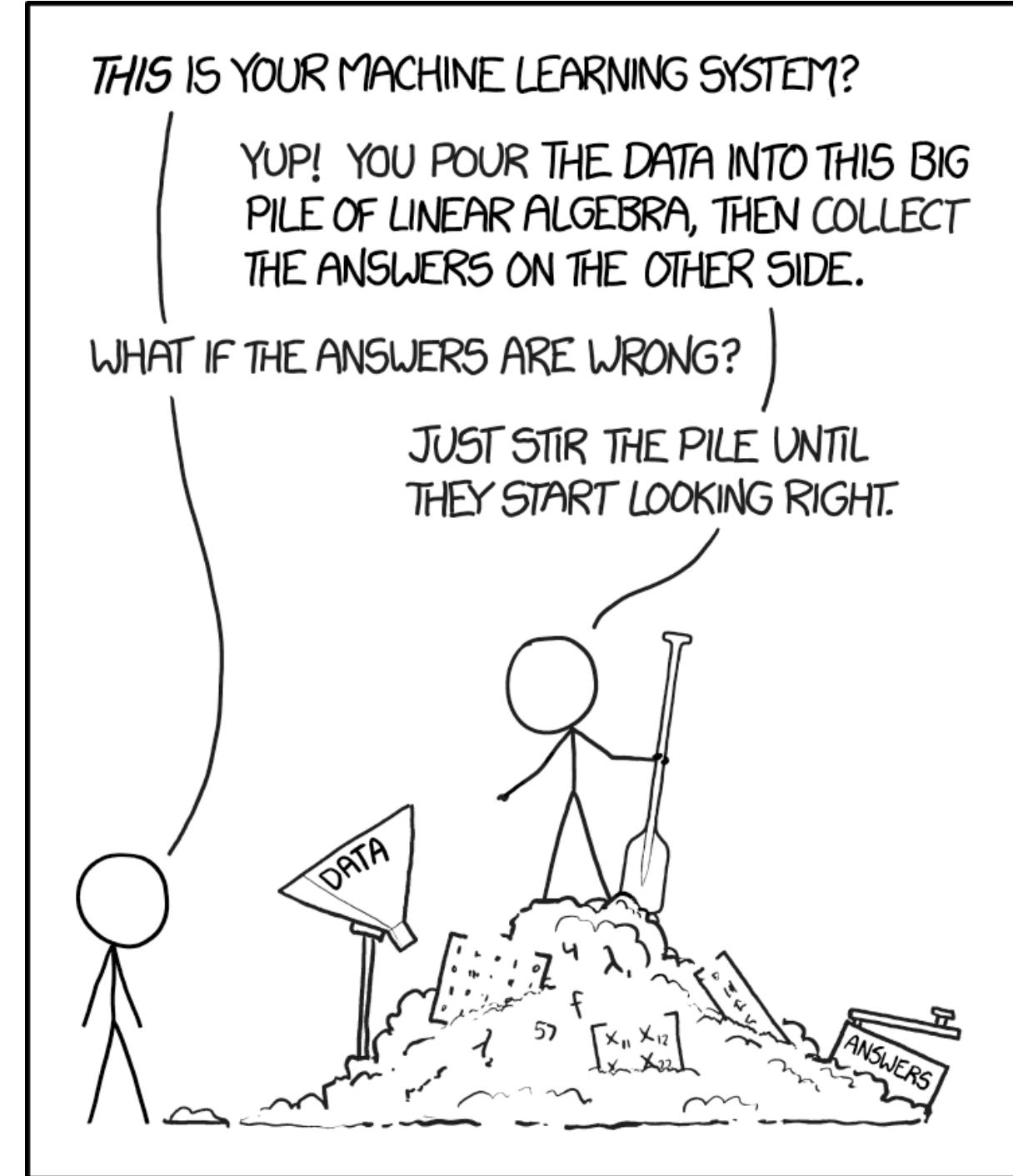


Machine Learning



From [xkcd](#)

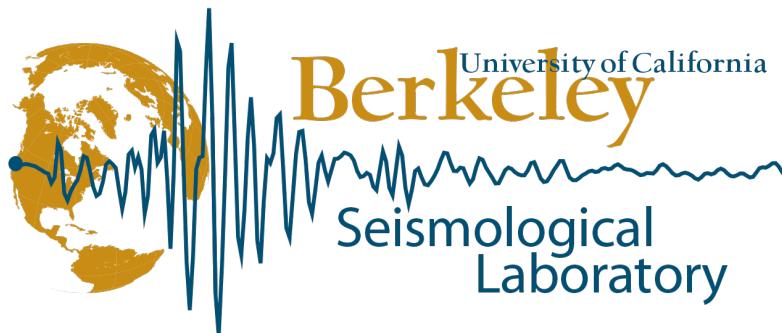
UC Berkeley
Doctoral



Career Development Initiative
for the Physical Sciences

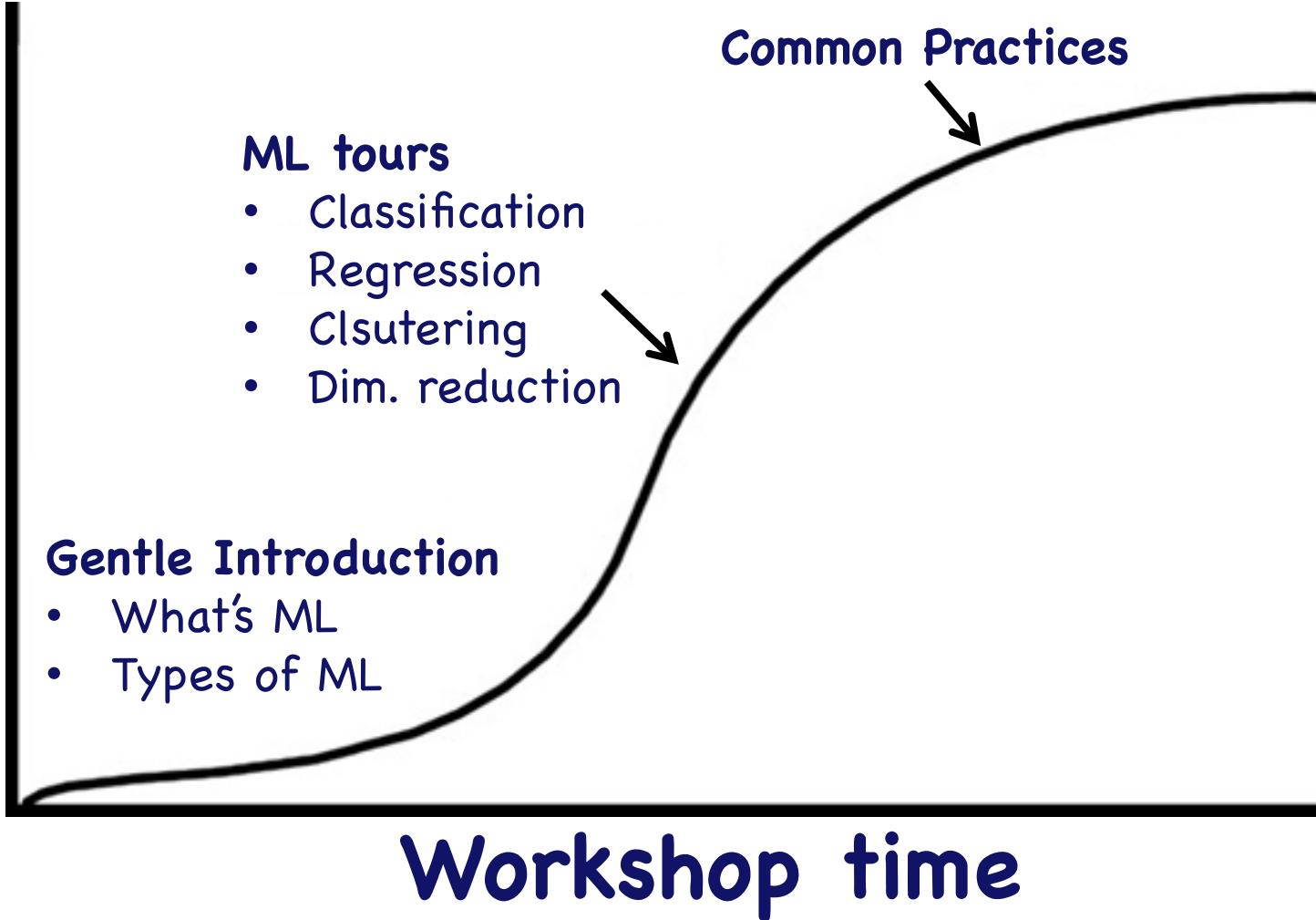
Machine learning - using scikit-learn

Qingkai Kong
2017-06-28



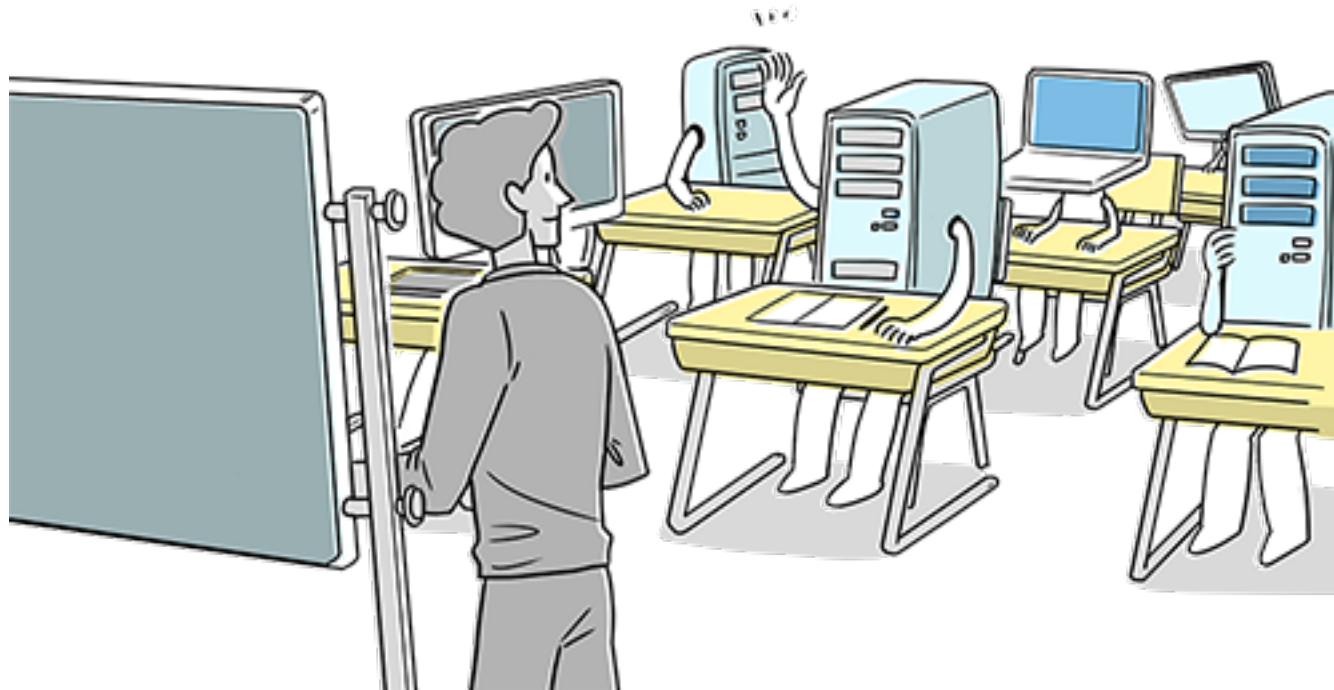
<http://seismo.berkeley.edu/qingkaikong/>

Learning curve



https://github.com/qingkaikong/20170628_ML_sklearn

What is machine learning?



https://github.com/qingkaikong/20170628_ML_sklearn

Data
examples

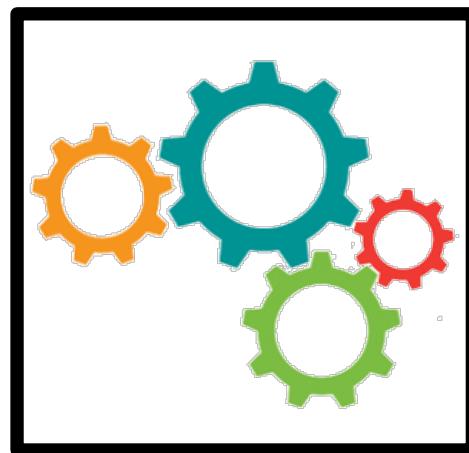
01100
10110
11110

Optimization
algorithm



Pipeline of training a machine learning model.

Tunable
Model



Trained
Model

MAKE
THINGS
HAPPEN!



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 Google Apps Deciphered: Compute in the Cloud to Streamline Your Desktop	 Google Apps Administrator Guide: A Private-Label Web Workspace	 Googlepedia: The Ultimate Google Resource (3rd Edition)
---	--	---

**Self-driving car
Voice recognition**

...

