1. $\because$ get a special-scaled.

$$\therefore \min_{n=1\sim N} y_n(w^T x_n + b) = 1$$

$$y_M(w^T x_M + b) = y_{M+1}(w^T x_{M+1} + b) = 1$$

$y_M = -1$

$y_{M+1} = 1$

$$-1(w^T x_M + b) = 1(w^T x_{M+1} + b)$$

$$-w^T x_M - b = w^T x_{M+1} + b$$

$$-w^T(x_M + x_{M+1}) = 2b$$

$$b = \frac{-w^T(x_M + x_{M+1})}{2}$$

$\because y_{M+1} w^T x_{M+1} > 0 \Rightarrow w^T x_{M+1} > 0$

$y_M w^T x_M > 0$, $\Rightarrow w^T x_M < 0$

$\Rightarrow$ W为正,

$\Rightarrow$ 令 $w = 1$, $b = \frac{-(x_M + x_{M+1})}{2}$

$\Rightarrow$ 答案為 (a)

2.

$$\text{margin}(b,w) = \min_{n=1\sim N} \frac{1}{\|w\|} y_n(w^T x_n + b)$$

$\because y_n(w^T x_n + b) = 1 \Rightarrow \text{distance}(b,w) = \frac{1}{\|w\|}$

(1),(2) ≠ (3) 故排除

(4) $\because \sum \alpha_n(1 - y_n(w^T z_n + b)) = 0$

$$\Rightarrow \sum \alpha_n - \sum \alpha_n y_n w^T z_n - \cancel{\sum \alpha_n y_n} b = 0$$

$$\sum \alpha_n = \sum \alpha_n y_n w^T z_n$$

$$\sum \alpha_n = w^T w$$

$$\|w\| = \sum \alpha_n^{\frac{1}{2}} \Rightarrow \frac{1}{\|w\|} = (\sum \alpha_n)^{\frac{-1}{2}}$$

(5) if all $\alpha_n != 1 \Rightarrow \sum_{n=1}^{N} [\alpha_n = 1] = 0$

if $n=2$ $\sum \alpha_n = 1$, $\alpha_1 = 0.5, \alpha_2 = 0.5$

$\sum \alpha_n = 1 = w^T w$, $\sum_{n=1}^{N} [\alpha_n = 1] = 0$

$0 \neq 1$

(6)

$$\left(2\sum_{n=1}^{N} \alpha_n - \|\sum_{n=1}^{N} \alpha_n y_n z_n\|^2\right)^{\frac{-1}{2}}$$

$$= \left(2\sum_{n=1}^{N} \alpha_n - \|w\|^2\right)^{\frac{-1}{2}}$$

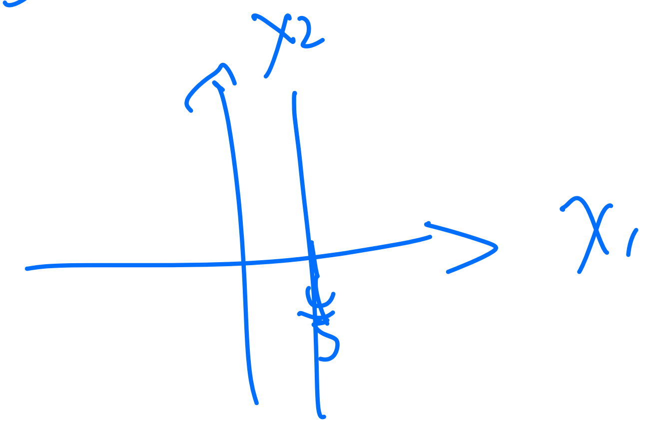
$$= \left(2\sum_{n=1}^{N} \alpha_n - \sum \alpha_n\right)^{\frac{-1}{2}} = (\sum \alpha_n)^{\frac{-1}{2}}$$

$\Rightarrow$ ans : (d)

3.

