Classification

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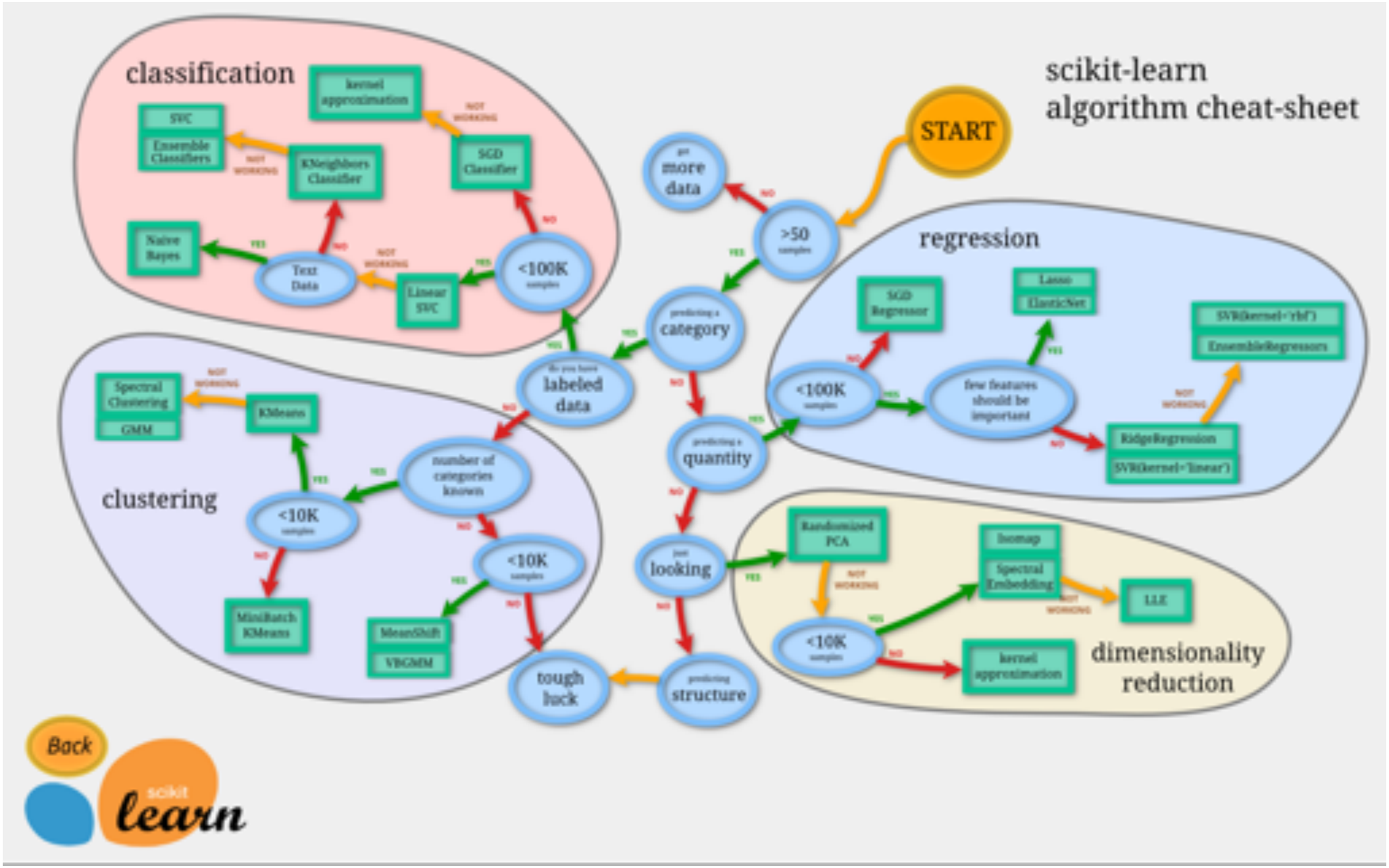
http://seismo.berkeley.edu/qingkaikong/



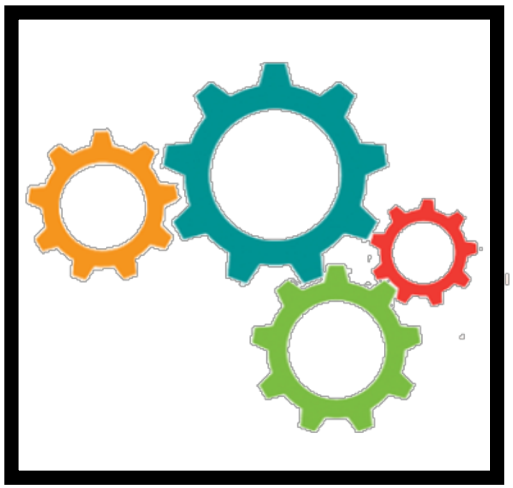
Interactive version: http://scikit-learn.org/stable/tutorial/machine_learning_map/index.html

Pipeline of training a machine learning model.

Data examples

01100
10110
11110

Tunable Model



Optimization algorithm

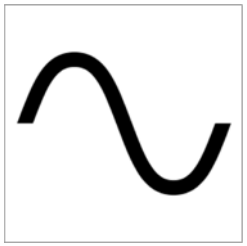
Trained Model

Representation of data

Raw data

Documents

Images



Numbers

Sounds

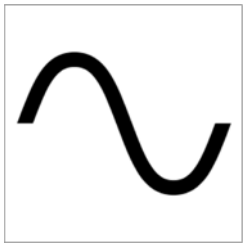
●●●

Representation of data

Raw data

Documents

Images



Numbers

Sounds

●●●

Feature matrix (X)

n_features ⟶

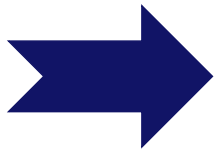
n_samples ↓

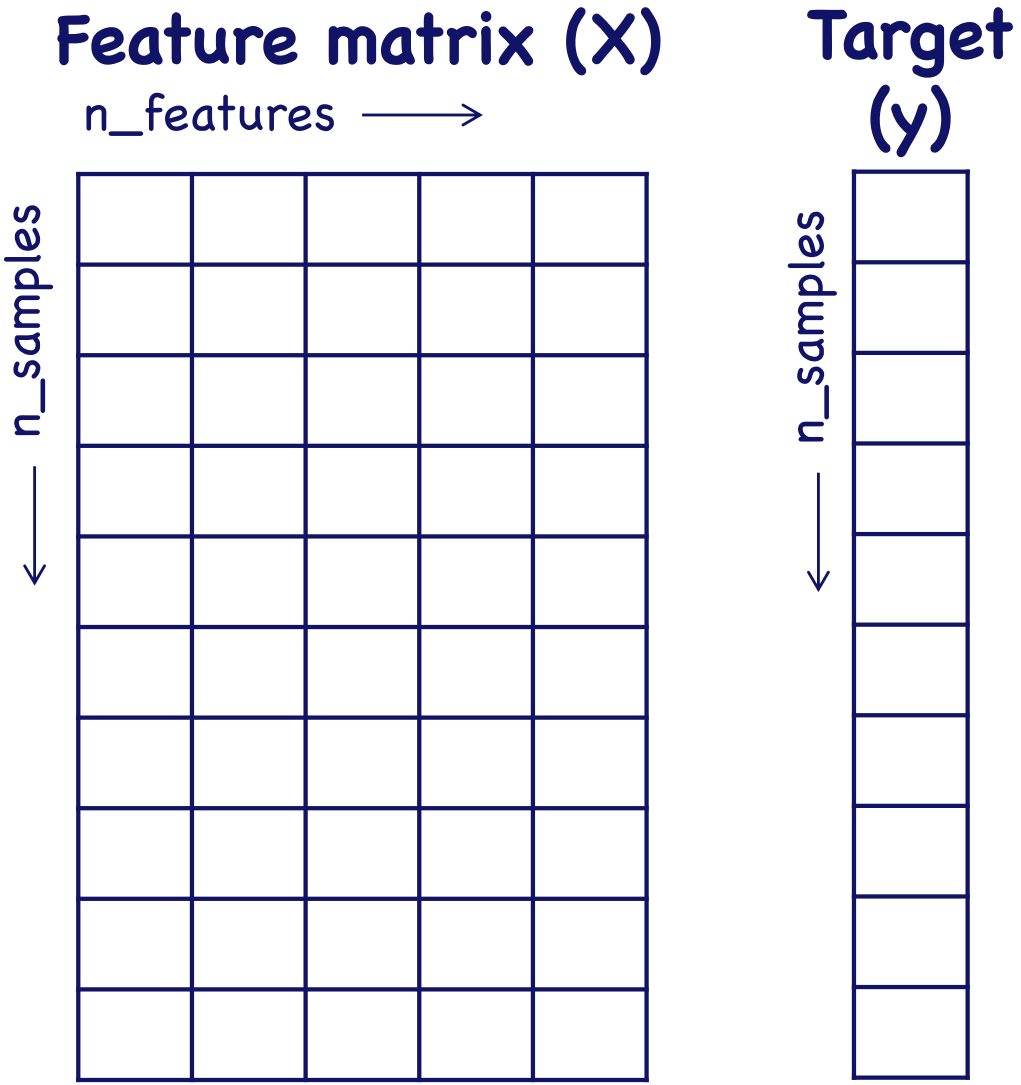
Target (y)

n_samples ↓

Example

Example





Example

Feature matrix (X)