https://github.com/qingkaikong/20170628_ML_sklearn

Not always
working

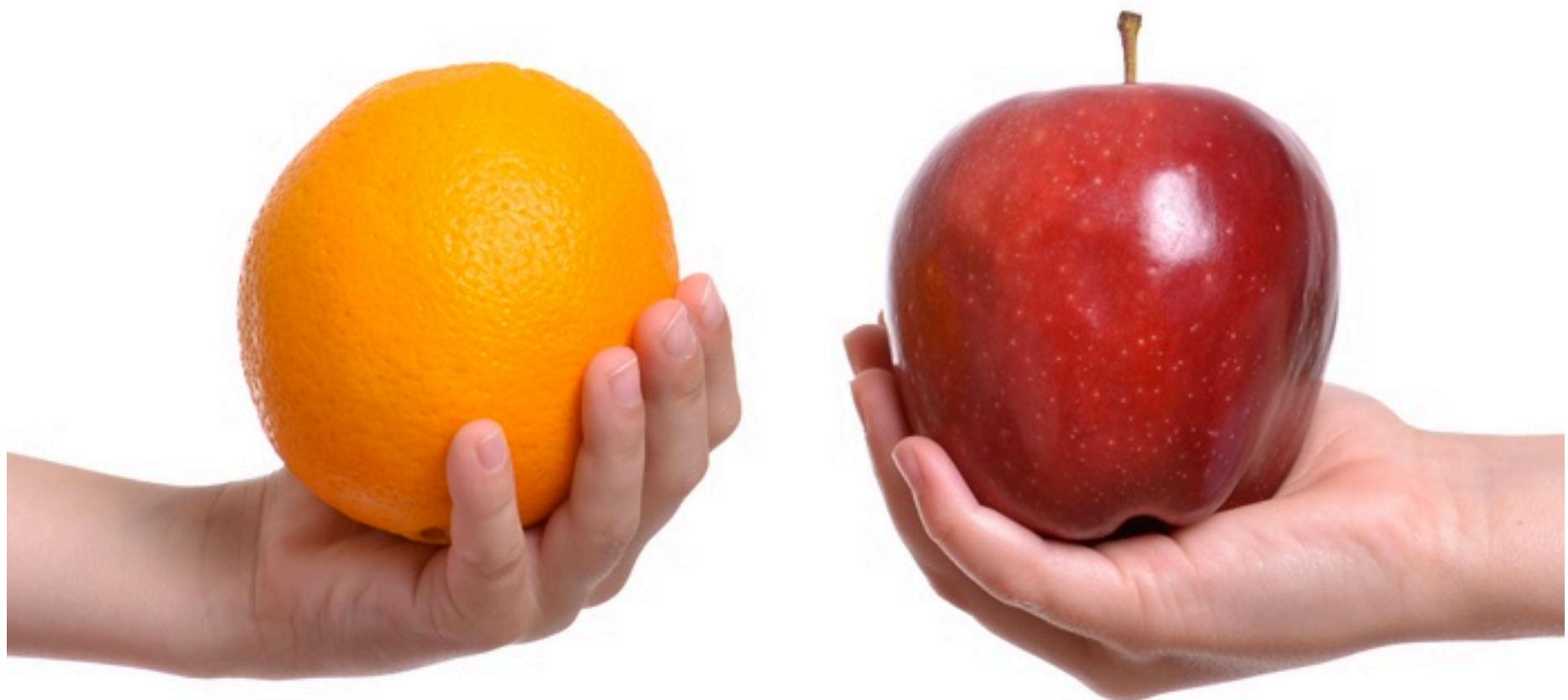


Common types of machine learning

Supervised
learning

Unsupervised
learning

Supervised learning





Unsupervised learning

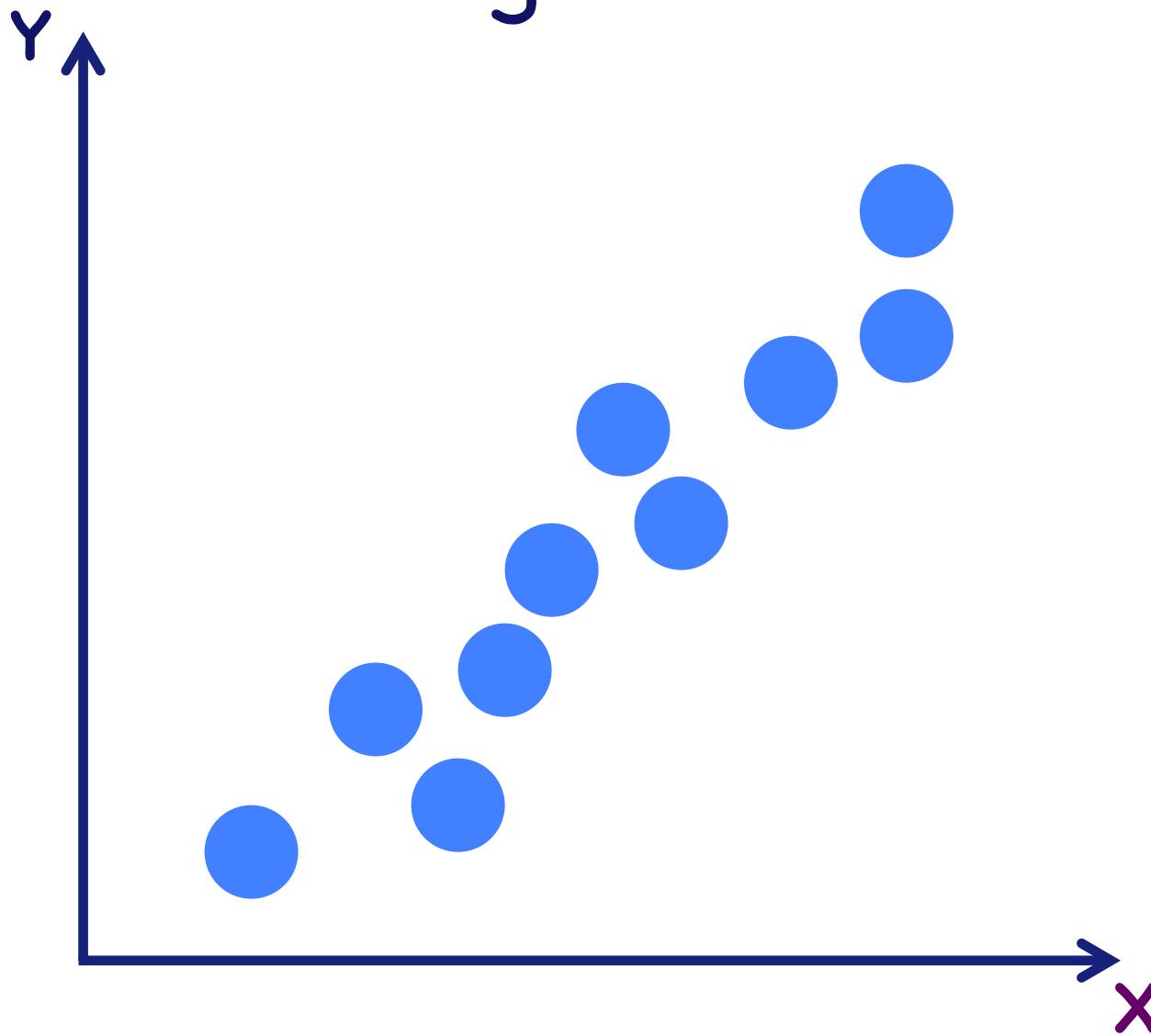


Supervised
learning

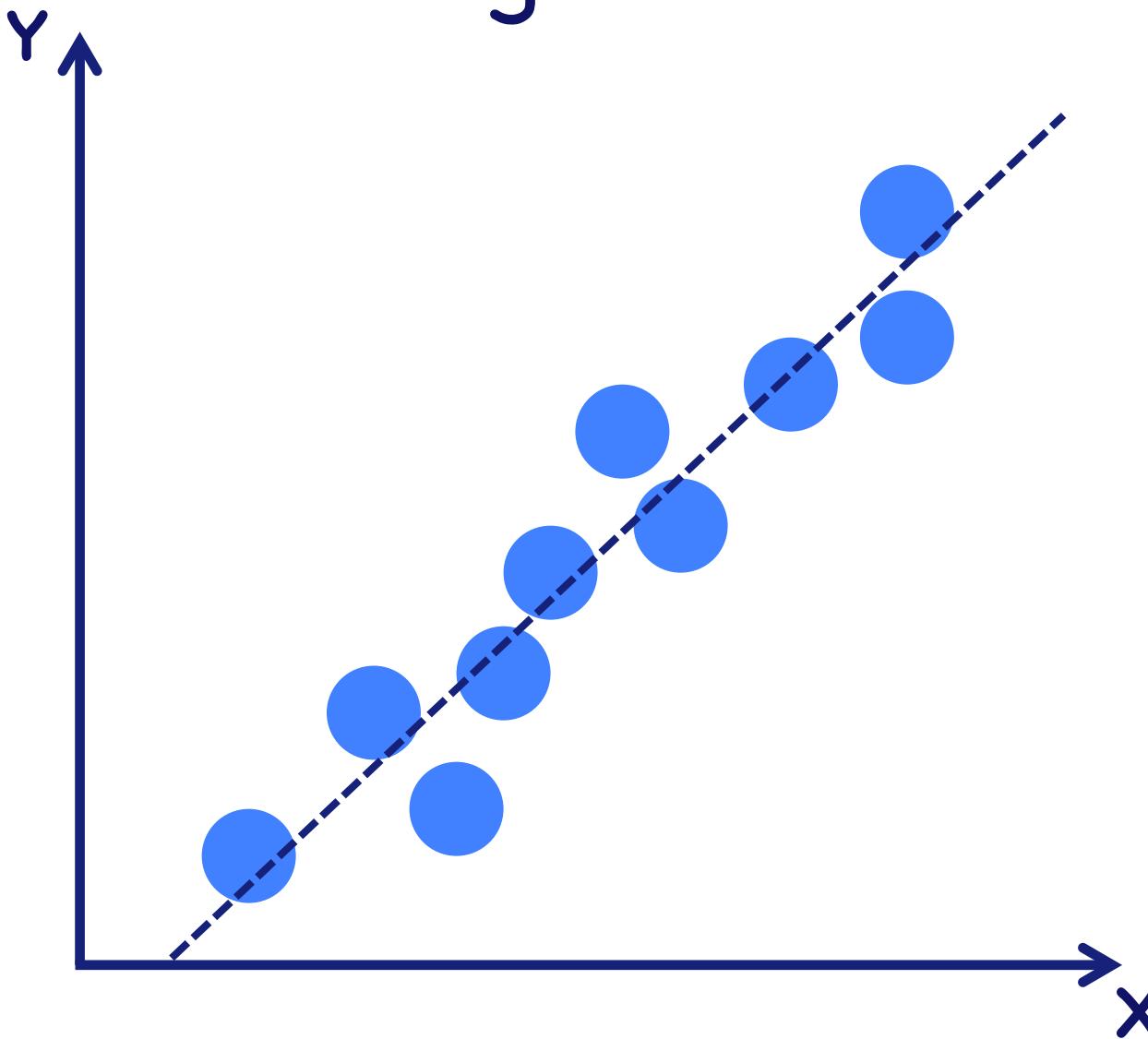
Regression

Classification

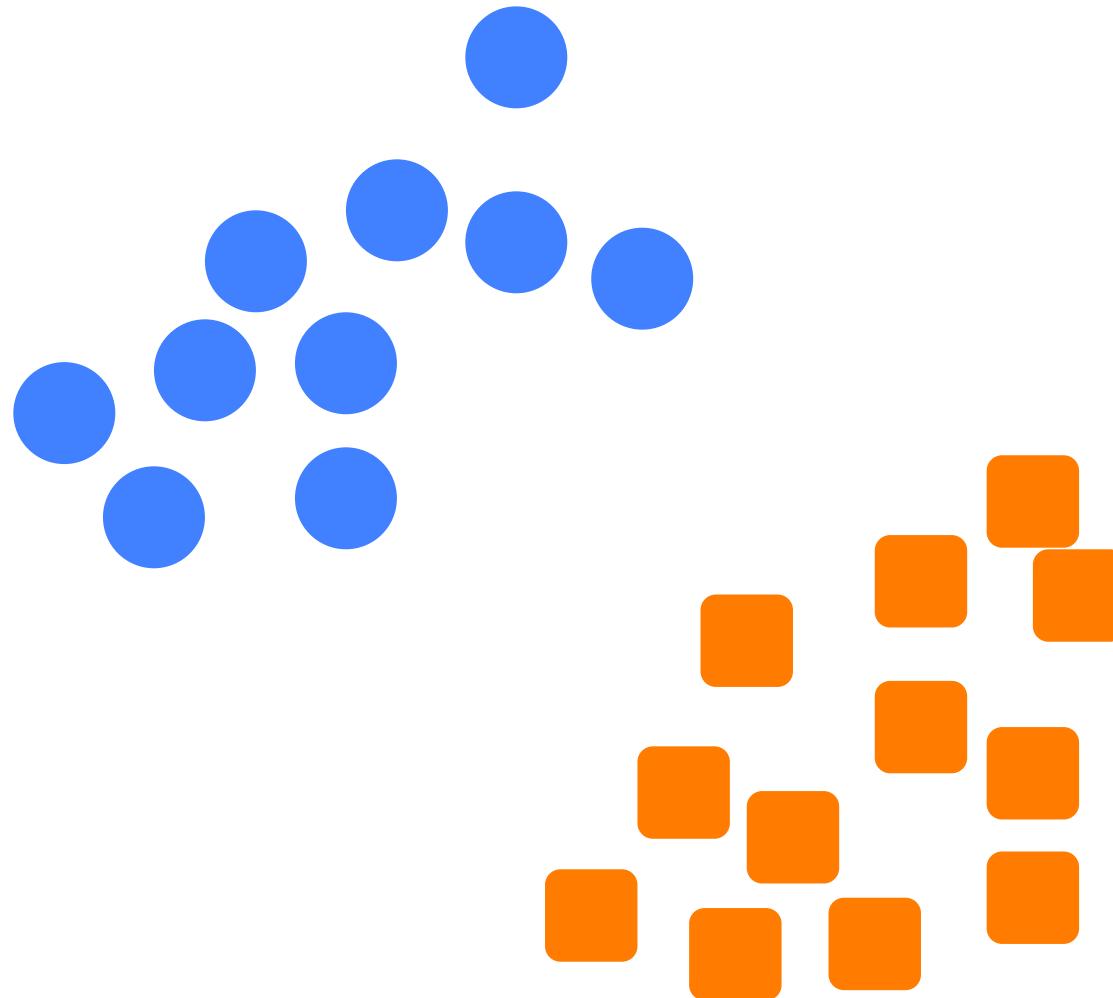
Regression



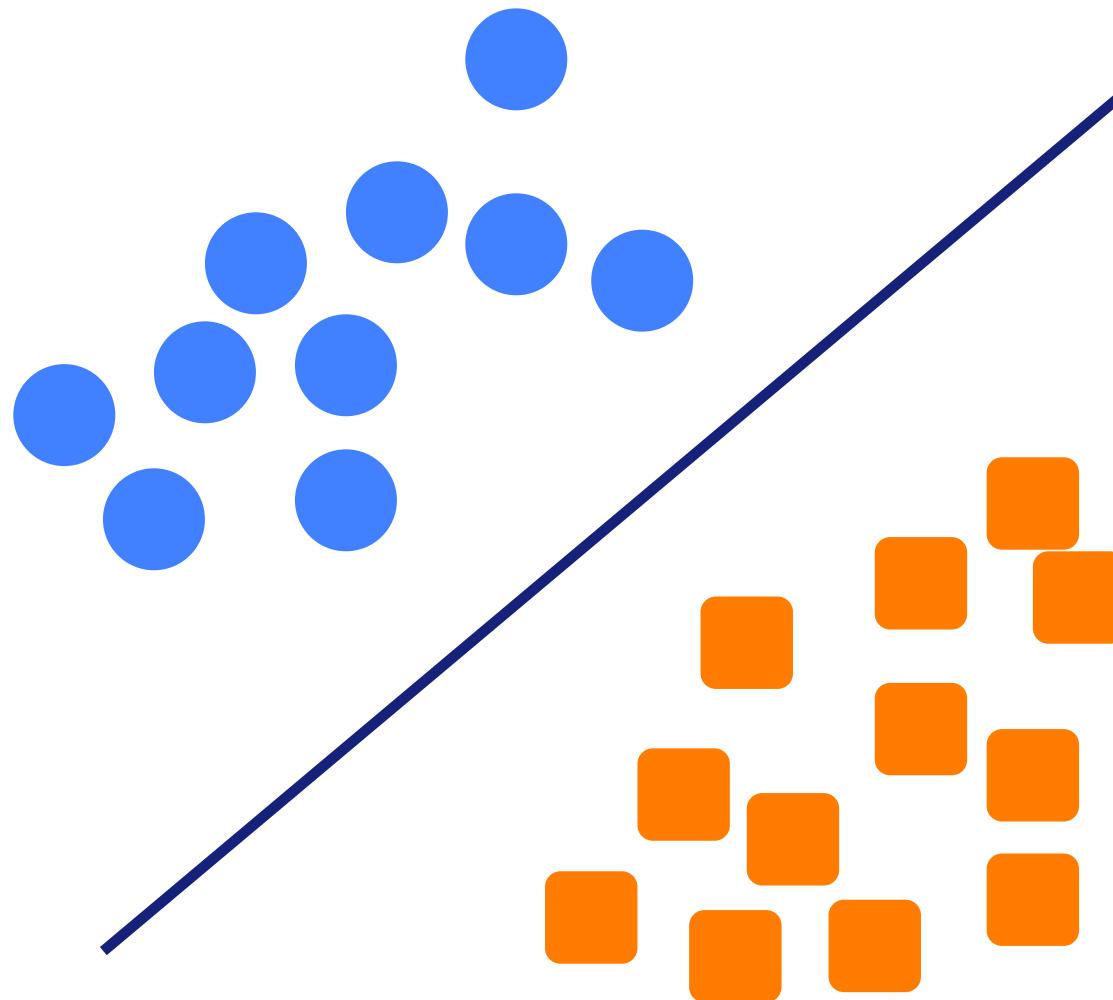
Regression



Classification



Classification



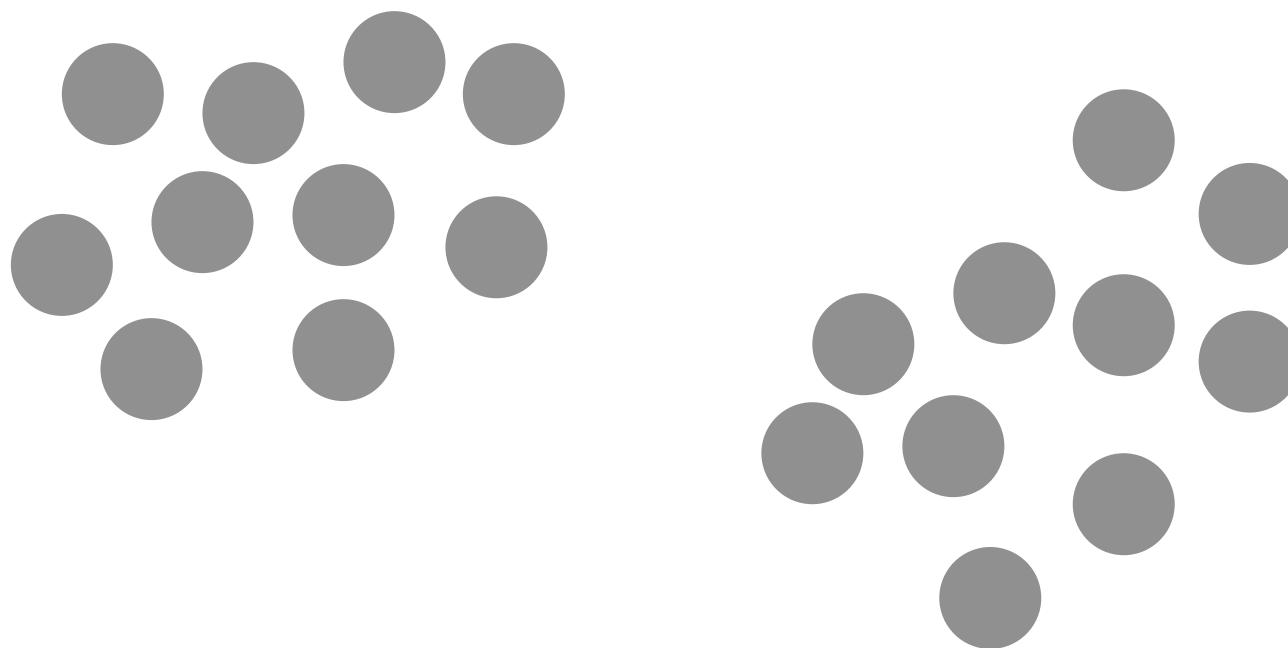


Unsupervised
learning

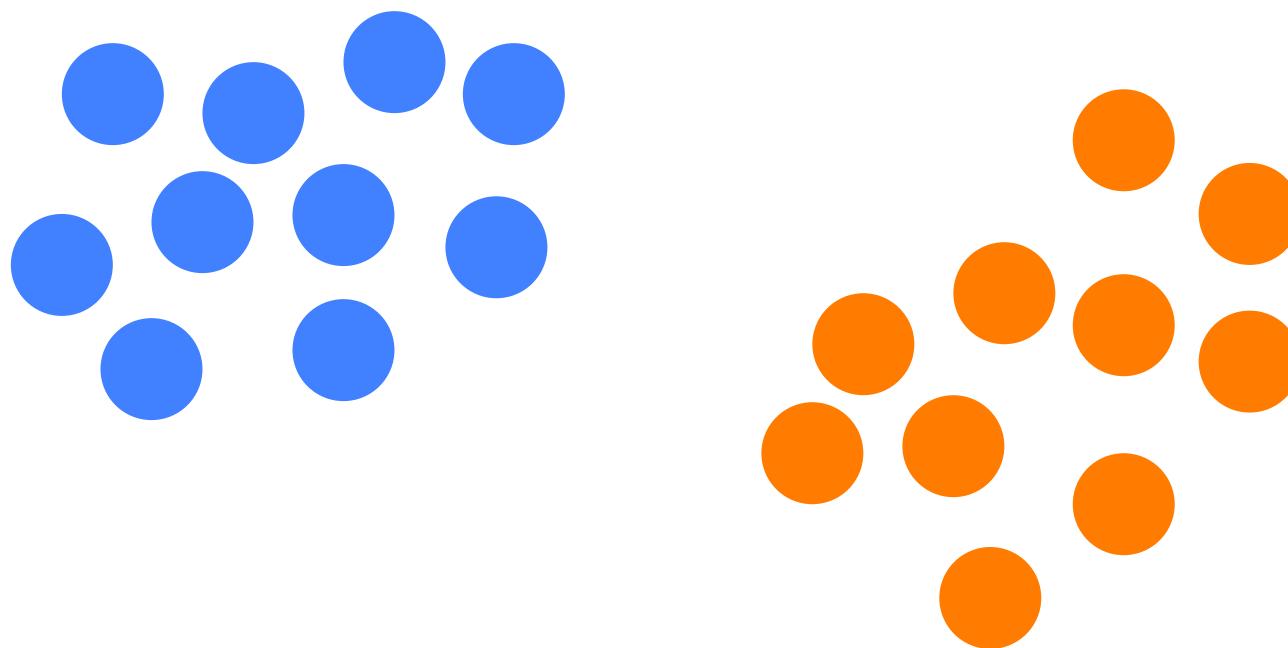
Clustering

Dimensionality
reduction

Clustering



Clustering



Dimensionality reduction

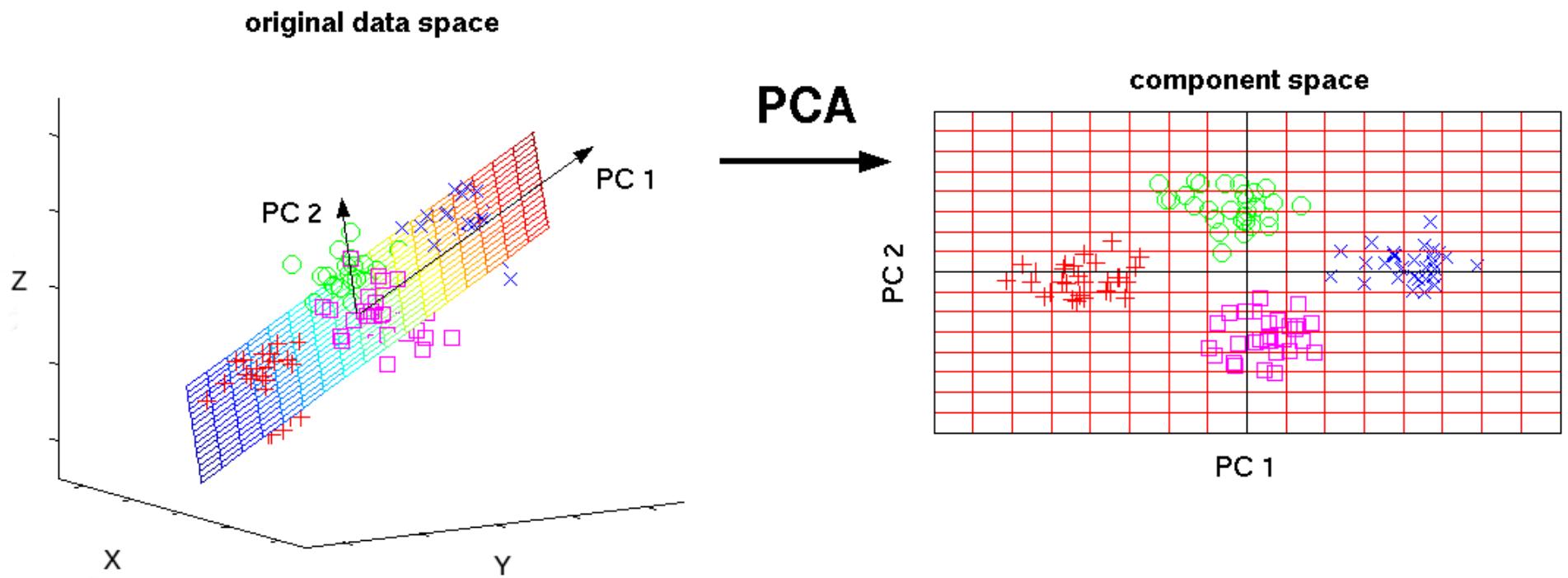


Figure from <https://stats.stackexchange.com/questions/183236/what-is-the-relation-between-k-means-clustering-and-pca>

Data
examples

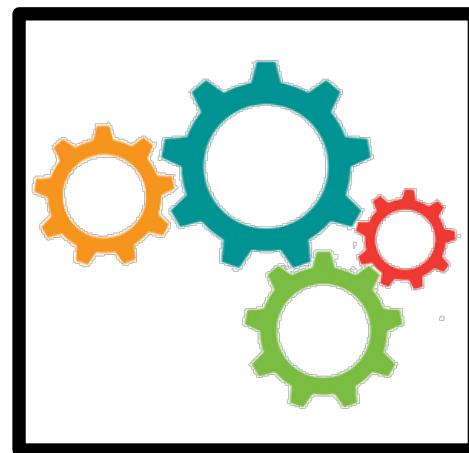
01100
10110
11110

Optimization
algorithm



Pipeline of training a machine learning model.

