

SVM (Support Vector Classifier)

1. Dot Product

$$A \cdot B = |A| \cos \theta + |B|$$

In SVM we just need the project of A not magnitude B

$$A \cdot B = |A| \cos \theta + |B| \cos \theta$$

yes we have

$$x = [x_1, x_2, x_3] \quad w = [w_1, w_2, w_3]$$

$$w^T x = w_1 x_1 + w_2 x_2 + w_3 x_3$$

$$y = w^T x + b$$

Use of dot product in SVM

Consider a random point X and we want to know whether it lies on the right side of the plane or left of the plane

X is my vector corresponding to x, I will take w vector and we take c which is the distance of w vector from origin to plane

no we calculate dot product

Xw so my point is on decision boundary (support vectors)

Xw > c so my point is in right side or positive class
Xw < c so my point is in negative class

the equation of margins are as below

$$\vec{X} \cdot \vec{w} - c \geq 0$$

putting $-c$ as b, we get

$$\vec{X} \cdot \vec{w} + b \geq 0$$

hence

$$y = \begin{cases} +1 & \text{if } \vec{X} \cdot \vec{w} + b \geq 0 \\ -1 & \text{if } \vec{X} \cdot \vec{w} + b < 0 \end{cases}$$

Hard Margin

x_1	x_2	y
1	1	1
2	2	1
3	3	1
4	4	1
5	5	1
6	6	1
7	7	1
8	8	1
9	9	1
10	10	1
11	11	1
12	12	1
13	13	1
14	14	1
15	15	1
16	16	1
17	17	1
18	18	1
19	19	1
20	20	1
21	21	1
22	22	1
23	23	1
24	24	1
25	25	1
26	26	1
27	27	1
28	28	1
29	29	1
30	30	1
31	31	1
32	32	1
33	33	1
34	34	1
35	35	1
36	36	1
37	37	1
38	38	1
39	39	1
40	40	1
41	41	1
42	42	1
43	43	1
44	44	1
45	45	1
46	46	1
47	47	1
48	48	1
49	49	1
50	50	1
51	51	1
52	52	1
53	53	1
54	54	1
55	55	1
56	56	1
57	57	1
58	58	1
59	59	1
60	60	1
61	61	1
62	62	1
63	63	1
64	64	1
65	65	1
66	66	1
67	67	1
68	68	1
69	69	1
70	70	1
71	71	1
72	72	1
73	73	1
74	74	1
75	75	1
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79	79	1
80	80	1
81	81	1
82	82	1
83	83	1
84	84	1
85	85	1
86	86	1
87	87	1
88	88	1
89	89	1
90	90	1
91	91	1
92	92	1
93	93	1
94	94	1
95	95	1
96	96	1
97	97	1
98	98	1
99	99	1
100	100	1

Step 1

$$x = x_1, x_2 \quad w = w_1, w_2$$

$$b = w_1 x_1 + w_2 x_2 + b = 0 \quad v = [1, 1], \quad b = -3$$

$$f(x) = x_1 + x_2 - 3$$

x_1	x_2	y
1	1	1
2	2	1
3	3	1
4	4	1
5	5	1
6	6	1
7	7	1
8	8	1
9	9	1
10	10	1
11	11	1
12	12	1
13	13	1
14	14	1
15	15	1
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92	92	1
93	93	1
94	94	1
95	95	1
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Step 2

$$D = \frac{1}{2} \|w\|^2$$

$$= \frac{1}{2} (\sqrt{v^T v})^2$$

$$= \frac{1}{2} v^T v$$

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Steps reduce w_1, w_2, b using GD

Step 4 Repeat Step 1 to 3

2. Soft margin

Soft Margin SVM Optimization Objective
Minimize (in following text):
$\frac{1}{2} \ w\ ^2 + c \sum_{i=1}^n \xi_i$
Subject to:
$y(w \cdot x_i + b) \geq 1 - \xi_i, \quad \xi_i \geq 0, \quad \forall i$

The role of c is if value of c is high so we have smaller margin distance, and less error allowed

If my c is low then the margin is larger, and allows more generalization

Agenda: Maximize Distance [Hard Margin]

In hard margin I don't want this

For all the red points $\vec{x}, \vec{x} \cdot \vec{w} + b \leq -1$
For all the blue points $\vec{x}, \vec{x} \cdot \vec{w} + b \geq 1$

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