Introduction to Data Science with Python

Chapter 3

July 28, 2023

Topics of the course

1. Chapter

2. Chapter

3. Chapter

Python Fundamentals

Basic concepts,
Variables, basic data
structures, functions

**Data Wrangling &
Simple visualizations**

How to process data with
pandas and visualize it
with matplotlib

**Visualizations &
Modelling**

More plots with matplotlib
and seaborn and an
introduction to modelling
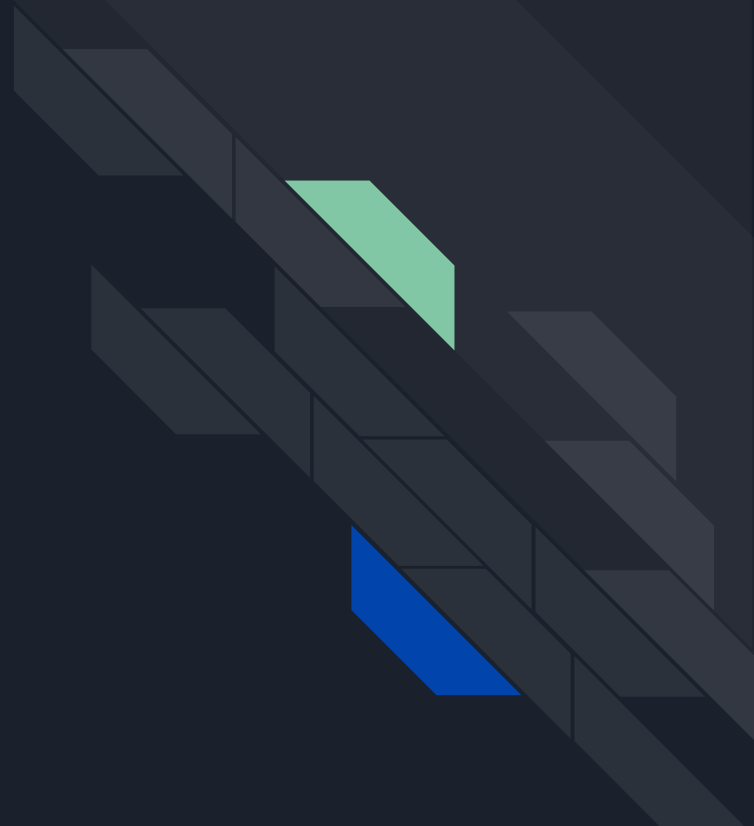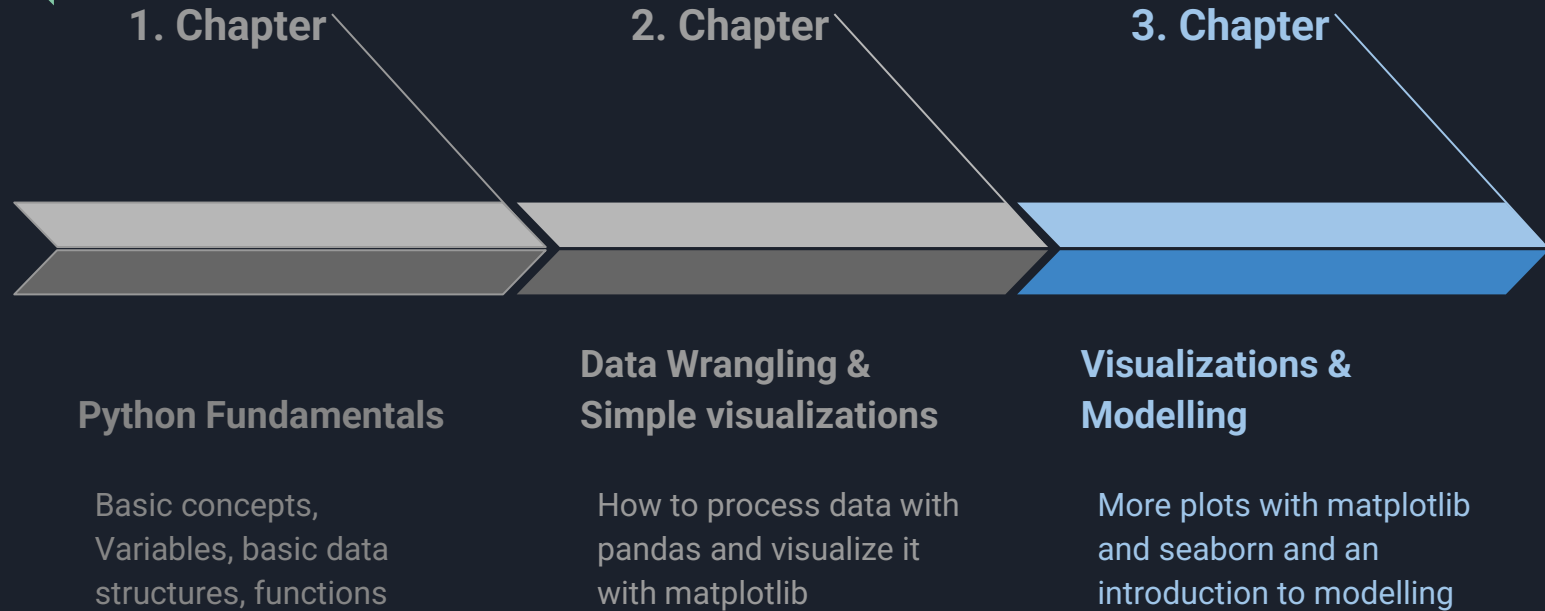
Advanced Visualisations & Modelling
Clean Data with Pandas

