

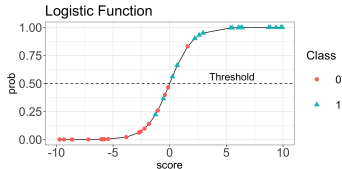
# Introduction to Machine Learning

## Supervised Classification: In a Nutshell



### Learning goals

- Understand basic concept of classifiers
- Know concepts of probabilistic and scoring classifier
- Know distinction between discriminant and generative approach
- Understand ideas of logistic regression and Naive Bayes

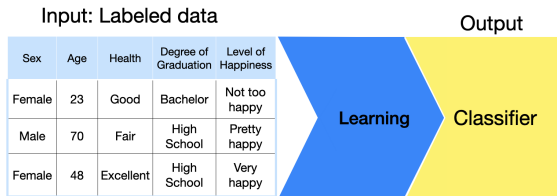


# CLASSIFICATION TASKS

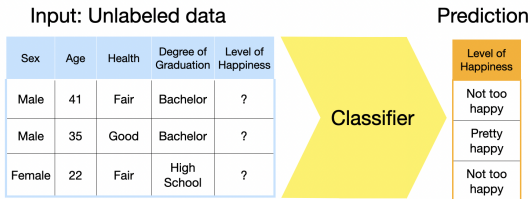
- Learn function that assigns categorical class labels to observations
- Each observation belongs to exactly one class
- The task can contain two (binary) or multiple (multi-class) classes



Training



Prediction



# BASIC DEFINITIONS

- For every observation a model outputs the probability (probabilistic classifier) or score (scoring classifier) of each class
- In the multi-class case, the class label is usually assigned by choosing the class with the maximum score or probability
- In the binary case, a class label is assigned by choosing the class whose probability or score exceeds a threshold value  $c$



Input: Unlabeled data

Sex	Age	Health	Degree of Graduation	Level of Happiness
Male	41	Fair	Bachelor	?

Classifier

Class Probabilities

Probability	Level of Happiness
0.4	Not too happy
0.35	Pretty happy
0.25	Very happy

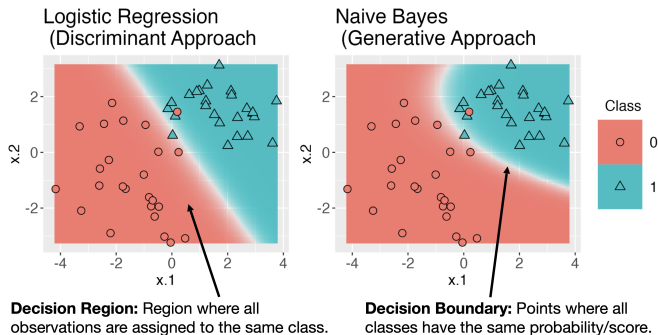
Assigned Label

Level of Happiness
Not too happy

# BASIC DEFINITIONS / 2

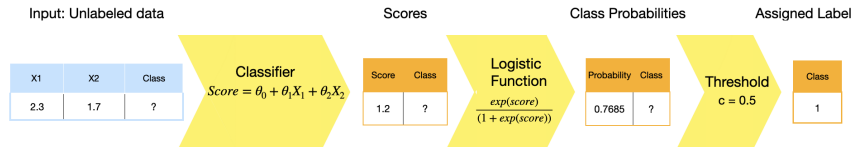
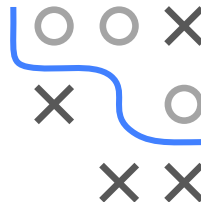
Two fundamental approaches exist to construct a classifier:

- **Discriminant approach** asks “What is the best prediction for the class given these data?” (uses loss functions and empirical risk minimization)
- **Generative approach** asks “Which class tends to have data like these?” (models the feature distributions in each class separately)

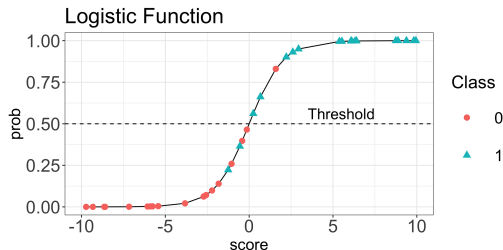


# LOGISTIC REGRESSION

- Logistic regression is a **discriminant approach** for binary classification. It turns scores into probabilities with the logistic function.
- We just need to compute the probability for **one** class (usually class 1).
- If the probability exceeds a threshold value **c**  $\Rightarrow$  class 1 is predicted.



The logistic function puts all scores in order along an s-shaped line.



# NAIVE BAYES

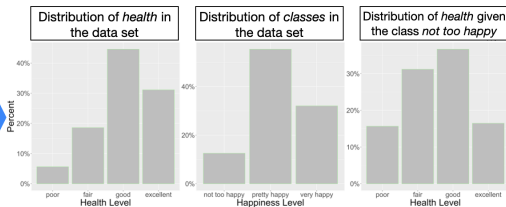
- Naive Bayes is a **generative multi-class approach**. It computes the class probability for each class based on the training data.
- It considers the data distribution on three different levels:
  - Marginal distributions  $\mathbb{P}(X)$  of each feature (in the entire data set)
  - Marginal distribution  $\mathbb{P}(Y)$  of classes (in the entire data set)
  - Conditional distributions  $\mathbb{P}(X|Y)$  of each feature in each class



Input: Labeled data

Health	Level of Happiness
Good	Not too happy
Fair	Pretty happy
...	...
Excellent	Very happy

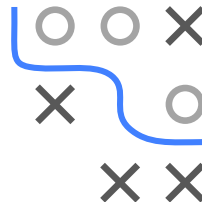
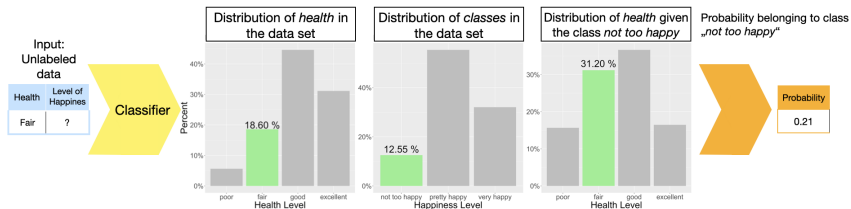
Learning  
From  
Distributions



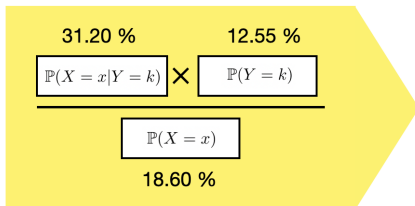
Classifier

# NAIVE BAYES / 2

Example: Class probability of “not too happy” given health = “fair”:



Naive Bayes Classifier



Class probability given the data

21.00 %