n_features →

n_samples ↓

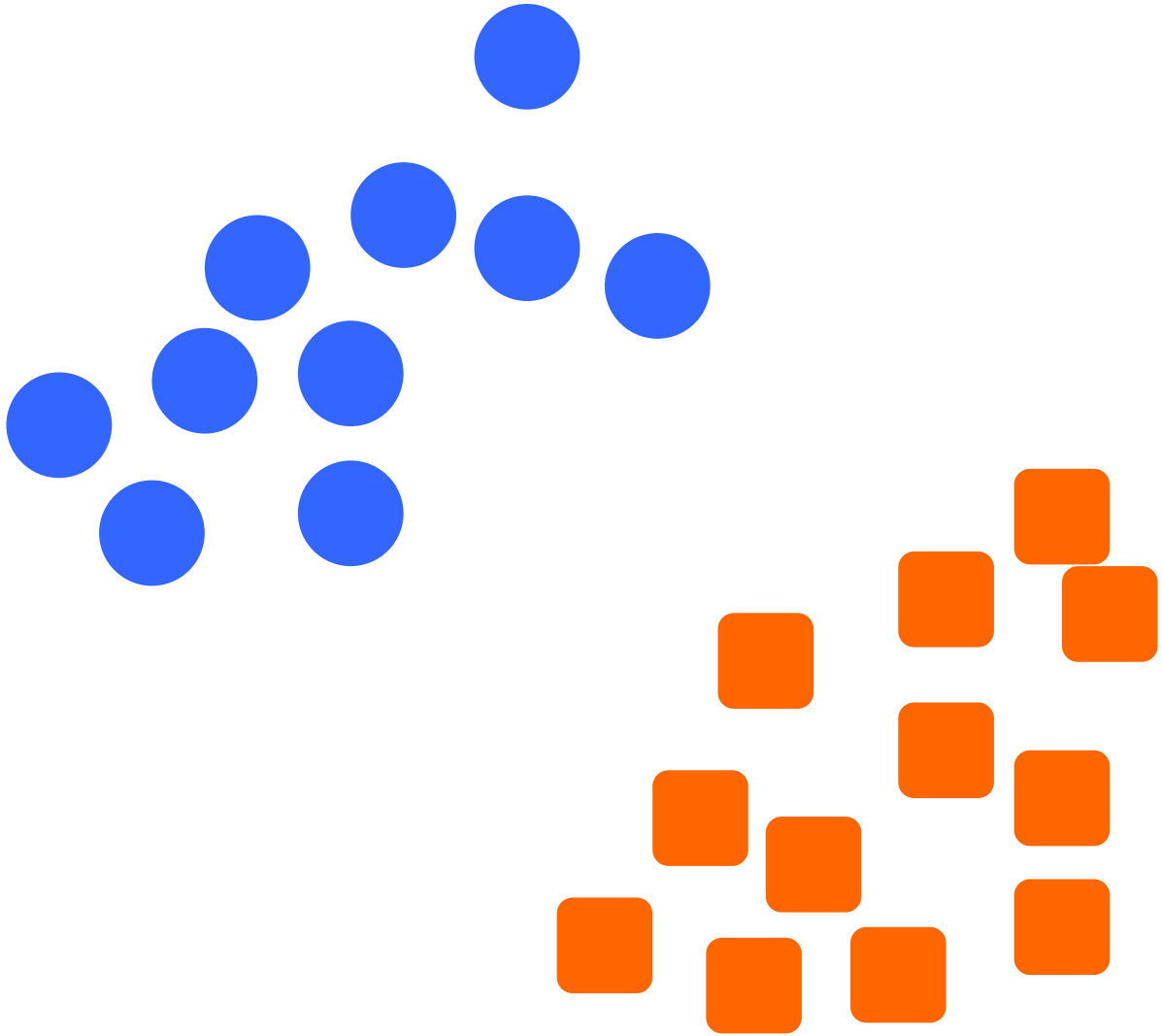
Color	Texture	Shape	Smell	Has core?

Target (y)

