(1) 1.1) B

1.2) A, B

(2) $f(x; a, b) = \text{sign}(a \cdot x + b)$

2.1) S_1 $a_1 = 2$ $b_1 = 5$

$f(1; 2, 5) = \text{sign}(2(1) - 5) = -1$ $y^{(1)} = -1$ ✓

$f(3; 2, 5) = \text{sign}(2(3) - 5) = 1$ $y^{(3)} = 1$ ✓

$f(4; 2, 5) = \text{sign}(2(4) - 5) = 1$ $y^{(4)} = -1$ ✗

S_2 $a_2 = 2$ $b_2 = -7$

$f(2; 2, -7) = \text{sign}(2(2) - 7) = -1$ $y^{(2)} = -1$ ✓

$f(5; 2, -7) = \text{sign}(2(5) - 7) = 1$ $y^{(5)} = 1$ ✓

$f(6; 2, -7) = \text{sign}(2(6) - 7) = 1$ $y^{(6)} = 1$ ✓

avg train acc = $\frac{5}{6}$

2.2) $S_1 \rightarrow S_2$ $a_1 = 2$ $b_1 = -5$

$f(2; 2, -5) = \text{sign}(2(2) - 5) = -1$ $y^{(2)} = -1$ ✓

$f(5; 2, -5) = \text{sign}(2(5) - 5) = 1$ $y^{(5)} = 1$ ✓

$f(6; 2, -5) = \text{sign}(2(6) - 5) = 1$ $y^{(6)} = 1$ ✓

$S_2 \rightarrow S_1$ $a_2 = 2$ $b_2 = -7$

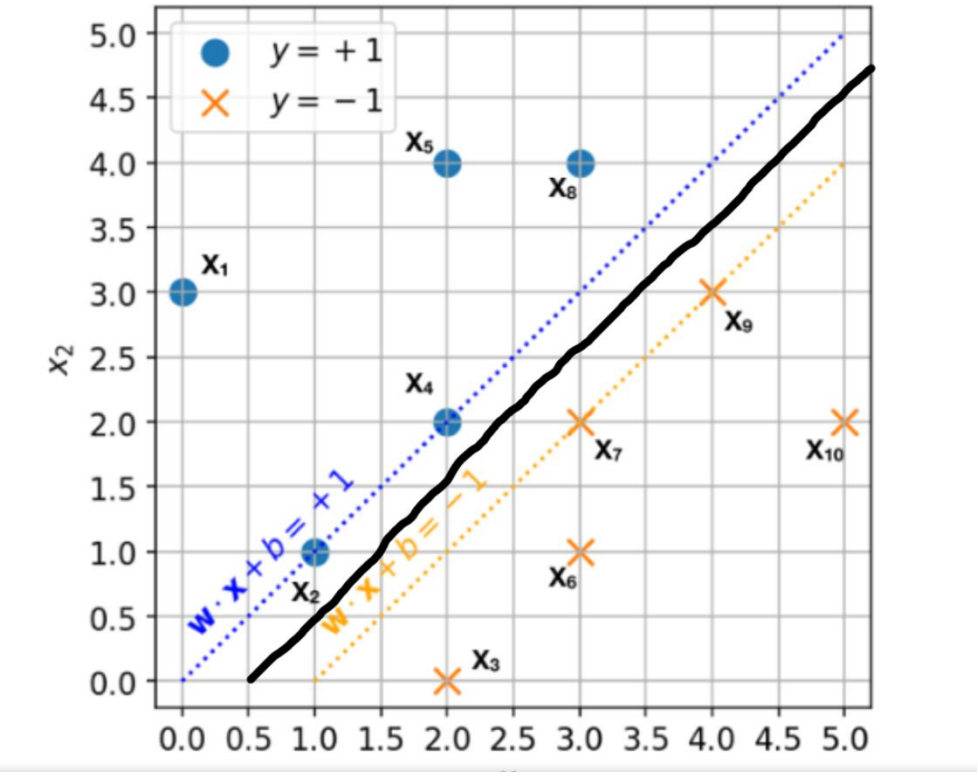
$f(1; 2, -7) = \text{sign}(2(1) - 7) = -1$ $y^{(1)} = -1$ ✓

