Intro to ML

marco milanesio
MS DATA SCIENCE 2020-2021

The problem

- *n* samples
- predict properties of the unknown

The problem

- *n* samples
- predict properties of the unknown
- that is: learn what the properties are

The problem

- *n* samples
- predict properties of the unknown
- that is: learn what the properties are
- learning:
  - supervised
    - we know some of the attributes
  - unsupervised
    - we know nothing (almost)

ML in a nutshell

- supervised learning
  - classification
    - finite set of labels
  - regression
    - “classification” in the continuum
- unsupervised learning:
  - clustering
    - “similarity”
  - density estimation
    - distribution
  - dimensionality reduction

pipeline

- gather the data
- clean the data
- create a model
- fit a model
- predict
- evaluate

training/testing

- learning from training set
- predicting on testing set (unknown)
- 80-20 / 70-30
- overfitting
- imbalanced datasets:
  - oversampling
  - undesampling

scikit-learn

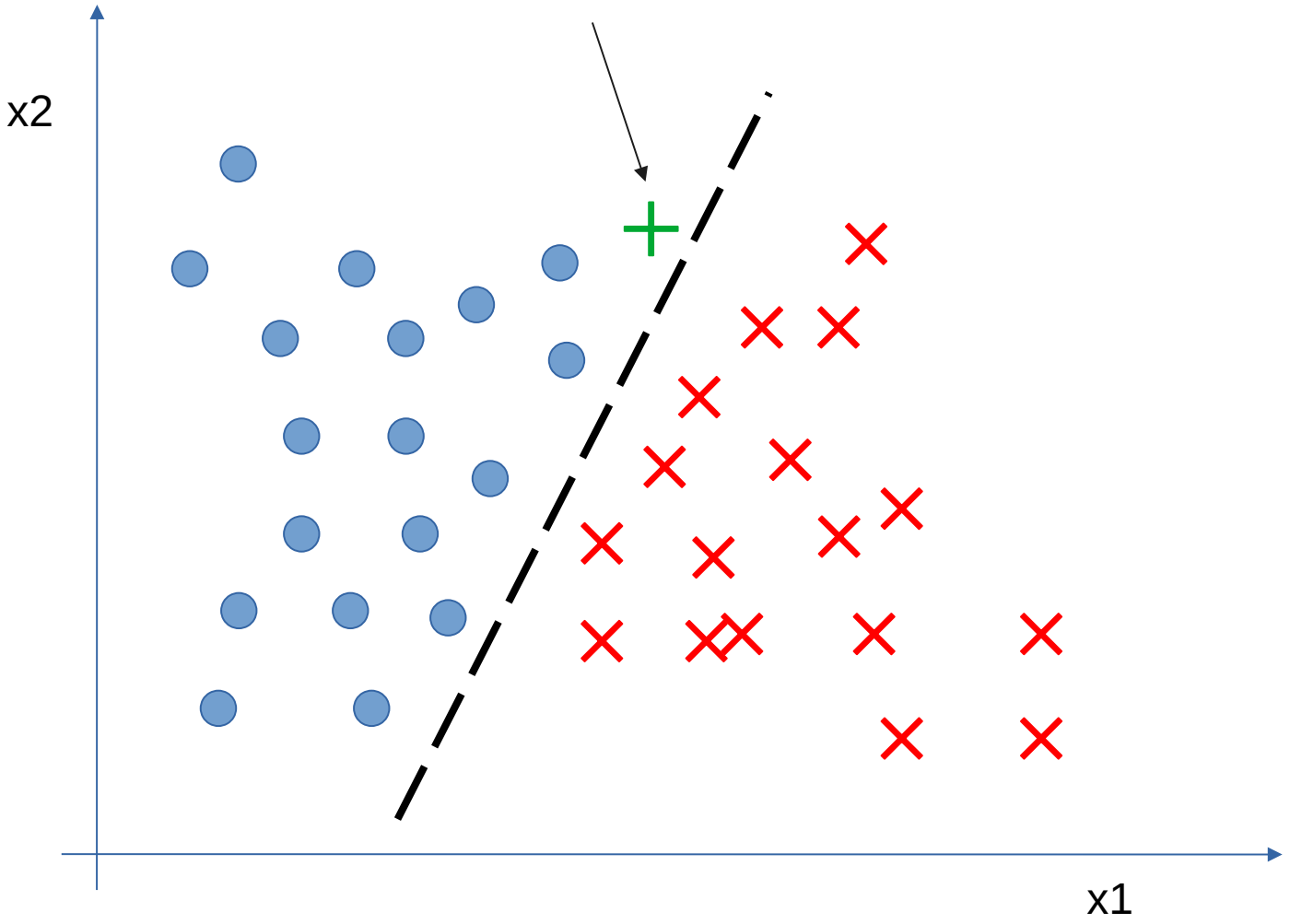
```
from sklearn import modelXYZ
from sklearn.metrics import some_score


my_model = modelXYZ(*args, **kwargs)
my_model.fit(training_set)
prediction = my_model.predict(testing_set)

print(some_score(ground_truth, prediction))
```