Clean data

Data comes often in an untidy form, therefore some data cleaning is necessary

Name	Town
Clara	Frankfurt a.M.
Sarah	Frankfurt am Main
John	Berlin

```python
df1['Town'] = df1['Town'].str.replace(
                        'a.M.','am Main')
```

Clean data

Data comes often in an untidy form, therefore some data cleaning is necessary

Name	Subject
Clara	Physics
Sarah	physics
John	Math

```python
df['Subject'] = df['Subject'].str.lower()
```

Fill missing values

Name	Score
Clara	10
Sarah	5
John	NaN

```python
df['Score'] = df['Score'].fillna(0)
```

Fill missing values

Name	Score
Clara	10
Sarah	5
John	NaN → 0

```python
df['Score'] = df['Score'].fillna(0)
```

Fill missing values

Name	Score
Clara	10
Sarah	5
John	NaN → 7.5

```python
df['Score'] = df['Score'].fillna(df.mean())
```

Drop missing values

Name	Score
Clara	10
Sarah	5
~~John~~	~~NaN~~

```python
df = df.dropna()
```

Working with dates
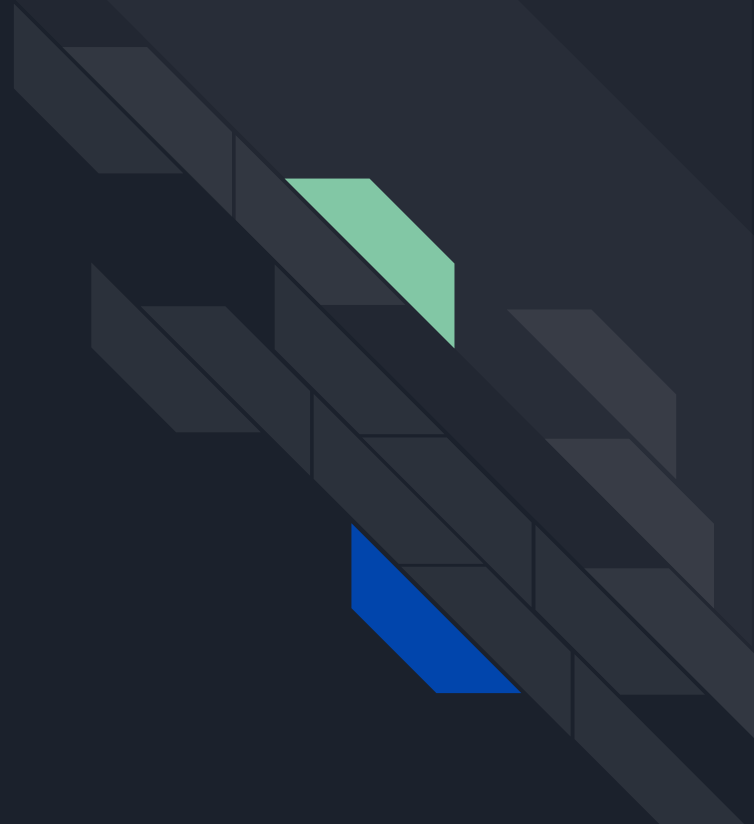
QUIZ

What kind of data type is this : `"27-03-2021"` ?

a)   integer   b) float   **c) string**   d) date

Transform string to datetime object

```python
df['Birthday'] = pd.to_datetime(df['Birthday'])
```

Name	Birthday
Clara	"10/10/1995"
Sarah	"01/10/1999"
John	"03/05/2001"

Transform string to datetime object

```
df['Birthday'] = pd.to_datetime(df['Birthday'], format="%d/%m/%Y")
```

Name	Birthday
Clara	"10/10/1995"
Sarah	"01/10/1999"
John	"03/05/2001"

Transform string to datetime object

```
df['Birthday'] = pd.to_datetime(df['Birthday'], format="%m-%d-%Y")
```

Name	Birthday
Clara	"10-10-1995"
Sarah	"10-01-1999"
John	"05-03-2001"

Transform string to datetime object

```python
df['day'] = df['Birthday'].dt.day
df['weekday'] = df['Birthday'].dt.weekday
df['month'] = df['Birthday'].dt.month
```

Name	Birthday	day	weekday	month
Clara	"10-10-1995"	10	1	10
Sarah	"10-01-1999"	1	4	10
John	"05-03-2001"	3	3	5

Set date as index

date	City	Temperature
"2021-04-20"	'Frankfurt'	10
"2021-04-21"	'Frankfurt'	11
"2021-04-22"	'Frankfurt'	12

```python
df = df.set_index(['date'])
```

Select timespans

When the index is in datetime format, you can access the data in the following way:

date	City	Temperature
"2021-04-20"	'Frankfurt'	10
"2021-04-21"	'Frankfurt'	11
"2021-04-22"	'Frankfurt'	12

```python
df['2021'] # all data from 2021
df['2021-04':'2021-05']
df['2021':]
```

Exercise 1

```python
df['date'] = pd.to_datetime(df['date'])
df = df.set_index(['date'])
df['2021-04':'2021-05']
df[df['col_name'] == 'some condition']


plt.plot(df['col_name']['2000'])
```

pandas has a lot of useful functionality

- The official documentation of pandas has more than 3000 pages
- work with missing values
  - fill with mean value
  - interpolate between values
  - fill with last value
- Read data from various sources
  - Excel, CSV, SQL, Stata, SPSS, SAS, HTML Tables from websites
- Windowing functions
  - Moving average,…