$5x_1 - 4 = 0 \quad x_1 = \frac{4}{5}$

$5x_1 + 0x_2 - 4 = 0$



$x_1 - 1 = 0$

$\cancel{x_1 = 1}$

$\frac{1}{5}x_1 = \cancel{4}$

$\cancel{x_1 = 20}$

$2x_1 = 1$

$\cancel{x_1 = 0.5}$

3. ① $w_1x_1+w_2x_2+b\ge 1$

$\Rightarrow$ 代 x_4

$\Rightarrow w_1\times 1+w_2\times 0+b\ge 1$

$\Rightarrow w_1+b\ge 1$ —(4)

② $-w_1x_1-w_2x_2-b\ge 4$

$\Rightarrow$ 代 x_2

$\Rightarrow 0-0-b\ge 4$

$\Rightarrow -b\ge 4$ —(1)

③ 代 x_1

$-w_2-b\ge 4$ —(2)

$w_2-b\ge 4$ —(3)

$\Rightarrow -2b\ge 8$ —(4)

$-b\ge 4$

$b\le -4$

$-b\ge 4$

$w_1+b\ge 1$

$-b\ge 4$

$w_1\ge 5$

$w_1\ge 5$ 且 $b\le -4$

Ans: C

4.

$$\max_{\text{all } \alpha_n \geq 0, \sum y_n \alpha_n = 0} \left(\min_{b,w} \frac{1}{2} w^T w + \sum_{n=1}^{N} \alpha_n \left(1 - y_n (w^T z_n + b)\right) \right)$$

$$\because \; y_n (w^T x_n + b) \geq 4 \Rightarrow y_n (w'^T x_n + b') \geq 1, \; w' = \frac{w}{4}, \; b' = \frac{b}{4}$$

$$= \max_{\text{all } \alpha_n \geq 0, \sum y_n \alpha_n = 0} \left(\min_{b,w} \frac{1}{2} w^T w + \sum_{n=1}^{N} [y_n = 1] \alpha_n \left(1 - y_n (w^T z_n + b)\right) + \sum_{n=1}^{N} [y_n = -1] \alpha_n \left(1 - \frac{1}{4} y_n (w^T z_n + b)\right) \right)$$

$$\min_{b,w} \frac{1}{2} w^T w + \sum_{n=1}^{N} [y_n = 1] \alpha_n \left(1 - y_n (w^T z_n + b)\right) + \sum_{n=1}^{N} [y_n = -1] \alpha_n \left(1 - \frac{1}{4} y_n (w^T z_n + b)\right))$$

$$\Rightarrow \min_{w} \frac{1}{2} w^T w + \sum_{n=1}^{N} [y_n = 1] \alpha_n \left(1 - y_n (w^T z_n)\right) + \sum_{n=1}^{N} [y_n = -1] \alpha_n \left(1 - \frac{1}{4} y_n (w^T z_n)\right)$$

$$\Rightarrow \frac{\partial \mathcal{L}(w,b,\alpha)}{\partial w} = w - \sum_{n=1}^{N} [y_n = 1] \alpha_n y_n z_n - \sum_{n=1}^{N} [y_n = -1] \alpha_n y_n z_n \cdot \frac{1}{4} = 0$$

$$w = \sum_{n=1}^{N} [y_n = 1] \alpha_n y_n z_n + \sum_{n=1}^{N} [y_n = -1] \alpha_n y_n z_n \cdot \frac{1}{4}$$

$$\Rightarrow \max_{\text{all } \alpha_n > 0, \sum y_n \alpha_n = 0, w = \sum \alpha_n y_n z_n} \left(-\frac{1}{2} w^T w + \sum_{n=1}^{N} [y_n = 1] \alpha_n + \sum_{n=1}^{N} [y_n = -1] \alpha_n \cdot \frac{1}{4} \right)$$

$$\Rightarrow \min_{\alpha} \left(\frac{1}{2} w^T w - \sum_{n=1}^{N} [y_n = 1] \alpha_n - \sum_{n=1}^{N} [y_n = -1] \alpha_n \cdot \frac{1}{4} \right.$$

$$\rho_- = 4, \frac{1}{4} = \frac{1}{\rho_-} \Rightarrow \text{ans}: (a)$$

5. 令 even margin SVM 的 $w, b = w^*, b^*$

uneven margin SVM 的 $w, b = w', b'$

$w^{*T}x_n + b^* = 1$ for $i = 1 \sim m_0$ — (1)

