

# ⑤ PERCEPTRON ZA VIŠE OD 2 RAZREDA

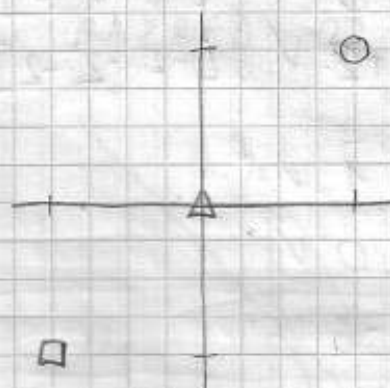
$$w_1 = \{ [1, 1]^T \} \circ$$

$$w_2 = \{ [0, 0]^T \} \Delta$$

$$w_3 = \{ [-1, -1]^T \} \square$$

$$c = 1$$

$$\vec{w}_1 = \vec{w}_2 = \vec{w}_3 = \vec{0}$$



1. KORAK, PROŠIRUJEMO VEZIKU SA [1]

$$w_1 = [1 \ 1 \ 1]^T$$

$$w_2 = [0 \ 0 \ 1]^T$$

$$w_3 = [-1 \ -1 \ 1]^T$$

1. epoha

$$\vec{w}_1(1)^T \cdot [1 \ 1 \ 1] = 0 \rightarrow \vec{w}_1(2) = \vec{w}_1(1) + c \cdot [1 \ 1 \ 1] = [1 \ 1 \ 1]$$

$$\vec{w}_2(1)^T \cdot [1 \ 1 \ 1] = 0 \rightarrow \vec{w}_2(2) = \vec{w}_2(1) - c \cdot [1 \ 1 \ 1] = [-1 \ -1 \ 0]$$

$$\vec{w}_3(1)^T \cdot [1 \ 1 \ 1] = 0 \rightarrow \vec{w}_3(2) = \vec{w}_3(1) - c \cdot [1 \ 1 \ 1] = [-1 \ -1 \ 0]$$

