# Data manipulation

Reading and manipulating the data

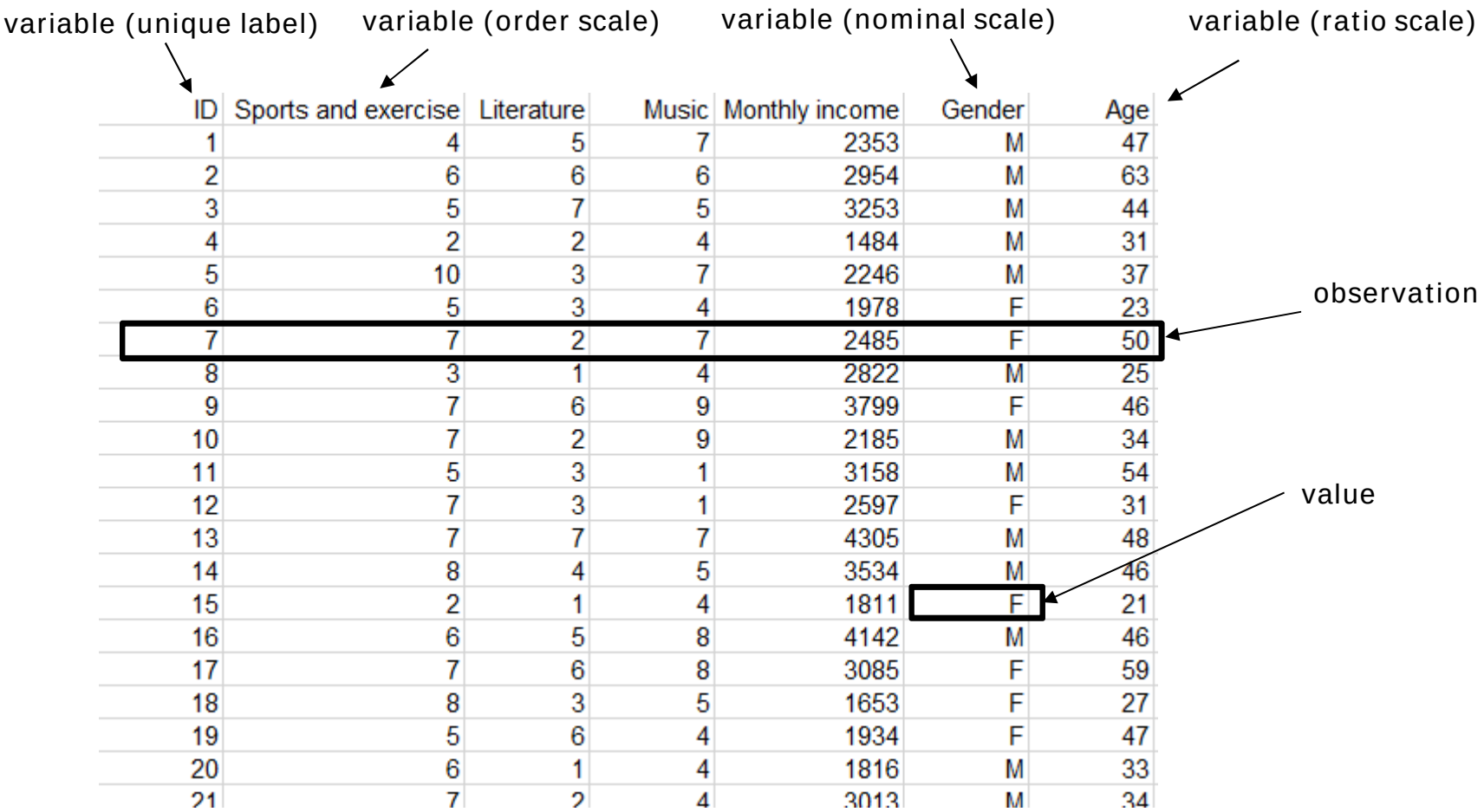
# Learning goals for this session

1. Learn the basics of examining, verifying and manipulation of data programmatically.
2. Learn to manipulate data with Python fluently.
   – Focus on **pandas** library

# Data preparation

- Data preparation is the most important phase in a machine learning project.
- It is also the most time-consuming.
  - Takes about 90% of the time.
- Idea: convert the data into a single table.