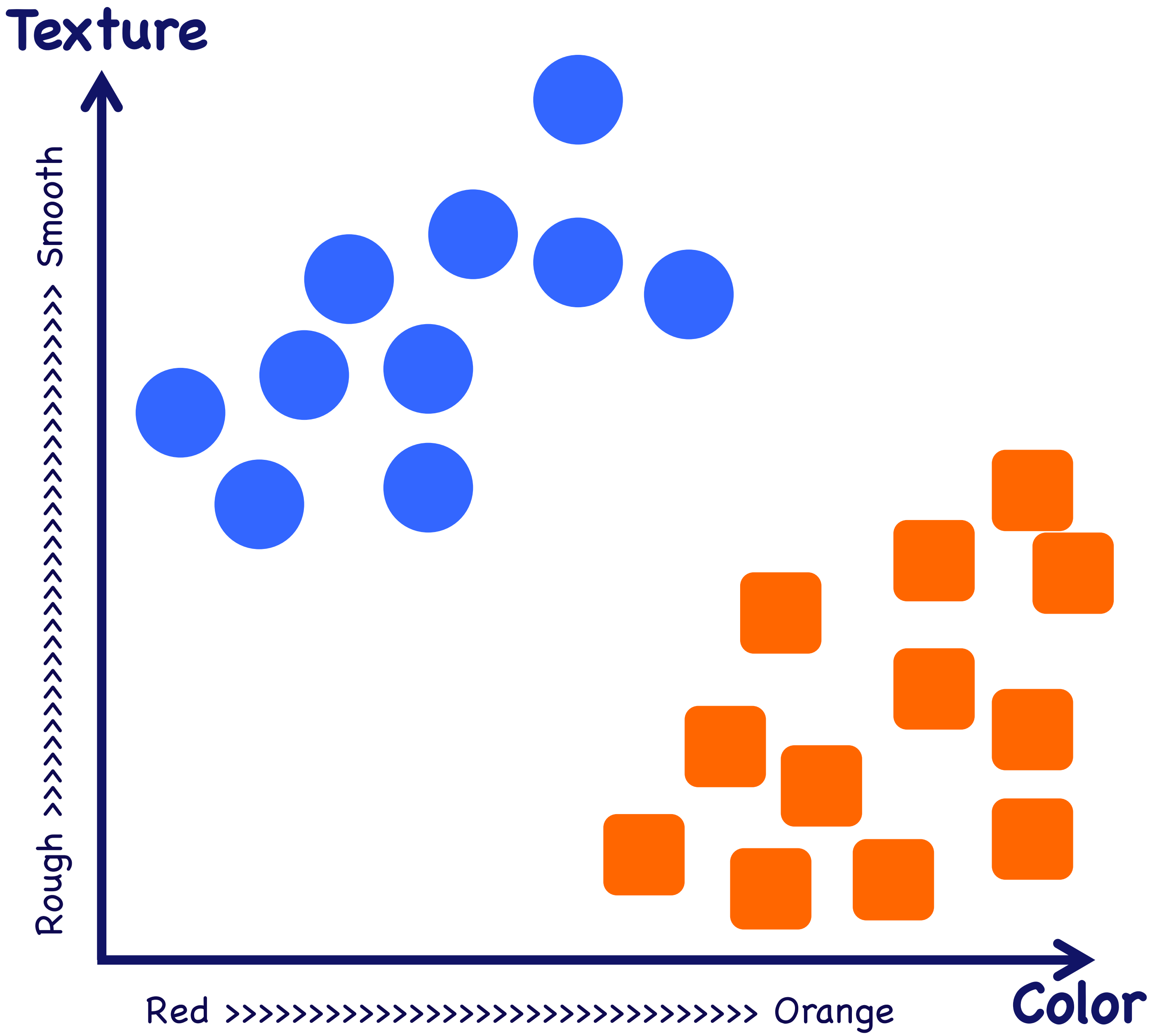
n_samples ↓

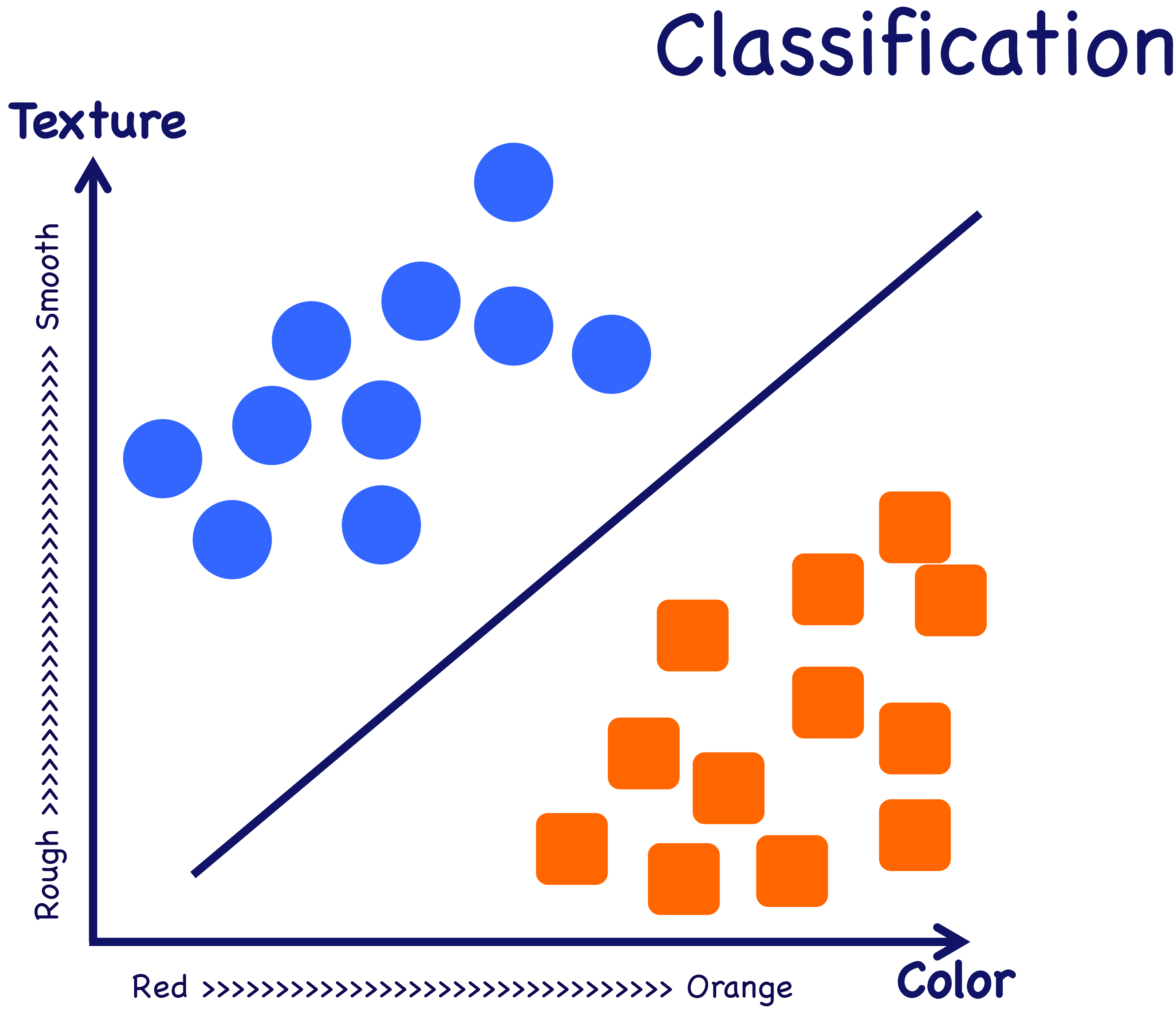
0
1
1
0
1
1
1
0
0
1

Classification



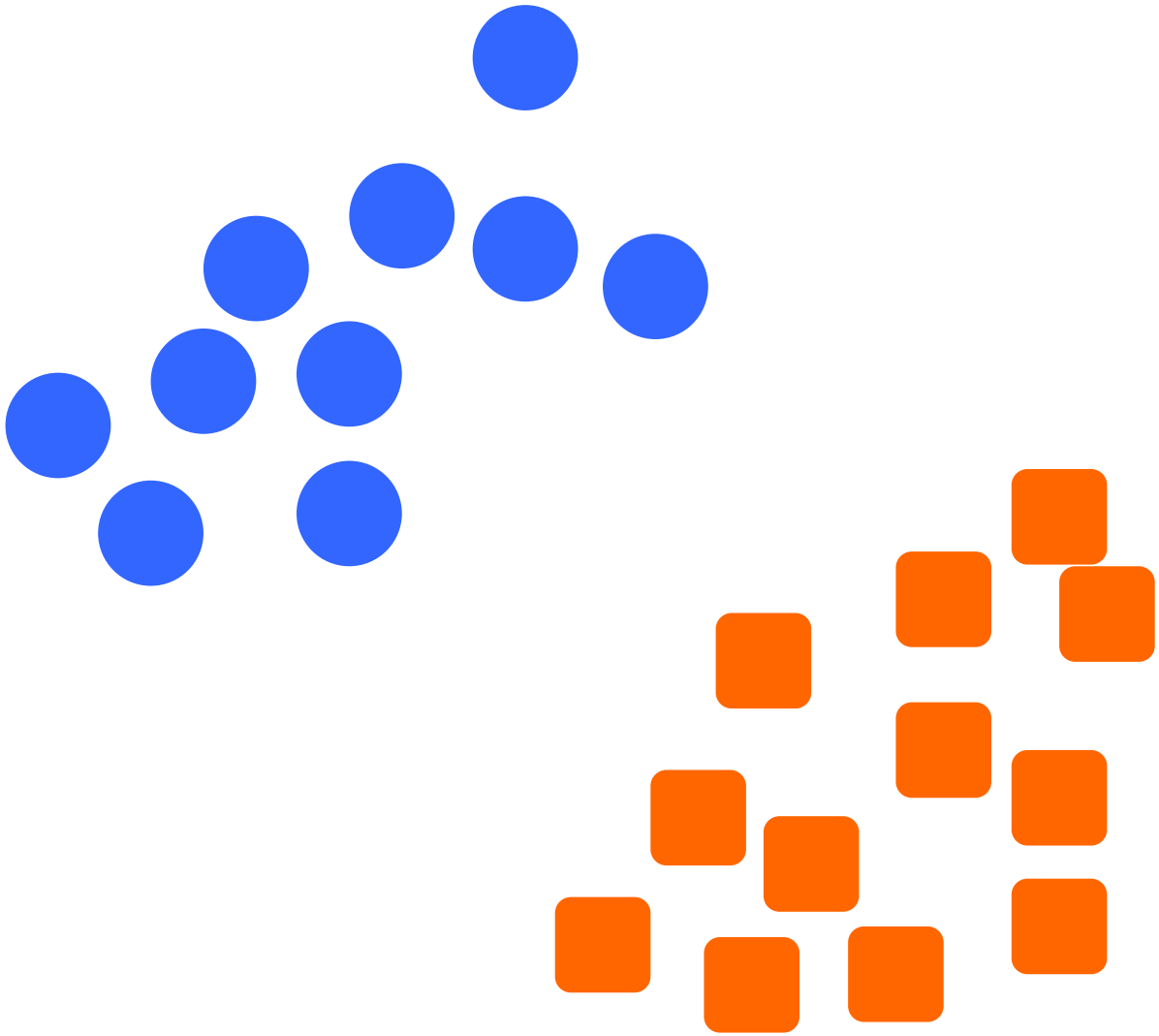
Classification

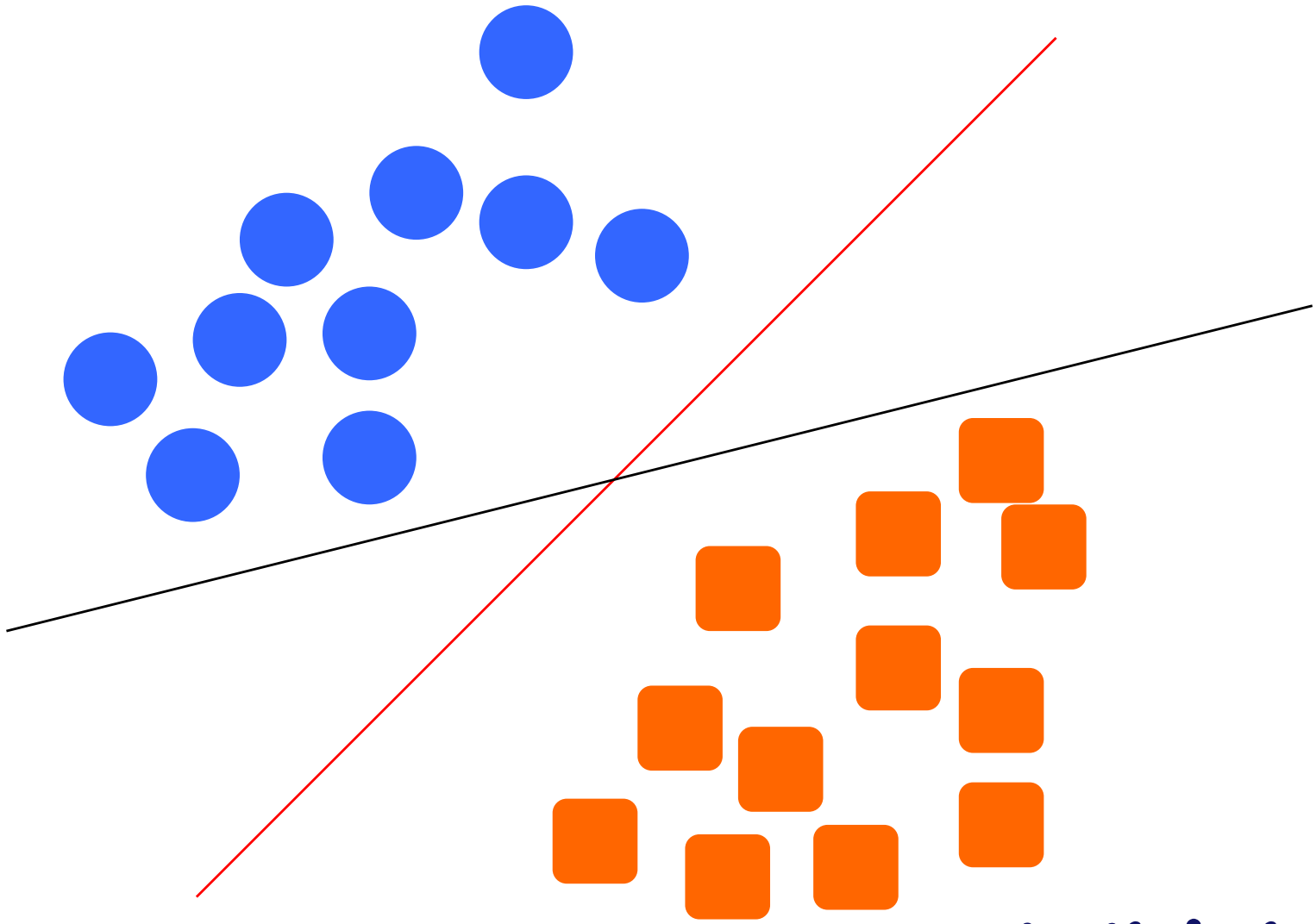



Classification
Texture
Rough >>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>> Smooth
Red >>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>> Orange
Color