$w^{*T}x_n + b^* > 1$ for $i = m_0+1 \sim m_1$ — (2)

$w^{*T}x_n + b^* = -1$ for $i = m_1+1 \sim m_2$ — (3)

$w^{*T}x_n + b^* < -1$ for $i = m_2+1 \sim m$ — (4)

其中 $1 \le m_0 \le m_1 \le m_2 \le m$

令 $w' = \frac{1+\rho_-}{2} w^*$, $b' = b^* + \frac{1-\rho_-}{2}(1 - b^*)$

by (1) $w'^T x_n + b' = \frac{1+\rho_-}{2} w^{*T} x_n + \frac{1+\rho_-}{2}(1 - b^*) + b^*$

$= \frac{1+\rho_-}{2}(1-b^*) + \frac{1-\rho_-}{2}(1-b^*) + b^*$

$= (1-b^*)\left(\frac{1+\rho_-}{2} + \frac{1-\rho_-}{2}\right) + b^* = 1 - b^* + b^* = 1$

by (2) $w'^T x_n + b' = \frac{1+\rho_-}{2} w^{*T} x_n + \frac{1+\rho_-}{2}(1 - b^*) + b^*$

$> \frac{1+\rho_-}{2}(1-b^*) + \frac{1-\rho_-}{2}(1-b^*) + b^*$

$= 1$

$$\text{by}(3)\quad w'^T x_n + b' = \frac{1+\rho_-}{2} w^{*T} x_n + \frac{1+\rho_-}{2}(1-b^*) + b^*$$

$$= \frac{1+\rho_-}{2}(-1-b^*) + \frac{1-\rho_-}{2}(1-b^*) + b^*$$

$$= \frac{1}{2}(1+\rho_-)(-1-b^*) + \frac{1}{2}(1-\rho_-)(1-b^*) + b^*$$

$$= \frac{1}{2}\left(\cancel{-1} - \rho_- - b^* - \cancel{\rho_- b^*} + \cancel{1} - \rho_- - b^* + \cancel{\rho_- b^*}\right)$$
$$+ b^*$$

$$= \frac{1}{2}(-2\rho_- - 2b^*) + b^*$$
$$= -\rho_- - b^* + b^* = -\rho_-$$

$$\text{by}(4)\quad w'^T x_n + b' = \frac{1+\rho_-}{2} w^{*T} x_n + \frac{1+\rho_-}{2}(1-b^*) + b^*$$

$$< \frac{1+\rho_-}{2}(-1-b^*) + \frac{1-\rho_-}{2}(1-b^*) + b^*$$

$$= -\rho_-$$

故 $y_n = 1$ 時 $w'^T x_n + b' \ge 1$

$y_n = -1$ 時 $w'^T x_n + b' \le -\rho_- \Rightarrow -(w'^T x_n + b') \ge \rho_-$

by lecture dual-inner optimal, $w = \sum \alpha_n y_n x_n$

$\Rightarrow w^* = \sum \alpha^* y_n x_n$

$\Rightarrow \frac{1+\rho}{2} w^* = \sum \frac{1+\rho}{2} \alpha^* y_n x_n$

$\Rightarrow w' = \sum \alpha' y_n x_n$，故 $\alpha' = \frac{1+\rho}{2} \alpha^*$, ans: (d)

6.