Tunable
Model



Trained
Model

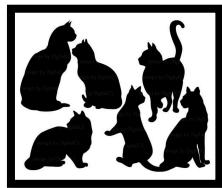
MAKE
THINGS
HAPPEN!

Representation of data

Raw data



Documents



Images



Numbers

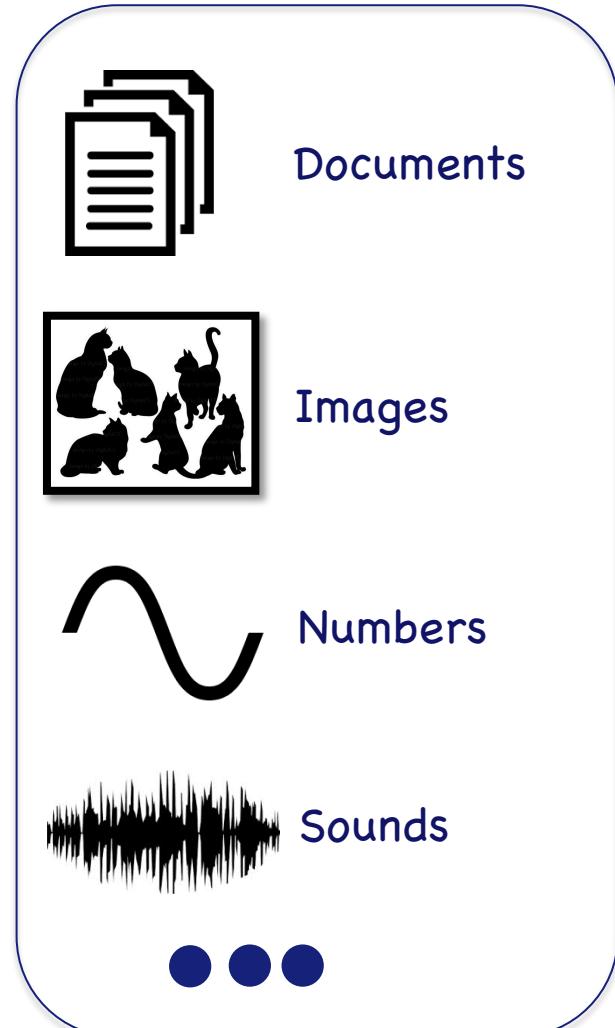


Sounds

• • •

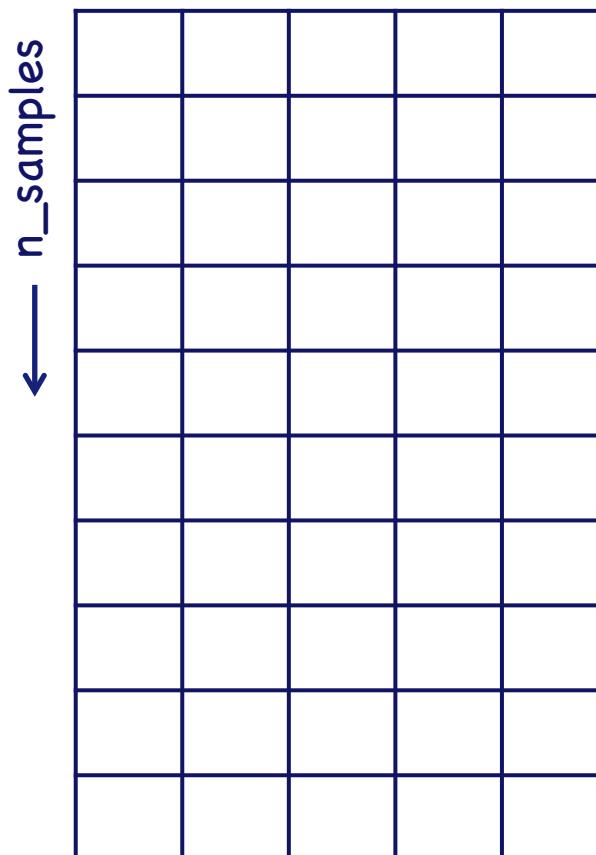
Representation of data

Raw data



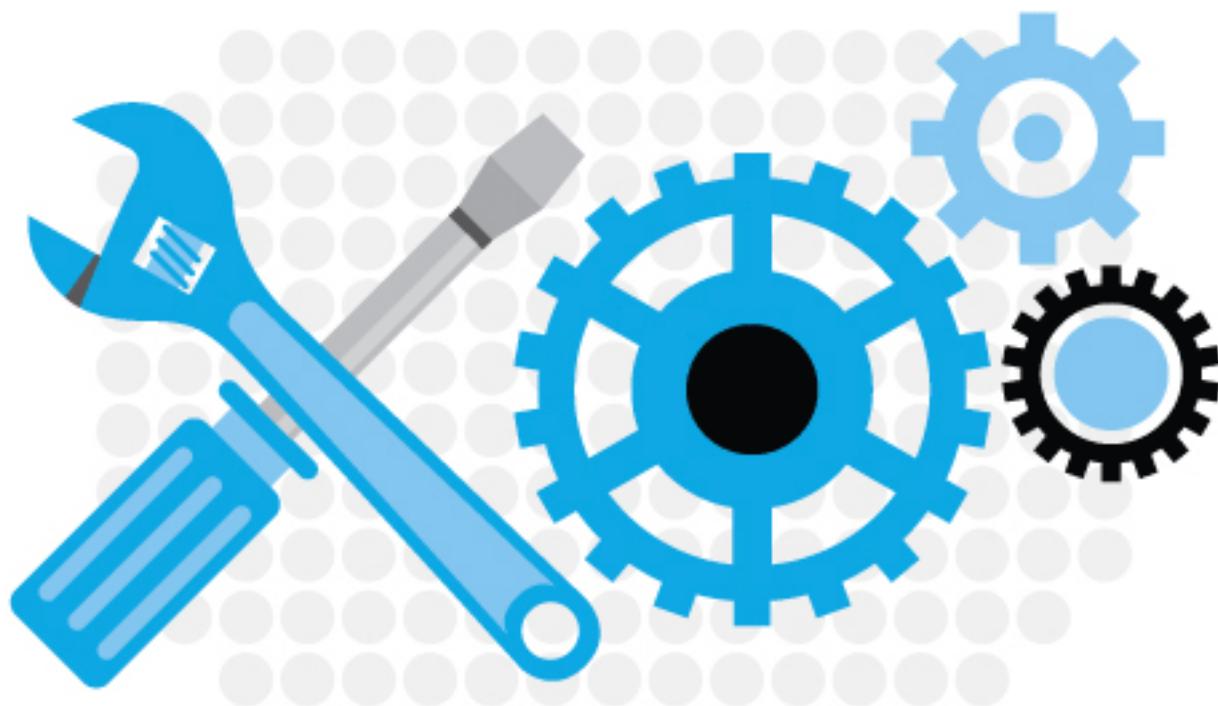
Feature matrix (X)

n_features →

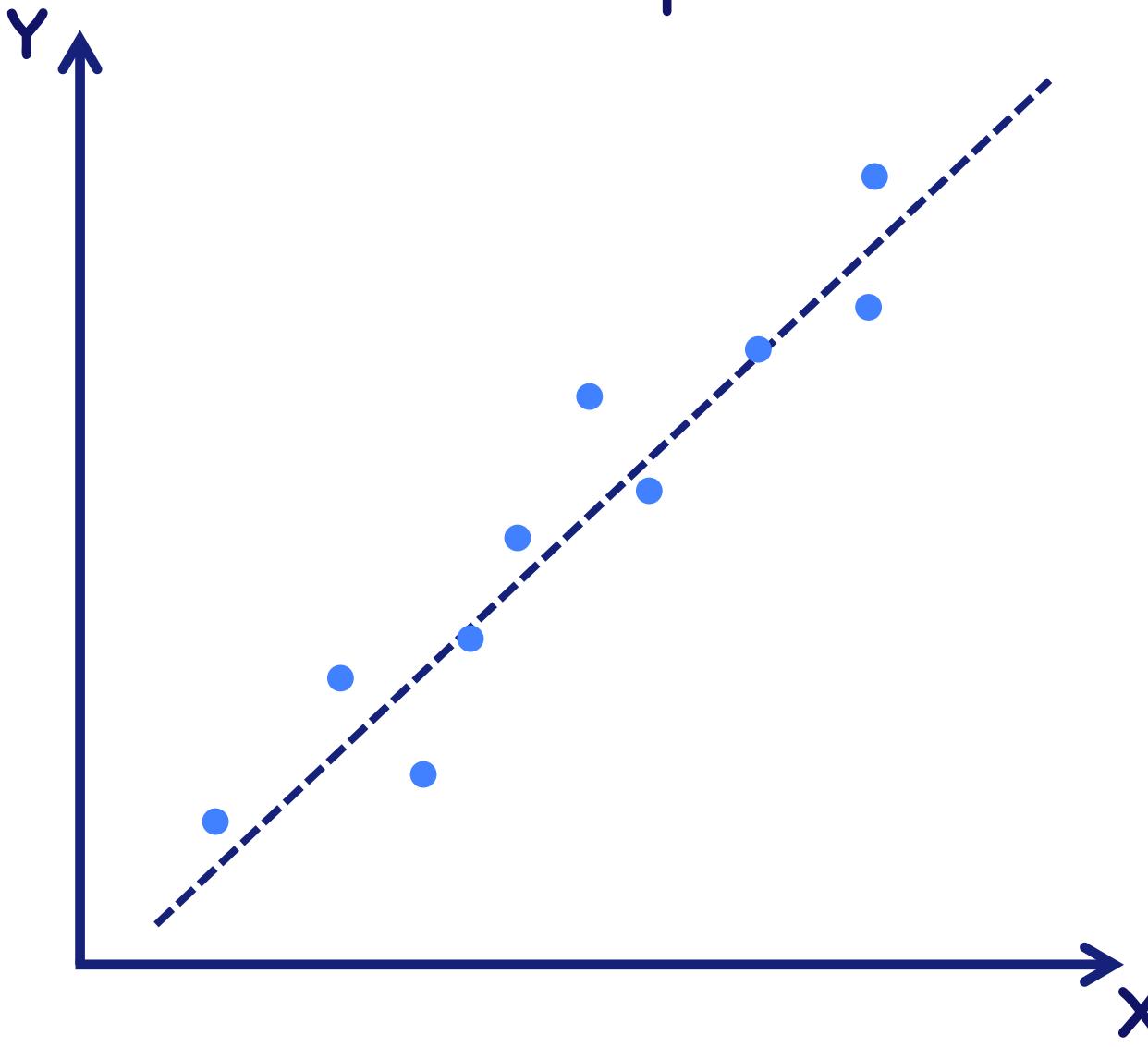


Target (y)

Optimization

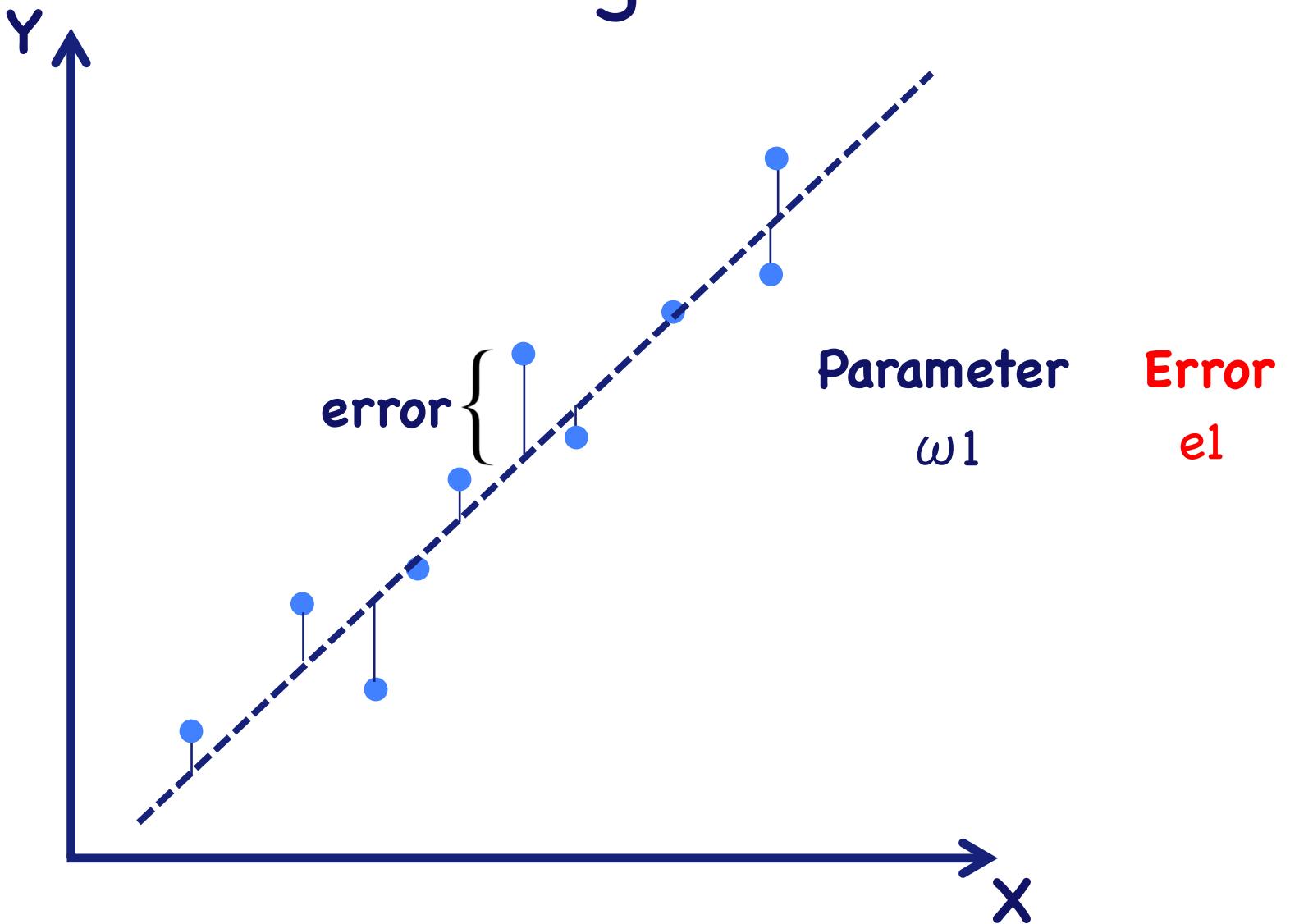


How we optimize?

