Artificial Intelligence

Algorithms and Applications with Python

Chapter 3

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</> course material: ↗ www.github.com/dominikjung42 | recordings: ↗ www.youtube.com/c/dominikjung42

Recap: Who Should Choose this Lecture

This lecture is aimed at two complementary audiences:

- Intermediate information systems / computer science students who want to get a general understanding of artificial intelligence (AI), understand how AI works, and learn new strategies for solving diverse AI problems.

- Students from other domains who are planning to use AI methods (e.g. machine learning) in their future and want to understand why it works the way it does.

If you are familiar with Python you can skip this chapter and continue in chapter 4.

Outline

3 AI Programming with Python

- 3.1 Python AI Programming Toolbox
- 3.2 Foundations of Programming with Python
- 3.3 Python Tutorial
- 3.4 The Extended AI Toolbox

Lectorial 1: Implement Problem-Solving Agents with Python

► **What we will learn:**

- Get an overview of AI software and programming with Python, so that you will be able to build your own agents and AI software components
- Workflow and tools to develop simple scripts and applications with Python
- Discuss advanced concepts of Python programming and AI related packages

Image source: ↗ Pixabay (2019) / ↗ CC0

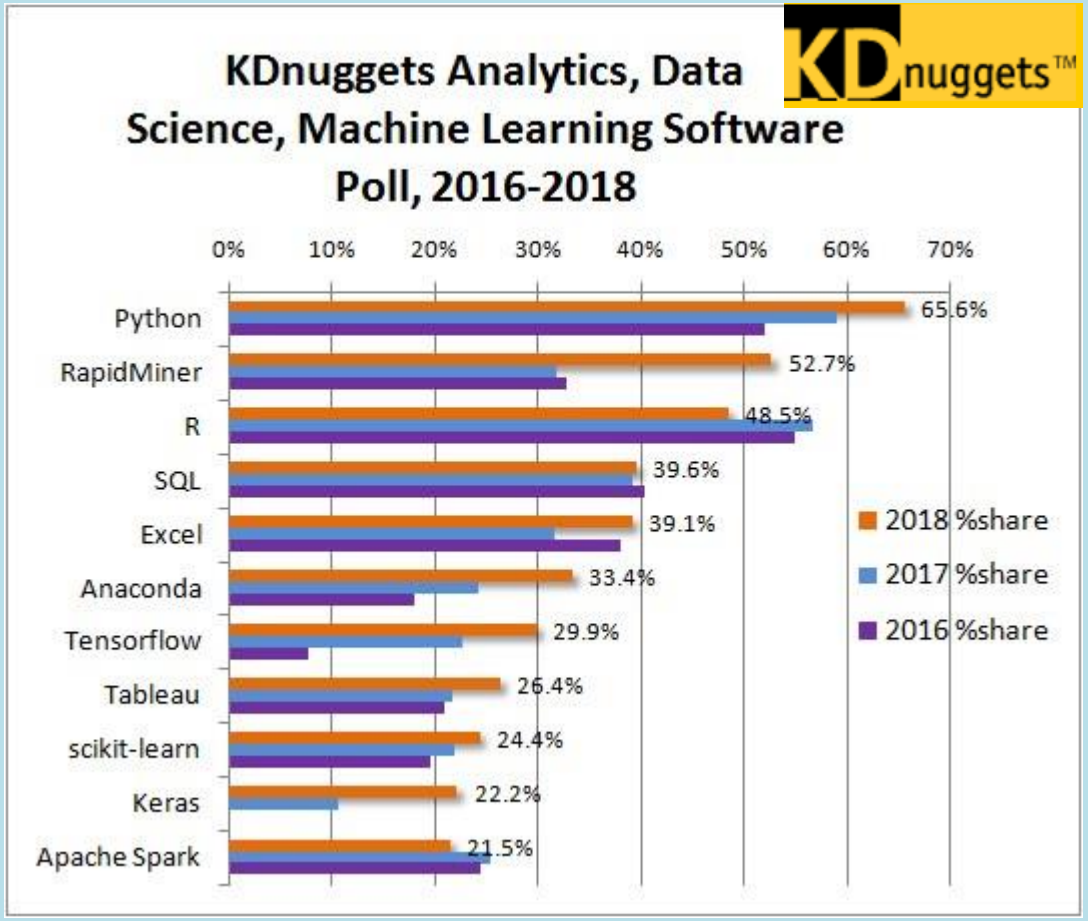
► **Duration:**

- 90 min

► **Relevant for Exam:**

- 3.1 - 3.4

3.1 Tools for AI Specialists



- The landscape of "Data Science Tools" is constantly changing
- Tools are often domain-specific: If you are interested in machine learning you better start with Python, if you are interested in statistics or analytics start with R
- But learn both!
- Tools are also customer-specific: If your customers can not program, you have to build your models with software tools

https://www.kdnuggets.com/2018/05/poll-tools-analytics-data-science-machine-learning-results.html

3.1 Tools of AI Specialists

Software Tools

Software that is designed to be used for a specific use case (e.g. Dashboarding, Data Visualization, Modelling). Most of the software tools in AI have graphical user interfaces (GUI), and only some come with proprietary languages to operate on.

Programming Languages

Language engineered to create a standard form of instructions for a computer. Like human languages they are split into two components, i.e. syntax (form) and semantics (meaning).

The major advantage of using programming languages is that they are usually open source and more flexible because they come with a rich stack of libraries and packages. In contrast, ready-made software tools are usually barely-configurable black boxes – that may however be easier to learn.

My team's reaction to using Power BI and realising they'll need to learn four or five programming languages (DAX, M, MDX, R etc) to deliver dashboards to users.

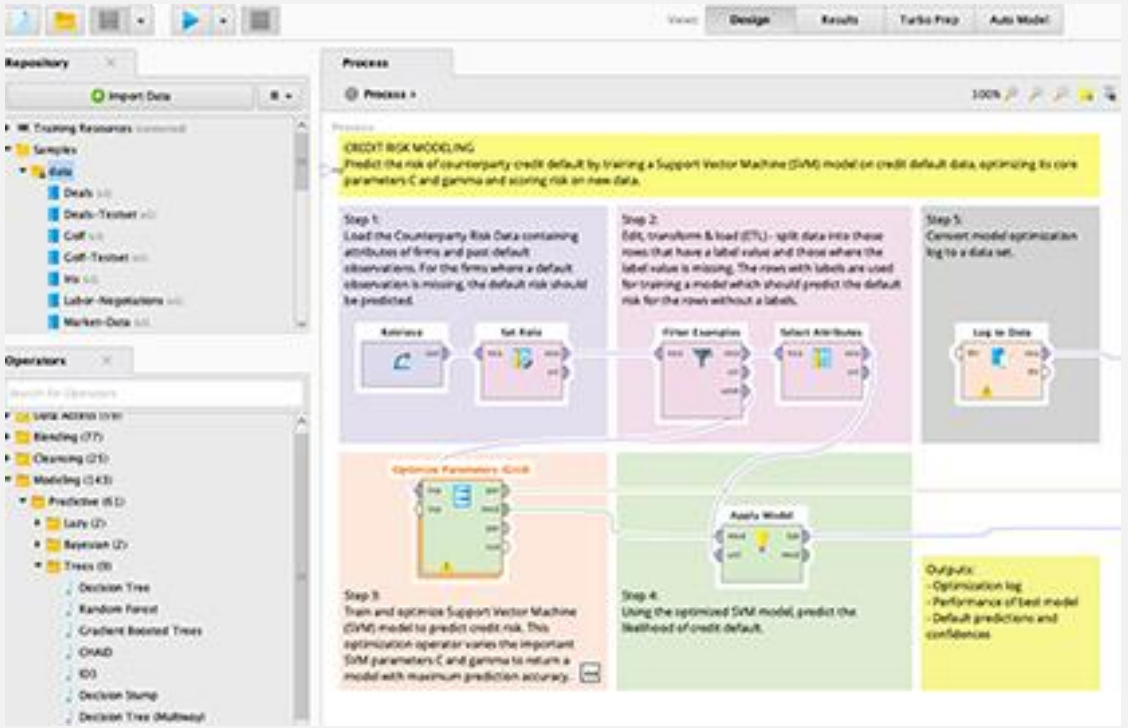
3.1 Machine Learning Tools: RapidMiner

Characteristics

- General purpose machine learning platform with a graphical user interface
- Developed from the AI Unit @TU Dortmund

Application

- Graphical workflow editor that supports all steps of the machine learning process (e.g. data processing, visualization and modelling)
- Many use cases for research, education, training, rapid prototyping, and application development



\+ Easy to use and no programming skills are necessary. Workflow can be communicated easily

\- Not as flexible and powerful as programming languages

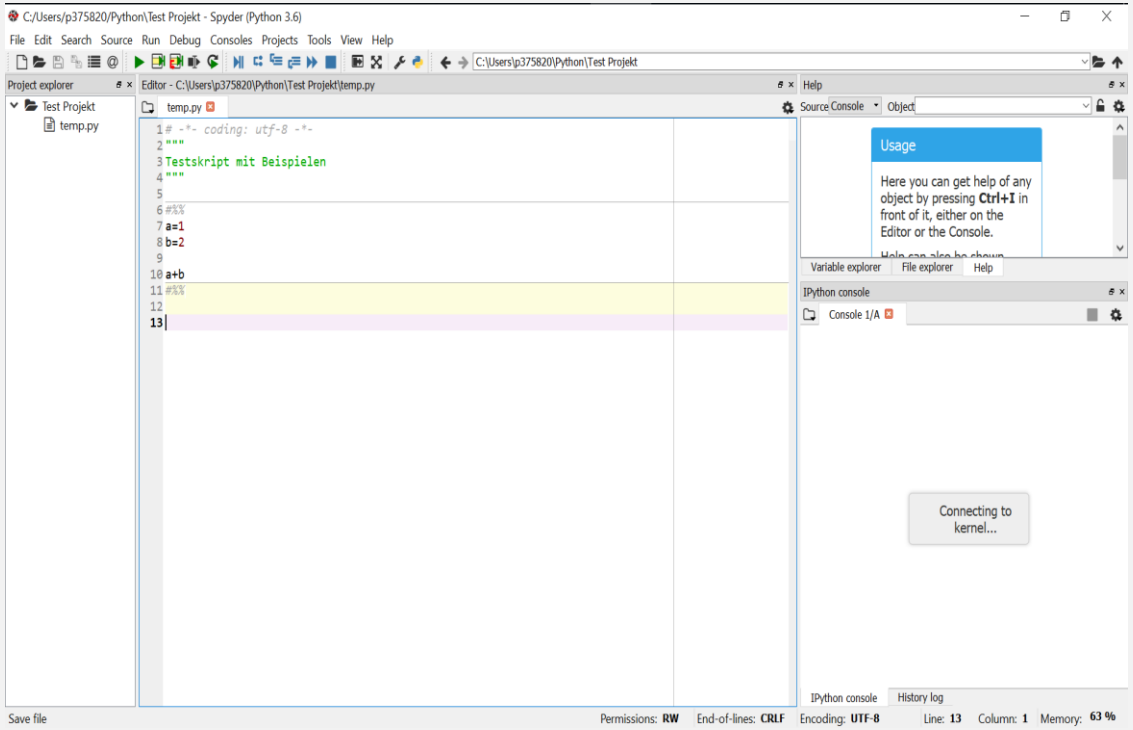
3.1 Programming Languages: Python

Characteristics

- General-purpose interpreted, interactive, object-oriented, and high-level programming language, widely used in various fields, thanks also to its readability
- Open source

Application

- Because it is a general purpose language, the use cases of Python are manifold
- Analytical/machine learning or data science P
- projects, where neural networks are used (e.g. for natural language processing)
- In particular, artificial neural networks (e.g. TensorFlow)



\+ Active and large community, with a huge number of great libraries for deep learning

\- Requires programming skills, but is easy to learn. Sometimes issues arising from version incompatibility

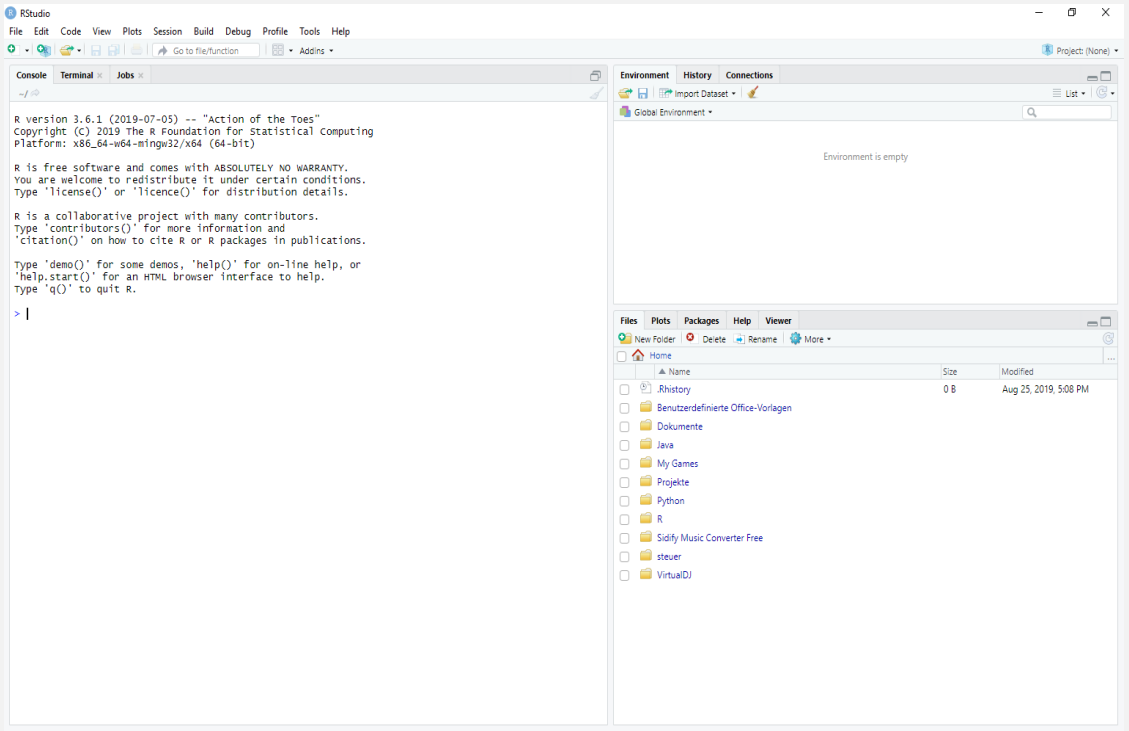
3.1 Programming Languages: R

Characteristics

- R: open source programming language designed for statistical computations
- State-of-the-Art in Analytics
- With R-Studio one of the best IDEs for Statistics

Application

- Popular among the academic and statistical community
- Excellent for Data Science Projects including statistical analysis (for small-to-medium sized amounts of Data) rather than Machine Learning



+ Large, active community with great libraries for visualization and dashboard design. Besides, language with the most statistical packages

- Slower and less readable than Python

3.1 What is Python?

- Python is a popular high-level programming language used in various applications
  - Python is an easy language to learn because of its simple syntax
  - Python can be used for simple tasks such as plotting or for more complex tasks in AI development like machine learning or natural language processing

3.1 Language properties

- Everything is an object
- Modules, classes, functions
- Exception handling
- Dynamic typing, polymorphism
- Static scoping
- Operator overloading
- Indentation for block structure

3.1 High-level data types

- Numbers: int, long, float, complex
- Strings: immutable
- Lists and dictionaries: containers
- Other types for e.g. binary data, regular expressions, introspection
- Extension modules can define new “built-in” data types

3.1 Why do we use Python in this Course?

```
Public class Crawler{
Public static void main(String[] args) throws IOException{
    Print Writer textFile = null;
    try{
        textFile = new PrintWriter(„results.txt“);
        System.out.println(„Enter the URL you with to crawl…“);
        System.out.println(„URL: “);
        String myUrl = new Scanner(System.in).nextLine();

        String response = getContentByUrl(myUrl);

        Matcher matcher = Pattern
           .compile(„href=[\“‘](.[^\“‘)+)[\“‘]“).matcher(response);
        while(matcher.find()){
            String url = matcher.group(1);
            System.out.println(url);
            textFile.println(url);
        }
    finally{
        if(textFile != null){
             textFile.close();
        }
    }
}

Private static String getContentByUrl(String myUrl) throws IOException{
    Url url = new URL(myUrl);
    URLConnection urlConnection = url.openConnection();
…
```

```
If __name__ == ‘__main__‘:
    with open(„results.txt“,“wt“) as textFile:
        print(„Enter the URL you wish to crawl:“)
        myUrl = input(„URL: “)
        for i in re.findall(„href=[\“‘](.[^\“‘)+)[\“‘]“,
        urllib.request.urlopen(myUrl).read().decode(), re.I):
        print(i)
        textFile.write(i+‘\n‘)
```

Characteristics:

- Main purpose was to design an easy to learn language with strong focus on code readability
- Multi-purpose programming languages, thus very flexible and applicable to a broad range of cases
- Healthy, active and supportive community that develops state-of-the-art AI packages, e.g.:TensorFlow

Python

- Python has a couple of characteristics that have bolstered its rise in the data science community over the past years.
- One of the main aspects is its elegance and readability compared to other languages.