# Concepts of tabular data model




| ID | Sports and exercise | Literature | Music | Monthly income | Gender | Age |
|---|---|---|---|---|---|---|
| 1 | 4 | 5 | 7 | 2353 | M | 47 |
| 2 | 6 | 6 | 6 | 2954 | M | 63 |
| 3 | 5 | 7 | 5 | 3253 | M | 44 |
| 4 | 2 | 2 | 4 | 1484 | M | 31 |
| 5 | 10 | 3 | 7 | 2246 | M | 37 |
| 6 | 5 | 3 | 4 | 1978 | F | 23 |
| 7 | 7 | 2 | 7 | 2485 | F | 50 |
| 8 | 3 | 1 | 4 | 2822 | M | 25 |
| 9 | 7 | 6 | 9 | 3799 | F | 46 |
| 10 | 7 | 2 | 9 | 2185 | M | 34 |
| 11 | 5 | 3 | 1 | 3158 | M | 54 |
| 12 | 7 | 3 | 1 | 2597 | F | 31 |
| 13 | 7 | 7 | 7 | 4305 | M | 48 |
| 14 | 8 | 4 | 5 | 3534 | M | 46 |
| 15 | 2 | 1 | 4 | 1811 | F | 21 |
| 16 | 6 | 5 | 8 | 4142 | M | 46 |
| 17 | 7 | 6 | 8 | 3085 | F | 59 |
| 18 | 8 | 3 | 5 | 1653 | F | 27 |
| 19 | 5 | 6 | 4 | 1934 | F | 47 |
| 20 | 6 | 1 | 4 | 1816 | M | 33 |
| 21 | 7 | 2 | 4 | 3013 | M | 34 |

# CSV format

```
ID, Birth year, Gender, Heart rate, Stress hormone level, Score for exam 1, Score for exam 2
1, 1992, M, 60, 7.5, 80, 17
2, 1991, M, 54, 4.0, 86, 31
3, 1993, F, 69, 2.7, 70, 30
4, 1987, F, 70, 3.3, 90, 35
```

- CSV is a comma (or semicolon) separated line-oriented data format.
  - It is supported in most machine learning environments.
- A CSV file is a human-readable ASCII file that can be edited with a common text editor.
- The first row contains variable names.
- The remaining rows contain observations.
  - The number of observations in data mining can vary from just a few to several billions.

# Python data manipulation example

| Id | Age | Weight | Cholesterol |
|---|---|---|---|
| 1 | 25 | 72 | 4,6 |
| 2 | 60 | 112 | 7,9 |
| 3 | 39 | 82 | 5,5 |
| 4 | 20 | 71 | 5,3 |
| 5 | 72 | 90 | 7,2 |
| 6 | 66 | 68 | 6,1 |
| 7 | 68 | 74 | 8,4 |
| 8 | 61 | 99 | 9,2 |
| 9 | 40 | 80 | 5,0 |

- Consider the data set above.
- The aim is to read the data set into Python and compute the basic statistics (minimum, maximum, average) for each of the variables.
- Verifying data quality is a vital steps for any inference and/or learning from the data.
  - Analyzing minimum, maximum, and mean values.
  - Inspecting outliers, coding missing data.
  - Bad quality data is useless: GIGO principle (“garbage in, garbage out”).

# Step 1: coding tabular data in python

```
In [6]: import pandas as pd

        data = {'age': [25,60,39,20,72,66,68,61,40],
                'weight': [72,112,82,71,90,68,74,99,80],
                'cholesterol': [4.6,7.9,5.5,5.3,7.2,6.1,8.4,9.2,5.0]}
        print(data)

        {'age': [25, 60, 39, 20, 72, 66, 68, 61, 40], 'weight': [72, 112, 82, 71, 90, 68, 74, 99, 80], 'cholesterol': [4.6,
        7.9, 5.5, 5.3, 7.2, 6.1, 8.4, 9.2, 5.0]}
```

- A data set can be constructed from the scratch by generating an associative array of lists.
  - An associative array named **`data`** holds three (key, value) pairs in this example.
  - Each key is a string that holds the variable name.
  - Each value is a list of values in the observations.

