

# ML Assignment 5

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4.1. 解: 设超平面为:  $w^T x + b = 0$ .

则  $x$  到超平面的距离为  $r = \frac{|w^T x + b|}{\|w\|}$ , 对所有样本, 有:

$$\begin{cases} w^T x_i + b \geq 1, & y_i = +1 \\ w^T x_i + b \leq -1, & y_i = -1. \end{cases}, \text{支持向量到超平面的距离和为 } \gamma = \frac{2}{\|w\|}$$

∴ 优化问题为:  $\min_{w, b} \frac{1}{2} \|w\|^2$ , 约束条件为  $y_i(w^T x_i + b) \geq 1, i = 1, 2, 3, \dots, m$

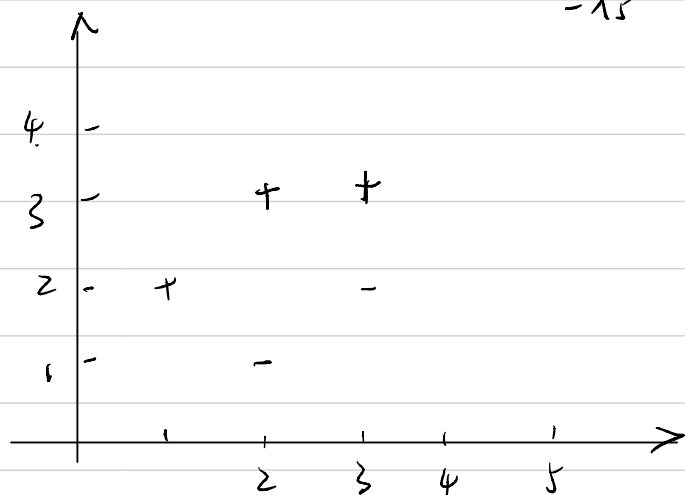
$$\text{对偶问题为 } \max_{\lambda} \sum_{i=1}^m (\alpha_i - \frac{1}{2} \sum_{i=1}^n \sum_{j=1}^n \lambda_i \lambda_j y_i y_j x_i^T x_j).$$

$$= \min_{\lambda} \left( \frac{1}{2} \sum_{i=1}^n \sum_{j=1}^n \lambda_i \lambda_j y_i y_j x_i^T x_j - \sum_{i=1}^n \lambda_i \right).$$

$$\begin{aligned} &= \frac{1}{2} \left[ \lambda_1 \lambda_1 (1,2)^T (1,2) + \lambda_1 \lambda_2 (1,2)^T (2,3) + \lambda_1 \lambda_3 (1,2)^T (3,3) - \lambda_1 \lambda_4 (1,2)^T (2,1) - \lambda_1 \lambda_5 (1,2)^T (3,2) \right. \\ &\quad + \lambda_2 \lambda_1 (2,3)^T (1,2) + \lambda_2^2 (2,3)^T (2,3) + \lambda_2 \lambda_3 (2,3)^T (3,3) - \lambda_2 \lambda_4 (2,3)^T (2,1) - \lambda_2 \lambda_5 (2,3)^T (3,2) \\ &\quad + \lambda_3 \lambda_1 (3,3)^T (1,2) + \lambda_3 \lambda_2 (3,3)^T (2,3) + \lambda_3^2 (3,3)^T (3,3) - \lambda_3 \lambda_4 (3,3)^T (2,1) - \lambda_3 \lambda_5 (3,3)^T (3,2) \\ &\quad - \lambda_4 \lambda_1 (2,1)^T (1,2) - \lambda_4 \lambda_2 (2,1)^T (2,3) - \lambda_4 \lambda_3 (2,1)^T (3,3) + \lambda_4^2 (2,1)^T (2,1) + \lambda_4 \lambda_5 (2,1)^T (3,2) \\ &\quad \left. - \lambda_5 \lambda_1 (3,2)^T (1,2) - \lambda_5 \lambda_2 (3,2)^T (2,3) - \lambda_5 \lambda_3 (3,2)^T (3,3) + \lambda_5 \lambda_4 (3,2)^T (2,1) + \lambda_5^2 (3,2)^T (3,2) \right] - \sum_{i=1}^5 \lambda_i \end{aligned}$$

$$\begin{aligned} &= \frac{1}{2} \left( 5\lambda_1^2 + 13\lambda_2^2 + 18\lambda_3^2 + 5\lambda_4^2 + 13\lambda_5^2 + 16\lambda_1\lambda_2 + 18\lambda_1\lambda_3 - 16\lambda_1\lambda_4 - 14\lambda_1\lambda_5 \right. \\ &\quad \left. + 30\lambda_2\lambda_3 - 14\lambda_2\lambda_4 - 24\lambda_2\lambda_5 - 18\lambda_3\lambda_4 - 30\lambda_3\lambda_5 + 16\lambda_4\lambda_5 \right) - \lambda_1 - \lambda_2 - \lambda_3 - \lambda_4 - \lambda_5 \end{aligned}$$

其中  $\lambda_1 + \lambda_2 + \lambda_3 - \lambda_4 - \lambda_5 = 0$



2. A 3. BB 4. B 5. C 6. B 7. D 8. B 9. C