3.1 Where to use python?

- System management (i.e., scripting)
- Web programming
- Database management and programming
- Natural language processing
- Distributed processing
- Numerical operations
- Graphics
- And so on…

3.1 Python 2 vs. Python 3

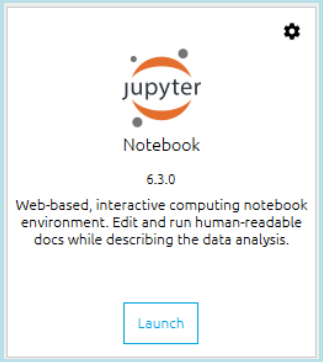
- „Breaking changes“ in the standard library functionality

```
print "hello world"
        vs
print("hello world")
```

- Modules added to standard library
  - For instance, `asyncio` module for native concurrency support
- Python 2 still dominant in some established libraries
- However, movement towards Python 3

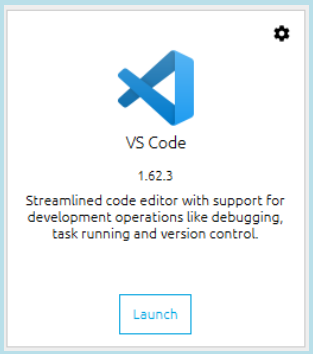
3.1 The AI Programming Toolbox - Popular Tools and IDEs for Python AI Programming

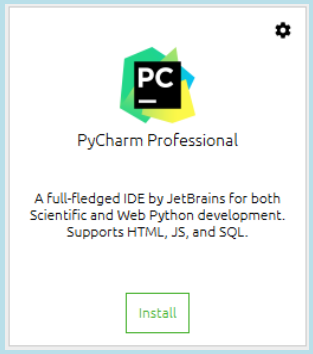
Applied AI & Data Science



- Google CoLab, Jupyter Notebook and Jupyter Lab are tools to develop Python in your browser or on an AI-server
- Google CoLab and Jupyter Lab is a kind of mix of Jupyter Notebook and Spyder that runs in your browser

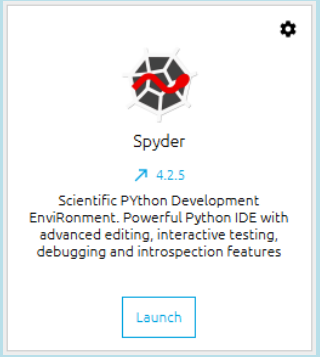
AI Development





- VS Code is my favorite IDE for web/software development and Python coding. It is free to use and supports many other programming languages
- PyCharm is an IDE that is also very popular in software development with Python

Data Analytics

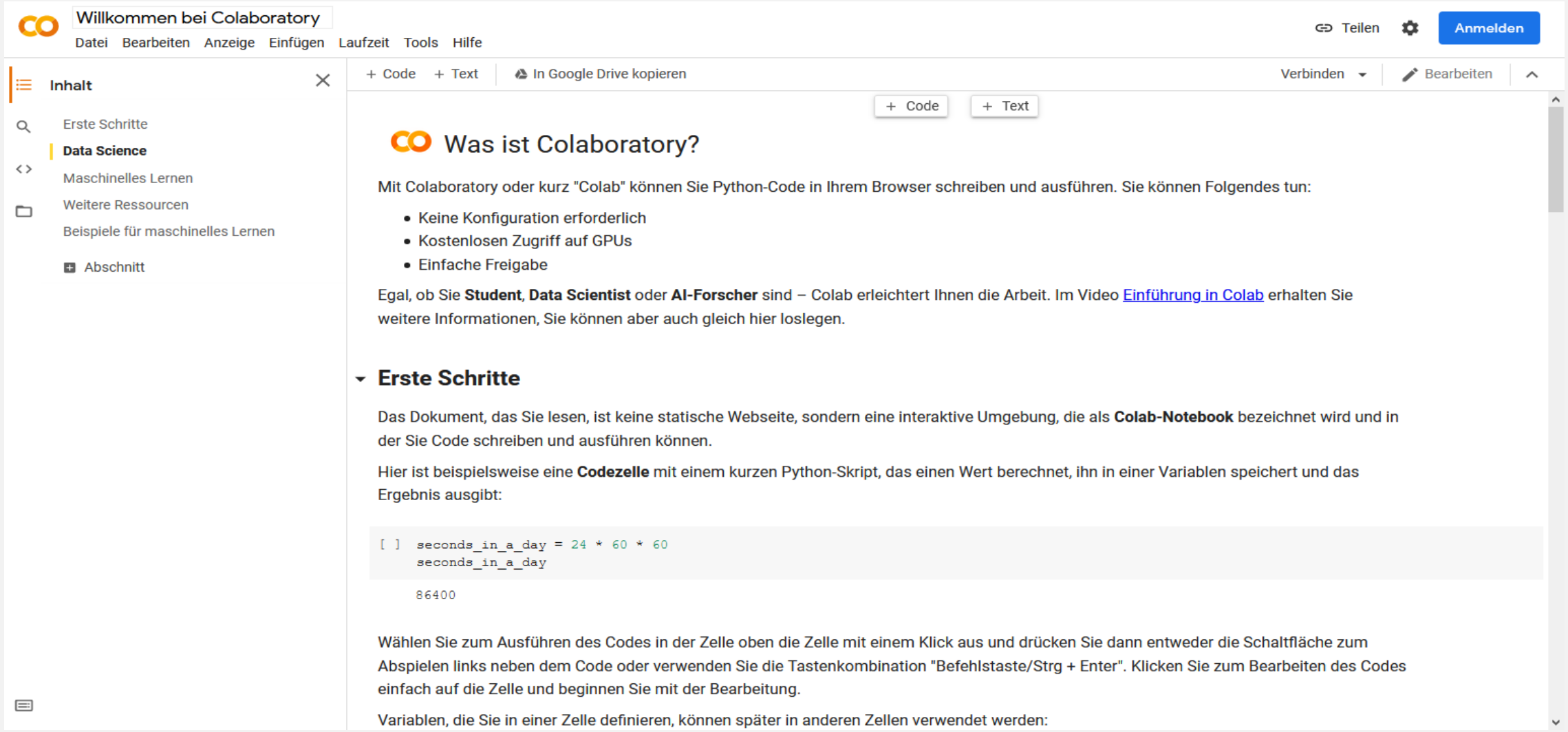


- Spyder is the most popular Python IDE for data analytics and diving deep in your data. In runs on your local machine
- Notebooks are best practice to share and discuss code with none-AI specialists or other experts due to their code buckets

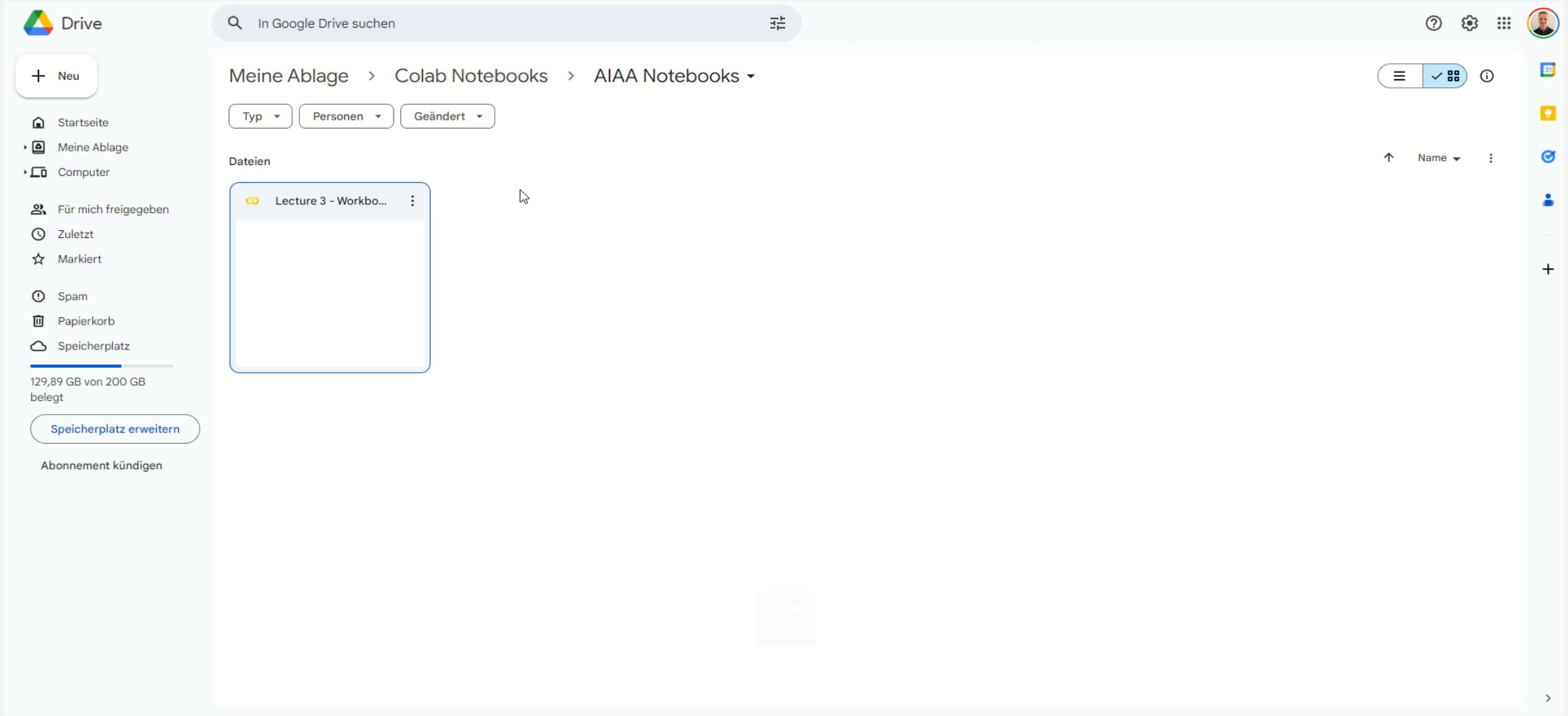
3.1 Jupyter Notebooks

- Jupyter allows you to build simple code/text documents with your Python code

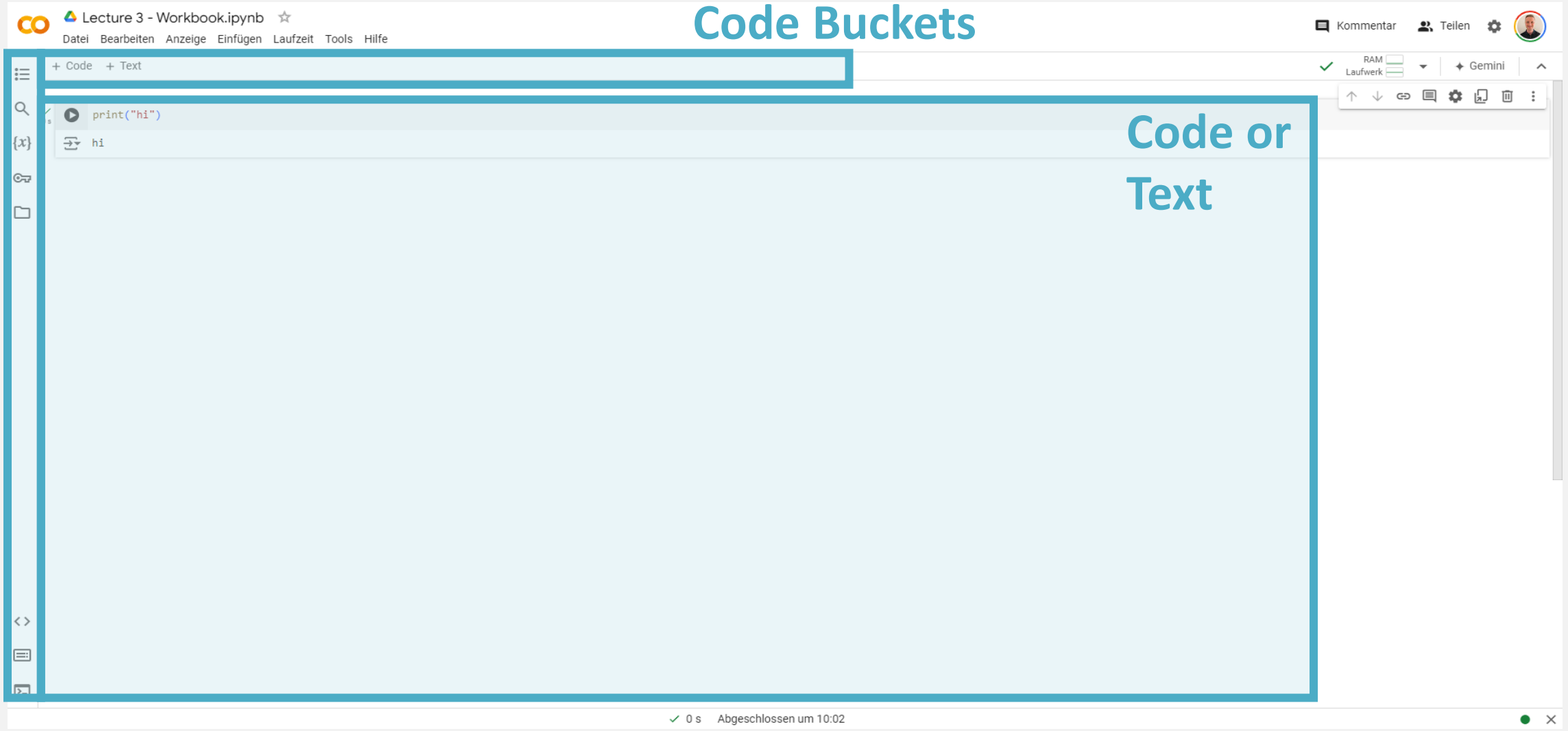
3.1 Jupyter Notebook in the Cloud: Colaboratory