SUPERVISED LEARNING

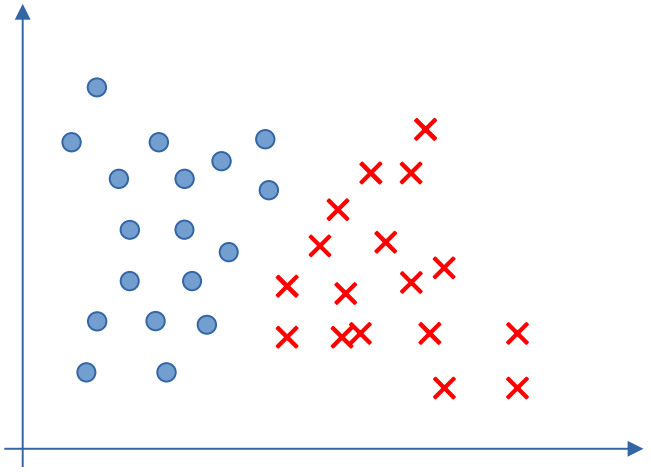
classification

- Goal: predict the **categorical** class labels
  - discrete
  - unordered
  - group membership
- Binary classification
  - spam / no spam
  - cat / no cat
- Multi-class classification
  - handwritten digits

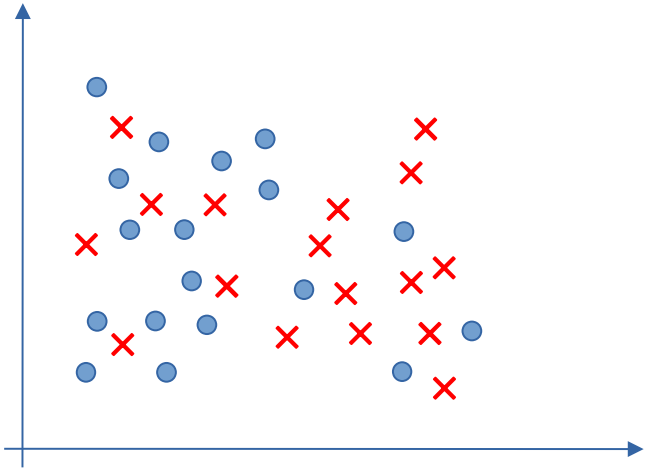
classification



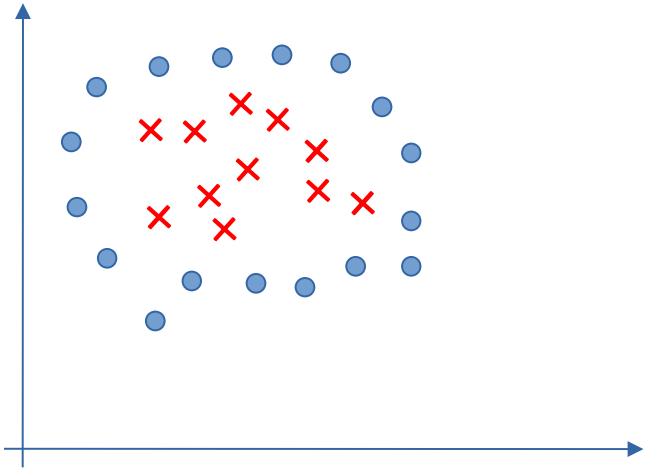
classification



linearly separable



non linearly separable



non linearly separable

classification

- logistic regression
- support vector machine
- decision tree
- random forest
- KNN