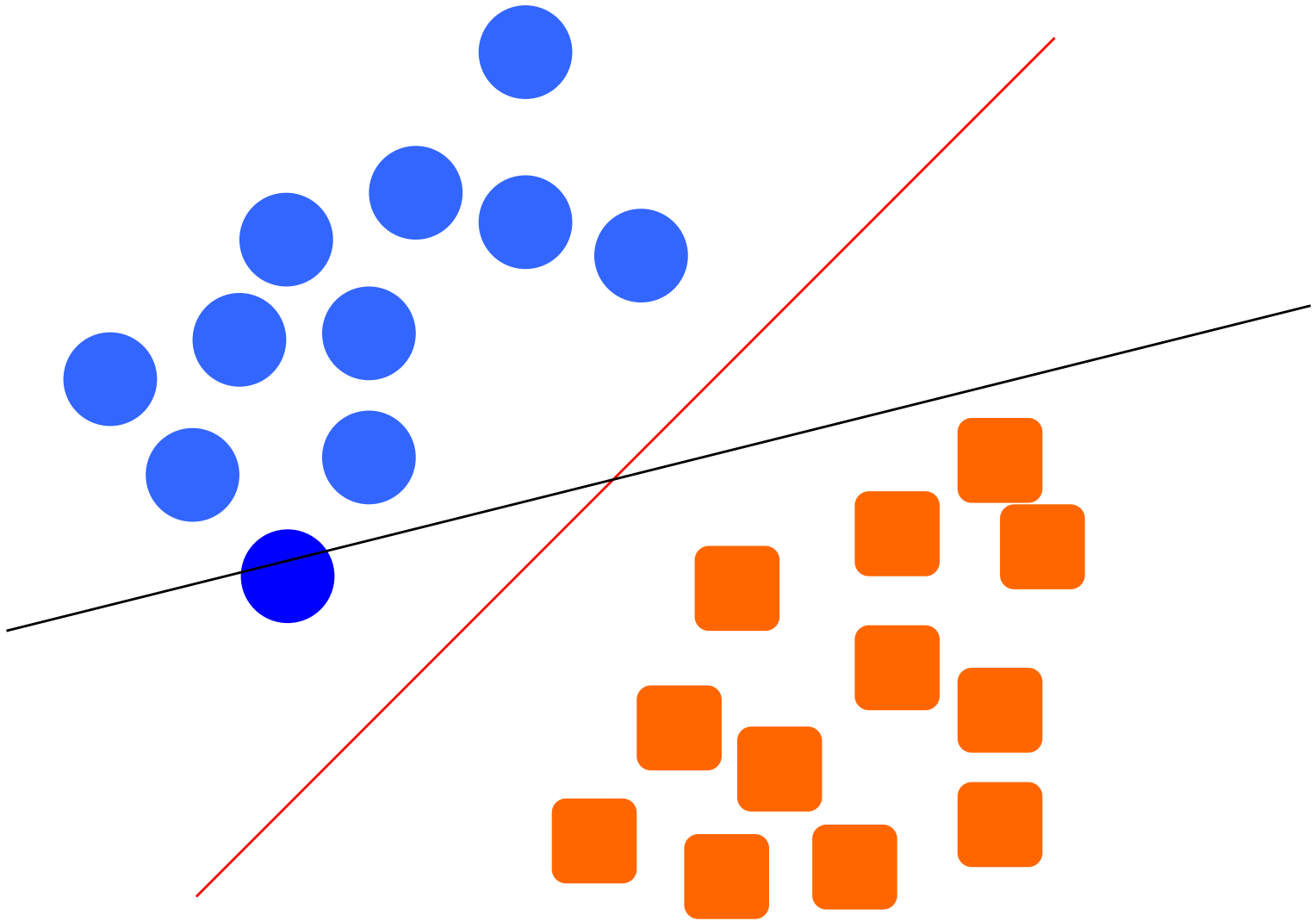
Classification

Support Vector Machine
Artificial Neural Network

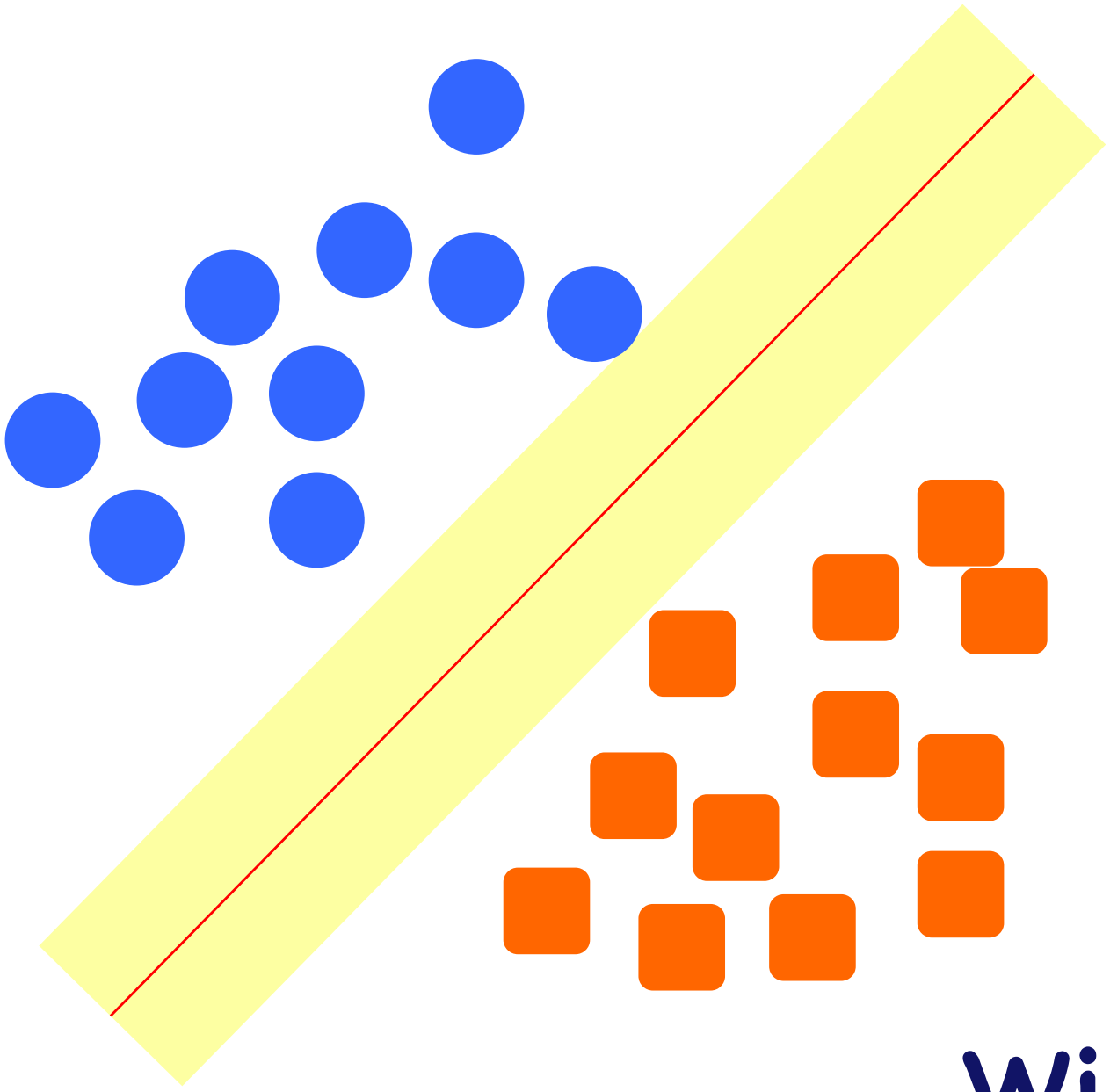




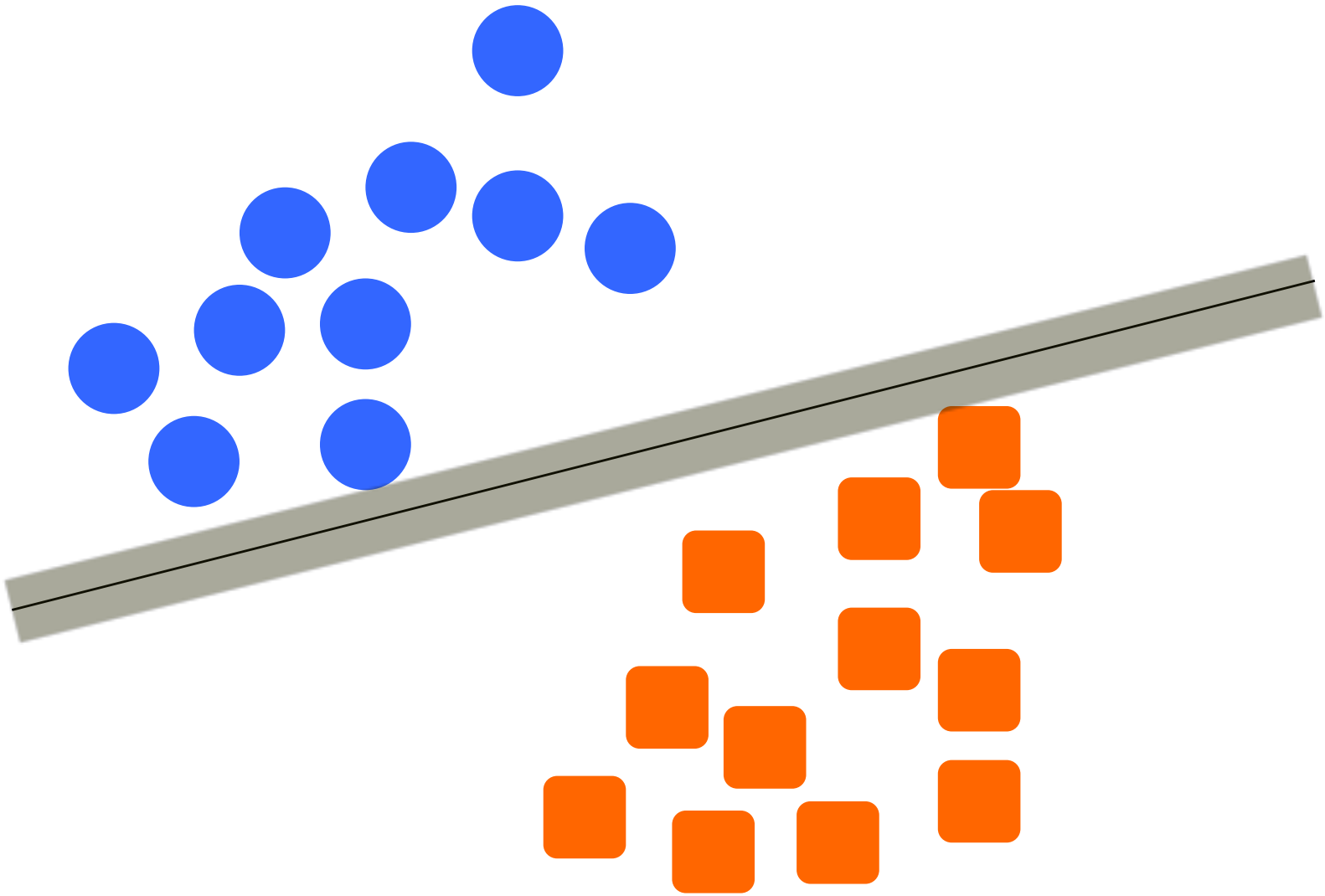
Which one is better?



