Python & pandas

A one day course

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Introduction

Why Python/pandas?

- You *have* a CSV-file with semicolon as column separator and comma as decimal separator
- You *need* a CSV-file with comma as column separator and dot as decimal separator

```python
import pandas as pd

df = pd.read_csv('myfile.csv', sep=';', decimal = ',')
df.to_csv('myfile_new.csv', sep=',', decimal = '.')
```

- Or: You need an Excel-file:

```python
import pandas as pd

df = pd.read_csv('myfile.csv', sep=';', decimal = ',')
df.to_excel('myfile_new.xlsx', index=FALSE)
```

Limits of this Course

- Basis for this tutorial is a course I held at the FOM („Fachhochschule für Ökonomie und Management“) in Cologne
- It is not a *full* Python & pandas course, we would need a whole week or more. . .
- Goal: give you an overview of Python and to teach you enough Python to a) read and b) understand Python-Code and c) write smaller programs relevant for your job
- We will skip many interesting things

Introduction

Python

- Datatypes
- Functions
- Flow control
- File-Operations
- Ranges and Strings
- Sequential Datatypes

pandas

Creating files with jinja2

Python

- Invented by Guido van Rossum at the „Centrum Wiskunde & Informatica“ in Amsterdam as successor for the teaching language ABC
- Published in 1991, so it is even older than Java (1995)
- Current version is 3.11
- For a long time, Python 3.x and Python 2.7 existed together
- Python 2.7 support expired in 2019:
- How to spot 2.7 code: → `print 'hello'` instead of `print('hello')`

Python versus Java & C

Python code is often much slower than C or Java but:

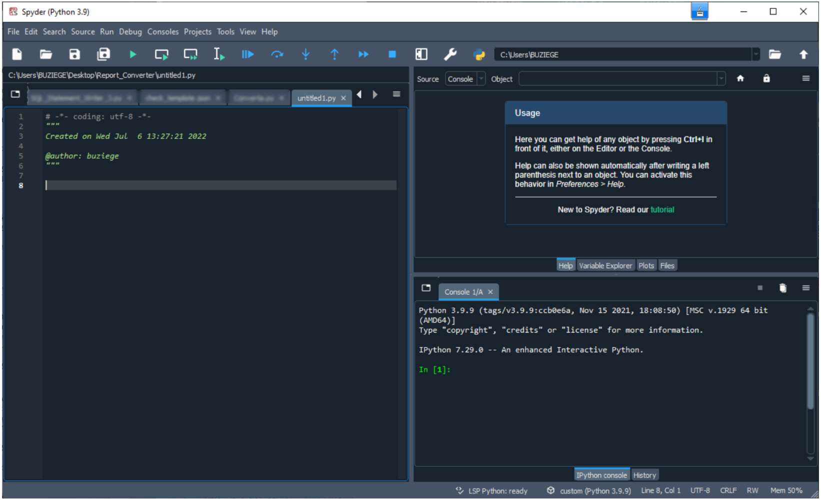
- the implementation time for Python is way faster
- speeds only matters sometimes, not always
- many computing-intensive Python modules use C/C++ modules „under the hood“

Python

Datatypes
Functions
Flow control
File-Operations
Ranges and Strings
Sequential Datatypes

Spyder

- We will use the Spyder5 IDE, make sure it is installed



```
# -*- coding: utf-8 -*-
"""
Created on Wed Jul  6 13:27:21 2022

@author: buziege
"""

```

Usage

Here you can get help of any object by pressing **Ctrl+I** in front of it, either on the Editor or the Console.

Help can also be shown automatically after writing a left parenthesis next to an object. You can activate this behavior in *Preferences > Help*.

New to Spyder? Read our tutorial

```
Python 3.9.9 (tags/v3.9.9:ccb0e6a, Nov 15 2021, 18:08:50) [MSC v.1929 64 bit
(AMD64)]
Type "copyright", "credits" or "license" for more information.

IPython 7.29.0 -- An enhanced Interactive Python.

In [1]:
```

Python as a Calculator

- Spyder5 runs an IPython kernel
- in this kernel we run our programs
- We can also use it as a calculator

```
In [1]: 4*5.4
Out[1]: 21.6

In [2]: 4/12
Out[2]: 0.3333333333333333

In [3]: _*3
Out[3]: 1.0

'hello'
Out[4]: 'hello'
```

Python as a Calculator

```

In [1]: 4%2
Out[1]: 0

In [2]: 5%2 # Modulo
Out[2]: 1

In [3]: 3**3 # Power
Out[3]: 27

In [4]: 5//2
Out[4]: 2
```

By the way: # indicates a comment

Exercise 1

- Start Spyder
- Run some basic calculations in the Console window
- Put them also in a Python file and run them from there using F5 and F9
- What is the difference between using F5 or F9?