Advanced Visualisations & Modelling

Advanced Visualizations with Seaborn

seaborn - library

- statistical data visualization tools
- based on matplotlib
- makes it easy to create more sophisticated plots
- best to visualize relations between columns of a dataset

```python
import seaborn as sns
```

Look into a penguins dataset

	species	island	bill_length_mm	bill_depth_mm	flipper_length_mm	body_mass_g	sex
0	Adelie	Torgersen	39.1	18.7	181.0	3750.0	Male
1	Adelie	Torgersen	39.5	17.4	186.0	3800.0	Female
2	Adelie	Torgersen	40.3	18.0	195.0	3250.0	Female
3	Adelie	Torgersen	NaN	NaN	NaN	NaN	NaN
4	Adelie	Torgersen	36.7	19.3	193.0	3450.0	Female

Look into a penguins dataset

	species	island	bill_length_mm	bill_depth_mm	flipper_length_mm	body_mass_g	sex
0	Adelie	Torgersen	39.1	18.7	181.0	3750.0	Male
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2	Adelie	Torgersen	40.3	18.0	195.0	3250.0	Female
3	Adelie	Torgersen	NaN	NaN	NaN	NaN	NaN
4	Adelie	Torgersen	36.7	19.3	193.0	3450.0	Female

Matplotlib vs Seaborn

```
plt.scatter(df['bill_length_mm'],df['flipper_length_mm'])
```
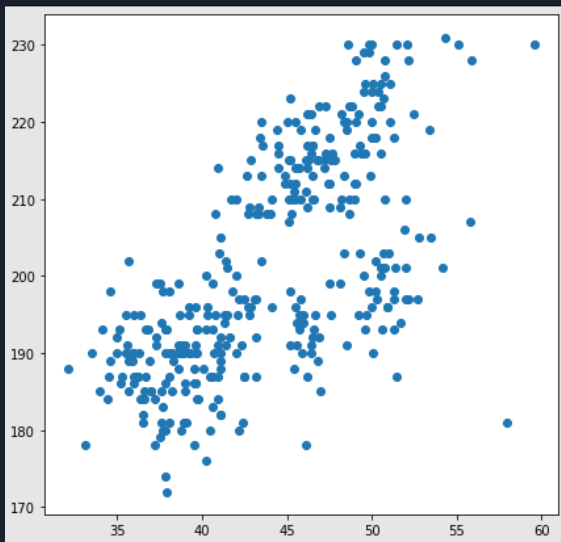
```
sns.relplot(df['bill_length_mm'],df['flipper_length_mm'])
```
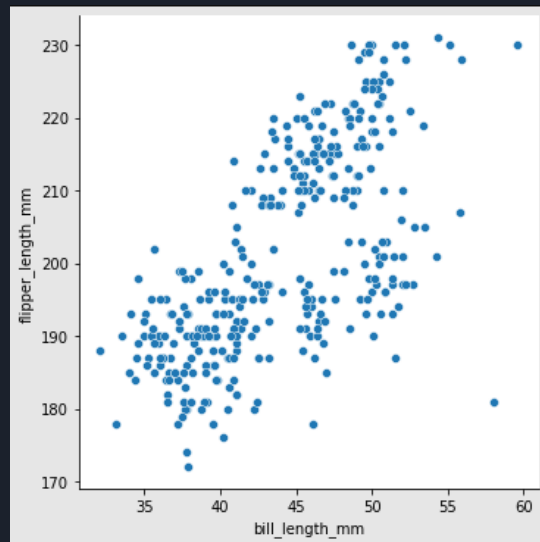
Matplotlib vs Seaborn

```
plt.scatter(df['bill_length_mm'],df[sex])
```

