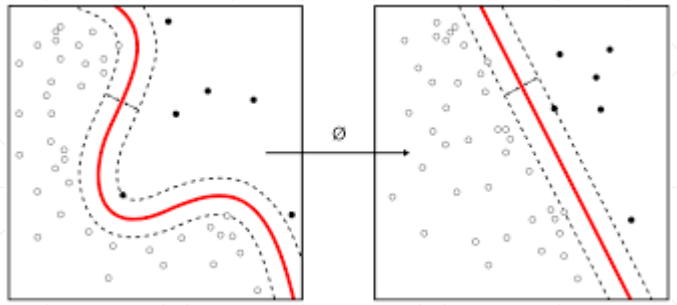


Support Vector Machine

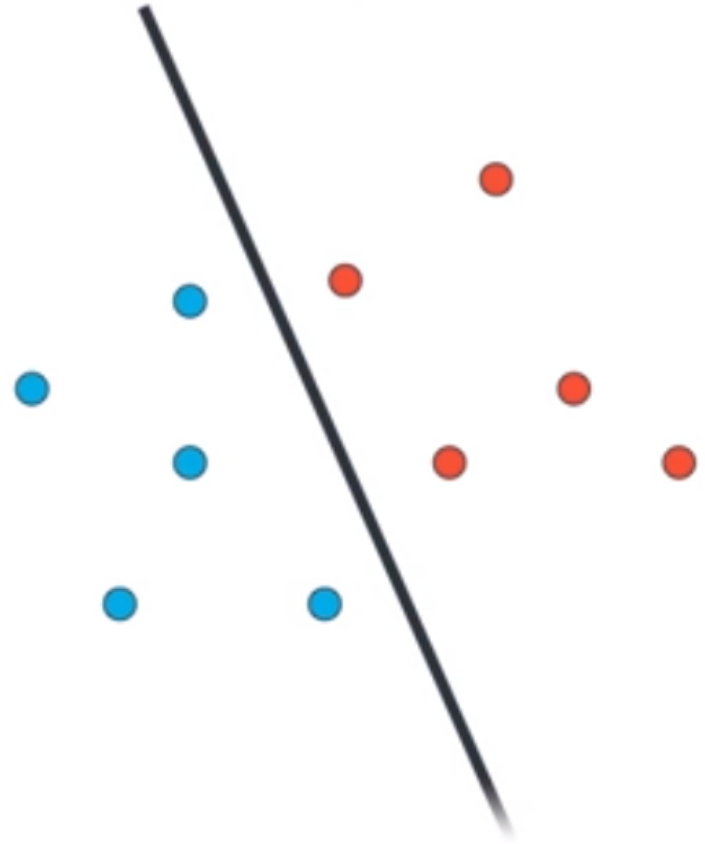
~Abhishek Kumar

SVM

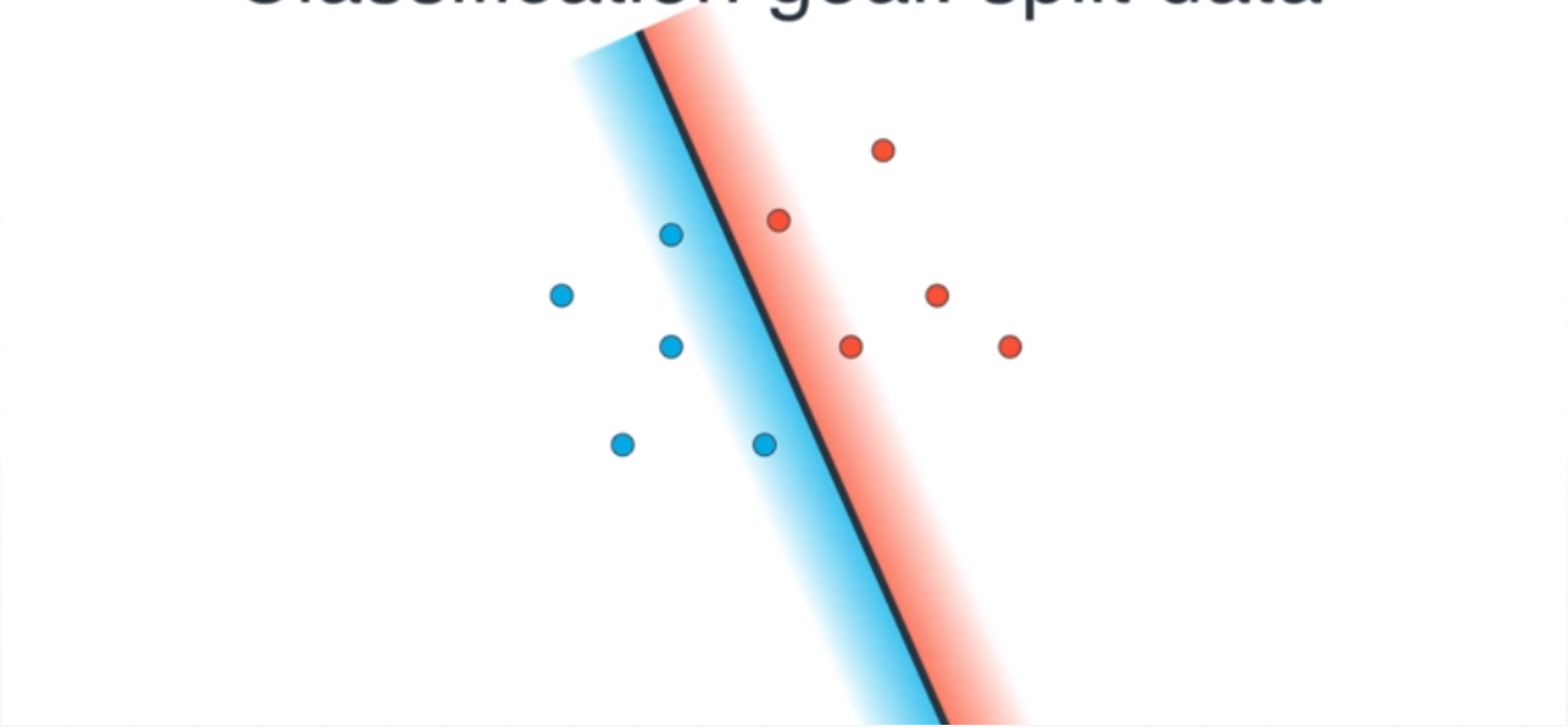
- Supervised
- Classification algorithm

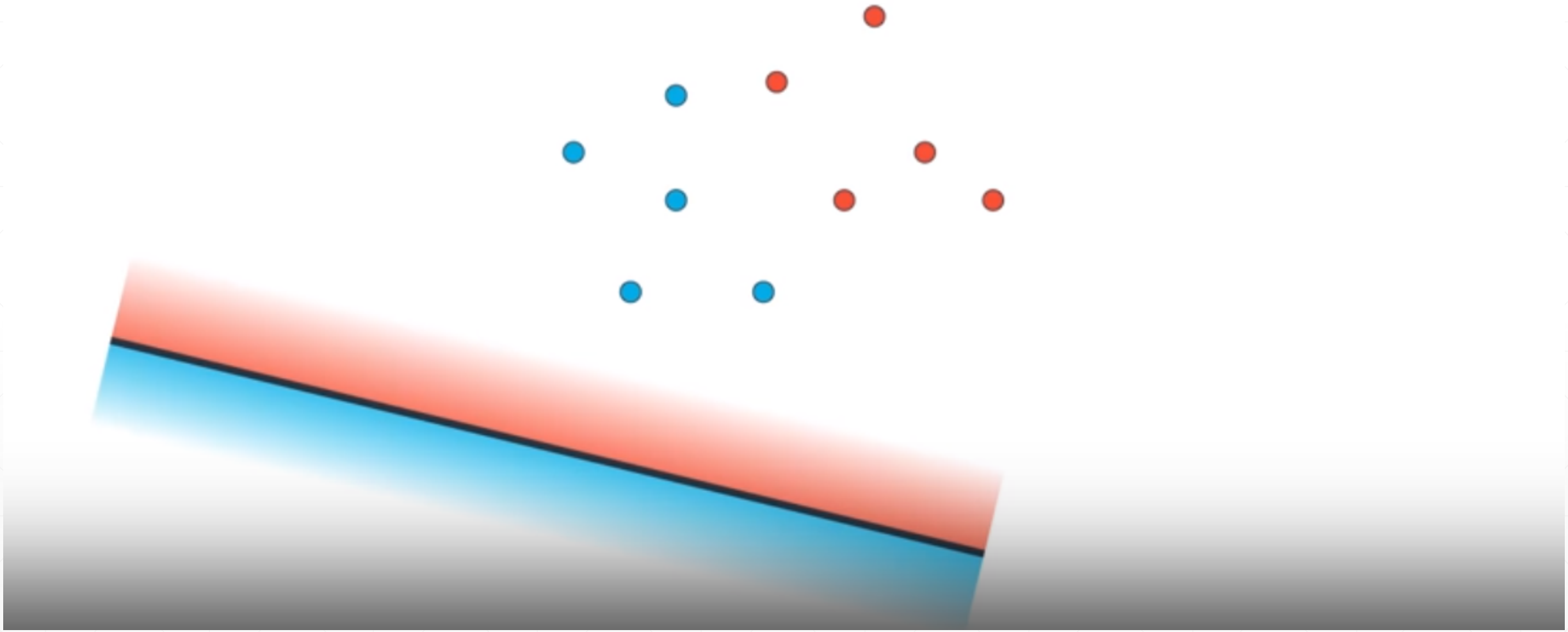
Classification goal: split data

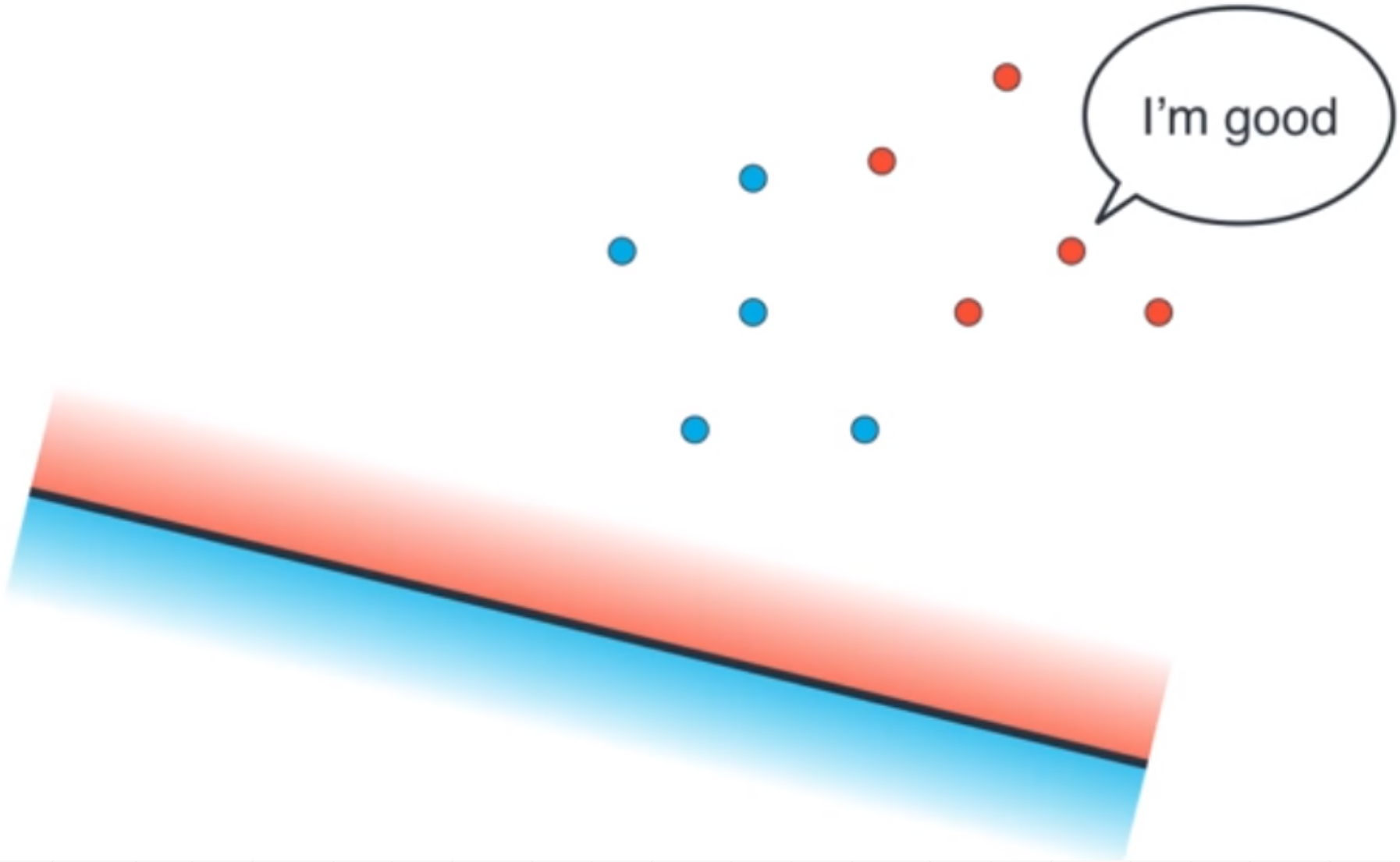
Classification goal: split data

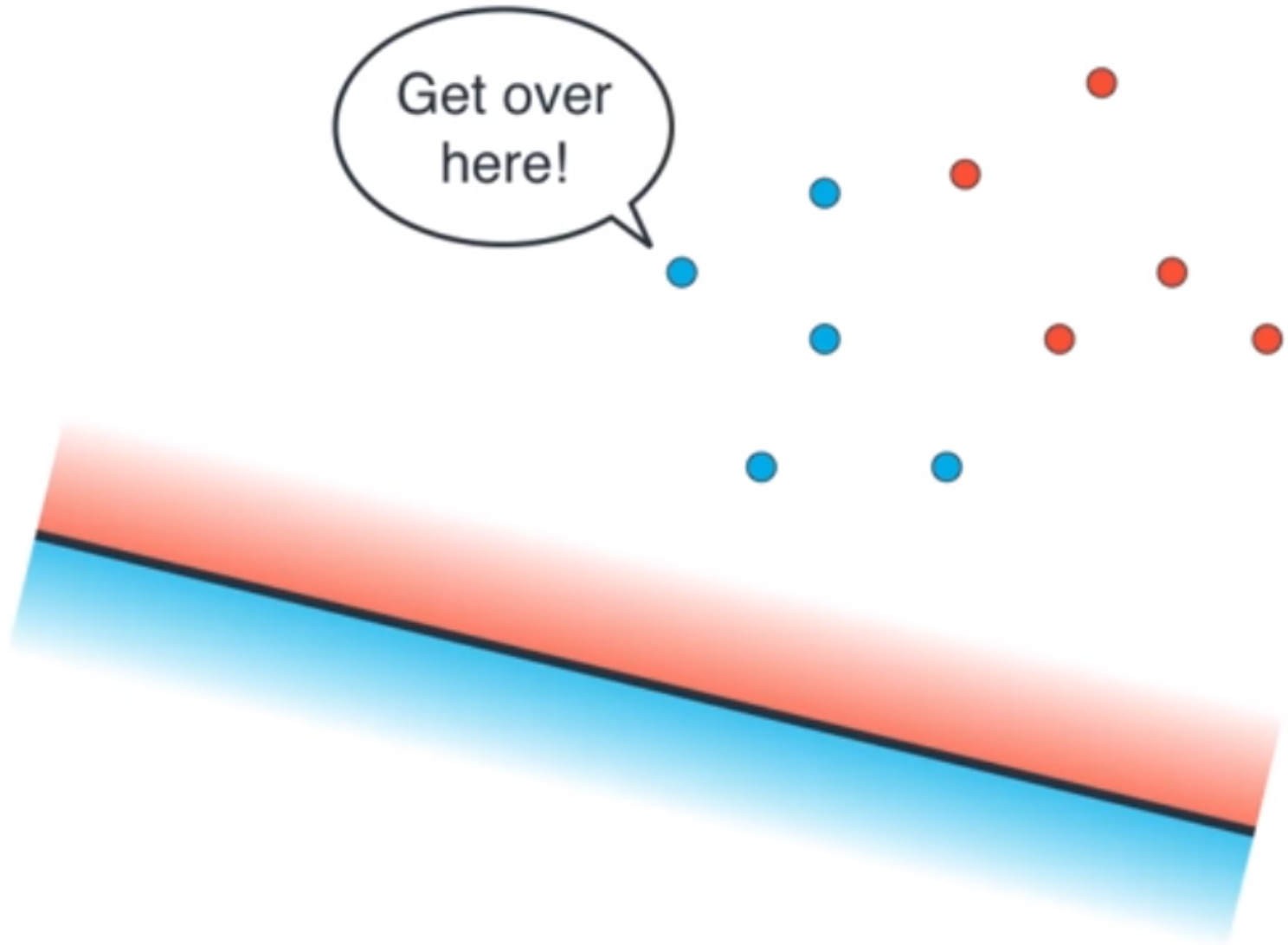


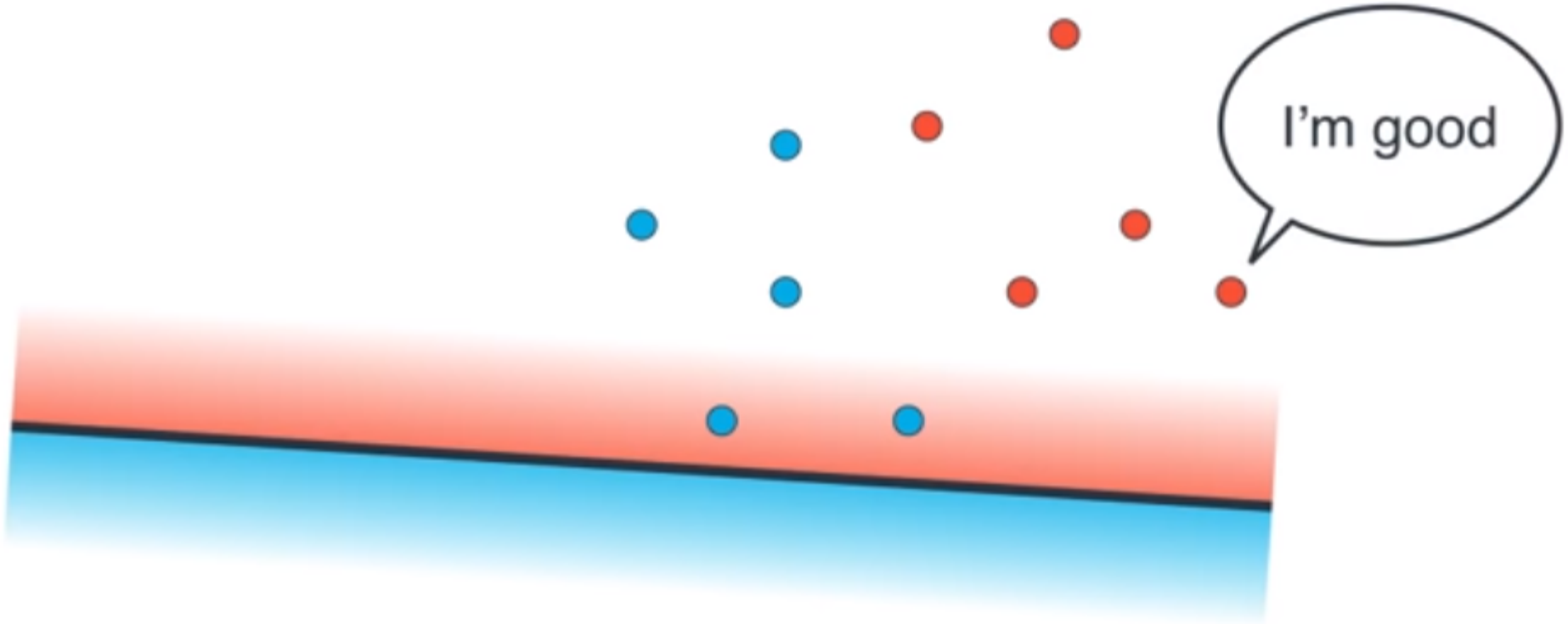
Classification goal: split data

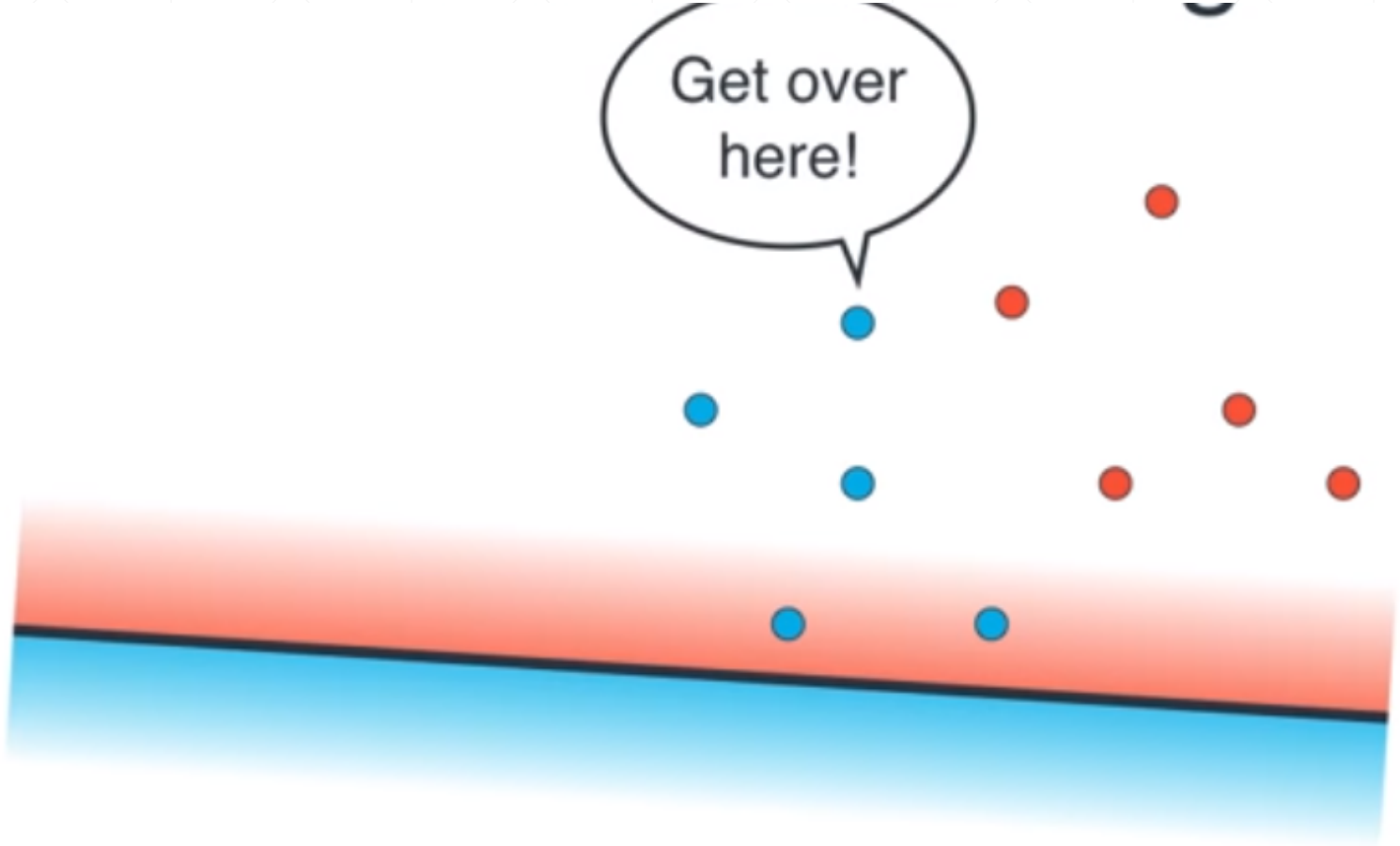


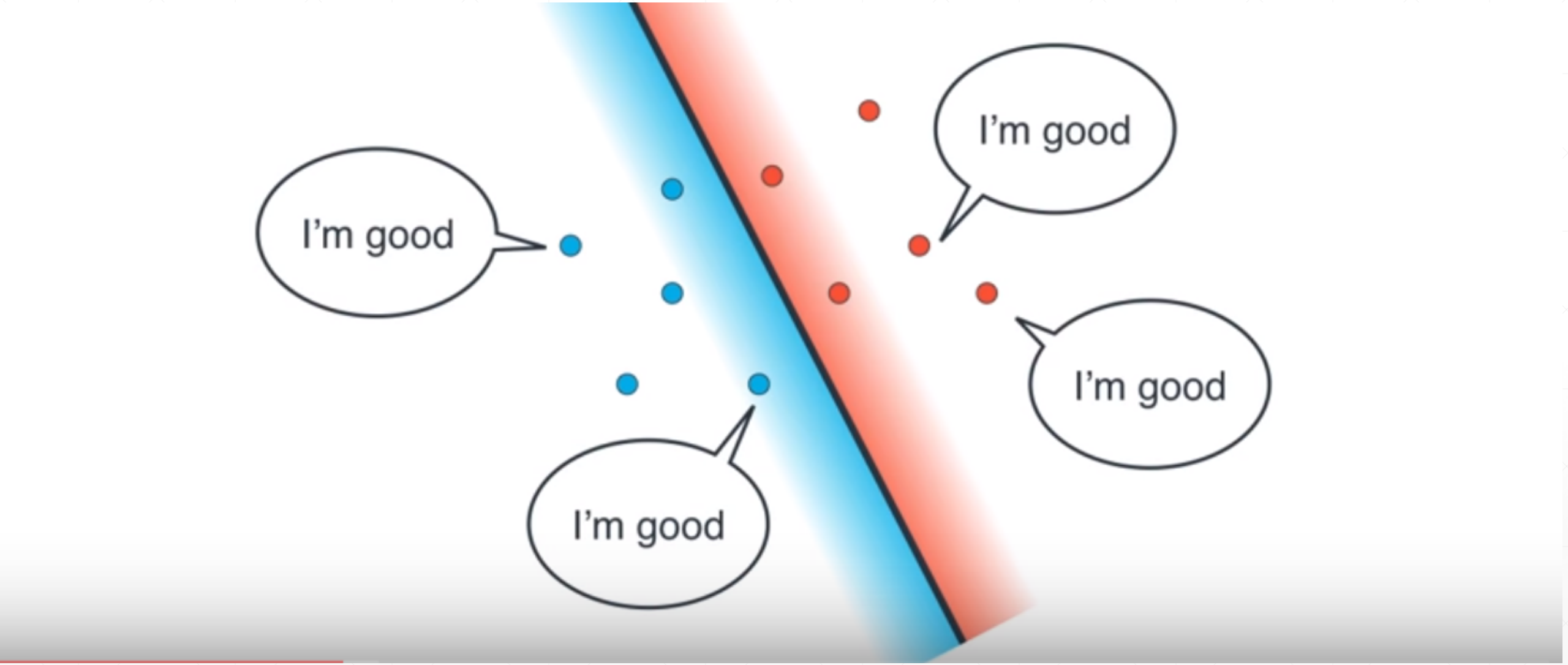



I’m good

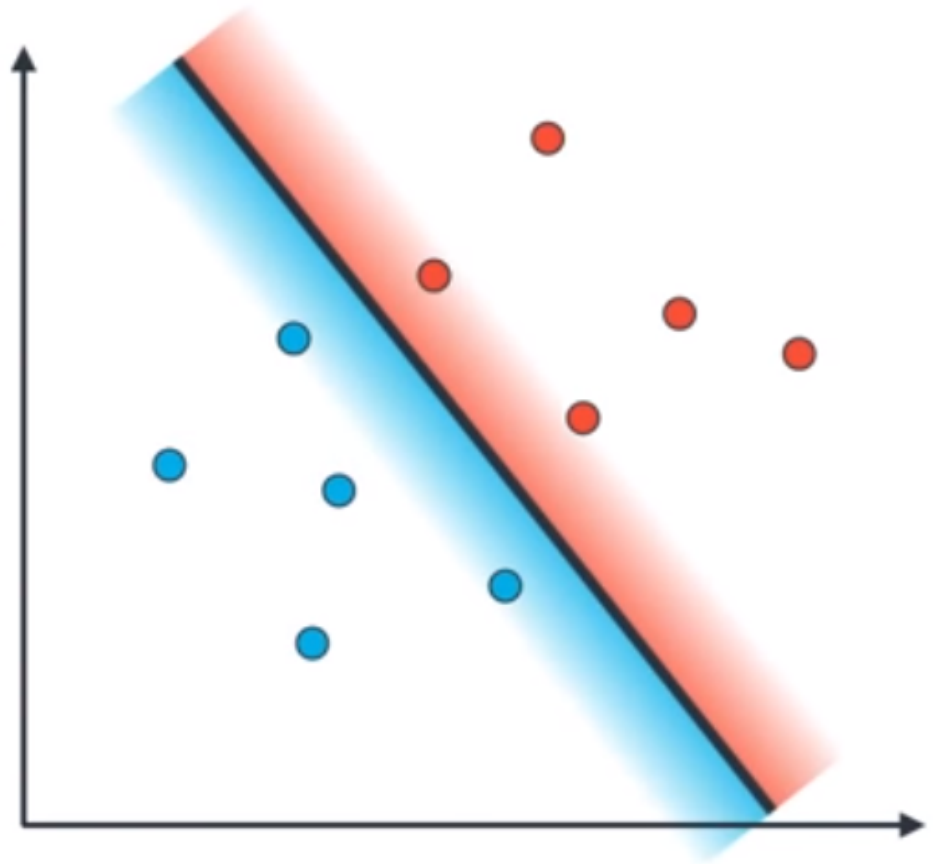

Get over here!


I’m good


Get over
here!


I'm good
I'm good
I'm good
I'm good

Logistic regression algorithm



Step 1: Start with a random line of equation $ax + by + c = 0$

Step 2: Pick a large number. 1000 (number of repetitions, or epochs)