logistic regression

- perfect for linearly separable
- can be extended to multiclass

$$\text{logit}(P) = \log \frac{P}{1-P}$$

logistic regression

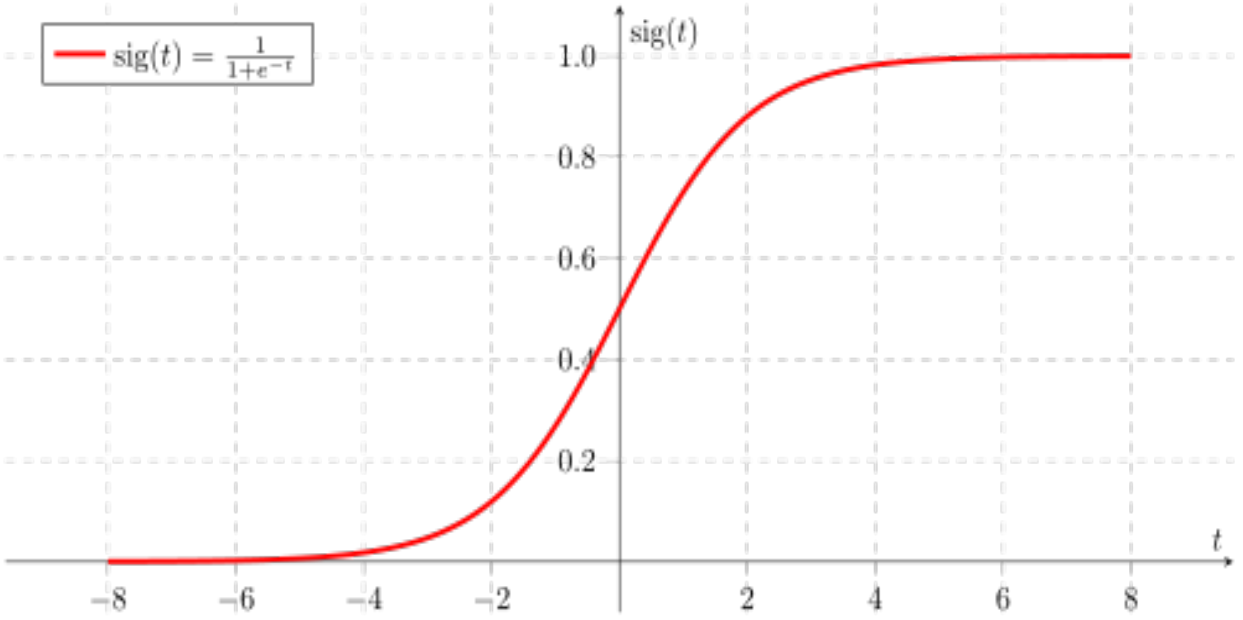
- the logit function takes input in [0,1] and returns in (-inf, +inf)
- express linear relationships between feature values and the log-odds

$$\text{logit}(P(y=1|x)) = \text{sum}(W_i X_i) = W^T X$$

- where is the conditional probability that a particular sample belongs to class 1 given its features x.