```
sns.relplot(df['bill_length_mm'],df[sex])
```
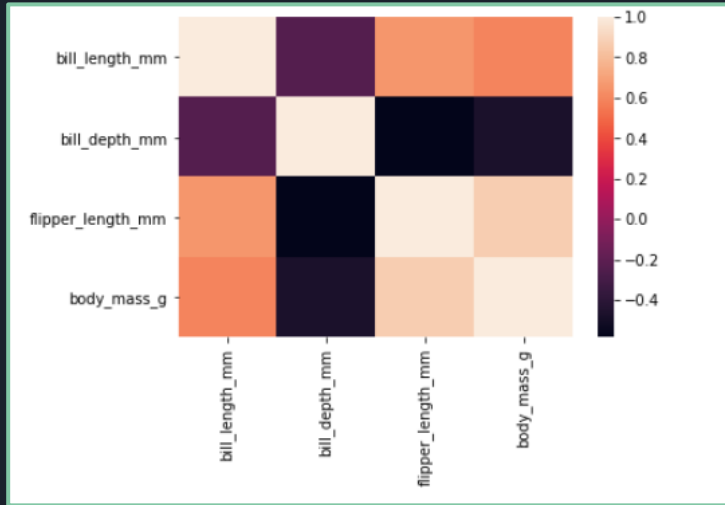
TypeError
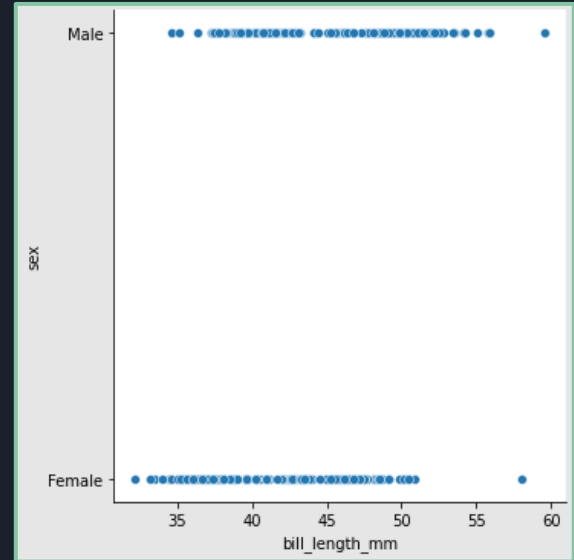
Pairplot

```
sns.pairplot(df)
```
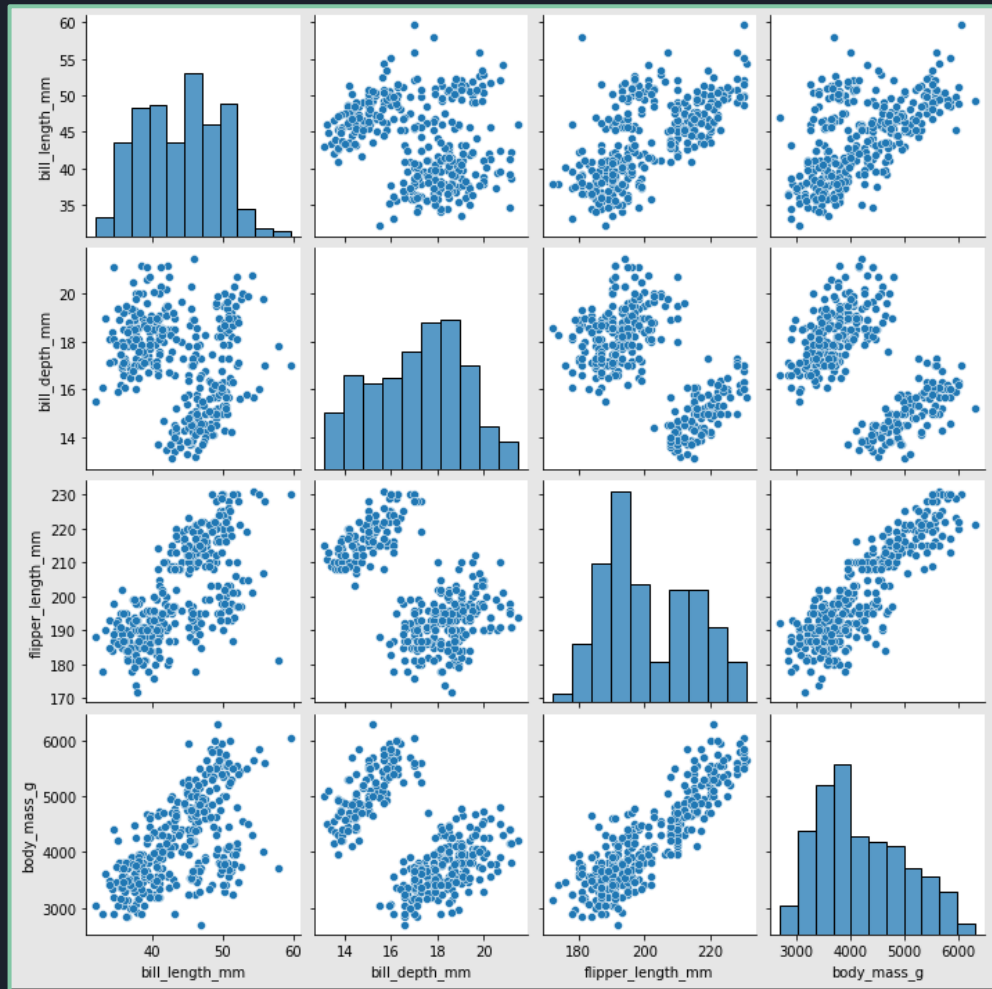
Visualize correlations

	bill_length_mm	bill_depth_mm	flipper_length_mm	body_mass_g
bill_length_mm	1.000000	-0.235053	0.656181	0.595110
bill_depth_mm	-0.235053	1.000000	-0.583851	-0.471916
flipper_length_mm	0.656181	-0.583851	1.000000	0.871202
body_mass_g	0.595110	-0.471916	0.871202	1.000000

```
df.corr()
```

Visualize correlations


```
sns.heatmap(df.corr())
```

Exercise 2

```python
sns.pairplot(df)
sns.pairplot(df, hue='col_name')
```

Matplotlib & Seaborn Gallery

- Documentation contains example plots
- Each plot comes with the corresponding code
- https://matplotlib.org/stable/gallery/index.html
- https://seaborn.pydata.org/examples/index.html

Advanced Visualisations & Modelling
Modelling Basics

Linear Regression

Source: https://avantecture.com/p/phoenixsee/

How expensive is this house?

Based on information like:

- amount of rooms
- location
- size

Housing regression

Old collected data

House	Location	Rooms	Price
A	Berlin	6	500k €
B	Frankfurt	8	600k €
C	Berlin	7	300k €

New data

House	Location	Rooms	Price
D	Frankfurt	8	?
E	Frankfurt	5	?
F	Berlin	4	?