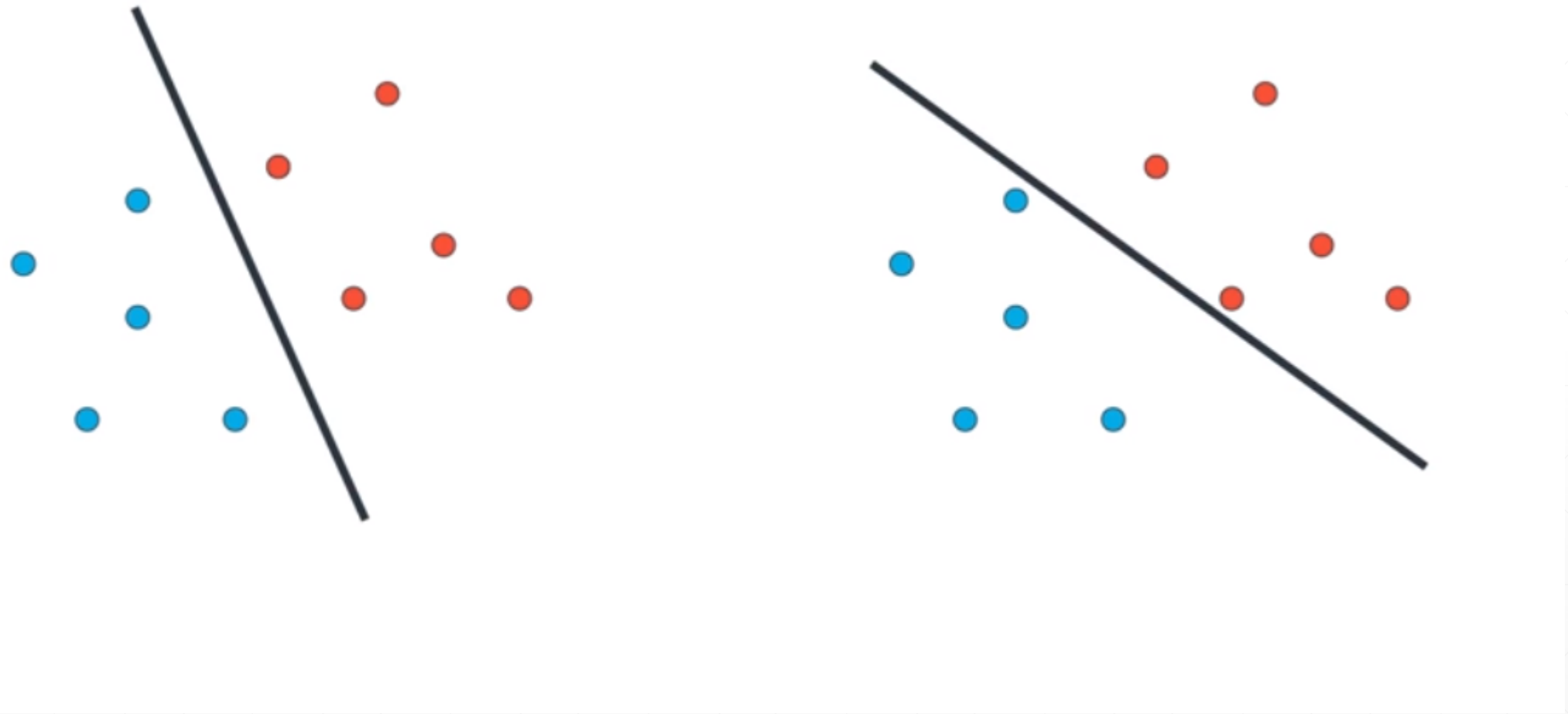
Step 3: Pick a small number. 0.01 (learning rate)

Step 4: (repeat 1000 times)

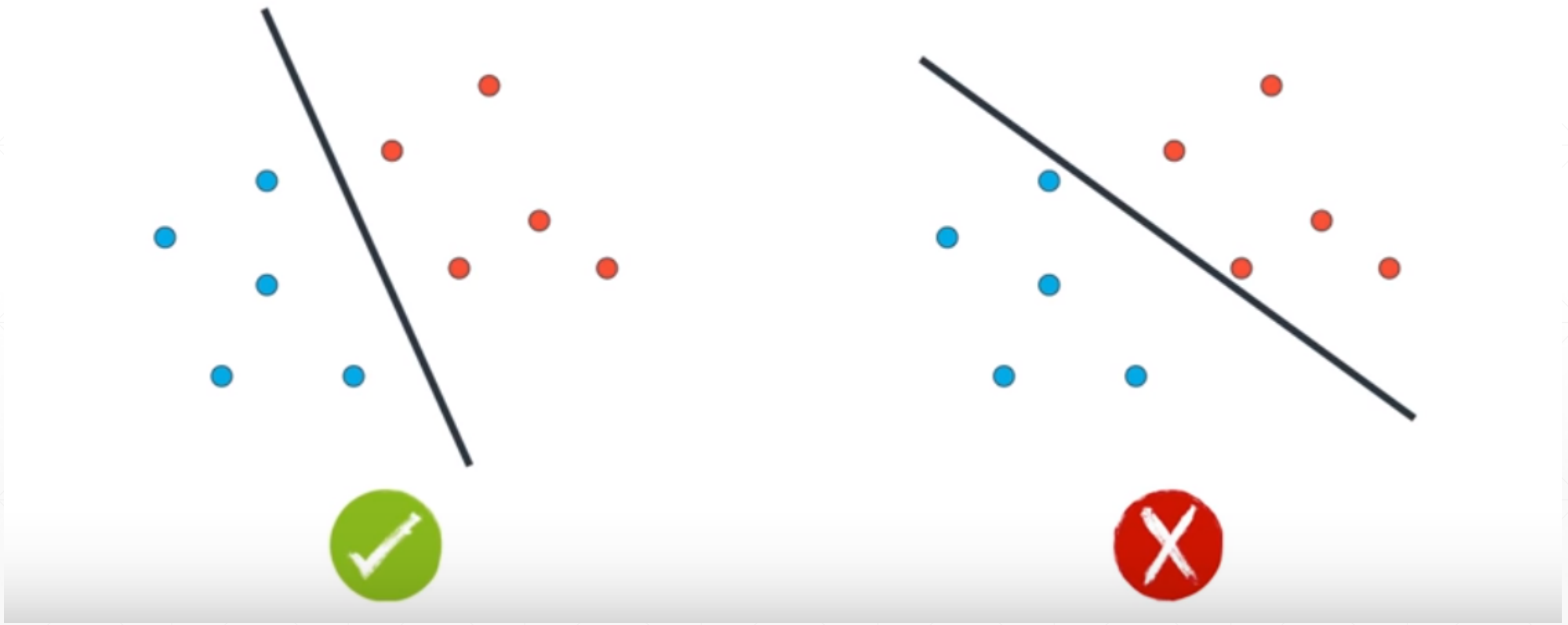
- Pick random point (p,q)
- If point is correctly classified:
  - Move line away from point
- If point is incorrectly classified
  - Move line towards point

Step 5: Enjoy your fitted line!

Which line is better?



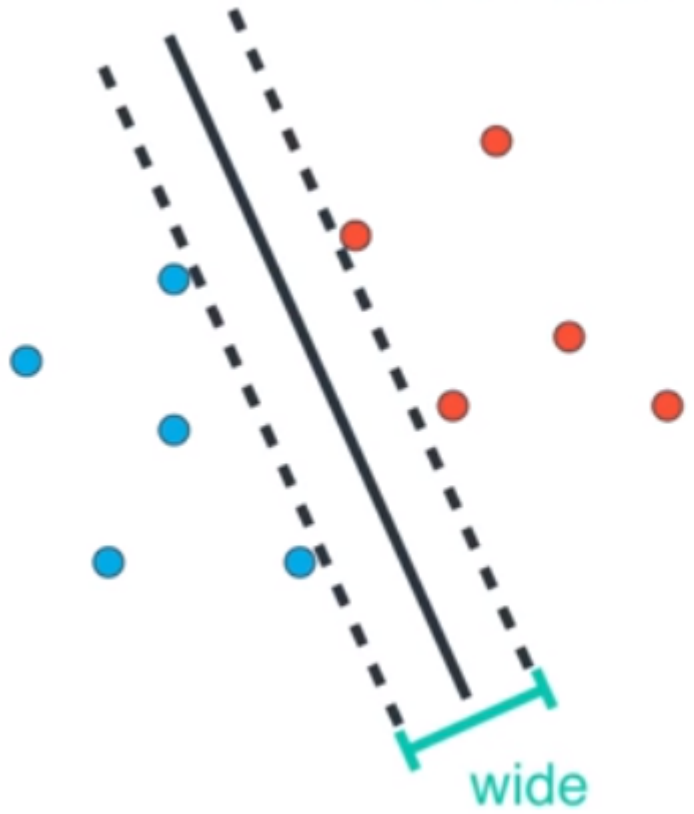
Which line is better?

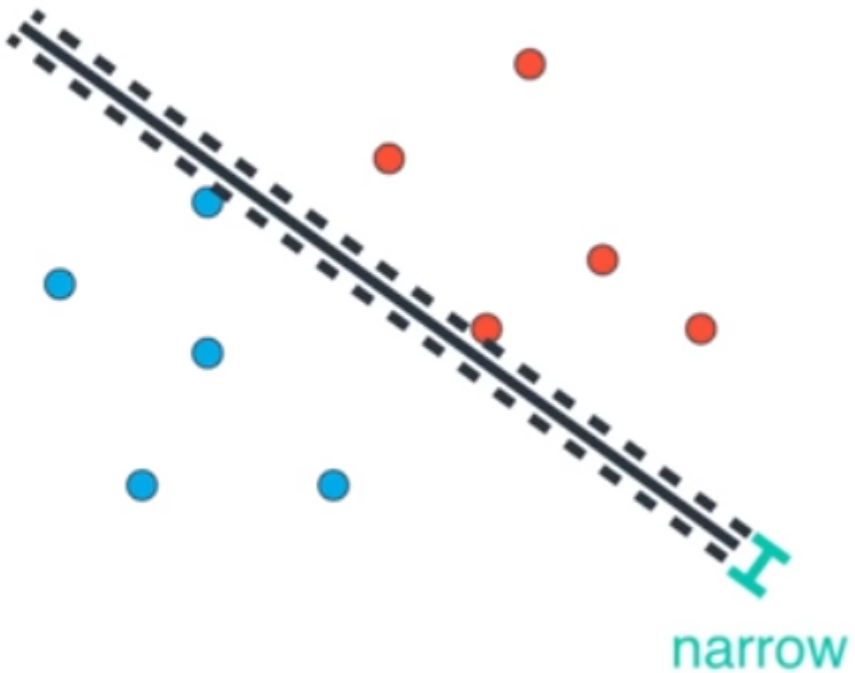


How do we tell the computer to pick the best line?

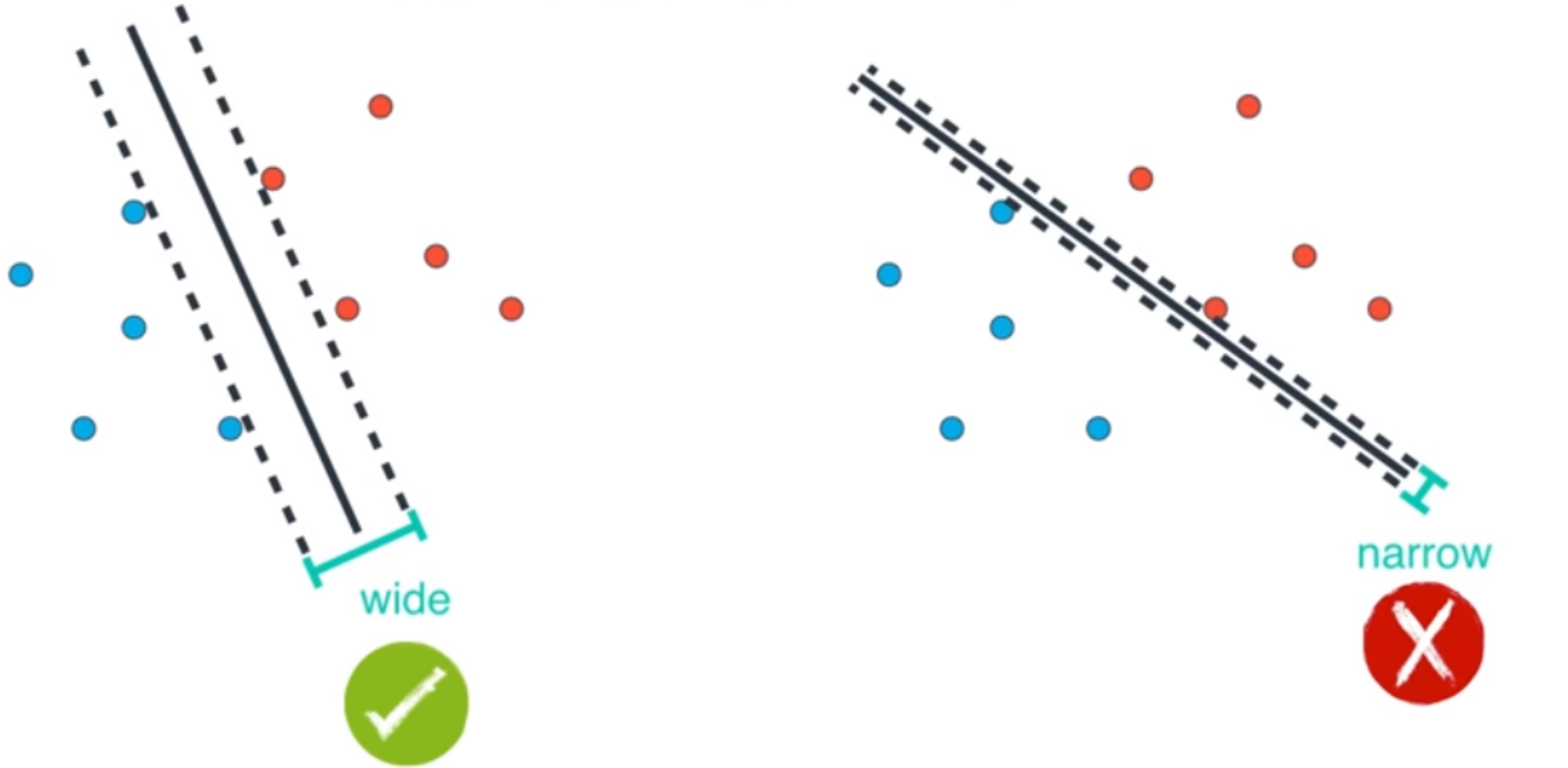
- Can we say that? We should find two lines that space apart as far as possible from each other

Which line is better?

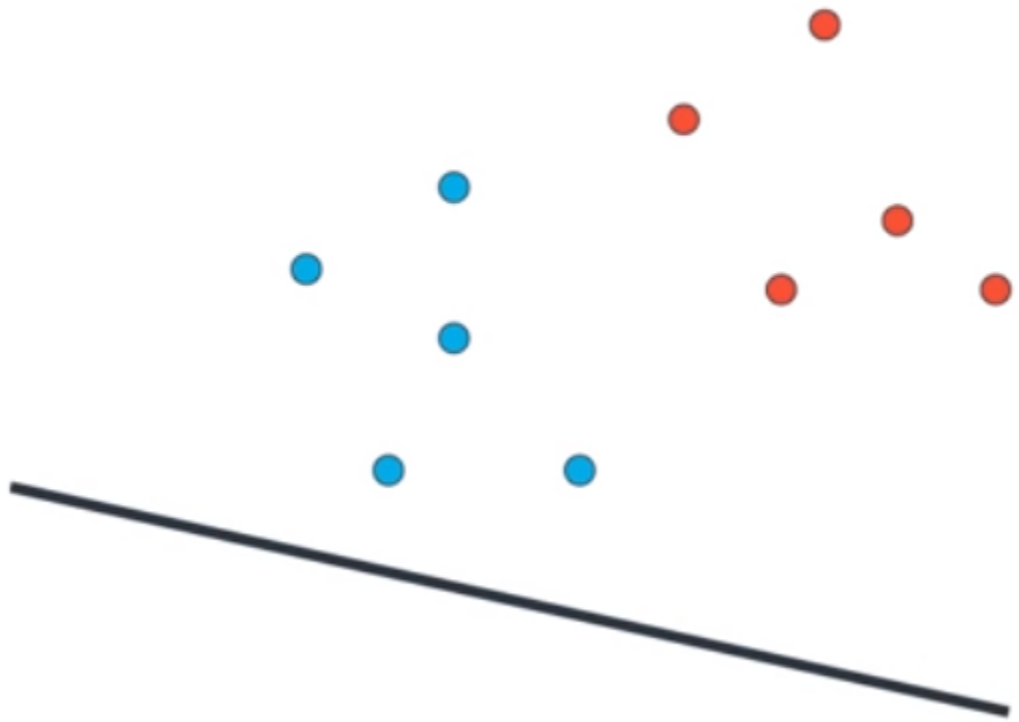




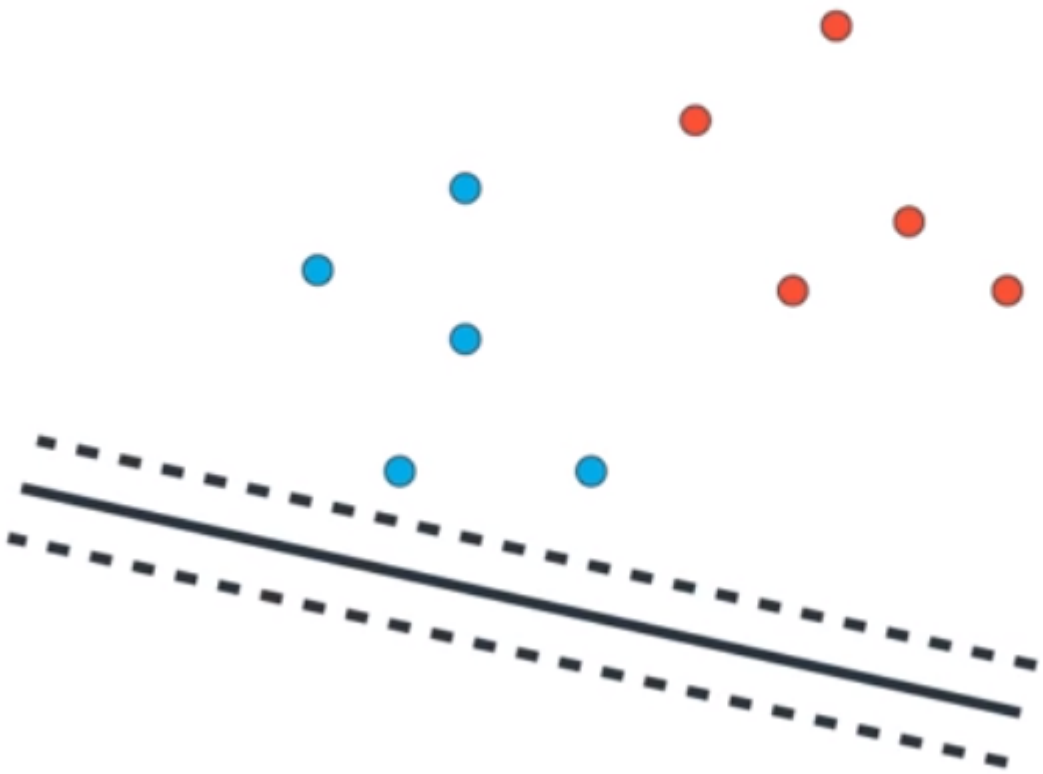
Which line is better?