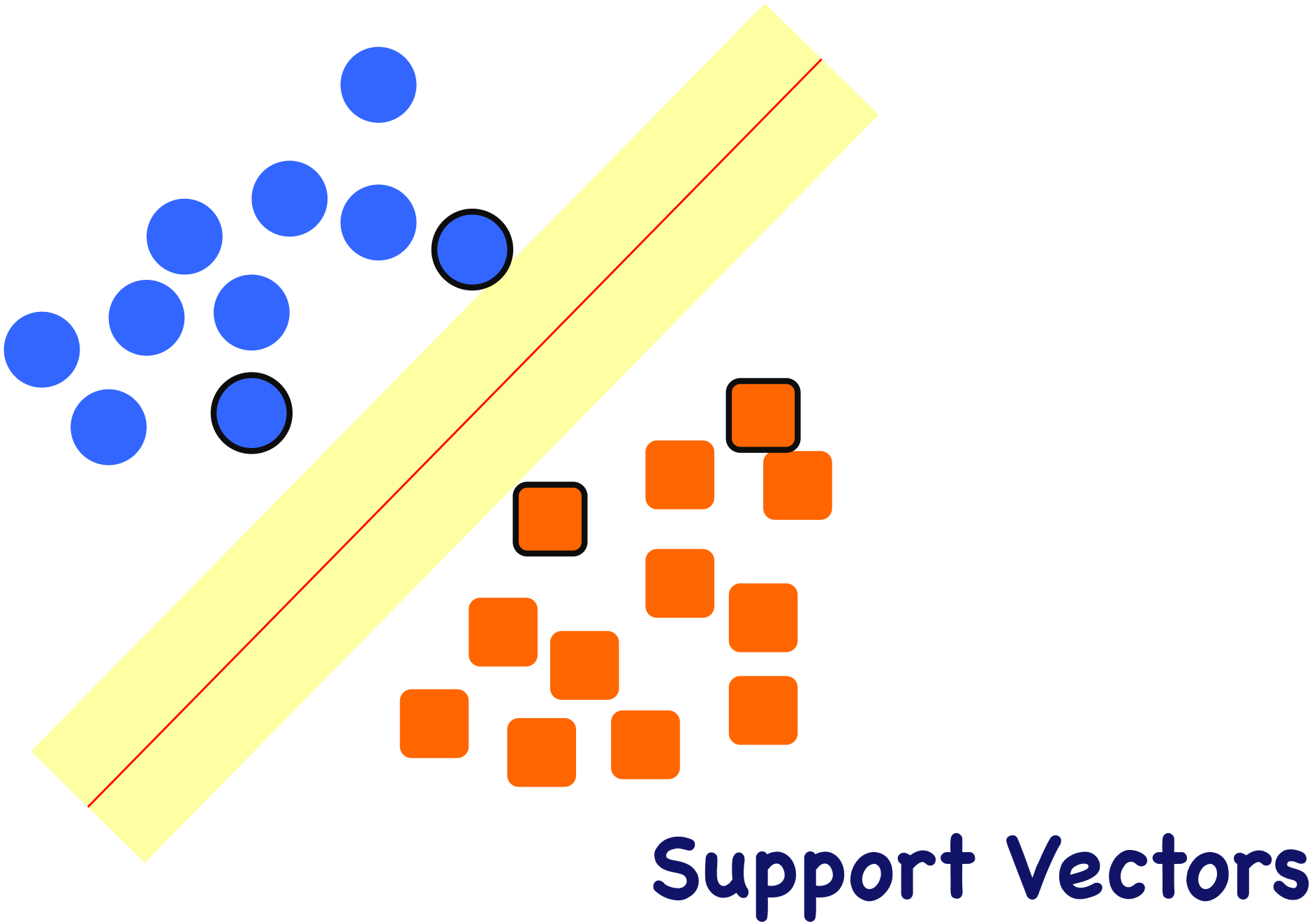
A new data point



Wide margin



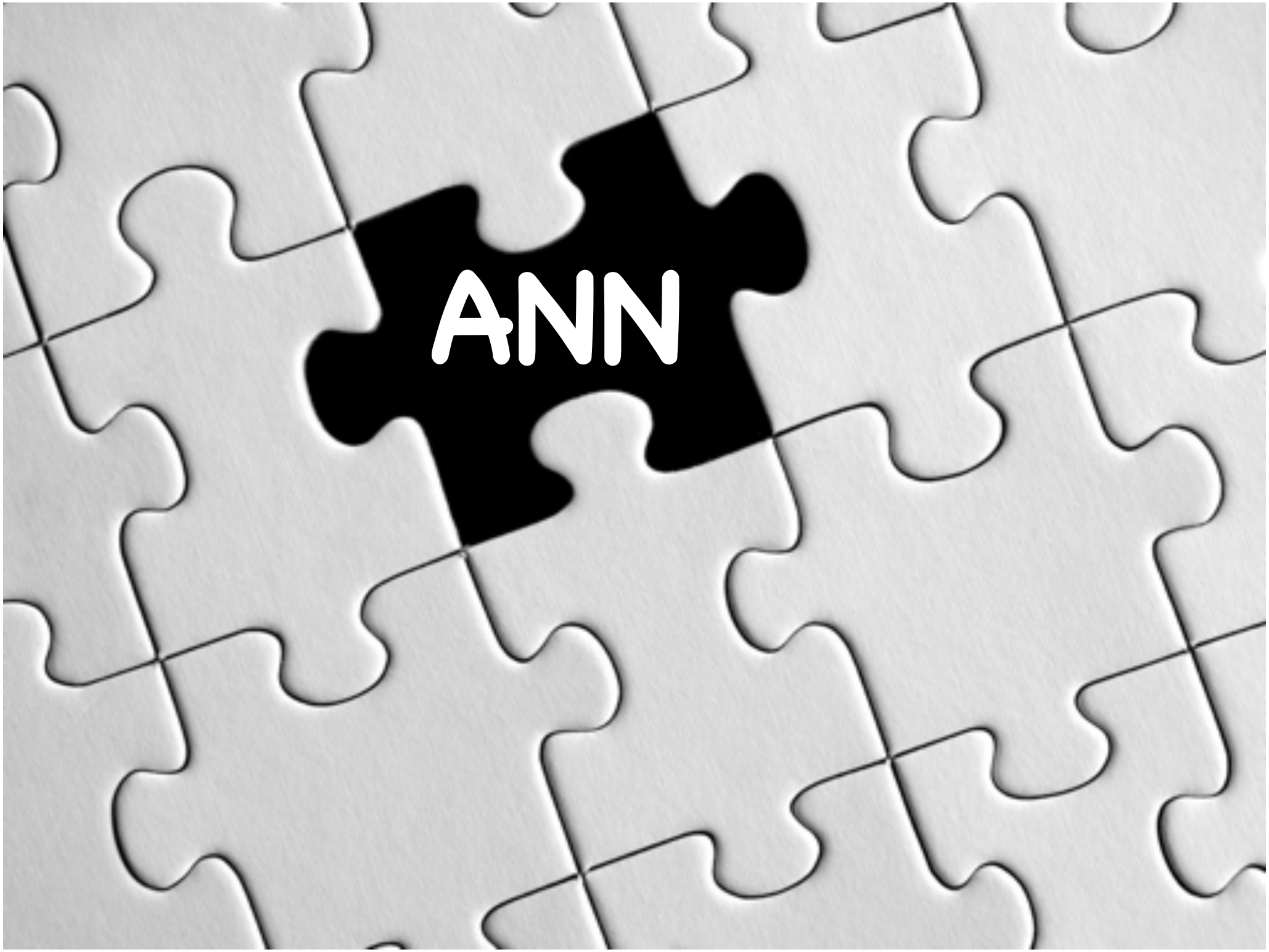
Narrow margin

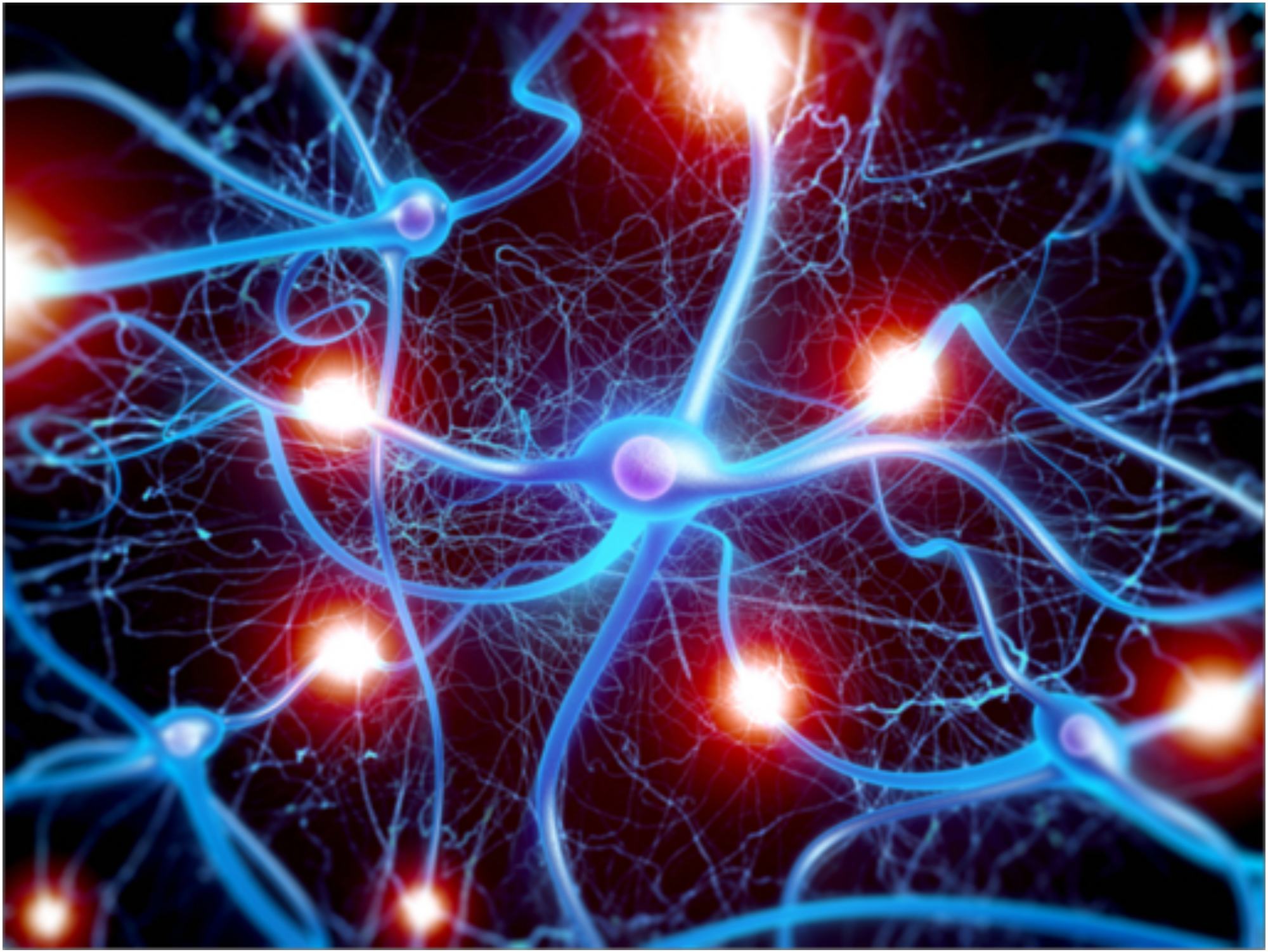

Support Vectors

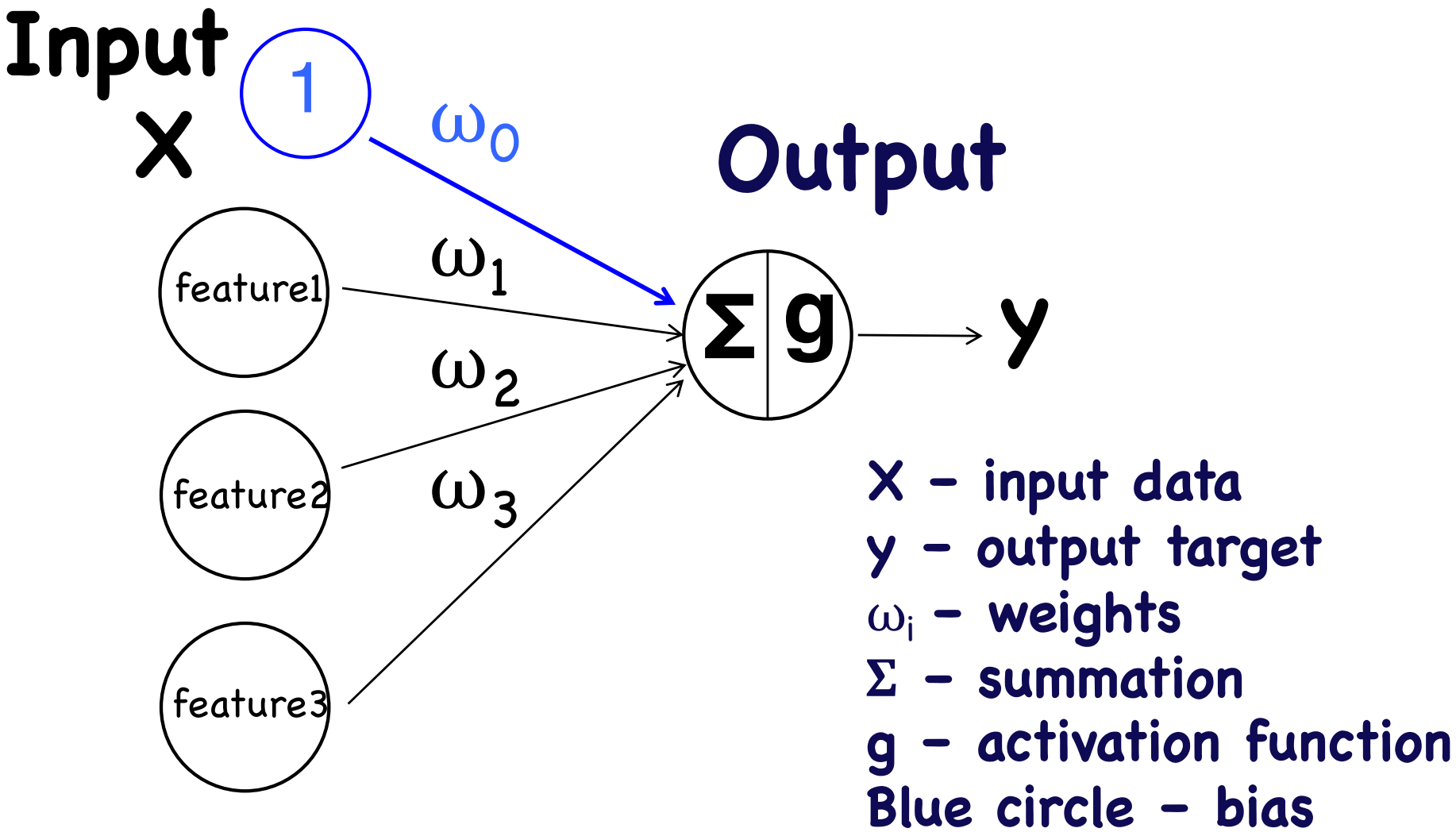
It is maximize the margin!

