Big Data and Automated Content Analysis

Week 7 – Monday

»Statistics with Python«

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Today

1. Statistics in Python
   - General considerations
   - Useful packages
2. Pandas
   - Working with dataframes
   - Plotting and calculating with Pandas
3. Pandas II: Data wrangling
   - Subsetting and slicing
   - Joining and Merging
   - Aggregation
4. Excercise
5. Next steps

Statistics in Python

General considerations

General considerations

After having done all your nice text processing (and got numbers instead of text!), you probably want to analyse this further.
You can always export to .csv and use R or Stata or SPSS or whatever. . .

BUT:

Reasons for not exporting and analyzing somewhere else

- the dataset might be too big
- it's cumbersome and wastes your time
- it may introduce errors and makes it harder to reproduce

What statistics capabilities does Python have?

- Basically all standard stuff (bivariate and multivariate statistics) you know from SPSS
- Some advanced stuff (e.g., time series analysis)
- However, for some fancy statistical modelling (e.g., structural equation modelling), you can better look somewhere else (R)

Statistics in Python

Useful packages

Useful packages

numpy (numerical python) Provides a lot of frequently used functions, like mean, standard deviation, correlation, ...

scipy (scientic python) More of that ;-)

statsmodels Statistical models (e.g., regression or time series)

matplotlib Plotting

seaborn Even nicer plotting

Example 1: basic numpy

```
import numpy as np
x = [1,2,3,4,3,2]
y = [2,2,4,3,4,2]
z = [9.7, 10.2, 1.2, 3.3, 2.2, 55.6]
np.mean(x)
```

```
2.5
```

```
np.std(x)
```

```
0.9574271077563381
```

```
np.corrcoef([x,y,z])
```

```
array([[ 1.        ,  0.67883359, -0.37256219],
       [ 0.67883359, 1.        , -0.56886529],
       [-0.37256219, -0.56886529, 1.        ]])
```

Characteristics

- Operates (also) on simple lists
- Returns output in standard datatypes (you can print it, store it, calculate with it, . . .)
- it's fast! `np.mean(x)` is faster than `sum(x)/len(x)`
- it is more accurate (less rounding errors)

Example 2: basic plotting

```python
import matplotlib.pyplot as plt
x = [1,2,3,4,3,2]
y = [2,2,4,3,4,2]
plt.hist(x)
plt.plot(x,y)
plt.scatter(x,y)
```

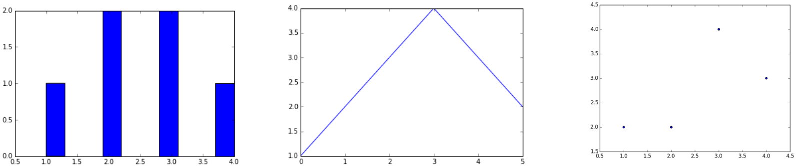


Figure: Examples of plots generated with `matplotlib`

Pandas

Working with dataframes

When to use dataframes

Native Python data structures (lists, dicts, generators)

pro:

- flexible (especially dicts!)
- fast
- straightforward and easy to understand

con:

- if your data is a table, modeling this as, e.g., lists of lists feels unintuitive
- very low-level: you need to do much stuff 'by hand'

Pandas dataframes

pro:

- like an R dataframe or a STATA or SPSS dataset
- many convenience functions (descriptive statistics, plotting over time, grouping and subsetting, . . .)

con:

- not always necessary ('overkill')
- if you deal with really large datasets, you don't want to load them fully into memory (which pandas does)

