = (-2 + 5) \cdot -4 = -12$

$y' = y - \frac{\partial f}{\partial y}$



máme bloky +, *, log, ...

→ vrstvy NN



DÚ ① vlastní NN v numpy

```
class Multiply():
    def forward(x, y):
        z = x * y
        self.y = y
        self.x = x
        return z

    def backward(self, dz):   # dz = dL/dz
        dx = dz * self.y
        dy = dz * self.x
        return [dx, dy]       # dL/dx, dL/dy

    def params():
```

② pytorch