Priority of Operators

The priority of operators is standard:

- Round brackets have highest priority
- followed by Power
- followed by multiplication and division
- followed by addition and substraction

Basic Input & Output

```python
print('Hello World')

yourName = input('Tell me your name: ')

print('Hello ' + yourName + ', welcome to this class')

print('Hello ', yourName,', welcome to this class', sep='')

print(f'Hello {yourName}, welcome to this class')
```

- Strings use either single or double quotation marks
- `input()` only reads strings
- If you need to process a number, you need to convert it
- there are better ways than `print()` for logging, but it works. . .
- f-Strings (last row) are recommended for mixed output![1]

[1] Hint: Do not mix logic and output, keep it clean!

Exercise 2

- The formula to convert degrees Celsius to degrees Fahrenheit is

  $$(c \times 1.8) + 32$$

  with c as the value in Celsius
- Write some code that
  - asks a celsius-value from the user
  - converts it into Fahrenheit
  - stores the result in a variable
  - prints the result using f-Strings
  - Hint: to convert the string into a floating-point number, use `float(<string>)`

Basic Input & Output - Raw Strings

- Certain characters need to be escaped
- A list is e. g. here: `https://www.w3schools.com/python/gloss_python_escape_characters.asp`
- Raw strings can be used to prevent (most) processing, simply put an „r“ before the string[2]

```
print('\\') # for a backslash

print('a\nb') # for a line-break

print(r'c:\windows') # to prevent most processing
```

[2] A raw string must not end with a backslash

Rules for Variables

- must start with a letter or _
- Case-sensitivity: 'A' is not 'a'
- For naming conventions see `https://realpython.com/python-pep8/`
- Most important hint: let them speak for themselves: 'diameter' is good, 'd' is bad

Reserved Keywords

The following keywords are reserved and must not be used to name variables:

and	as	assert	break	class
continue	def	del	elif	else
except	False	finally	for	from
global	if	import	in	is
lambda	None	nonlocal	not	or
pass	raise	return	True	try
while	with	yield		

Datatypes

- Integer (integer numbers)
- Float (Floating point number)
- Strings
- Booleans
- Complex numbers

Integer

- unlimited length
- must not start with 0 if they shall represent decimal numbers
- Leading 0 by representation in hex-, binary- or Octal system:

`0b/0B`	binary
`0x/0X`	hex
`0o/0O`	octal

- Functions `hex()`, `bin()`, `oct()` for conversions into string, are internally represented as decimal numbers

Float

- floating point numbers
- `3.1415927`
- `3.1e8`
- Hint: Not every floating point number can be represented *exactly* („Floating-Point Arithmetic“)
- This can get tricky, if you compare numbers for equality
- `docs.python.org/3/tutorial/floatingpoint.html`

Strings

- Single or double quotes
- For multiline strings:
  - Triple double or single quotes
  - Alternatively backslash at the end of the line
- Python has numerous functions for strings, more on this later
- Comments start with a hash #

```python
a = "I am a string"

b = 'me too'

c = """I am
as string as well """

# I am a comment
```

Booleans

- Named after George Boole
- 1854: „An investigation into the Laws of Thought“
- Essence of modern computing
- Boolean operators or (∪), and (∩), `not`

```
a = True
b = False

a == b #False
a or b # True
a and b # False
a and not b # True
not a and b # False
```

Type Conversions

- Mixing strings and floats/integers requires explicit type conversion using the `str()` function
- Use `int()` and `float()` to convert from string to number

```
>>> a + str(b)
'abc123'
>>> a+str(c)
'abc3.141'
>>> a*str(b)
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: can't multiply sequence by non-int of type 'str'

>>> 'a' * 3
'aaa'

>>>3 * 'a'
'aaa'
```

Functions

- Functions: named sequence of commands
- Purpose: encapsule code for multiple calls
- *Can* take arguments as input, *can* have return values
- Define a new function as
    - Determine name
    - Determine arguments
    - Define function code

Built-in Functions

- abs
- all
- any
- ascii
- bin
- bool
- breakpoint
- bytearray
- bytes
- callable
- chr
- classmethod
- compile
- complex
- delattr
- dict
- dir
- divmod
- enumerate
- eval
- exec
- filter
- float
- format
- frozenset
- getattr
- globals
- hasattr
- hash
- help
- hex
- id
- input
- int
- isinstance
- issubclass
- iter
- len
- list
- locals
- map
- max
- memoryview
- min
- next
- object
- oct
- open
- ord
- pow
- print
- property
- range
- repr
- reversed
- round
- set
- setattr
- slice
- sorted
- staticmethod
- str
- sum
- super
- tuple
- type
- vars
- zip
- __import__

Simple Functions with any parameter

- `def` starts function definition
- do not forget `:` at the end of the `def` line
- indent the code inside the function using tabulator[3]
- No input parameter in round brackets
- No return value (`void`)

```python
def print_hello():
    print('Hello')


print_hello()
```

