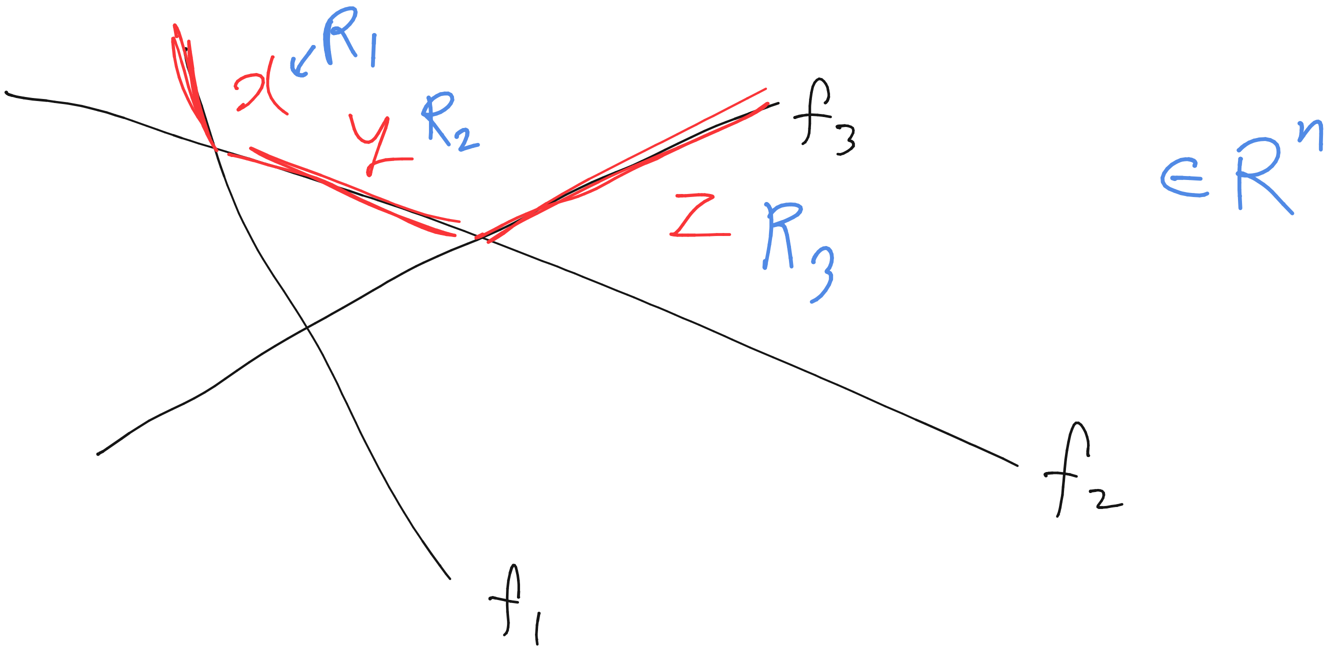
① Three way linear classification



$$f_1(x) > \max\{f_2(x), f_3(x)\}$$

$\vdots$

$$\Rightarrow f_1(x) \geq \max(f_2(x), f_3(x)) \underline{\underline{+1}}$$

can be any number

✓ Regularizing constraint

$a_1 + a_2 + a_3 = 0$

b 〃

c 〃

② Efficient numerical method for a regularized least-squares problem with smoothing

✓ prob: minimize

$$f(x) = \underbrace{\sum_{i=1}^{k} (a_i^T x - b_i)^2}_{\text{Least-square}} + \underbrace{\delta \sum_{i=1}^{n-1} (x_i - x_{i+1})^2}_{\text{Smoothness}} + \underbrace{\eta \sum_{i=1}^{n} x_i^2}_{\text{ridge}}$$

(a) $f(x) = x^T (A^T A + \delta \Delta + \eta I) x - 2 b^T A x + b^T b$

$$\frac{\partial}{\partial x} \quad 2(A^T A + \delta \Delta + \eta I) x - 2 A^T b = 0$$

(b) $$(\underbrace{A^T A}_{\substack{\text{PSD} \\ \text{Symmetric}}} + \underbrace{\delta \Delta + \eta I}_{\text{banded}}) x = \underbrace{A^T b}_{q}$$

$\delta \Delta + \eta I$: P

→ if no structure : $\frac{1}{3} n^3$

→ if use Woodbury :

1. $P z_1 = q$, $P Z_2 = A^T$, $A z_1$, $A Z_2$
2. $(I + A Z_2) z_3 = A z_1$
3. $x = z_1 - Z_2 z_3$

$\simeq 2nk^2$ flop count