Support Vectors

More details: https://www.youtube.com/watch?v=eHsErlPJWUU

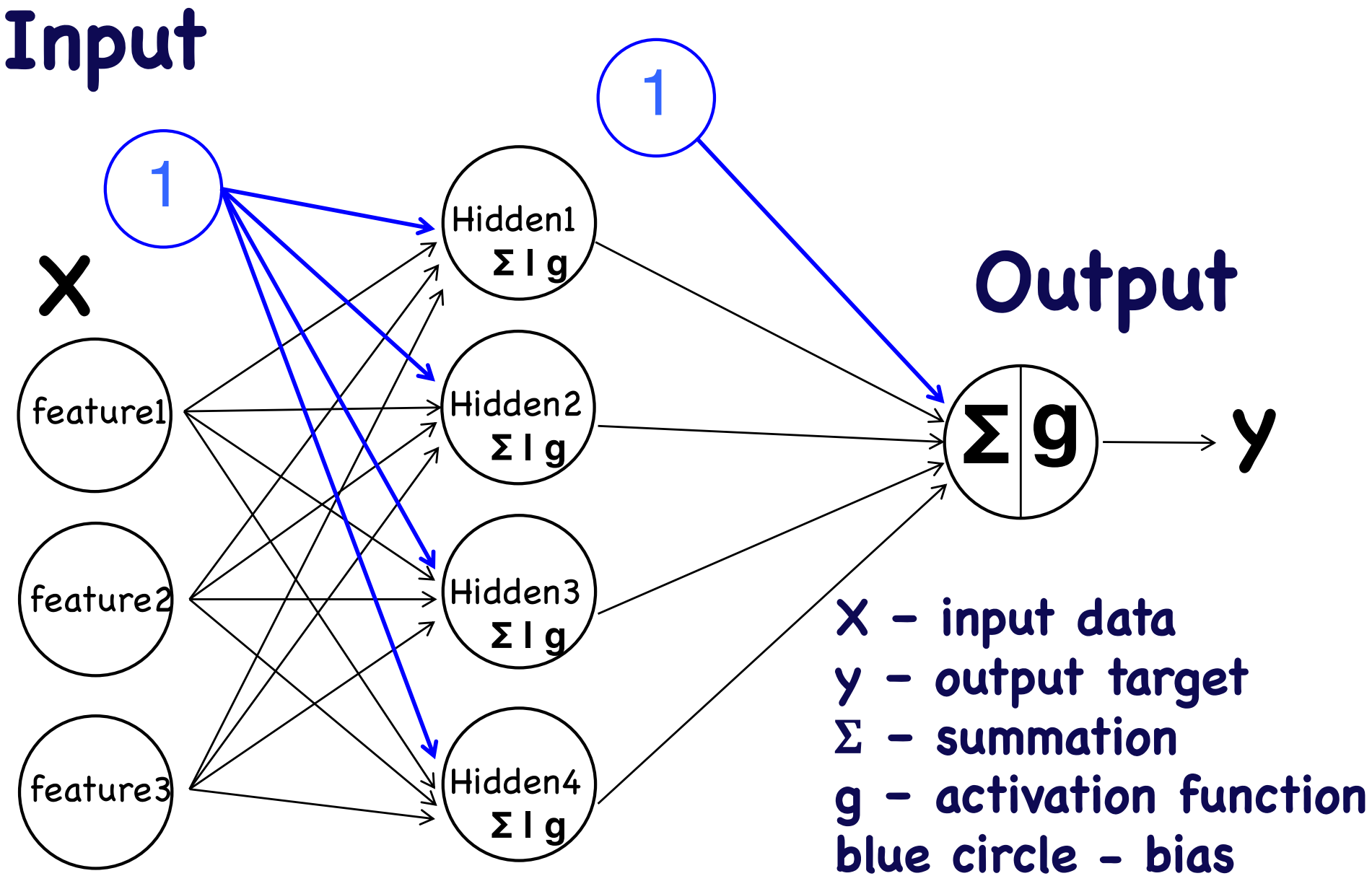

ANN

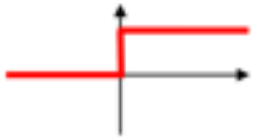
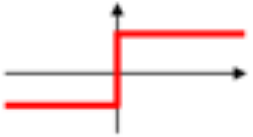
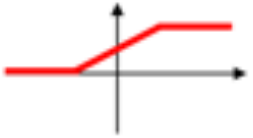
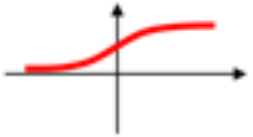
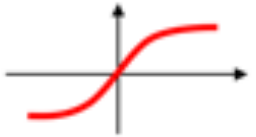




$$Z = \Sigma = \omega_0 x_0 + \omega_1 x_1 + \omega_2 x_2 + \omega_3 x_3 + \ldots + \omega_n x_n$$

$$y = g(\omega_0 x_0 + \omega_1 x_1 + \omega_2 x_2 + \omega_3 x_3 + \ldots + \omega_n x_n)$$


Input
1
1
X
feature1
feature2
feature3
Hidden1
Σ I g
Hidden2
Σ I g
Hidden3
Σ I g
Hidden4
Σ I g
Output
Σ g
y
X - input data
y - output target
Σ - summation
g - activation function
blue circle - bias

Activation function	Equation	Example	1D Graph
Unit step (Heaviside)	$\phi(z) = \begin{cases} 0, & z < 0, \\ 0.5, & z = 0, \\ 1, & z > 0, \end{cases}$	Perceptron variant	
Sign (Signum)	$\phi(z) = \begin{cases} -1, & z < 0, \\ 0, & z = 0, \\ 1, & z > 0, \end{cases}$	Perceptron variant	
Linear	$\phi(z) = z$	Adaline, linear regression	
Piece-wise linear	$\phi(z) = \begin{cases} 1, & z \geq \frac{1}{2}, \\ z + \frac{1}{2}, & -\frac{1}{2} < z < \frac{1}{2}, \\ 0, & z \leq -\frac{1}{2}, \end{cases}$	Support vector machine	
Logistic (sigmoid)	$\phi(z) = \frac{1}{1 + e^{-z}}$	Logistic regression, Multi-layer NN	
Hyperbolic tangent	$\phi(z) = \frac{e^{z} - e^{-z}}{e^{z} + e^{-z}}$	Multi-layer Neural Networks	
Rectifier, ReLU (Rectified Linear Unit)	$\phi(z) = max(0, z)$	Multi-layer Neural Networks	
Rectifier, softplus	$\phi(z) = \ln(1 + e^{z})$	Multi-layer Neural Networks	


YOU'RE IN MY SPOT
GRAPHICS GARAGE

Intuitive
Artificial Neural Network

Input

.
.
.

w_1

w_2

w_n

$F(eye \times w_1 + nose \times w_2 + \ldots + mouth \times w_n)$

Output

Intuitive
Artificial Neural Network

Input

.
.
.

w_1

w_2

w_n

$F(eye \times w_1 + nose \times w_2 + \ldots + mouth \times w_n)$

Output

error
feedback

Intuitive
Artificial Neural Network

Input

.
.
.

w_1

w_2

w_n

$F(eye \times w_1 + nose \times w_2 + \ldots + mouth \times w_n)$

Output

error
feedback

Intuitive
Artificial Neural Network

Input

.
.
.

