# Introduction to Machine Learning

# Introduction: Supervised Learning & Tasks

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# IDEA OF SUPERVISED LEARNING

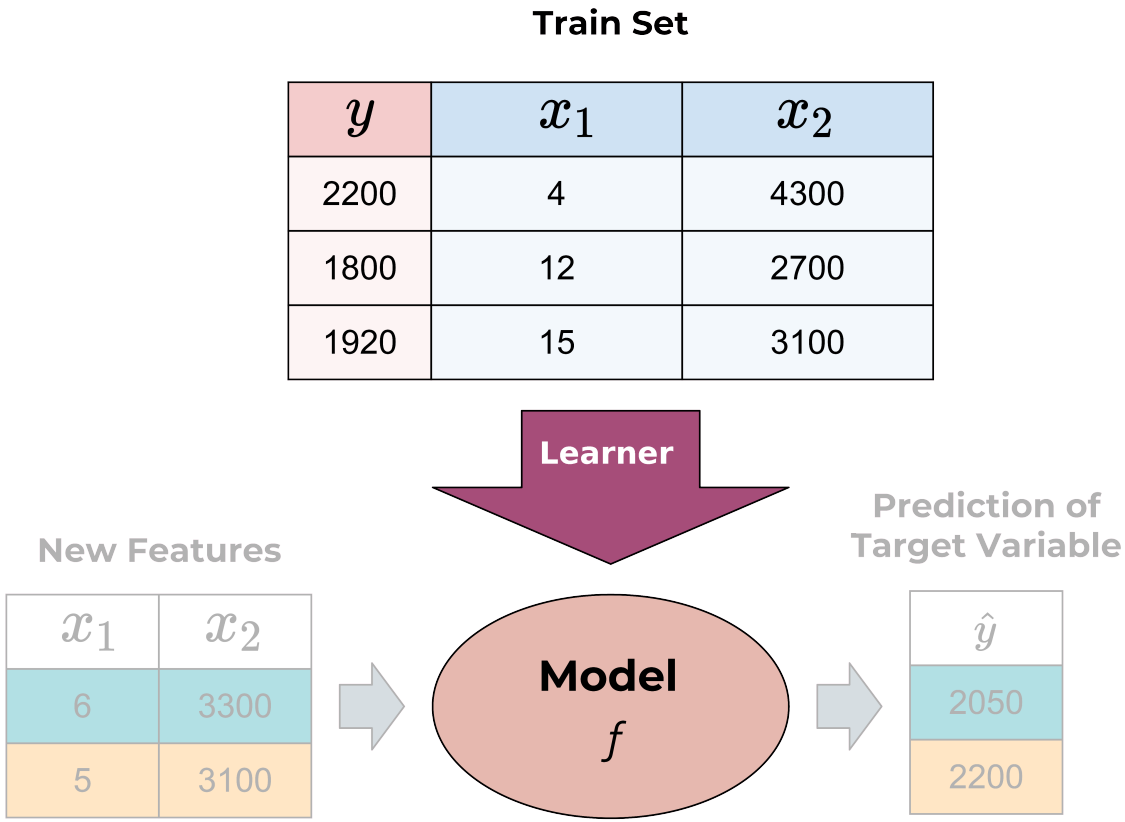
- **Goal:** Identify the fundamental functional relation in the data that maps an object's features to the target.
- Ideally, we would have full knowledge about the data-generating process and thus be able to specify this mapping function precisely.
- However, since this is basically impossible, we must try to **learn** the mapping function: for objects exhibiting certain patterns or properties, certain outcomes are much more likely.
  $\rightarrow$ We call such an assumed mapping a **model** $f$.

# IDEA OF SUPERVISED LEARNING

- **Supervised** learning means we make use of *labeled* data, i.e., observations for which we already know the target outcome.
- We try to construct $f$ automatically from an example set of such labeled objects.
  $\rightarrow$ The algorithm for finding $f$ is called **learner**.
- Using the thus learned model, we can make **predictions** based on the features of our data.
- Knowing the "truth" allows us to test how well we have grasped the nature of the underlying mapping: we just need to compare our predictions to the actually observed values.

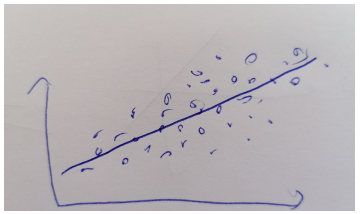
# IDEA OF SUPERVISED LEARNING

- Ultimately, we will use our model to compute predictions for **new** data whose target values are unknown.

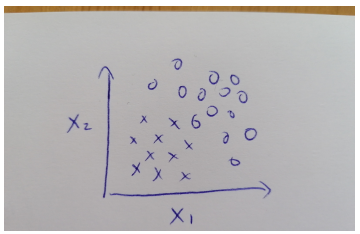


# TASKS IN SUPERVISED LEARNING

- In general, supervised learning comes in two flavors we call **tasks**:
  - **Regression**: Given features **x**, predict corresponding output from $\mathcal{Y} \in \mathbb{R}^m$.



  - **Classification**: Assign an observation with features **x** to one class of a finite set of classes $\mathcal{Y} = \{C_1, ..., C_g\}, g \geq 2$ (details later).



# REGRESSION TASKS: EXAMPLE

Imagine you want to investigate how salary and workplace conditions (*features*) affect productivity of employees (*target*) – a standard **regression** task. Therefore, you collect data about their worked minutes per week (productivity), how many people work in the same office as the employees in question, and the employees' salary.