$f(3; 2, -7) = \text{sign}(2(3) - 7) = -1$ $y^{(3)} = 1$ ✗

$f(4; 2, -7) = \text{sign}(2(4) - 7) = 1$ $y^{(4)} = -1$ ✗

avg valid acc = 2/3

3.1)


y = +1
y = −1
x1
x2
x3
x4
x5
x6
x7
x8
x9
x10
w · x + b = +1
w · x + b = −1
x2
0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0

(3) 3.2) $\vec{x}_1 = [1,1]$ $\vec{x}_4 = [2,2]$ $\vec{x}_7 = [3,2]$

$\Rightarrow : w_1(3) + w_2(2) + b = -1$

$-1 \cdot (w_1(1) + w_2(1) + b) = (1) \cdot -1$

$2w_1 + w_2 = -2$

$w_2 = -2(1 + w_1)$ *

$w_1(2) + w_2(2) + b = 1$

$-w_1(3) - w_2(2) + b = 1$

$-w_1 = 2 \Rightarrow w_1 = -2$

$w_2 = -2(1 + (-2))$

$= -2(-1)$

$= 2$

$-2(1) + (2)(1) + b = 1$

$b = 1$

$\vec{w} = \begin{bmatrix} -2 \\ 2 \end{bmatrix}$

3.3) $margin = \frac{2}{\|w\|_2} = \frac{2}{\sqrt{2^2 + 2^2}} = \frac{2}{\sqrt{8}} = \frac{\sqrt{2}}{2} = 0.71$

(4) $g(w) = \|\vec{w}\|^2 + \frac{1}{n} \sum_{i=1}^{n} (y_i - (\vec{w} \cdot \vec{x}_i + b))^2$

4.1) $\frac{\partial g(w)}{\partial (w)} = 2\vec{w} + \frac{1}{n} \sum_{i=1}^{n} 2(y_i - (\vec{w} \cdot \vec{x}_i + b)) \cdot -\vec{x}_i$

$= 2\vec{w} + \frac{1}{n} \sum_{i=1}^{n} -2\vec{x}_i (y_i - (\vec{w} \cdot \vec{x}_i + b))$

4.2) $L(w) = \frac{1}{2}\|w\|^2 + C \times \sum_{i=1}^{n} (1 - y_i \times (w \cdot x_i + b))_+$

$\frac{\partial L(w)}{\partial w} = \|w\| + C \times \sum_{i=1}^{n} \frac{\partial (1 - y_i w x_i - y_i b)_+}{\partial w}$

$= \|w\| + C \times \sum_{i=1}^{n} \begin{cases} 0 & \text{if } y_i \times (w \cdot x_i + b) \geq 1 \\ -y_i x_i & \text{else} \end{cases}$

(5) 5.1)

1) $(6, y=-1)$

2) $x_{pred} = -1$

5.2) 1) $(6, y=-1)$ $(2, y=1)$ $(5, y=-1)$

2) $x_{pred} = -1$

5.3) 1) $(6, y=-1)$ $(2, y=1)$ $(5, y=-1)$
$(4, y=1)$ $(8, y=-1)$

2) $x_{pred} = -1$

⑥ $V_k(x|y) = \pi r^2$

6.1) $k = \frac{100}{\pi}$ $V_k = \pi(2)^2 = 4\pi$

$k_k(x|y=1) = 3$ $k_k(x|y=-1) = 2$

$$p_k(x_{pred}|y=1) = \frac{k_k(x|y=1)}{k \times V_k(x|y)}$$

$$= \frac{3}{\frac{100}{\pi} \cdot 4\pi}$$

$$= \frac{3}{400}$$

$$= 0.0075$$

$$p_k(x_{pred}|y=-1) = \frac{2}{\frac{100}{\pi} \cdot 4\pi} = \frac{2}{400} = 0.005$$

6.2) $$P(y=1|x) = \frac{p(x|y=1)}{p(x|y=1) + p(x|y=-1)}$$

$$= \frac{0.0075}{0.0075 + 0.005}$$

$$= 0.6$$