$d=2$

$Q=2$

$X=(x_1, x_2)$

$\Phi_2(x) = (1, x_1, x_2, x_1^2, x_1x_2, x_2^2)$

$\Rightarrow$ 6 項

上課: $\Phi_2(x) = (1, x_1, x_2, x_1^2, x_1x_2, x_2x_1, x_2^2)$

$\Rightarrow$ 7 項

6. 假設 $X \in R^d$

$$\Phi_Q(X) = \binom{d-1}{0} + \binom{d-1+1}{1} + \cdots + \binom{d-1+Q}{Q} = \sum_{i=0}^{Q} \binom{d-1+i}{i}$$

$$\text{pf: } \sum_{i=0}^{Q} \binom{d-1+i}{i} = \binom{d+Q}{Q}$$

$$\Rightarrow \frac{(d-1)!}{0!(d-1)!} + \frac{d!}{1!(d-1)!} + \frac{(d+1)!}{2!(d-1)!} + \cdots + \frac{(d-1+Q)!}{Q!(d-1)!}$$

分母通分

$$\Rightarrow \frac{d \times \left[(d-1)!(Q!/0!) + d!(Q!/1!) + (d+1)!(Q!/2!) + \cdots + (d-1+Q)!(Q!/Q!) \right]}{Q!(d-1)!}$$

$$d \times \left[(d-1)!(Q!/0!) + d!(Q!/1!) + (d+1)!(Q!/2!) + \cdots + (d-1+Q)!(Q!/Q!) \right] = (d+Q)!$$

$$\Rightarrow d!(Q!/0!) + d!\left(\frac{d \times Q!}{1!}\right) + (d+1)!\,\frac{d \times Q!}{2!} + \cdots$$

$$\Rightarrow (d+1)\,d!\,\frac{Q!}{1!} + (d+1)!\left(\frac{d \times Q!}{2!}\right) + \cdots$$

$$= (d+1)!\,\frac{Q!}{1!} + (d+1)!\left(\frac{d\times Q!}{2!}\right) + \cdots$$

$$= (d+1)!\,\frac{2\times Q!}{2!} + (d+1)!\,\frac{d\times Q!}{2!} + \cdots$$

$$= (d+1)!\,\frac{(d+2)\,Q!}{2!} + \cdots$$

$$= (d+2)!\,\frac{Q!}{2!} + \cdots$$ (為sum至第3項)

故sum至第Q+1項

為 $(d+Q)!\,\frac{Q!}{Q!} = (d+Q)!$

$$\Rightarrow \sum_{i=0}^{Q} d\times(d-1+i)\times\frac{Q!}{i!} = (d+Q)!$$

$$\Rightarrow \sum_{i=0}^{Q}\binom{d-1+i}{i} = \binom{d+Q}{Q} \Rightarrow \text{ans}:(C)$$

7. $\|\Phi(x)-\Phi(x')\|^2$

$= \Phi(x)^2 + \Phi(x')^2 - 2\,\Phi(x)\Phi(x')$

$= \Phi(x)\Phi(x) + \Phi(x')\Phi(x') - 2\,\Phi(x)\Phi(x')$

$= 1+2\underbrace{x^Tx}_{1}+(\underbrace{x^Tx}_{1})^2 + 1+2\underbrace{x'^Tx'}_{1}+(\underbrace{x'^Tx'}_{1})^2 - 2(1+2x^Tx'+(x^Tx')^2)$

$= 4+4-2(1+2x^Tx'+(x^Tx')^2)$

x^Tx' 最小是 -1

$= 8-2(1-2+1)=8$ ans is d.

