# Introduction to Machine Learning

# Introduction: Supervised Learning & Learning Tasks


**Learning goals**

- Understand the idea of supervised learning
- Know examples of supervised learning
- Understand the difference between the regression and classification task

# 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, in practical applications we don't know this mapping and we must try to **learn** the mapping function: for objects with certain patterns or properties, some values of the target are much more likely than others.
  $\rightarrow$ 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.
- We try to construct $f$ automatically from a set of labeled data.
  $\rightarrow$ The algorithm for finding $f$ is called **learner**.
- Using the learned model, we can make **predictions** of the target, 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.

# SUPERVISED LEARNING EXAMPLE (1)

## House Prices

**Aim**: Predict the price for a house in a certain area

| Features $x$ | | | | Target $y$ |
|---|---|---|---|---|
| square footage of the house | number of bedrooms | swimming pool (yes/no) | ... | house price in US$ |
| 1,180 | 3 | 0 | ... | 221,900 |
| 2,570 | 3 | 1 | ... | 538,000 |
| 770 | 2 | 0 | ... | 180,000 |
| 1,960 | 4 | 1 | ... | 604,000 |

# SUPERVISED LEARNING EXAMPLE (2)

## Length-of-stay in a hospital

**Aim**: Predict the number of days a single patient has to stay in hospital at the time of admission

| Features $x$ | | | | | Target $y$ |
|---|---|---|---|---|---|
| **diagnosis category** | **admission type** | **gender** | **age** | **...** | **Length-of-stay in the hospital in days** |
| heart disease | elective | male | 75 | ... | 4.6 |
| injury | emergency | male | 22 | ... | 2.6 |
| psychosis | newborn | female | 0 | ... | 8 |
| pneumonia | urgent | female | 67 | ... | 5.5 |

# SUPERVISED LEARNING EXAMPLE (3)

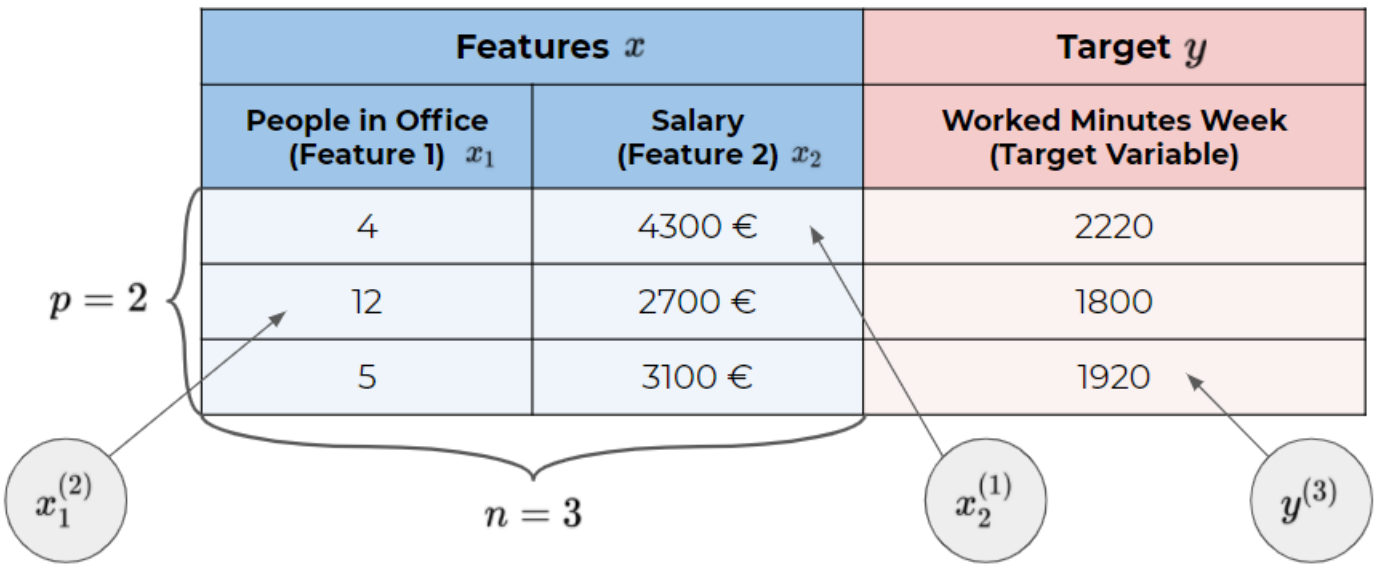
**Risk category in life insurance**

**Aim**: Predict one of five risk categories (**classification**) for a life insurance customer to determine the insurance premium