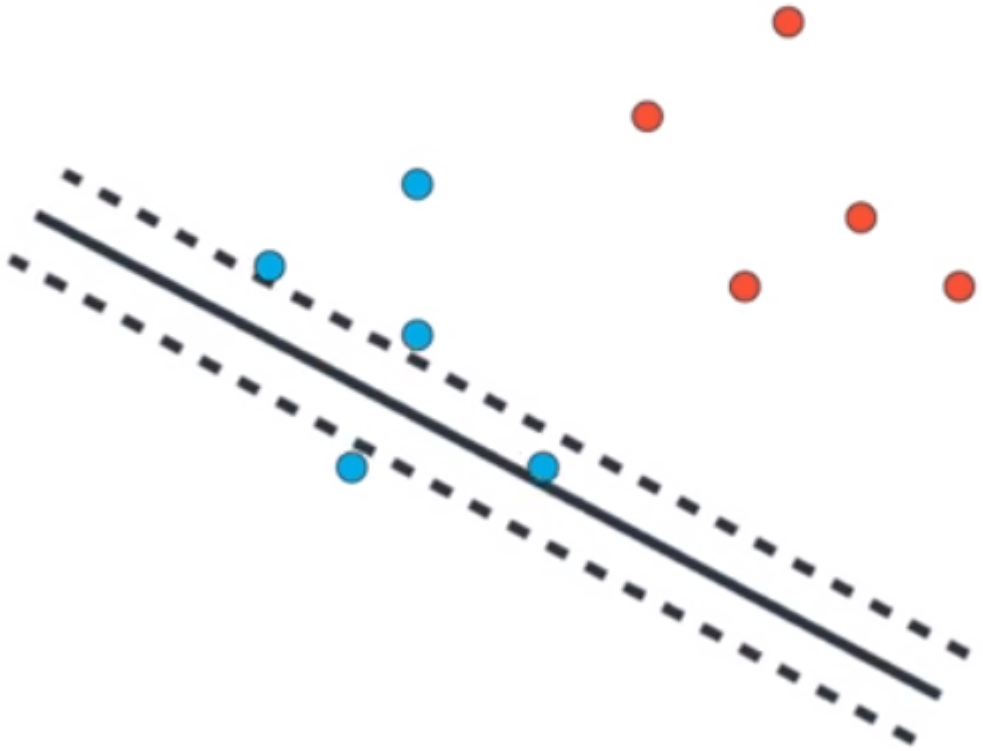
Split data - separate lines



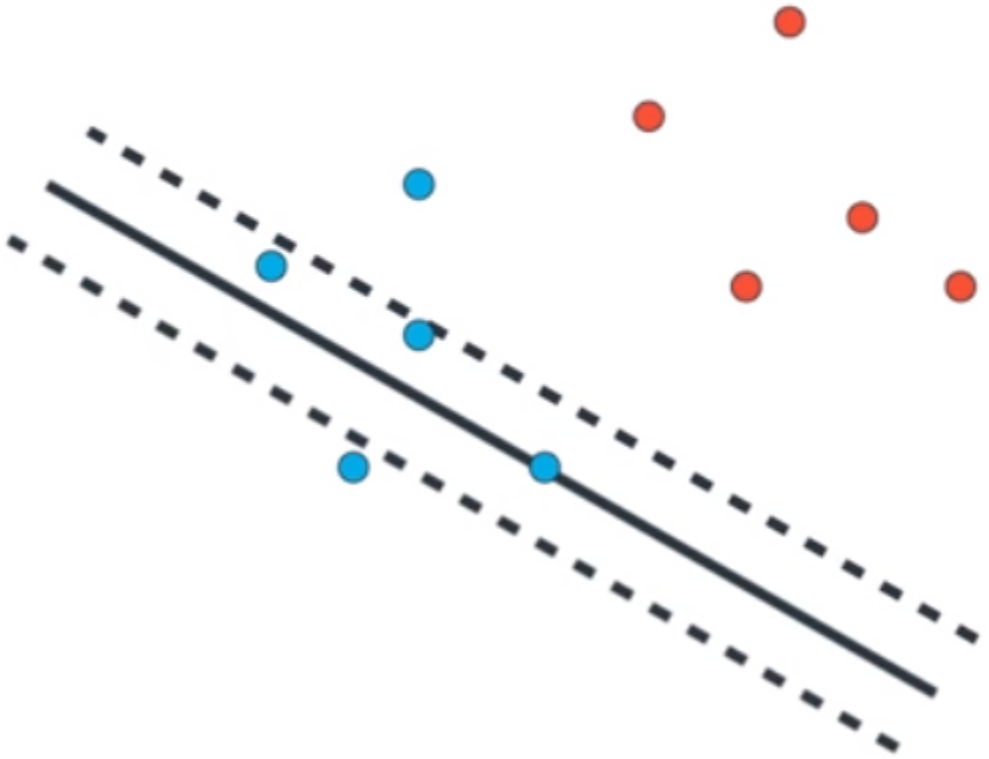
Split data - separate lines



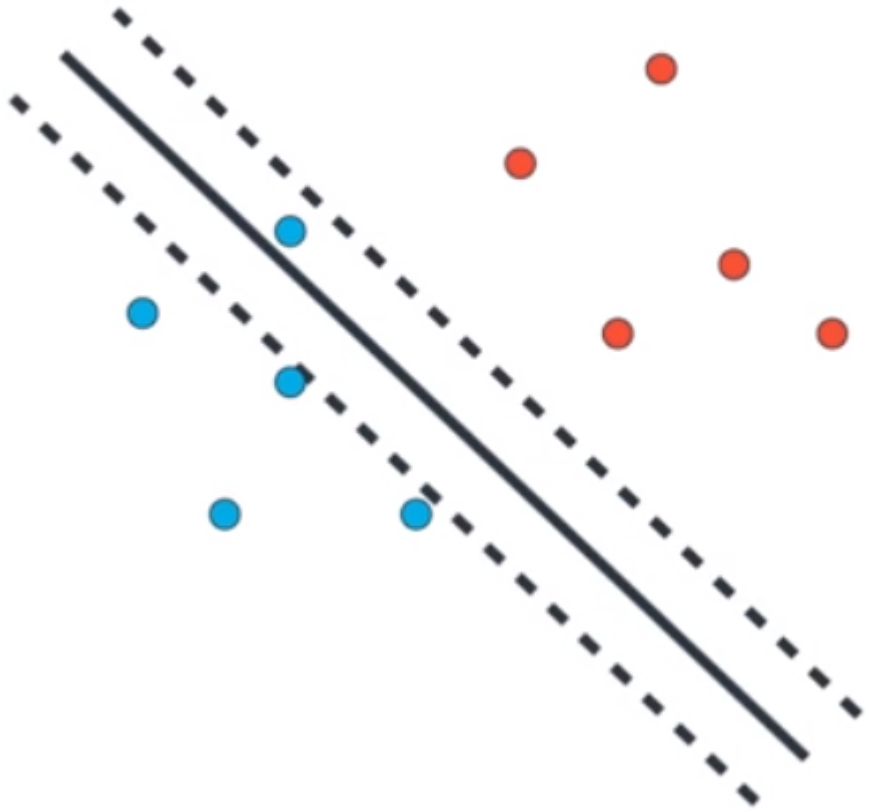
Split data - separate lines



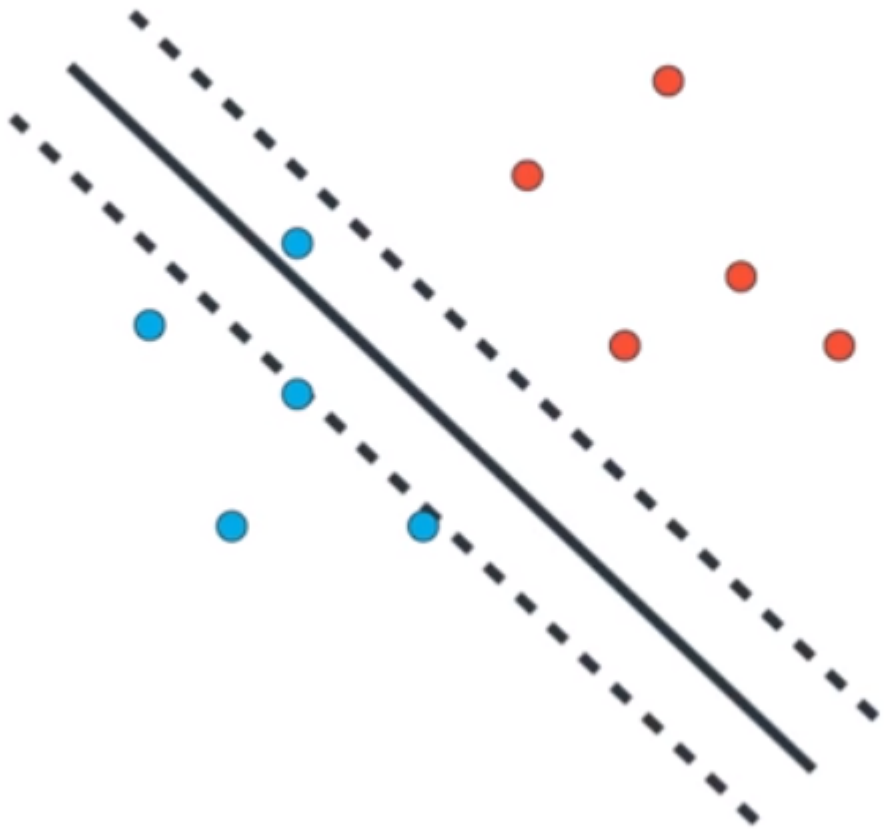
Split data - separate lines



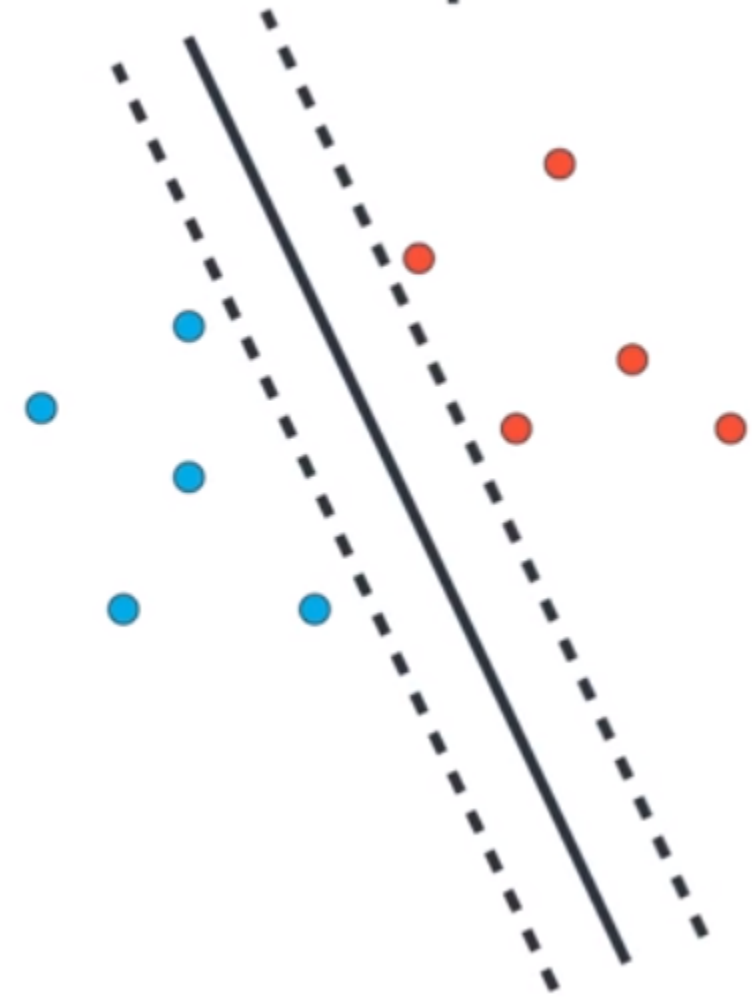
Split data - separate lines



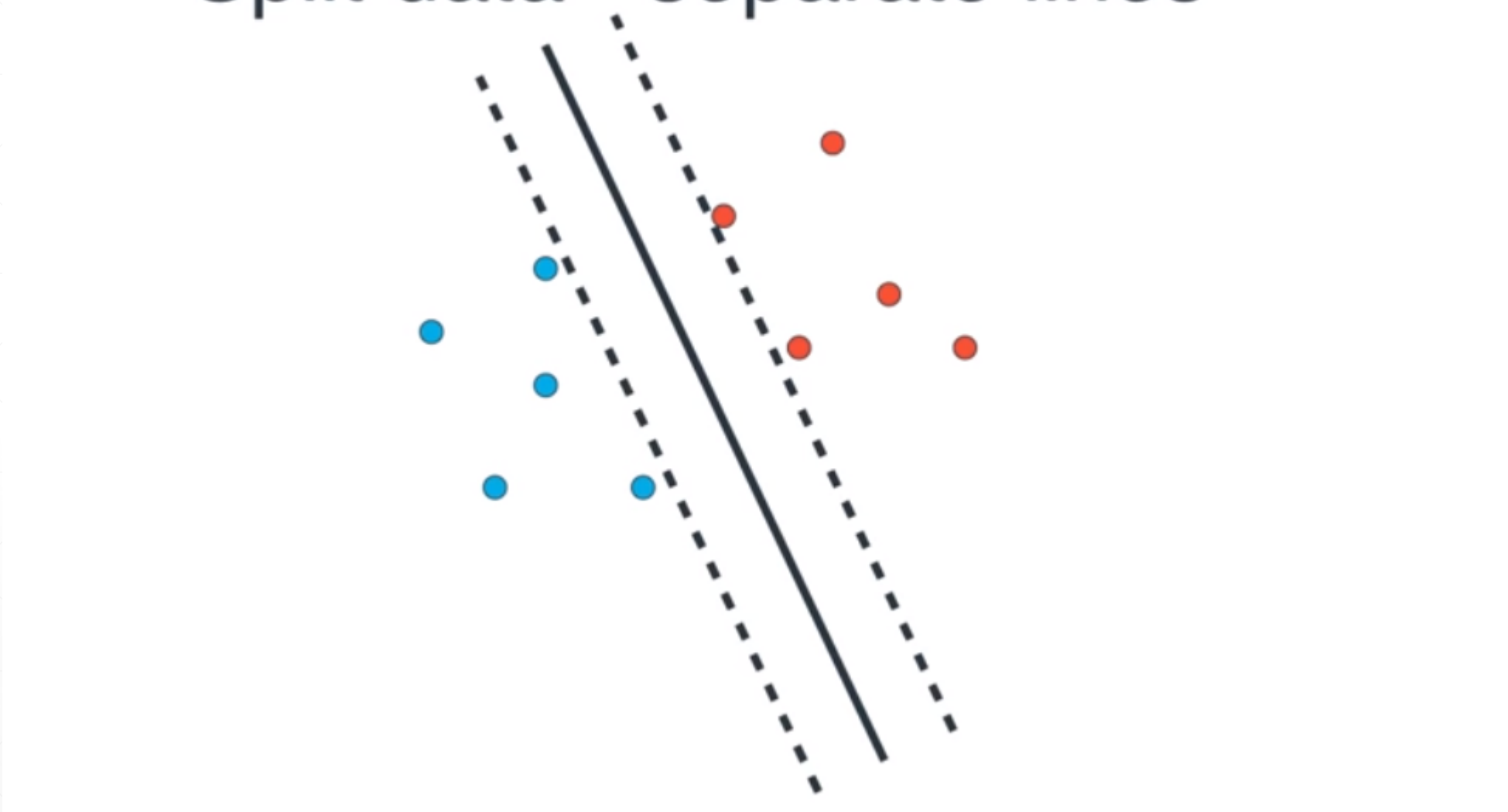
Split data - separate lines



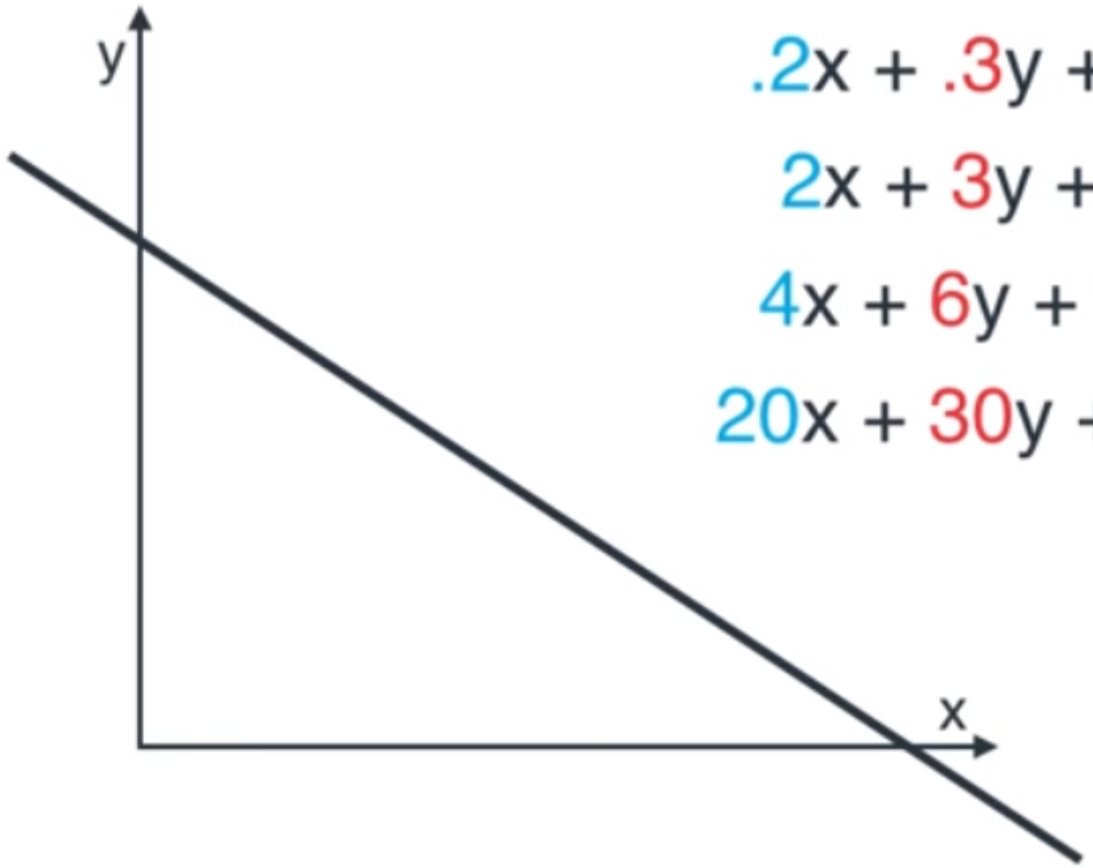
Split data - separate lines



Split data - separate lines



How to separate lines?