10.

$$E_{smooth} = \frac{1}{2}(1-\rho)^2 \quad , \quad 0 < \rho < 1$$

$$E_{hinge} = \max(1-\rho, 0)$$

$$= 1-\rho \quad , \quad 0 < \rho < 1$$

$$\Rightarrow \int_0^1 \left(\frac{1}{2}(1-\rho)^2 - (1-\rho)\right)^2 d\rho$$

$$= \int_0^1 (-0.5 + 0.5\rho^2)^2 d\rho$$

$$= \int_0^1 (0.25\rho^4 - 0.5\rho^2 + 0.25)\, d\rho$$

$$= \frac{0.25}{5}\rho^5\Big|_0^1 - \frac{0.5}{3}\rho^3\Big|_0^1 + 0.25\rho\Big|_0^1$$

$$= \frac{0.25}{5} - \frac{0.5}{3} + 0.25$$

$$= \frac{0.75}{15} - \frac{2.5}{15} + \frac{3.75}{15}$$

$$= \frac{2}{15}$$ ans is e.

9. primal $\min_{b,w,\xi} \frac{1}{2} w^T w + \sum_{n=1}^{N} u_n \cdot \xi_n$

subject to $y_n(w^T \Phi(x_n) + b) \geq 1 - \xi_n$

$\xi_n \geq 0 \quad , \quad n = 1, \cdots, N$

$$\Rightarrow \mathcal{L}(b, w, \xi, \alpha, \beta) = \frac{1}{2} w^T w + \sum_{n=1}^{N} u_n \cdot \xi_n + \sum_{n=1}^{N} \alpha_n \cdot (1 - \xi_n - y_n(w^T z_n + b)) + \sum_{n=1}^{N} \beta_n \cdot (-\xi_n)$$

$$\Rightarrow \max_{\alpha_n \geq 0, \beta_n \geq 0} \left(\min_{b,w,\xi} \mathcal{L}(b, w, \xi, \alpha, \beta) \right)$$

$$\Rightarrow \min_{b,w,\xi} \frac{1}{2} w^T w + \sum_{n=1}^{N} u_n \cdot \xi_n + \sum_{n=1}^{N} \alpha_n \cdot (1 - \xi_n - y_n(w^T z_n + b)) + \sum_{n=1}^{N} \beta_n (-\xi_n)$$

$$\frac{\partial \mathcal{L}}{\partial \xi_n} = \frac{\partial}{\partial \xi_n}\left(\sum u_n \xi_n + \sum \alpha_n(-\xi_n) + \sum \beta_n(-\xi_n)\right)$$

$$= u_n - \alpha_n - \beta_n = 0$$

$$\min_{b,w,\xi} \frac{1}{2} w^T w + \sum_{n=1}^{N} \alpha_n \cdot \left(1 - y_n(w^T z_n + b)\right)$$

$$+ \sum_{n=1}^{N} \overset{0}{(u_n - \alpha_n - \beta_n)} \cdot \xi_n$$

$$\text{dual SVM}: \min_{b,w,\xi} \frac{1}{2} w^T w + \sum_{n=1}^{N} \alpha_n\left(1 - y_n(w^T z_n + b)\right) \quad \text{—①}$$

$$\frac{\partial ①}{\partial b} = -\sum_{n=1}^{N} \alpha_n y_n = 0 = \sum_{n=1}^{N} \alpha_n \cdot y_n$$

① 改写为 $\min_{b,w} \frac{1}{2} w^T w + \sum_{n=1}^{N} \alpha_n\left(1 - y_n(w^T z_n)\right)$

$$- \cancel{\sum_{n=1}^{N} \alpha_n y_n \cdot b} \quad \text{—②}$$

$$\Rightarrow \max_{\alpha_n \geq 0,\ \sum y_n \alpha_n = 0} \left(\min_{w} \frac{1}{2} w^T w + \sum_{n=1}^{N} \alpha_n\left(1 - y_n(w^T z_n)\right)\right)$$

$$\frac{\partial ②}{\partial w} = w_i - \sum_{n=1}^{N} \alpha_n y_n z_{n,i} \Rightarrow w = \sum_{n=1}^{N} \alpha_n y_n z_n$$

$$\max_{\alpha_n \geq 0,\ \sum y_n \alpha_n = 0} \left(\min_{w} \frac{1}{2} w^T w + \sum_{n=1}^{N} \alpha_n - \sum_{n=1}^{N} y_n w^T z_n \right)$$