Listing 1: funktion-01.py Code

```
Hello
```

[3] Spyder expands it to four space characters

Simple Functions

Empty Functions

- pass is often used in the development process
- Useful, when parts of the code are not ready, yet
- without pass you get „IndentationError: expected an indented block“ error

```python
def unfinished_function():
    pass


unfinished_function()
```

Listing 2: funktion-12.py Code

Functions with Arguments

- Function with one argument `text`
- Error message, when argument is missing

```python
def print_text(text):
    print(text)


print_text('Hello World!')
```

Listing 3: funktion-02.py Code

```
Hello World!
```

Functions with Arguments

- Two arguments, text and count

```python
def print_text_multiple(text, anzahl):
    print(text*count)


print_text_multiple('Hello!', 0)

print_text_multiple('Hello!', 1)

print_text_multiple('Hello!', 3)

print_text_multiple('Hello!', -1)
```

Listing 4: funktion-03.py Code

```

Hello!
Hello!Hello!Hello!
```

Functions with Arguments

- Setting standard values for parameters
- Allows calling the function without parameters

```python
def print_text_multiple(text='Hello CGN', count=2):
    print(text*count)


print_text_multiple()

print_text_multiple('Hello!')

print_text_multiple('Hello!',3)
```

Listing 5: funktion-04.py Code

```
Hello CGNHello CGN
Hello!Hello!
Hello!Hello!Hello!
```

Functions with return values

- Functions can return values for further processing

```python
def clone_text(text, count=2):
    return text*count


a = clone_text('Huhu')

print(a)
```

Listing 6: funktion-05.py Code

```
HuhuHuhu
```

Exercise 3

- Use the code from the temperature conversion
- create a function for the conversion from Celsius to Fahrenheit
- Call the function multiple times for different degrees

Solution for Exercise 3

```python
def c2f(celsius):
    f = (celsius * 1.8) + 32
    return f


c = 0
f = c2f(c)
print(f'{c} degrees Celsius are {f} degrees Fahrenheit')

c = 10
f = c2f(c)
print(f'{c} degrees Celsius are {f} degrees Fahrenheit')

c = 20
f = c2f(c)
print(f'{c} degrees Celsius are {f} degrees Fahrenheit')
```

Listing 7: c2f-function Code

Info: Functions with multiple return values

- Functions can have more than one return value
- Function then return tuples, an unmutuable list of values[4]
- Dealing with the tuple is called „Unpacking“
- Remark: Parameter `sep` in the example is a parameter of the `print()` function

```python
def clone_text(text, count=2):
    return count, text*count


i, a = clone_text('Huhu')

print(i, a, sep='>')
```

Listing 8: funktion-06.py Code

```
2>HuhuHuhu
```

[4] more on this later

Info: Functions with variable count of arguments

- Parameter with *: variable count of arguments
- Parameter with **: variable count of key-value arguments

```python
def addthem(*args):
    result = 0
    for number in args:
        result += number
    return result


print(addthem(1, 2, 3, 4, 5))
```

Listing 9: funktion-08.py Code

```python
def give(**args):
    for key, value in args.items():
        print(key, value, sep=': ')


print(give(Vorname='Uwe', Nachname='Ziegenhagen'))
```

Listing 10: funktion-09.py Code

Flow control

- Input & Output ✓
  - input
  - print
- Branching
  - if else elif
- Loops
  - for
  - while

Branching

- `if <condition>:`

```python
def check_length(text):
    if len(text)>8:
        print('Longer than 8 characters!')

check_length('Köln')
check_length('Düsseldorf')
```

Listing 11: if-01.py Code

```
Longer than 8 characters!
```

Branching

- There is no `switch()` in Python < 3.10[5]
- `if` statements can be used multiple times
- maybe not the most pythonic approach

```python
def check_length(text):
    if len(text)>8:
        print(text, 'Longer than 8 characters!', sep=': ')
    if len(text)<=8:
        print(text, 'Shorter or equal to 8 characters!', sep=': ')

check_length('Köln')
check_length('Düsseldorf')
```

Listing 12: if-02.py Code

```
Köln: Shorter or equal to 8 characters!
Düsseldorf: Longer than 8 characters!
```

[5] From 3.10 there is `match/case`, see `stackoverflow.com/questions/11479816/`

Branching

- more „pythonic“: `else`:

```python
def check_length(text):
    if len(text)>8:
        print(text, 'Longer than 8 characters!', sep=': ')
    else:
        print(text, 'Shorter or equal to 8 characters!', sep=': ')

check_length('Köln')
check_length('Düsseldorf')
```

Listing 13: if-03.py Code

```
Köln: Shorter or equal to 8 characters!
Düsseldorf: Longer than 8 characters!
```