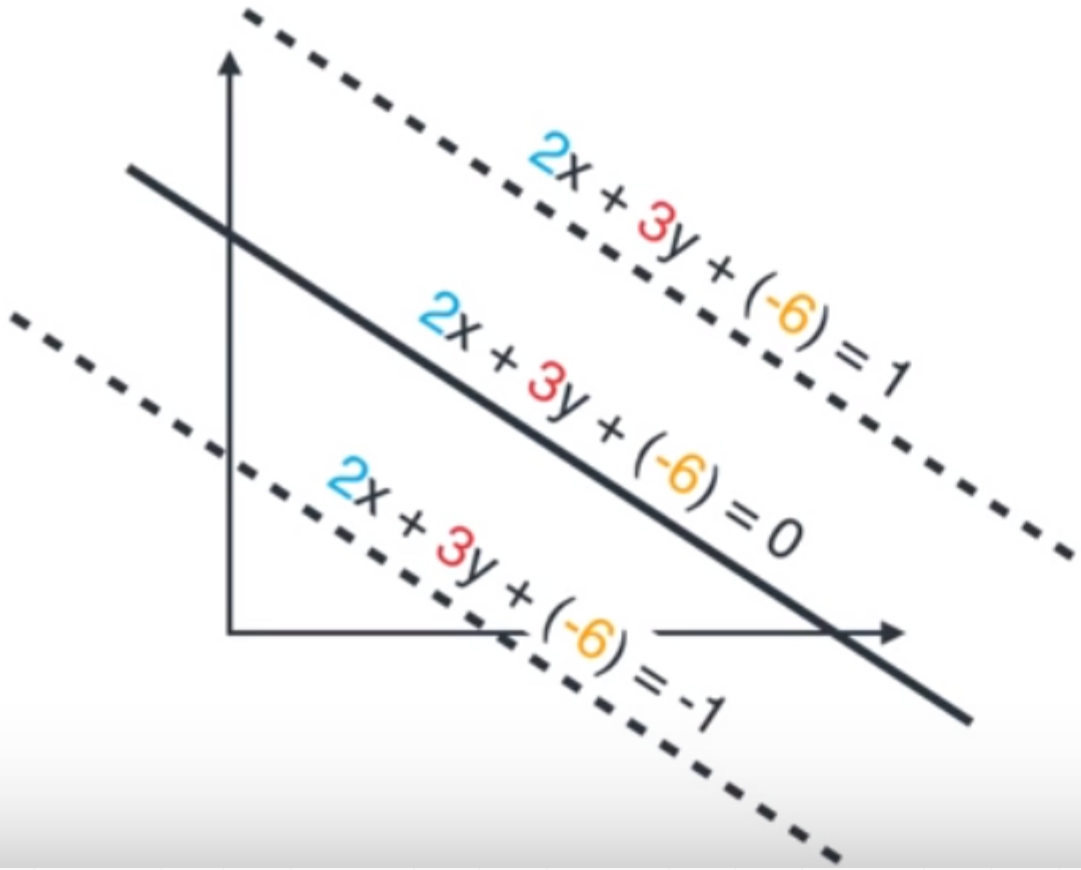
$.2x + .3y + (-.6) = 0$

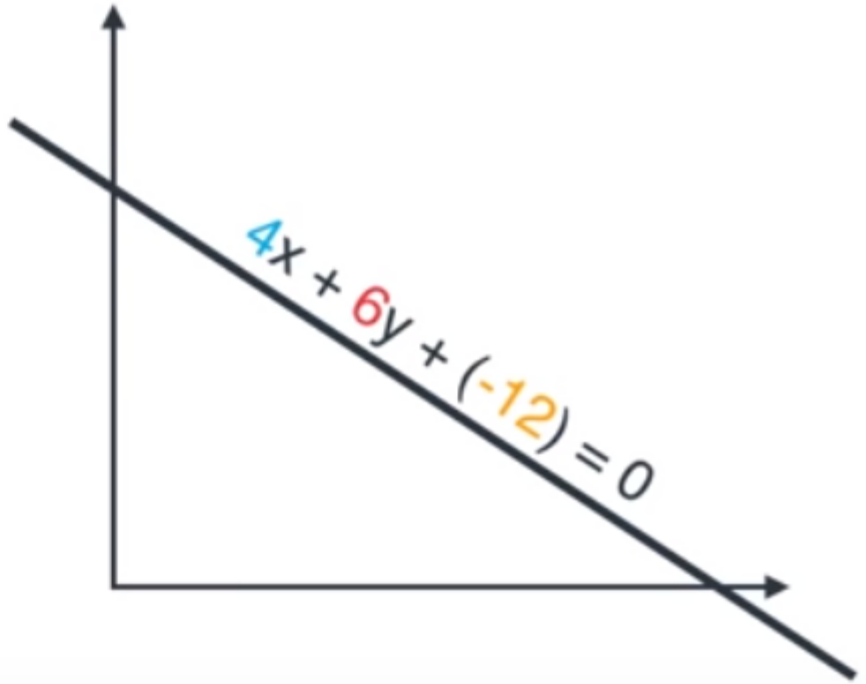
$2x + 3y + (-6) = 0$

$4x + 6y + (-12) = 0$

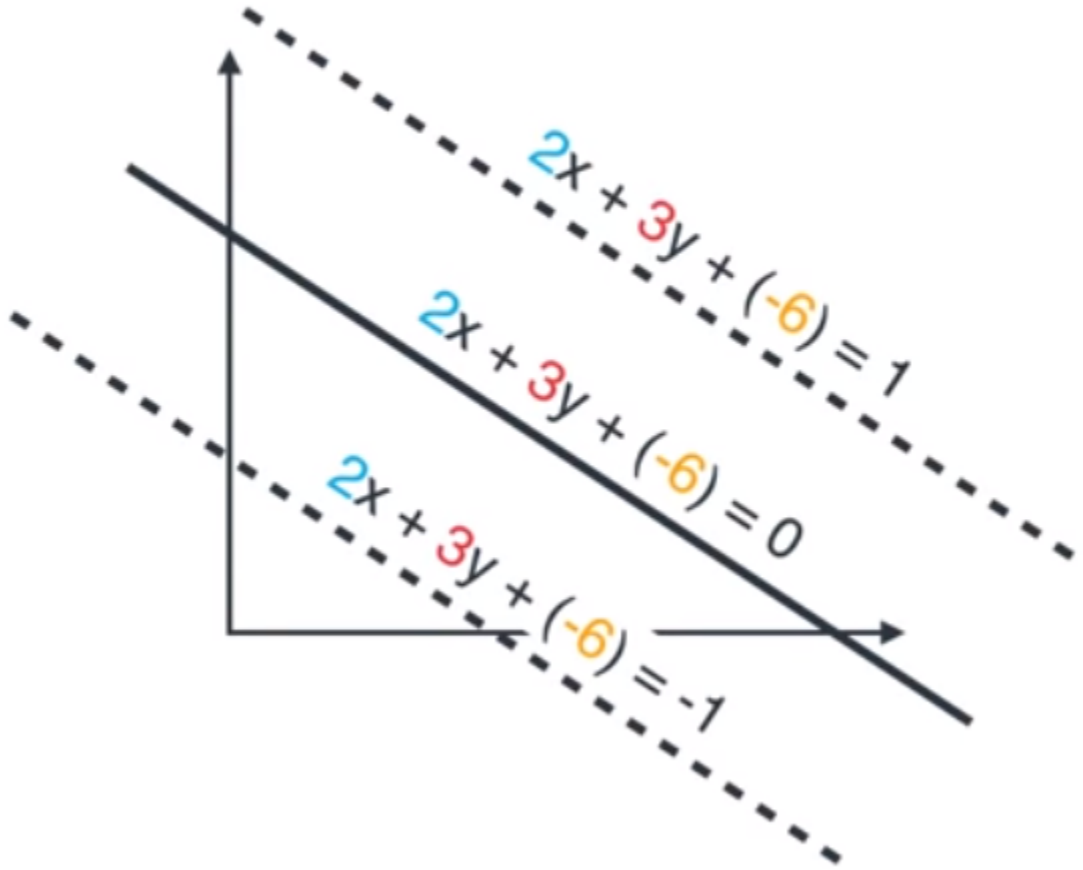
$20x + 30y + (-60) = 0$

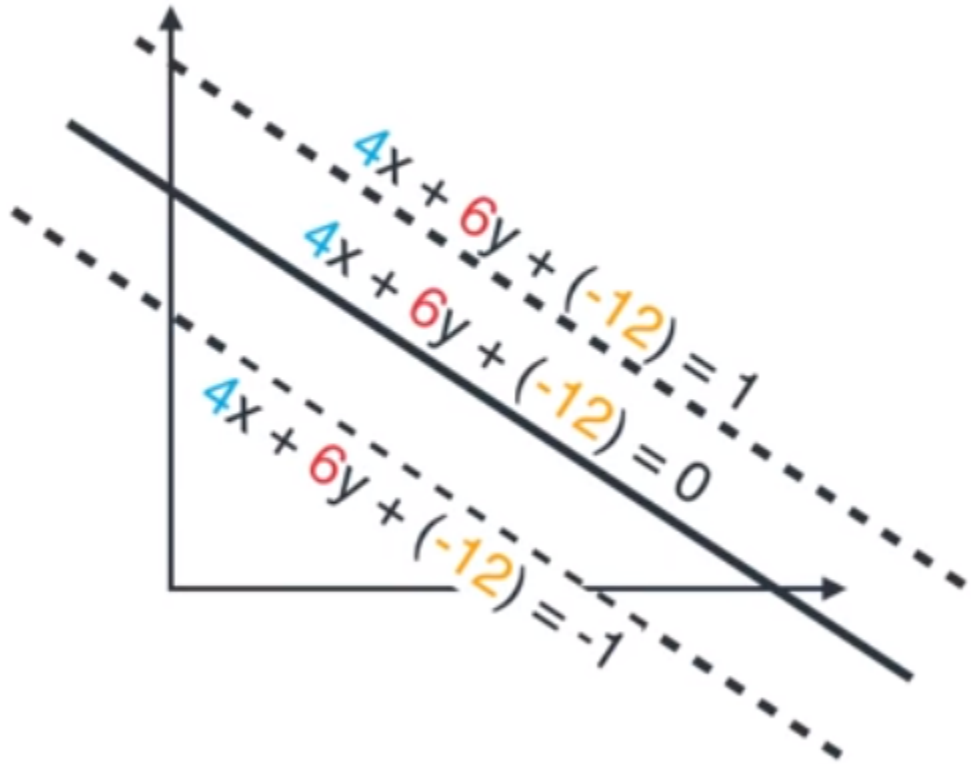
How to separate lines?



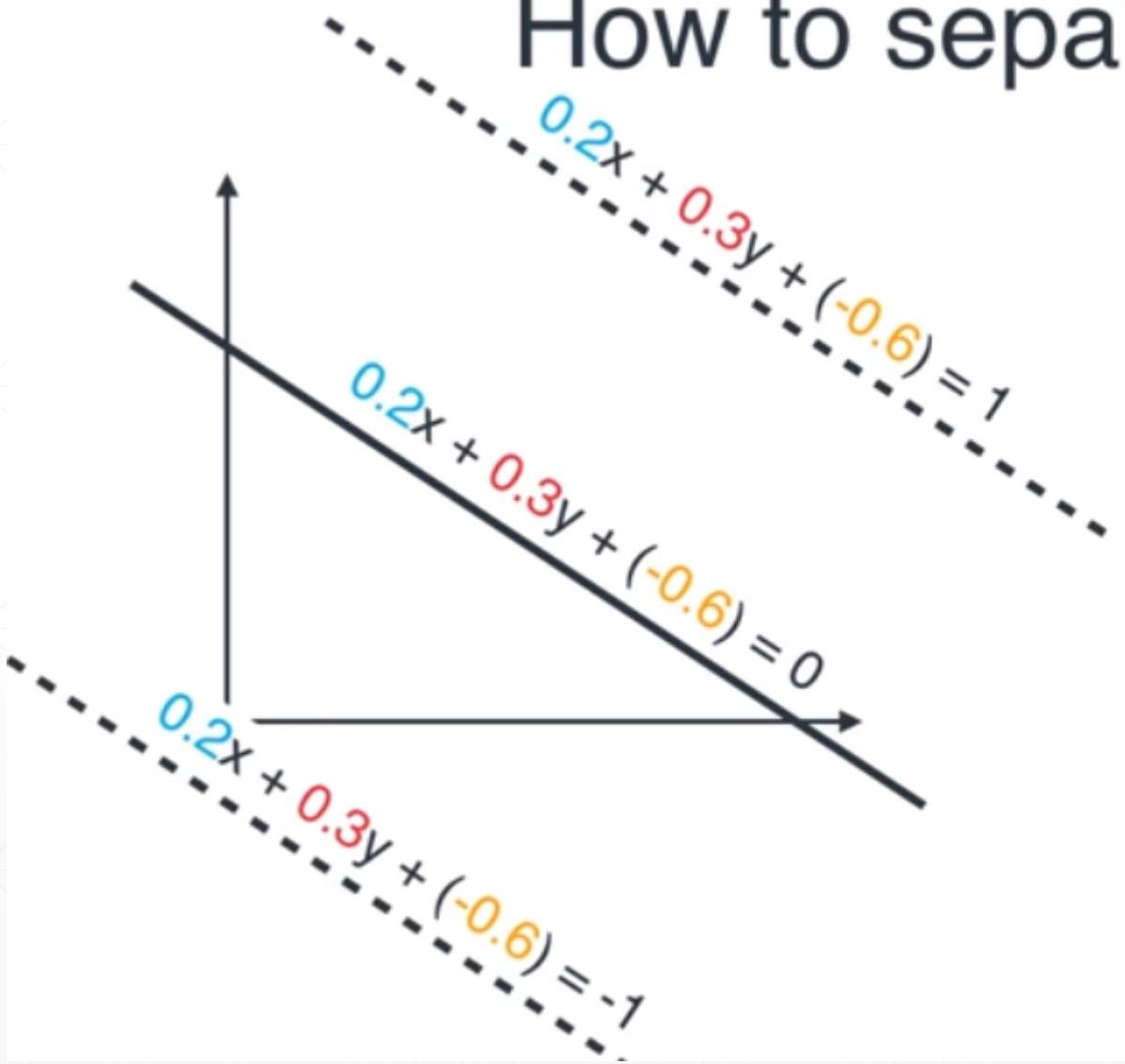


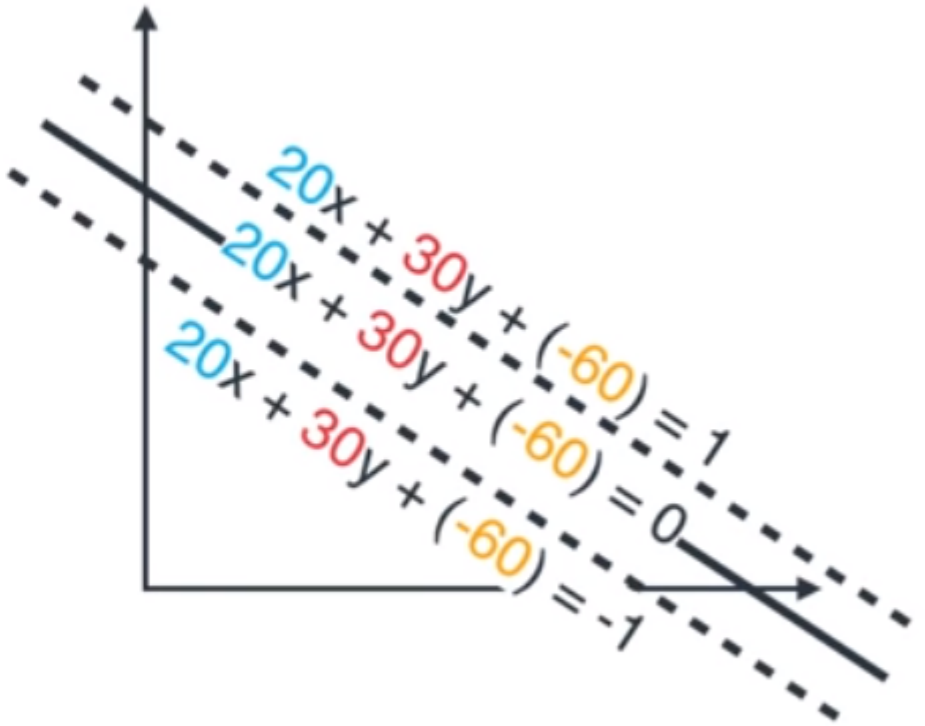
How to separate lines?



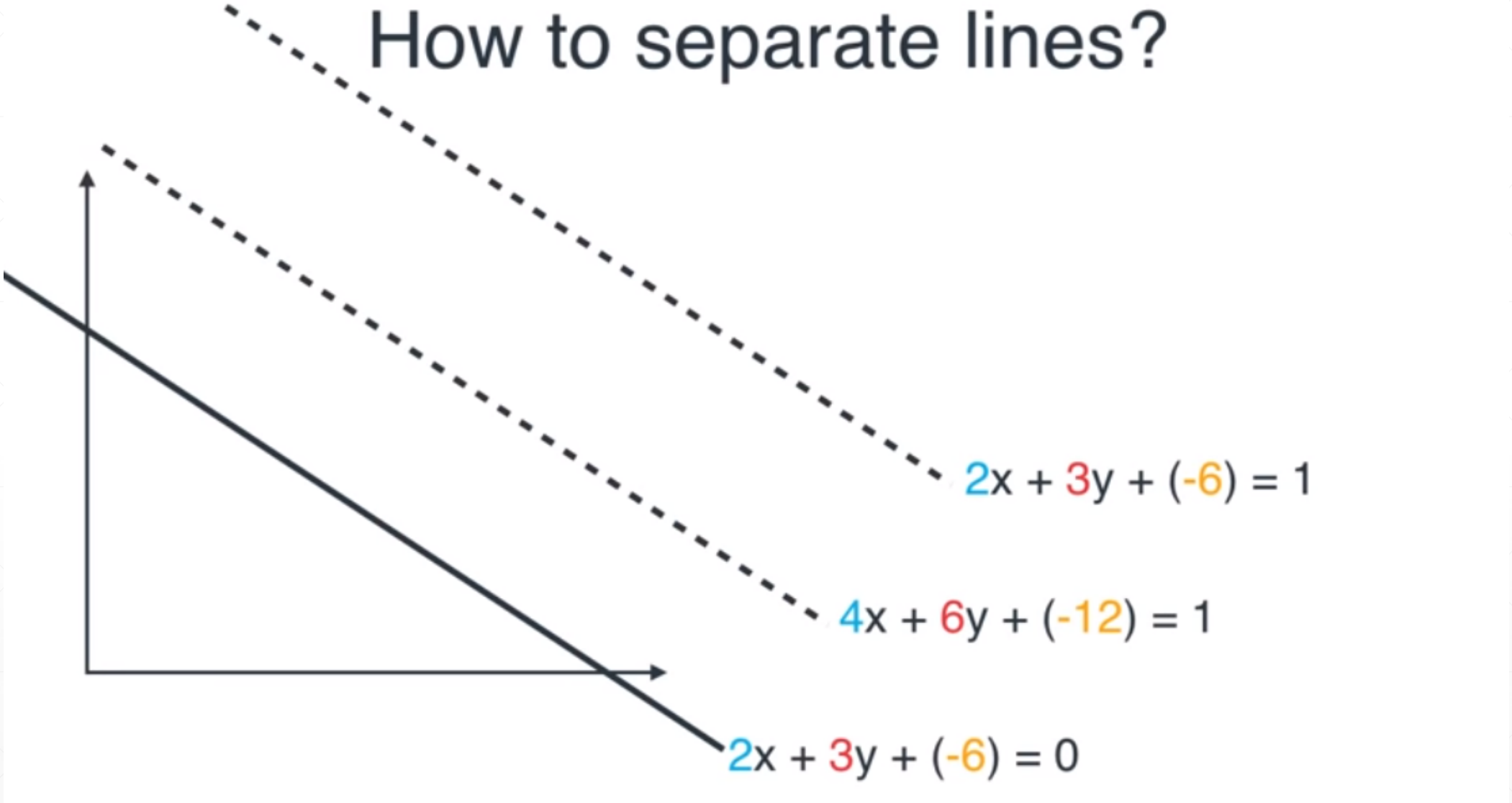


How to separate lines?

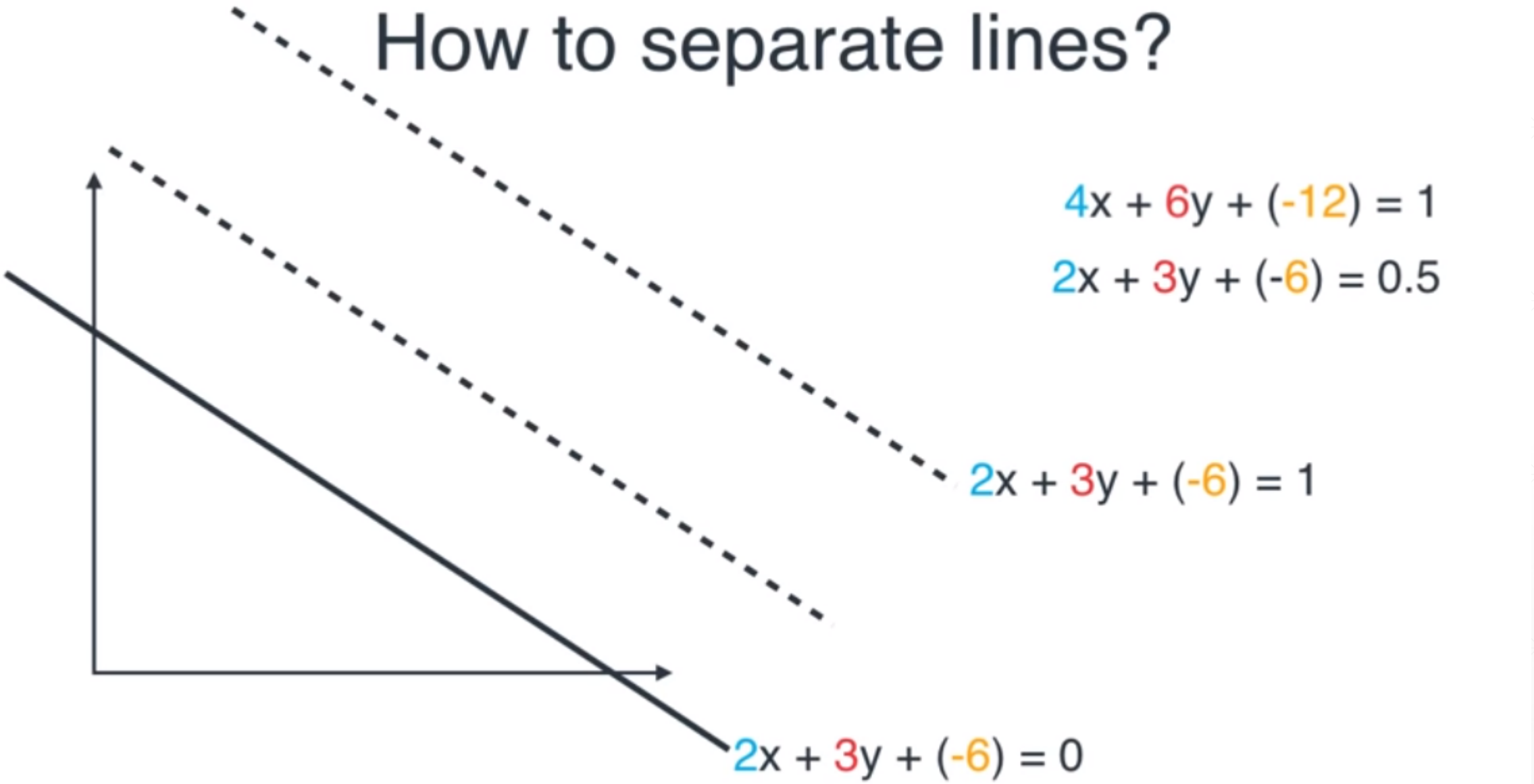




How to separate lines?

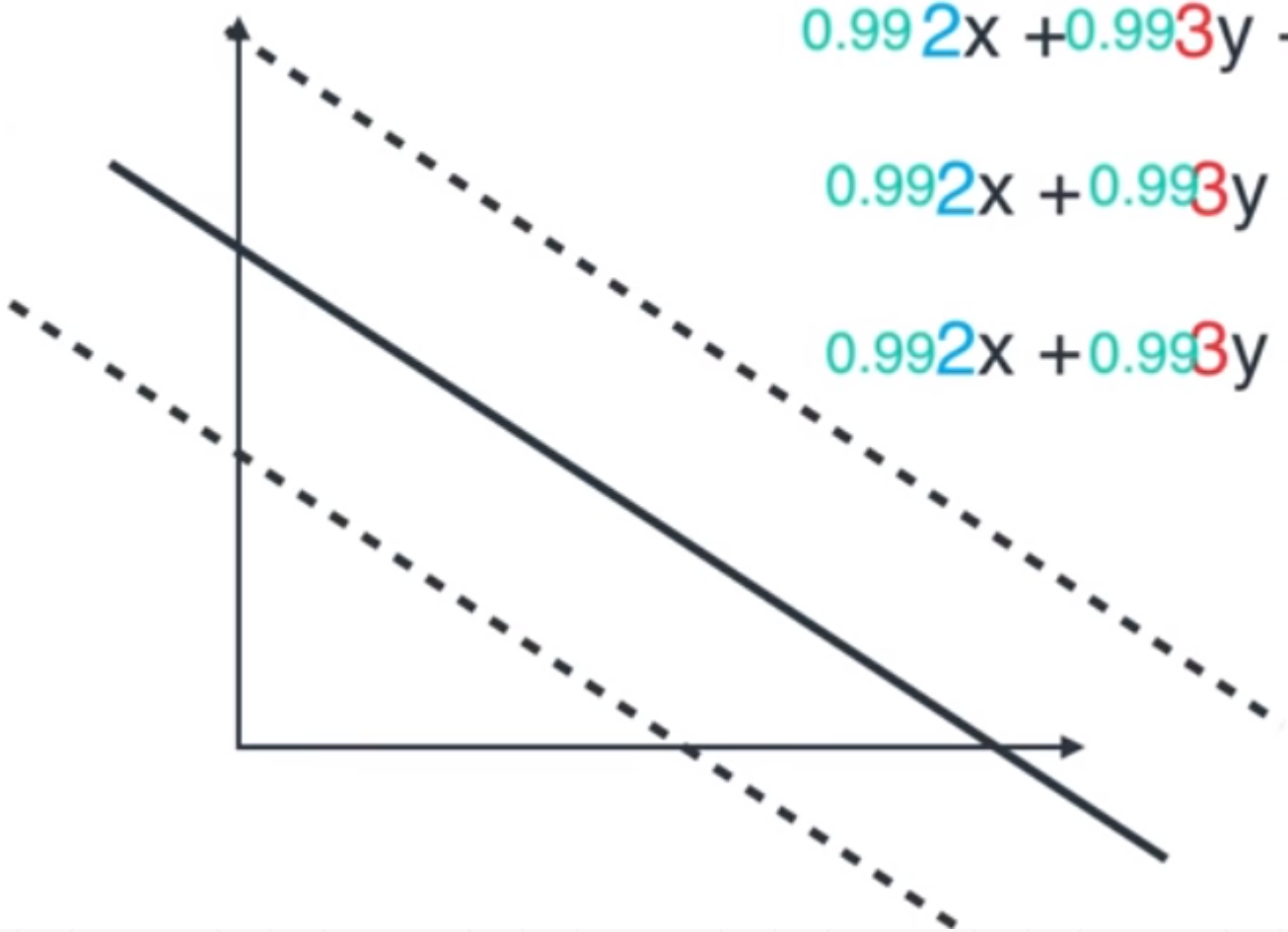


How to separate lines?