$$= \max_{\alpha_n \geq 0,\ \sum y_n \alpha_n = 0,\ w = \sum \alpha_n y_n z_n} \left(\frac{1}{2} w^T w + \sum_{n=1}^{N} \alpha_n - w^T w \right)$$

$$= \max_{\alpha_n \geq 0,\ \sum y_n \alpha_n = 0,\ w = \sum \alpha_n y_n z_n} \left(\frac{-1}{2} w^T w + \sum_{n=1}^{N} \alpha_n \right)$$

$$= \min_{\alpha_n \geq 0,\ \sum y_n \alpha_n = 0,\ w = \sum \alpha_n y_n z_n} \frac{1}{2} w^T w - \sum_{n=1}^{N} \alpha_n$$

ans is a

```python
# import liblinear
import numpy as np
from libsvm.svmutil import *
import scipy
from scipy.sparse import dok_matrix
from sys import getsizeof
import random
from tqdm import tqdm



# y, x = svm_read_problem('./satimage.scale_test.txt')
# set train mode
'''

-s svm_type : set type of SVM (default 0)
    0 -- C-SVC      (multi-class classification)
    1 -- nu-SVC     (multi-class classification)
    2 -- one-class SVM
    3 -- epsilon-SVR    (regression)
    4 -- nu-SVR     (regression)
-t kernel_type : set type of kernel function (default 2)
    0 -- linear: u'*v
    1 -- polynomial: (gamma*u'*v + coef0)^degree
    2 -- radial basis function: exp(-gamma*|u-v|^2)
    3 -- sigmoid: tanh(gamma*u'*v + coef0)
    4 -- precomputed kernel (kernel values in training_set_file)
-d degree : set degree in kernel function (default 3)
-g gamma : set gamma in kernel function (default 1/num_features)
-r coef0 : set coef0 in kernel function (default 0)
-c cost : set the parameter C of C-SVC, epsilon-SVR, and nu-SVR (default 1)
-n nu : set the parameter nu of nu-SVC, one-class SVM, and nu-SVR (default 0.5)
-p epsilon : set the epsilon in loss function of epsilon-SVR (default 0.1)
-m cachesize : set cache memory size in MB (default 100)
-e epsilon : set tolerance of termination criterion (default 0.001)
-h shrinking : whether to use the shrinking heuristics, 0 or 1 (default 1)
-b probability_estimates : whether to train a SVC or SVR model for probability estimates, 0 or 1
(default 0)
-wi weight : set the parameter C of class i to weight*C, for C-SVC (default 1)
-v n: n-fold cross validation mode
-q : quiet mode (no outputs)
'''
def multiclass_to_binary(labels,target_num : int):
    # try to trans non target num's label to -1
    # and trans targets num's label to +1

    labels = np.array(labels)
    labels[labels != target_num] = -1.0
    labels[labels == target_num] = 1.0
    pos = np.where(labels == 1)
    labels = list(labels)
    return labels


def Q11(y,x,target_num,C):
    y = multiclass_to_binary(y,target_num)
    m = svm_train(y, x, f'-s 0 -t 0 -c {C} -q')
    mul_alpha_y = m.get_sv_coef()
    SVs = m.get_SV()
    SVs_num = len(SVs)
    coef = dok_matrix((1, SVs_num), dtype=np.float32)
    vecters = dok_matrix((60, SVs_num), dtype=np.float32)

    for i in range(SVs_num):
        coef[0,i] = mul_alpha_y[i][0]

    for i,dict_ in enumerate(SVs):
        for k,v in dict_.items():
            vecters[k,i] = v
    inner_dot = vecters.dot(scipy.transpose(coef))
    W = (scipy.transpose(inner_dot).dot(inner_dot) )[0,0] **0.5
    return W