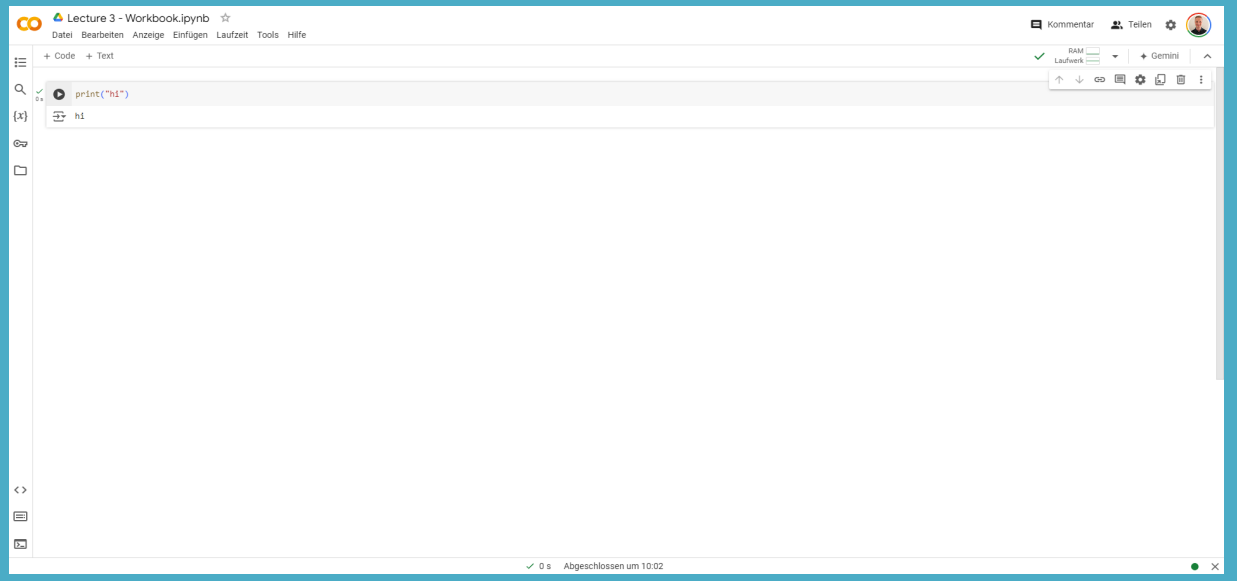
3.1 Ready-to-go: Google Colabs



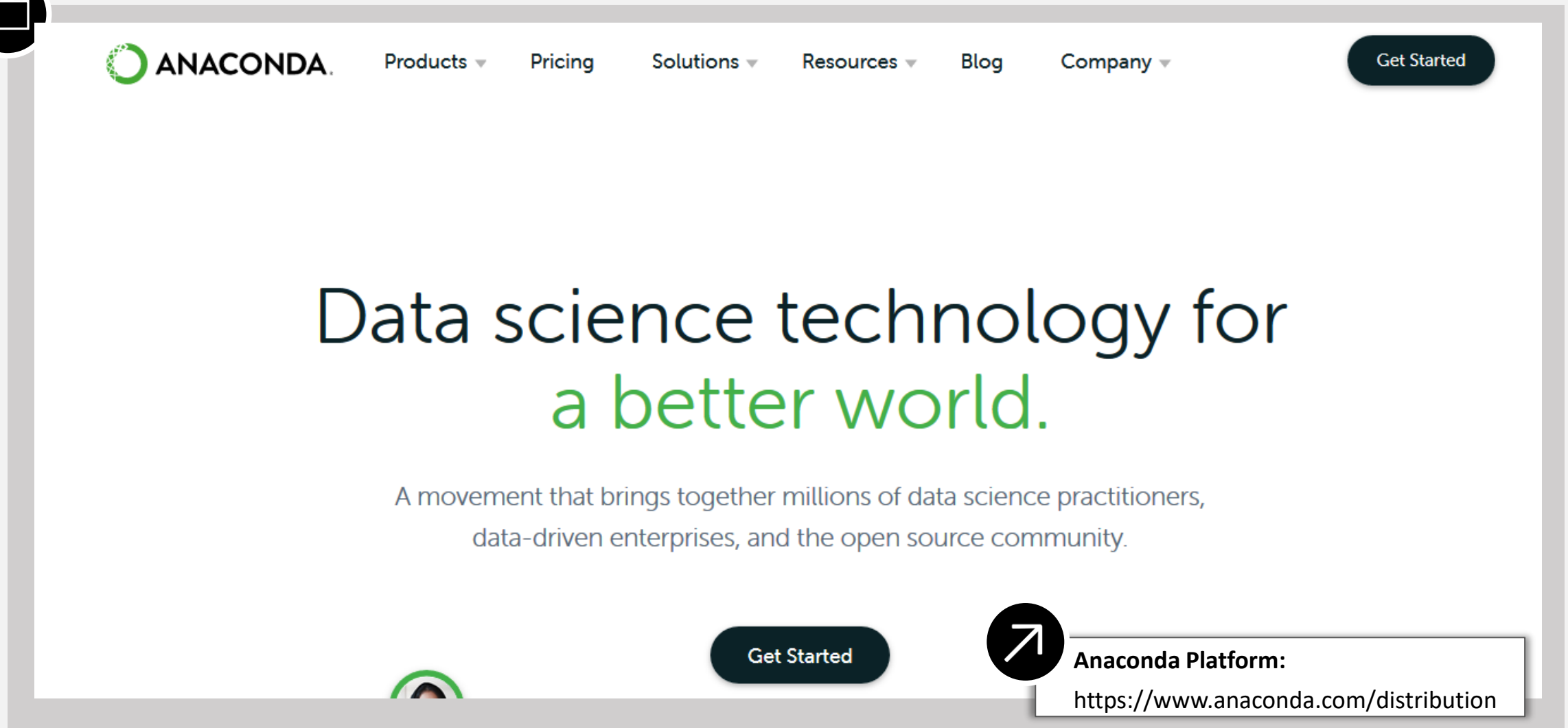
3.1 Google Colabs Overview



Now, please start Google CoLab in your Browser

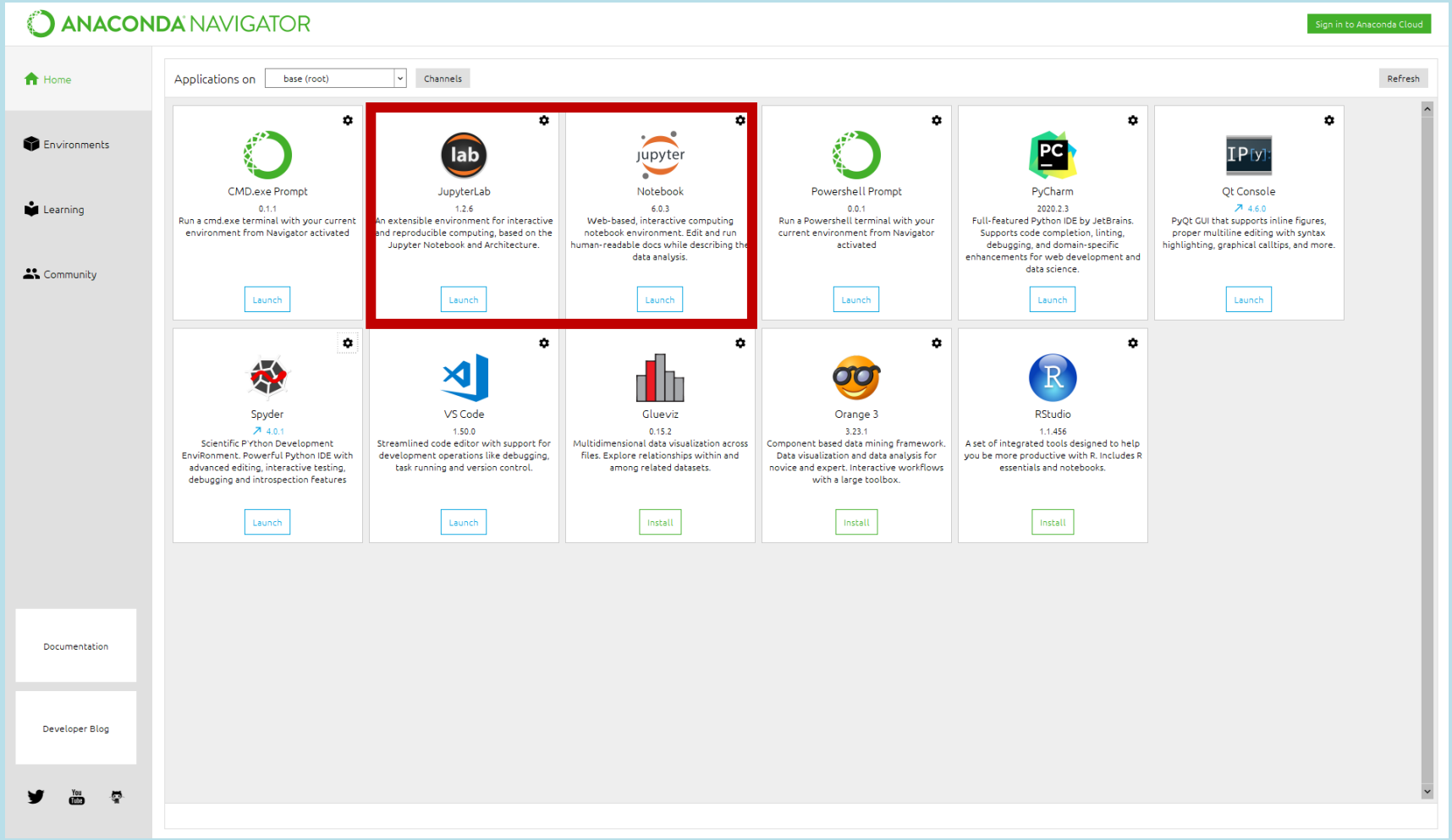


3.1 Install Anaconda

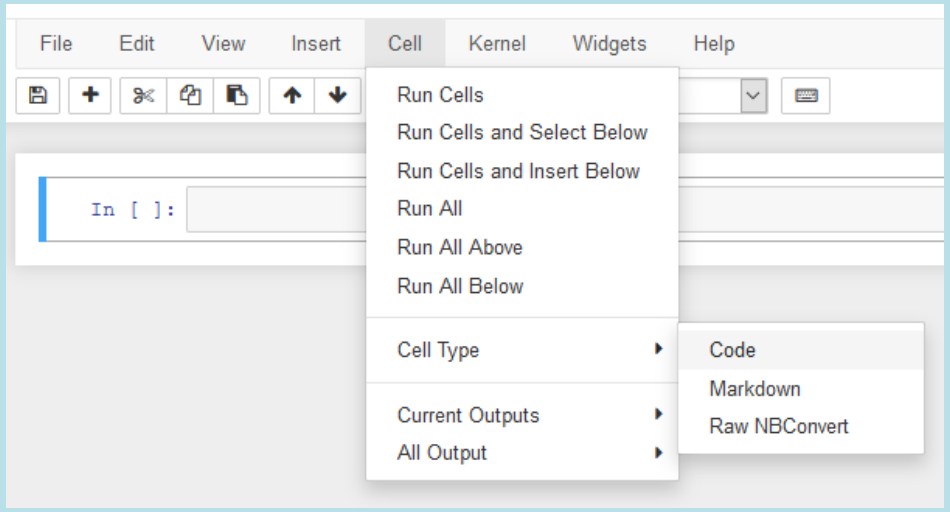


Anaconda Platform:
https://www.anaconda.com/distribution

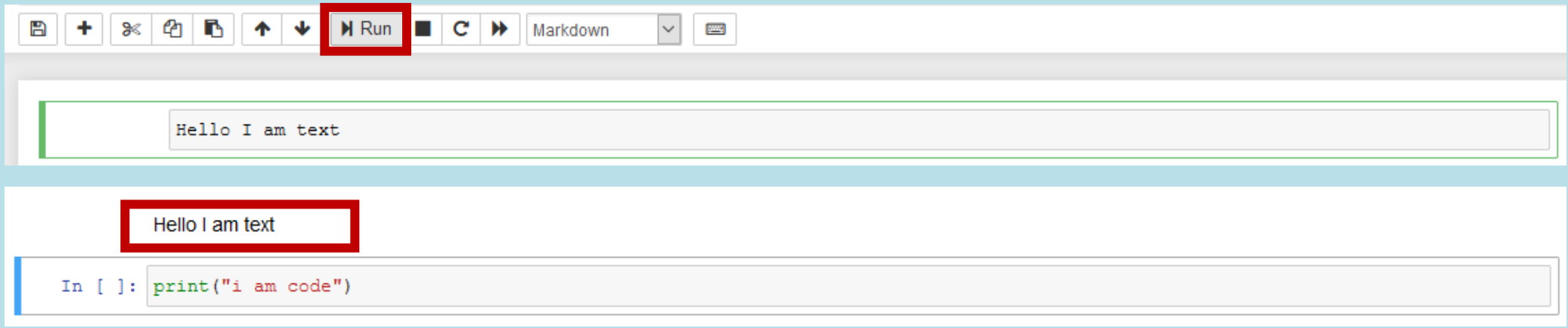
3.1 Start Jupyter from Anaconda



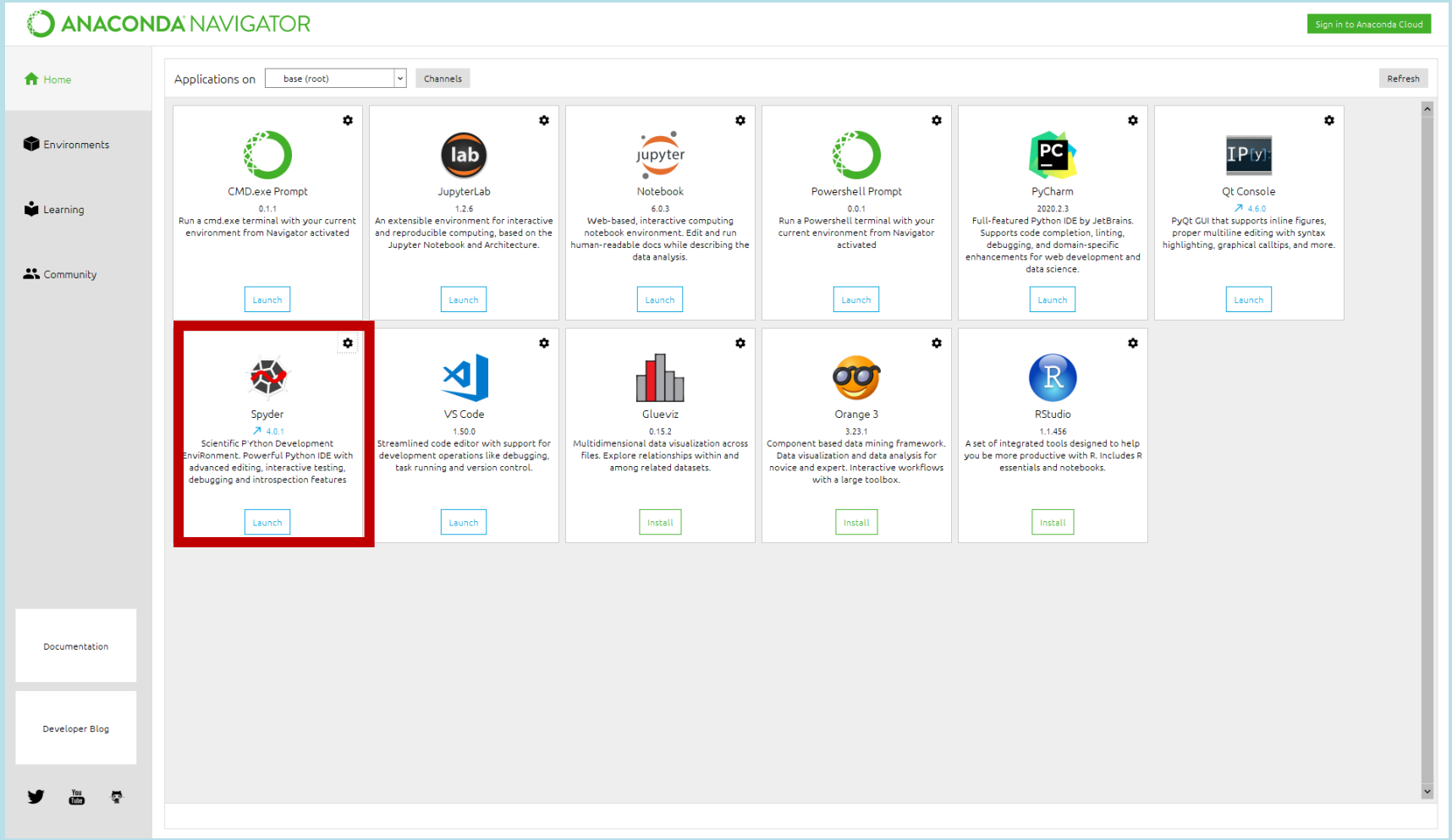
3.1 Jupyter Notebooks / Labs



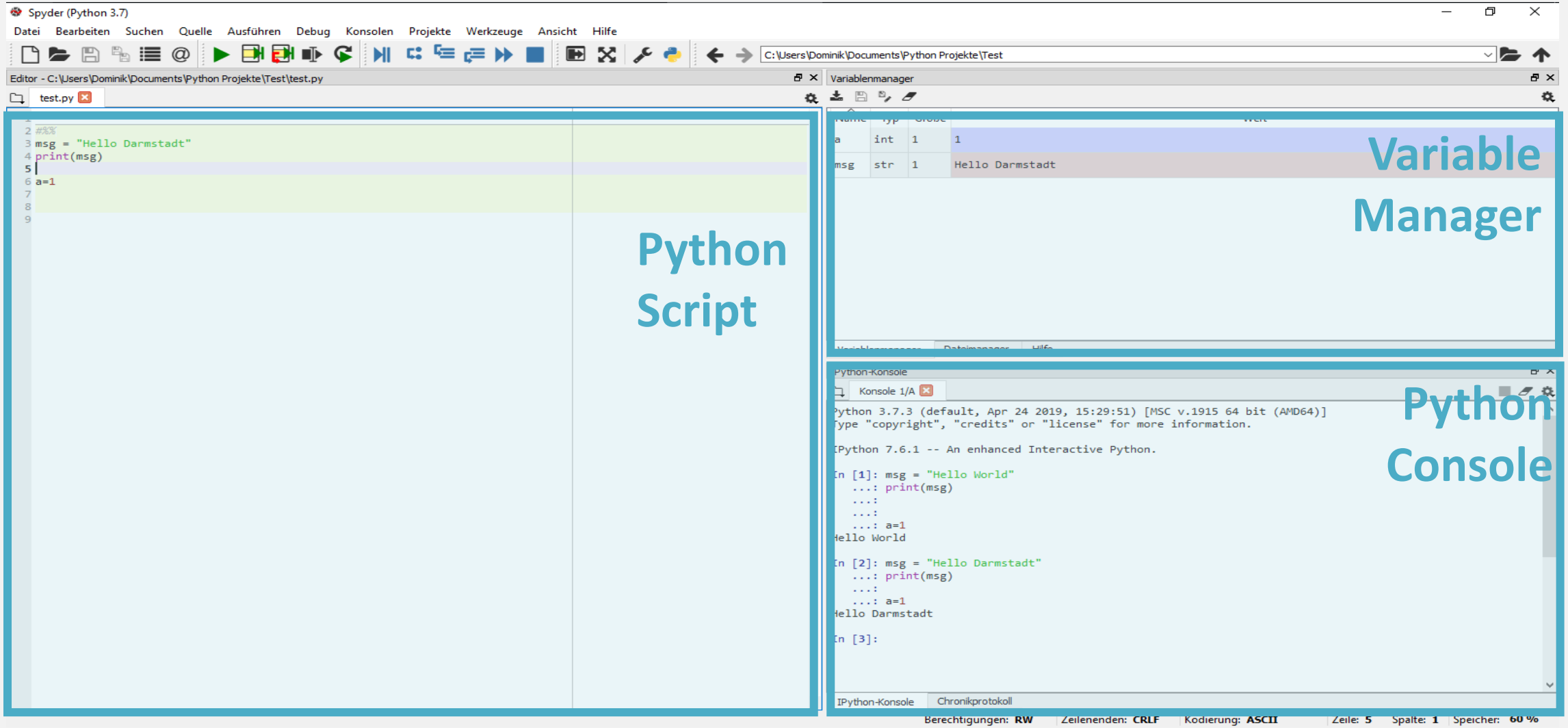
- Jupyter works with different cells. You can mark cells as text (markdown) or code (Python code) cells.
- If you press, run they get activated



3.1 Lets Take a Quick Look at Programming with the Spyder IDE in Anaconda

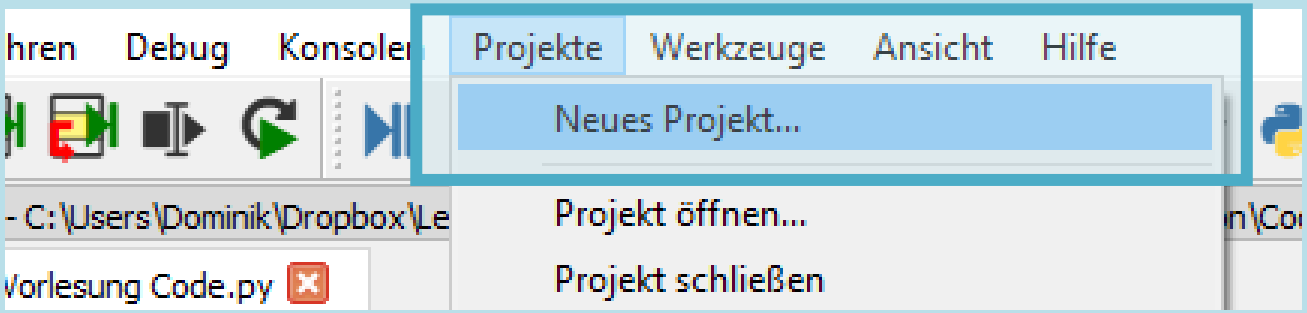


3.1 Spyder IDE

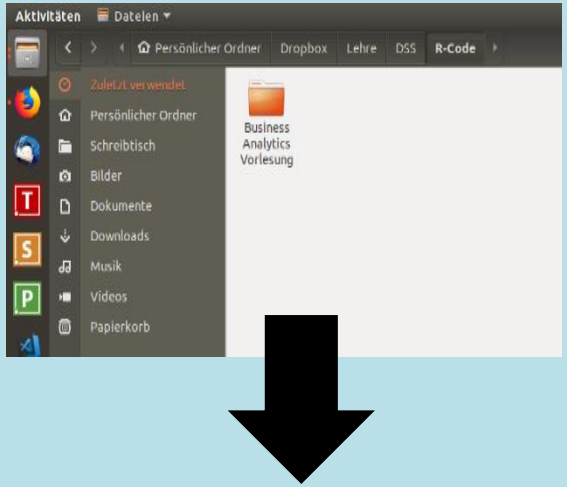


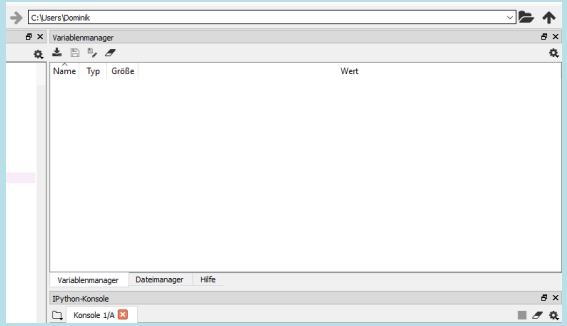
3.1 Projects with Spyder

- Spyder allows you to manage all your files and data with “projects”
- The benefit is that you can throw all your stuff in one folder and have direct access without browsing your files
- Furthermore you can save your current session
- And reload it easily



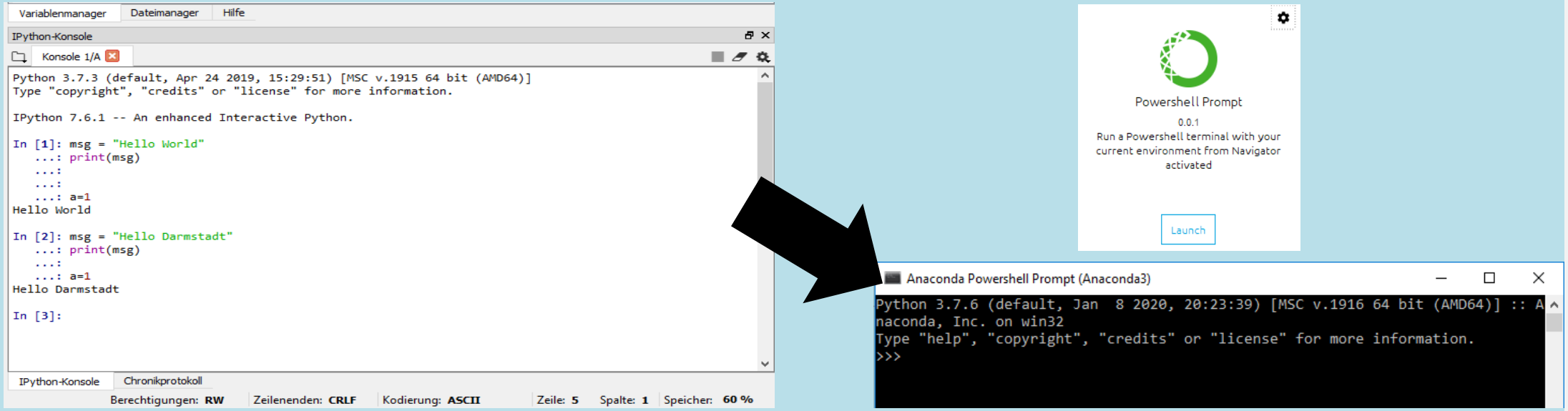
Data Management





3.1 First Steps in the Interactive Mode

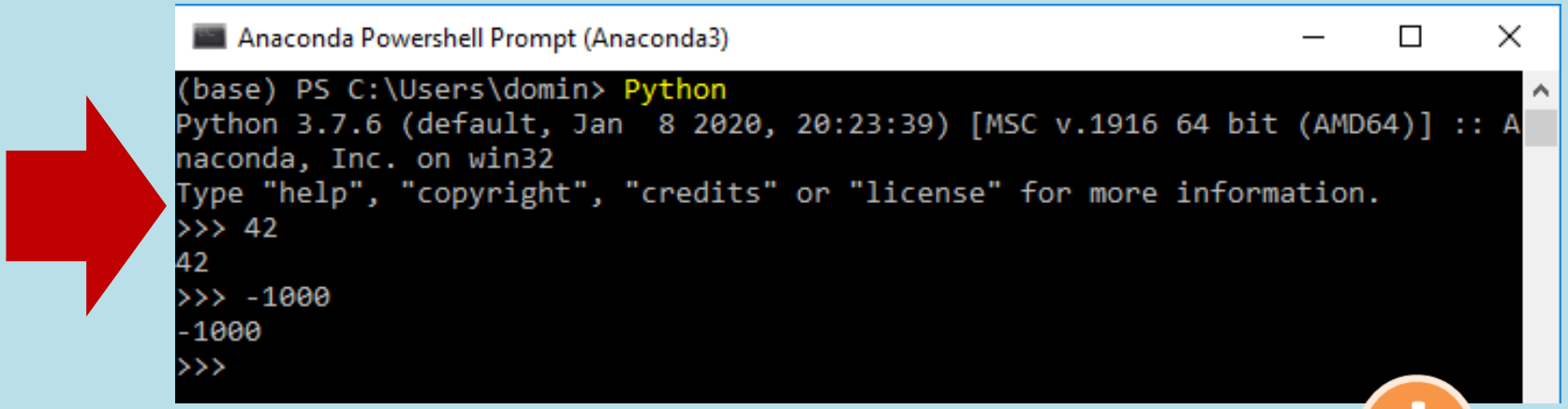
- To run Python commands you can use the console from the Spyder IDE or open the Anaconda-Shell and type „Python“