Expanding rate

Expanding rate



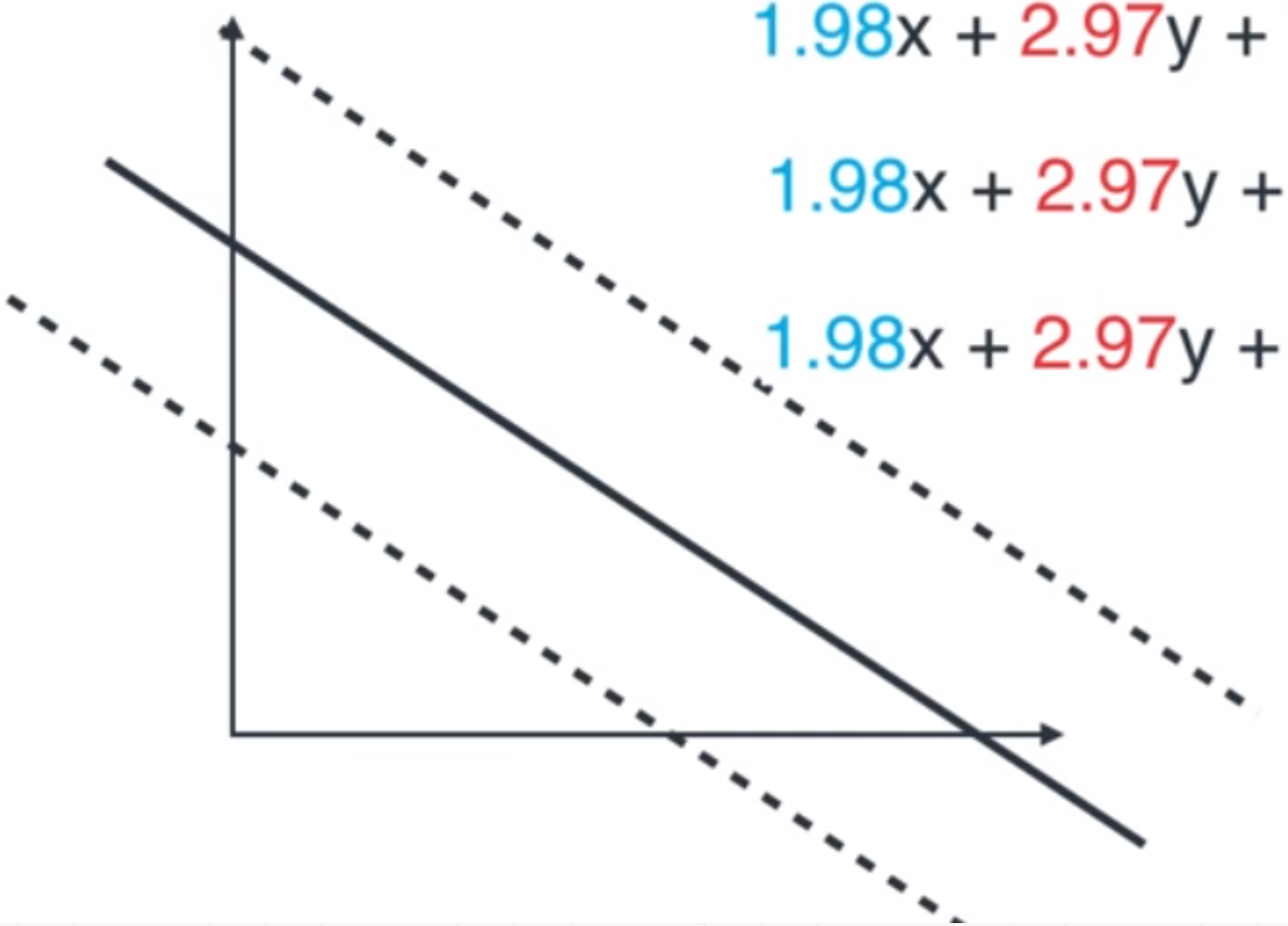
$$0.992x + 0.993y + 0.99(-6) = -1$$

$$0.992x + 0.993y + 0.99(-6) = 0$$

$$0.992x + 0.993y + 0.99(-6) = 1$$

Expanding rate

Expanding rate



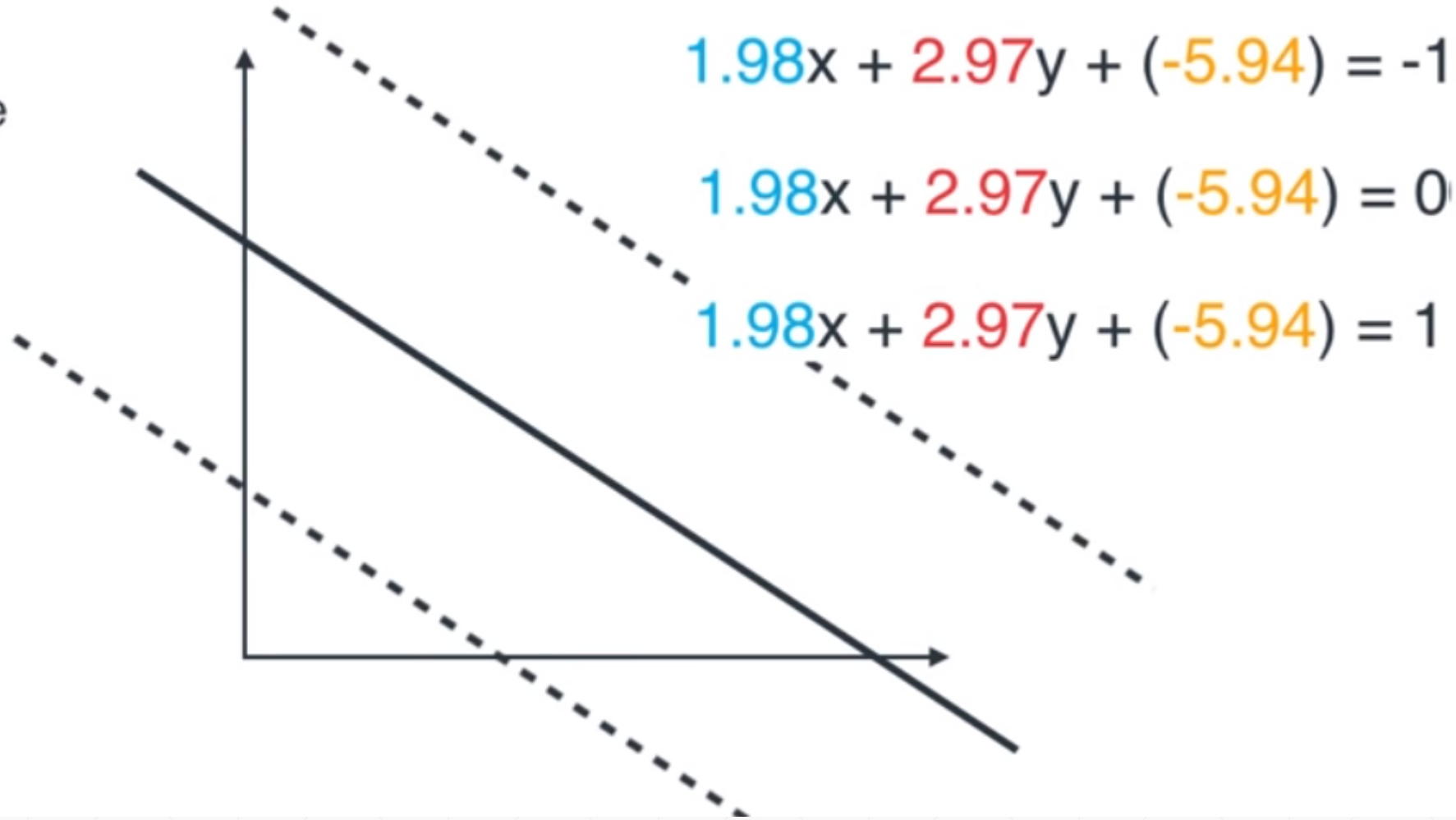
$1.98x + 2.97y + (-5.94) = -1$

$1.98x + 2.97y + (-5.94) = 0$

$1.98x + 2.97y + (-5.94) = 1$

Expanding rate

Expanding rate

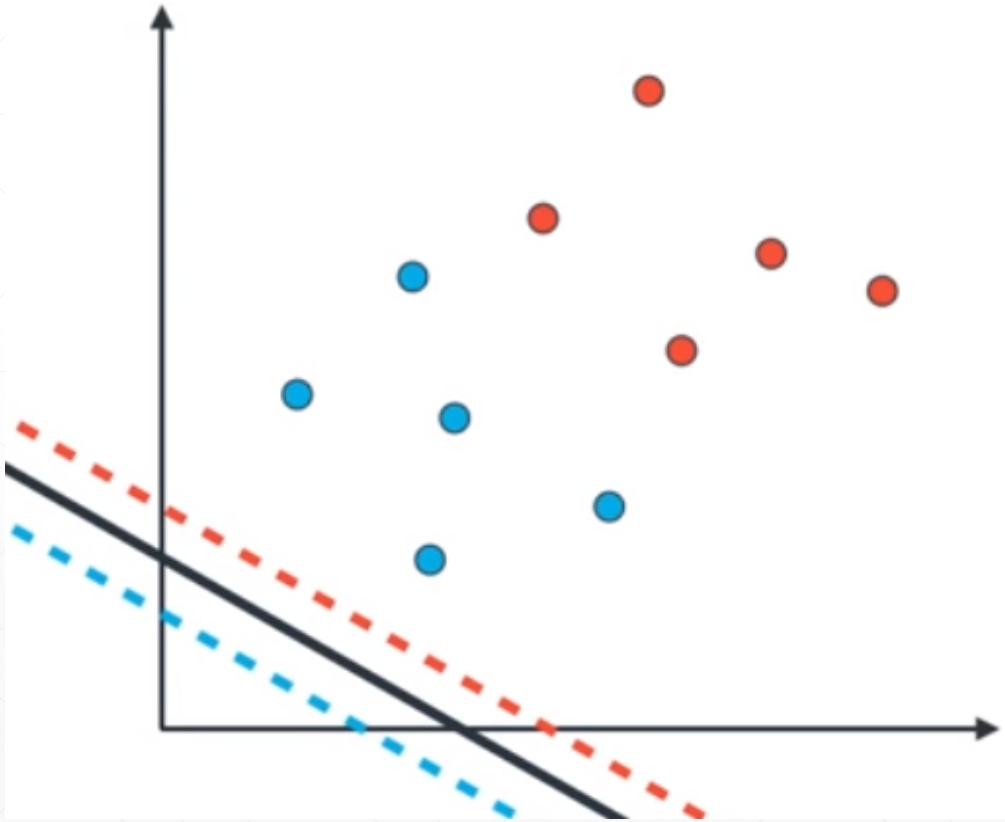


$1.98x + 2.97y + (-5.94) = -1$

$1.98x + 2.97y + (-5.94) = 0$

$1.98x + 2.97y + (-5.94) = 1$

SVM algorithm

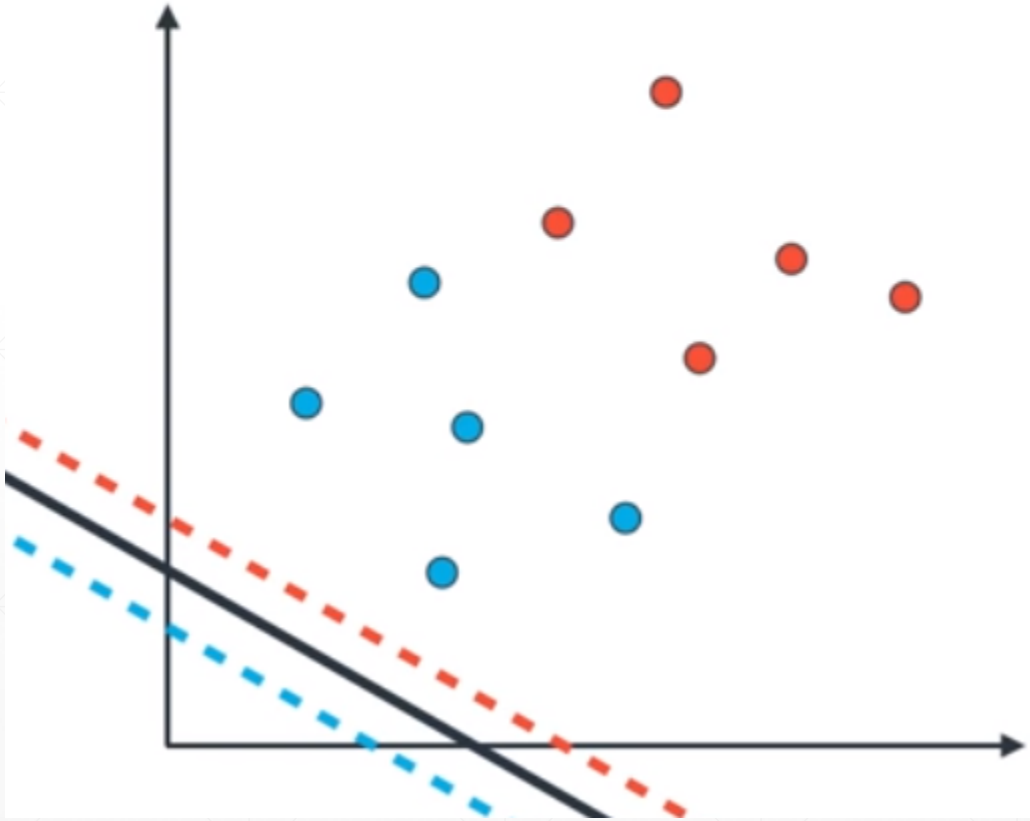


Step 1: Start with a line, and two equidistant parallel lines to it.

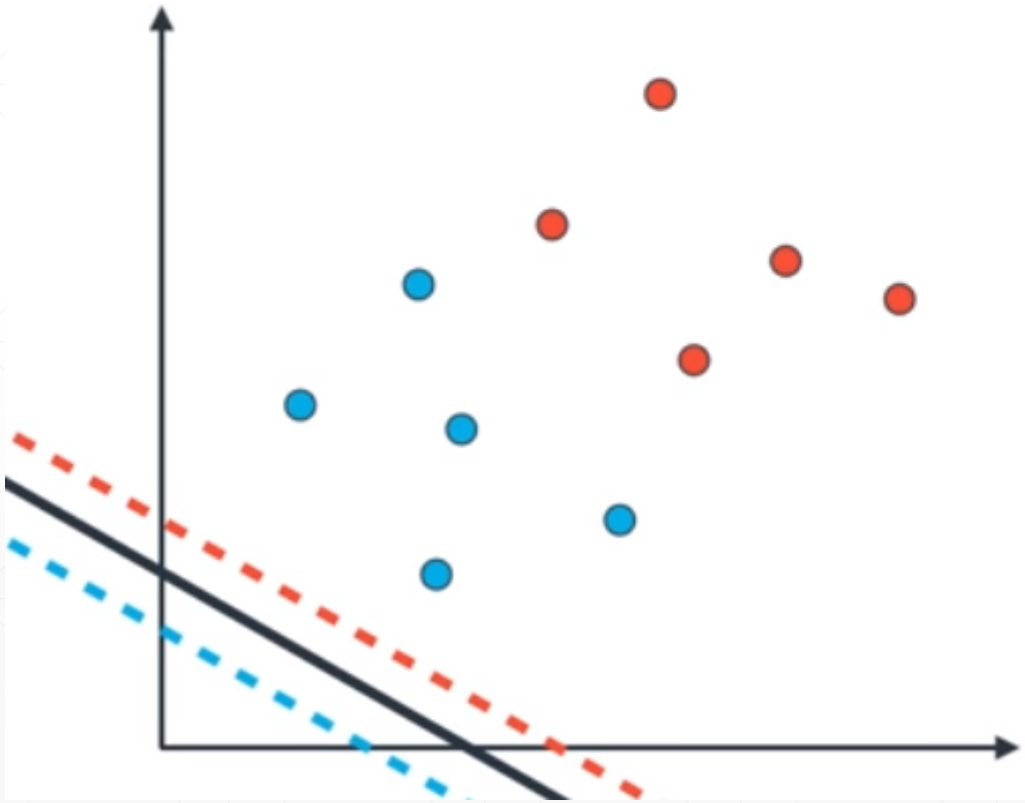
SVM algorithm

Step 1: Start with a line, and two equidistant parallel lines to it.

Step 2: Pick a large number. 1000 (number of repetitions, or epochs)



SVM algorithm

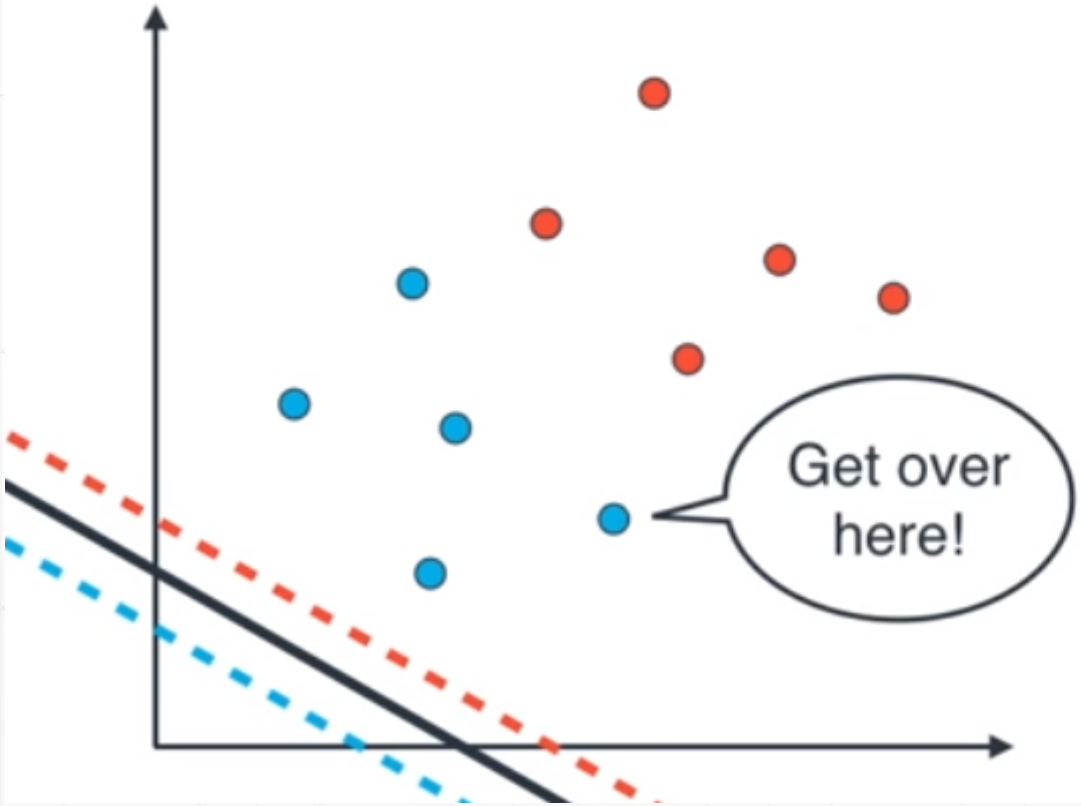


Step 1: Start with a line, and two equidistant parallel lines to it.

Step 2: Pick a large number. 1000 (number of repetitions, or epochs)

Step 3: Pick a number close to 1. (the expanding factor) 0.99

SVM algorithm



Step 1: Start with a line, and two equidistant parallel lines to it.

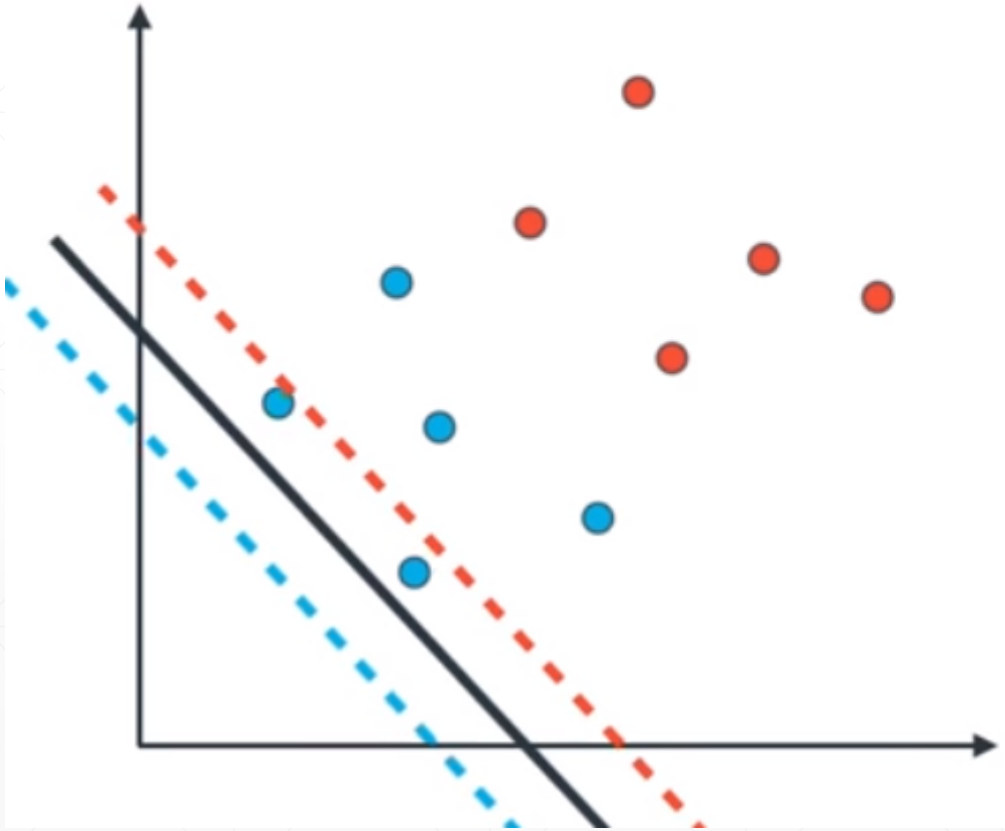
Step 2: Pick a large number. 1000 (number of repetitions, or epochs)

Step 3: Pick a number close to 1. (the expanding factor) 0.99

Step 4: (repeat 1000 times)

- Pick random point
- If point is correctly classified:
  - Do nothing
- If point is incorrectly classified
  - Move line towards point

SVM algorithm



Step 1: Start with a line, and two equidistant parallel lines to it.

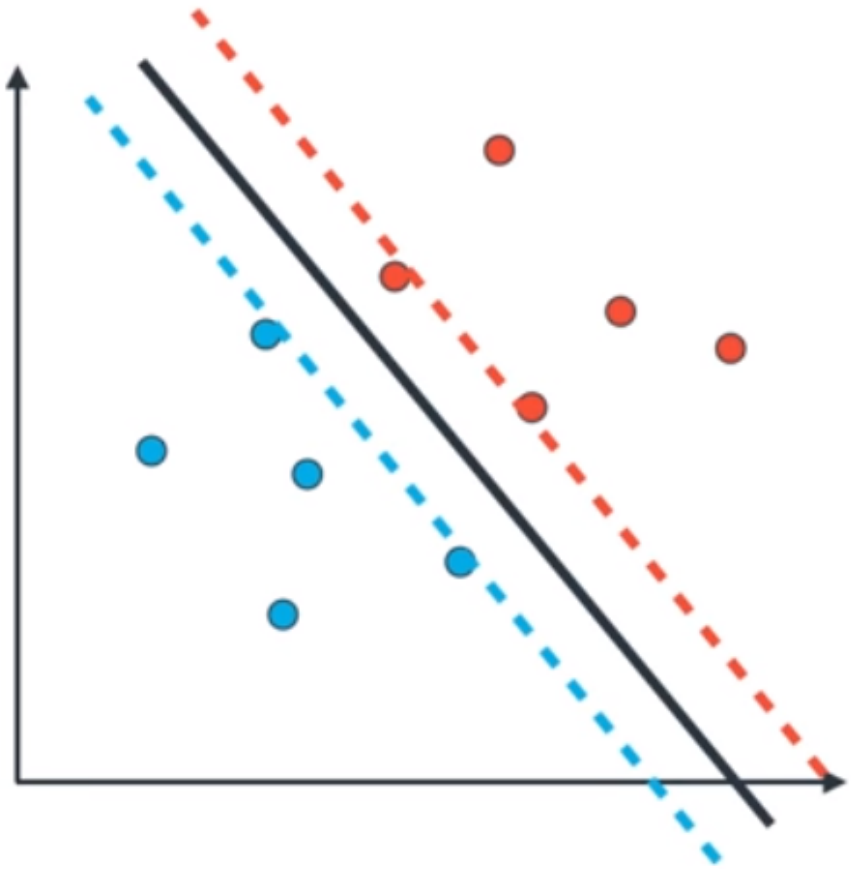
Step 2: Pick a large number. 1000 (number of repetitions, or epochs)

Step 3: Pick a number close to 1. (the expanding factor) 0.99

Step 4: (repeat 1000 times)

- Pick random point
- If point is correctly classified:
  - Do nothing
- If point is incorrectly classified
  - Move line towards point
- Separate the lines using the expanding factor

SVM algorithm



Step 1: Start with a line, and two equidistant parallel lines to it.