def Q12(train_y, train_x,C,degree,coef,gamma):

    Q12_acc_bag = []
    Q13_SVs_num = []

    for target_num in [2,3,4,5,6]:
        train_y_temp = multiclass_to_binary(train_y, target_num)
        m = svm_train(train_y_temp, train_x, f'-s 0 -t 1 -c {C} -d {degree} -r {coef} -g {gamma} -q' )
        SVs = m.get_SV()
        Q13_SVs_num.append(len(SVs))
        # test_y = multiclass_to_binary(test_y, target_num)
        p_label, p_acc, p_val = svm_predict(train_y_temp, train_x, m)
        Q12_acc_bag.append(p_acc[0])
    return Q12_acc_bag,Q13_SVs_num
def Q14(target_num,train_y,train_x,test_y,test_x,gamma):
    C_list = [0.01,0.1,1,10,100]
    train_y_temp = multiclass_to_binary(train_y, target_num)
    test_y_temp = multiclass_to_binary(test_y,target_num)
    Q14_acc_bag = []
    for C in C_list:
        m = svm_train(train_y_temp, train_x, f'-s 0 -t 2 -c {C} -g {gamma} -q')
        p_label, p_acc, p_val = svm_predict(test_y_temp, test_x, m)
        Q14_acc_bag.append(p_acc[0])
    return Q14_acc_bag
# print(Q14_ans)

def Q15(target_num,train_y,train_x,test_y,test_x,C):
    gamma_list = [0.1,1,10,100,1000]
    train_y_temp = multiclass_to_binary(train_y, target_num)
    test_y_temp = multiclass_to_binary(test_y,target_num)
    Q15_acc_bag = []
    for gamma in gamma_list:
        m = svm_train(train_y_temp, train_x, f'-s 0 -t 2 -c {C} -g {gamma} -q')
        p_label, p_acc, p_val = svm_predict(test_y_temp, test_x, m)
        Q15_acc_bag.append(p_acc[0])
    return Q15_acc_bag
# print(Q15_ans)
def Q16(target_num,train_y,train_x,C = 0.1):

    gamma_list = [0.1,1,10,100,1000]
    train_y= multiclass_to_binary(train_y, target_num)
    vote_list = [0,0,0,0,0]
    for i in tqdm(range(1000)):

        acc_bag = []
        randon_sample = random.sample(range(len(train_y)), 200)
        train_y_temp = np.array(train_y)
        train_x_temp = np.array(train_x)
        val_x = list(train_x_temp[randon_sample])
        val_y = list(train_y_temp[randon_sample])
        train_x_temp = list(np.delete(train_x_temp, randon_sample))
        train_y_temp = list(np.delete(train_y_temp, randon_sample))
        for gamma in gamma_list:
            m = svm_train(train_y_temp, train_x_temp, f'-s 0 -t 2 -c {C} -g {gamma} -q')
            p_label, p_acc, p_val = svm_predict(val_y, val_x, m)
            acc_bag.append(p_acc[0])
        best_E_val = acc_bag.index(max(acc_bag))
        vote_list[best_E_val] += 1
    return vote_list

if __name__ == '__main__':
    train_y, train_x = svm_read_problem('./satimage.scale_train.txt')
    test_y, test_x = svm_read_problem("./satimage.scale_test.txt")
    Q11_ans = Q11(train_y,train_x,5,C=10)
    Q12_ans,Q13_ans = Q12(train_y, train_x,10,3,1,1)
    Q14_ans = Q14(1,train_y,train_x,test_y,test_x,10)
    Q15_ans = Q15(1,train_y,train_x,test_y,test_x,0.1)
    Q16_ans = Q16(1,train_y,train_x,0.1)
    print(f"Q11_ans{Q11_ans}")
    print(f"Q12_ans{Q12_ans}")
    print(f"Q13_ans{Q13_ans}")
    print(f"Q14_ans{Q14_ans}")
    print(f"Q15_ans{Q15_ans}")
    print(f"Q16_ans{Q16_ans}")
```