3.1 First Steps in the Interactive Mode

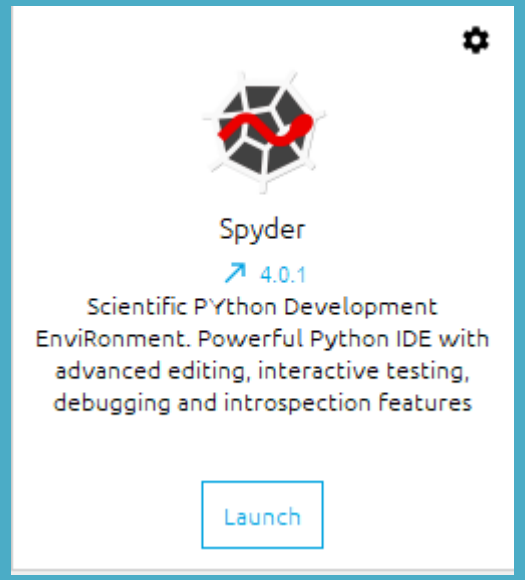
- Let us start by printing the following command in the Python interpreter (in the Spyder IDE or in the Python prompt directly)

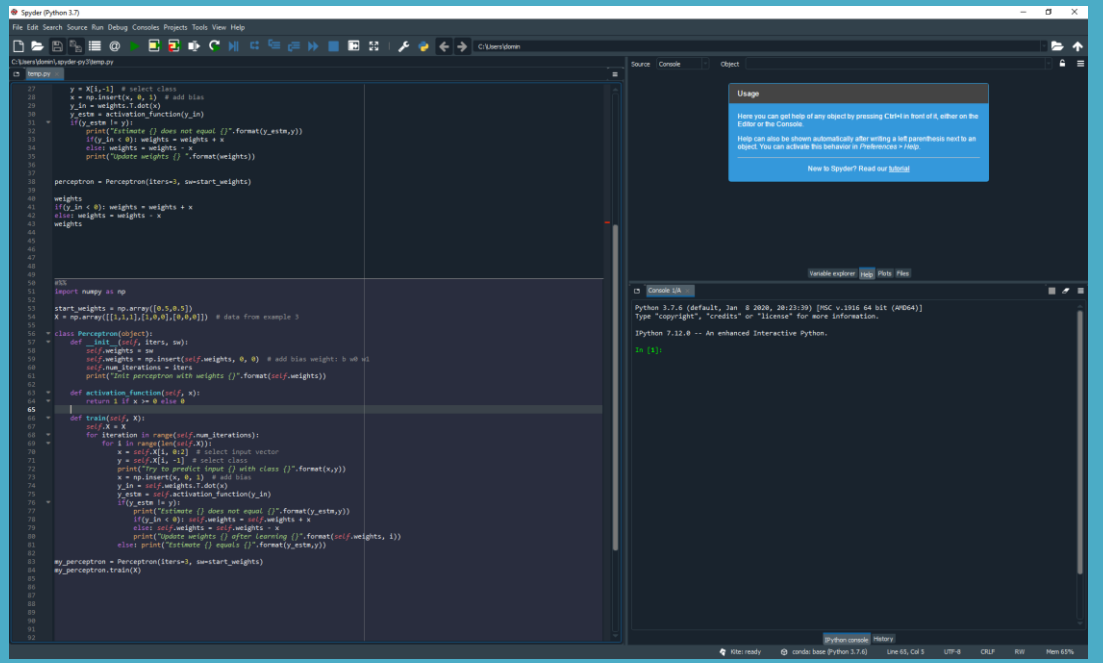
```
42
```



The interactive Python mode has a history functionality. Press ↑ or ↓ to re-read your previous code.

Now, please start the Spyder IDE from your Anaconda!





3.1 Run Python Files from Console

- If you want to write and run simple scripts you have to write your Python commands (code) into text files and store them as <filename>.py
- Then you can run them from console

```
Python '<PATH TO YOUR FILE>.py'
```

Adapted from Ernesti, J. & Kaiser, P. (2017)

3.1 Python Shebang

- **Under a Unix-like operating system** such as Linux, Python program **files can be made directly executable with the help of a shebang**, also called Magic Line. To do this, the first line of the program file must usually be as follows:

```
#!/usr/bin/python
```

- In this case, the operating system is forced to always execute this program file with the Python interpreter. On other operating systems, for example Windows, the shebang line is ignored.

Adapted from Ernesti, J. & Kaiser, P. (2017)

3.1 Classroom Task

Your turn!

Task

Please open one of the presented python IDEs and run the following code:

```
print('Hello World!')
```

Task

Please discuss with your neighbors:

- In which kind of AI project scenario you would work with software tools and in which you recommend to use an programming language!

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- 3.1 Python AI Programming Toolbox
- 3.2 Foundations of Programming with Python
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- 3.4 The Extended AI Toolbox

Lectorial 1: Implement Problem-Solving Agents with Python

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Image source: ↗ Pixabay (2019) / ↗ CC0

► **Duration:**

- 90 min

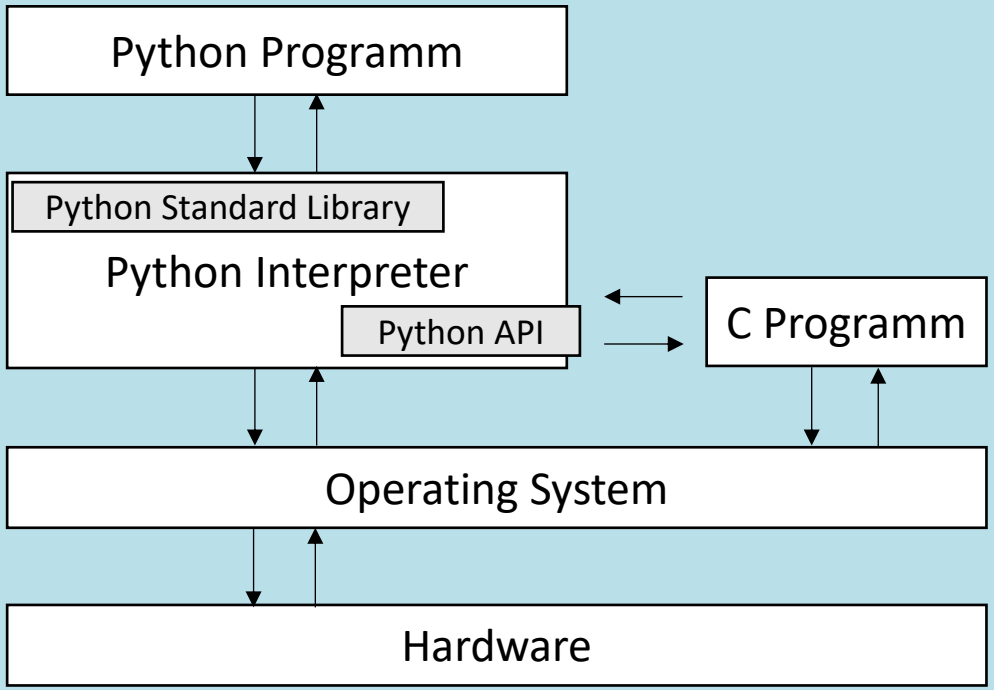
► **Relevant for Exam:**

- 3.1 - 3.4

3.2 Programming Basics

- code or source code: The sequence of instructions in a program.
- syntax: The set of legal structures and commands that can be used in a particular programming language.
- output: The messages printed to the user by a program.
- console: The text box onto which output is printed.
- Some source code editors pop up the console as an external window, and others contain their own console window.

3.2 The Python Interpreter



- The Python interpreter executes your Python program without requiring it previously to have been compiled into a machine language program
- There is a big Standard Library with basic functionalities that the program can rely on
- Python can be extended easily by the Python API

Image adapted from Ernesti, J. & Kaiser, P. (2017)

3.2 Key Concepts of Writing Python Code

Whitespace Formatting

```
if True:
    print("AI is such a cool lecture")
else:
    print("AI is my favorite lecture")
```

Line indentation

Comments

```
print("Hello Darmstadt!")  # This is a comment

'''
This is a multi-line comment.
Bla bla
'''
```

Multiple statements

```
print("Hello Darmstadt!");print(" What's up? ")
```

Python does not use braces to indicate code blocks (e.g. for functions or flow control). Blocks are denoted by line indentation instead. The number of spaces in the indentation is variable, but has to be the same within the block.

- Python is an interpreted language
- The interpreter provides an interactive environment to play with the language
- Results of expressions are printed on the screen

3.2 Variables

- **Expression**: A data value or set of operations to compute a value.

```
1 + 4 * 3
42
```

- **Variables**: A Python variable is a reserved memory location to store values
  - The name of your variable is placed on the left of the “=“ operator.
  - Most variable names are in camel case where the first word begins with a lowercase letter and any subsequent words are capitalized
  - Variable names may also appear in snake case where all words are lowercase, with underscores between words

Adapted from Ernesti, J. & Kaiser, P. (2017)

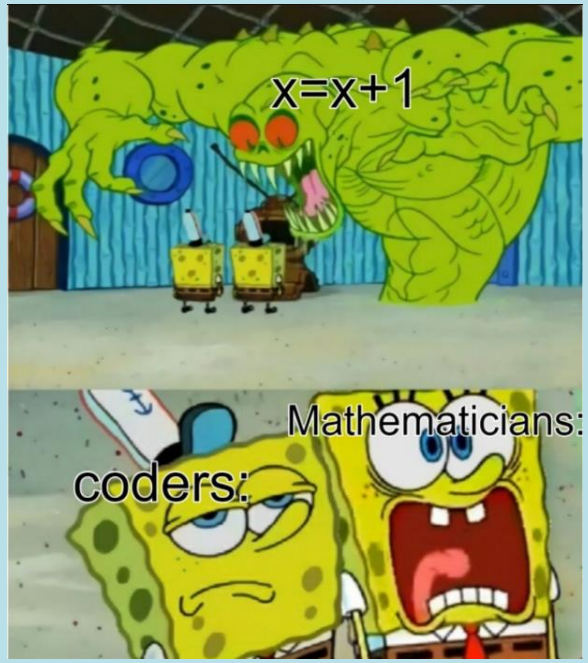
3.2 Variables

- Consequently, you can define variables

```
>>> name = 0.5
>>> var123 = 12
>>> string = "Hallo Welt!"
>>> liste = [1,2,3]
```

- You can access variables later by „calling“ them

```
>>> name
0.5
>>> 2 * name
1.0

>>> else = 4
?
```



Error to run `else = 4`? Some variable names are not allowed in Python, they are reserved for other purposes (e.g. “and”, “if”, “else” etc)

Adapted from Ernesti, J. & Kaiser, P. (2017)

3.2 Python Runtime Model I

- We have discussed that you can assign variables with `var = value`

```
your_variable = 42
```

- Then you can call the variable

```
>>> your_variable/2
21.0
```

- Alternatively, you can make an instance of the value directly

```
>>> 42
42
```

Adapted from Ernesti, J. & Kaiser, P. (2017); Offical Python Documentation (2019): https://docs.python.org

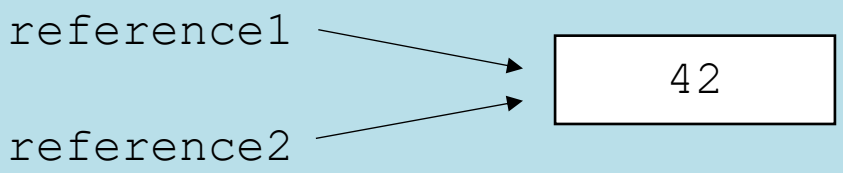
3.2 Python Runtime Model II

- We have discussed that you can assign variables with `var = value`

```
your_variable = 42
```

- Then you can call the variable

```
reference1 = 42
reference2 = reference1
```

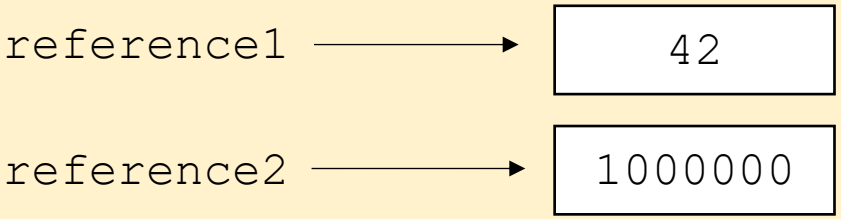


Adapted from Ernesti, J. & Kaiser, P. (2017); Offical Python Documentation (2019): https://docs.python.org

3.2 Python Runtime Model - Example

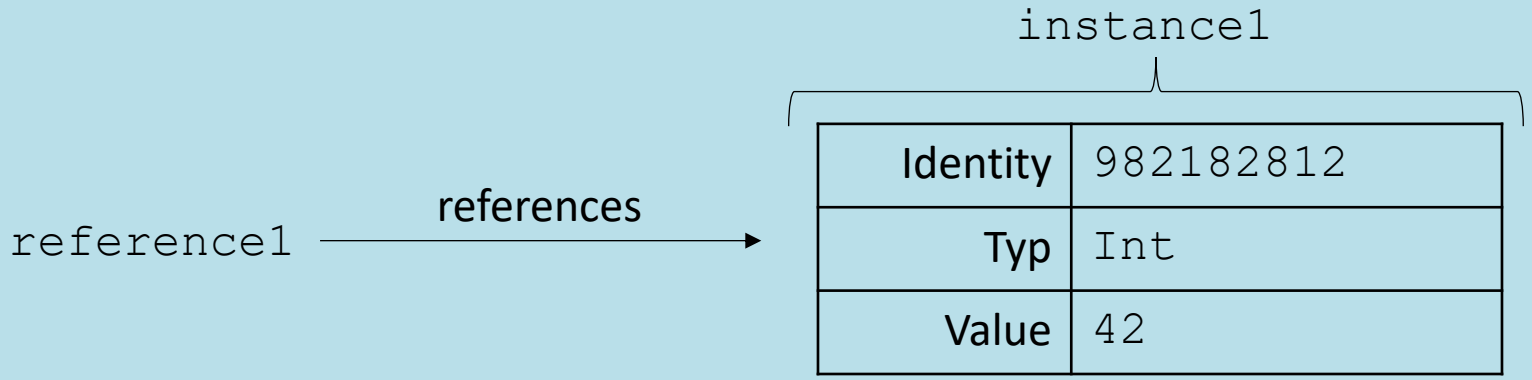
```
>>> reference1 = 42
>>> reference2 = reference1

>>> reference1
42

>>> reference2
42

>>> reference1 = 1000000
>>> reference1
1000000

>>> reference2
42
```

You have to distinguish references as references to instances from the instances themselves. This is a common error in Python programming!



Adapted from Ernesti, J. & Kaiser, P. (2017); Offical Python Documentation (2019): https://docs.python.org

3.2 Structure of Instances in Python



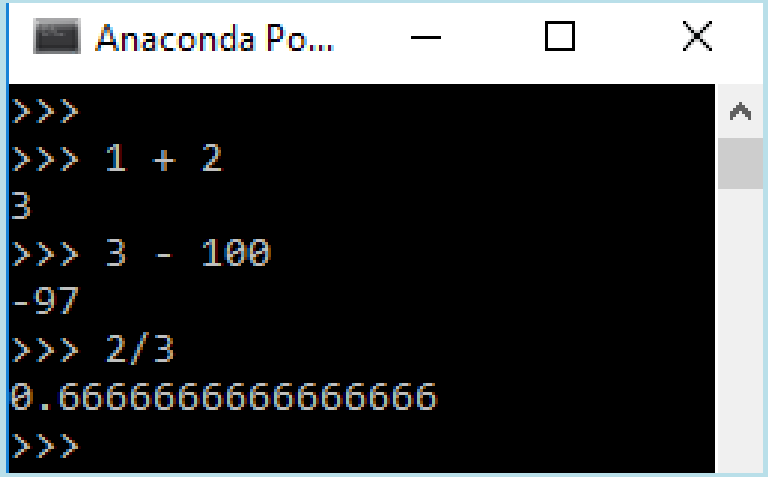
- Every object has an identity, a type and a value
- An object's *identity* never changes once it has been created; you may think of it as the object's address in memory

Adapted from Ernesti, J. & Kaiser, P. (2017); Offical Python Documentation (2019): https://docs.python.org

3.2 Common Data Types and Operators

- A data type is a means of classifying a value and determining what operations can be performed on it. All objects have a data type.

- Operators are symbols used carry out specific functions/computations.



Arithmetic Operators	
Operator	Command
Addition	`a + b = 3`
Subtraction	`a - b = 3`
Multiplication	`a * b = 3`
Division	`b/a = 1`
Modulus	`b % a = 0`
Exponent	`a ** b`

3.2 Data Types and Structures in Python

Data Structure

A data structure is a collection of data values, the relationships among them, and the functions or operations that can be applied to the data (Wegner & Reilly, pp. 507-512, 2003)

Data Types

Python has the following primitive data types

- `Integer` (42)
- `Float` (2.34567)
- `String` (“Hi world!”)
- `Boolean` (TRUE, FALSE)

To use that primitive data structures, Python stores the type of an object with the object (see dynamic typing)

Data Structures

Python has six non-primitive data structures

- `Array`
- `List`
  a. Linear: `Stacks, Queues`
  b. Non-Linear: `Graphs, Trees`
- `Tuple`
- `Dictionary`
- `Set`
- `File`

They contain the primitive data structures within more complex data structures for special purposes

Adapted from Ernesti, J. & Kaiser, P. (2017)

3.2 Float and Strings

- Float numbers are defined in the following manner

```
>>> 1.2345
1.2345
```

- And strings like this

```
>>> "Hello Python fan"
‘Hello Python fan’

>>> "Hello" + "Python fan"
'HelloPython fan'
```

3.2 More Complex Data Structures in Python

Array

```
import array as arr
a = arr.array("I",[3,6,9])
```

List

```
l = []  # empty list
l2 = [4, 8, 15, 16, 23, 42]
```

Dictionary

```
d = { "John" : ["alive", "0.5"],
      "Sansa" : ["alive ", "1"],
      "Eddard" : ["dead ", "1"],
      "Bran" : ["alive", "0"],
      "Arya" : ["missing", "1"]
    }
```

key value

Tuple

```
t = 1,2,3,4,5
```

Set

```
s = set("CAKE&COKE")
```

Files

```
f = open("file_name", "w")
```

Adapted from Ernesti, J. & Kaiser, P. (2017)

3.2 Lists

- You retrieve values in a data structure by declaring an index inside a square bracket "[]" operator.

```
>>> l = [4, 8, 15, 16, 23, 42]

>>> l[1]
8
```

- You can add new values with append (add new value at the end of the list) and extend (add new list at the end of the list)

```
>>> l.append(1000)
>>> l
[4, 8, 15, 16, 23, 42, 1000]
```