$$\vec{w}_1(2)^T \cdot [0 \ 0 \ 1] = 1 \rightarrow [1 \ 1 \ 0]$$

$$\vec{w}_2(2)^T \cdot [0 \ 0 \ 1] = -1 \rightarrow [-1 \ -1 \ 0]$$

$$\vec{w}_3(2)^T \cdot [0 \ 0 \ 1] = -1 \rightarrow [-1 \ -1 \ 0]$$

$$\vec{w}_1(3)^T \cdot [-1 \ -1 \ 1] = -2 \rightarrow [1 \ 1 \ 0]$$

$$\vec{w}_2(3)^T \cdot [-1 \ -1 \ 1] = 2 \rightarrow [0 \ 0 \ -1]$$

$$\vec{w}_3(3)^T \cdot [-1 \ -1 \ 1] = 0 \rightarrow [-2 \ -2 \ -1]$$

$$\vec{w}_1(4) = [1 \ 1 \ 1] = 2 \checkmark$$

$$\vec{w}_2(4) \cdot [1 \ 1 \ 1] = -1 \checkmark$$

$$\vec{w}_3(4) \cdot [1 \ 1 \ 1] = -5 \checkmark$$

$$\vec{w}_1(5) \cdot [0 \ 0 \ 1] = 0 \rightarrow [1 \ 0 \ -1]$$

$$\vec{w}_2(5) \cdot [0 \ 0 \ 1] = -1 \rightarrow [0 \ 0 \ 0]$$

$$\vec{w}_3(5) \cdot [0 \ 0 \ 1] = -1 \rightarrow [-2 \ -2 \ -2]$$

$$\vec{w}_1(6)^T \cdot [-1 -1 1] = -3 \checkmark \quad [1 \ 1 \ -1]$$

$$\vec{w}_2(6)^T \cdot [-1 -1 1] = 0 \checkmark \quad [0 \ 0 \ 0]$$

$$\vec{w}_3(6)^T \cdot [-1 -1 1] = +2 \checkmark \quad [-2 \ -2 \ -2]$$

$$\vec{w}_1(7)^T \cdot [1 \ 1 \ 1] = 1 \checkmark$$

$$\vec{w}_2(7)^T \cdot [1 \ 1 \ 1] = 0 \checkmark$$

$$\vec{w}_3(7)^T \cdot [1 \ 1 \ 1] = -6 \checkmark$$

$$\vec{w}_1(8)^T \cdot [0 \ 0 \ 1] = -1 \checkmark$$

$$\vec{w}_2(8)^T \cdot [0 \ 0 \ 1] = 0 \checkmark$$

$$\vec{w}_3(8)^T \cdot [0 \ 0 \ 1] = -2 \checkmark$$

$$d_1(\vec{x}) = x_1 + x_2 - 1$$

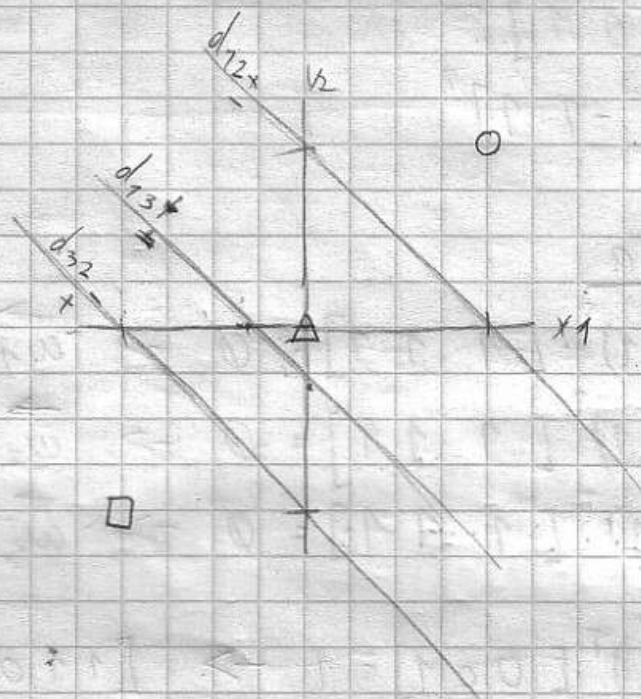
$$d_2(\vec{x}) = \emptyset$$

$$d_3(\vec{x}) = -2x_1 - 2x_2 - 2$$

$$d_{12}(\vec{x}) = x_1 + x_2 - 1$$

$$d_{13}(\vec{x}) = 3x_1 + 3x_2 + 1$$

$$d_{32}(\vec{x}) = -2x_1 - 2x_2 - 2$$



(4 boda) Za skup uzoraka

$$\omega_1 = \{ [0, 0]^T, [1, 1]^T \},$$

$$\omega_2 = \{ [-1, 2]^T \},$$

naći granice između razreda poopćenim postupkom perceptrona **za više od 2 razreda**. Neka su na početku svi težinski vektori nul-vektori, a konstanta  $c=1$ . Biste li isto rješenje dobili postupkom perceptrona za 2 razreda? Komentirajte zašto.

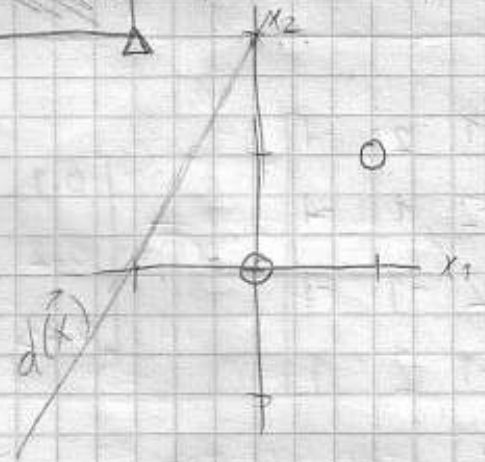


$$\omega_1 = \{ [0 \ 0]^T, [1 \ 1]^T \}$$

$$\omega_2 = \{ [-1 \ 2]^T \}$$

$$\bar{\omega}(0) = [\emptyset]$$

$$c = 1$$



$$1) \quad \omega_1 = \left\{ \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}, \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} \right\} \quad \circ$$

$$\omega_2 = \left\{ \begin{bmatrix} -1 \\ 2 \\ 1 \end{bmatrix} \right\} \quad \Delta$$