| Features $x$ | | | | Target $y$ |
|---|---|---|---|---|
| **job type** | **age** | **smoker** | **...** | **risk group** |
| carpenter | 34 | 1 | ... | 3 |
| stuntman | 25 | 0 | ... | 5 |
| student | 23 | 0 | ... | 1 |
| white-collar worker | 39 | 0 | ... | 2 |

# SUPERVISED LEARNING EXAMPLE (4)

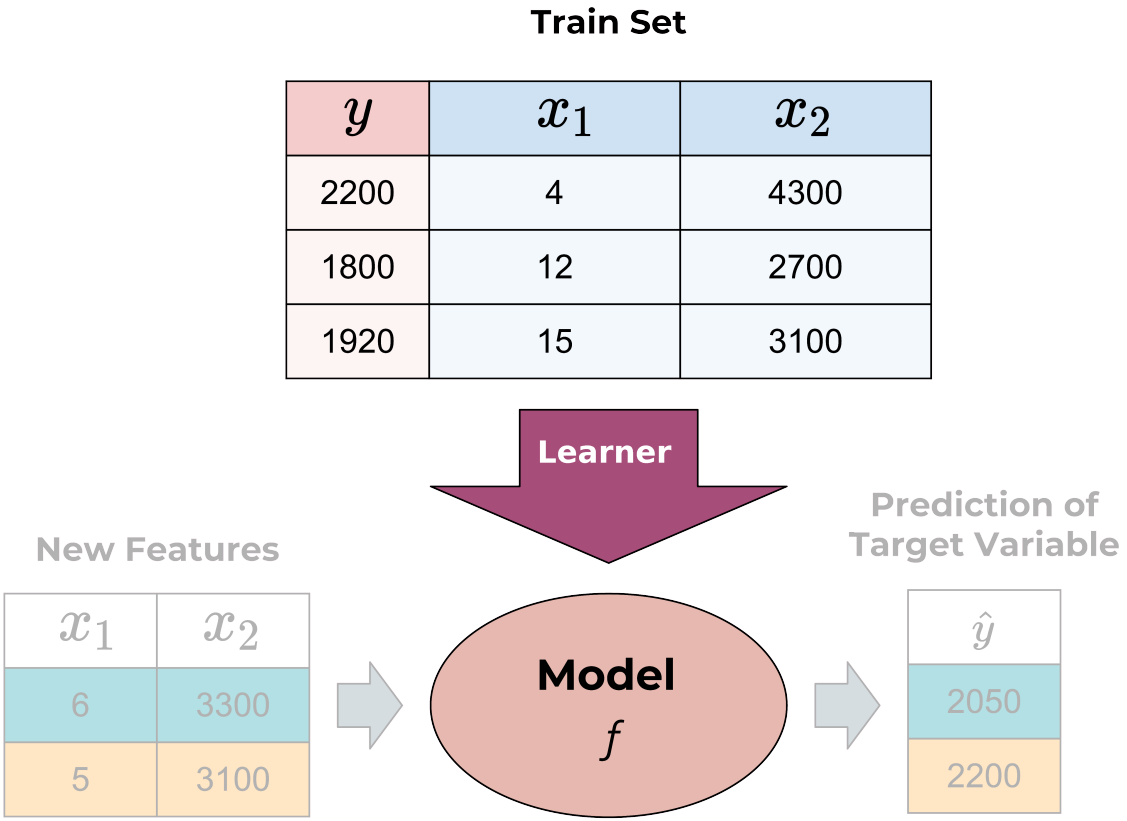
Imagine you want to investigate how salary and workplace conditions (*features*) affect productivity of employees (*target*) – a standard **regression** task. Therefore, you collect data about their worked minutes per week (productivity), how many people work in the same office as the employees in question,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