3.2 Dictionaries

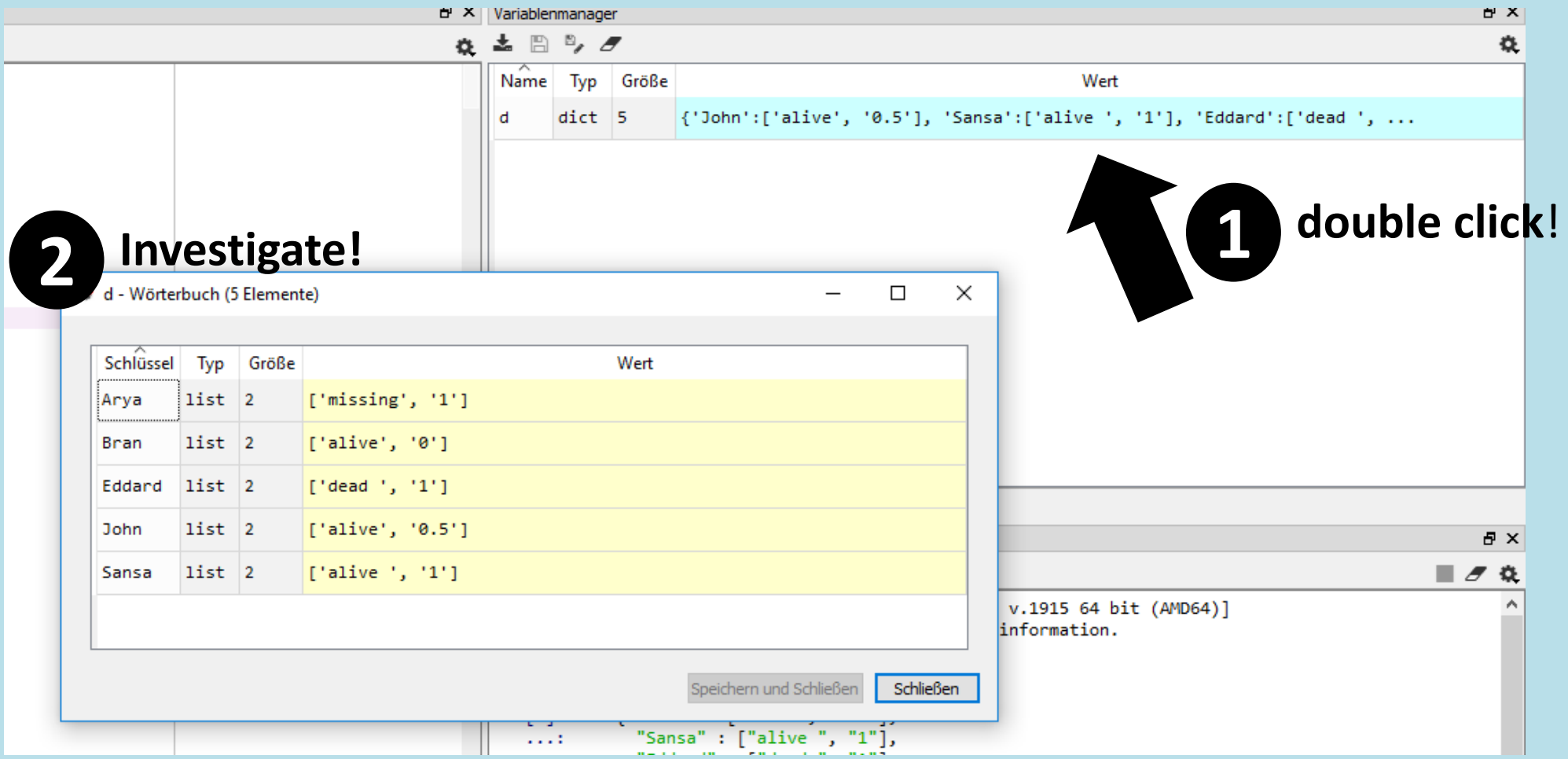
- You retrieve values in a data structure by declaring an index inside a square bracket "[]" operator.

```
>>> d = { "John" : ["alive", "0.5"],
>>>       "Arya" : ["missing", "1"]
>>>    }

>>> d["Arya"]
['missing', '1']
```

- And you can add new entries with

```
d["Brandon"] = ["crazy", "1"]
```

3.2 Investigate Complex Data Structures with the Variable Manager



3.2 Input/Output

- Input functions (`input()`) allow users of a program to place values into code.
  - The parameter for an input function is called a prompt. This is a string (this can be indicated by “” or ‘’) such as “Enter a number: “
  - The user’s response to the prompt will be returned to the input statement call as a string. To use this value as any other data type, it must be converted with another function (`int()`).
- Print functions (`print()`) allow programs to output strings to users on a given interface.
  - The parameter of this function is of any type. All types will automatically be converted to strings.

```
xString = input(“Enter a number: “)
x = int(xString)
y=x+2
print(y)
```

3.2 Example: print Statement

- Elements separated by commas print with a space between them
- A comma at the end of the statement (print ‘hello’,) will not print a newline character

```
print('hello’)
hello
```

3.2 Input

- input : Reads a number from user input.
- You can assign (store) the result of input into a variable.

```
age = input("How old are you? ")
print("Your age is", age)
print("You have", 65 - age, "years until retirement“)

Output:
How old are you? 53
Your age is 53
You have 12 years until retirement
```

3.2 Reading Files

- You can open and read files with the built-in Function `open()`.
- This function returns a so-called file object that we can access:

```
fobj = open("<name of your file>", "r")
for line in fobj:
    print(line)
fobj.close()
```

We will discuss data imports and handling with Python later in chapter 4!

Adapted from Ernesti, J. & Kaiser, P. (2017)

3.2 Write Data into Files

- You can also write data back into files

```
data = 12345

fobj = open("my_file.txt", "w")

for car in data:
    fobj.write(data)
fobj.close()
```

Adapted from Ernesti, J. & Kaiser, P. (2017); Offical Python Documentation (2019): https://docs.python.org

3.2 Read Files Online

- Online files can be accessed directly from Python

```
# Read from online
import urllib3

http = urllib3.PoolManager()

target_url =
"https://raw.githubusercontent.com/dominikjung42/AIAlgorithmsAndApplic
ations/master/Code/database_extract.txt"

response = http.request("GET", target_url)

data = response.data.decode("utf-8")
```

3.2 Functions

- From math we know that functions are a kind of assignment rules like:

$$f(x) = x + 2x$$

name, parameters, rule

- In computer science, we use functions to compute an output based on an input, like:

```
>>> max(1,2,3,4,5)
5
```

Functions without return values are termed “procedures”. But compared to other programming values (e.g. C or PASCAL) this makes no difference.

Adapted from Ernesti, J. & Kaiser, P. (2017); Offical Python Documentation (2019): https://docs.python.org

3.2 Writing Functions

- In Python you can encapsulate parts of your code into „functions“. You can call them later in your code to reduce redundance

```
def function_name(parameter_1, …, parameter_n):
    command
    …
    command
```

```
def fancy_function(num1, num2):
    result = 42
    num3 = num1 + num2
    return(result-num3)
```

```
>>> variable = fancy_function(1,2)
39
```

Adapted from Ernesti, J. & Kaiser, P. (2017); Offical Python Documentation (2019): https://docs.python.org

3.2 yield and return

- Python provides generator functions as concentient way to build iterators:

```
def firstn(n):
    num = 0
    while num < n:
        yield num
        num +=1

top5 = firstn(5)
```

- The previous generator stops the execution and yields its items instead of returning a list

```
>>>next(top5)
0
>>>next(top5)
1
```

3.2 If else Statements

- In Python you can write simple if statements

```
if x == 1:
    print("x is 1")
```

- Or more complex if-else-statements

```
if x == 1:
    print("x is 1")
elif x == 2:
    print("x is 2 or 1")
elif x == 3:
    print("I have no idea about x")
```

Adapted from Ernesti, J. & Kaiser, P. (2017)

3.2 Loops - `while`

- While statements

```
secret = 42
guess = 123
while guess != secret:
    guess = int(input("Please, give a guess: "))
print("You won!")
```

- You can “break” (leave) loops

```
secret = 42
guess = 123
while guess != secret:
    guess = int(input("Please, give a guess: "))
    if guess == 0:
        break
print("You won!")
```

Adapted from Ernesti, J. & Kaiser, P. (2017)

3.2 Loops - for

- For statements

```
for x in [1,2,3]:
   print(x)
```

What will the print function return?

- If you want to use for as counting loop use range()

```
range(stop)
range(start, stop)
range(start, stop, step)
```

```
for i in range(1, 10, 2):
    print(i)
```

What will the print function return?

Adapted from Ernesti, J. & Kaiser, P. (2017)

3.2 Object-oriented Programming I

- Python also supports object-oriented programming (oop):

```
class Porsche:
    # Class attribute
    type = "718"

    # Constructor
    def __init__(self, owner):
        self.owner = owner
```

```
>>> my_car = Porsche("Dominik")
>>> my_car.owner

'Dominik'
```

Adapted from Ernesti, J. & Kaiser, P. (2017); Offical Python Documentation (2019): https://docs.python.org

3.2 Object-oriented Programming II

```
class Porsche:
    # Class attribute
    type = "718"

    # Constructor
    def __init__(self, owner):
        self.owner = owner

    # Instance method
    def speak(self):
        return ("{} says: Hello {}!".format(self.type, self.owner))
```

```
>>> my_car.speak()
'718 says: Hello Dominik!'
```

Adapted from Ernesti, J. & Kaiser, P. (2017); Offical Python Documentation (2019): https://docs.python.org

3.2 Classroom Task

Your turn!

Task

Please open the interactive mode to solve the following tasks.

In Python you can read in user input with `input()`. Save an user input into a new variable age. Then declare a variable `methusalem = 969`. Compare the user's `age` with `methusalem`'s age and `print()` the result.

Please note that you probably have to cast the user input as `int` (with `int()`) and to `string` (with `str()`) to print it.

Too difficult? Do not worry! We come back to this point in the exercise of this course.

3.2 Classroom Task

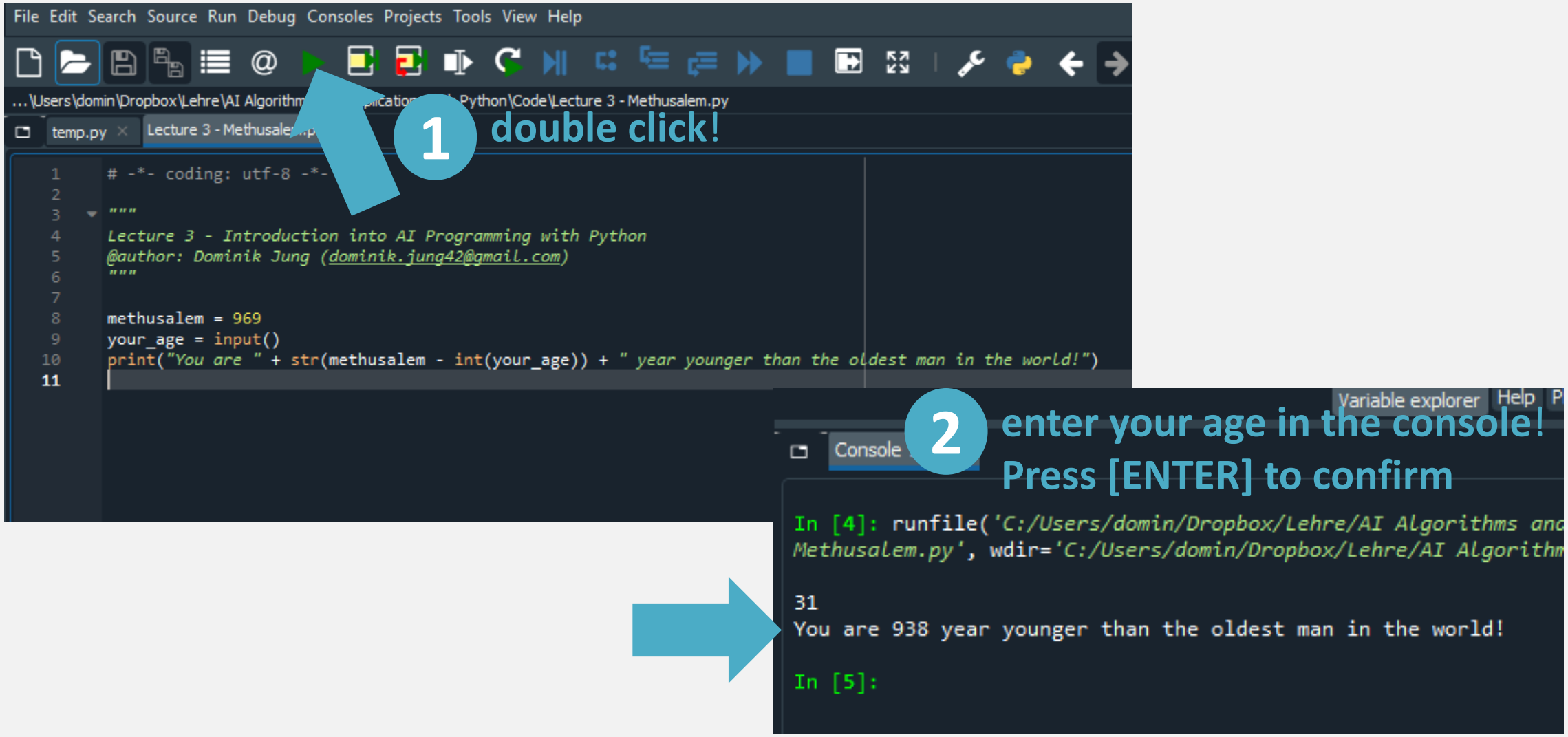
- **Possibility 1**: Run the code from the interactive mode

```
>>> methusalem = 969
>>> your_age = input()
31
>>> print("You are " + str(methusalem - int(your_age)) + " year younger than the oldest man in the world!")
You are 938 year younger than the oldest man in the world!
>>>
```

- **Possibility 2**: Save your code as Python file (*.py) and run it from the console

```
(base) PS C:\Users\domin\Dropbox\Lehre\AI Algorithms and Applications with
Python\Code> Python '.\Lecture 3 -
Methusalem.py'
31
You are 938 year younger than the oldest man in the world!
```

3.2 Classroom Task



Outline

3 AI Programming with Python

- 3.1 Python AI Programming Toolbox
- 3.2 Foundations of Programming with Python
- 3.3 Python Tutorial
- 3.4 The Extended AI Toolbox

Lectorial 1: Implement Problem-Solving Agents with Python

► **What we will learn:**

- Get an overview of AI software and programming with Python, so that you will be able to build your own agents and AI software components
- Workflow and tools to develop simple scripts and applications with Python
- Discuss advanced concepts of Python programming and AI related packages

Image source: ↗ Pixabay (2019) / ↗ CC0

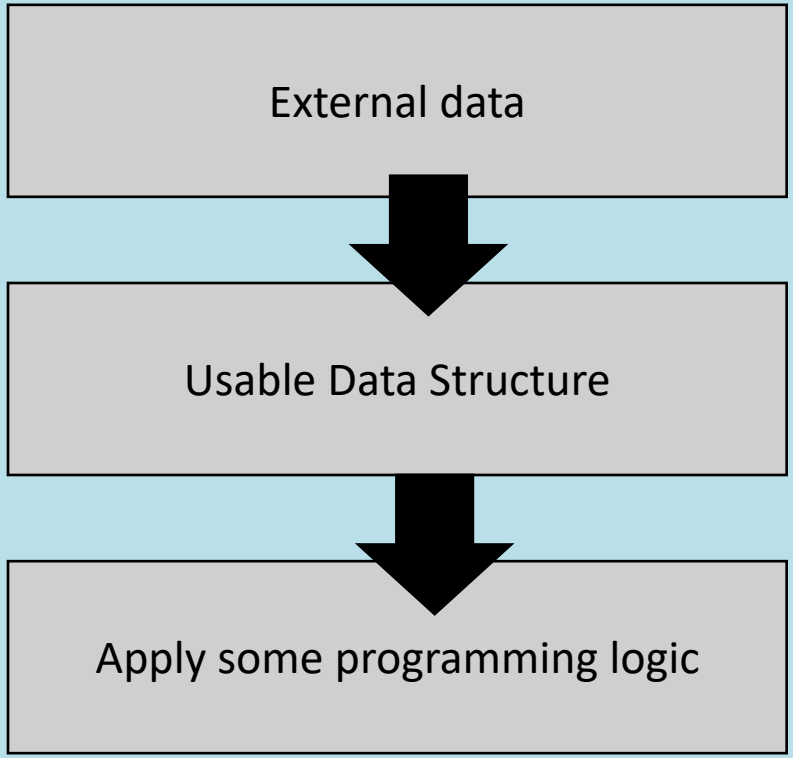
► **Duration:**

- 90 min

► **Relevant for Exam:**

- 3.1 - 3.4

3.3 Typical AI Programming Workflow (High-Level)



Example: Porsche „Wikipedia“

```
Please enter a Porsche model: 991
Unknown Porsche model

Please enter a Porsche model: 911
The car has the following VMax:  330 km/h

Please enter a Porsche model:
```

Adapted from Ernesti, J. & Kaiser, P. (2017); Image Source: ↗ Porsche 911 R im Porsche Museum 2018 (2018) by Alexander Migl from ↗ Wikimedia / ↗ CC-BY-SA-4.0 (image not edited)

3.3 Classroom Task

Your turn!

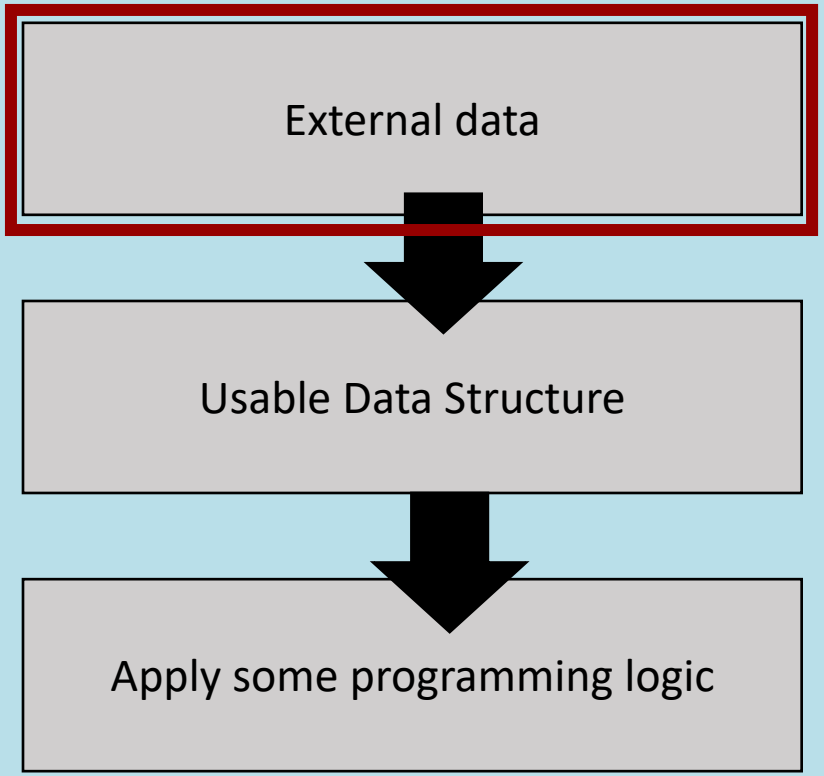
Task

Please implement the Porsche “Wikipedia” based on the following steps

- Load the external data from the file “`database_extract.txt`” into your Python environment
- Transform it in a usable data structure e.g. `dictionary` or `dataframe` with a `for` loop
- Implement the input-output logic with an `while` loop

```
Please enter a Porsche model: 991
Unknown Porsche model

Please enter a Porsche model: 911
The car has the following VMax:  330 km/h

Please enter a Porsche model:
```