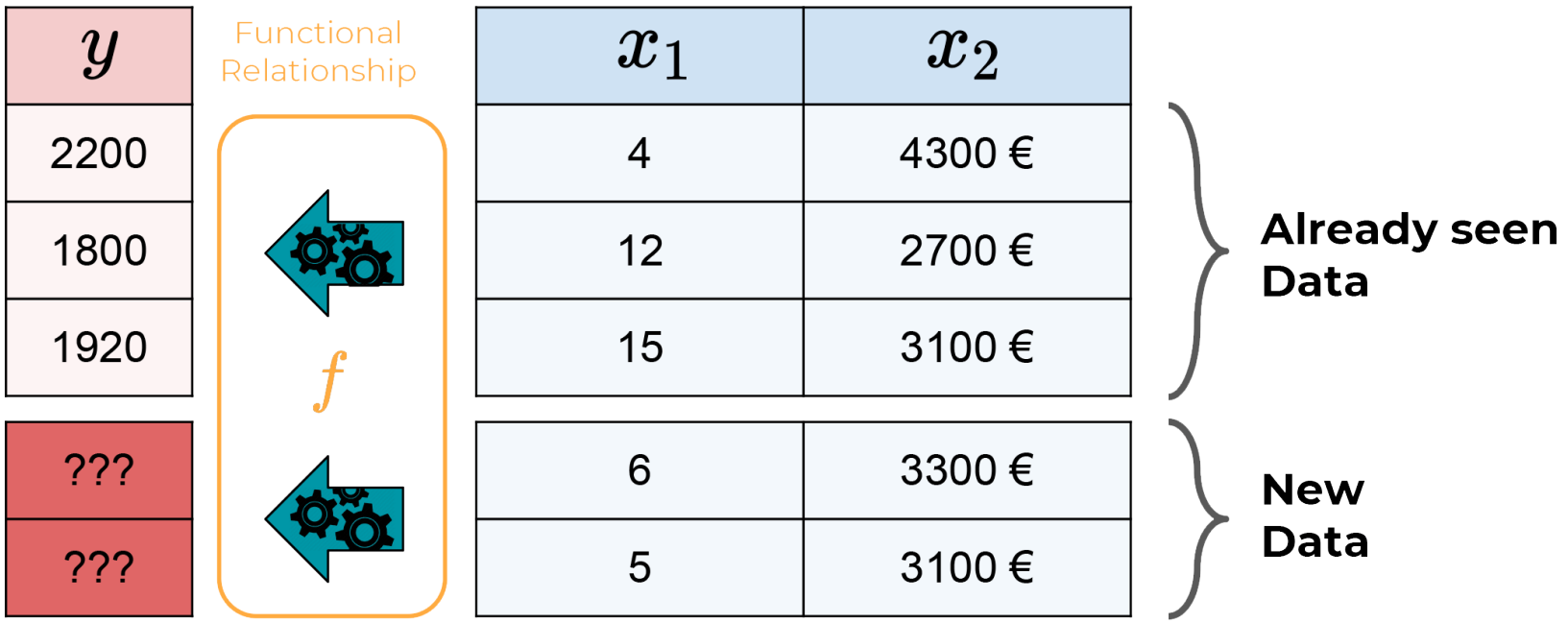
| | | Features $x$ | | | |
|---|---|---|---|---|---|
| **Worked Minutes Week (Target Variable)** | $y$ | **People in Office (Feature 1)** | $x_1$ | **Salary (Feature 2)** | $x_2$ |
| 2220 | $y^{(1)}$ | 4 | $x_1^{(1)}$ | 4300 € | $x_2^{(1)}$ |
| 1800 | $y^{(2)}$ | 12 | $x_1^{(2)}$ | 2700 € | $x_2^{(2)}$ |
| 1920 | $y^{(3)}$ | 5 | $x_1^{(3)}$ | 3100 € | $x_2^{(3)}$ |

$n = 3$

$p = 2$

# REGRESSION TASKS: EXAMPLE

- For our observed data we know which outcome is produced.
- For new employees can only observe the features but not the target.



# MORE REGRESSION TASKS

1. **Predict house prices**
   - **Aim**: Predict the price for a house in a certain area
   - **Features**: e. g.
     - square footage
     - number of bedrooms
     - swimming pool yes/no
2. **Predict the length-of-stay in a hospital at the time of admission**
   - **Aim**: Predict the number of days a single patient has to stay in hospital
   - **Features**: e. g.
     - diagnosis category (heart disease, injury,...)
     - admission type (urgent, emergency, newborn,...)
     - age
     - gender

# CLASSIFICATION TASKS: EXAMPLE

- Imagine you work for an insurance company which **classifies** its life insurance customers according to five risk categories, depending on which insurance premiums are charged.
- You might use features such as
  - job type (white collar, carpenter, stuntman, ...)
  - age
  - smoking behavior

  to perform this classification.

# PARAMETERS, STATISTICS AND SUPERVISED ML

- Supervised ML additionally assumes that $f$ is of a certain "form" or comes from a certain **class of functions**.
  This is necessary to make the problem of automatically finding a "good" model feasible at all.
- The specific behavior of a mapping from this class can then be described by **parameters** that define its shape.
- Statistics, too, studies how to learn such functions (or, rather: their parameters) from example data and how to perform inference on them and interpret the results.
- For historical reasons though, statistics is mostly focused on fairly simple classes of mappings, like (generalized) linear models.
- Supervised ML also includes more complex kinds of mappings that can typically deal with more complicated and high-dimensional inputs.