Branching

- Nesting von `if <condition>: else:` leads to confusing code

```python
def check_length(text):
    if len(text)>8:
        print(text, 'Longer than 8 chars!', sep=': ')
    else:
        if len(text)<=5:
            print(text, 'Shorter or equal 5 chars!', sep=': ')
        else:
            print(text, 'Longer than 5, shorter than 8', sep=': ')

check_length('Köln')
check_length('Berlin')
check_length('Düsseldorf')
```

Listing 14: if-04.py Code

```
Köln: Shorter or equal 5 chars!
Berlin: Longer than 5, shorter than 8
Düsseldorf: Longer than 8 chars!
```

Branching

- `if <condition>: else:` can be shortened to `elif:`

```python
def check_length(text):
    if len(text)>8:
        print(text, 'Longer than 8 chars!', sep=': ')
    elif len(text)<=5:
        print(text, 'Shorter or equal 5 chars!', sep=': ')
    else:
        print(text, 'Longer than 5, shorter than 8', sep=': ')

check_length('Köln')
check_length('Berlin')
check_length('Düsseldorf')
```

Listing 15: if-05.py Code

```
Köln: Shorter or equal 5 chars!
Berlin: Longer than 5, shorter than 8
Düsseldorf: Longer than 8 chars!
```

Loops

for

- `for` loops iterate over a sequence
- sequence can be a string, a liste, etc.
- `range(start, end, stepsize=1)` creates numerical sequence from `start` until below (!) `end` with step size `stepsize`

```python
for char in 'Hallo Welt':
    print(char)

for j in range(1, 10):
    print(j) # 1 bis 9

for j in range(1, 10, 3):
    print(j) # 1, 4 und 7
```

Listing 16: for-01.py Code

Loops

while

- while loop runs, until condition is not fulfilled anymore

```python
s = 'Hallo Welt'
l = len(s)

while (l>0):
    print(s[l-1])
    l-=1

i = 1
while (i<100):
    i += 1

print(i)
```

Listing 17: while-01.py Code

Loops

break and continue

- break and continue influence loops
- break can e. g. be used to exit a loop

```python
s = 'Hallo Welt'
l = len(s)

while (l>0):
    temp = s[l-1]
    if temp == 'W':
        break
    print(temp)
    l-=1
```

Listing 18: while-02.py Code

File-Operations

- open() opens file for read/write access
- two parameters:

  Path Path to the file

  Mode Read, Write, Binary, Text

```
f = open('u:/hello.txt', 'w')
f.write("Hello World!")
f.close()
```

Listing 19: Simple example for write()

Not optimal, in case of errors the file-handle might remain open!
The file is not usable by other applications.

File-Operations

Improved version, uses „Context manager“, closes file handle in each situation

```python
with open('r:/hello.txt', 'w') as f:
    f.write("Hello World!")
```

Listing 20: Improved example for `write()`

Hint: Context managers are also very useful when dealing with SQL databases.

Exercise 4: Files and Branching

- Ask the user to input a number
- If the number <0 write „Hello“ to a text file
- If the number >0 write „World“ to a text file
- If the number $=0$ write „Foobar“ to a text file
- Open the file and printout the file on the screen
- Delete the created file afterwards (Use e. g. the `os` module)

File-Operations

Read-/Write- parameters

- r Read; Error, when file is not present
- r+ Read and Write
- a+ Read and append, file is created if not existent
- x Creates file, error if file exists
- a Append; creates file if not existent, appends at the end
- w Write; creates file if not existent; overwrite, if file exists

Content format

- t for text files
- b for binary files (images, zip, etc)

File-Operations

```python
with open('r:/hello.txt', 'rt') as file:
    print(file.read())
```

Listing 21: Read a complete file

```python
with open('r:/hello.txt', 'rt') as file:
    for line in file:
        print(line)
```

Listing 22: Row-wise reading a file

File-Operations

Deleting files

```python
import os

if os.path.exists('r:/hello.txt'):
    os.remove('r:/hello.txt')
else:
    print("File does not exist!")
```

Listing 23: Deleting a file

The range() Function

- range() function creates a sequence of numbers via generator⇒ see next slide
- Three parameters maximum : start, stop and step
- range(<stop>) with one parameter, range(0,<stop>,1) implicitly
- range(<start>, <stop>) with two parameters, <start>,<stop>,1) implicitly
- range(<start>,<stop>,<step>) with three parameters
- Important: <start> is inclusive, <stop> not!!!
- range(0,10) runs from 0 to 9

Examples for range()-Function

```
# -*- coding: utf-8 -*-

for i in range(10):
    print('1', i)

print('\n')
for i in range(2, 10):
    print('2', i)

print('\n')
for i in range(2, 10, 2):
    print('3', i)

print('\n')
for i in range(10, -10, -2):
    print('4', i)
```

Listing 24: range_beispiel.py Code

```
1: 0  1 1 1 2 1 3 1 4 1 5 1 6 1 7 1 8 1 9
2: 2  2 3 2 4 2 5 2 6 2 7 2 8 2 9
3: 2  3 4 3 6 3 8
4: 10 4 8 4 6 4 4 4 2 4 0 4 -2 4 -4 4 -6 4 -8
```