3.3 Typical AI Programming Workflow (High-Level)

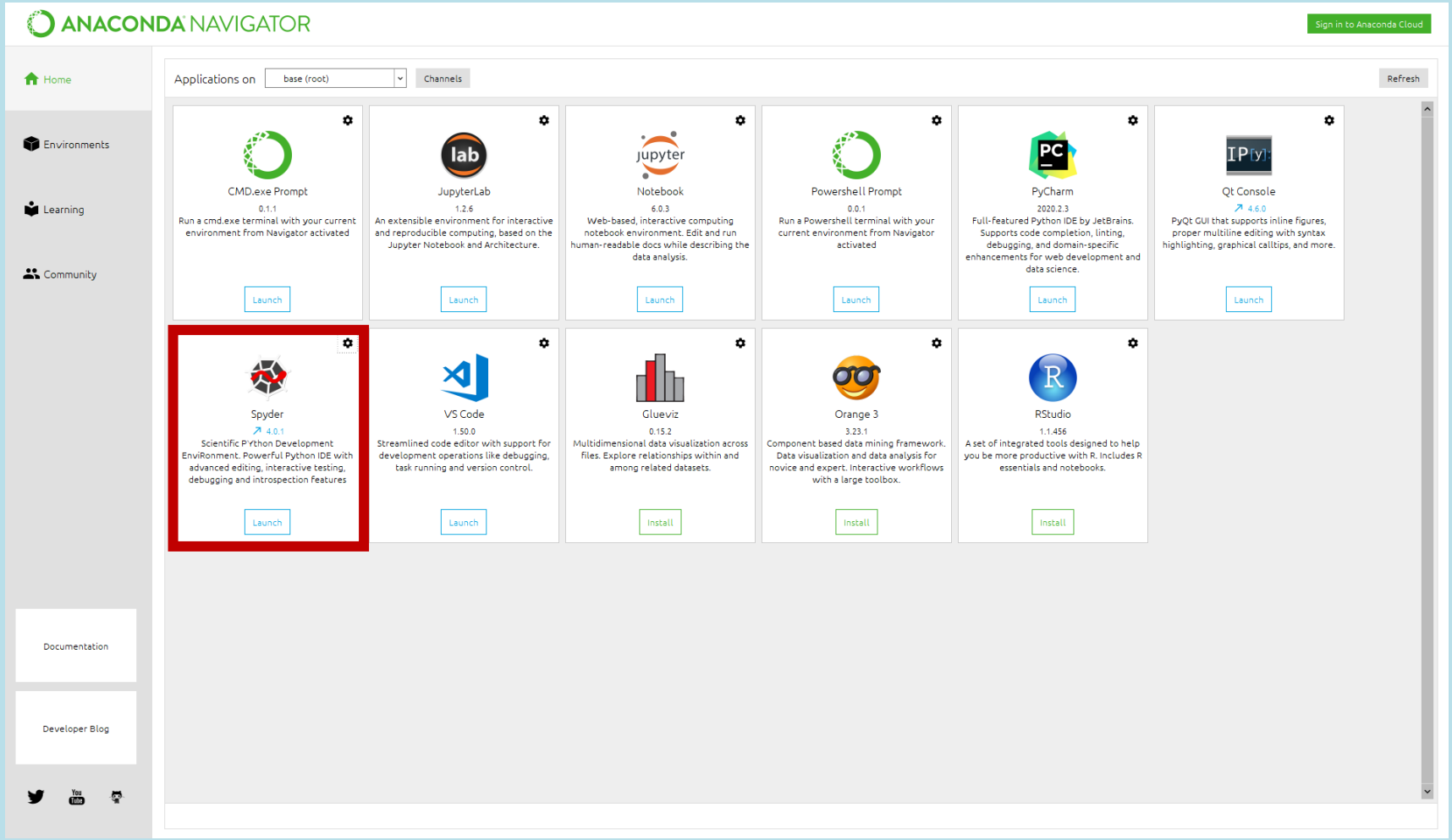


Example: Guessing Game

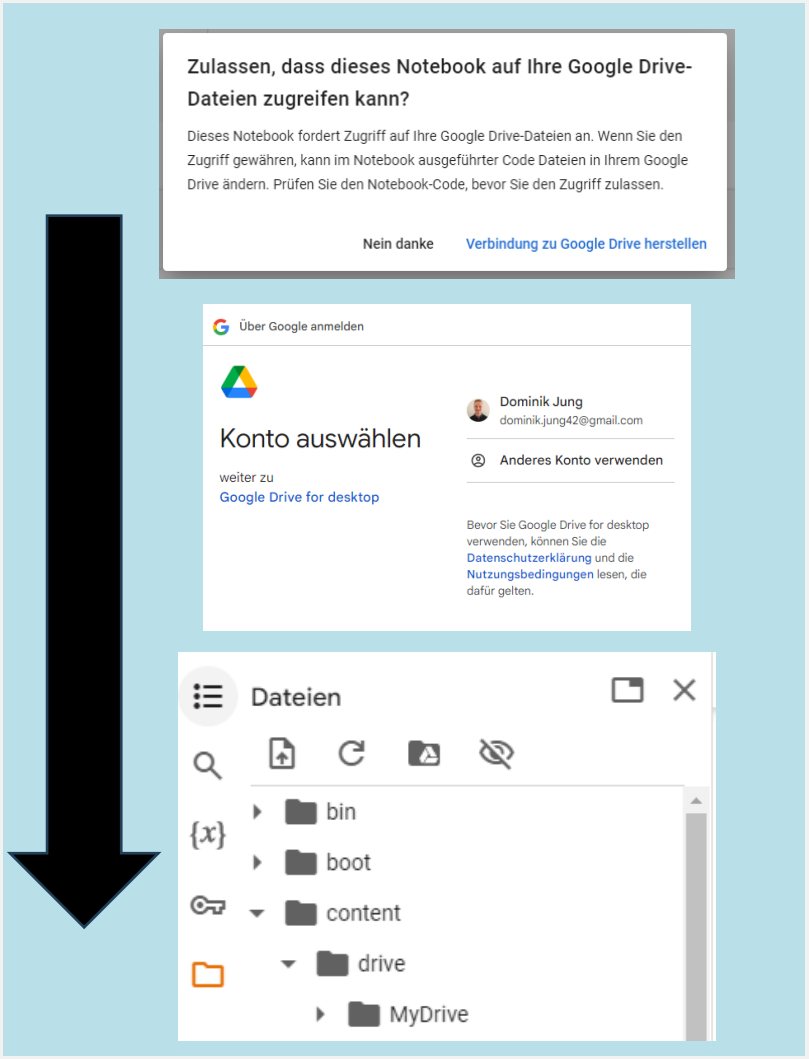
```
Please enter a Porsche model: 991
Unknown Porsche model

Please enter a Porsche model: 911
The car has the following VMax:  330 km/h

Please enter a Porsche model:
```

Adapted from Ernesti, J. & Kaiser, P. (2017); Image Source: ↗ Porsche 911 R im Porsche Museum 2018 (2018) by Alexander Migl from ↗ Wikimedia / ↗ CC-BY-SA-4.0 (image not edited)

3.3 Start Spyder from Anaconda



3.3 Or use Google Colab



- You can also use Google Colab for this tutorial. However, you have to link your Google Drive to access local files:

```
# Acess your files from Google Drive

from google.colab import drive
drive.mount('/content/drive')
```

```
Mounted at /content/drive
```

3.3 Reading Files

- If you want to read a file in your Python code, it must be open for reading
- For this we use the Built-in Function `open()`. This function returns a so-called file object that we can access:

```
fobj = open("database_extract.txt", "r")
for line in fobj:
    print(line)
fobj.close()
```

We will discuss data imports and handling with Python later in chapter 4!

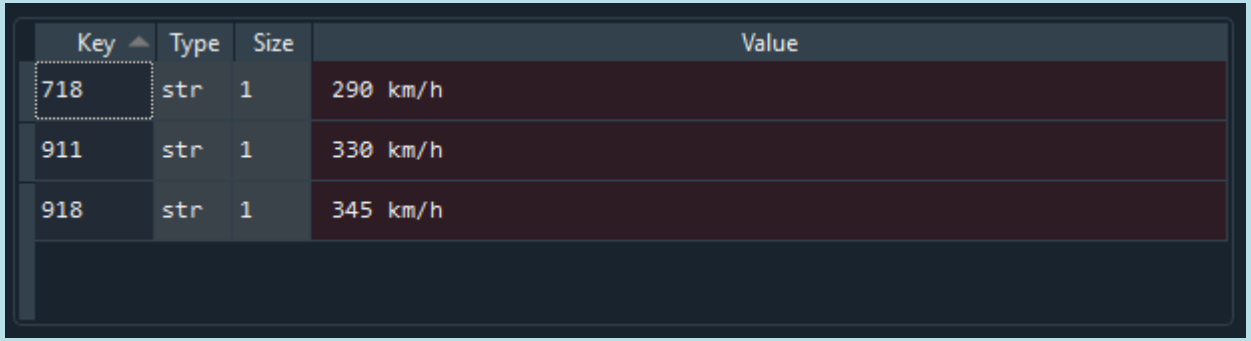
718	290 km/h
911	330 km/h
918	345 km/h

Adapted from Ernesti, J. & Kaiser, P. (2017); Image Source: ↗ Porsche 911 R im Porsche Museum 2018 (2018) by Alexander Migl from ↗ Wikimedia / ↗ CC-BY-SA-4.0 (image not edited)

3.3 Reading Files into Variables I

- Let us now load the file data into a dictionary

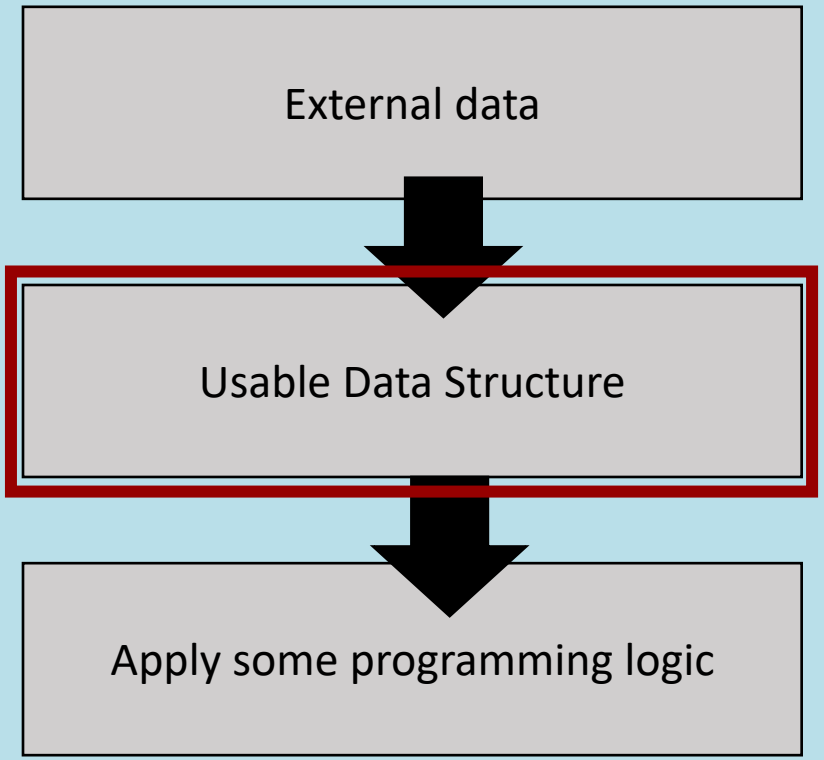
```
data = {}
fobj = open("database_extract.txt", "r")
for line in fobj:
    line = line.strip()
    l = line.split(",")
    data[l[0]] = l[1]
fobj.close()
```



Key	Type	Size	Value
718	str	1	290 km/h
911	str	1	330 km/h
918	str	1	345 km/h

Adapted from Ernesti, J. & Kaiser, P. (2017); Offical Python Documentation (2019): https://docs.python.org

3.3 Typical AI Programming Workflow (High-Level)



Example: Guessing Game

```
Please enter a Porsche model: 991
Unknown Porsche model

Please enter a Porsche model: 911
The car has the following VMax:  330 km/h

Please enter a Porsche model:
```

Adapted from Ernesti, J. & Kaiser, P. (2017); Image Source: ↗ Porsche 911 R im Porsche Museum 2018 (2018) by Alexander Migl from ↗ Wikimedia / ↗ CC-BY-SA-4.0 (image not edited)

3.3 Reading Files into Variables II

- Let us now load the file data into a dictionary

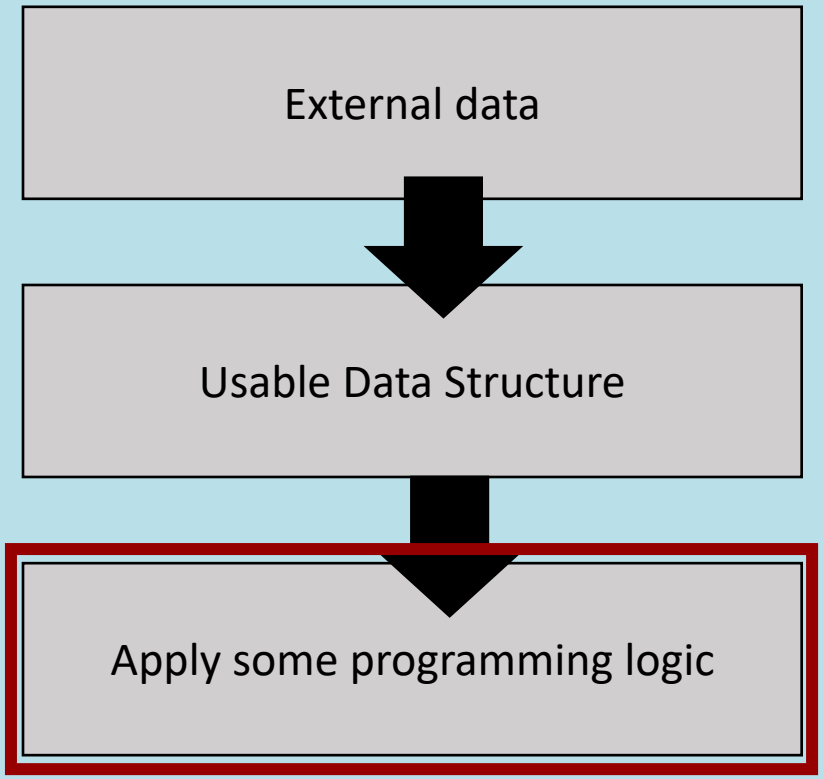
```
data = {}
fobj = open("database_extract.txt", "r")
for line in fobj:
    line = line.strip()
    l = line.split(",")
    data[l[0]] = l[1]
fobj.close()

while True:
    car = input("Please enter a Porsche model: ")
    if car in data:
        print("The car has the following VMax:", data[car])
    else:
        print("Unknown Porsche model")
```

```
Please enter a Porsche model: 991
Unknown Porsche model

Please enter a Porsche model: 911
The car has the following VMax:  330 km/h

Please enter a Porsche model:
```

718	290 km/h
911	330 km/h
918	345 km/h

Adapted from Ernesti, J. & Kaiser, P. (2017); Offical Python Documentation (2019): https://docs.python.org

3.3 Typical AI Programming Workflow (High-Level)



Example: Guessing Game

```
Please enter a Porsche model: 991
Unknown Porsche model

Please enter a Porsche model: 911
The car has the following VMax:  330 km/h

Please enter a Porsche model:
```

Adapted from Ernesti, J. & Kaiser, P. (2017); Image Source: ↗ Porsche 911 R im Porsche Museum 2018 (2018) by Alexander Migl from ↗ Wikimedia / ↗ CC-BY-SA-4.0 (image not edited)

3.3 Write Data into Files

- You can also write data back into files

```
data = {"Taycan" : "260 km/h", "Tesla" : "250 km/h"}

fobj = open("my_file.txt", "w")

for car in data:
    fobj.write("{}, {}\n".format(car, data[car]))
fobj.close()
```

Adapted from Ernesti, J. & Kaiser, P. (2017); Offical Python Documentation (2019): https://docs.python.org

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Lectorial 1: Implement Problem-Solving Agents with Python

► **What we will learn:**

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- Workflow and tools to develop simple scripts and applications with Python
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Image source: ↗ Pixabay (2019) / ↗ CC0

► **Duration:**

- 90 min

► **Relevant for Exam:**

- 3.1 - 3.4

3.4 Modules

- We learnt that in Python exists many build-in functions you can use

```
>>> max([1,5,2,7,42,3])
42
```

build-in functions

- However, there are many functions organized in external modules (like specific AI functions) we can use in our programm

Adapted from Ernesti, J. & Kaiser, P. (2017)

3.4 Modules Import

- Import moduls

```
import module
module.spec_func()
```

- Import specific function from modul

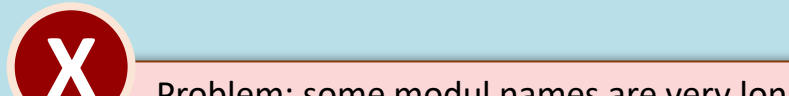
```
from module import spec_func
spec_func()
```

- Import moduls with specific namespaces

```
import module as mo
mo.spec_func()
```

- Import every function from modul

```
from moduls import *
spec_func()
```



Problem: some modul names are very long and you import functions you probably do not need

import os

from os import *

Do this only if you know what you are doing!

Offical Python Documentation (2019): https://docs.python.org

3.4 Use Modules in Python

- You can import existing modules (global modules) with `import`

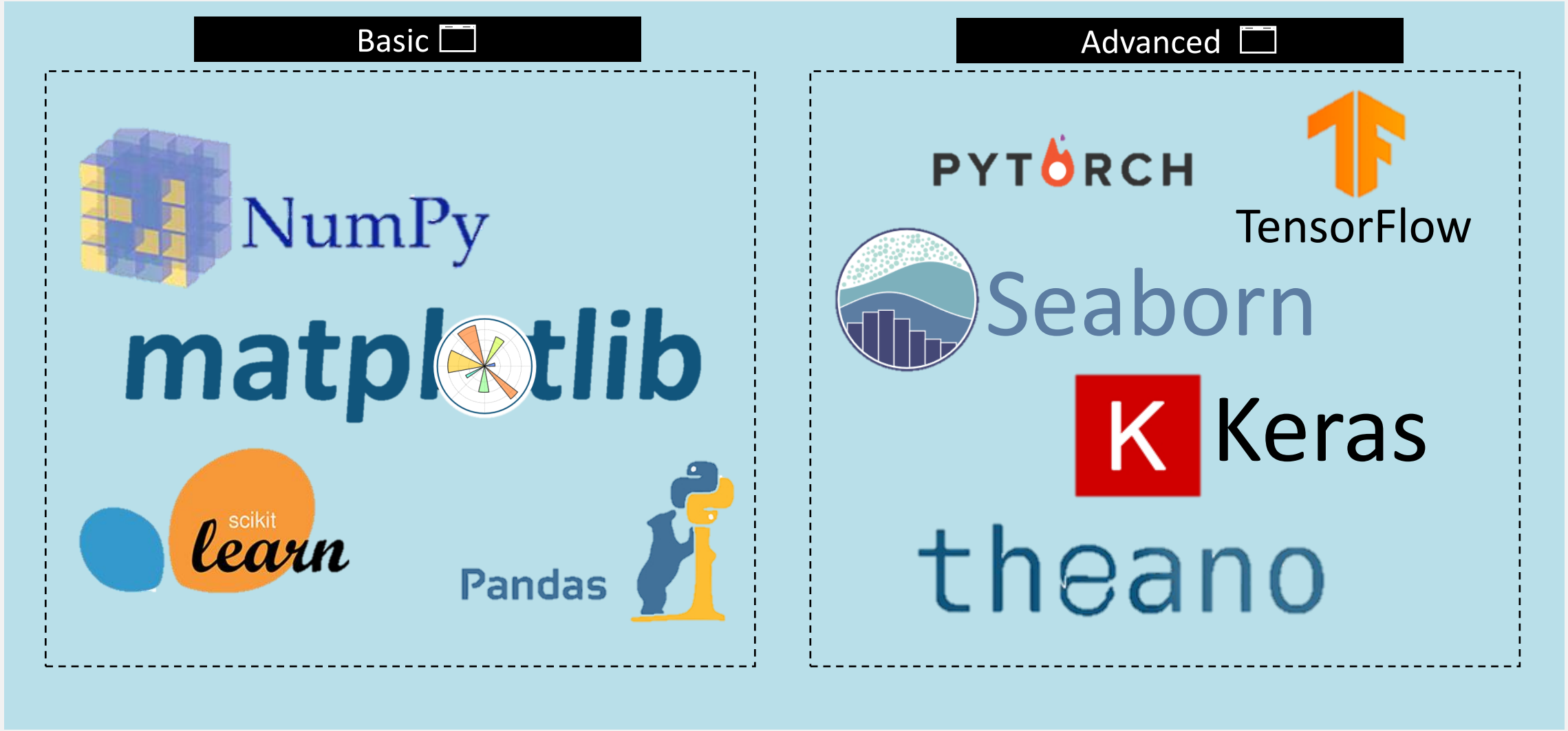
```
>>> import math
>>> math.sin(math.pi)
1.2246467991473532e-16
```

```
>>> from math import *
>>> sin(math.pi)
1.2246467991473532e-16
```

```
>>> from math import sin, pi
>>> sin(math.pi)
1.2246467991473532e-16
```