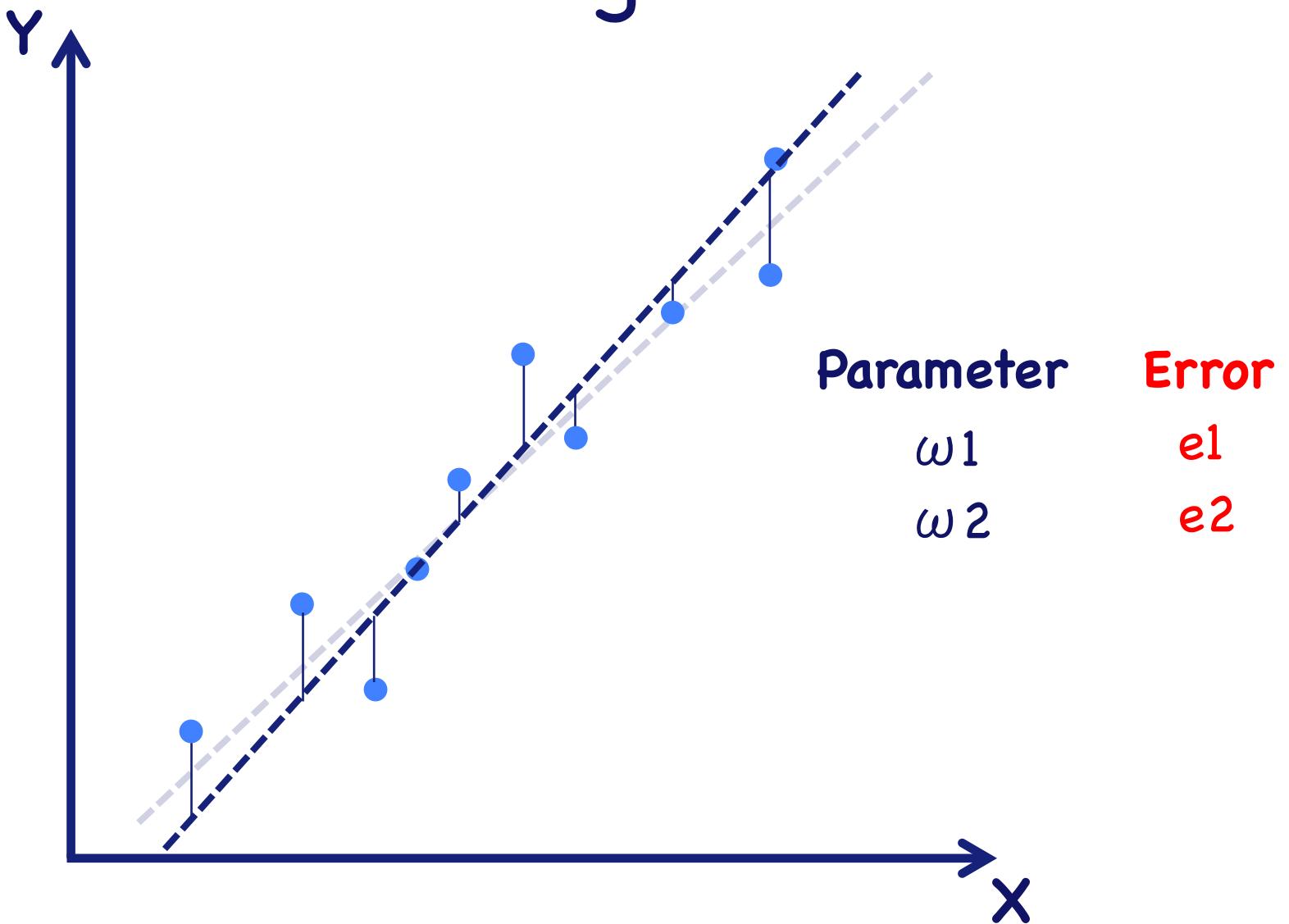


A simple example

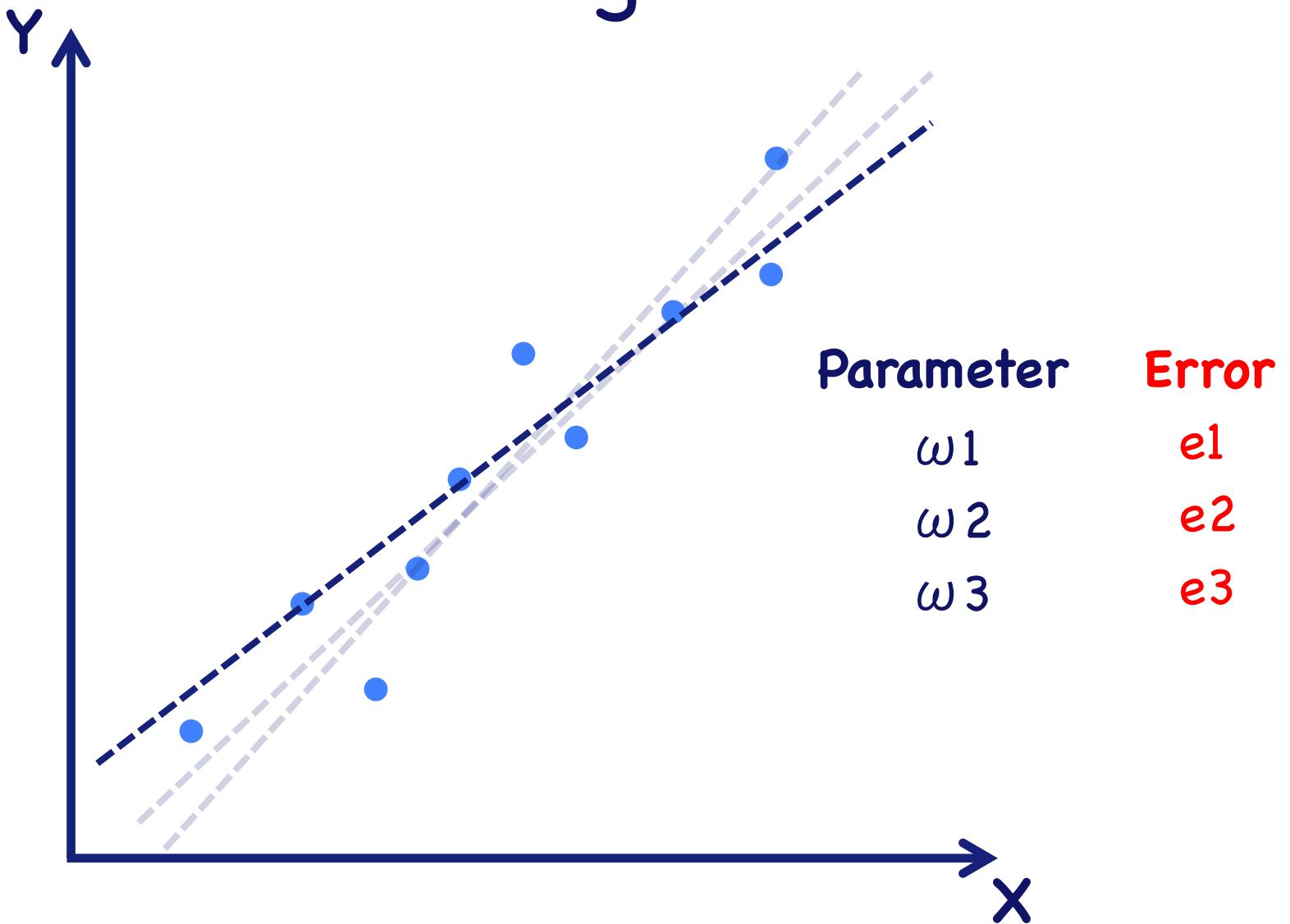
Measuring error



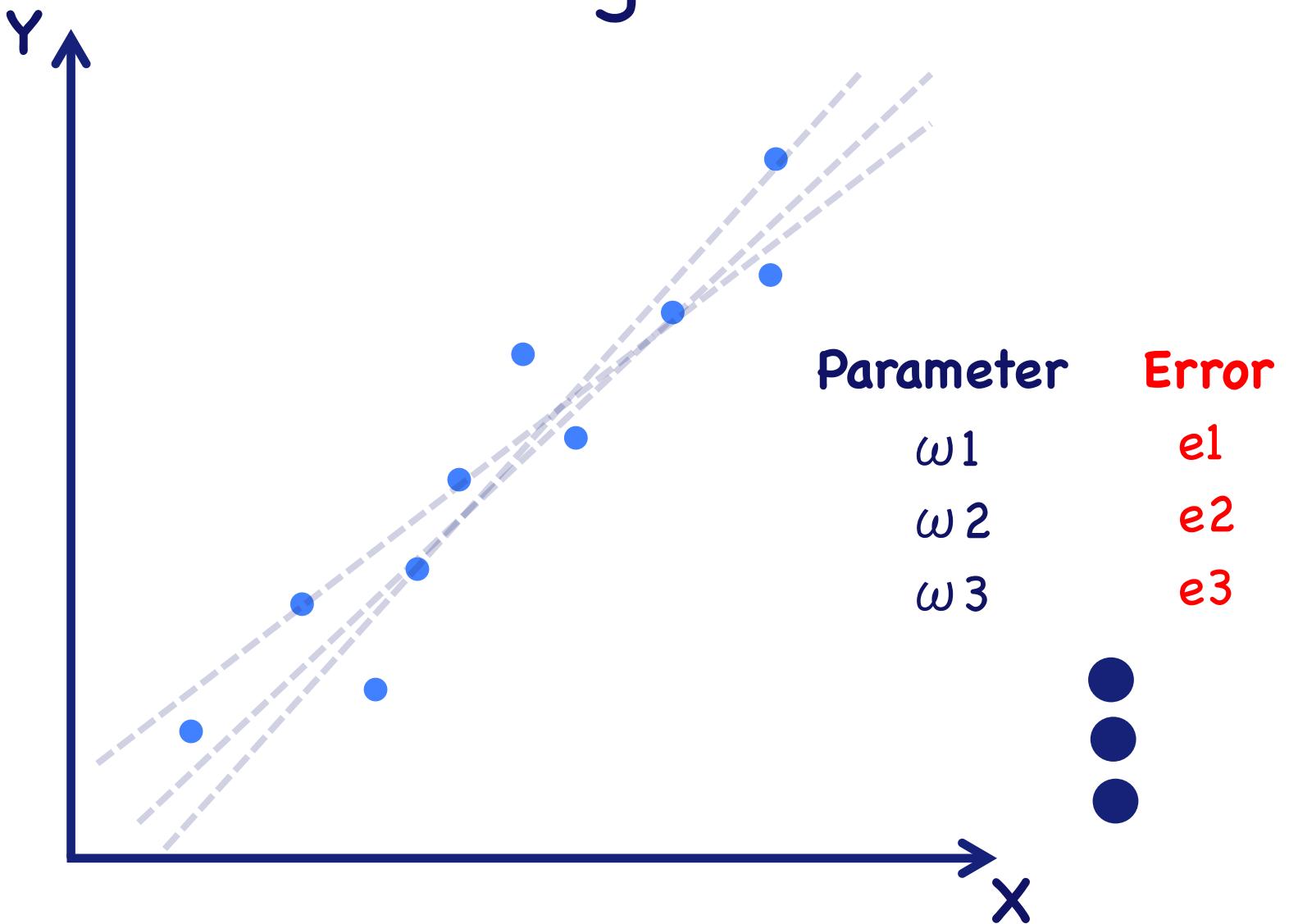
Measuring error



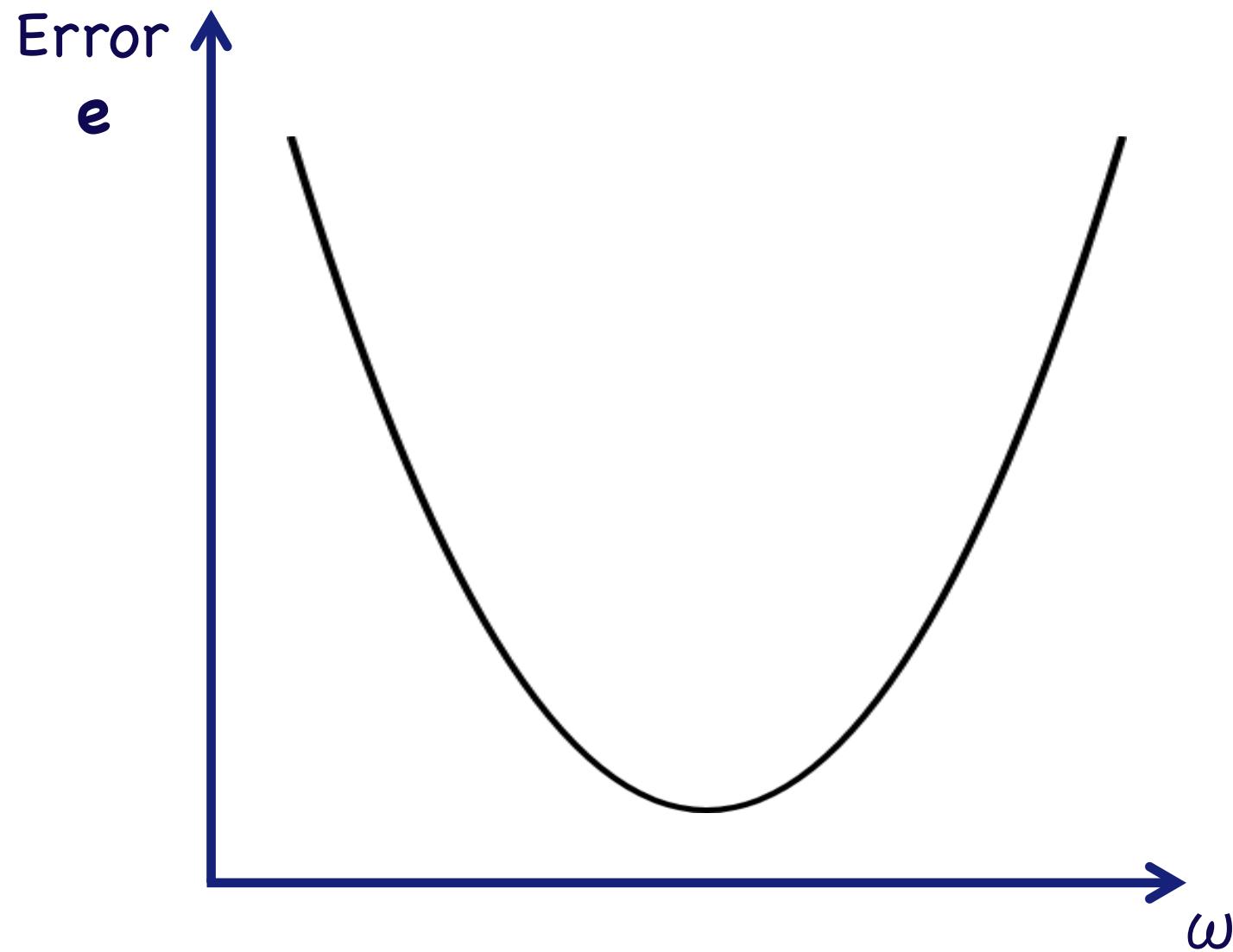
Measuring error



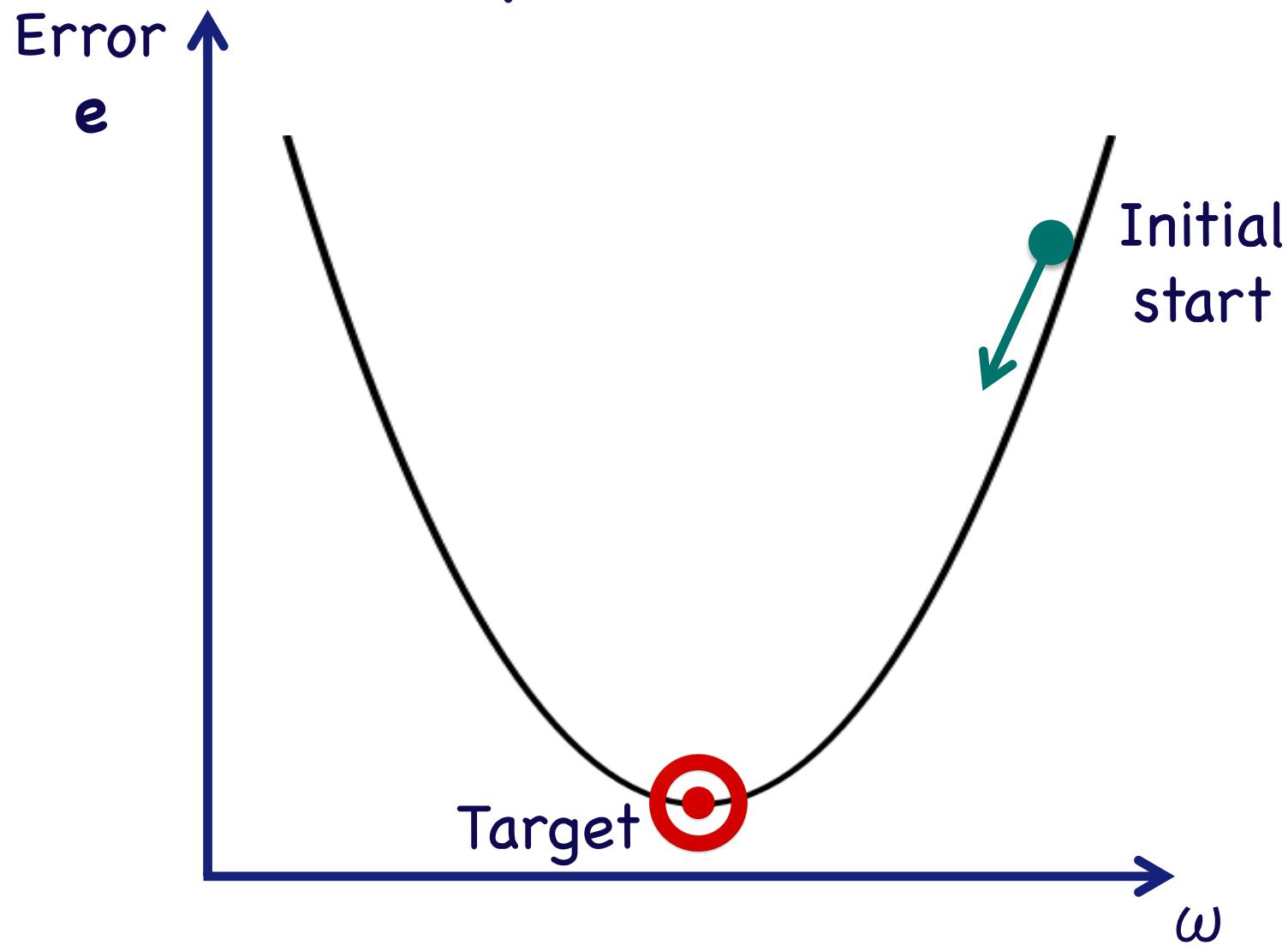
Measuring error



Cost function

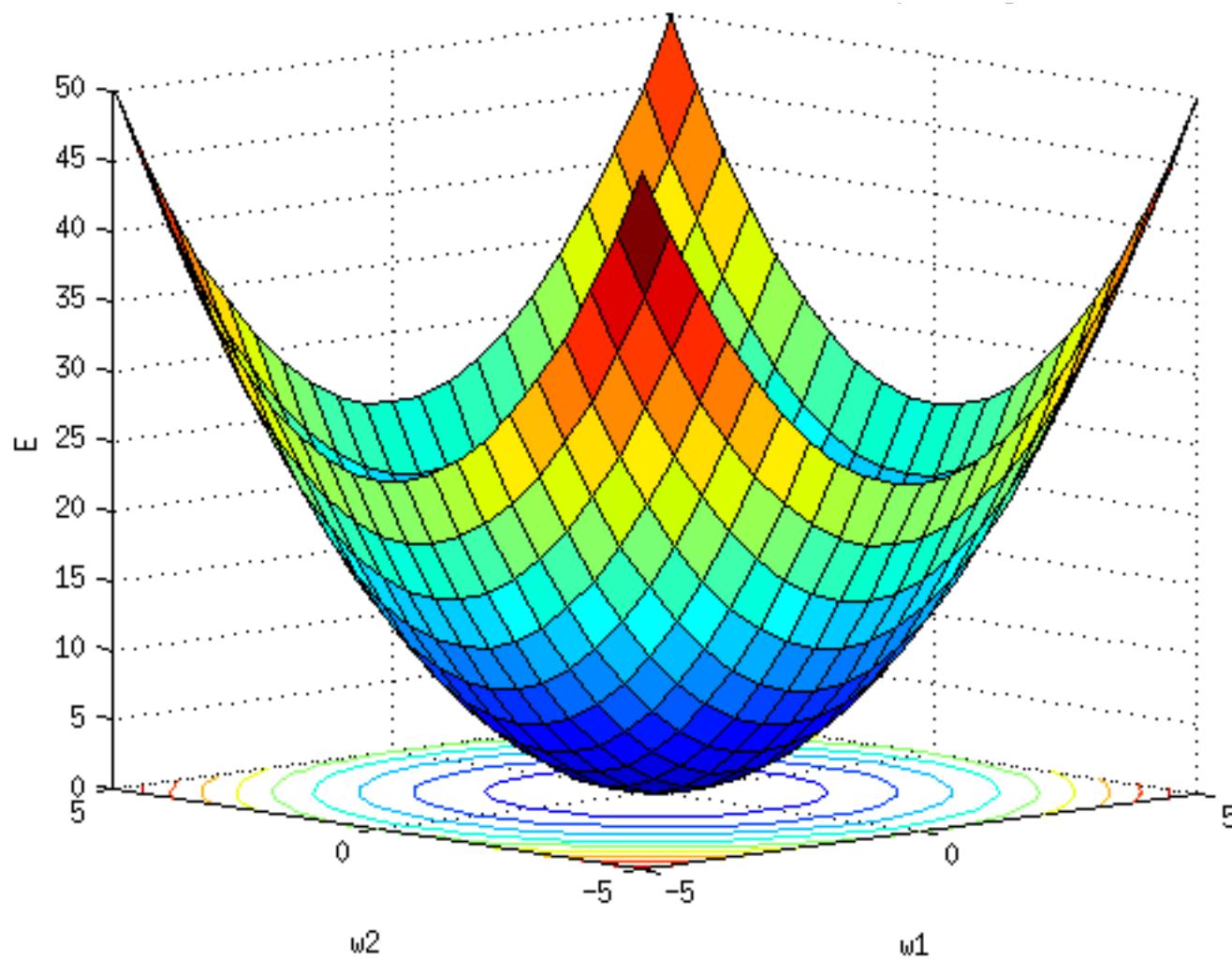


Optimization



Of course, there are many different types of cost functions and optimization algorithms, but the general idea is very similar.

Ideal Cost Function



Real-world Cost Function



Convolutional Neural Network Quadratic Discriminant Analysis

Generative Adversarial Networks Hierarchical clustering

Nearest Neighbor

Radial Basis Function Network

Support Vector Machine

Artificial Neural Network

K-means

Linear Regression

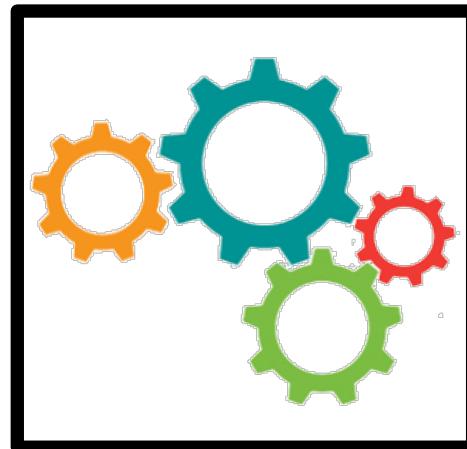
Naïve Bayes

Logistic Regression

AdaBoost Boosting

Self-Organizing Map

Decision Tree



Stepwise Regression

Ridge Regression

Random Forest LASSO

Recurrent Neural Network

Principle Component Analysis

Bayesian Network

Ordinary Least Squares Regression

Linear Discriminant Analysis

Gaussian Mixture Model

Convolutional Neural Network Quadratic Discriminant Analysis

Generative Adversarial Networks Hierarchical clustering

Nearest Neighbor

Radial Basis Function Network

Support Vector Machine

Artificial Neural Network

K-means

Linear Regression

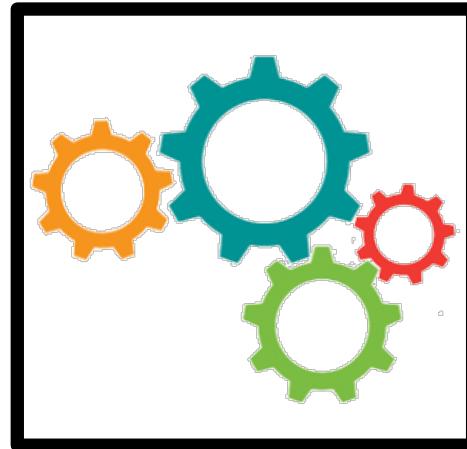
Naïve Bayes

Logistic Regression

AdaBoost Boosting

Self-Organizing Map

Decision Tree



Stepwise Regression

Ridge Regression

Random Forest

LASSO

Recurrent Neural Network

Principle Component Analysis

Bayesian Network

Ordinary Least Squares Regression

Linear Discriminant Analysis

Gaussian Mixture Model



<http://scikit-learn.org/stable/>

Machine Learning



what society thinks I do

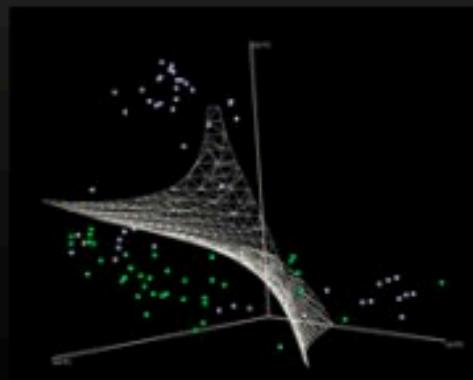


what my friends think I do



what my parents think I do

$$\begin{aligned}L_p &= \frac{1}{2}\|\mathbf{w}\|^2 - \sum_{i=1}^n \alpha_i y_i (\mathbf{x}_i \cdot \mathbf{w} + b) + \sum_{i=1}^n \alpha_i \\ \alpha_i &\geq 0, \forall i \\ \mathbf{w} &= \sum_{i=1}^n \alpha_i y_i \mathbf{x}_i, \quad \sum_{i=1}^n \alpha_i = 0 \\ \nabla g(\theta_t) &= \frac{1}{n} \sum_{i=1}^n \nabla \ell(x_i, y_i; \theta_t) + \nabla r(\theta_t). \\ \theta_{t+1} &= \theta_t - \eta_t \nabla \ell(x_{i(t)}, y_{i(t)}; \theta_t) - \eta_t \cdot \nabla r(\theta_t) \\ E_{i(t)}[\ell(x_{i(t)}, y_{i(t)}; \theta_t)] &= \frac{1}{n} \sum_{i=1}^n \ell(x_i, y_i; \theta_t).\end{aligned}$$



```
>>> from sklearn import svm
```