# Step 2: making a **pandas** data frame

```
In [7]: # convert to data frame
        df = pd.DataFrame(data)
        print(df)
```

```
   age  cholesterol  weight
0   25          4.6      72
1   60          7.9     112
2   39          5.5      82
3   20          5.3      71
4   72          7.2      90
5   66          6.1      68
6   68          8.4      74
7   61          9.2      99
8   40          5.0      80
```

- Many machine learning methods implemented in the **scikit-learn** assume **pandas** data frames as the input format.
- Above, the associative array is converted into a data frame and printed.
- **pd** refers to the alias name for the imported **pandas** library.
- From now on, use **pandas** documention at https://pandas.pydata.org/ → Documentation.

# Step 3: printing basic statistics

```
In [14]: #show basic statistics
         res = df.describe()
         print(res)
```

```
              age  cholesterol      weight
count    9.000000     9.000000    9.000000
mean    50.111111     6.577778   83.111111
std     19.464355     1.649074   14.692213
min     20.000000     4.600000   68.000000
25%     39.000000     5.300000   72.000000
50%     60.000000     6.100000   80.000000
75%     66.000000     7.900000   90.000000
max     72.000000     9.200000  112.000000
```

- By default, mean, standard deviation, minimum and maximum values as well as 25%, 50% and 75% percentiles are displayed.
  - E.g. the 75% percentile for cholesterol shows that 75% of the cholesterol values in the data set are smaller than or equal to 7.9.

# Data structures

- Pandas supports two data structures:
  1. A series
  2. A data frame

- In addition, there is a deprecated Panel.
  - Deprecated functionality should not be used.

# Series

```
In [19]: import numpy as np
         import pandas as pd

         hours = pd.Series([8,5,3,2,7,0,0])
         print(hours)
         print(hours[2])
```

```
0    8
1    5
2    3
3    2
4    7
5    0
6    0
dtype: int64
3
```

- A series represents a vector of values.
  - One-dimensional
  - Labeled
  - Values can be of any data types
- Above, a series is constructed from a Python list structure.

# Data frames

```
In [15]: # play with data frames
         print(df)
         print(df['cholesterol'])
         print(df['cholesterol'][2])
```

```
   age  cholesterol  weight gender  height
0   25          4.6      72      F     172
1   60          7.9     112      M     163
2   39          5.5      82      M     179
3   20          5.3      71      M     188
4   72          7.2      90      F     192
5   66          6.1      68      M     153
6   68          8.4      74      F     159
7   61          9.2      99      F     169
8   40          5.0      80      F     170
0    4.6
1    7.9
2    5.5
3    5.3
4    7.2
5    6.1
6    8.4
7    9.2
8    5.0
Name: cholesterol, dtype: float64
5.5
```

- A data frame stores an array of values.
- Columns can be accessed by labels.
- A data frame can be generated from various structures.

# Adding columns, changing data types

```
In [181]: # add new columns
          df['gender']=['F','M','M','M','F','M','F','F','F']
          df['height']=[172,163,179,188,192,153,159,169,170]
          # change gender's dtype to categorical
          df['gender'] = df['gender'].astype(pd.api.types.CategoricalDtype(ordered=false))
          df.dtypes

Out[181]: age              int64
          cholesterol    float64
          weight           int64
          gender        category
          height           int64
          dtype: object
```

- The data types of the columns should reflect the scales of the variables.
- This is vital for some of the machine learning algorithms to work correctly.
- Commonly used data types:
  - For ratio scale: int64 or float64
  - For interval scale: int64 or float64
  - For ordinal scale: CategoricalDtype(ordered=True)
  - For nominal scale: CategoricalDtype(ordered=False)