Adapted from Ernesti, J. & Kaiser, P. (2017); Offical Python Documentation (2019): https://docs.python.org

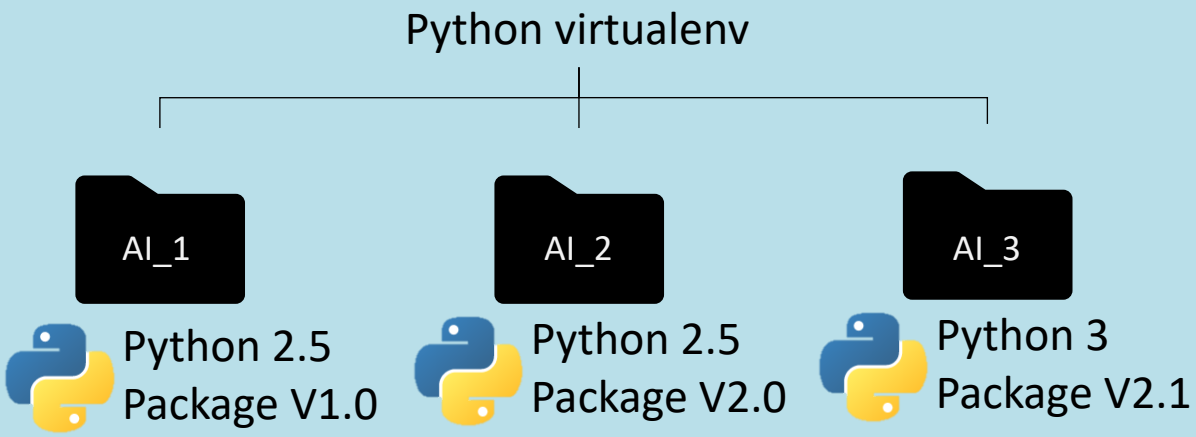
3.4 Most relevant Packages for AI-Specialists



Images: From the respective websites

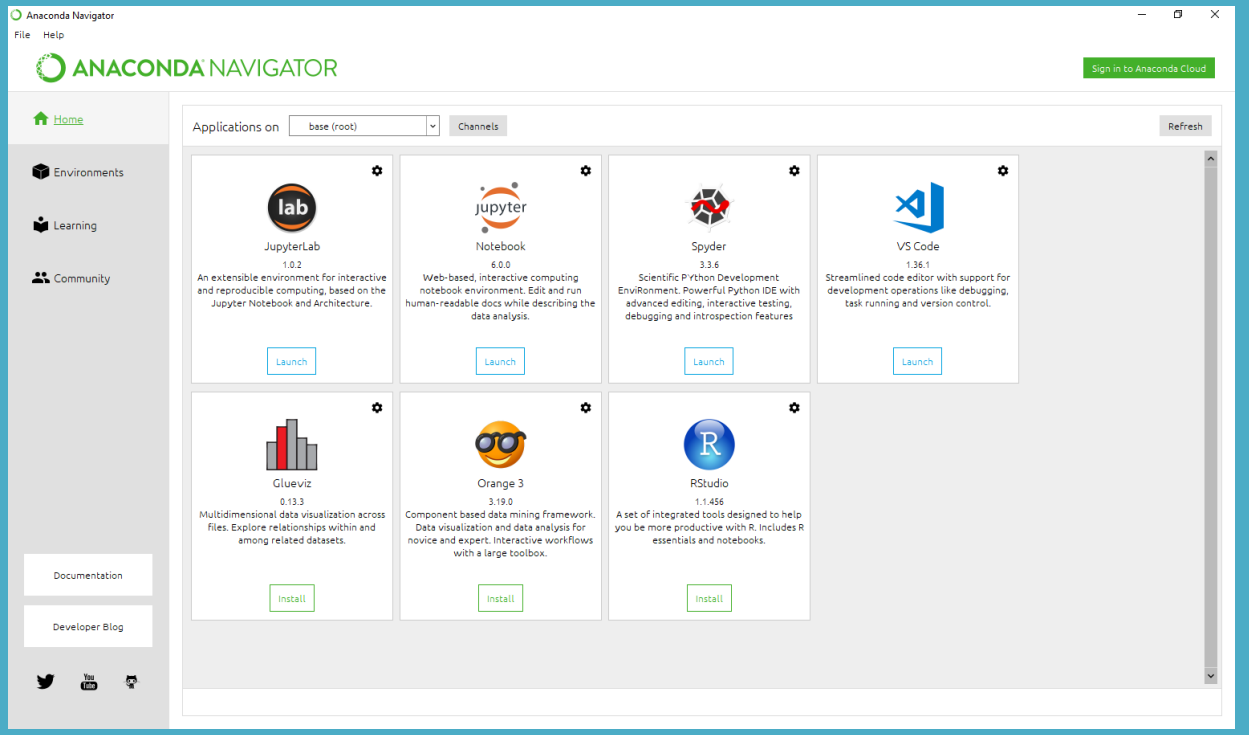
3.4 Management of Different Packages and Versions?

- Python virtual environments allow to create an isolated environment for Python projects so that each of your projects has its own individual dependencies, regardless of what dependencies every other project has.

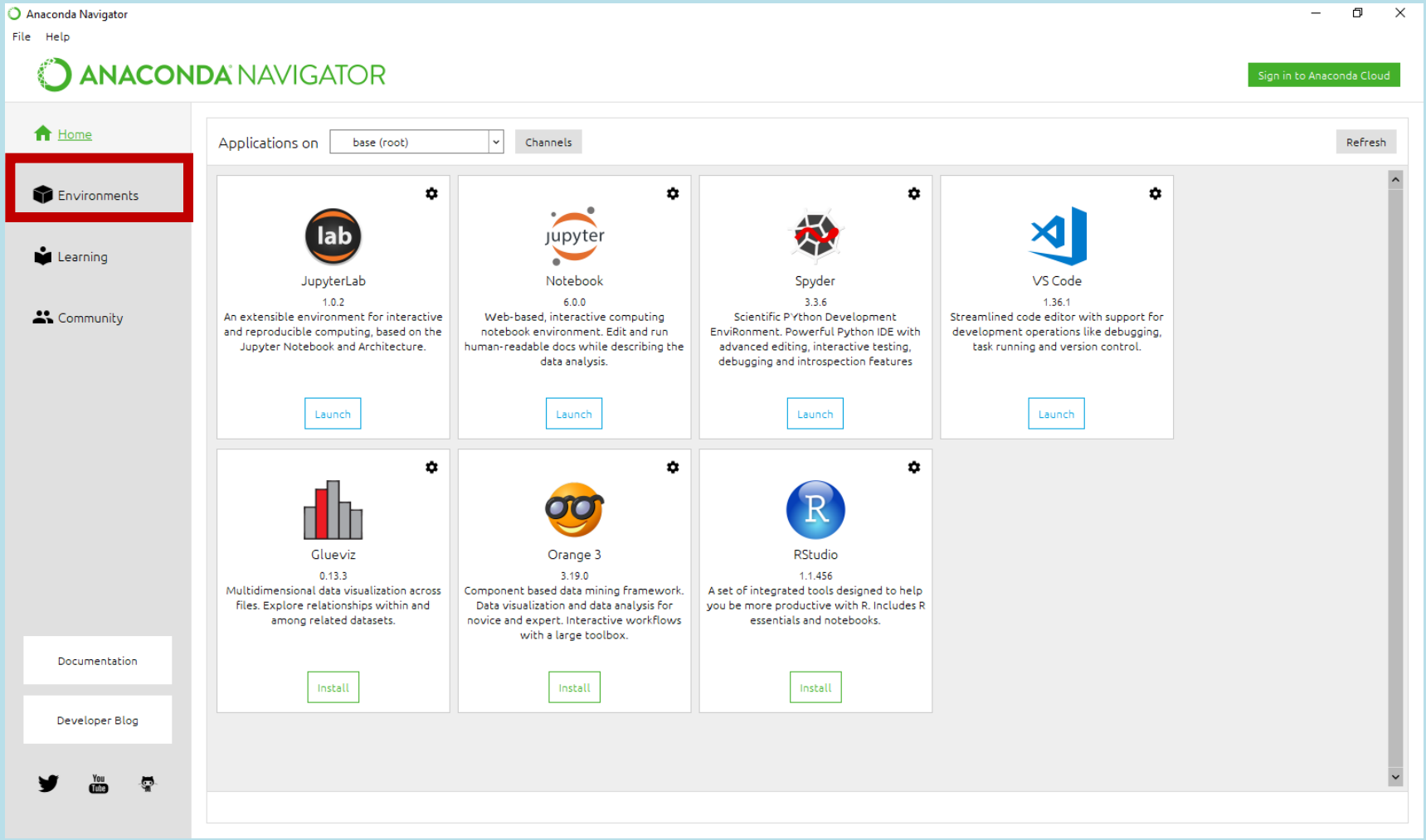


Offical Python Documentation (2019): https://docs.python.org

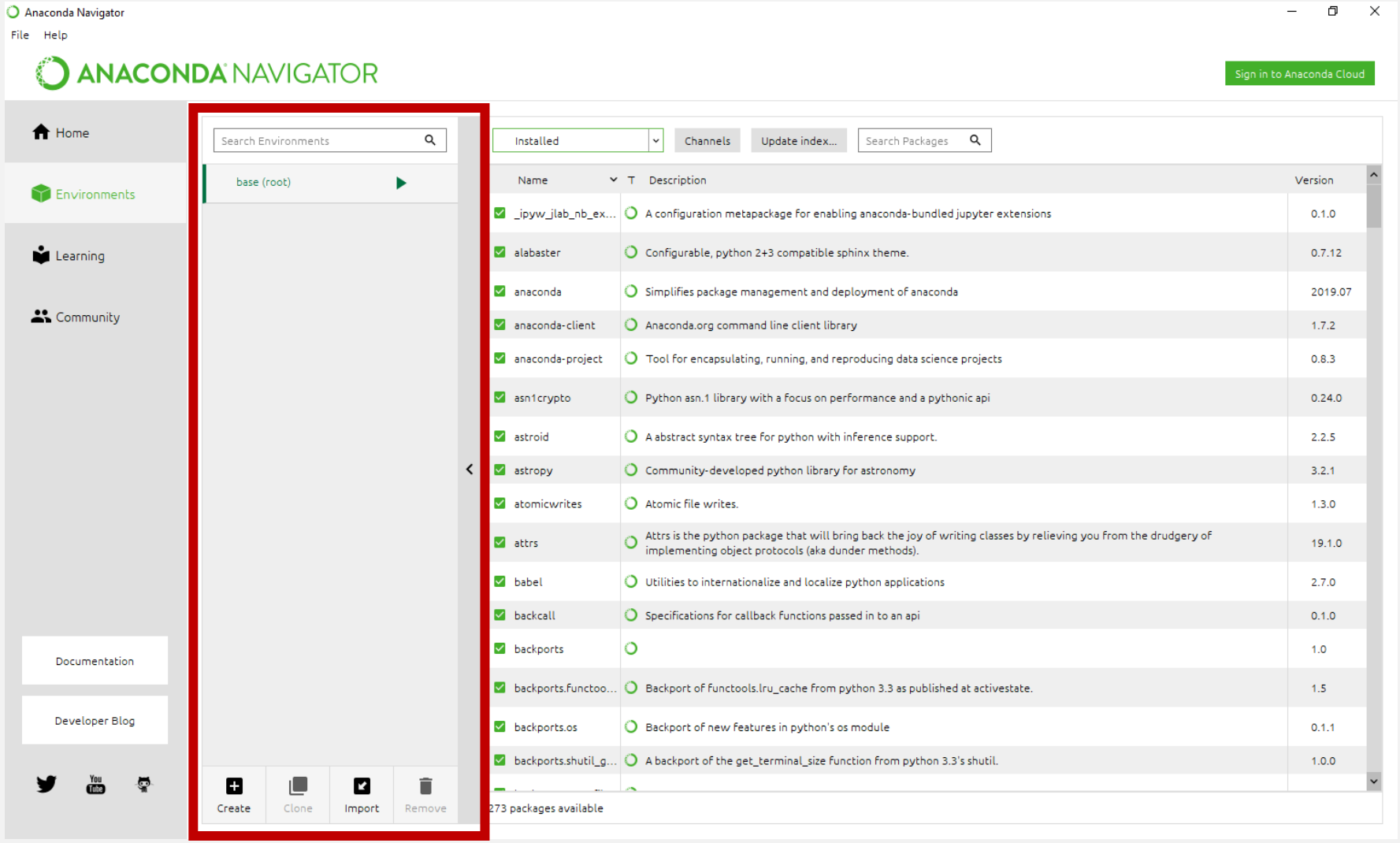
Now, please start Anaconda!



3.4 Package Management in Anaconda



3.4 Install and Load New Packages



- You can manage and organize your environments with the Anaconda Navigator

3.4 Install Required Packages for this Course

- Please activate your environment (if you have one)

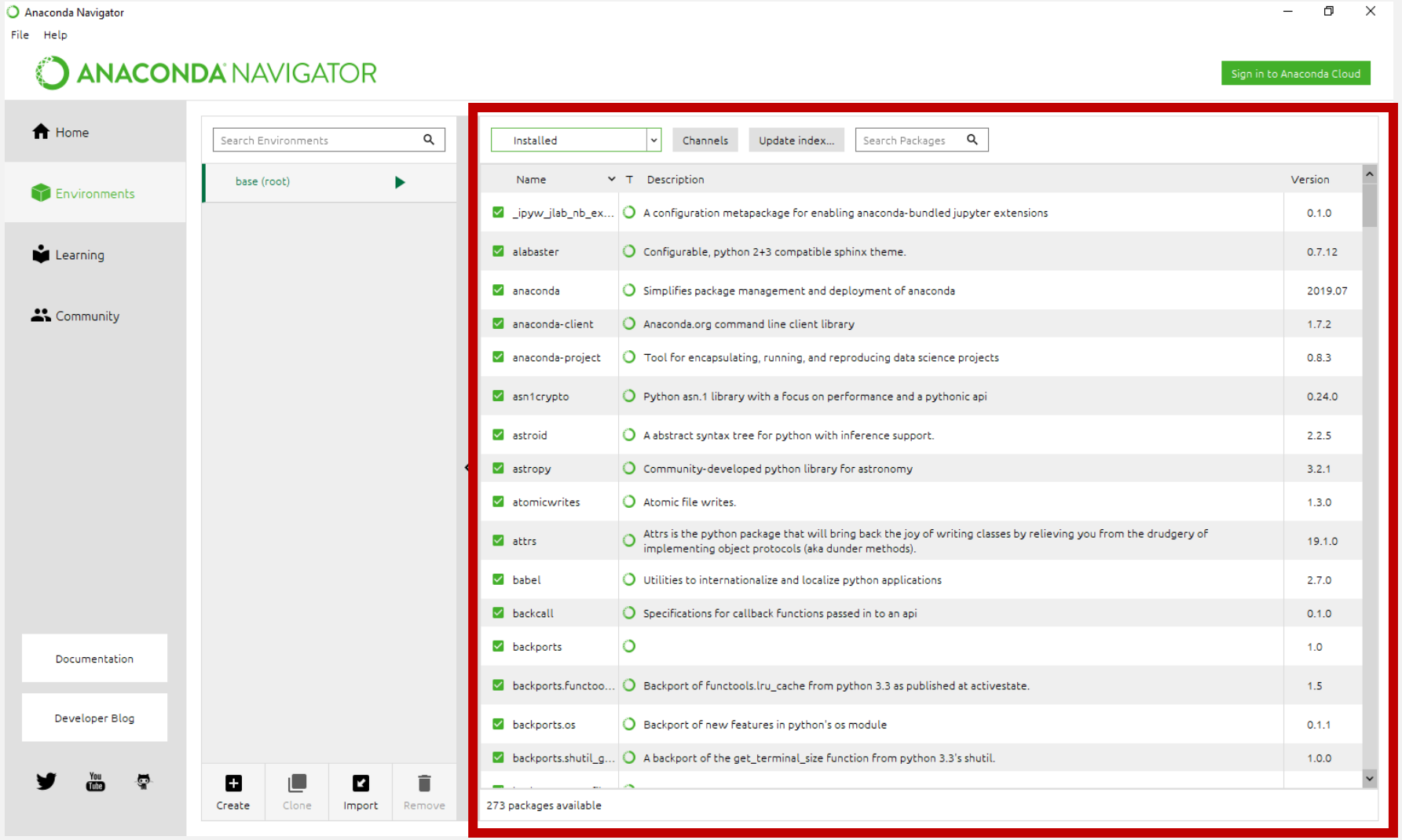
```
>>> conda activate <environmentname>
```

- And then read in the requirements.txt to automatically install all required packages for this course

```
>>> pip install -r packages.txt
```

Offical Python Documentation (2019): https://docs.python.org

3.4 Install and Load New Packages



- Use it to install and load new packages

3.4 Numpy

```
>>> import numpy
```

The fundamental package for scientific computing with Python

GET STARTED

We will use this package for each kind of mathematical computation in this lecture (see e.g. chapter 9)!

3.4 Basics of Numpy

- In Numpy you will mainly work with homogeneous multidimensional arrays

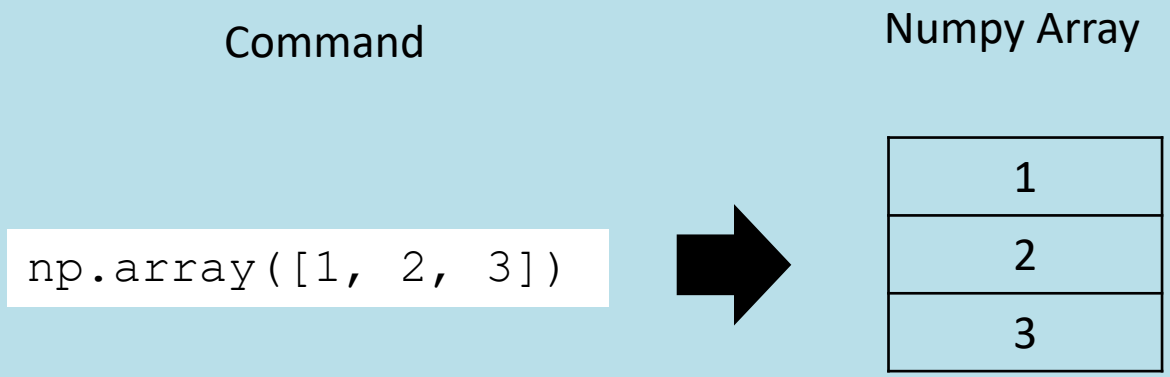
```
[[ 1., 1., 4.],
 [ 0., 3., 2.]]
```

- NumPy gives you an enormous range of fast and efficient ways of creating arrays and manipulating numerical data inside them.
- While a Python list can contain different data types within a single list, all of the elements in a NumPy array should be homogeneous. The mathematical operations that are meant to be performed on arrays would be extremely inefficient if the arrays weren't homogeneous.