Pandas

Plotting and calculating with Pandas

OLS regression in pandas

```
import pandas as pd
import statsmodels.formula.api as smf

df = pd.DataFrame({’income’: [10,20,30,40,50], ’age’: [20, 30, 10, 40, 50], ’facebooklikes’: [32, 234, 23, 23, 42523]})

# alternative: read from CSV file (or stata...):
# df = pd.read_csv(’mydata.csv’)

myfittedregression = smf.ols(formula=’income ~ age + facebooklikes’, data=df).fit()
print(myfittedregression.summary())
```

```
OLS Regression Results
==============================================================================
Dep. Variable:              income  R-squared:                       0.579
Model:                         OLS  Adj. R-squared:                  0.158
Method:              Least Squares  F-statistic:                     1.375
Date:             Mon, 05 Mar 2018  Prob (F-statistic):              0.421
Time:                     18:07:29  Log-Likelihood:                -18.178
No. Observations:                5  AIC:                             42.36
Df Residuals:                    2  BIC:                             41.19
Df Model:                        2
Covariance Type:         nonrobust
=================================================================================
coef   std err        t     P>|t|     [95.0% Conf. Int.]
---------------------------------------------------------------------------------
Intercept      14.9525   17.764     0.842     0.489      -61.481   91.386
age             0.4012    0.650     0.617     0.600       -2.394    3.197
facebooklikes   0.0004    0.001     0.650     0.583       -0.002    0.003
==============================================================================
Omnibus:                       nan  Durbin-Watson:                   1.061
Prob(Omnibus):                 nan  Jarque-Bera (JB):                0.498
Skew:                       -0.123  Prob(JB):                        0.780
Kurtosis:                    1.474  Cond. No.                     5.21e+04
==============================================================================
```

Other cool df operations

df['age'].plot() to plot a column

df['age'].describe() to get descriptive statistics

df['age'].value_counts() to get a frequency table

and MUCH more. . .

Recoding and transforming

To transform your data, you can use `.apply()`, `.applymap()`, and `.map()` or the .str.XXX() methods:

```
df['is_center'] = df['hood'].str.contains('[cC]enter')
```

or define your own function:

```
def is_center(x):
    return int(x.lower().find('center') > -1)

df['is_center'] = df['hood'].map(is_center)
```

or use a throwaway-function:

```
df['is_center'] = df['hood'].map(lambda x: int(x.lower().find('center')
    > -1))
```

Subsetting and slicing

Subsetting and slicing

Recap:

- `[0:5]` to get elements 0, 1, 2, 3, 4 (works with lists, dataframes . . .)
- `mydict['keyicareabout']` to get value (content) associated with the key

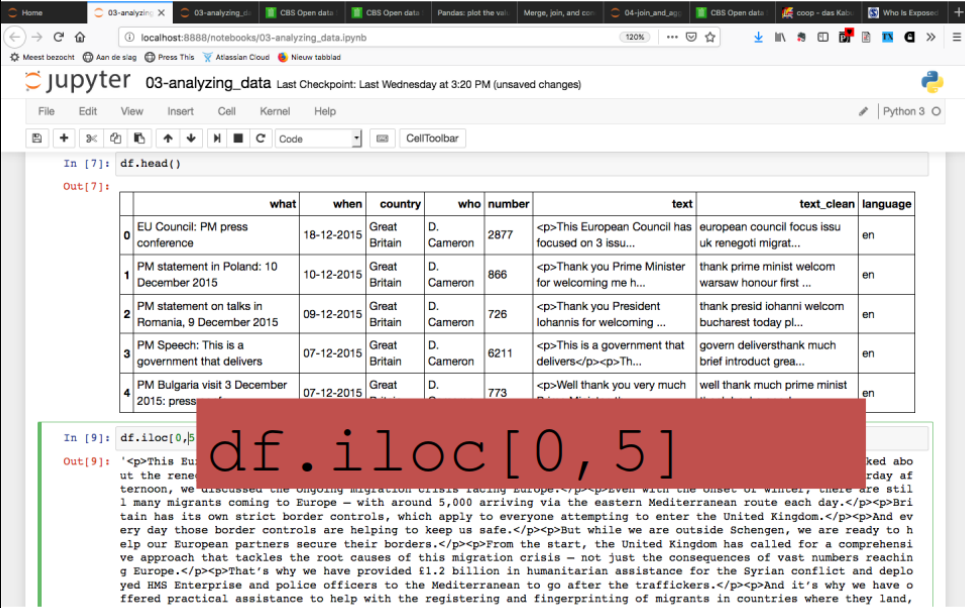
And therefore, also:

- `df[['col1', 'col2']]` to get only these two columns of a dataset
- `df[df['col1']=='whatever']` to get only the rows in which col1 is identical to the string 'whatever'
- `df[df['col2']>0]` to get only the rows in which col2 is a number bigger than 0