sigmoid function

- the inverse of the logit function
- sigmoid(logit(p)) = p



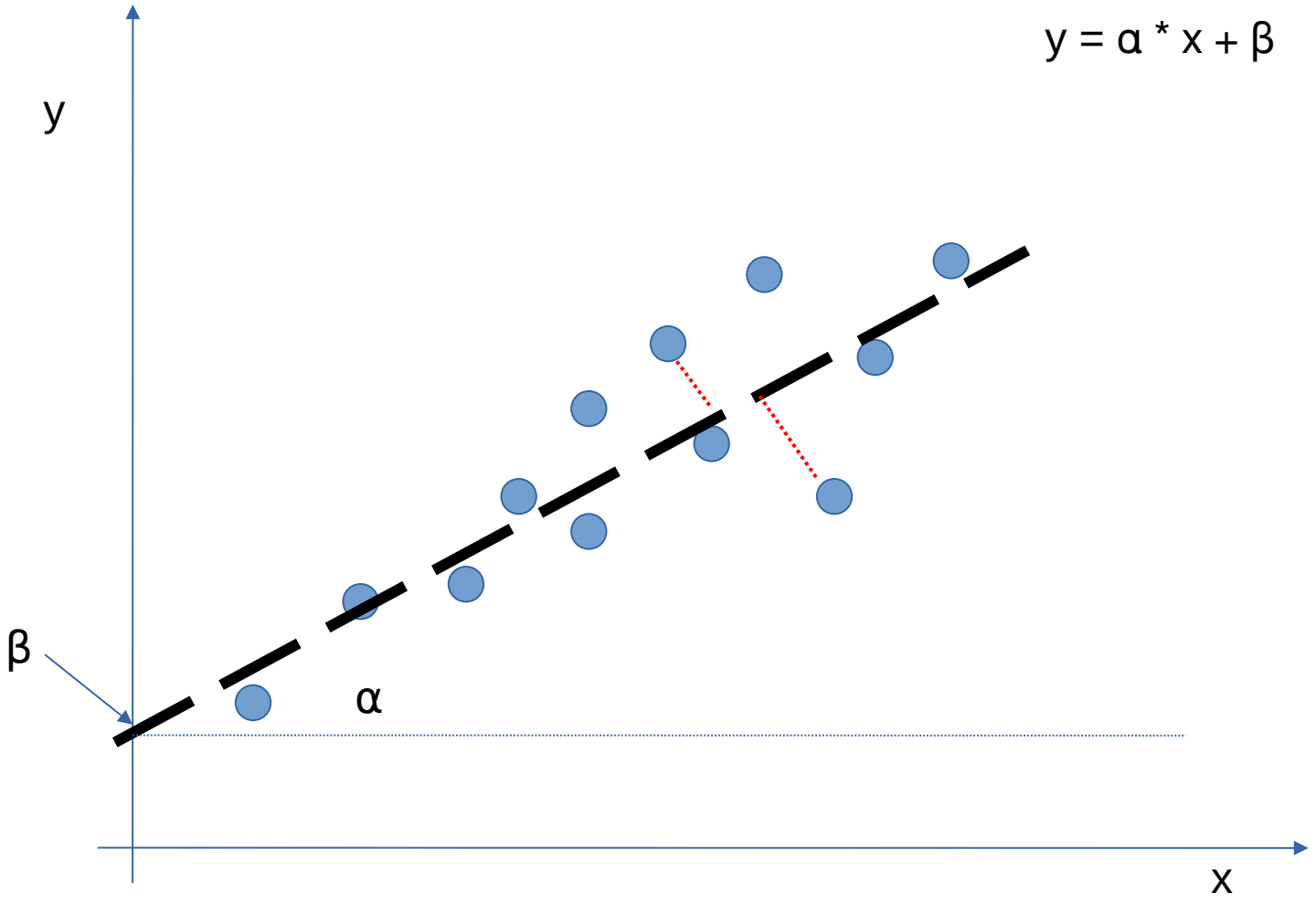
sigmoid

- from (-inf, +inf) to [0,1]
- takes real values and transform them in the [0,1] range with an intercept at 0.5
- THIS IS WHAT THE logit function does while trained.
- the output of the sigmoid is the probability of a certain sample to be of class 1, given its feature **x** parametrized by the weigths **w**