Step 2: Pick a large number. 1000 (number of repetitions, or epochs)

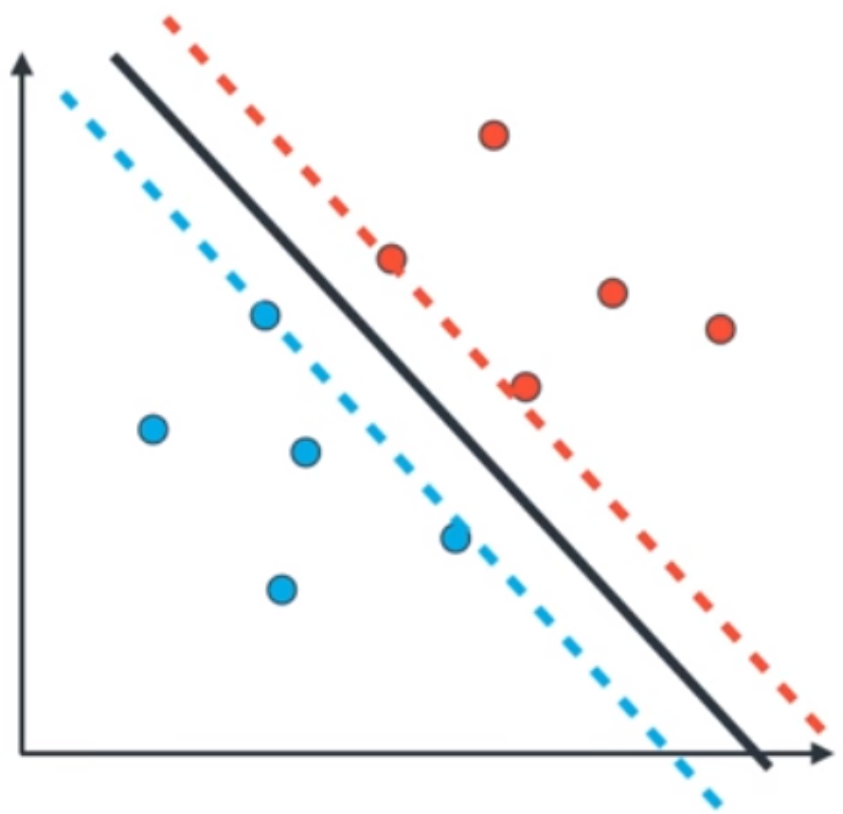
Step 3: Pick a number close to 1. (the expanding factor) 0.99

Step 4: (repeat 1000 times)

- Pick random point
- If point is correctly classified:
  - Do nothing
- If point is incorrectly classified
  - Move line towards point
- Separate the lines using the expanding factor

Step 5: Enjoy your lines that separate the data!

SVM algorithm



Step 1: Start with a random line of equation $ax + by + c = 0$.
Draw parallel lines with equations:
- $ax + by + c = 1$, and
- $ax + by + c = -1$

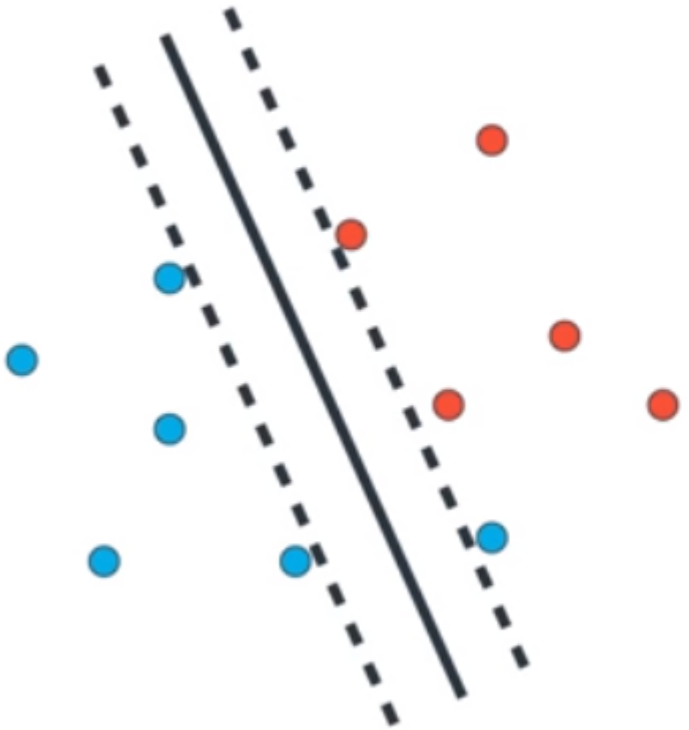
Step 2: Pick a large number. **1000** (number of repetitions, or epochs)

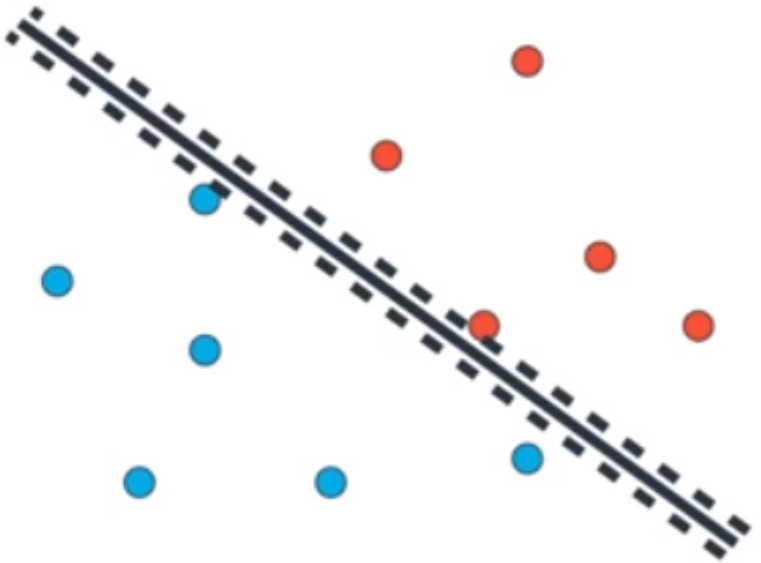
Step 3: Pick a learning rate. **0.01**

Step 4: Pick an expanding rate. 0.99

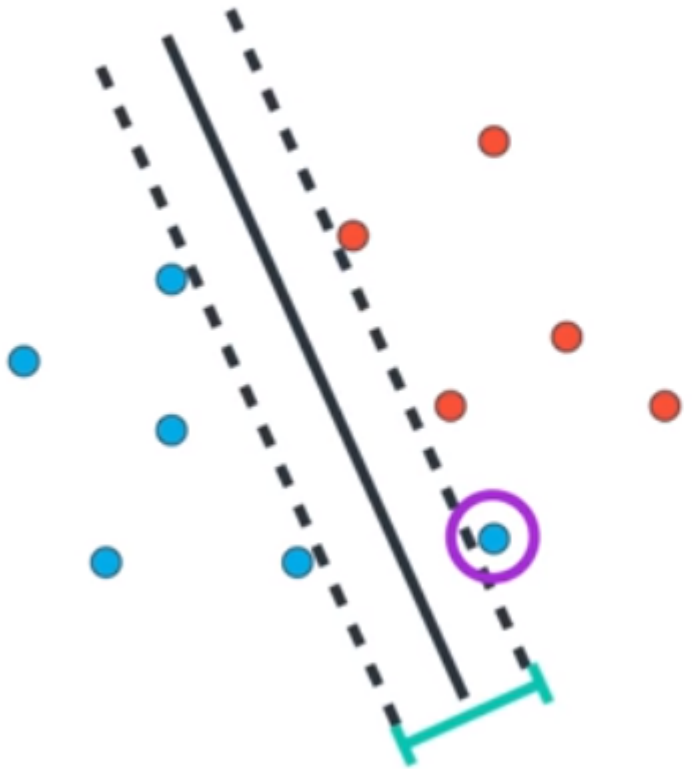
Step 5: (repeat **1000** times)
- Pick random point **(p,q)**
- If point is correctly classified
  - Do nothing
- If point is blue, and $ap+bq+c > 0$
  - Subtract 0.01**p** to a
  - Subtract 0.01**q** to b
  - Subtract 0.01 to c
- If point is, red and $ap+bq+c < 0$
  - Add 0.01**p** to a
  - Add 0.01**q** to b
  - Add 0.01 to c
- **Multiply a, b, c, by 0.99**

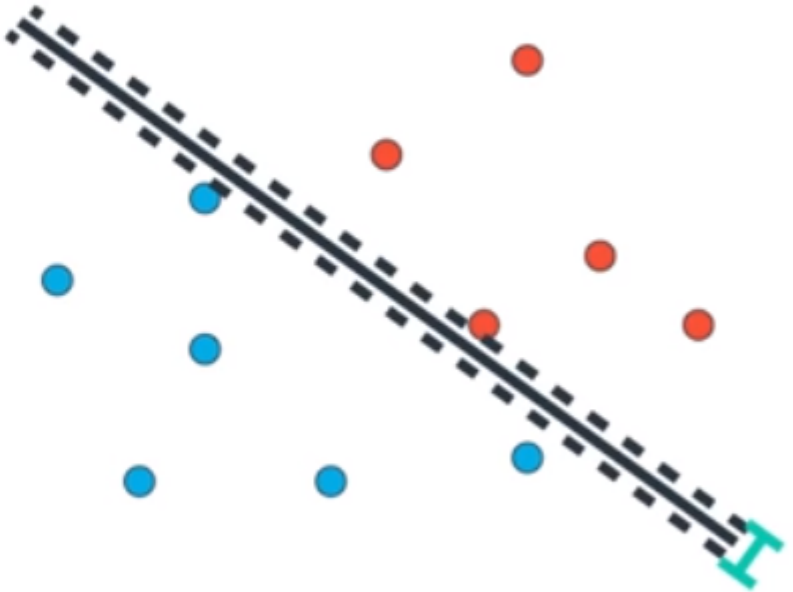
Which line is better?

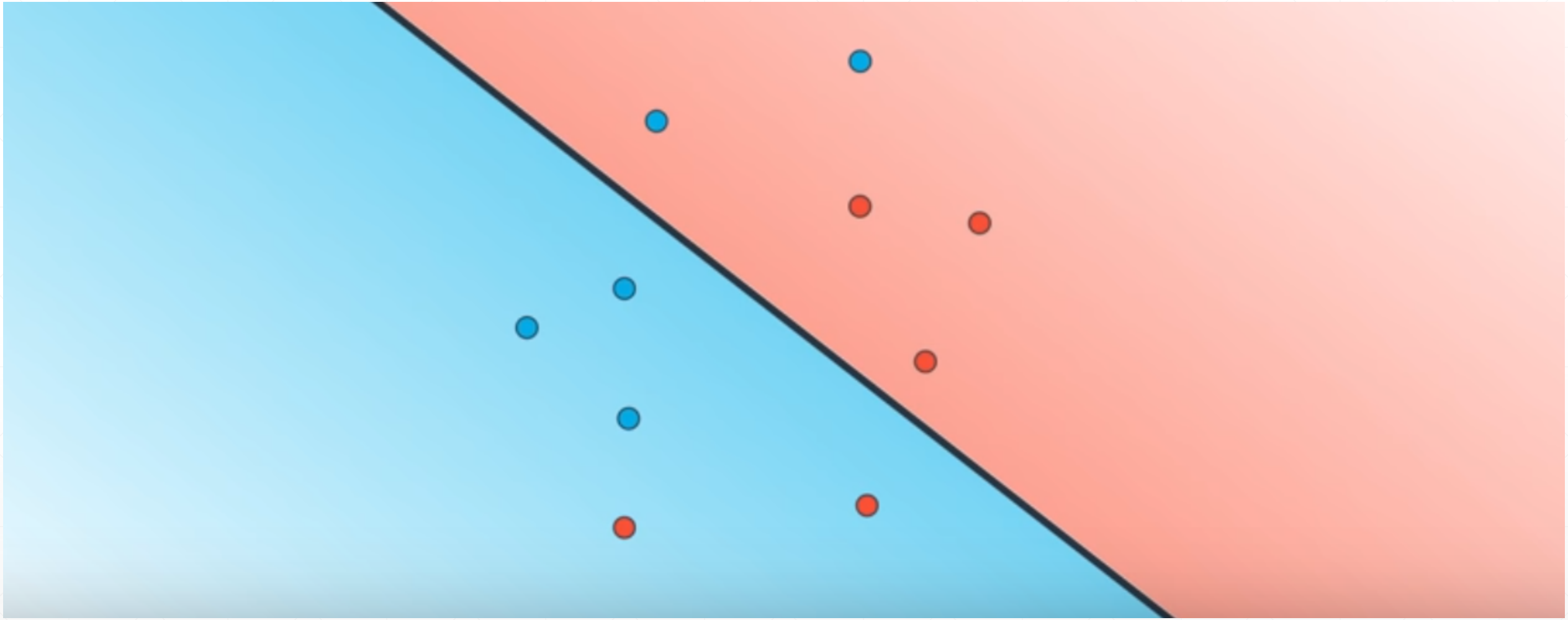


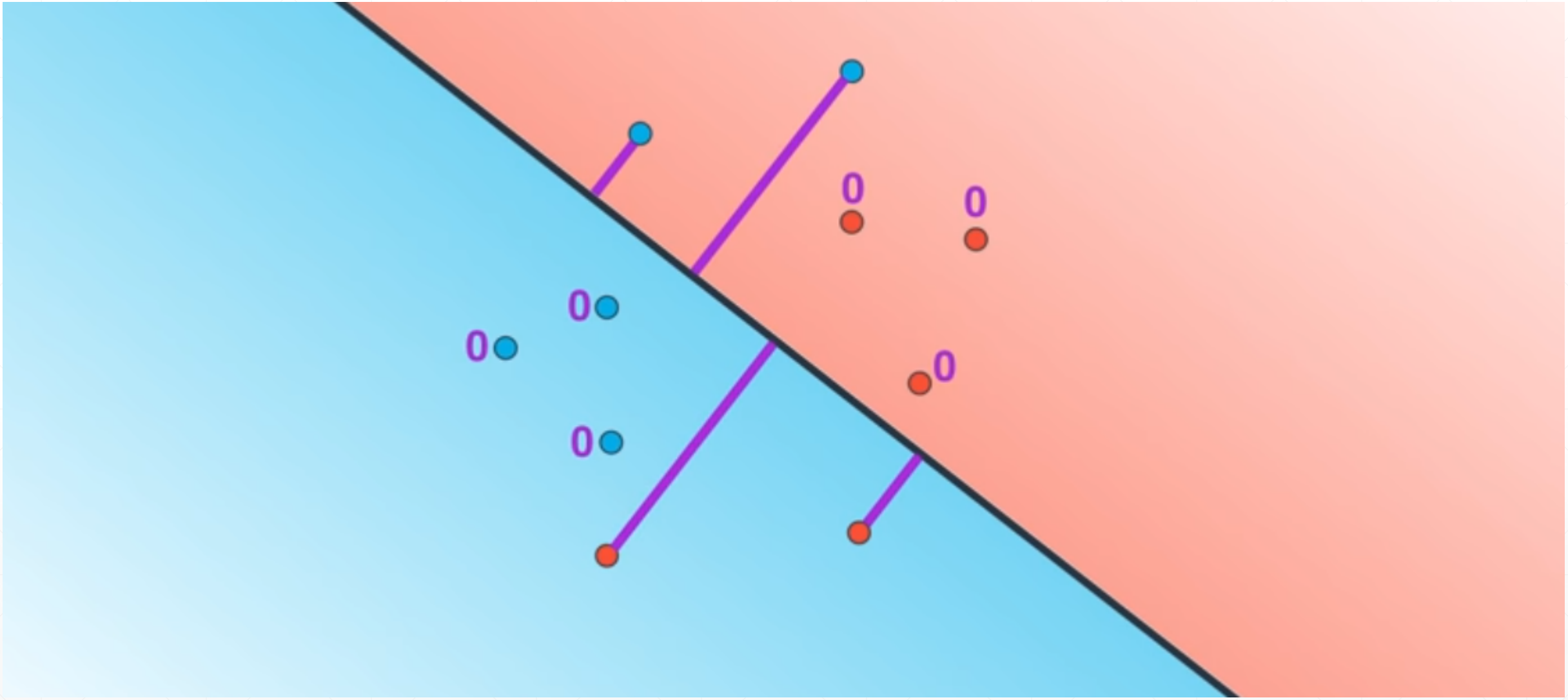


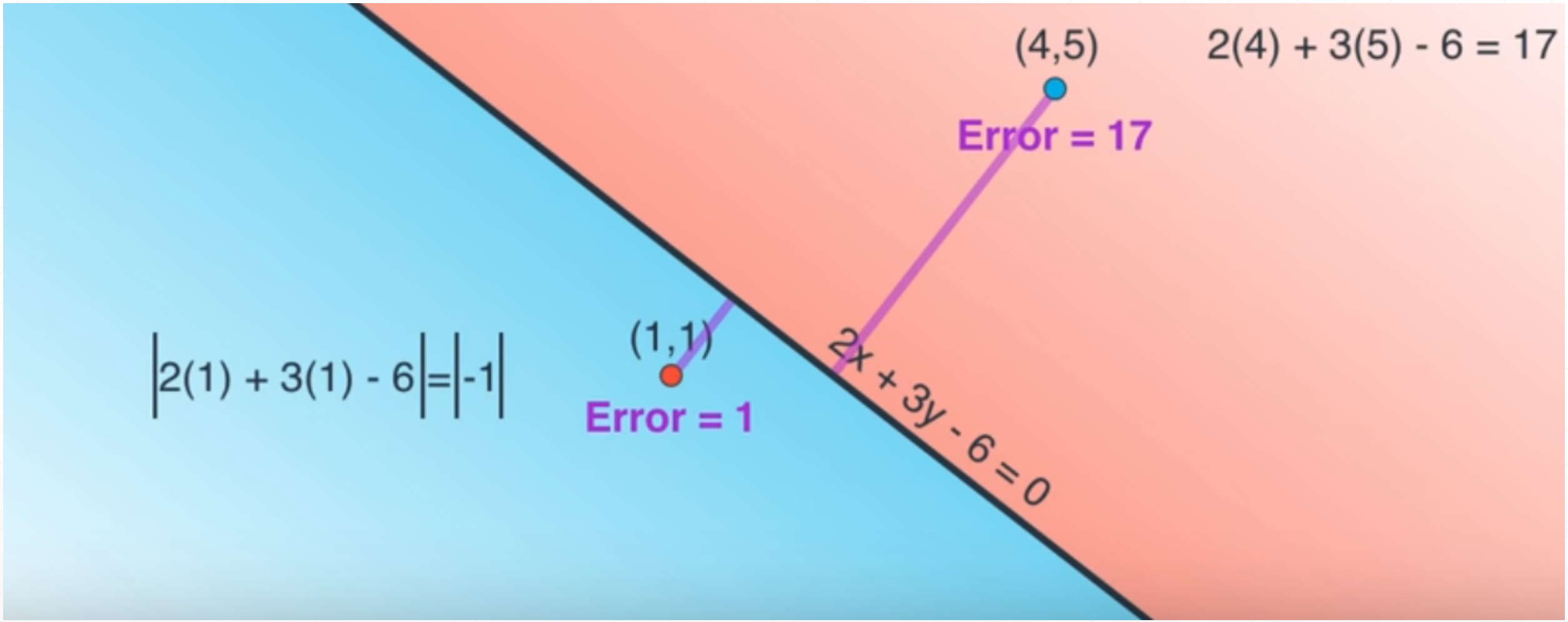
Which line is better?