what other programmers think I do

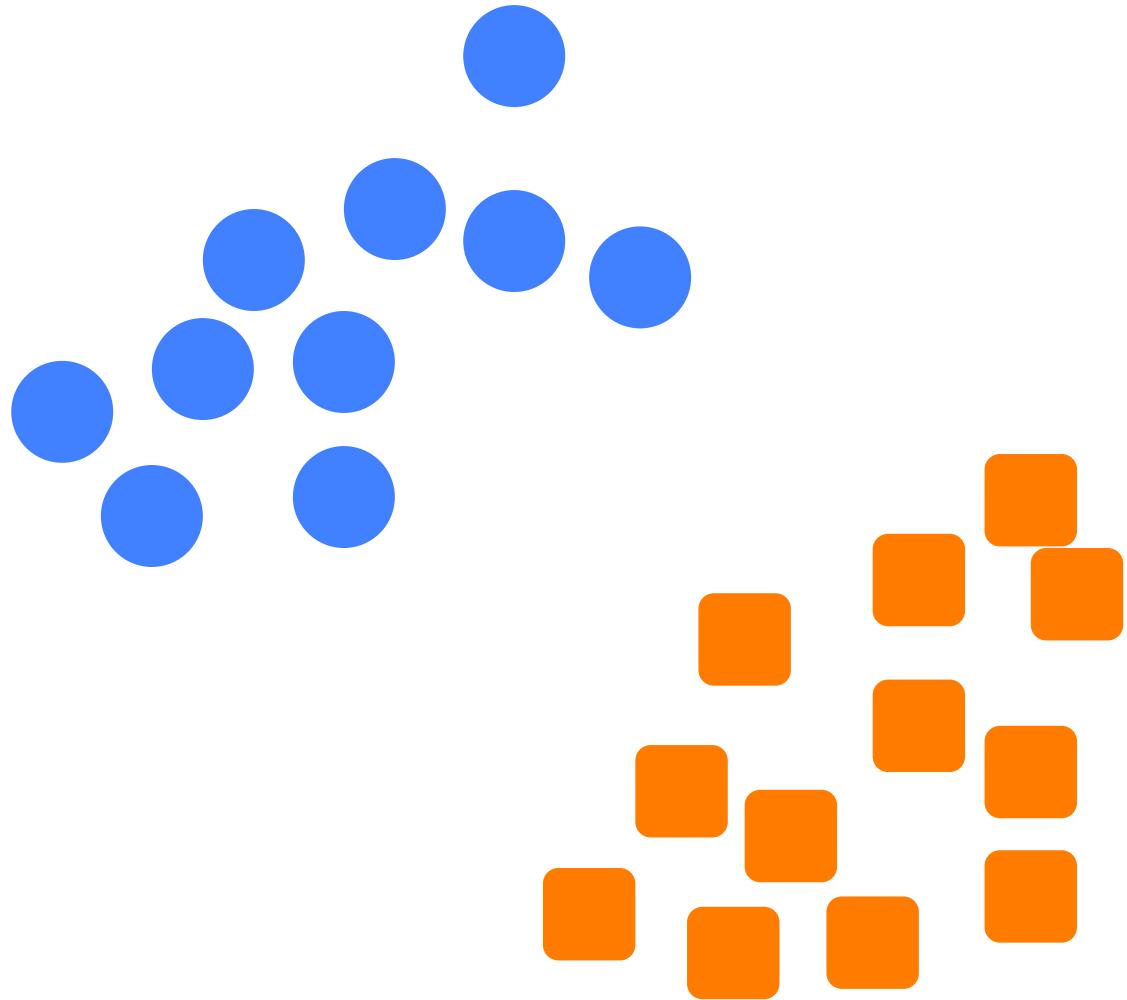
what I think I do

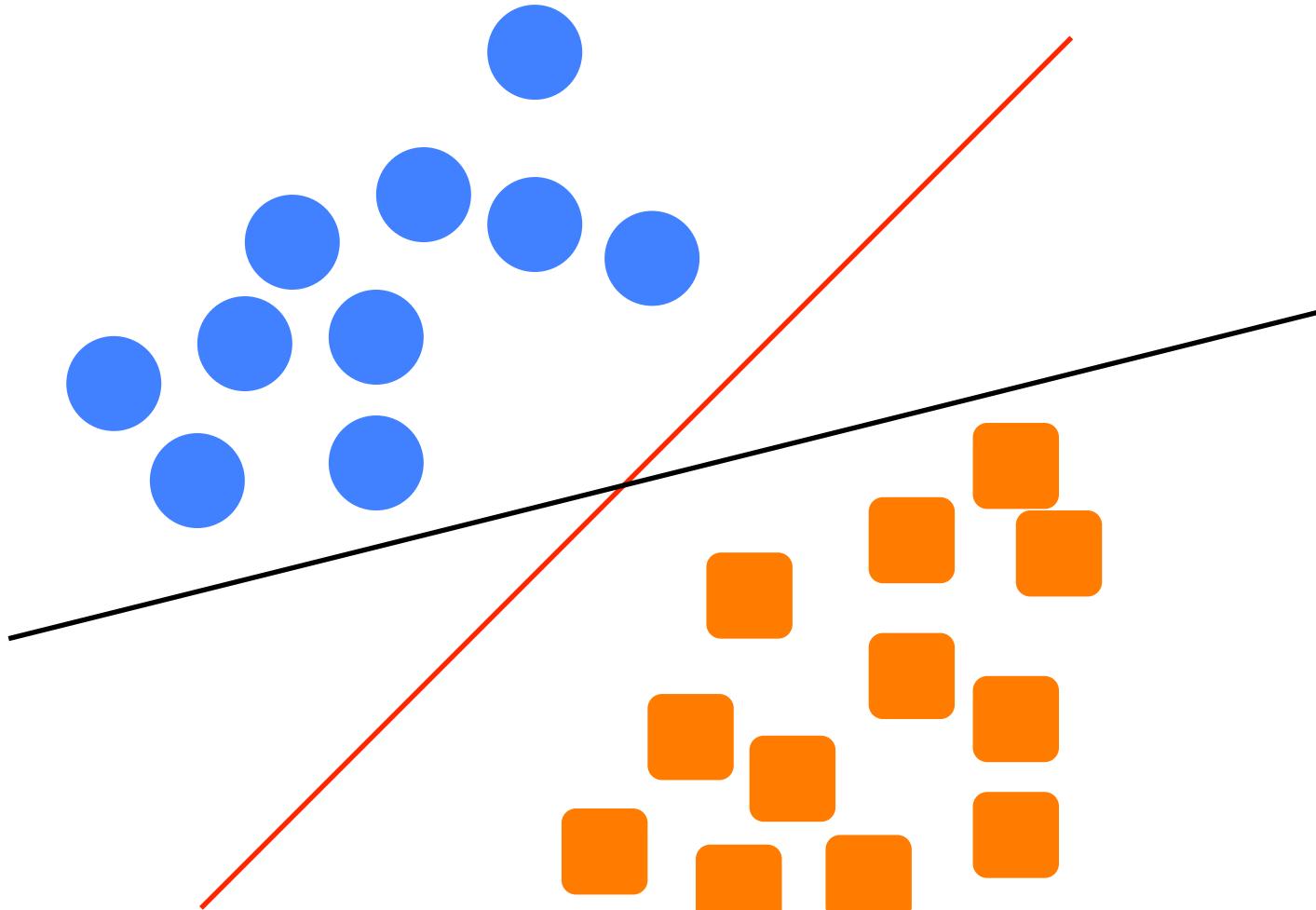
what I really do

Go to notebook 01

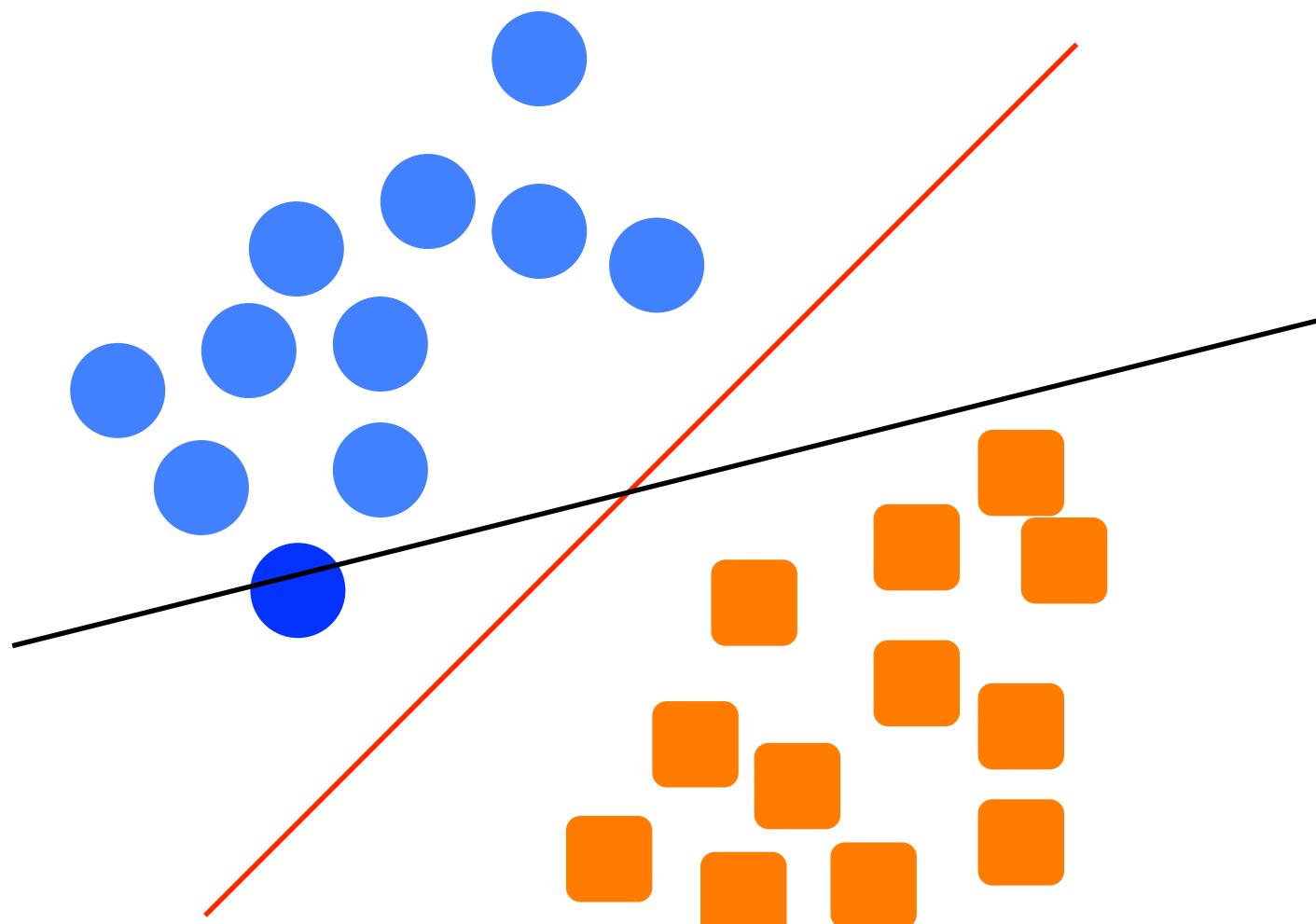
Classification

Support Vector Machine
Artificial Neural Network

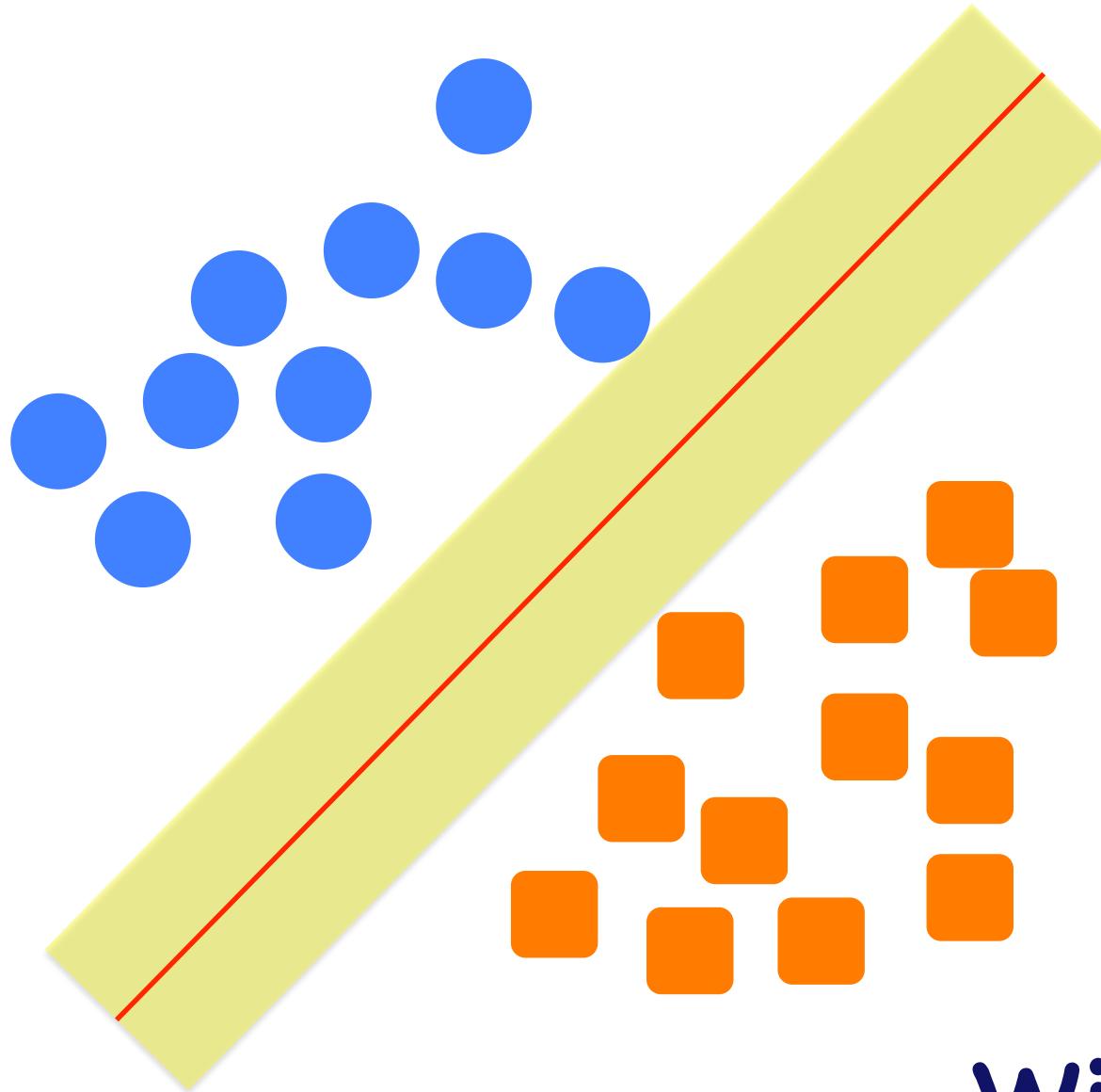




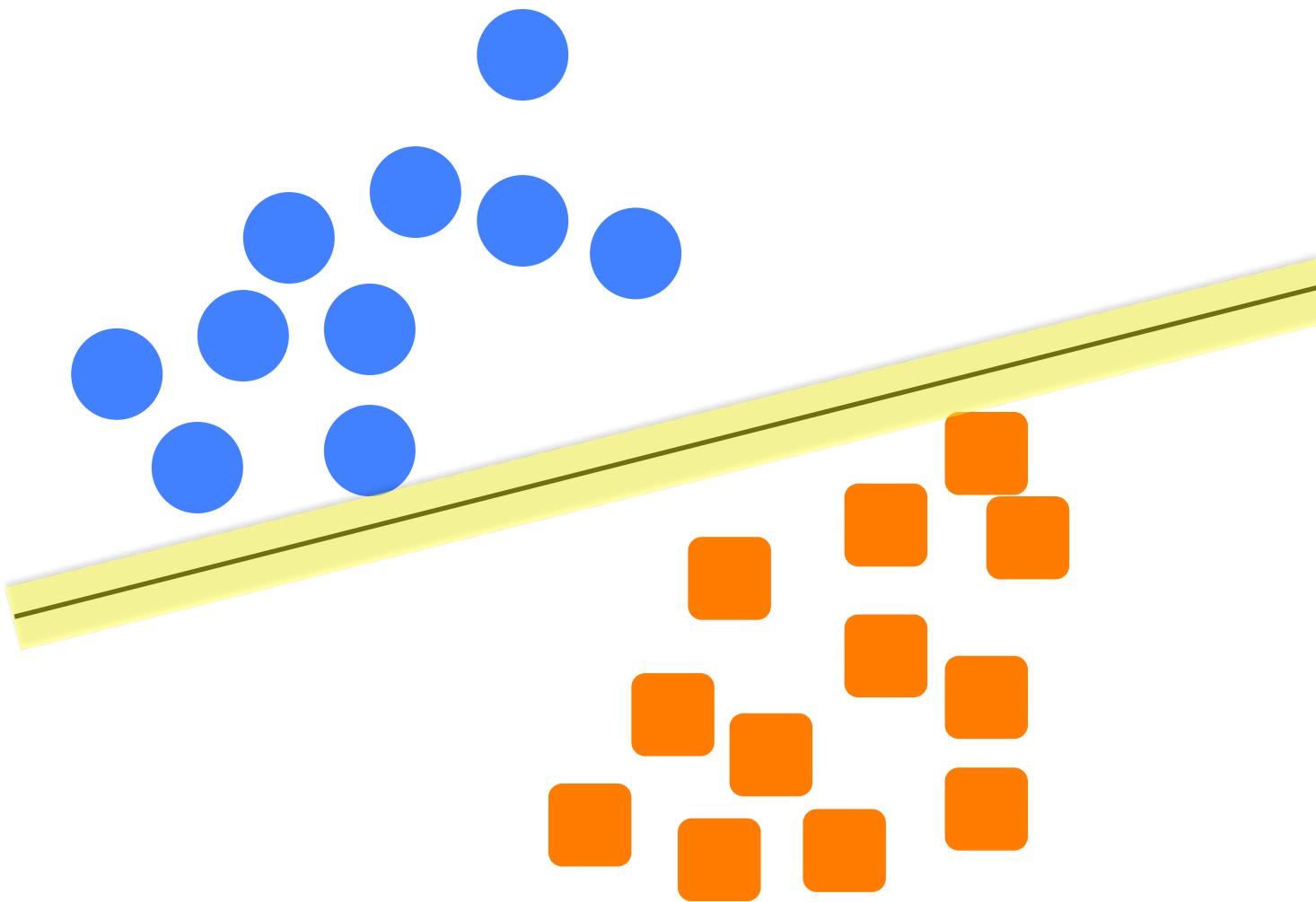
Which one is
better?