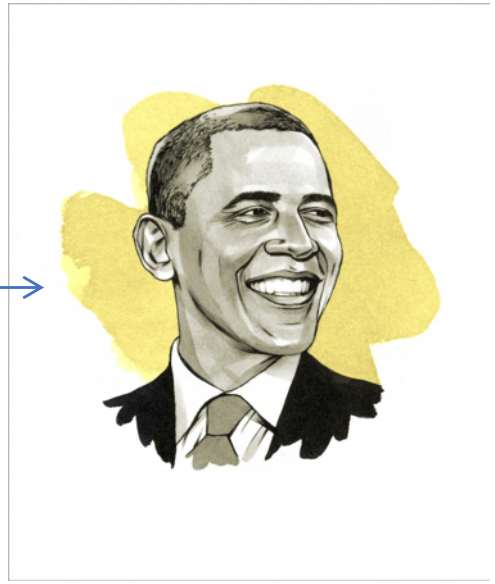
w_1

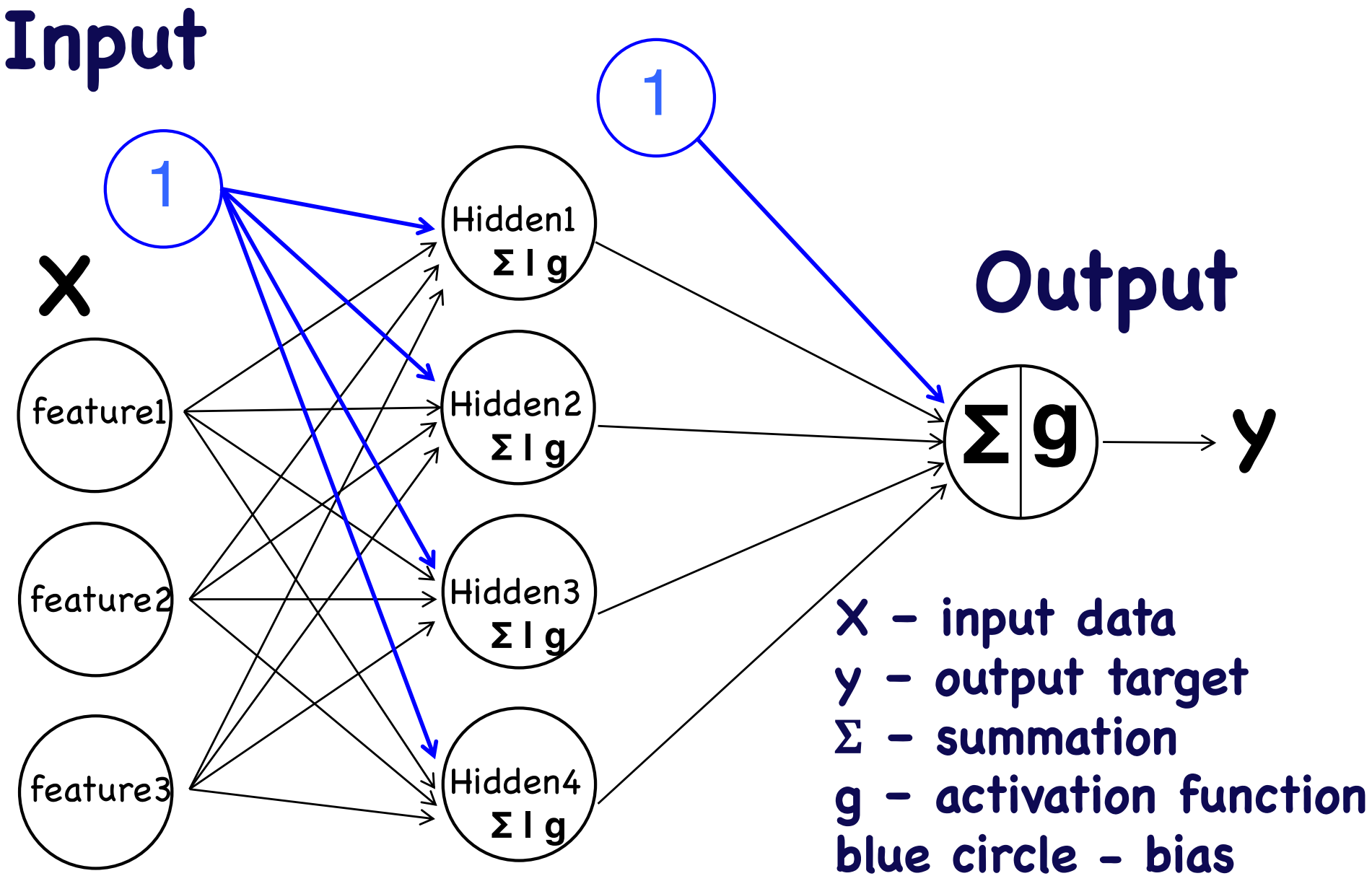
w_2

w_n

$F(eye \times w_1 + nose \times w_2 + \ldots + mouth \times w_n)$

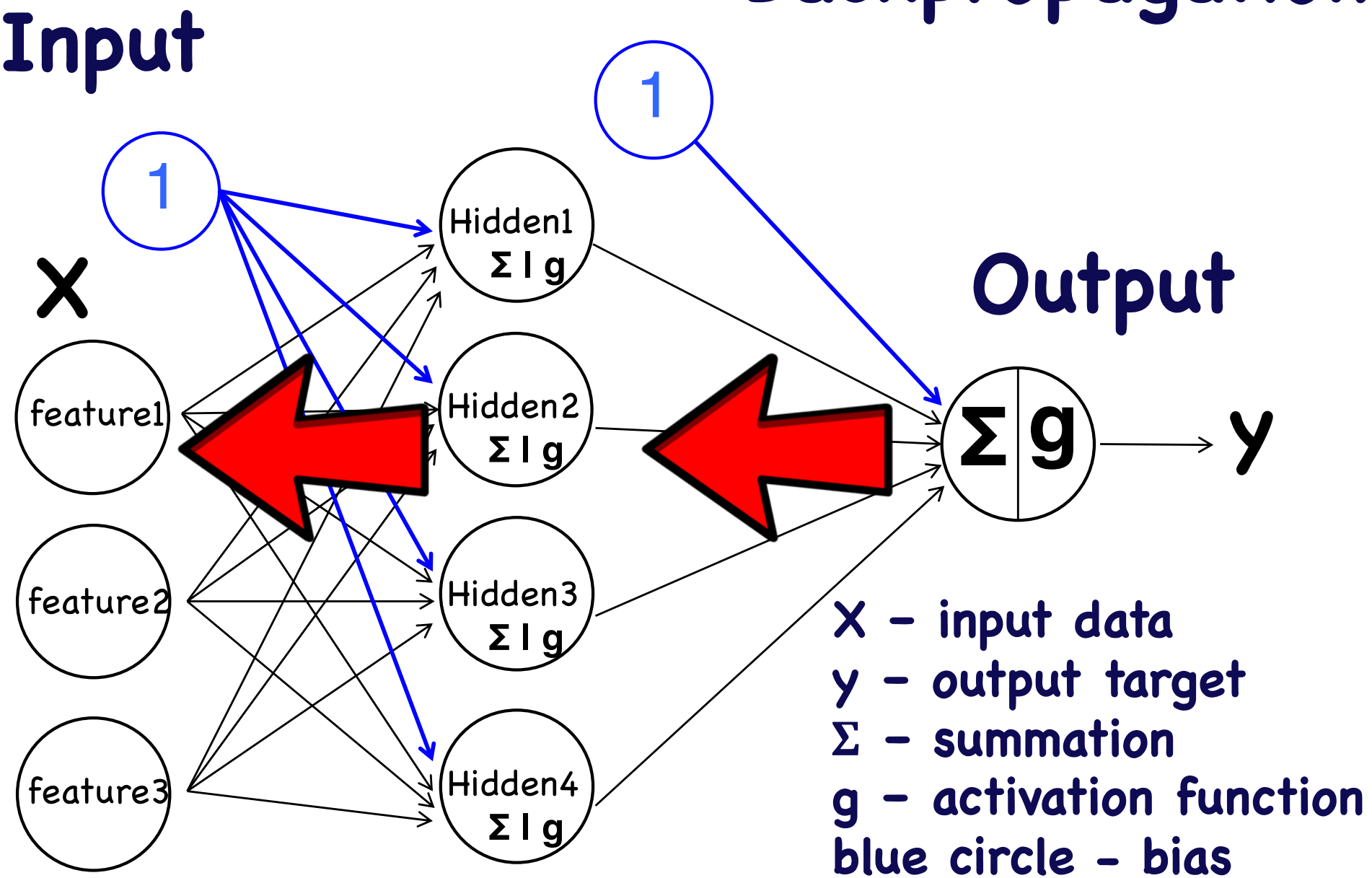
Output




Input
1
1
X
feature1
feature2
feature3
Hidden1
Σ I g
Hidden2
Σ I g
Hidden3
Σ I g
Hidden4
Σ I g
Output
Σ g
y
X - input data
y - output target
Σ - summation
g - activation function
blue circle - bias

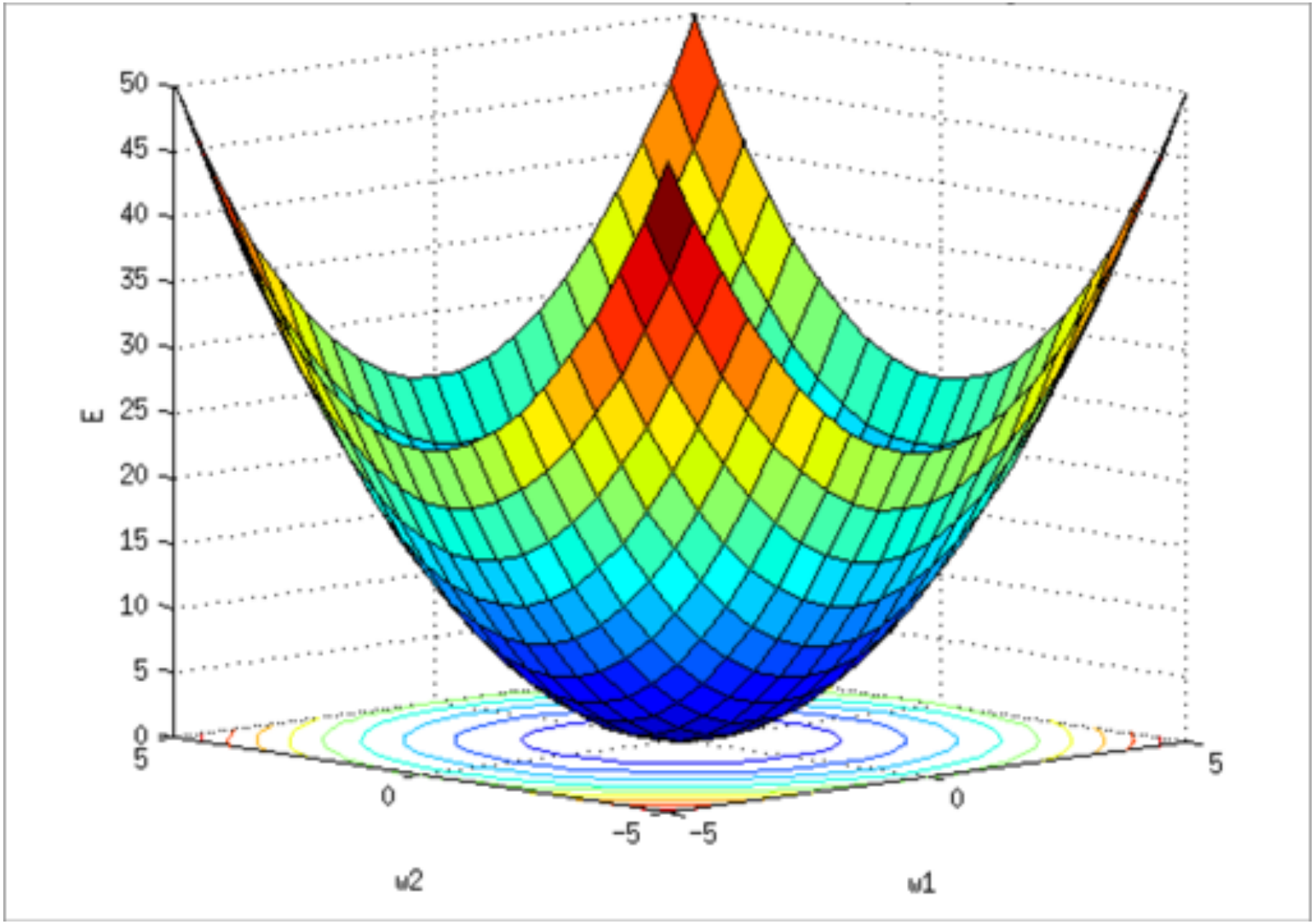

ERROR

Backpropagation



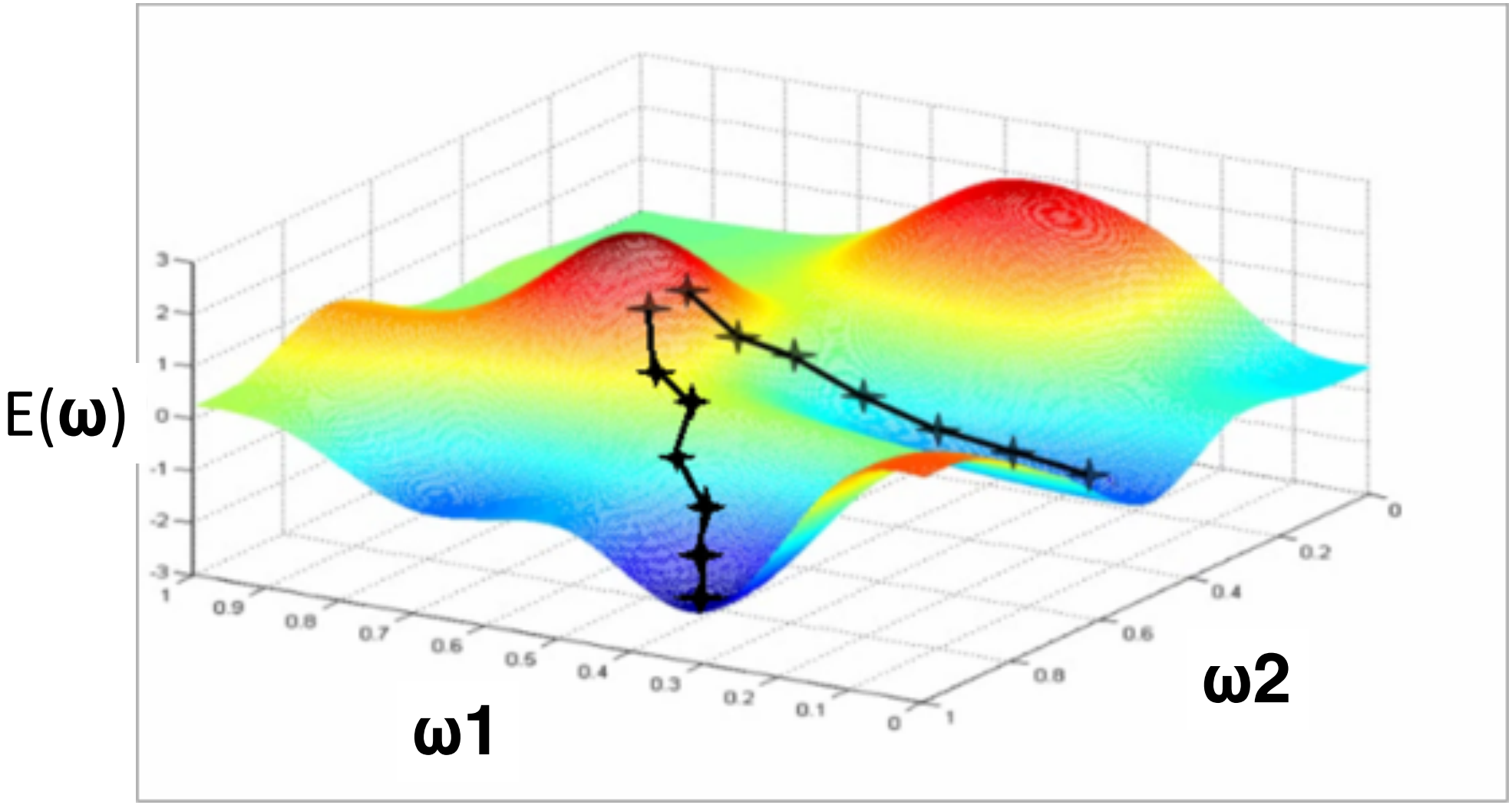
More details: https://www.youtube.com/watch?v=x_Eamf8MHwU