More subsetting

To get a apecific row and/or column, you can use `.iloc[]` and `.loc[]`

- `.iloc[]` takes an int (the row/column numbers, `.loc[]` the names)
- `df.iloc[0,5]` to get row 0, column 5
- `df.loc[0,'what']` to get row 0, column 'what'



	what	when	country	who	number	text	text_clean	language
0	EU Council: PM press conference	18-12-2015	Great Britain	D. Cameron	2877	<p>This European Council has focused on 3 issu...	european council focus issu uk renegoti migrat...	en
1	PM statement in Poland: 10 December 2015	10-12-2015	Great Britain	D. Cameron	866	<p>Thank you Prime Minister for welcoming me h...	thank prime minist welcom warsaw honour first ...	en
2	PM statement on talks in Romania, 9 December 2015	09-12-2015	Great Britain	D. Cameron	726	<p>Thank you President Iohannis for welcoming ...	thank presid iohanni welcom bucharest today pl...	en
3	PM Speech: This is a government that delivers	07-12-2015	Great Britain	D. Cameron	6211	<p>This is a government that delivers</p><p>Th...	govern deliversthank much brief introduct grea...	en
4	PM Bulgaria visit 3 December 2015: press	07-12-2015	Great	D.	773	<p>Well thank you very much	well thank much prime minist	en

df.iloc[0,5]

localhost:8888/notebooks/03-analyzing_data.ipynb

jupyter 03-analyzing_data Last Checkpoint: Last Wednesday at 3:20 PM (unsaved changes)

File Edit View Insert Cell Kernel Help — Python 3

In [7]:
```
df.head()
```

Out[7]:

	what	when	country	who	number	text	text_clean	language
0	EU Council: PM press conference	18-12-2015	Great Britain	D. Cameron	2877	<p>This European Council has focused on 3 issu...	european council focus issu uk renegoti migrat...	en
1	PM statement in Poland: 10 December 2015	10-12-2015	Great Britain	D. Cameron	866	<p>Thank you Prime Minister for welcoming me h...	thank prime minist welcom warsaw honour first ...	en
2	PM statement on talks in Romania, 9 December 2015	09-12-2015	Great Britain	D. Cameron	726	<p>Thank you President Iohannis for welcoming ...	thank presid iohanni welcom bucharest today pl...	en
3	PM Speech: This is a government that delivers	07-12-2015	Great Britain	D. Cameron	6211	<p>This is a government that delivers</p><p>Th...	govern deliversthank much brief introduct grea...	en
4	PM Bulgaria visit 3 December 2015: press	07-12-2015	Great	D.	773	<p>Well thank you very much	well thank much prime minist	en

In [10]:
```
df.loc[0,'t
```

df.loc[0,'text']

Out[10]:
```
'<p>This Eu                                                        ked abo
ut the rene                                                        rday af
ternoon, we                                                        are stil
l many migrants coming to Europe – with around 5,000 arriving via the eastern Mediterranean route each day.</p><p>Bri
tain has its own strict border controls, which apply to everyone attempting to enter the United Kingdom.</p><p>And ev
ery day those border controls are helping to keep us safe.</p><p>But while we are outside Schengen, we are ready to h
elp our European partners secure their borders.</p><p>From the start, the United Kingdom has called for a comprehensi
ve approach that tackles the root causes of this migration crisis – not just the consequences of vast numbers reachin
g Europe.</p><p>That's why we have provided £1.2 billion in humanitarian assistance for the Syrian conflict and deplo
yed HMS Enterprise and police officers to the Mediterranean to go after the traffickers.</p><p>And it's why we have o
ffered practical assistance to help with the registering and fingerprinting of migrants in countries where they land,
```

Advanced Example

Out of a dataset with 1, 000 speeches, get the one that talks most about [Tt]error

1. We create a new column to count how many a word is mentioned:
   `df['terror'] = df['speech'].str.count('[Tt]error')`
2. We do
   `df.iloc[df['terror'].idxmax()]`
3. That works because df.iloc[] expects an integer to identify the row number, and `df['terror'].idxmax()` returns an integer (687 in our case)

```
df['terrorrefs'].idxmax()
```

```
687
```

```
df.iloc[687]
```

```
what             Permanent Link to Press conference in Islamabad
when                                                  14-12-2008
country                                            Great Britain
who                                                     G. Brown
number                                                      2954
text           <p>Transcript of a press conference given by t...
text_clean     transcript press confer given prime minist mr ...
language                                                      en
terrorrefs                                                    44
Name: 687, dtype: object
```