Housing regression

Old collected data

House	Location	Rooms	Price
A	Berlin	6	500k €
B	Frankfurt	8	600k €
C	Berlin	7	300k €

Features

New data

House	Location	Rooms	Price
D	Frankfurt	8	?
E	Frankfurt	5	?
F	Berlin	4	?

Housing regression

Old collected data

House	Location	Rooms	Price
A	Berlin	6	500k €
B	Frankfurt	8	600k €
C	Berlin	7	300k €

Features   Target column

New data

House	Location	Rooms	Price
D	Frankfurt	8	?
E	Frankfurt	5	?
F	Berlin	4	?

Linear Regression
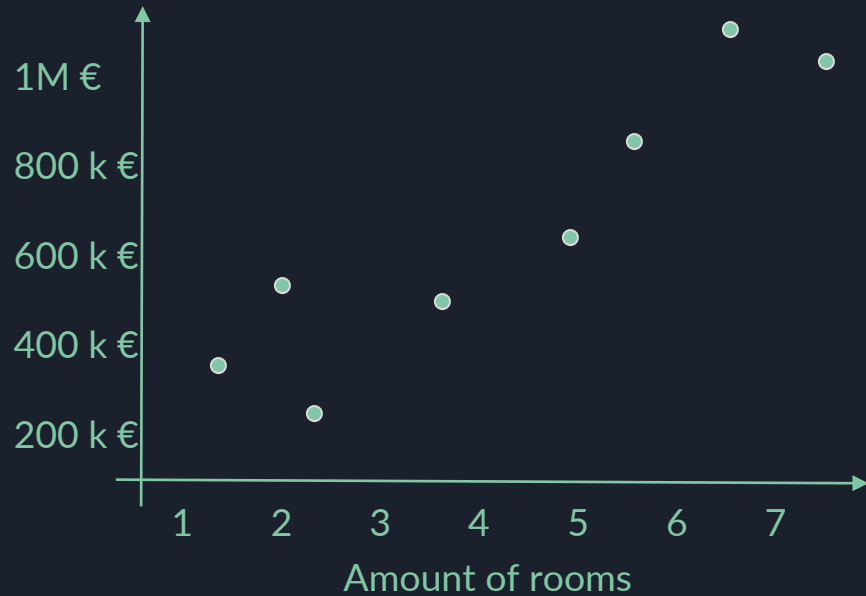
Linear Regression
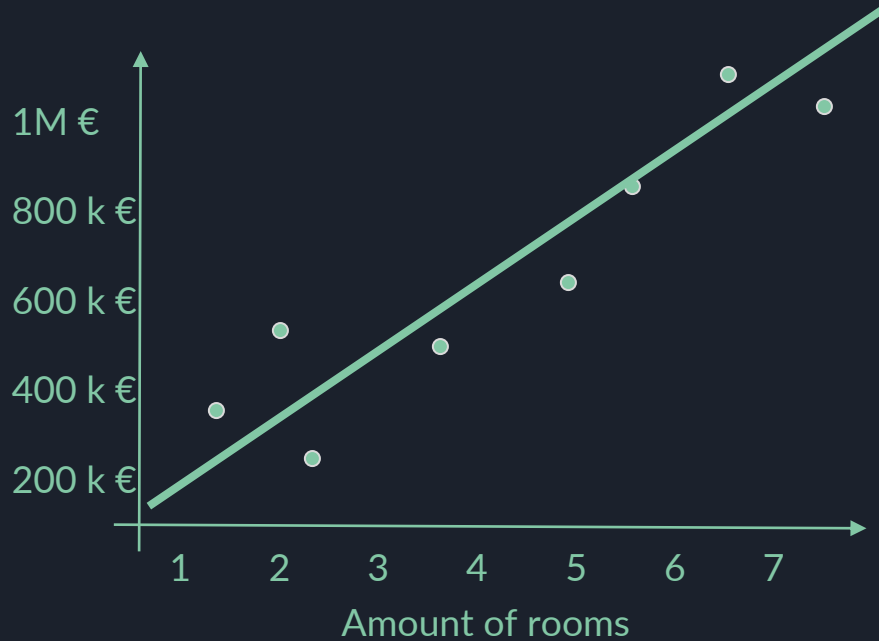
$$price = a \cdot rooms + b$$

Linear Regression
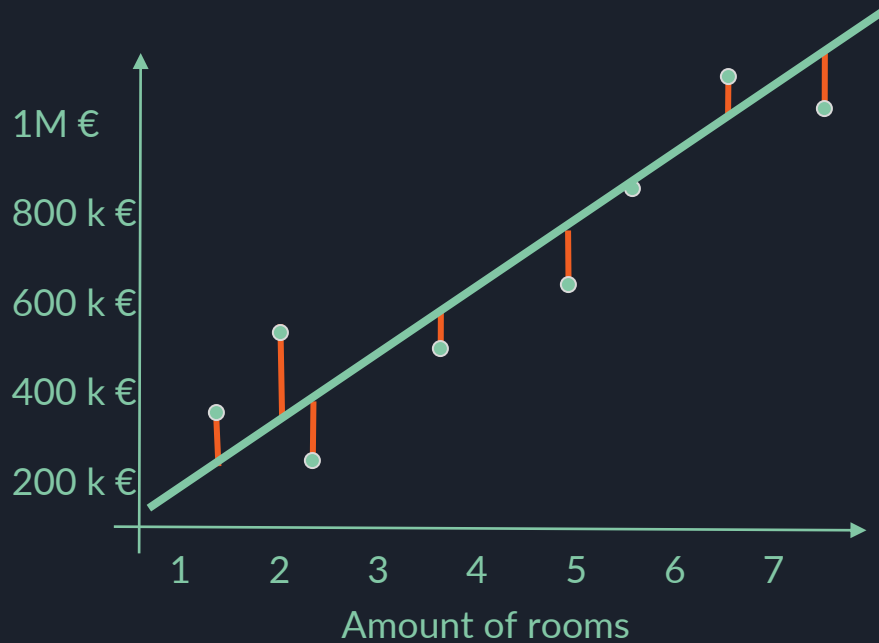
$$price = a \cdot rooms + b$$