2)

$$\bar{\omega}_1(1) \cdot [0 \ 0 \ 1]^T = \emptyset \Rightarrow \bar{\omega}_1(2) = \bar{\omega}_1(1) + c \cdot [0 \ 0 \ 1] = [0 \ 0 \ 1]^T$$

$$\bar{\omega}_2(1) \cdot [0 \ 0 \ 1]^T = \emptyset \Rightarrow \bar{\omega}_2(2) = \bar{\omega}_2(1) - c \cdot [0 \ 0 \ 1] = [0 \ 0 \ -1]^T$$

$$\bar{\omega}_1(2) \cdot [1 \ 1 \ 1]^T = 1 \quad \checkmark$$

$$\bar{\omega}_2(2) \cdot [1 \ 1 \ 1]^T = -1 \quad \checkmark$$

$$\bar{\omega}_1(3) \cdot [-1 \ 2 \ 1] = 1 \Rightarrow \bar{\omega}_1(4) = [1 \ -2 \ 0]^T$$

$$\bar{\omega}_2(3) \cdot [-1 \ 2 \ 1] = -1 \Rightarrow \bar{\omega}_2(4) = [-1 \ 2 \ 0]^T$$

$$\bar{\omega}_1(4) \cdot [0 \ 0 \ 1] = \emptyset \Rightarrow \bar{\omega}_1(5) = [1 \ -2 \ 1]^T$$

$$\bar{\omega}_2(4) \cdot [0 \ 0 \ 1] = \emptyset \Rightarrow \bar{\omega}_2(5) = [-1 \ 2 \ -1]^T$$

$$\bar{\omega}_1(5) \cdot [1 \ 1 \ 1] = \emptyset \Rightarrow \bar{\omega}_1(6) = [2 \ -1 \ 2]^T$$

$$\bar{\omega}_2(5) \cdot [1 \ 1 \ 1] = \emptyset \Rightarrow \bar{\omega}_2(6) = [-2 \ 1 \ -2]^T$$

$$\bar{\omega}_1(6) \cdot [-1 \ 2 \ 1] = -2 \quad \checkmark$$

$$\bar{\omega}_2(6) \cdot [-1 \ 2 \ 1] = 2 \quad \checkmark$$

$$d(\vec{x}) = 2x_1 - x_2 + 2$$

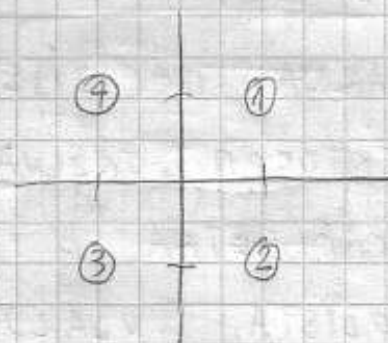
$$\bar{\omega}_1(7) \cdot [0 \ 0 \ 1] = 2 \quad \checkmark$$

$$\bar{\omega}_2(7) \cdot [0 \ 0 \ 1] = -2 \quad \checkmark$$

$$\bar{\omega}_1(8) \cdot [1 \ 1 \ 1] = 3 \quad \checkmark$$

$$\bar{\omega}_2(8) \cdot [1 \ 1 \ 1] = -3 \quad \checkmark$$

$$\begin{aligned}
 w_1 &= \{[1 \ 1]\} & x_1 &= \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} & x_2 &= \begin{bmatrix} 1 \\ -1 \\ 1 \end{bmatrix} \\
 w_2 &= \{[1 \ -1]\} \\
 w_3 &= \{[-1 \ -1]\} & x_3 &= \begin{bmatrix} -1 \\ -1 \\ 1 \end{bmatrix} & x_4 &= \begin{bmatrix} -1 \\ 1 \\ -1 \end{bmatrix} \\
 w_4 &= \{[-1 \ 1]\}
 \end{aligned}$$