Joining and Merging

Joining and Merging

Typical scenario

- You have two datasets that share one column
- For instance, data from `www.cbs.nl`: one with economic indicators, one with social indicators
- You want to make one dataframe

```python
economie = pd.read_csv('82800ENG_UntypedDataSet_15112018_205454.csv', delimiter=';')
economie.head()
```

	ID	EconomicSectorsSIC2008	Regions	Periods	GDPVolumeChanges_1
0	132	T001081	PV20	1996JJ00	9.3
1	133	T001081	PV20	1997JJ00	-2.0
2	134	T001081	PV20	1998JJ00	-0.9
3	135	T001081	PV20	1999JJ00	-0.7
4	136	T001081	PV20	2000JJ00	1.5

```python
population = pd.read_csv('37259eng_UntypedDataSet_15112018_204553.csv', delimiter=';')
population.head()
```

	ID	Sex	Regions	Periods	LiveBornChildrenRatio_3
0	290	T001038	PV20	1960JJ00	18.6
1	291	T001038	PV20	1961JJ00	18.9
2	292	T001038	PV20	1962JJ00	18.9
3	293	T001038	PV20	1963JJ00	19.5
4	294	T001038	PV20	1964JJ00	19.6

What do you think: How could/should a joined table look like?

```python
# remove unnecessary columns
economie.drop('ID',axis=1,inplace=True)
population.drop('ID',axis=1,inplace=True)
# remove differentiation by sex
population = population[population['Sex']=='T001038']
population.drop('Sex',axis=1,inplace = True)
# keep only rows of economie dataframe that contain the total economic activity
economie = economie[economie['EconomicSectorsSIC2008']=='T001081    ']
economie.drop('EconomicSectorsSIC2008', axis=1, inplace=True)
```

First clean up...

```python
# remove those evil spaces at the end of the names of the provinces
population['Regions'] = population['Regions'].map(lambda x: x.strip())
economie['Regions'] = economie['Regions'].map(lambda x: x.strip())
```

```python
population.merge(economie, on=['Periods','Regions'], how='inner')
```

	Regions	Periods	LiveBornChildrenRatio_3	GDPVolumeChanges_1
0	PV20	1996JJ00	11.0	9.3
1	PV20	1997JJ00	11.4	-2.0
2	PV20	1998JJ00	11.6	-0.9
3	PV20	1999JJ00	11.6	-0.7
4	PV20	2000JJ00	11.5	1.5
5	PV20	2001JJ00	11.7	3.9
6	PV20	2002JJ00	11.4	2.1

Then merge

On what do you want to merge/join?

Standard behavior of.join(): on the row index (i.e., the row number, unless you changed it to sth else like a date)

```
df3 = df1.join(df2)
```

But that's only meaningful if the indices of df1 and df2 mean the same. Therefore you can also join on a column if both dfs have it:

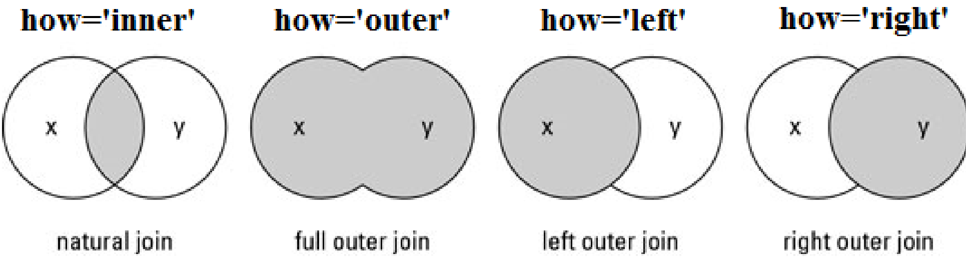
```
df3 = df1.merge(df2, on='Regions')
```

`.merge()` is the more powerful tool, `.join()` is a bit easier when joining on indices.

Inner, Outer, Left, and Right

Main question: What do you want to do with keys that exist only in one of the dataframes?

```
df3 = df1.join(df2, how='xxx')
```



Aggregation

An example

- Suppose you have two dataframes, both containing information on something per region per year.
- You want to merge (join) the two, however, in one of them, the information is also split up by age groups. You don't want that.
- How do you bring these rows back to one row? With `.agg()`!