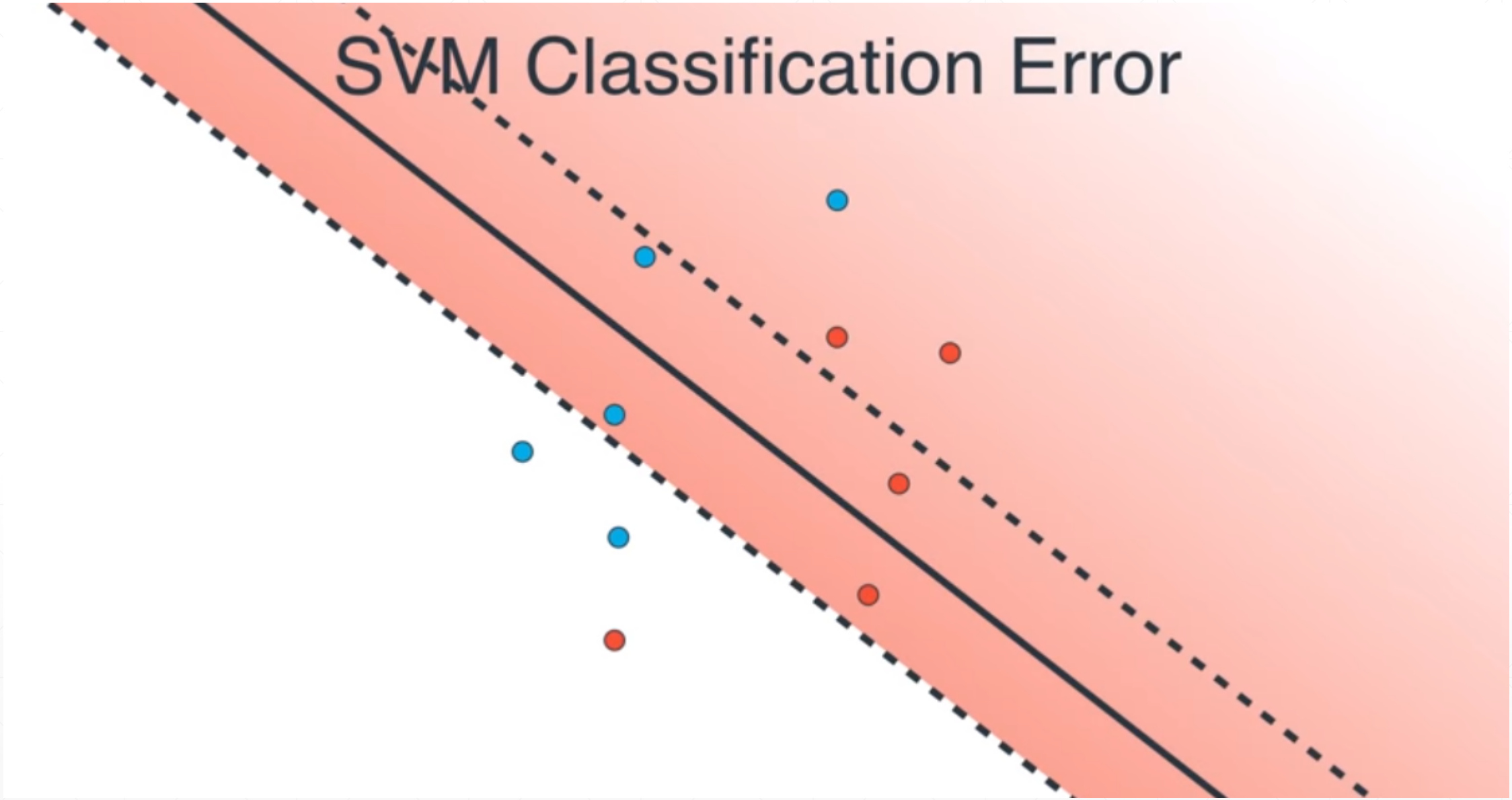


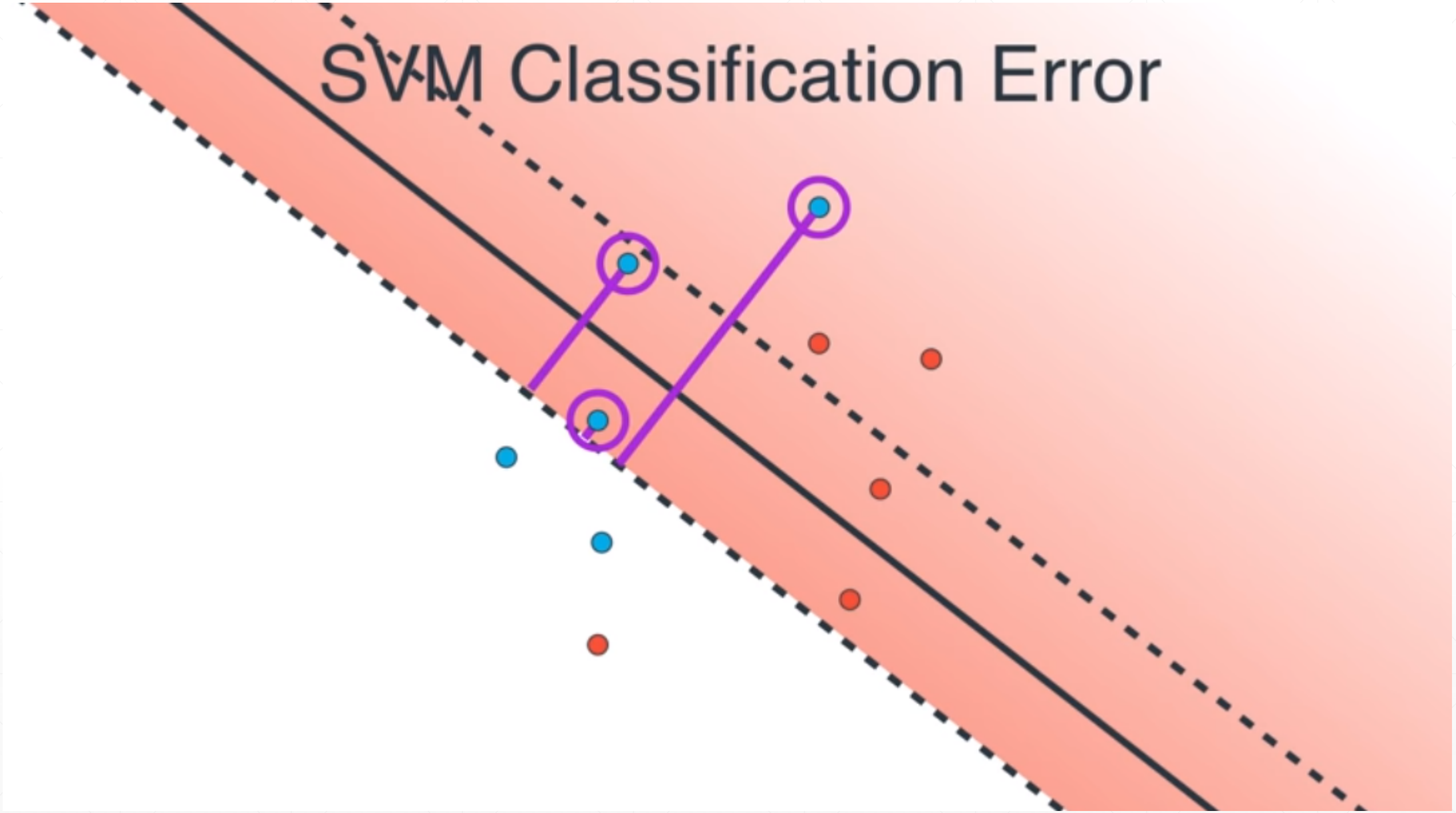


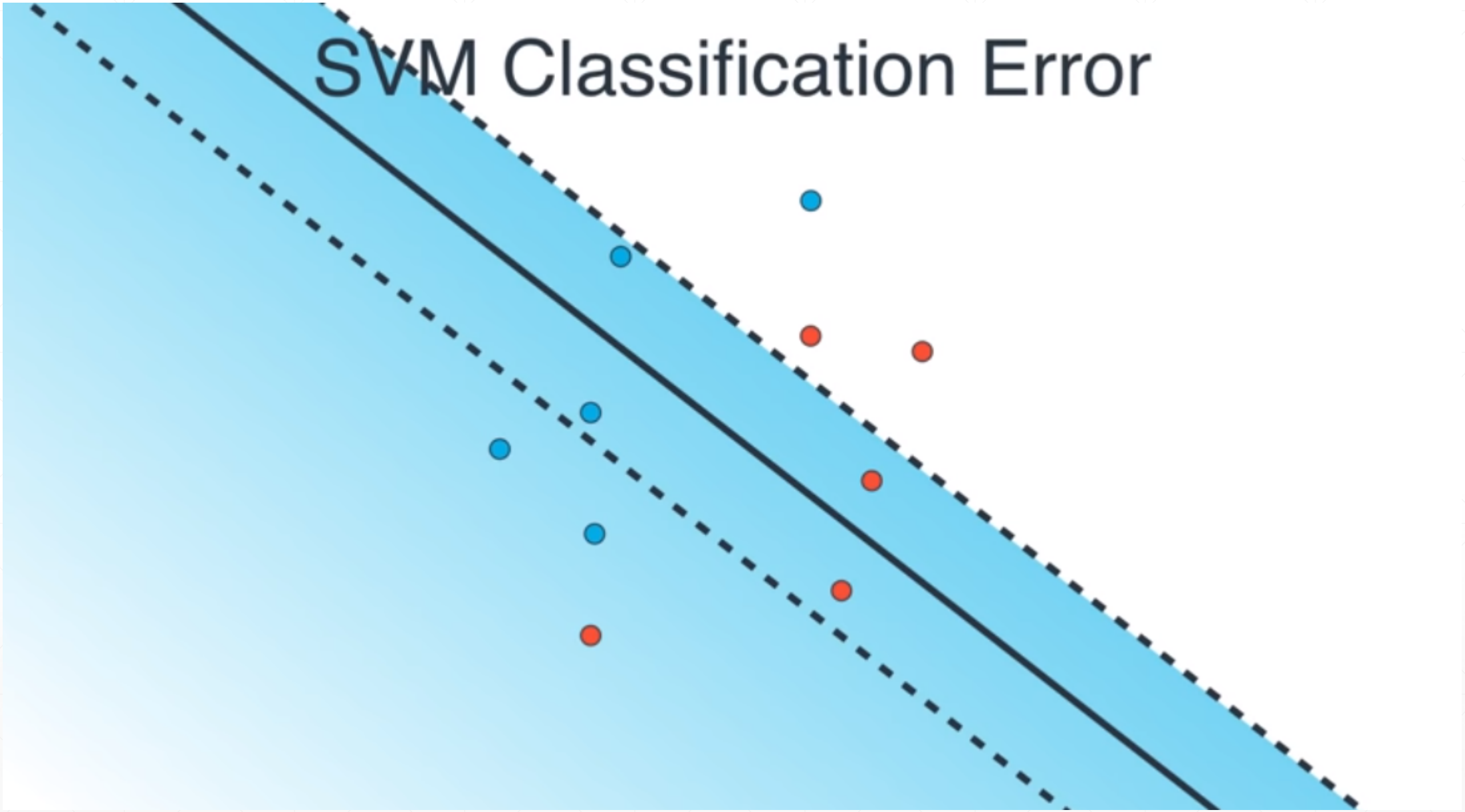


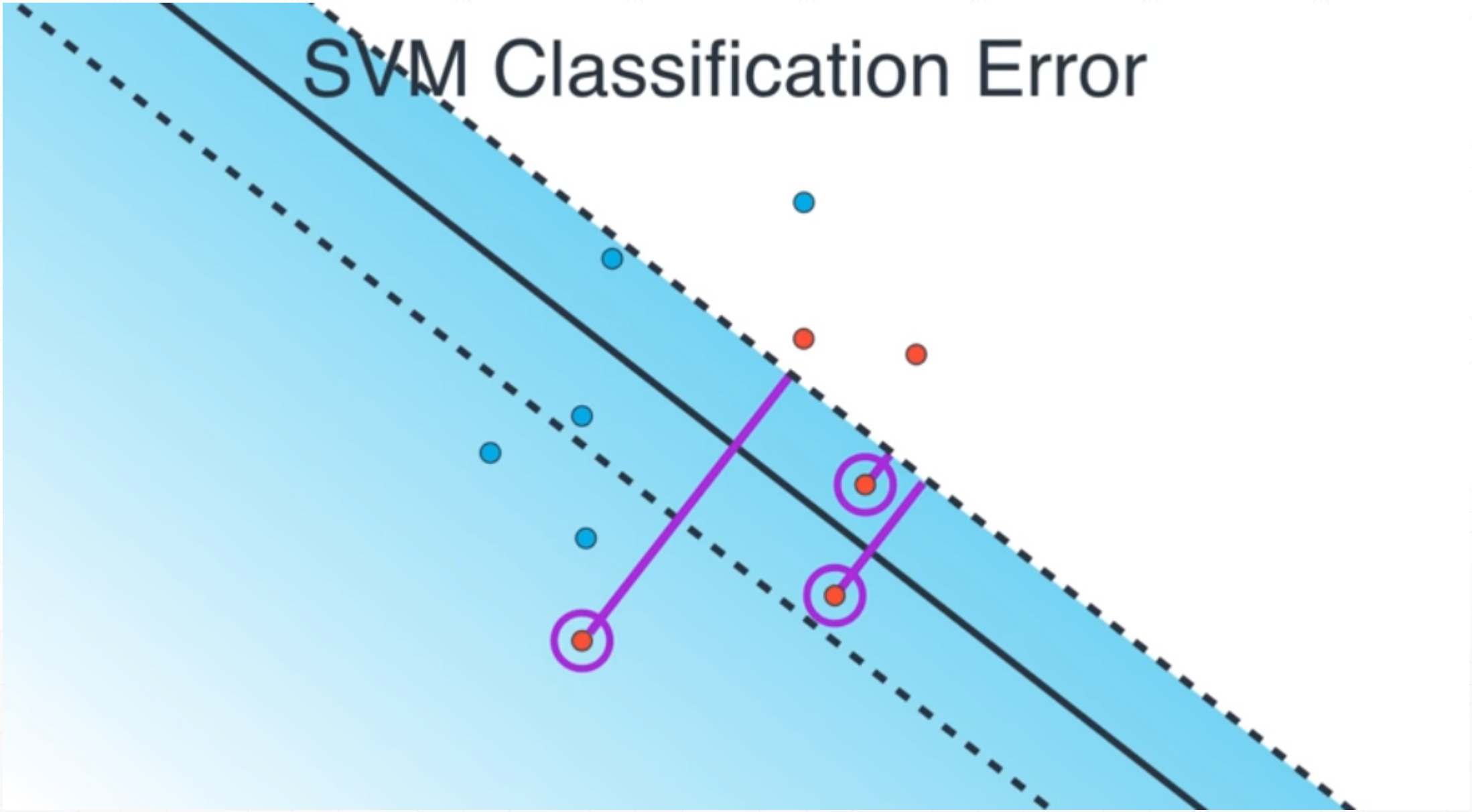

0
0
0
0
0
0

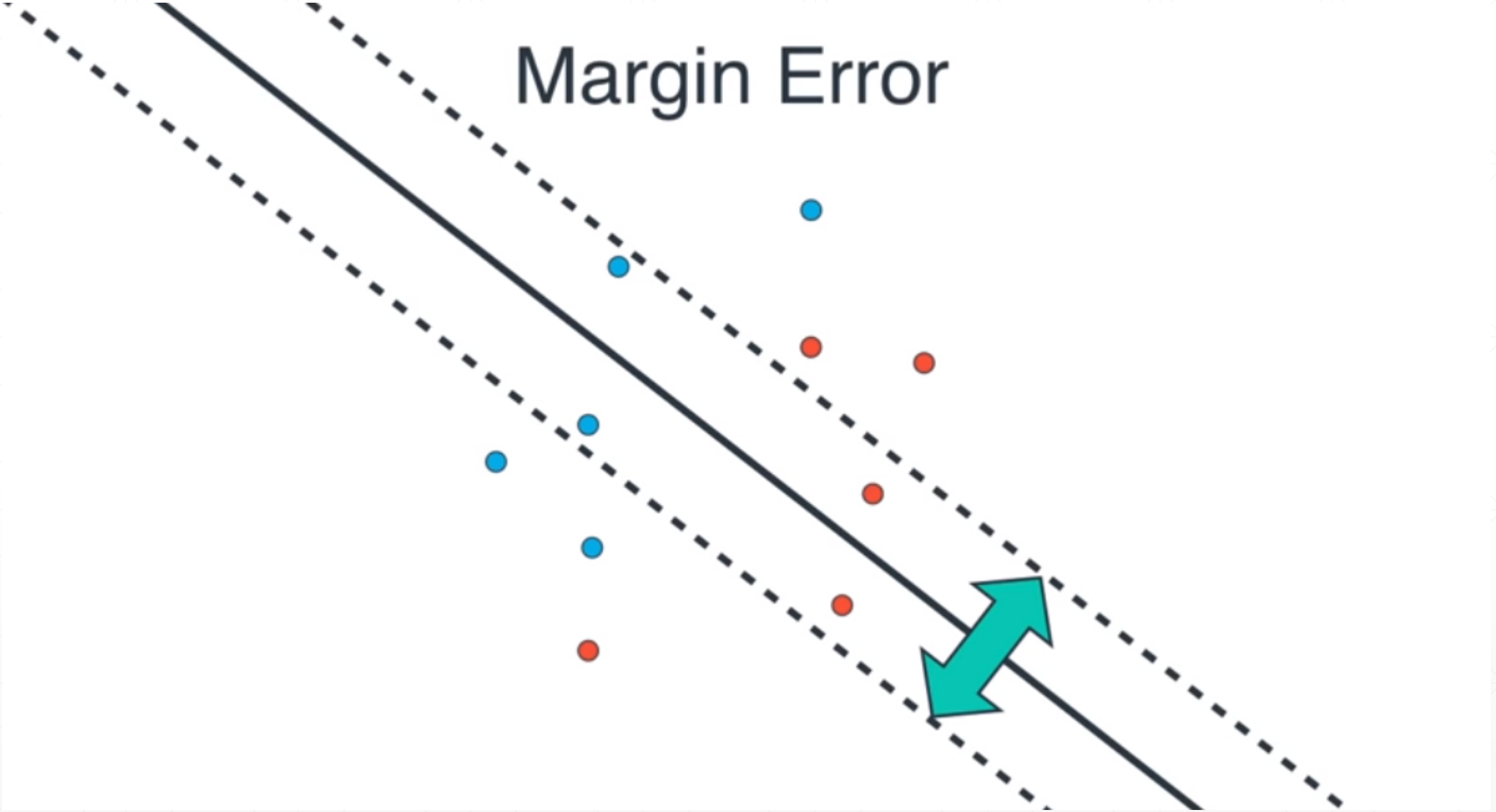

(4,5)
2(4) + 3(5) - 6 = 17
Error = 17
(1,1)
|2(1) + 3(1) - 6| = |-1|
Error = 1
2x + 3y - 6 = 0