regression

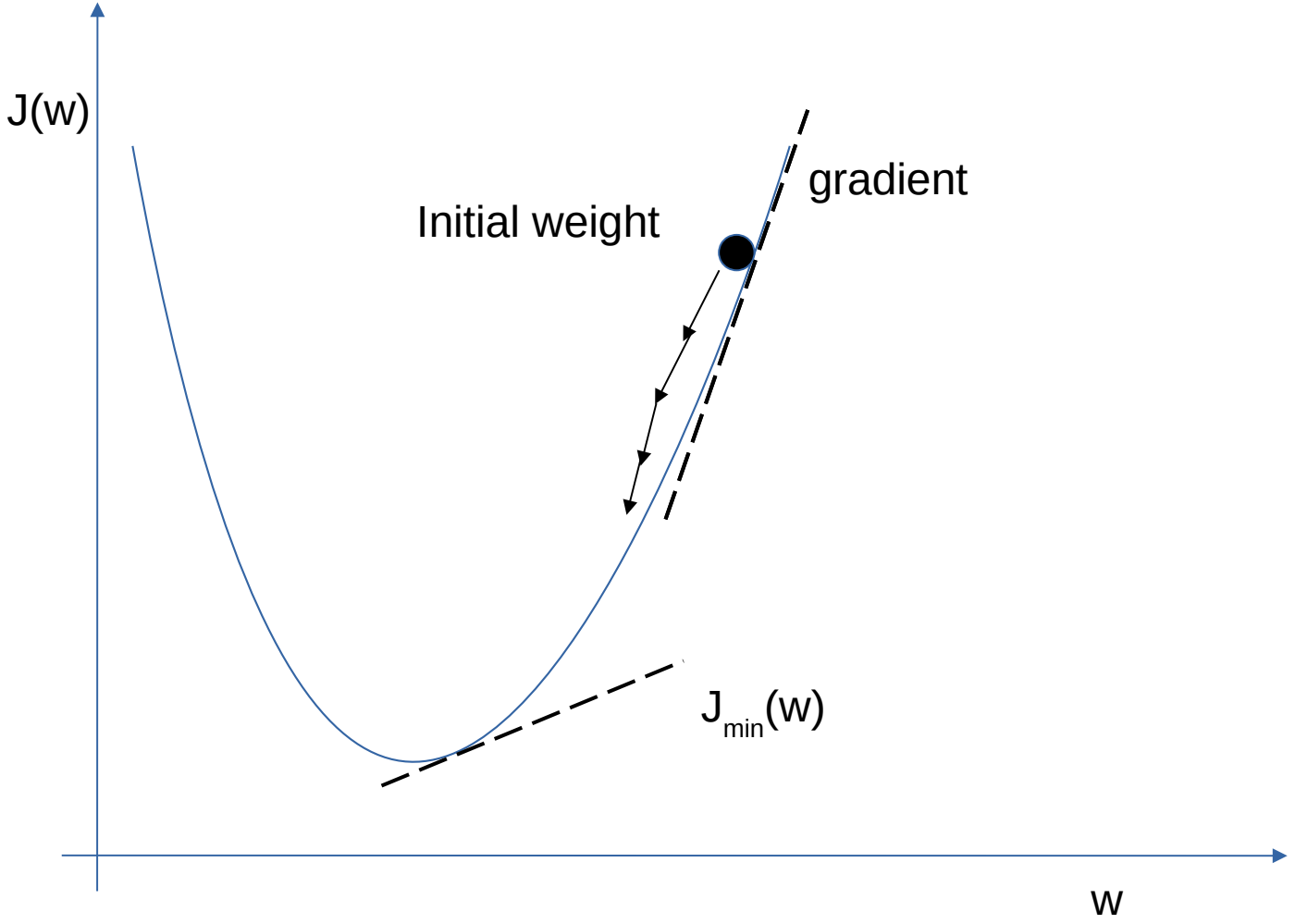
- Goal: model the relation between a number of features and a **continuous** target
  - continuous
  - fitting a line through the data
- Predict the house pricing given the neighborhood
- Predict how many seconds a user will watch a video
- …

regression



error evaluation

- gradient descent



UNSUPERVISED LEARNING

unsupervised

- trickier
  - no answer labels (no ground truth)
  - external evaluation vs internal evaluation
    - experts vs objective function
- but:
  - annotating large datasets is very costly (Speech Recognition)
  - we don’t know how many classes can be (Data Mining)
  - gain some insight into the structure of the data before designing a classifier

clustering

- more problems:
  - define distance
  - define similarity
  - define clusters
- Examples:
  - Kmeans
  - Fuzzy Kmeans
  - GMM
  - Hierarchical
  - …