$$w_1(1) = [0 \ 0 \ 0] \cdot x_1 = 0 \uparrow = [1 \ 1 \ 1]$$

$$w_2(1) = [0 \ 0 \ 0] \cdot x_1 = 0 \downarrow = [-1 \ -1 \ -1]$$

$$w_3(1) = [0 \ 0 \ 0] \cdot x_1 = 0 \downarrow = [-1 \ -1 \ -1]$$

$$w_4(1) = [0 \ 0 \ 0] \cdot x_1 = 0 \downarrow = [-1 \ -1 \ -1]$$

$$w_1 \cdot x_2 = 1 \downarrow [0 \ 2 \ 0]$$

$$w_2 \cdot x_2 = -1 \uparrow [0 \ -2 \ 0]$$

$$w_3 \cdot x_2 = -1 \downarrow [-2 \ 0 \ -2]$$

$$w_4 \cdot x_2 = -1 \downarrow [-2 \ 0 \ -2]$$

$$w_1 \cdot x_3 = -2 [0 \ 2 \ 0]$$

$$w_2 \cdot x_3 = 2 [0 \ -2 \ 0]$$

$$w_3 \cdot x_3 = 4 \uparrow [-3 \ -1 \ -3]$$

$$w_4 \cdot x_3 = 4 \downarrow [-1 \ 1 \ -1]$$

$$w_1 \cdot x_4 = 2 \downarrow [1 \ 1 \ -1]$$

$$w_2 \cdot x_4 = -2 [0 \ -2 \ 0]$$

$$w_3 \cdot x_4 = -1 [-3 \ -1 \ -3]$$

$$w_4 \cdot x_4 = 1 \uparrow [-2 \ 2 \ 0]$$

$$w_1 \cdot x_1 = 1 \checkmark \quad x_2 = -1 \quad x_3 = -3 [1 \ 1 \ -1]$$

$$w_2 \cdot x_1 = -2 \quad x_2 = 2 \checkmark \quad x_3 = 2 \downarrow [1 \ -1 \ -1]$$

$$w_3 \cdot x_1 = -7 \quad x_2 = -5 \quad x_3 = 1 \uparrow [-4 \ -2 \ -2]$$

$$w_4 \cdot x_1 = 0 \quad x_2 = -4 \quad x_3 = 0 [-2 \ 2 \ 0]$$

$$\cdot x_4 = -1 \quad \cdot x_1 = 1 \checkmark \quad \cdot x_2 = -1 \quad \cdot x_3 = -3 \checkmark$$

$$\cdot x_4 = -3 \quad \cdot x_1 = -1 \quad \cdot x_2 = 1 \checkmark \quad \cdot x_3 = -1 \checkmark$$

$$\cdot x_4 = 0 \quad \cdot x_1 = -8 \quad \cdot x_2 = -4 \quad \cdot x_3 = 4 \checkmark$$

$$\cdot x_4 = 4 \checkmark \quad \cdot x_1 = 0 \quad \cdot x_2 = -4 \quad \cdot x_3 = 0 \checkmark$$

$$d_1(\vec{x}) = x_1 + x_2 - 1$$

$$d_3(\vec{x}) = -4x_1 - 2x_2 - 2$$

$$d_2(\vec{x}) = x_1 - x_2 - 1$$

$$d_4(\vec{x}) = -2x_1 + 2x_2$$

$$d_{12} = 2x_2 \quad ; \quad d_{13} = 5x_1 + 3x_2 + 1$$

$$d_{14} = 3x_1 - x_2 - 1 \quad ; \quad d_{23} = 5x_1 + x_2 + 1$$

$$d_{24} = 3x_1 - 3x_2 - 1 \quad ; \quad d_{34} = -2x_1 - 4x_2 - 2$$