Sequential Datatypes aka: for i in whatever

- Sequential Datatypes = Datatypes that store elements sequentially

  Strings contain characters only

  Lists different objects possible, mutuable (changeable)

  Tuple different objects possible, not mutuable (not changeable)

- Identical methods for the access: `object[<number>]` to access a specific element, `len()` for the length, Slicing-Notation

String Functions

- Numerous string-functions are available, see `docs.python.org/3/library/stdtypes.html#text-sequence-type-str`
- Length of a string using `len(<String>)`
- Upper- or lowercase a string with `upper(<String>)` and `lower(<String>)`
- `index(<String>)`, `find(<String>)` and `replace(<String>)`
- `startswith(<String>)` and `endwith(<String>)`
- `split(<String>)` and `strip(<String>)`

Lists

- Lists contain arbitrary objects
- Square brackets, elements separated by comma
- first element is `listname[0]`
- Can be nested
- Can be changed at runtime ⇒ „mutuable“

```python
abc = ['a', 'b', 'c', 3.1234]
efg = [1, 2, [1, 2, 3], 3, 4]
```

Tuples

- Round brackets, can be left out
- Recommendation: do not leave them out
- Immutable, objects cannot be changed after creation
- can be unpacked via multi-assignment: `a, b, c = (1, 2, 3)`
- hint: switch two numbers by `a, b = b, a`

Indexing Sequential Datatypes

- Two ways of indexing: from 0 to $n - 1$ and $-n$ to -1

Index	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1
	H	e	l	l	o		W	o	r	l	d
Index	0	1	2	3	4	5	6	7	8	9	10

Slicing

- Slicing = very powerful, especially for strings
- two parameters, start and stop, separated by :, both are optional
- third parameter: step size

```
>>> a = 'Hello World'
>>> a[:]
'Hello World'
>>> a[1:-1]
'ello Worl'
>>> a[1:-5]
'ello '
>>> a[::1]
'Hello World'
>>> a[::2]
'HloWrd'
>>> a[1:-1:3]
'eoo'
>>>a[::-1]
```

Exercise 5: String manipulation

- Ask the user to input a file name, or alternatively: use the filenames in a directory of your choice
- print the filename without the file extension as well as the file extension separately

Dictionaries

- Dictionaries = Associative fields, maps, hashes
- consist of Key-Value pairs, for each („Key“) a („Value“) is assigned
- each key must only exist once in each dict
- can arbitrarily grow and shrink
- all immutable objects can be keys: strings, floats, integers, tuples, but no lists or dictionaries
- Dictionaries can be nested (well, if you ever need this, think again. . .)

Dictionaries

```python
de_en = {'Glücklich':'Happy', 'Baum':'Tree'}
de_en['Freunde'] = 'Friends'

print(de_en['Baum'])
# print(de_en['Tree']) # => KeyError
'Baum' in de_en

monatsnamen = {1:'Januar', 2: 'Februar', 3: 'März'}
print(monatsnamen[1])
```

Listing 25: dict-01.py Code

```
Tree
Januar
```

Accessing a Dictionary

```python
d = {1:'one',2:'two',3:'three'}

print(d.keys())
print(d.values())
print(d.items())

print(d.get(4))
print(d.get(3))

for k, v in d.items():
    print(k, v)
```

Listing 26: dict-04.py Code

```
dict_keys([1, 2, 3])
dict_values(['one', 'two', 'three'])
dict_items([(1, 'one'), (2, 'two'), (3, 'three')])
None
three
1 one
2 two
3 three
```

Functions for Dictionaries (Selection)

`clear()`	deletes all entries
`copy()`	creates a flat copy
`keys()`	set of all keys
`pop()`	removes key and its value from dict
`update()`	adds dict2 to dict, overwrites values eventually
`popitem()`	removes arbitrary key-value combination from dict, KeyError if dict is empty. Important: „arbitrary“ $\neq$ random!

pandas

pandas

- A Python library for data wrangling and management
- Invented by Wes McKinney during his time at AQR Capital Management
- In his own words: „I tell them that it enables people to analyze and work with data who are not expert computer scientists,“ he says. „You still have to write code, but it's making the code intuitive and accessible. It helps people move beyond just using Excel for data analysis.“[6]

[6] `qz.com/1126615/the-story-of-the-most-important-tool-in-data-science/`

Das SciPy Framework

pandas is just a piece among many:

NumPy	Matrices, vectors, algorithms
IPython	Matlab/Mathematica-like environment
Matplotlib	Scientific Plotting, Basis for seaborn library
SymPy	Symbolic mathematics
...	etc, etc