# SUPERVISED LEARNING EXAMPLE (4)

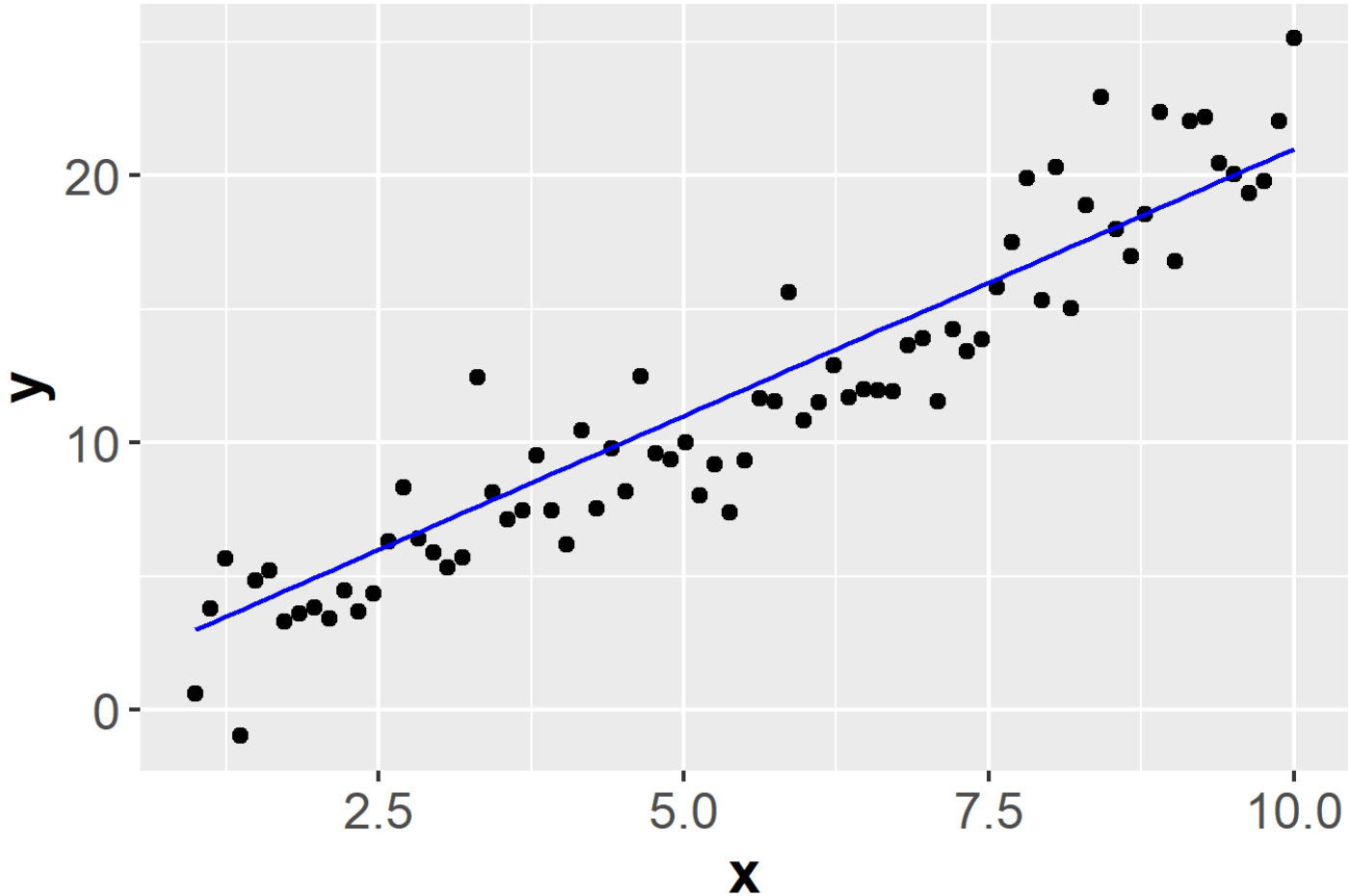
- For our observed data we know which outcome is produced.
- For new employees we can only observe the features but not the target.
- We use the labeled data to learn the model f.
- Ultimately, we use our model to compute predictions for **new** data whose target values are unknown.

# SUPERVISED LEARNING EXAMPLE (4)



# TASKS IN SUPERVISED LEARNING

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



# TASKS IN SUPERVISED LEARNING

- **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).