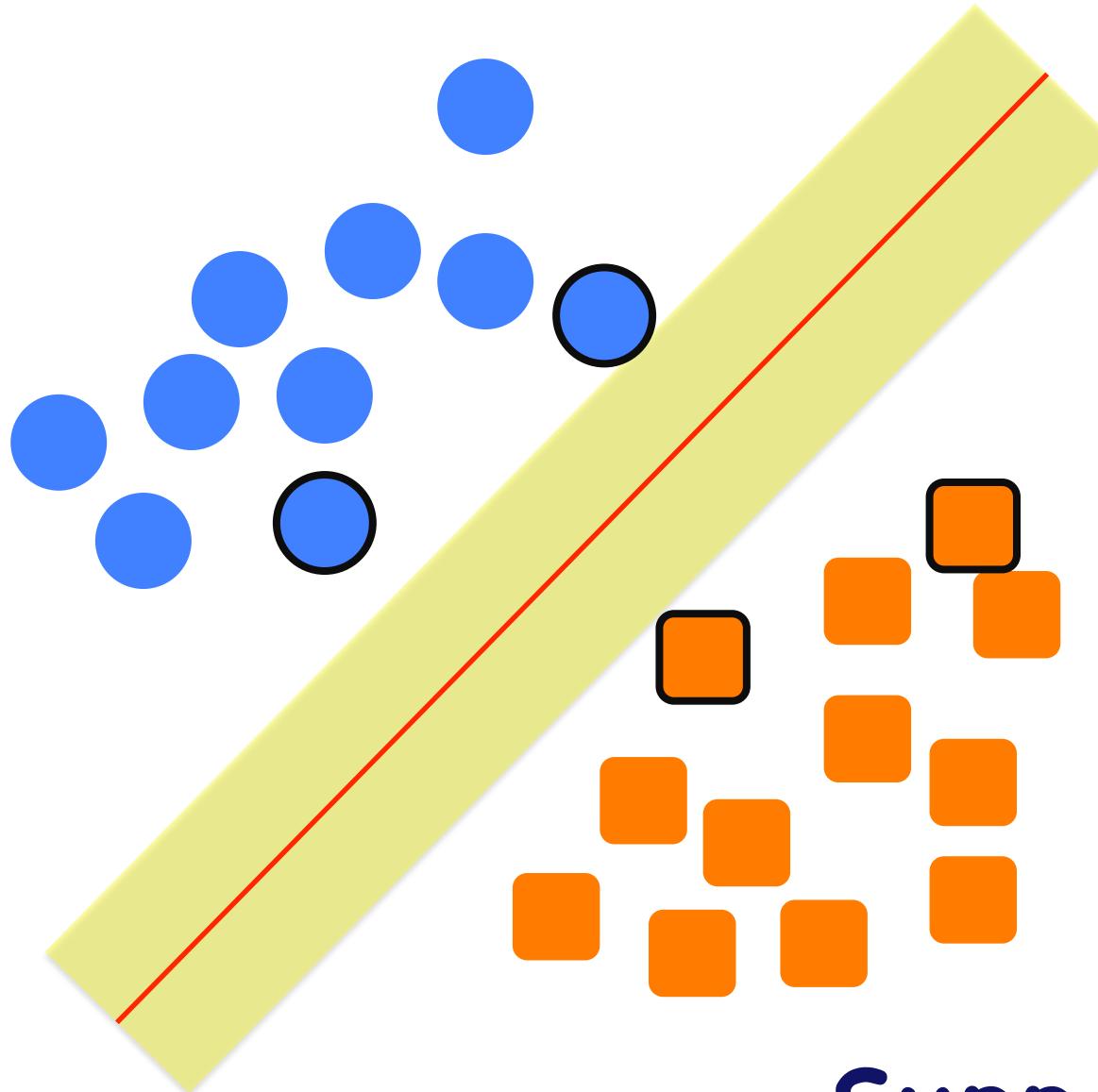
A new data point



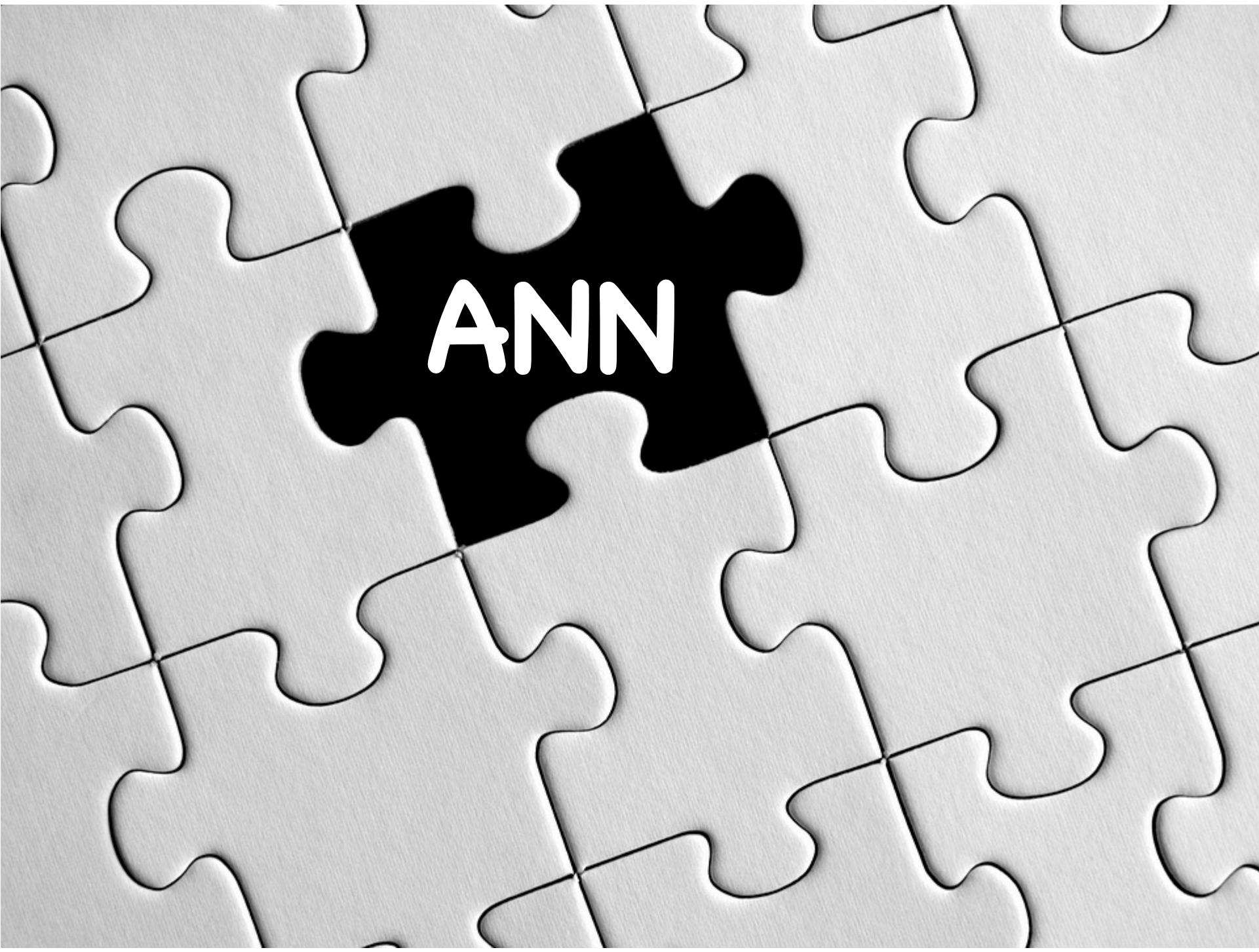
Wide margin



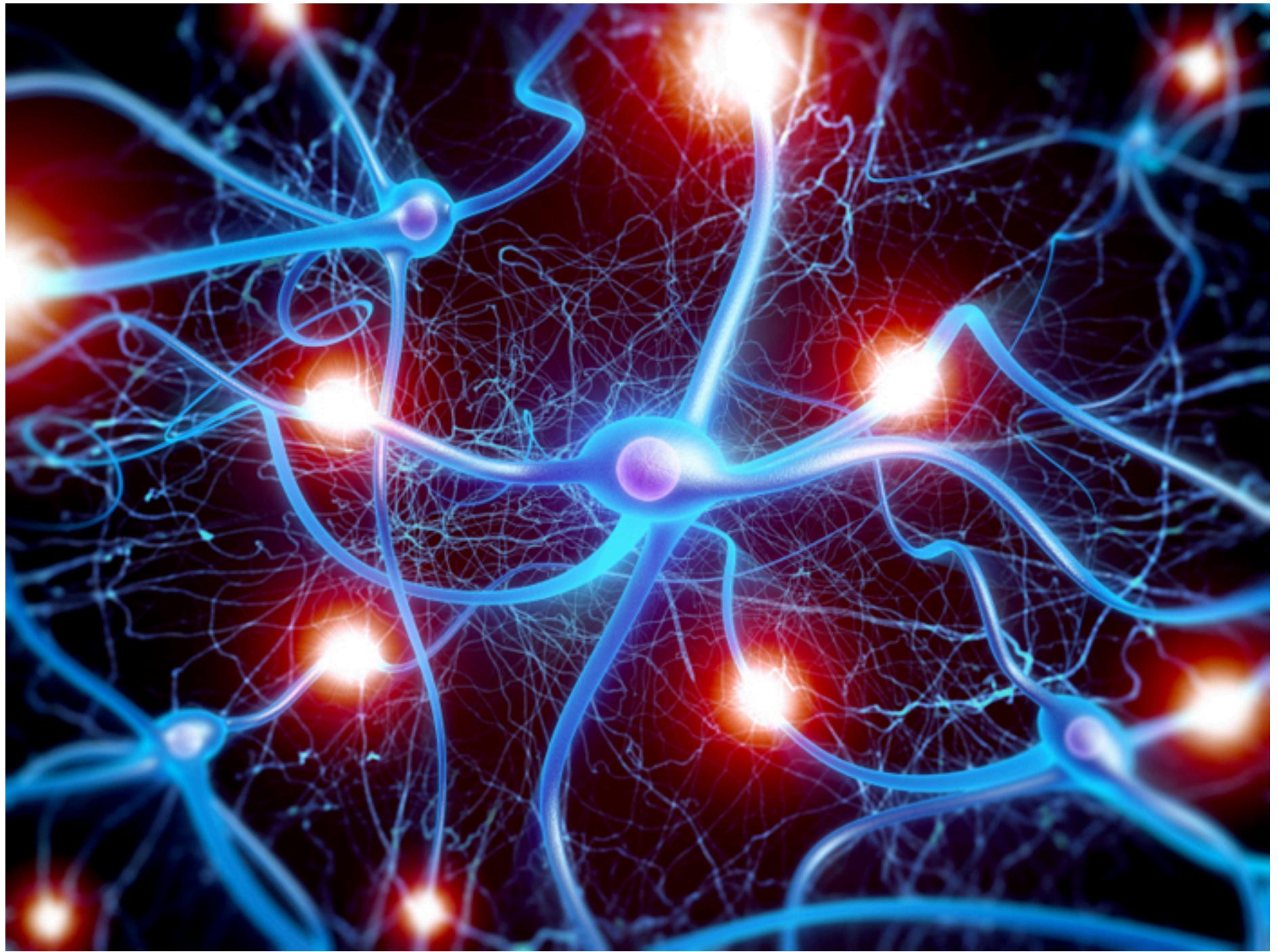
Narrow margin

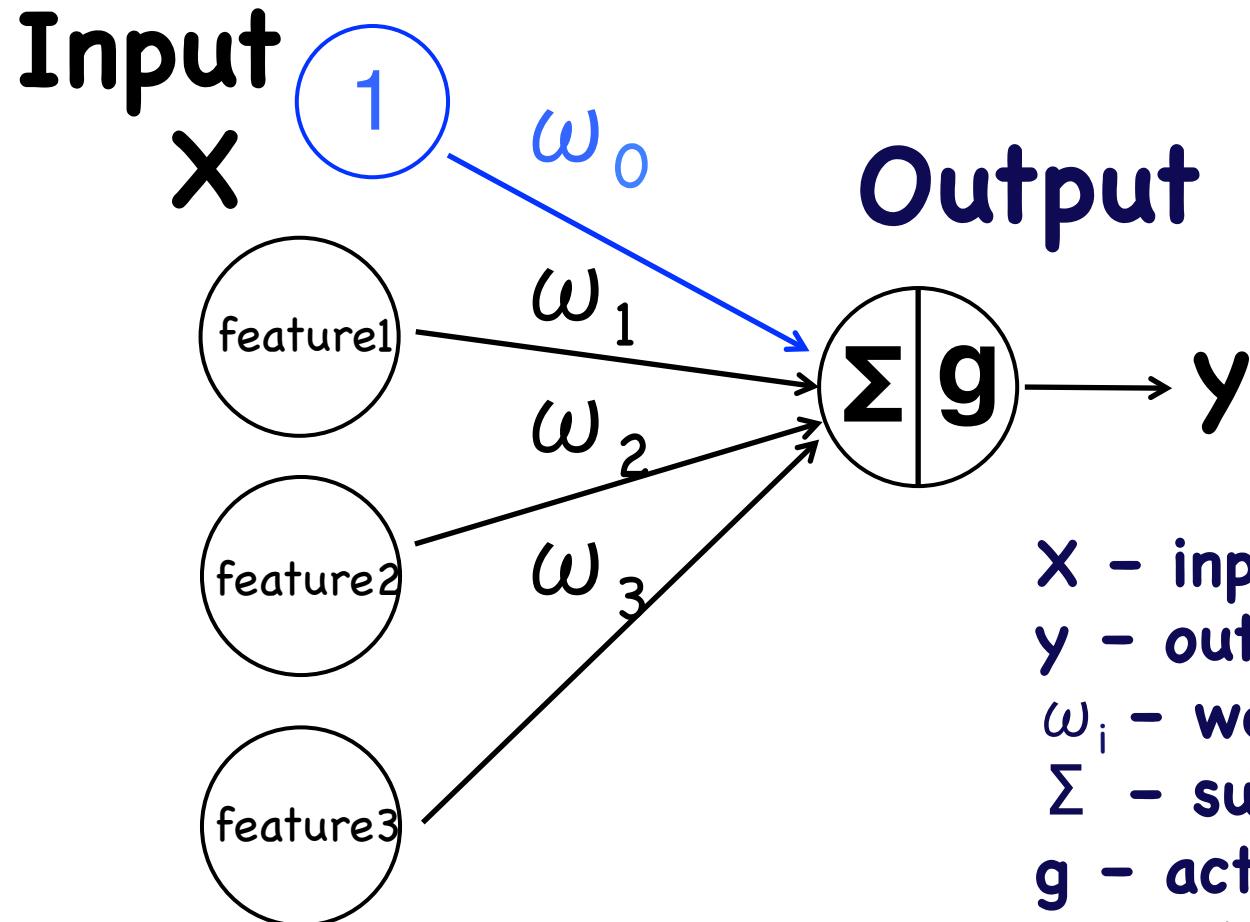


Support Vectors



ANN



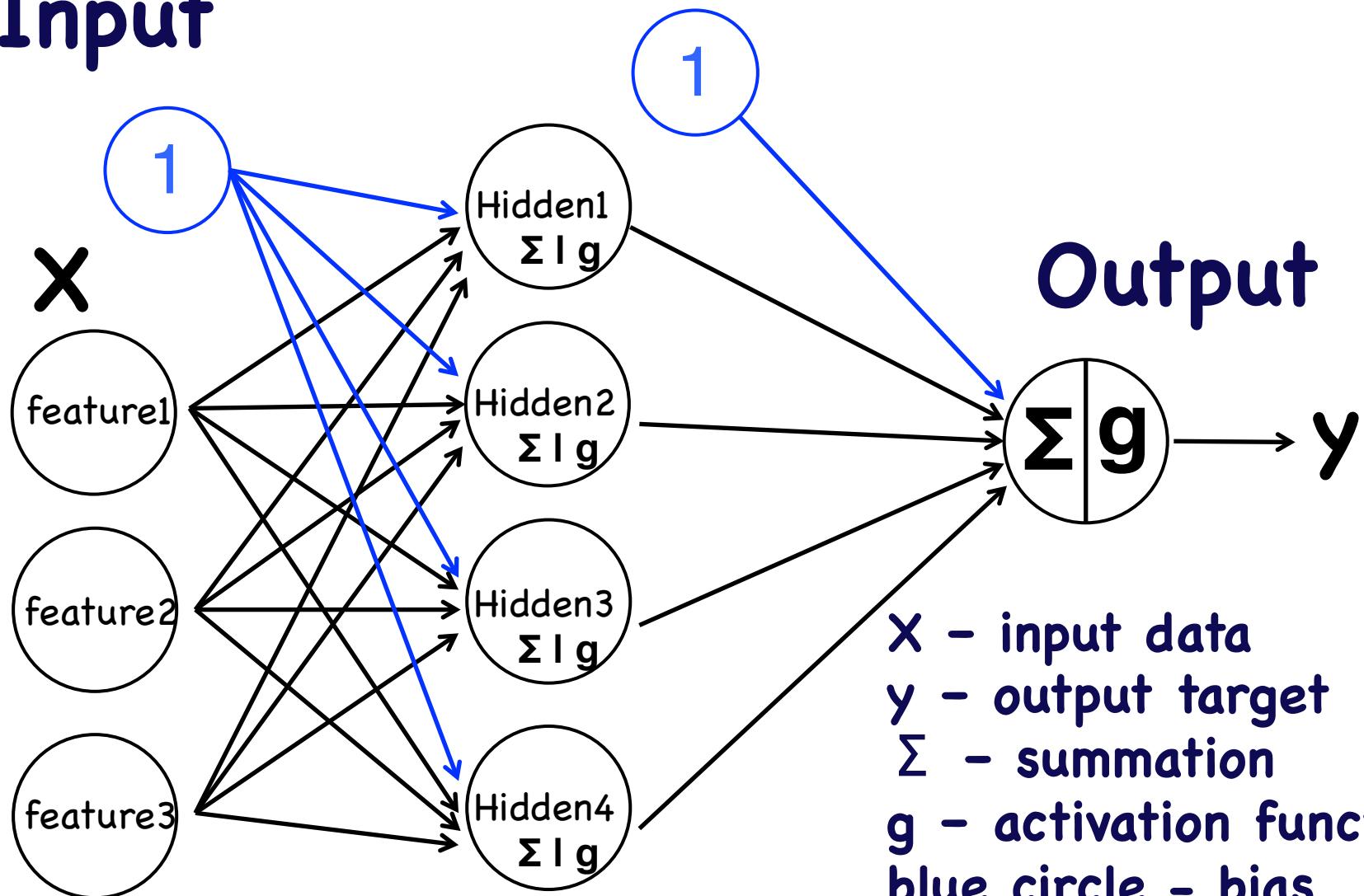


x - input data
 y - output target
 ω_i - weights
 Σ - summation
 g - activation function
 Blue circle - bias

$$Z = \Sigma = \omega_0x_0 + \omega_1x_1 + \omega_2x_2 + \omega_3x_3 + \dots + \omega_nx_n$$

$$y = g(\omega_0x_0 + \omega_1x_1 + \omega_2x_2 + \omega_3x_3 + \dots + \omega_nx_n)$$

Input



x - input data
 y - output target
 Σ - summation
 g - activation function
blue circle - bias



YOU'RE IN MY SPOT

GRAPHICS GARAGE

Input



•
•
•



Intuitive Artificial Neural Network

$$w_1 \quad \downarrow \\ w_2 \quad \downarrow \\ \vdots \\ w_n \quad \uparrow$$

$$F(\text{eye} \times w_1 + \text{nose} \times w_2 + \dots + \text{mouth} \times w_n)$$