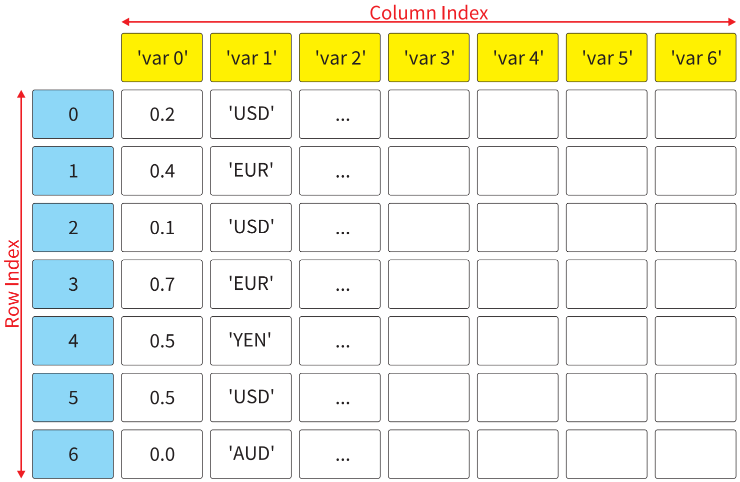
We only focus on pandas today:

```python
import pandas as pd
```

Series and DataFrames

- central data structures in `pandas`: `series` and `dataframes`
- quite similar to dataframes in R
- Definition „Series“: a vector with data of the same type and an index
- Definition „Dataframe“: matrix from various series, the series can have different data types haben but they share the same index

Series und DataFrames



Column Index

Row Index

	'var 0'	'var 1'	'var 2'	'var 3'	'var 4'	'var 5'	'var 6'
0	0.2	'USD'	...				
1	0.4	'EUR'	...				
2	0.1	'USD'	...				
3	0.7	'EUR'	...				
4	0.5	'YEN'	...				
5	0.5	'USD'	...				
6	0.0	'AUD'	...				

Manual Creation of pandas Objects

- pandas-objecs *can* be created manually
- normally not used, data is usually loaded from files/databases

```python
import pandas as pd

d = pd.DataFrame({'A': ['A0','A1','A2','A3'],
  'Key': ['K0','K1','K2','K4']})
a = pd.Series([1,2,3,4,5,6,7,8,9,10])
b = pd.Series(['A','C','D','B','F','G','I','K','L','P'])
df = pd.concat([a,b], axis=1)
# alternatively
df = pd.DataFrame({'a': a,'b':b})
df = a.to_frame().join(b.to_frame())
df = pd.DataFrame(data=dict(a=a, b=b))
```

Daten einlesen

- various functions to read files

Befehl	Beschreibung
read_pickle	reads Pickle objects
read_table	table-like formats
read_csv	Comma-Separated Values
read_fwf	fixed-width formats
read_clipboard	clipboard
read_excel	Excel-files

other commands for HTML, JSON, HDF5, . . .

Reading CSV

- „CSV“: Comma-Separated Value
- CSV is not a unique format
  - Column-separator
  - Decimal-separator
  - Text Encoding
- Specifications: `http://pandas.pydata.org/pandas-docs/stable/generated/pandas.read_csv.html`

sep	Column-separator
thousands	seperator for thousands
encoding	Encoding
decimal	Decimal-separator
converters	converters={'A': str} for explicit conversion to a format

Reading Excel

- `pd.read_excel()` to read XLSX-files (!)
- Documentation: `http://pandas.pydata.org/pandas-docs/stable/generated/pandas.read_excel.html`
- Export to Excel using `pd.to_excel()`
- Remarks:
  - Excel-Export is way slower than CSV-Export
  - Export of well-formatted Excel is possible but takes effort
  - One can even control Excel via COM (Common Object Model)

DataFrames bearbeiten

Exploratory Data Analysis

- We use `Northwind` data as an example
- First task after loading: check data consistency

```python
customers = pd.read_excel('Northwind.xlsx', sheetname = 'Customers')

print(len(customers))   # number of rows
print(customers.head()) # first five rows
print(customers.tail()) # last five rows
print(list(customers))  # list of columns
```

Pandas Dataframe Operations

Selection and Filtering I

- pandas has advanced methods for selecting, filtering and transforming data
- Select only specific columns

  ```
  df = df[['colA', 'colB']]
  ```
- Select the top two rows (Index starting at 0)

  ```
  df.iloc[:1]
  ```
- Select only those rows where one row $>$ 50

  ```
  df[df['colA'] > 50]
  ```

Pandas Dataframe Operations

Selection and Filtering II

- Select only those rows where value is between two values

  ```
  df[(df['colA'] > 50)| (df['colA'] < 500)]
  ```

- Select rows that **do not** have a certain value

  ```
  df[~(df['colA'] == 'HelloWorld')]
  ```

- Select rows, where column b is either value 'A' or 'B'

  ```
  df = df[ (df['b'] == 'A')| (df['b'] == 'I')]
  ```