SVM Classification Error

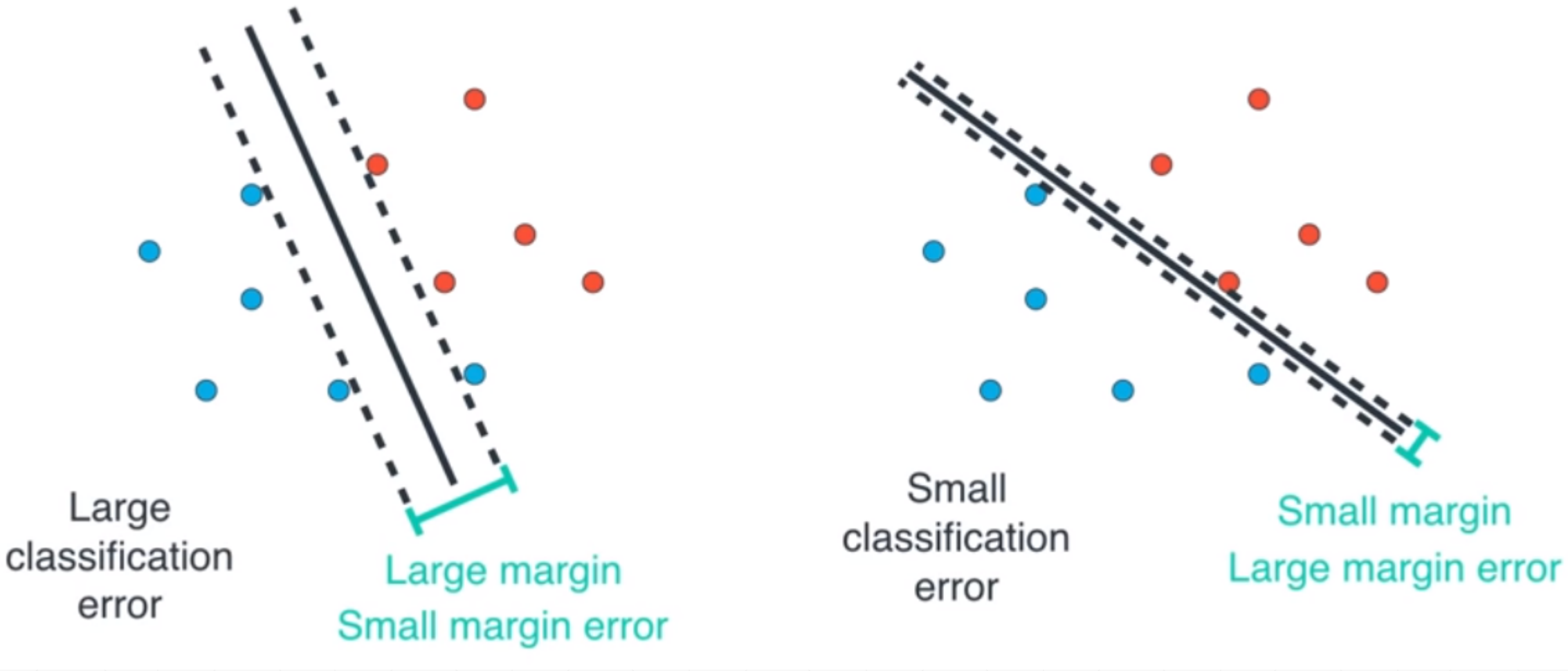

SVM Classification Error


SVM Classification Error

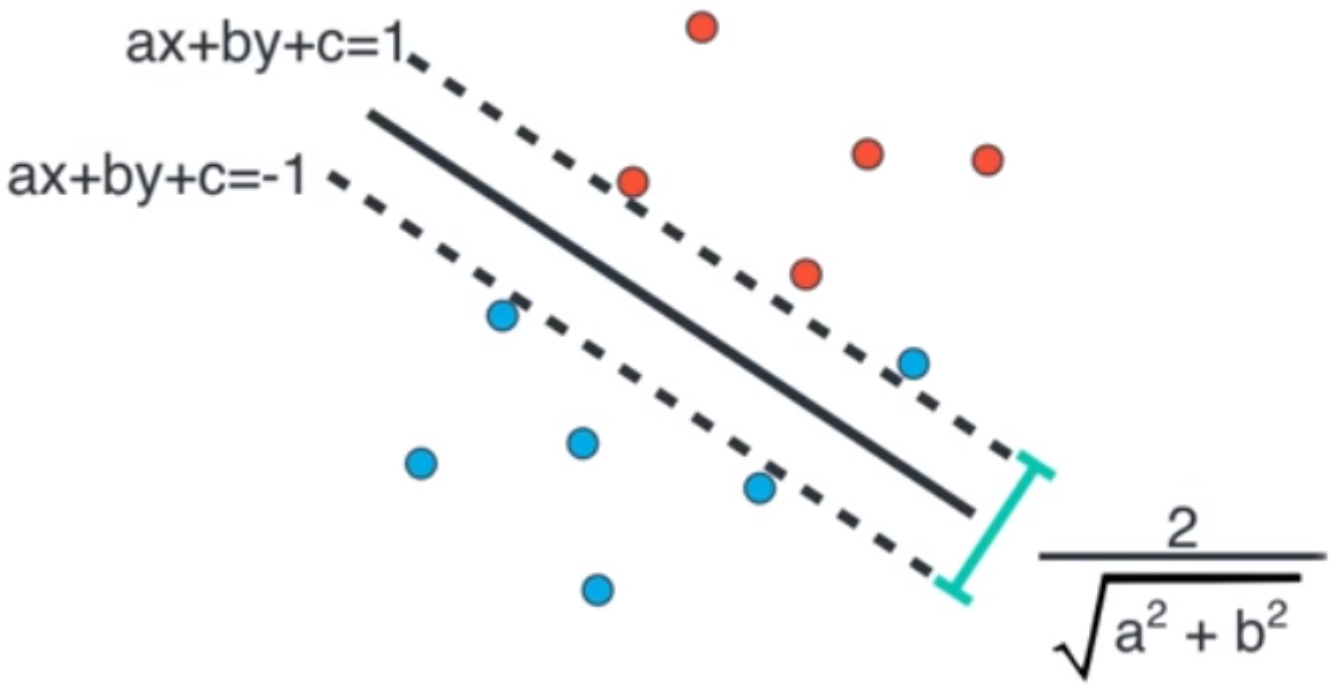

SVM Classification Error


Margin Error

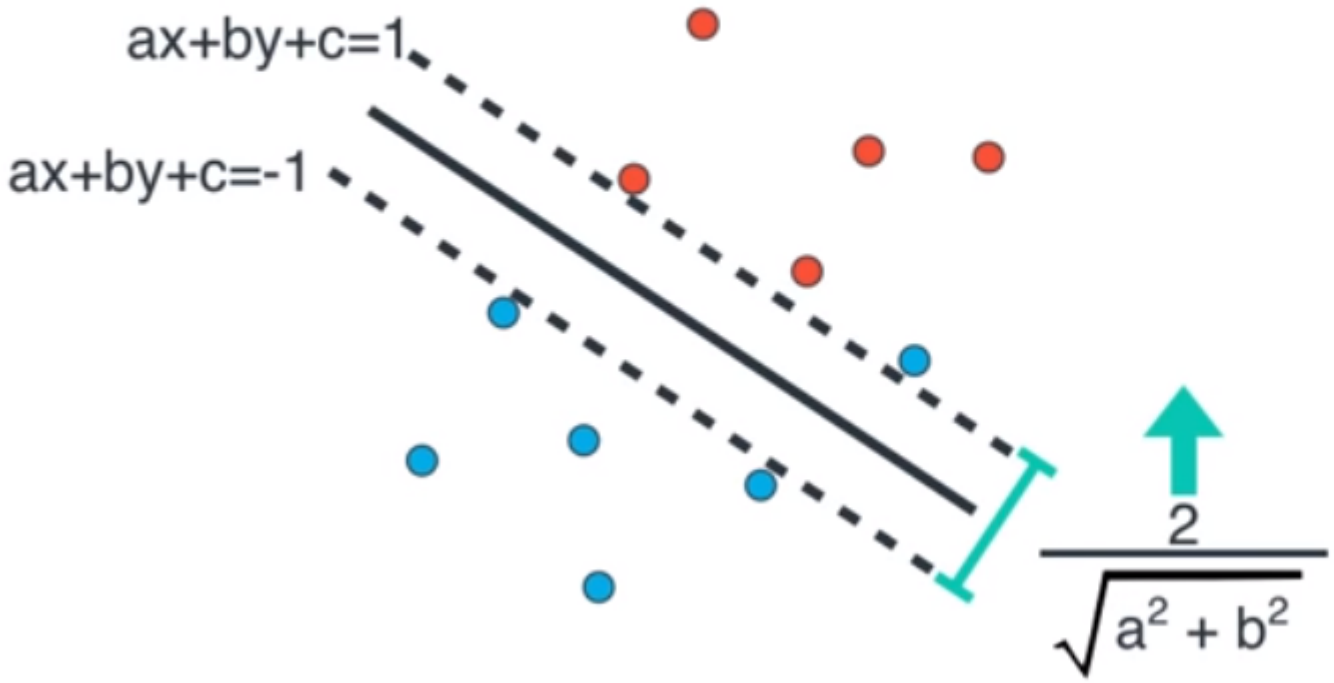
Margin Error



Margin Error



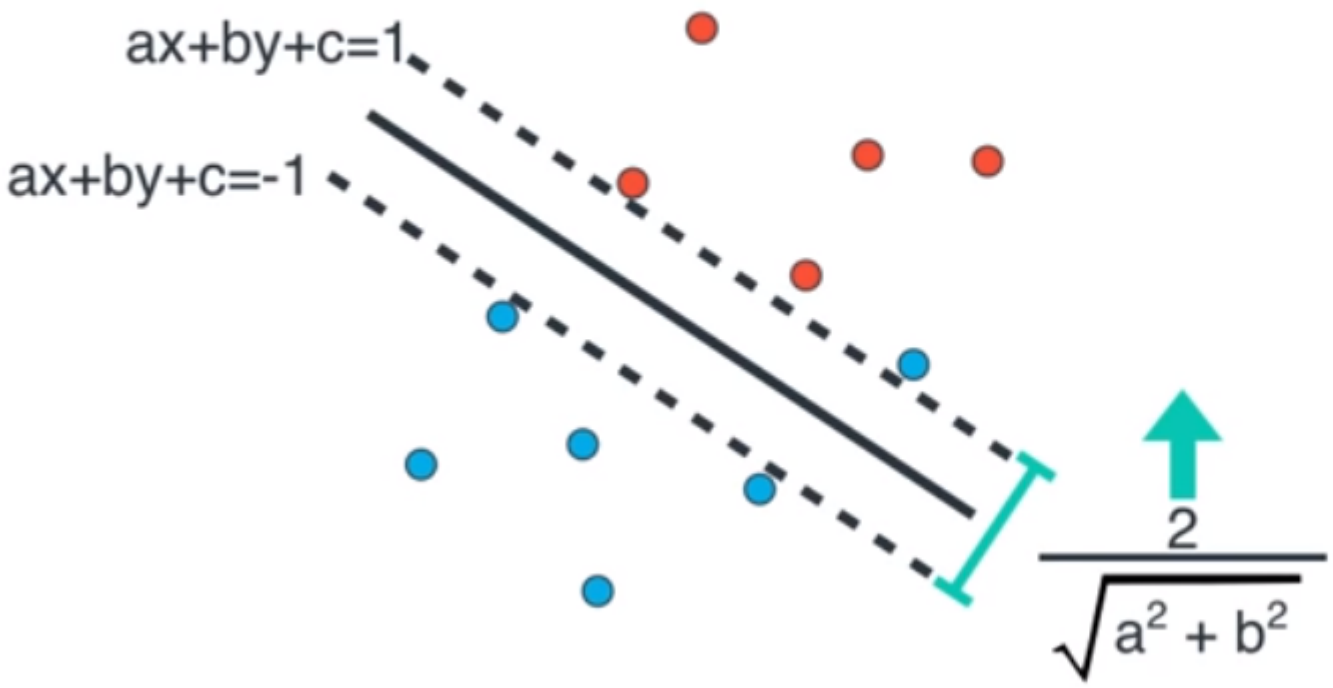
Margin Error



$$\frac{2}{\sqrt{a^2 + b^2}}$$

Margin error = $a^2 + b^2$

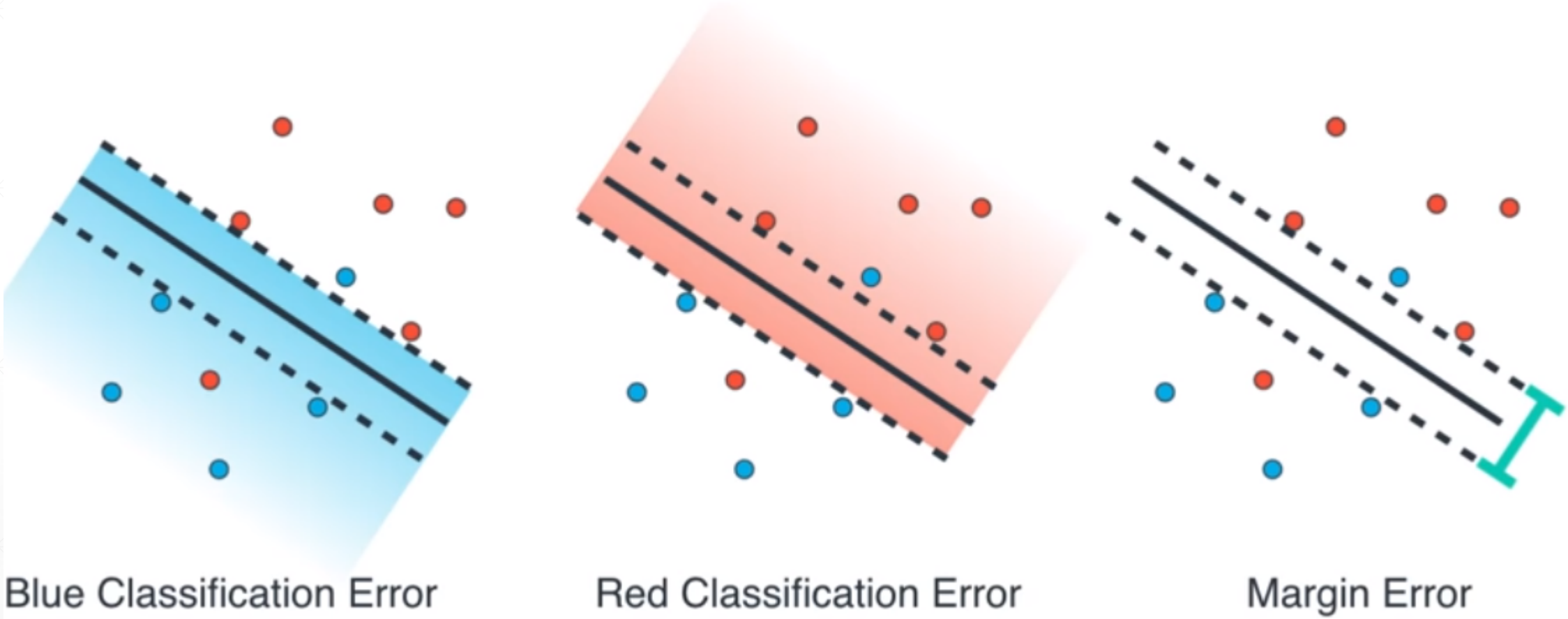
Margin Error



Regularization term!

Margin error = $a^2 + b^2$

SVM Error

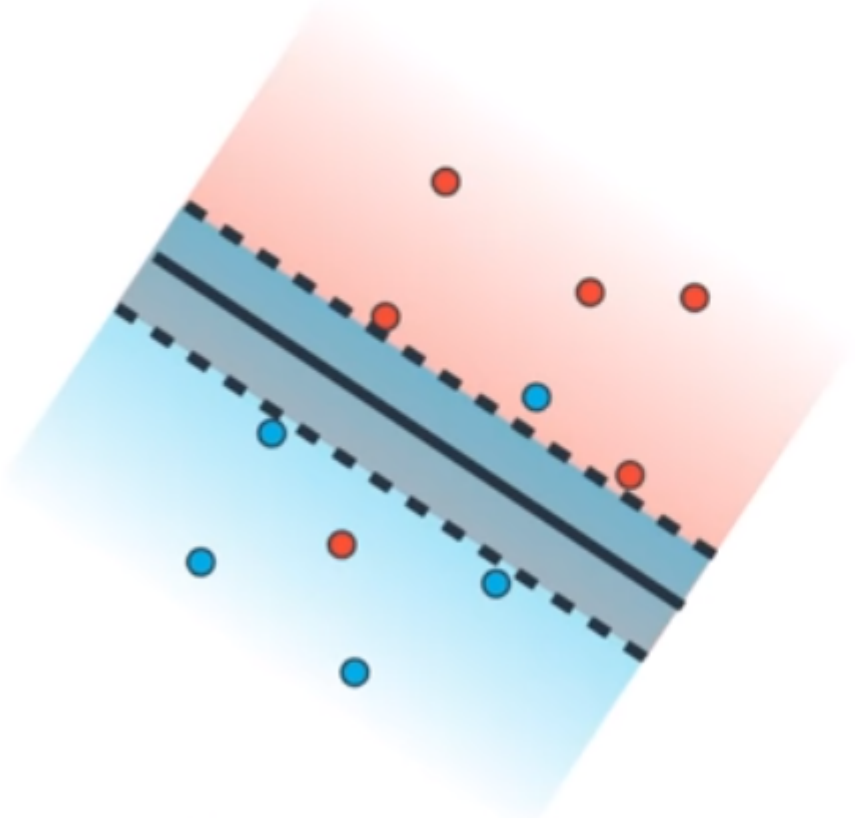


Blue Classification Error

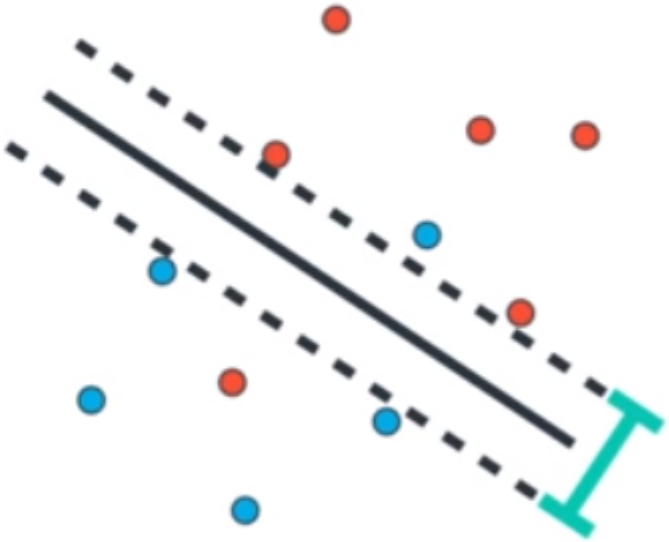
Red Classification Error

Margin Error

SVM Error

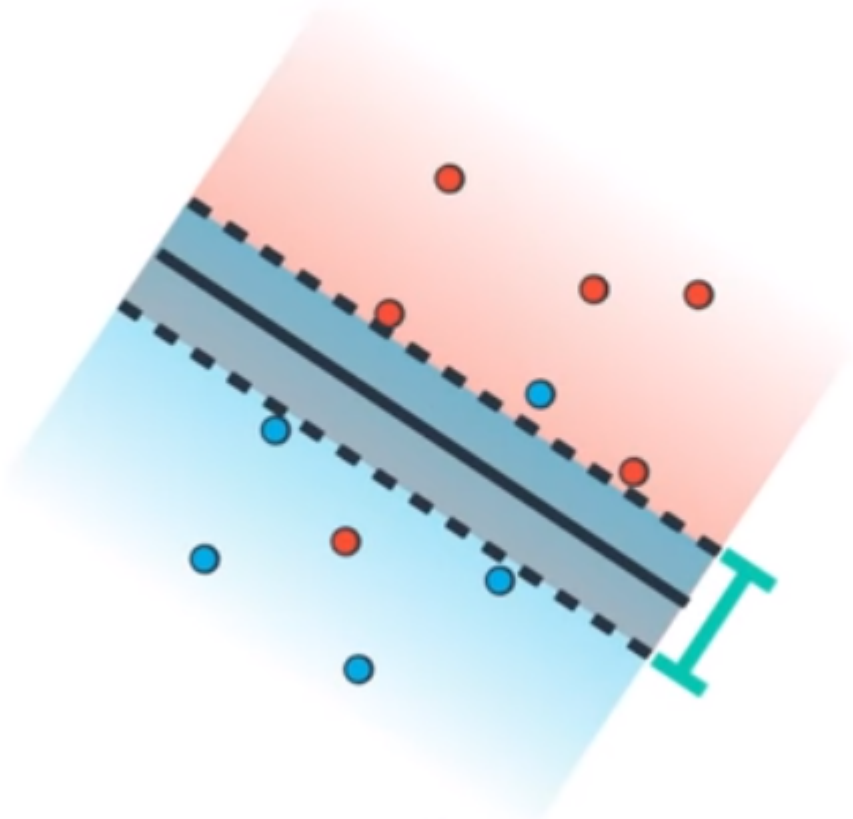


Classification Error



Margin Error

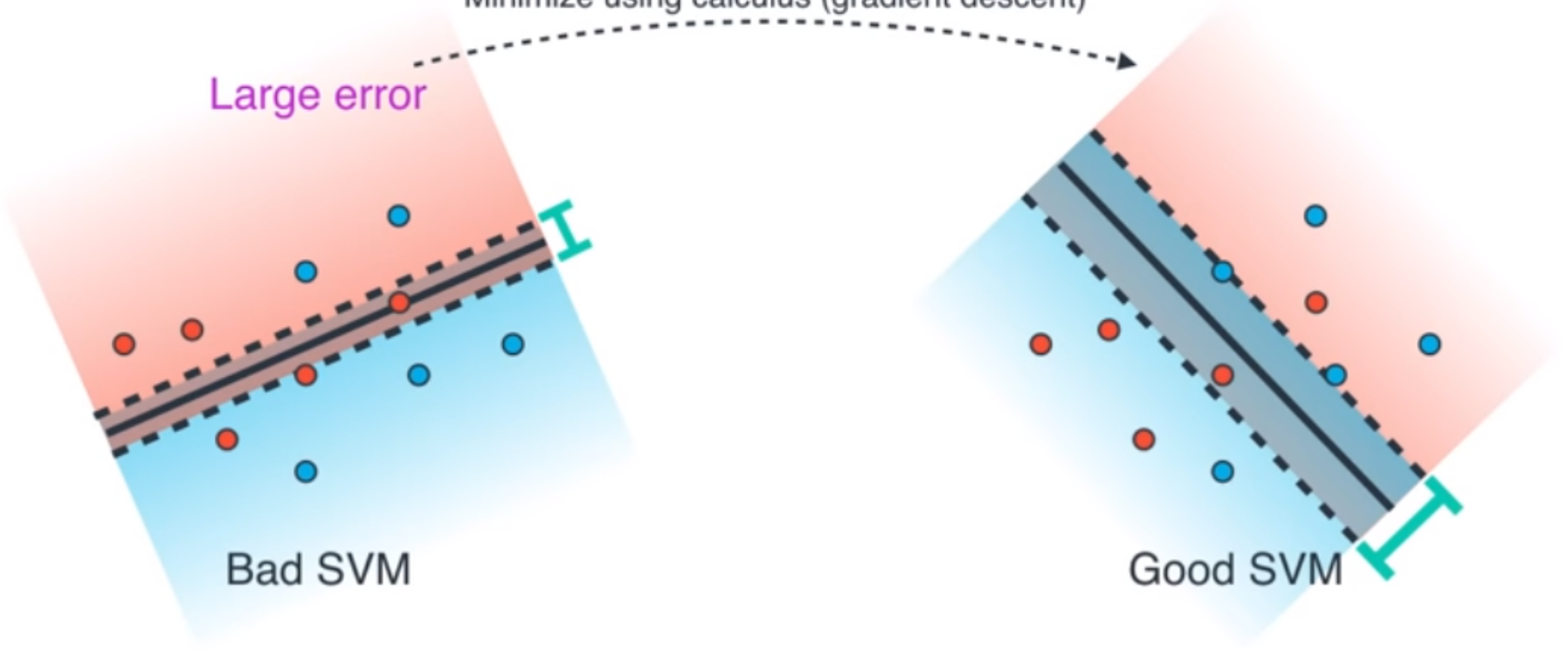
SVM Error



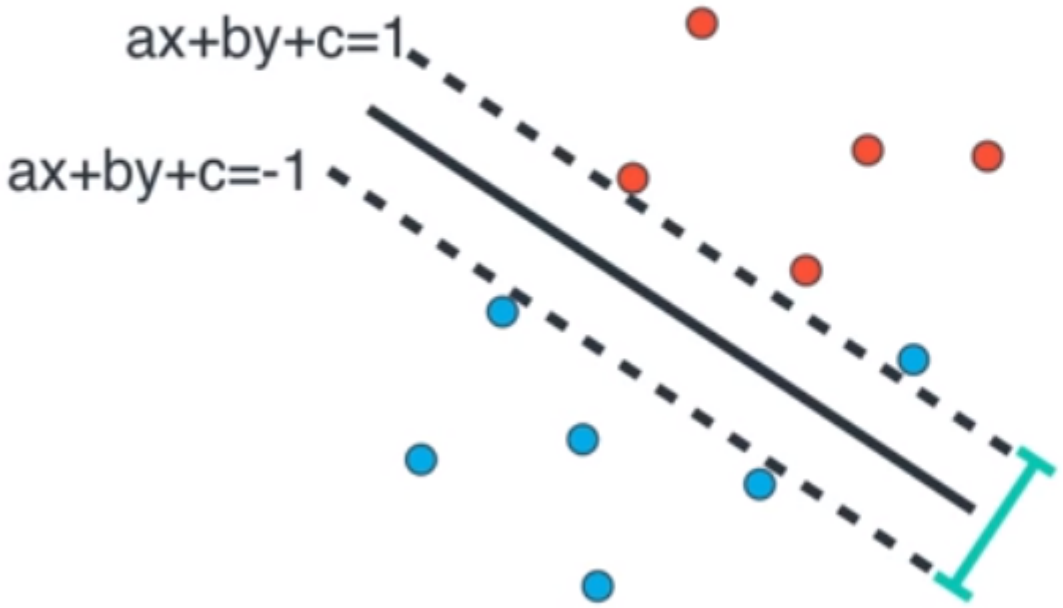
Gradient Descent

Same as the SVM trick!

Minimize using calculus (gradient descent)



Challenge - Gradient Descent



Margin error = $a^2 + b^2$

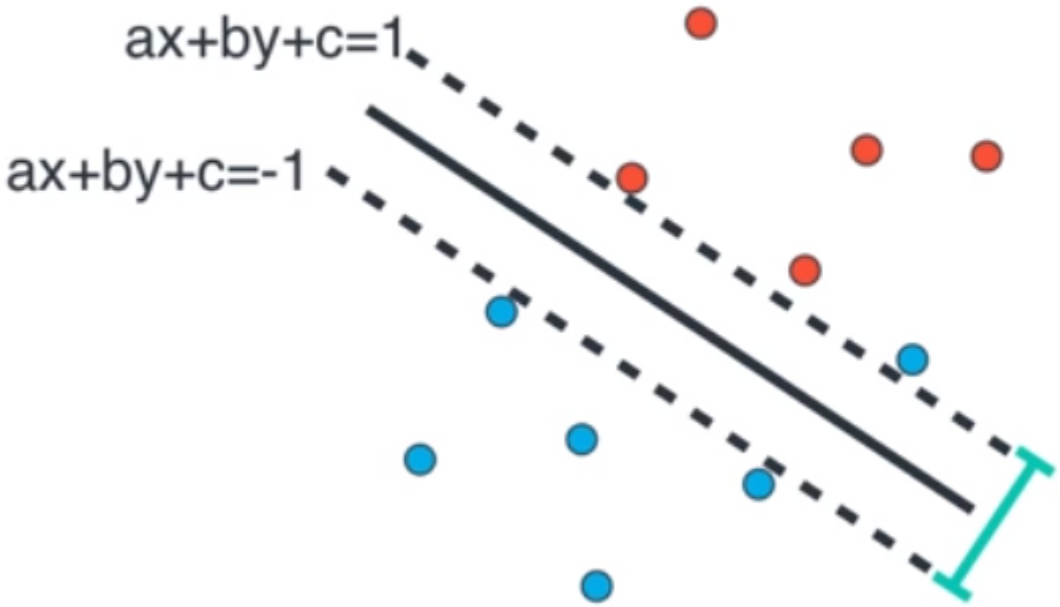
dError/da = 2a

dError/db = 2b

$a \longrightarrow a - \eta\, 2a = a(1 - 2\eta)$

$b \longrightarrow b - \eta\, 2b = b(1 - 2\eta)$

Challenge - Gradient Descent



Margin error = $a^2 + b^2$

expanding factor!

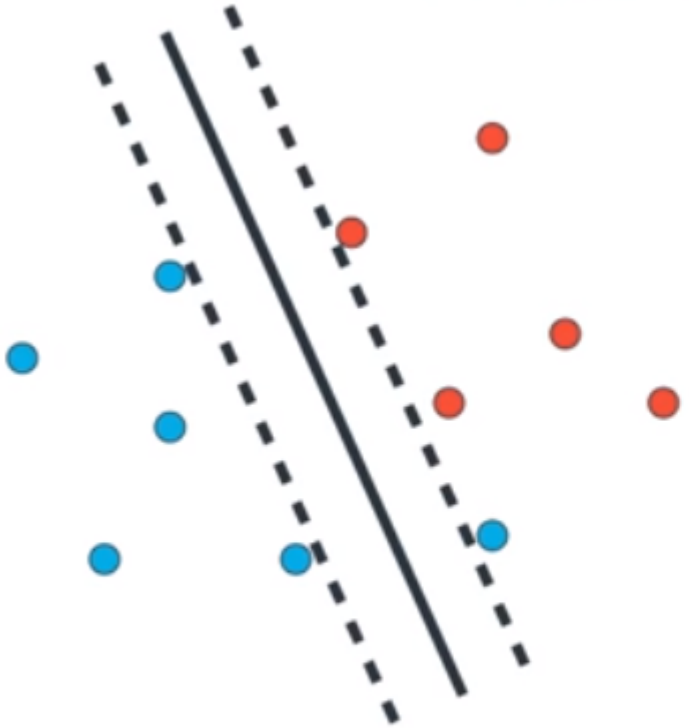
dError/da = 2a

dError/db = 2b

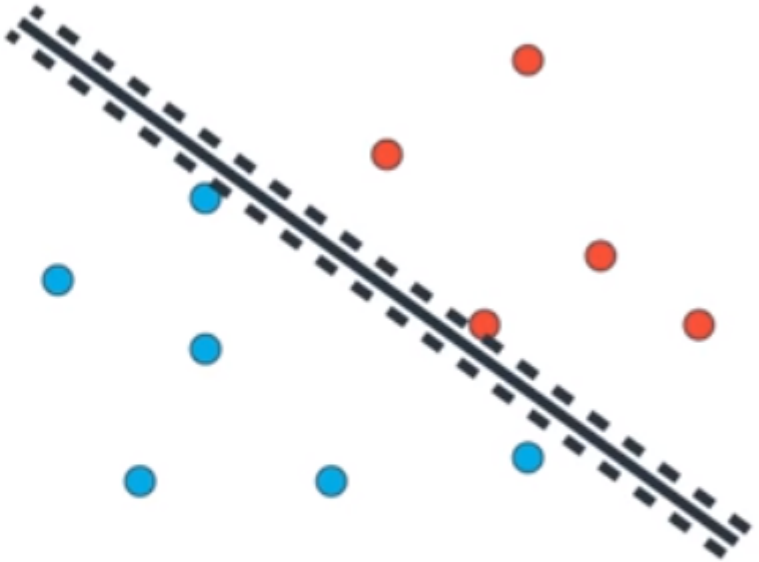
$a \longrightarrow a - \eta\, 2a = a(1 - 2\eta)$

$b \longrightarrow b - \eta\, 2b = b(1 - 2\eta)$

Which line is better?



Classification Error + Margin Error



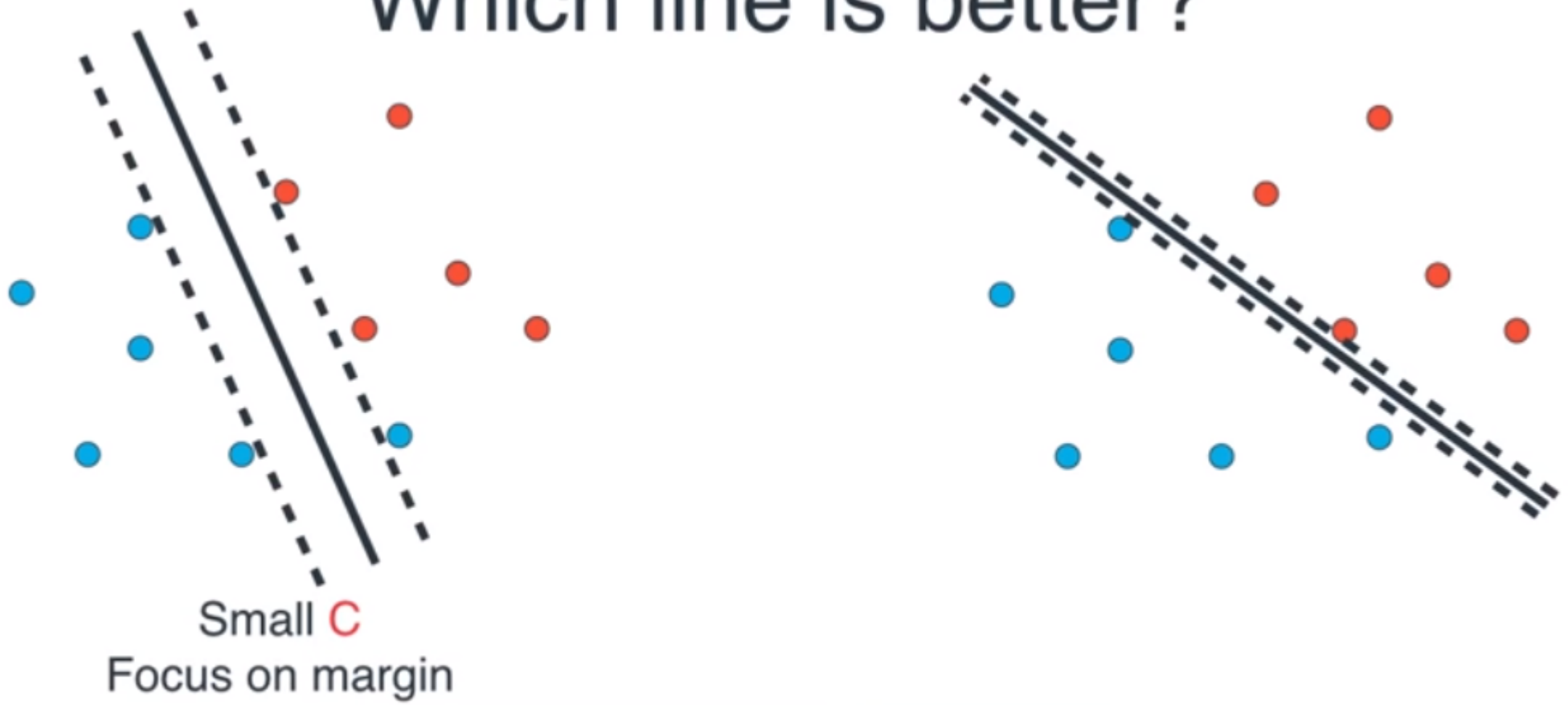
Classification Error + Margin Error

The C parameter

Which line is better?

C Classification Error + Margin Error

Which line is better?



Which line is better?

Small C
Focus on margin

Large C
Focus on classification

C Classification Error + ~~Margin Error~~

Discussion

Thank you!