Output



Input



•
•
•



Intuitive Artificial Neural Network

Output

$$F(\text{eye} \times w_1 + \text{nose} \times w_2 + \dots + \text{mouth} \times w_n)$$



error
feedback



Input



•
•
•



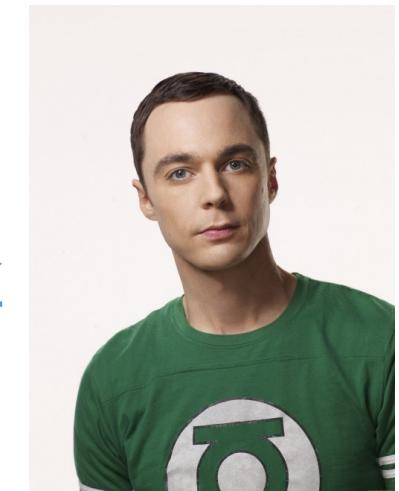
Intuitive Artificial Neural Network

Output

$$F(\text{eye} \times w_1 + \text{nose} \times w_2 + \dots + \text{mouth} \times w_n)$$



error
feedback



Input



•
•
•



Intuitive Artificial Neural Network

$$w_1$$

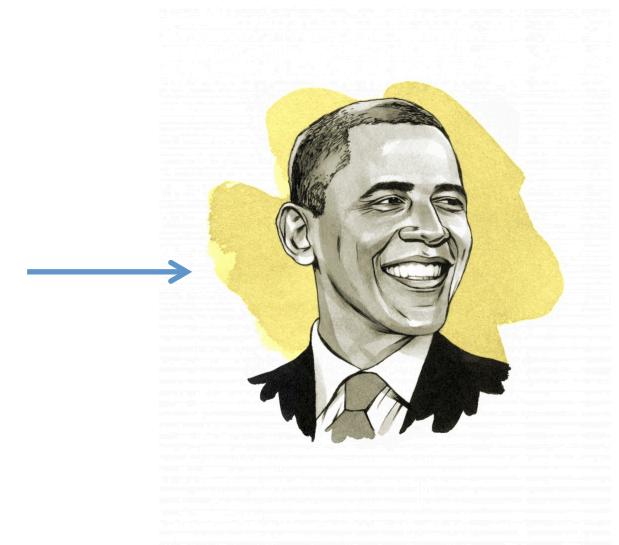
$$w_2$$

$$w_n$$

$$F(\text{eye} \times w_1 + \text{nose} \times w_2 + \dots + \text{mouth} \times w_n)$$



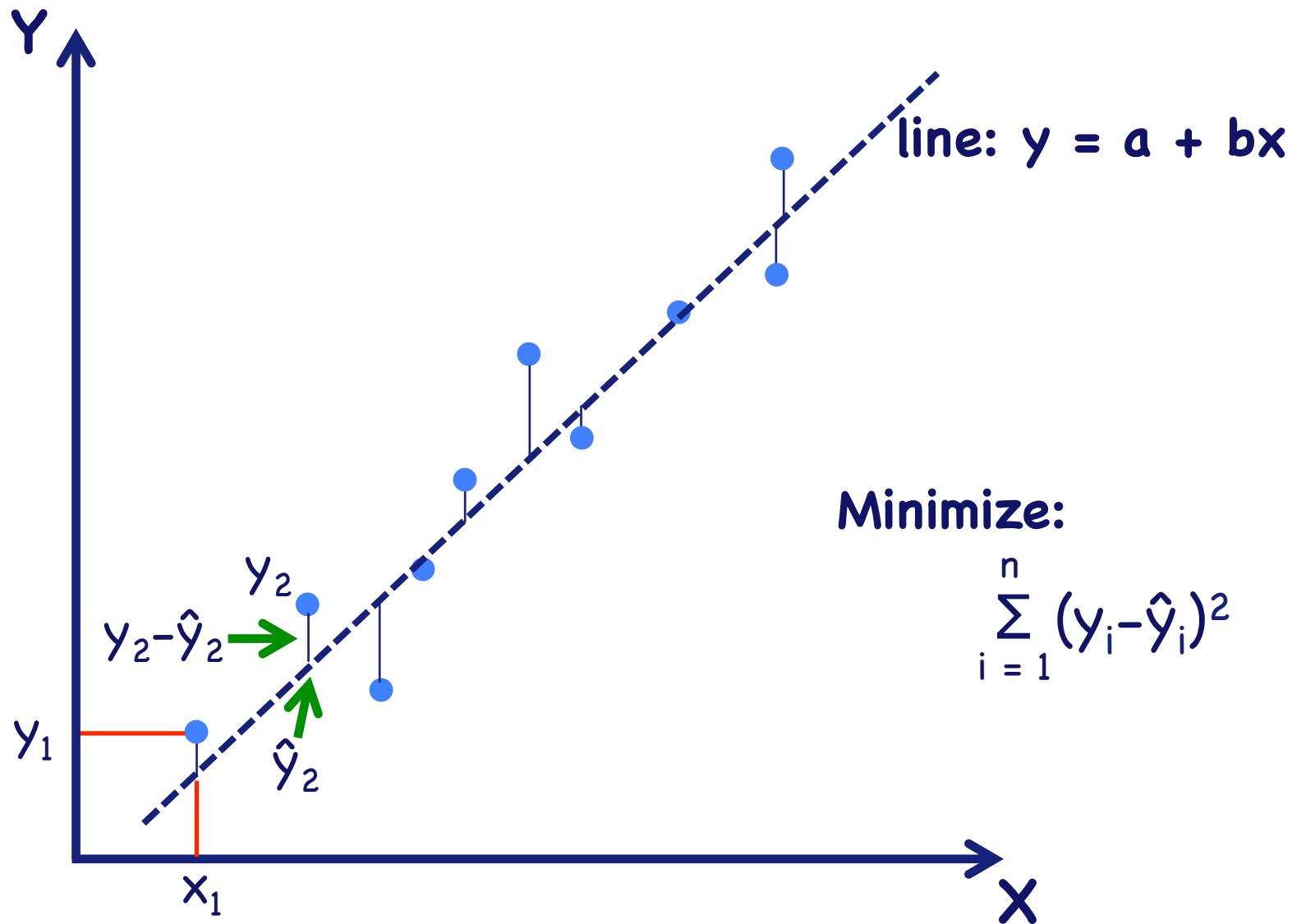
Output



Go to notebook 02

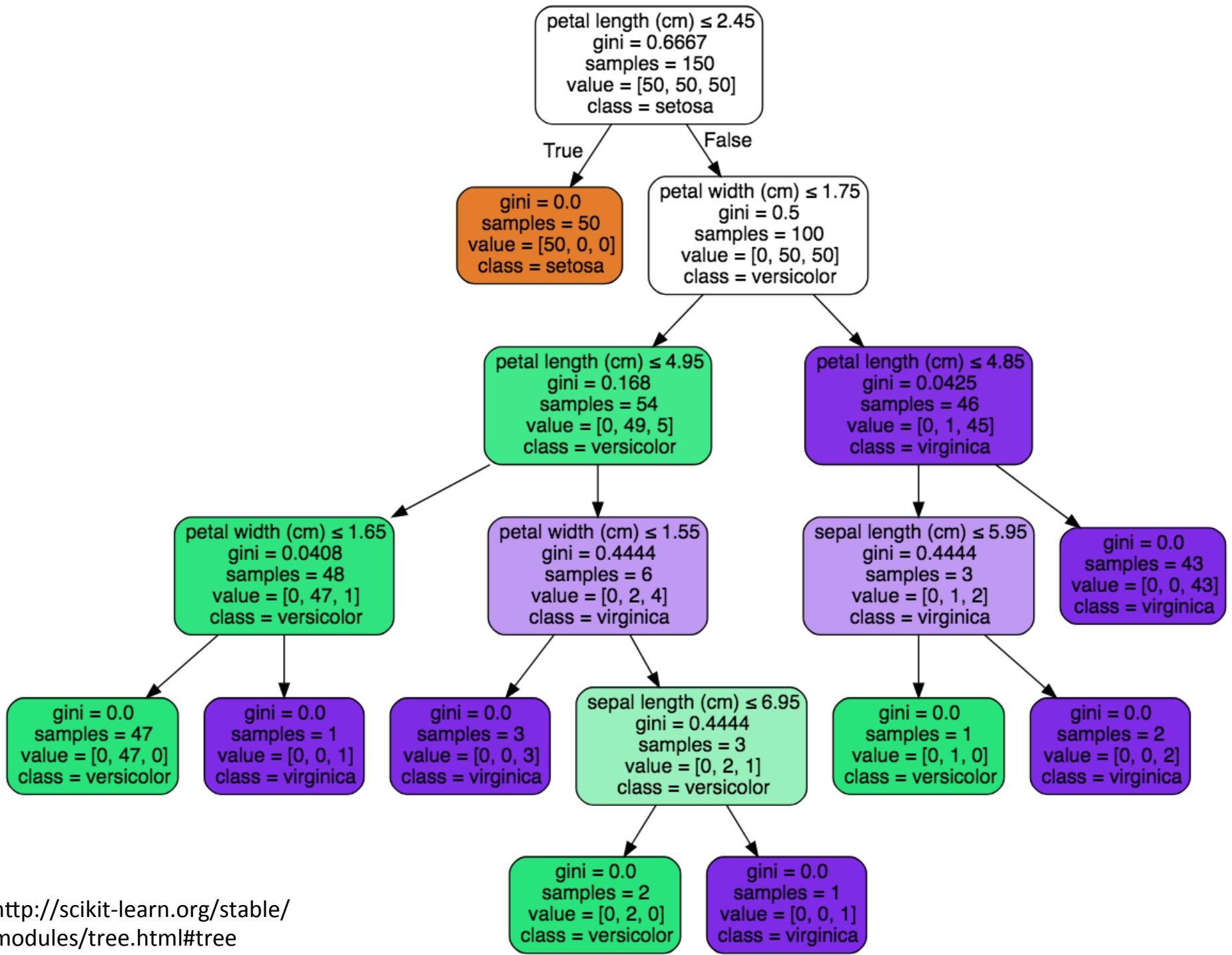
Regression

Simple linear regression

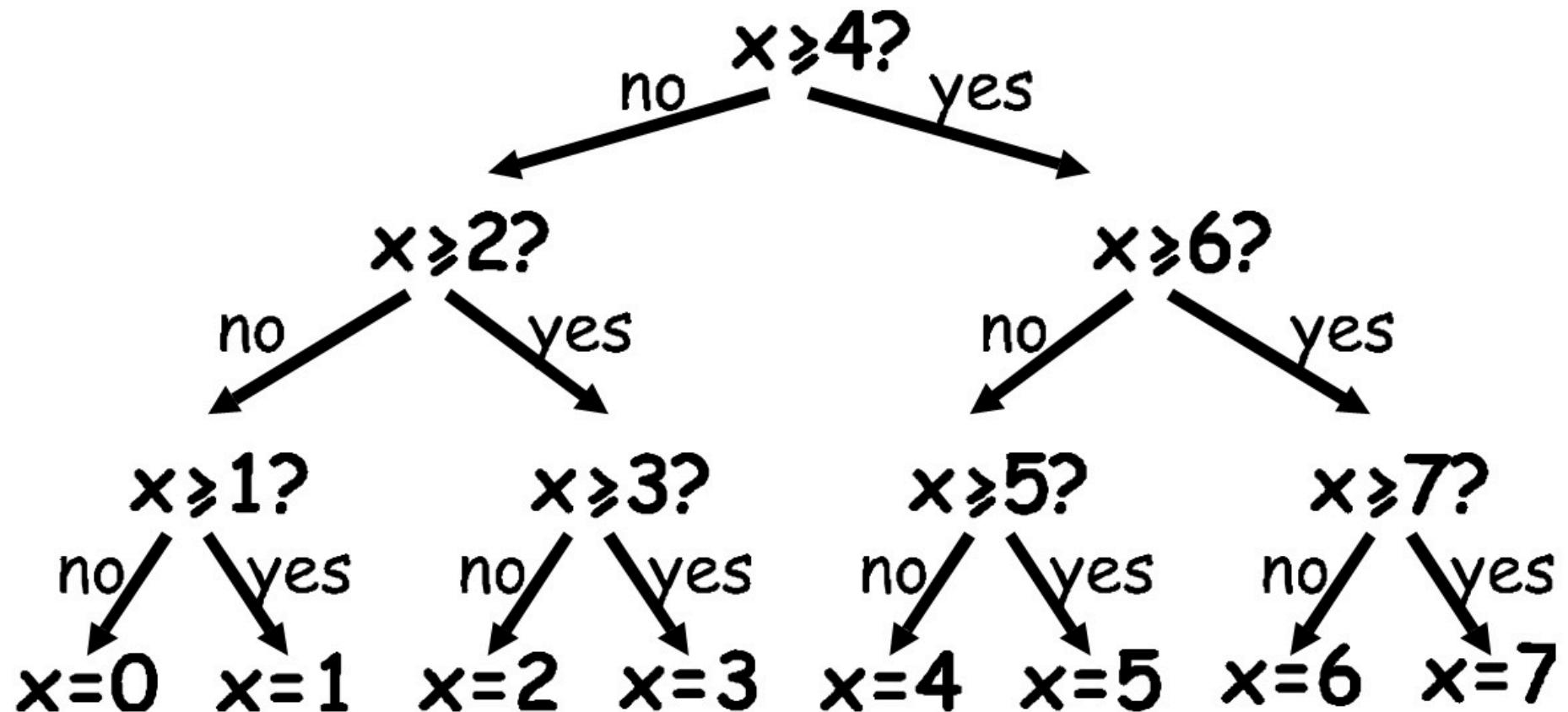


Random Forest

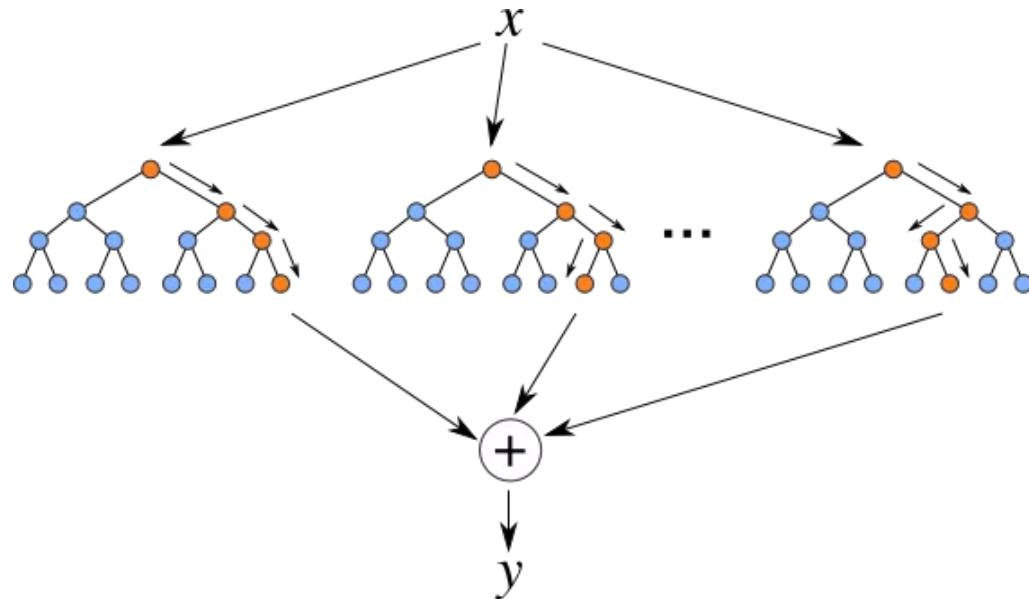




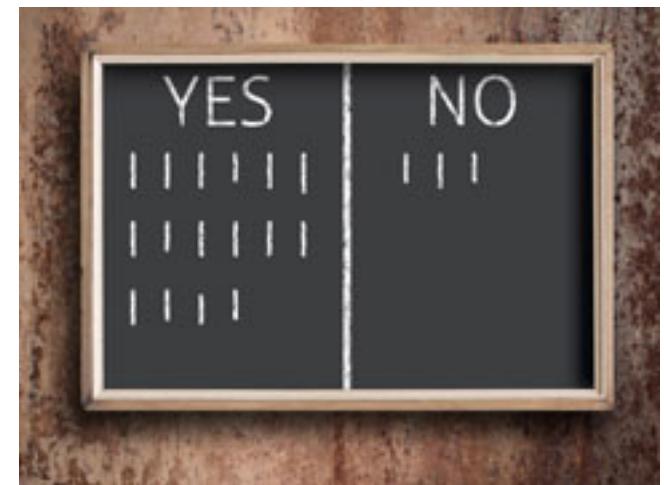
Decision Trees



Random Forest



Majority vote



Go to notebook 03

Unsupervised

Principle component analysis
K-means

PCA

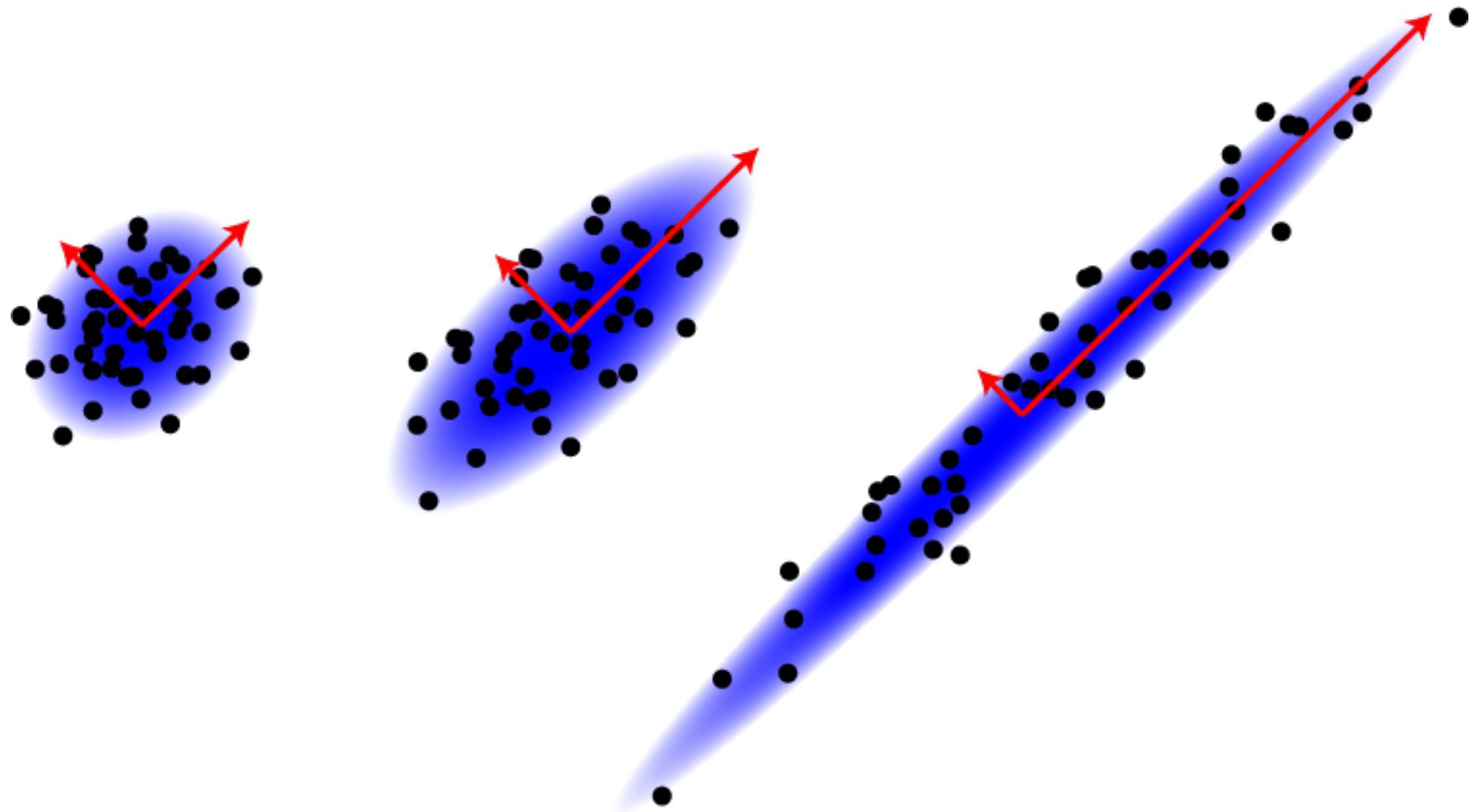
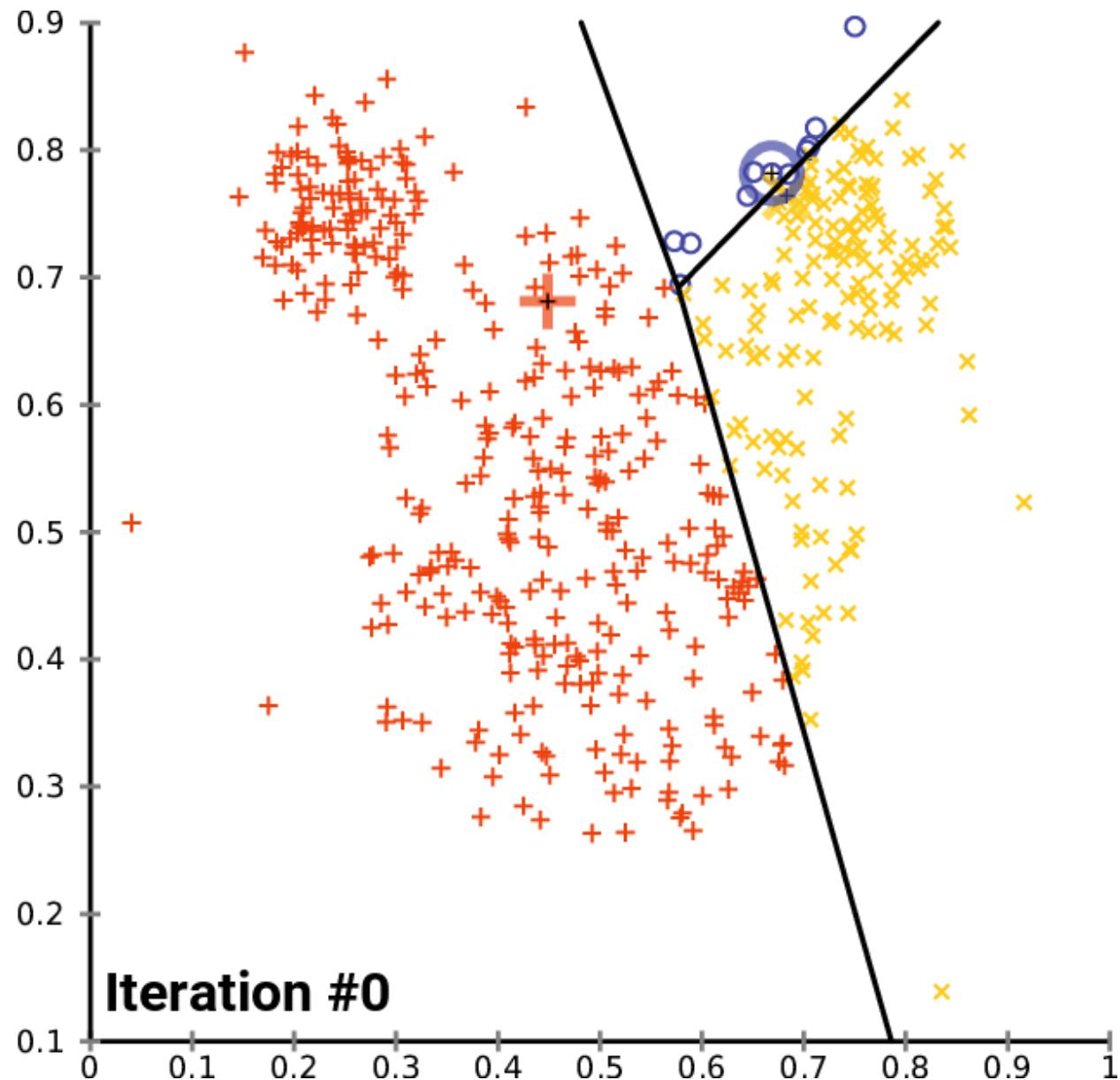