$$RMSE = \sqrt{\frac{1}{T} \sum_{i=1}^{T} (y_{i,predicted} - y_{i,true})^2)}$$

Linear Regression

House	Bedrooms	Rooms	Price
A	1	6	500k €
B	3	8	600k €
C	2	7	300k €

$$price = a_1 \cdot rooms + a_2 \cdot size + a_3 \cdot bedrooms + b$$

How good is your model?

How does the model perform on unseen data?

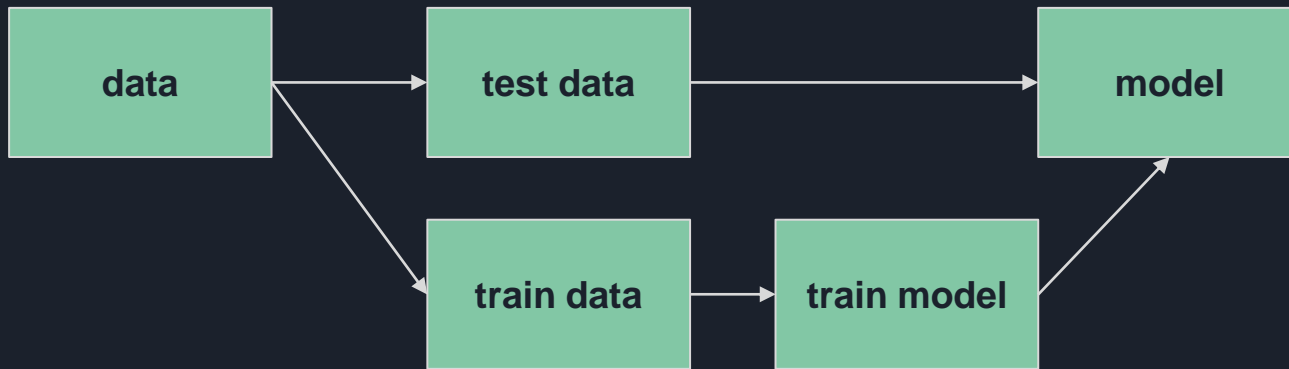Split data in a train (70%) and test (30%) set to evaluate your model
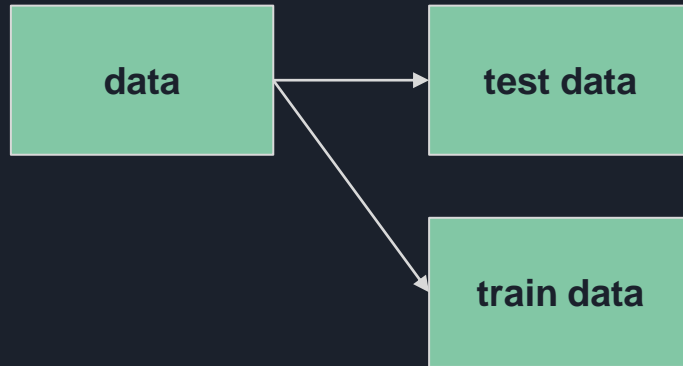
Typical workflow
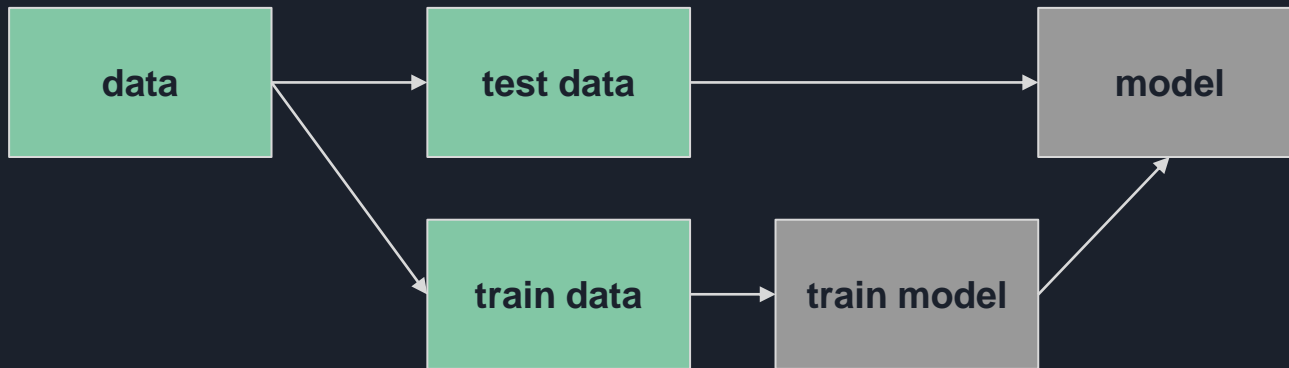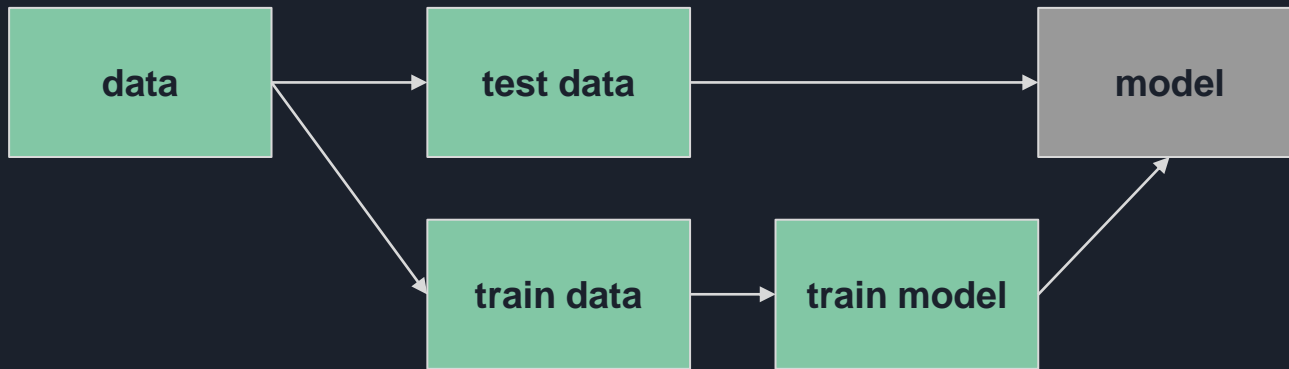
Typical workflow