3.4 Create Arrays with Numpy

- To create a NumPy array, you can use the function `np.array()`.

```
>>> import numpy as np
>>> a = np.array([1, 2, 3])
```



3.4 Numpy Indexing

```
data = np.array([1, 2, 3])
```

1	1
2	2
3	3

`data[0]`

1

`data[1]`

2

`data[0:2]`

1
2

`data[1:]`

2
3

`data[-2:]`

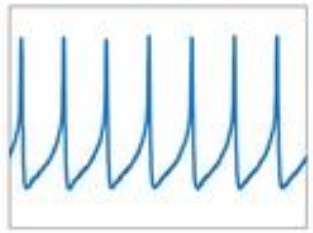
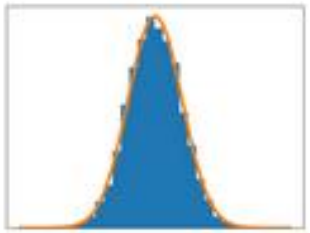
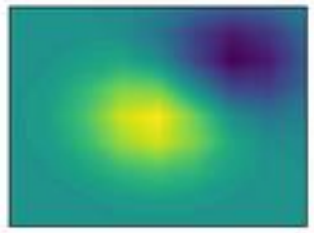
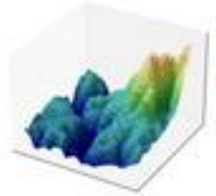
0	1	
1	2	-2
2	3	-1
3		

3.4 Matplotlib

```
>>> import matplotlib
```

Matplotlib: Visualization with Python

Matplotlib is a comprehensive library for creating static, animated, and interactive visualizations in Python.

Matplotlib makes easy things easy and hard things possible.

We will use this package for each kind of visualization in this lecture (see e.g. chapter 4)!

3.4 About Matplotlib

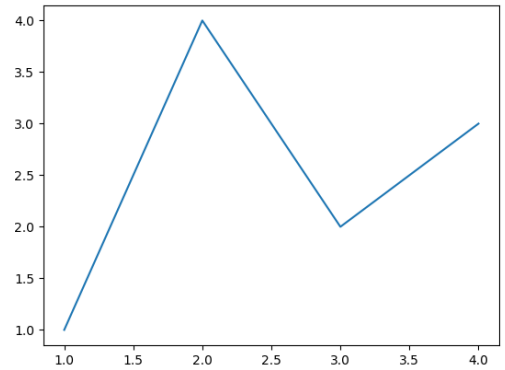
- Matplotlib is a visualization library for Python, and in particular its numerical mathematics extension `Numpy`

- It provides an object-oriented API for embedding plots into applications using general-purpose GUI toolkits like Tkinter, wxPython, Qt, or GTK+.

3.4 Generating Plots

- Matplotlib graphs your data on Figures, each of which can contain one or more Axes

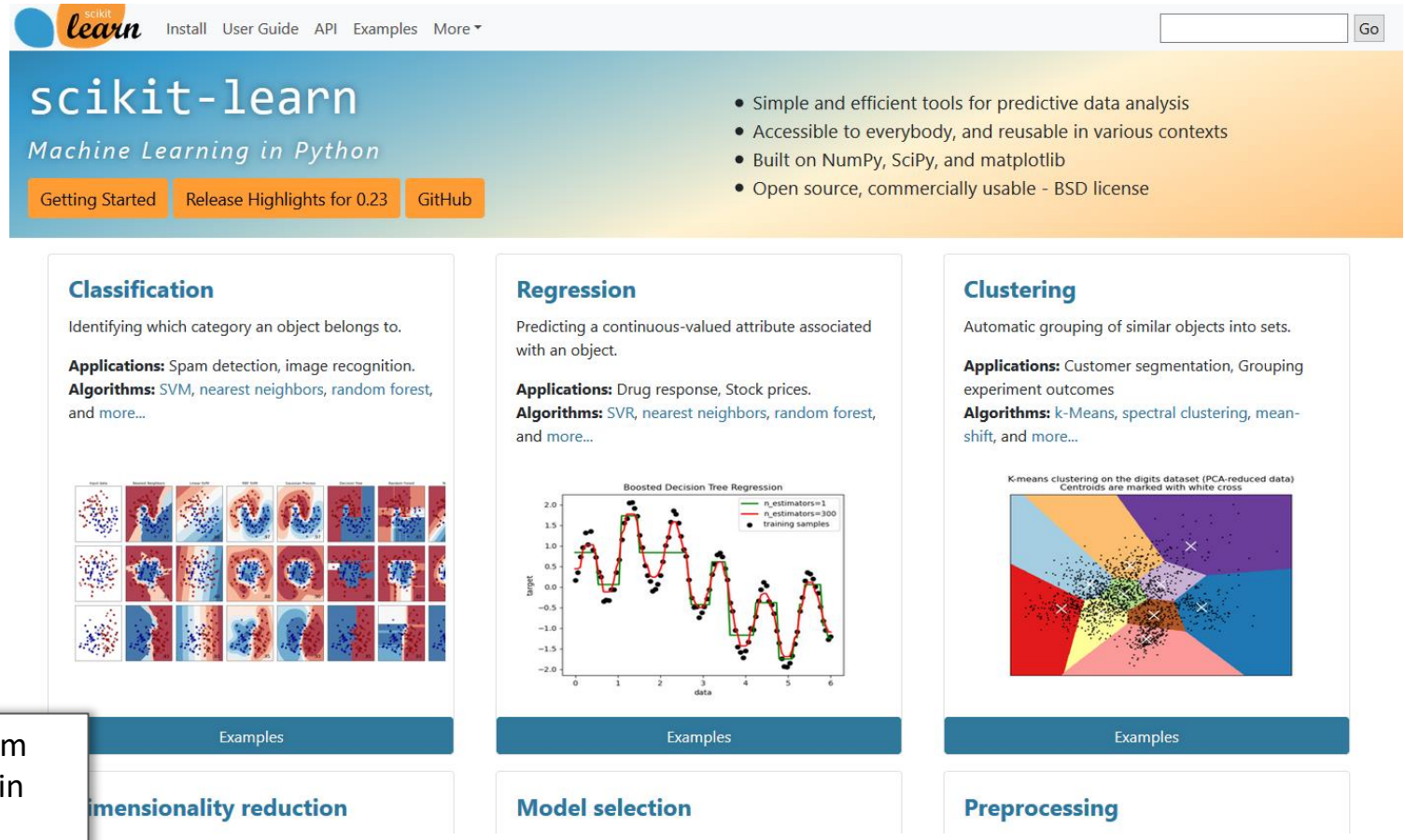
```
import matplotlib.pyplot as plt
import numpy as np

fig, ax = plt.subplots()  # Create a figure containing a single axes.
ax.plot([1, 2, 3, 4], [1, 4, 2, 3])  # Plot some data on the axes.
```



Adapted from matplotlib.org

3.4 Scikit-learn

```
>>> import sklearn
```

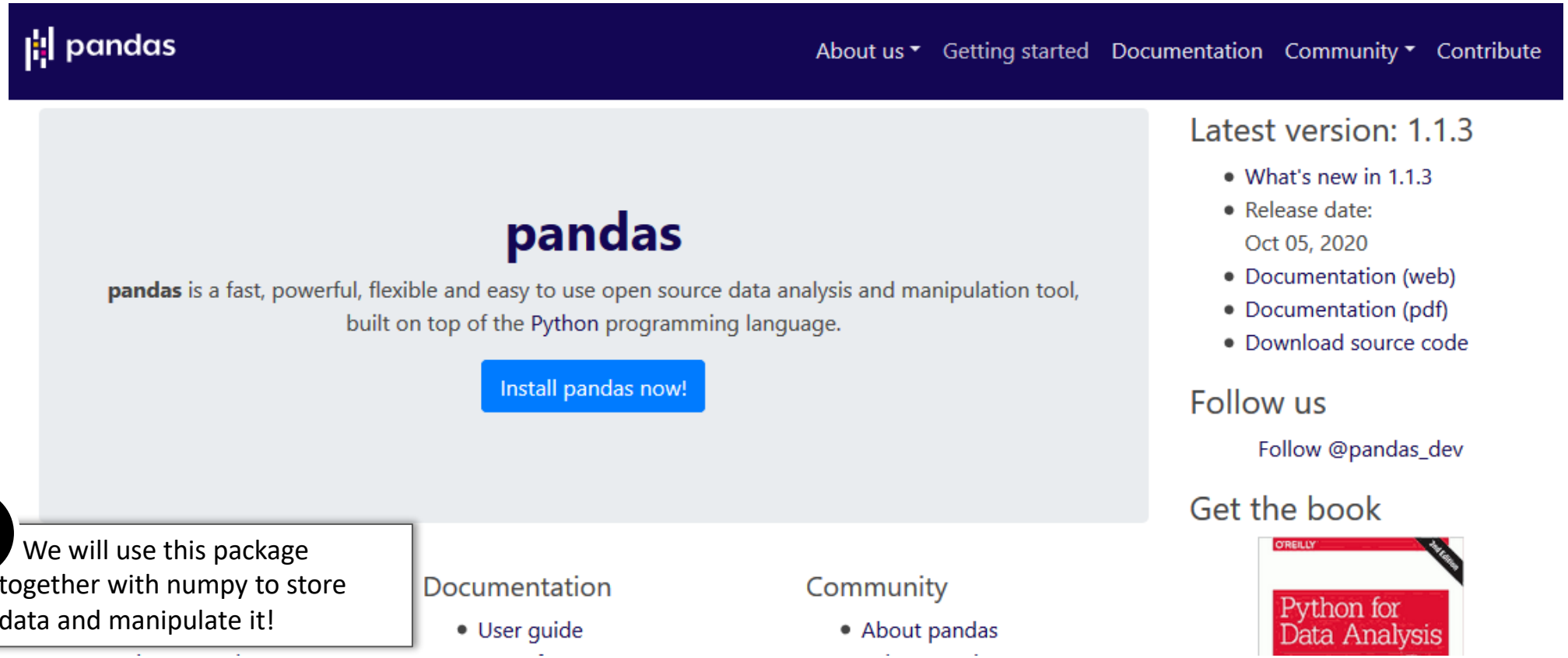


We will use the AI algorithms from this package (see e.g. chapter 5,6) in the following parts of this lecture!

3.4 Pandas

Pandas

```
>>> import pandas
```



We will use this package together with numpy to store data and manipulate it!

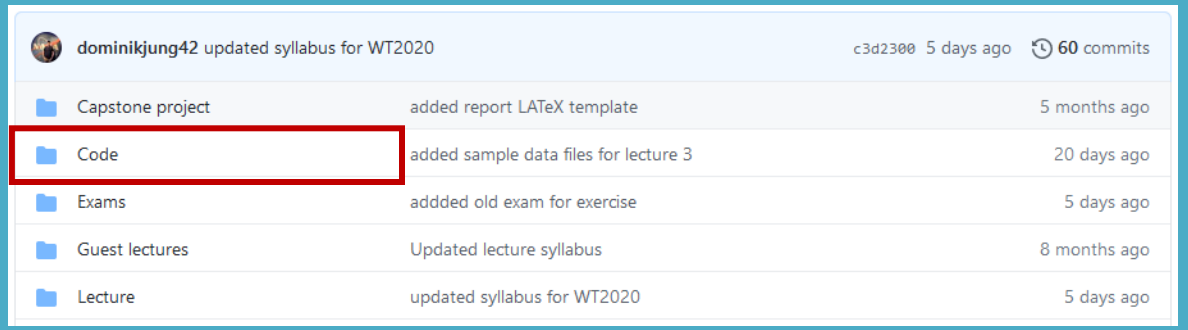
3.4 Classroom Task

Your turn!

Task

Please explain the difference between Python Development in the Spyder IDE and Jupyter notebooks. Can you name specific use cases when Spyder is a better choice than Jupyter and vice-versa?

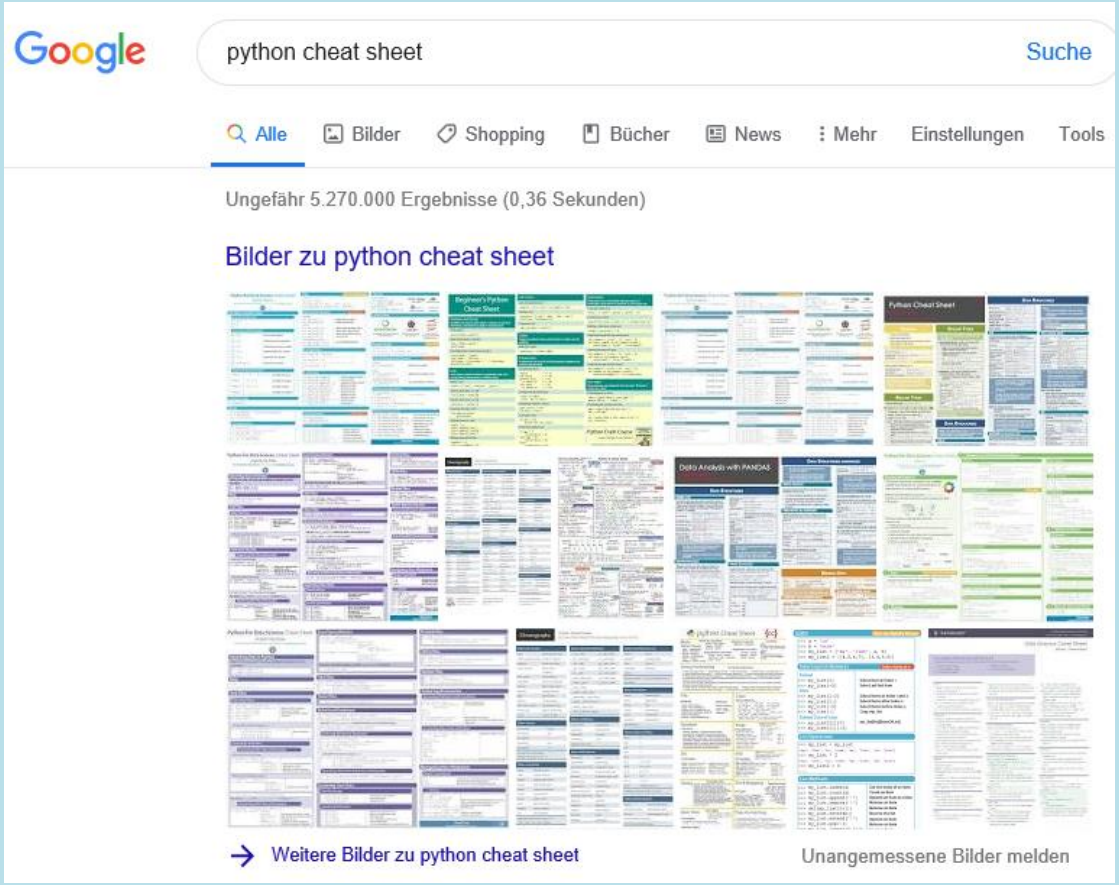
Your first end-to-end project: Problem-Solving Agents



Feel free to start directly or just continue with the lecture and come back to it later.

Handouts

Python Cheatsheet



- Python cheatsheets are very helpful to learn the basics
- They exist for very different topics

Exercises

Workbook Exercises

- *There are no workbook exercises in this unit*

Coding Exercises

- There are many, many Python Beginner books and videos on Youtube. However, the official Python Beginner Tutorial is also not a bad place to start. Make at least this tutorial to deepen the information of this lecture: ↗Python getting started.

You do not have to start the coding exercises directly after each lecture to understand the following lectures. However, they will definitly help you to deepen your understanding of the presented concepts and algorithms.

References

Literature

1. Ernesti, J., & Kaiser, P. (2017). *Python 3: das umfassende Handbuch*. Rheinwerk Verlag.
2. Offical Python Documentation (2020). The Python Language Reference. Online available at https://docs.python.org

News articles

1. Waggoner, P (2018): Advice to Young (and Old) Programmers: A Conversation with Hadley Wickham. Online available at https://www.r-bloggers.com/2018/08/advice-to-young-and-old-programmers-a-conversation-with-hadley-wickham/

References

Images

All images that were not marked other ways are made by myself, or licensed ↗CC0 from ↗Pixabay.

Further reading

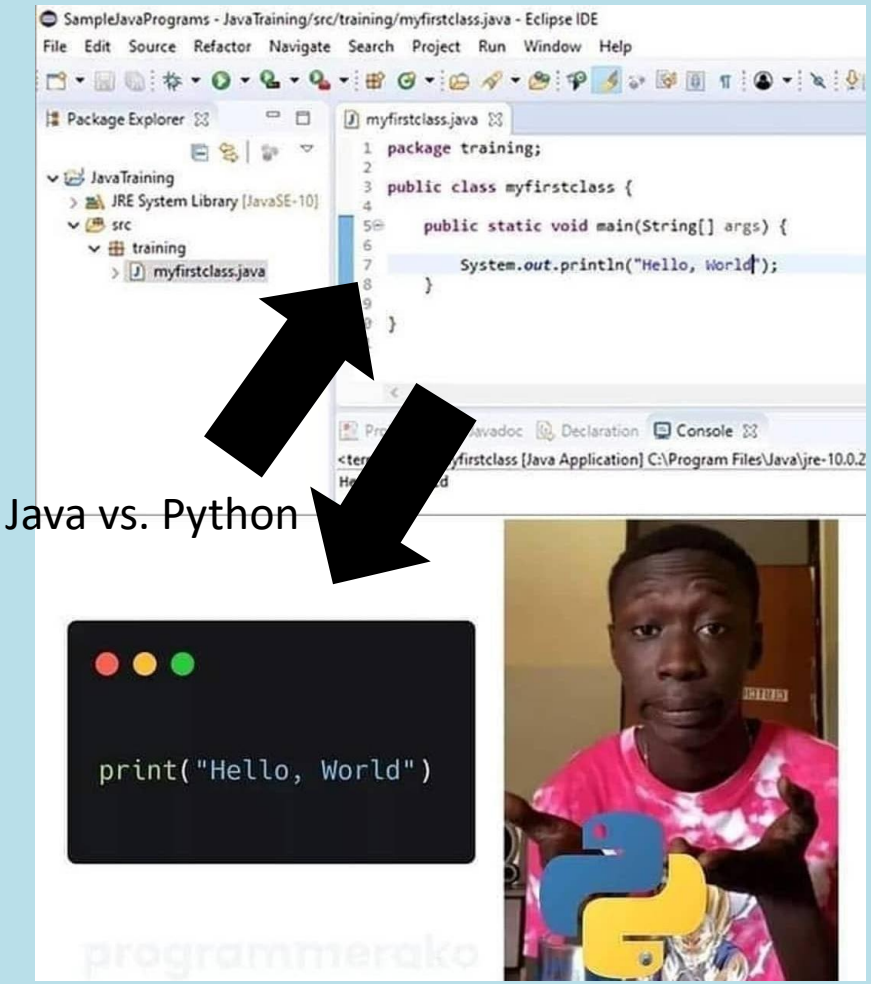
- I also can recommend to take a look at the beginner tutorials of the different Python packages (↗Numpy, ↗Matplotlib, ↗Scikit-learn, ↗Pandas)
- Python has a manifest of ist design principles, which you can find inside the Python interpreter itself by typing `import this`. Check it out!

Glossary

Data Frame	*A two-dimensional data structure, where data is aligned in a tabular fashion in rows and columns.*
IDE	*Integrated Development Environment. Applications that facilitate the development of software or code by giving the user an interface to work with.*
Libraries/Packages	*Collection of pre-written code (functions and methods) to perform certain task.*
Notebooks	*Virtual environment that enables literate programming.*
Programming language	*Language engineered to create a standard form of instructions for a computer. Like human languages they are split into two components, i.e. syntax (form) and semantics (meaning).*
Software Tool	*Software that is designed to be used for a specific use case (e.g. Dashboarding, Data Visualization, Modelling).*

The Zen of Python (Tim Peters)

Beautiful is better than ugly.
Explicit is better than implicit.
Simple is better than complex.
Complex is better than complicated.
Flat is better than nested.
Sparse is better than dense.
Readability counts.
Special cases aren't special enough to break the rules.
Although practicality beats purity.
Errors should never pass silently.
Unless explicitly silenced.
In the face of ambiguity, refuse the temptation to guess.
There should be one-- and preferably only one --obvious way to do it.
Although that way may not be obvious at first unless you're Dutch.
Now is better than never.
Although never is often better than *right* now.
If the implementation is hard to explain, it's a bad idea.
If the implementation is easy to explain, it may be a good idea.
Namespaces are one honking great idea -- let's do more of those!



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