Figure from: <https://shapeofdata.wordpress.com/2013/04/09/principle-component-analysis/>

Kmeans



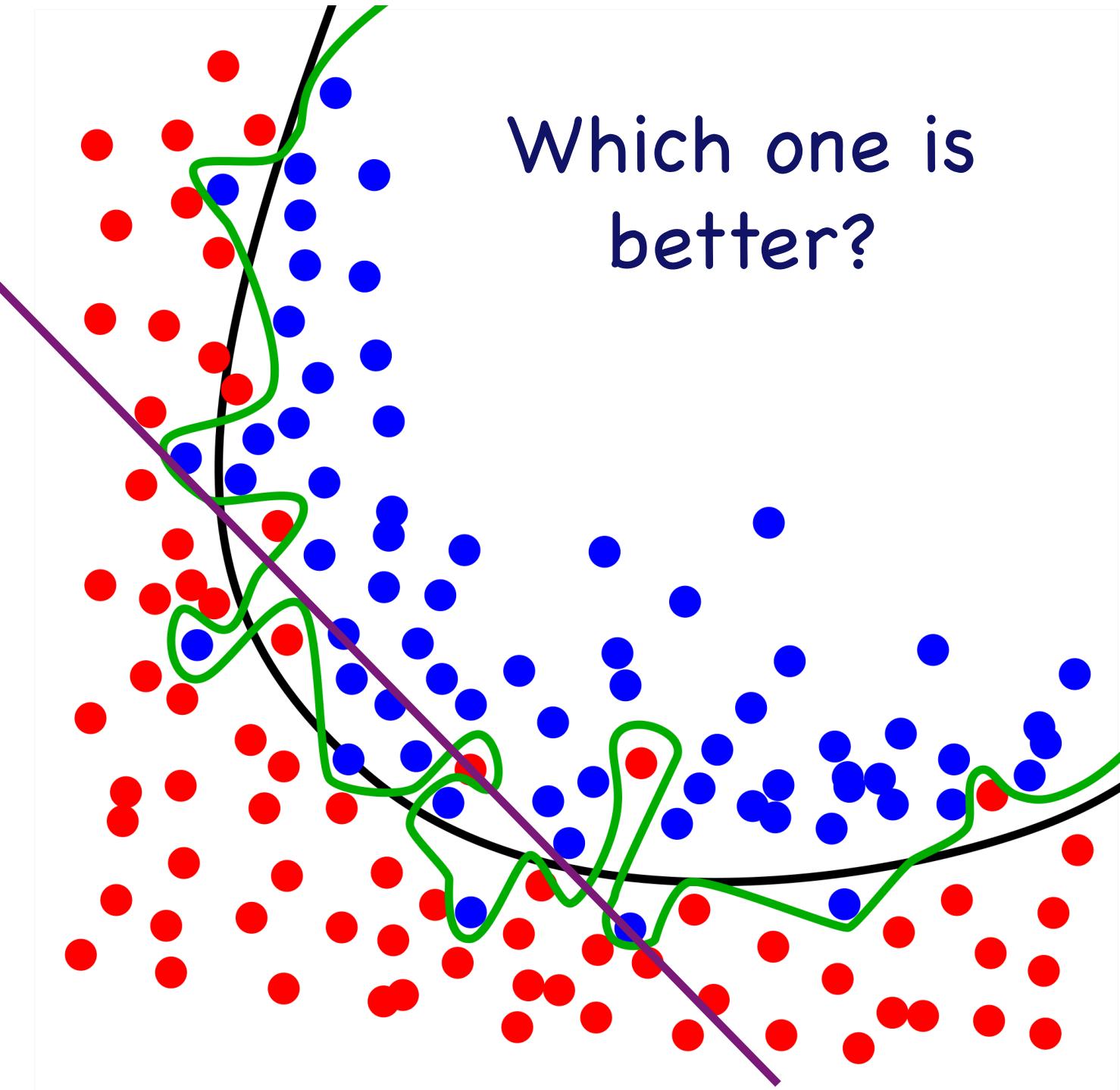
Go to notebook 04

More on common practices

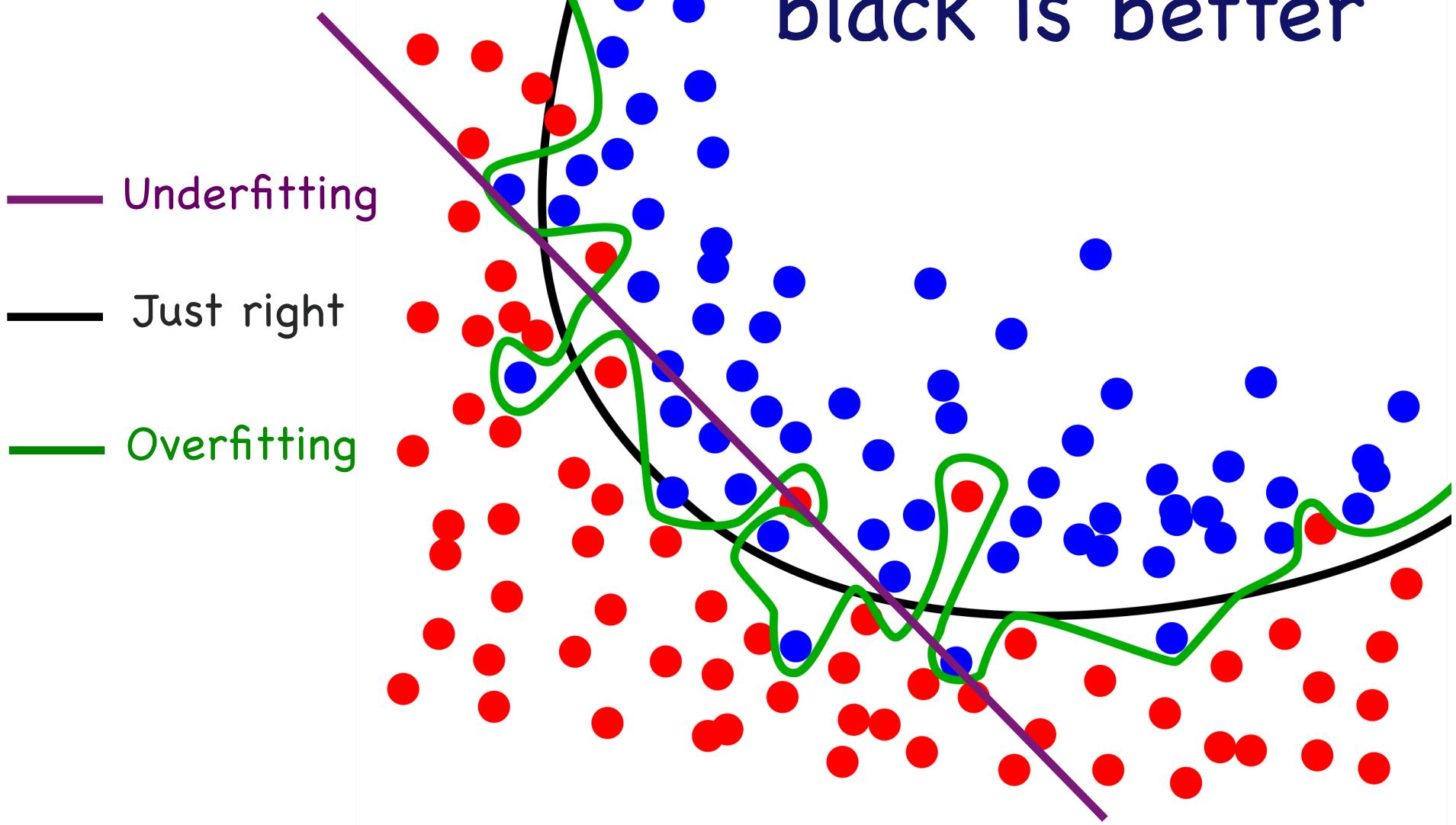
Machine learning is all about
Generalization

Which one is
better?

— ?
— ?
— ?



Clearly,
black is better

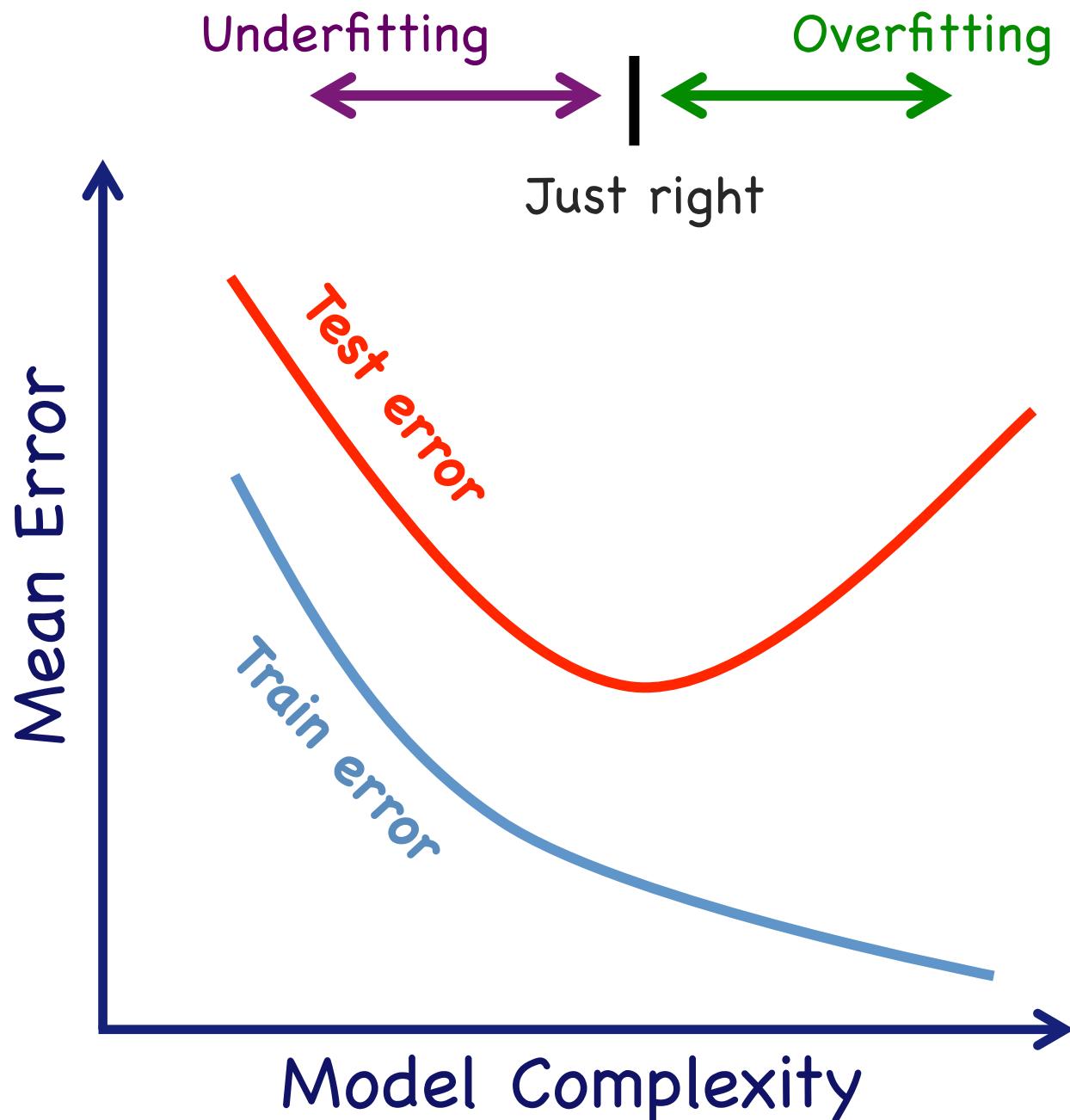


Train/test dataset split



Train/test dataset split



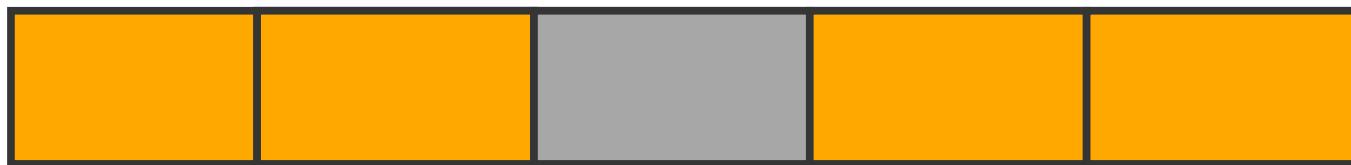


5-fold cross-validation

Test



Train





Data
processing

Shift

Why do we need?

Age	Salary
24	\$110,000
36	\$130,000
38	\$80,000
44	\$420,000
27	\$420,000
43	\$12,000,000
...	...

Many ways

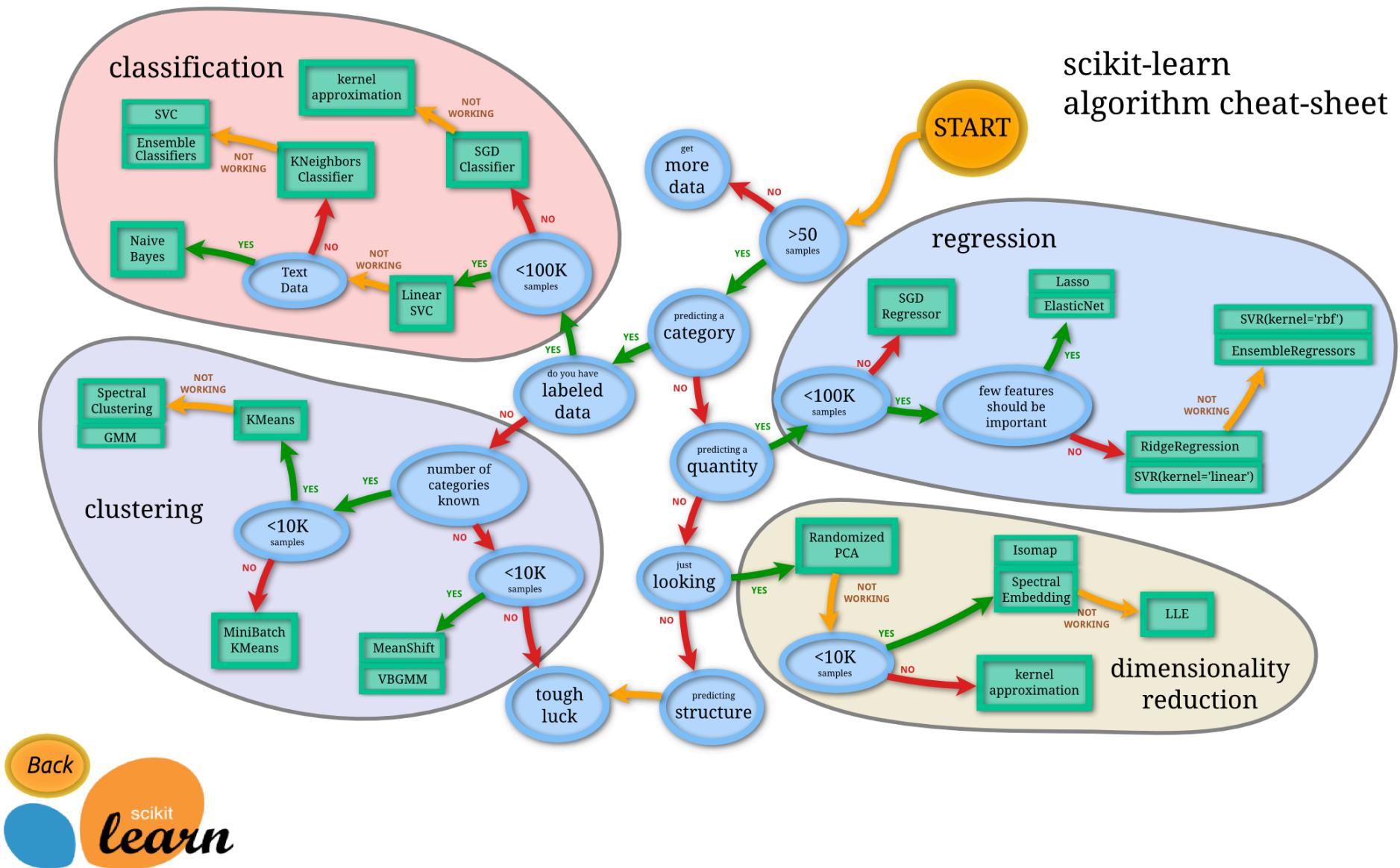
- **Standardization**
 - Zero mean and unit variance
- **Scale to a range**
 - i.e. (0, 1)
- **Normalization**
 - Unit norm
- ...

Check out: <http://scikit-learn.org/stable/modules/preprocessing.html>

Go to notebook 05

More resources

scikit-learn algorithm cheat-sheet



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

Conclude with notebook 06