.agg()

- Very useful after a `.groupby()`
- Takes a function as argument:
  `df2 = df.groupby('region').agg(sum)`
- Or multiple functions:
  `df2 = df.groupby('region').agg([sum, np.mean])`
- → yes, you could do `.describe()`, but `.agg()` is more flexible

An example

How do housing prices (WOZ-waarde) develop over time in different neighborhoods?

```
wijken
```

put; double click to hide

0	Burgwallen-Oude Zijde	263417.0	273525.0	289984.0	339548.0	400010.0	A00	Centrum
1	Burgwallen-Nieuwe Zijde	267895.0	281193.0	296762.0	351214.0	391011.0	A01	Centrum
2	Grachtengordel-West	490251.0	502230.0	560841.0	674610.0	755091.0	A02	Centrum
3	Grachtengordel-Zuid	469946.0	478371.0	531225.0	627625.0	697576.0	A03	Centrum
[illegible]	[illegible]arkt/Lastage	295239.0	303500.0	340364.0	386716.0	438942.0	A04	Centrum
5	Haarlemmerbuurt	304924.0	311743.0	345189.0	403267.0	458522.0	A05	Centrum
6	Jordaan	270390.0	285877.0	307344.0	347740.0	402186.0	A06	Centrum
7	De Weteringschans	344649.0	359119.0	399942.0	458010.0	515192.0	A07	Centrum
8	Weesperbuurt/Plantage	307440.0	322276.0	353628.0	413388.0	473643.0	A08	Centrum
9	Oostelijke Eilanden/Kadijken	253990.0	256421.0	276481.0	316261.0	381774.0	A09	Centrum
11	Westelijk Havengebied	NaN	189402.0	224491.0	NaN	NaN	B10	Westpoort
13	Houthavens	164263.0	167242.0	188360.0	349525.0	483318.0	E12	West
14	Spaarndammer- en Zeeheldenbuurt	207439.0	209713.0	222371.0	256300.0	322981.0	E13	West
15	Staatsliedenbuurt	209792.0	222070.0	241366.0	277214.0	325787.0	E14	West

Steps

1. Get it into a tidy format (1 row = 1 observation) ("long" format)
2. Optionally, but more neat (also for automatically getting correct plot labels):
   index rows by year
3. use `.groupby()` and `.agg()` to aggregate the data

```python
wijken_long = wijken.melt(id_vars=['wijk','stadsdeel'],
                          value_vars=['2014', '2015', '2016', '2017', '2018'],
                          value_name='woz-waarde',
                          var_name = 'year')
```

```python
wijken_long
```

.melt() transforms a df from wide to long

	wijk	stadsdeel	year	woz-waarde
0	Burgwallen-Oude Zijde	Centrum	2014	263417.0
1	Burgwallen-Nieuwe Zijde	Cen		
2	Grachtengordel-West	Cen		
3	Grachtengordel-Zuid	Cen		
4	Nieuwmarkt/Lastage	Cen		
5	Haarlemmerbuurt	Cen		
6	Jordaan	Cen		
7	De Weteringschans	Centrum	2014	344649.0
8	Weesperbuurt/Plantage	Centrum	2014	307440.0
9	Oostelijke Eilanden/Kadijken	Centrum	2014	253990.0
10	Westelijk Havengebied	Westpoort	2014	NaN

id_vars: what are the cases?

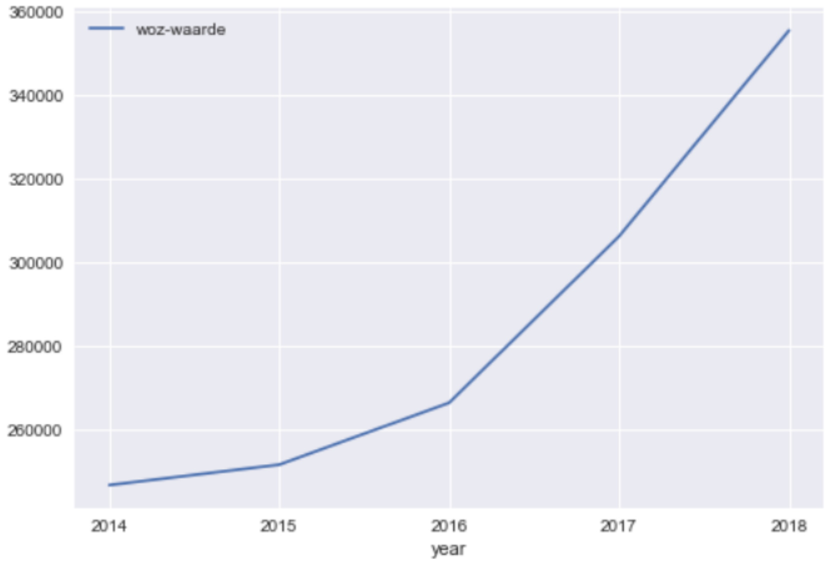
value_vars: which vars contain the values?