- Use alternatively `isin()`

  ```
  df = df[df['b'].isin(['A','I'])]
  ```

- or the opposite

  ```
  df = df[~df['b'].isin(['A','I'])]
  ```

Apply functions to pandas columns

```python
import pandas as pd

def capitalizeColumn(text):
    return text.capitalize()

df = pd.DataFrame({'Key': ['K0','K1','K2','K4'],
        'Name': ['anna','bernd','cesar','dana']})

print(df)

df['Nachname'] = df['Name'].apply(capitalizeColumn)

print(df)
```

```
  Key   Name Nachname
0  K0   anna     Anna
1  K1  bernd    Bernd
2  K2  cesar    Cesar
3  K4   dana     Dana
```

Mapping I

- Similar to Excel's `vlookup()` function
- Example: `countries` is a key-value dictionary
- `country` column in the dataframe is used as key in the dictionary, a new column is created

```
import pandas as pd

df = pd.DataFrame({'A': ['A0','A1','A2','A3'],
  'Country': ['DEU','USA','ARE','ESP']})

countries = { 'DEU':'Germany',
              'USA':'United States',
              'ARE':'Arabic Emirates',
              'ESP':'Spain'}

df['Country'] = df['Country'].map(countries)

print(df)
```

Mapping II

- `map()` can also be used to make simple calculations
- keyword here is „lambda“ ⇒ anonymous function

```python
import pandas as pd

df = pd.DataFrame({'A': ['A0','A1','A2','A3'],
  'Net': [100, 200, 300, 400]})

df['Gross'] = df['Net'].map(lambda x: x * 1.19)

print(df)
```

Pandas Dataframe Operations

Merge and Join

- `merge()` SQL-like merging of datasets
- useful to combine data
- Supports the following join types:
  - Left
  - Right
  - Inner
  - Full Outer
- `join()` is a special alias for `merge()`, works on the index, not the columns

Pandas Dataframe Operations

Merge and Join

- Standard-command for `merge()`

```
leftDataFrame.merge(rightDataFrame, how='inner',
on=None, left_on=None, right_on=None, left_index=False,
right_index=False, sort=False, suffixes=('_x', '_y'),
copy=True, indicator=False)
```

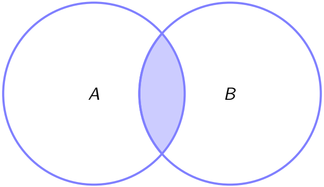
Workflow

1. define other dataset
2. define type of merge
3. define keys for the merger

Merging

Inner Join

- Select all data, that is in A **and** B



left

	A	Key
0	A0	K0
1	A1	K1
2	A2	K2
3	A3	K4

right

	B	Key
0	B0	K0
1	B1	K1
2	B2	K2
3	C3	K5

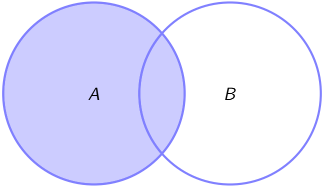
merged

	A	B	Key
0	A0	B0	K0
1	A1	B1	K1
2	A2	B2	K2

Merging

Left Join

- Select all data in A, get data from B if available



left

	A	Key
0	A0	K0
1	A1	K1
2	A2	K2
3	A3	K4

right

	B	Key
0	B0	K0
1	B1	K1
2	B2	K2
3	C3	K5

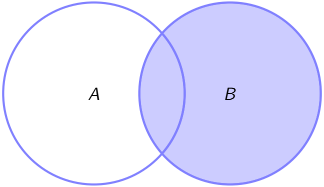
merged

	A	B	Key
0	A0	B0	K0
1	A1	B1	K1
2	A2	B2	K2
3	A3	NaN	K4

Merging

Right Join

- Select all data in B, get data from A if available



left

	A	Key
0	A0	K0
1	A1	K1
2	A2	K2
3	A3	K4

right

	B	Key
0	B0	K0
1	B1	K1
2	B2	K2
3	C3	K5

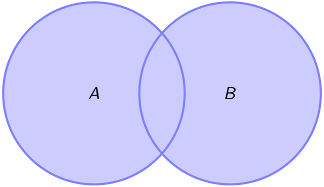
merged

	A	B	Key
0	A0	B0	K0
1	A1	B1	K1
2	A2	B2	K2
3	NaN	B3	K5

Merging

Full Outer Join

- Select all data which is in A **or** B



left

	A	Key
0	A0	K0
1	A1	K1
2	A2	K2
3	A3	K4

right

	B	Key
0	B0	K0
1	B1	K1
2	B2	K2
3	C3	K5

merged

	A	B	Key
0	A0	B0	K0
1	A1	B1	K1
2	A2	B2	K2
3	A3	NaN	K4
4	NaN	B3	K5

Exercise 6: pandas merging

- Create two smaller Excel files with a few rows and columns
- merge both files using the different join types