Ideal Cost Function



Real-world Cost Function

Gradient descend



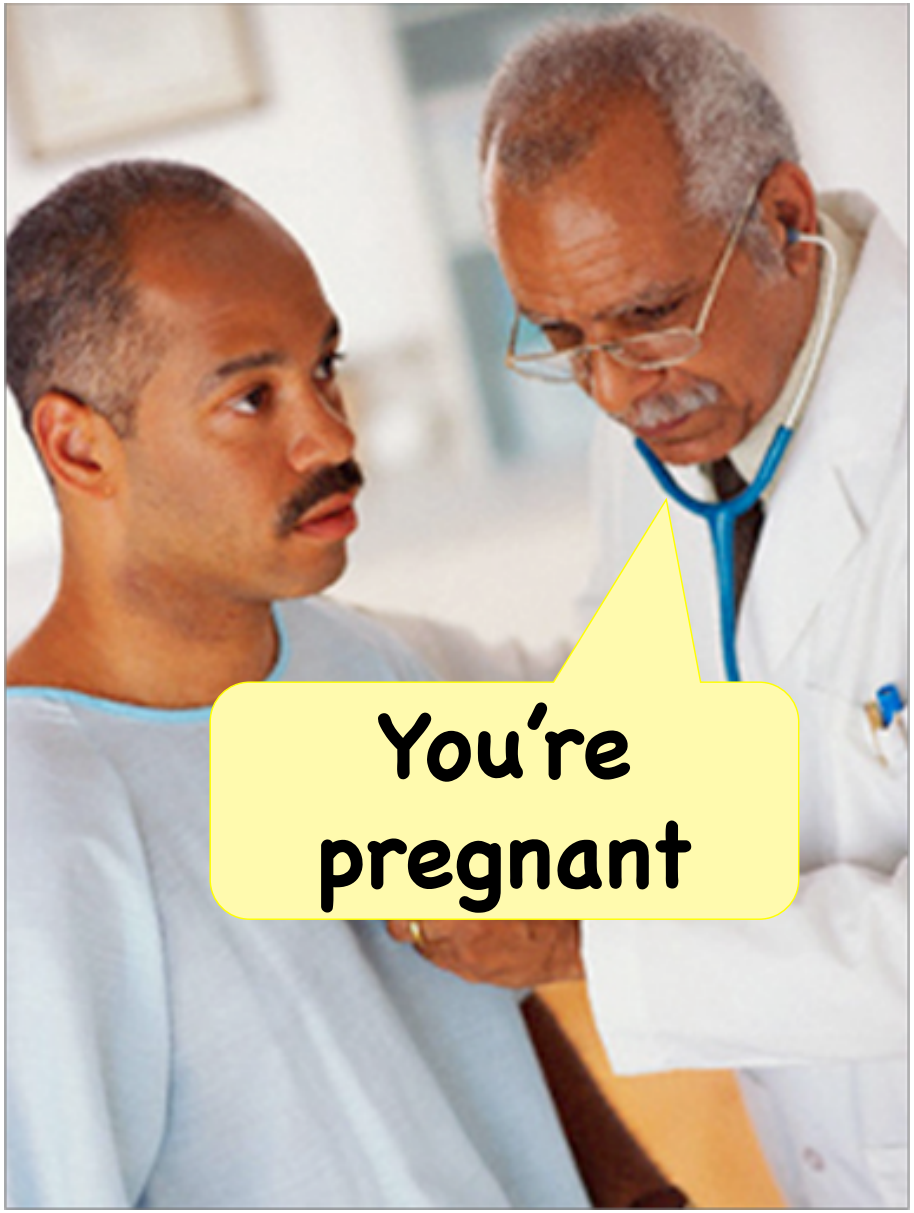
More details: https://www.youtube.com/watch?v=TveJaJs5Fqk

Iterate many times

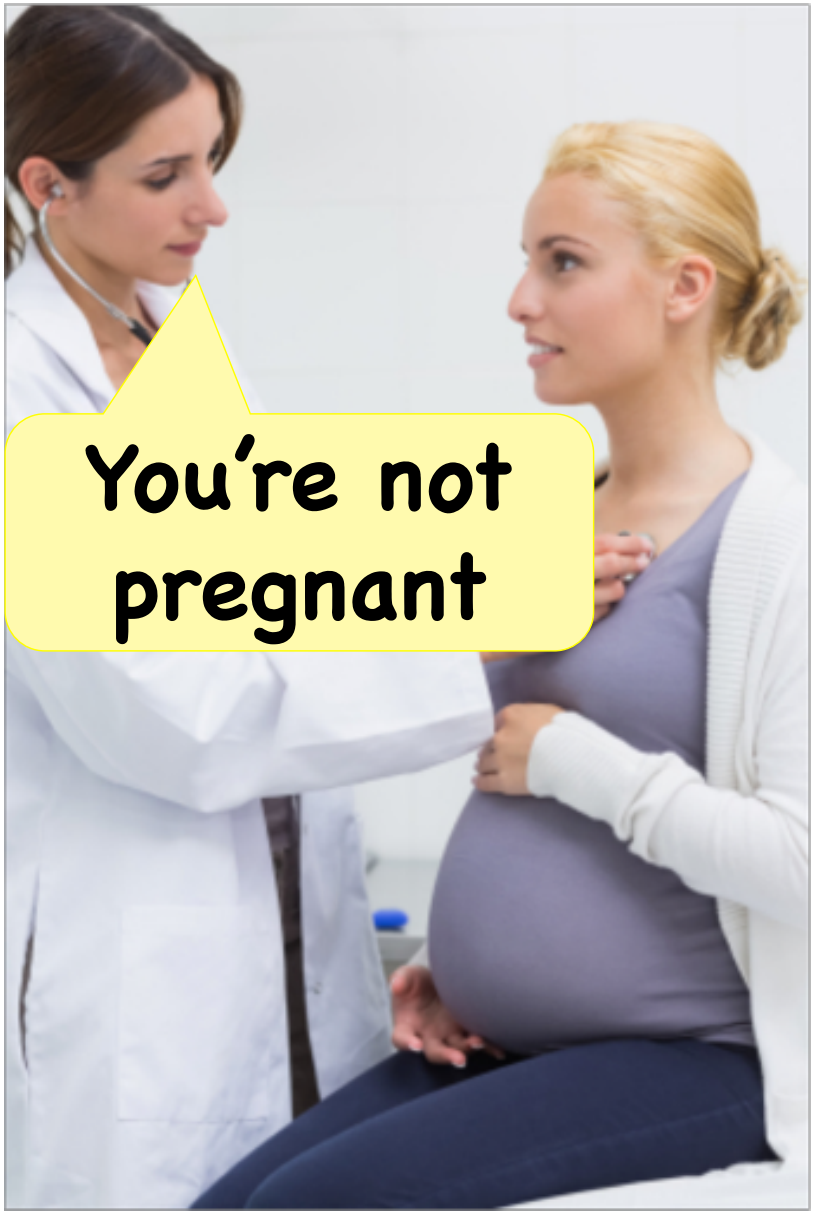
Evaluate performance

- Confusion matrix
- Precision & Recall
- ROC curve (Receiver operating characteristic)

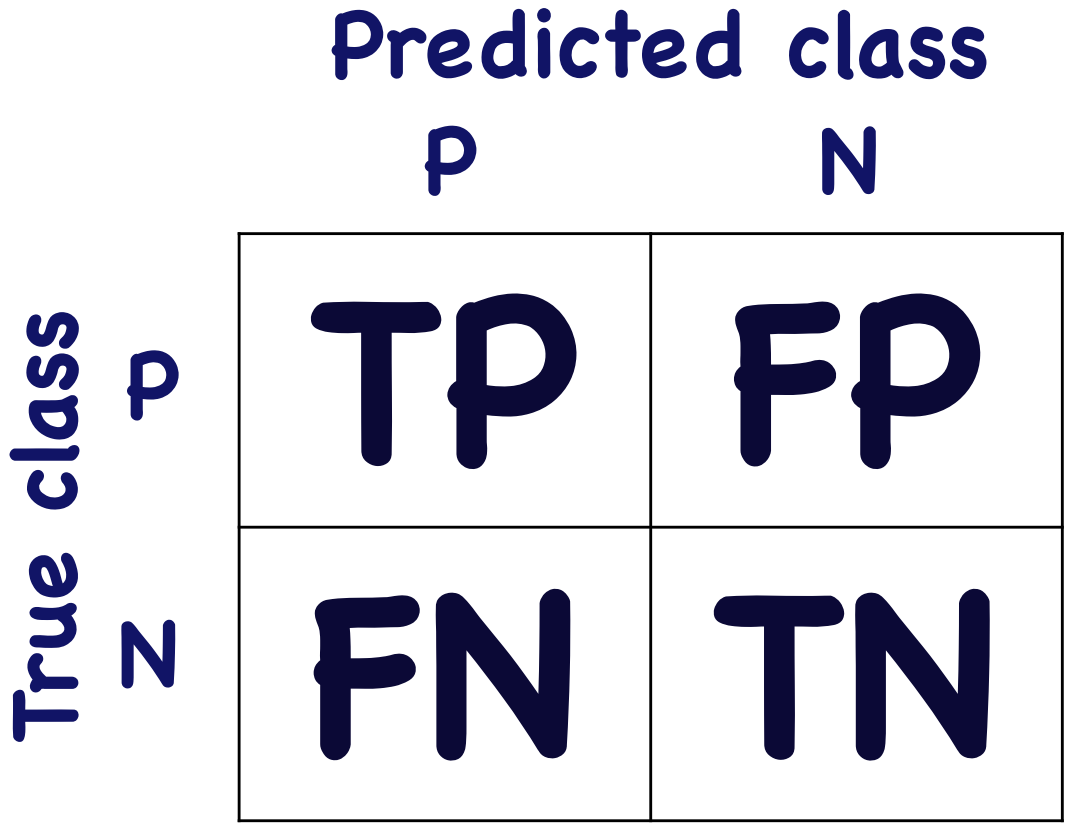
False Positive



False Negative



Confusion matrix



Some useful resources

- https://playground.tensorflow.org
- https://seat.massey.ac.nz/personal/s.r.marsland/MLBook.html
- http://neuralnetworksanddeeplearning.com/
- Python machine learning - Sebastian Raschka
- Deep learning with Python - Francois Chollet
- Machine Learning - An Algorithmic Perspective - Stephen Marsland
- Datasets put together by Men-Andrin and Zach Ross
  - http://scedc.caltech.edu/research-tools/deeplearning.html

Many pictures in this talk are from internet, I thank all the authors here!

Go to the notebook