And now?

- Let's think about a strategy for `.groupby().agg()`: What should we group by and how do we need to aggregate?
- Group by:
  1. Group only by year
  2. Group by year and 'stadsdeel'
- Aggregation function
  1. `mean`
  2. Possibly also `min`, `max`, or even `lambda x: max(x)-min(x)`

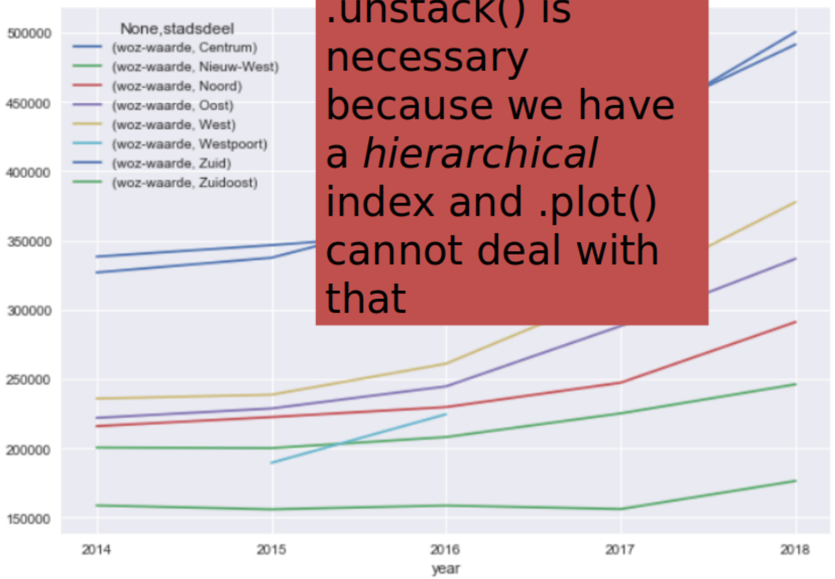
```
wijken_long.groupby('year').agg(np.mean).plot(xticks=[0,1,2,3,4])
```

<matplotlib.axes._subplots.AxesSubplot at 0x1191a4128>



```
wijken_long.groupby(['year','stadsdeel']).agg(np.mean).unstack().plot(
    figsize=[10,7], xticks=range(5))
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x1196ad7f0>
```



.unstack() is necessary because we have a *hierarchical* index and .plot() cannot deal with that

What's unstacking?

```
wijken_long.groupby(['year','stadsdeel']).agg(np.mean)
```

		woz-waarde
year	**stadsdeel**	
2014	**Centrum**	326814.100000
	Nieuw-West	200453.500000
	Noord	215879.500000
	Oost	221828.142857
	West	2358
	Westpoort	NaN
	Zuid	3382
	Zuidoost	1586
2015	**Centrum**	3374
	Nieuw-West	2000
	Noord	2224
	Oost	228636.000000

-> Turn hierararchical indices into non-hierarchical structure

```
wijken_long.groupby(['year','stadsdeel']).agg(np.mean).unstack()
```

	woz-waarde						
stadsdeel	**Centrum**	**Nieuw-West**	**Noord**	**Oost**	**West**	**Westpoort**	**Zuid**
year							
2014	326814.1	200453.500000	215879.500000	221828.142857	235801.0	NaN	3382
2015	337425.5	200028.000000	222417.200000	228636.000000	238568.8	189402.0	3465
2016	370176.0	208002.428571	229650.466667	244608.428571	260979.4	224491.0	3559

There are example datasets and notebooks on Canvas!

Find an exercise here: `https://github.com/annekroon/bdaca/blob/master/ipynb/basic_statistics.ipynb` or on Canvas (under 'modules')

Next steps

Thursday: Final lecture

You are now able to read and write Python code. Therefore, we can now introduce some advanced analysis topics, mainly machine learning.

Monday 20/ 05

Not mandatory: In case you need (individual) consultation regarding final project.