Typical workflow

Linear Regression with Python

```python
import pandas as pd # data
from sklearn.model_selection import train_test_split # split data
from sklearn.linear_model import LinearRegression # create model
from sklearn.metrics import mean_squared_error # test model
```

Linear Regression with Python

```python
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LinearRegression
from sklearn.metrics import mean_squared_error

df = pd.read_csv('/content/housing.csv')
X = df[['total_rooms','households']]
y_target = df['median_house_value']
```
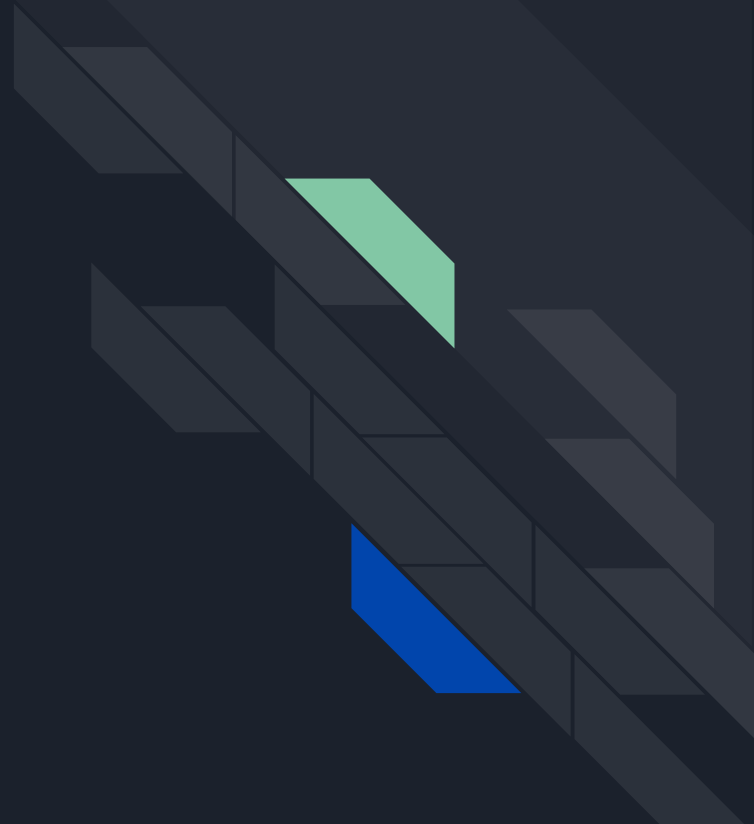
Linear Regression with Python

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import pandas as pd
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df = pd.read_csv('/content/housing.csv')
X = df[['total_rooms','households']]
y_target = df['median_house_value']

X_train, X_test, y_train, y_test = train_test_split(X, y_target, test_size=0.3)
model = LinearRegression()
model.fit(X_train, y_train)
```

Linear Regression with Python

```python
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LinearRegression
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df = pd.read_csv('/content/housing.csv')
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X_train, X_test, y_train, y_test = train_test_split(X, y_target, test_size=0.3)
model = LinearRegression()
model.fit(X_train, y_train)

y_predict = model.predict(X_test)
rmse = mean_squared_error(y_test, y_predict, squared=False)
```

Exercise 3

Linear Regression with Python