Loop through DataFrames

```python
import pandas as pd

df = pd.DataFrame({'Key': ['K0','K1','K2','K4'],
        'Name': ['Anna','Bernd','Cesar','Dana']})

for index, row in df.iterrows():
    print(row['Key'], 'belongs to', row['Name'])
```

```
K0 belongs to Anna
K1 belongs to Bernd
K2 belongs to Cesar
K4 belongs to Dana
```

Creating files with jinja2

Jinja2

- Example: you need to create XML files from Excel to test something
- Elegant way: use a template engine like jinja2
- Allows to separate the template code from the program code

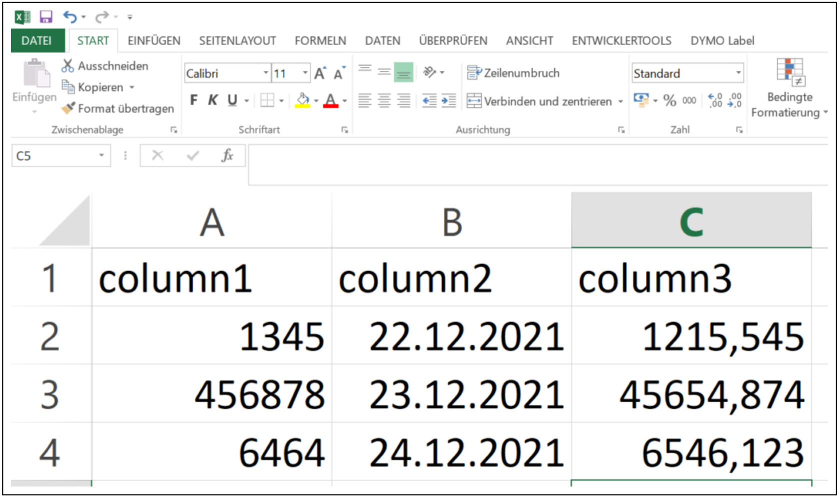
Some basic jinja

```python
import jinja2


# standard Python
name = 'Uwe'
print(f'Hello, {name}')


# Jinja2 way
environment = jinja2.Environment()
template = environment.from_string("Hello, {{ name }}!")

print(template.render(name="World"))
```

- Standard Python way looks easier, but...
- When it gets more complex, jinja2 wins!

Jinja2 Power

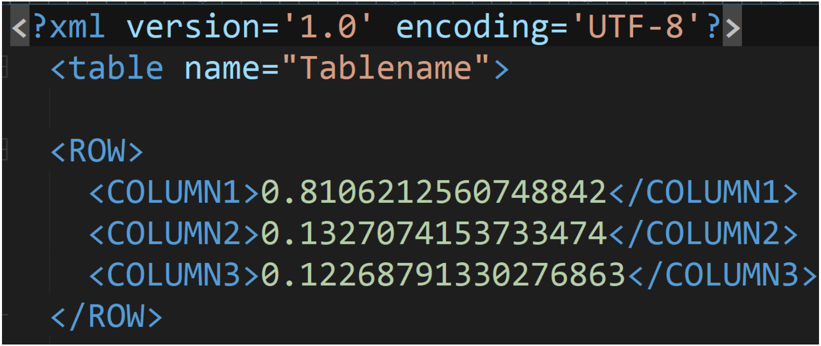
We have an Excel file:



	A	B	C
1	column1	column2	column3
2	1345	22.12.2021	1215,545
3	456878	23.12.2021	45654,874
4	6464	24.12.2021	6546,123

Jinja2 Power

and need an XML file:



```
<?xml version='1.0' encoding='UTF-8'?>
  <table name="Tablename">

  <ROW>
    <COLUMN1>0.8106212560748842</COLUMN1>
    <COLUMN2>0.1327074153733474</COLUMN2>
    <COLUMN3>0.12268791330276863</COLUMN3>
  </ROW>
```

Jinja2 Power

We define a template template.xml that contains some Jinja2 magic:

```
<?xml version='1.0' encoding='UTF-8'?>
  <table name="Tablename">
  {% for _,row in data.iterrows() %}
  <ROW>
    <COLUMN1>{{row['column1']}}</COLUMN1>
    <COLUMN2>{{row['column2']}}</COLUMN2>
    <COLUMN3>{{row['column3']}}</COLUMN3>
  </ROW>
  {% endfor %}
</table>
```

Jinja2 Power

```python
import pandas as pd # data wrangling
import jinja2 # template engine
import os # for file-related stuff

# create jinja env that can load template from filesystem
jinja_env = jinja2.Environment(loader = jinja2.FileSystemLoader(os.path.abspath('.')))

df = pd.read_excel('Daten.xlsx')
template = jinja_env.get_template('template.xml')

with open('FertigesXML.xml','w') as output:
    output.write(template.render(data=df))
```

⇒ It takes less than a second to write 10K rows!