```python
from sklearn.metrics import mean_squared_error
from sklearn.metrics import r2_score
from sklearn.metrics import median_absolute_error


rmse = mean_squared_error(y_test, y_predict, squared=False)
r2 = r2_score(y_test, y_predict)
mae = median_absolute_error(y_test, y_predict)
```
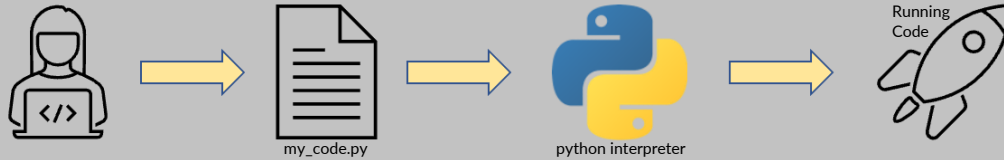
Advanced Visualisations & Modelling
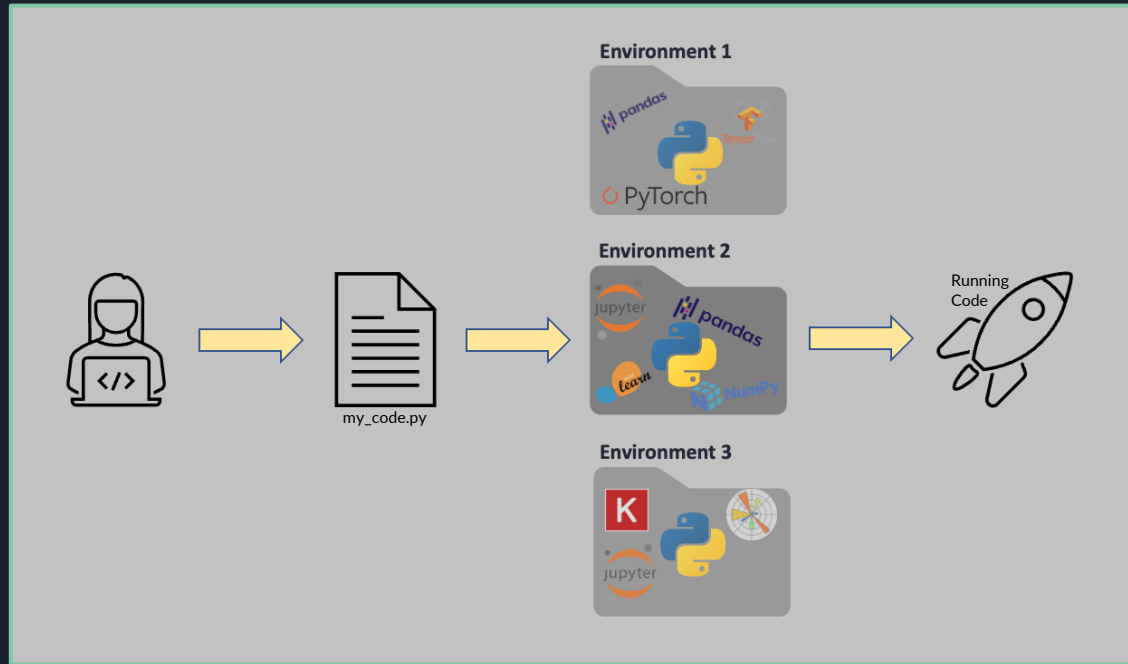# Python Local Installation
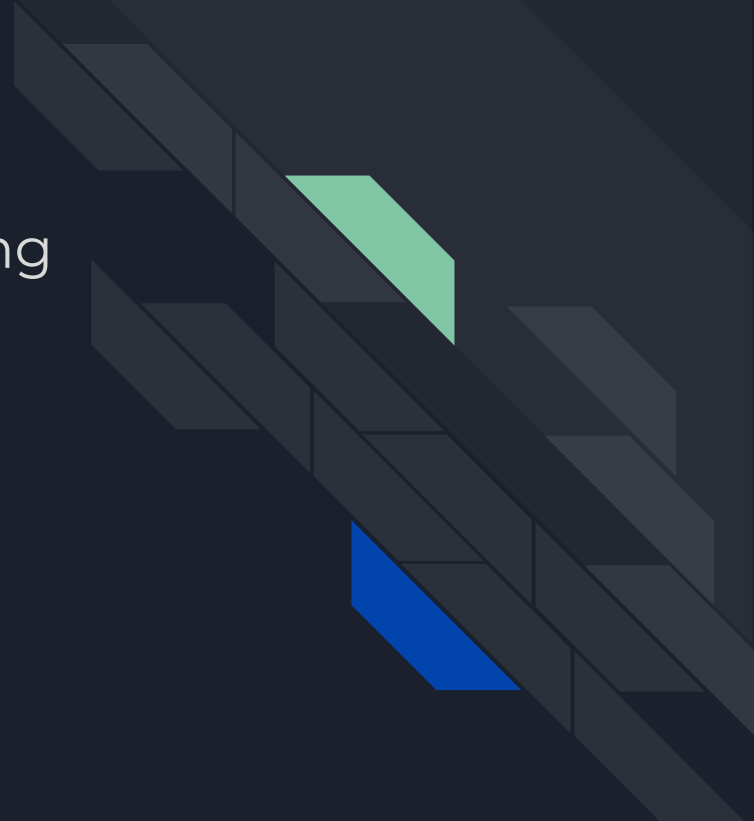
Code Execution

- **Download Python:** https://www.python.org/

Environments

- To install packages for a particular project

- Dependencies are installed in different directories

Anaconda distribution

- Python interpreter
- Jupyter Notebooks (similar to Colab, but local)
- Manage environments and packages
- Runs on Windows, Mac and Linux

Installation:
https://docs.anaconda.com/anaconda/install/

Getting started:
https://docs.anaconda.com/anaconda/user-guide/getting-started/

Pycharm

- Python IDE
- Free Educational License for Pro Version
- Many Alternatives: VS Code, Atom, …

Installation:
https://www.jetbrains.com/community/education/#students