Version 1.6

HOCHSCHULE HEILBRONN

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A Jump Start for Beginners

Content

1 Installation

Step 1.

Download Anaconda.

ANACONDA

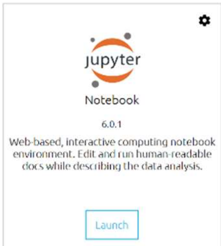
Download link:

- Anaconda:

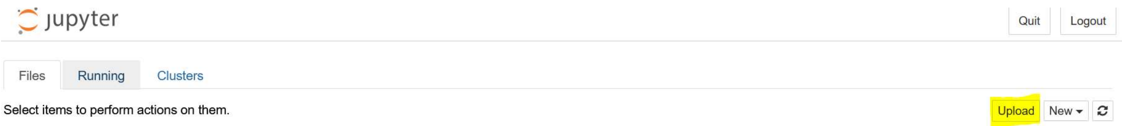
  https://www.anaconda.com/products/individual

Step 2.

- Open Anaconda and launch Jupyter notebook:



- Upload *install_python.ipynb* to JupyterNotebook:



- Open the file *install_python.ipynb* within JupyterNotebook by hitting:

- Execute *install_python.ipynb* within JupyterNotebook by hitting:

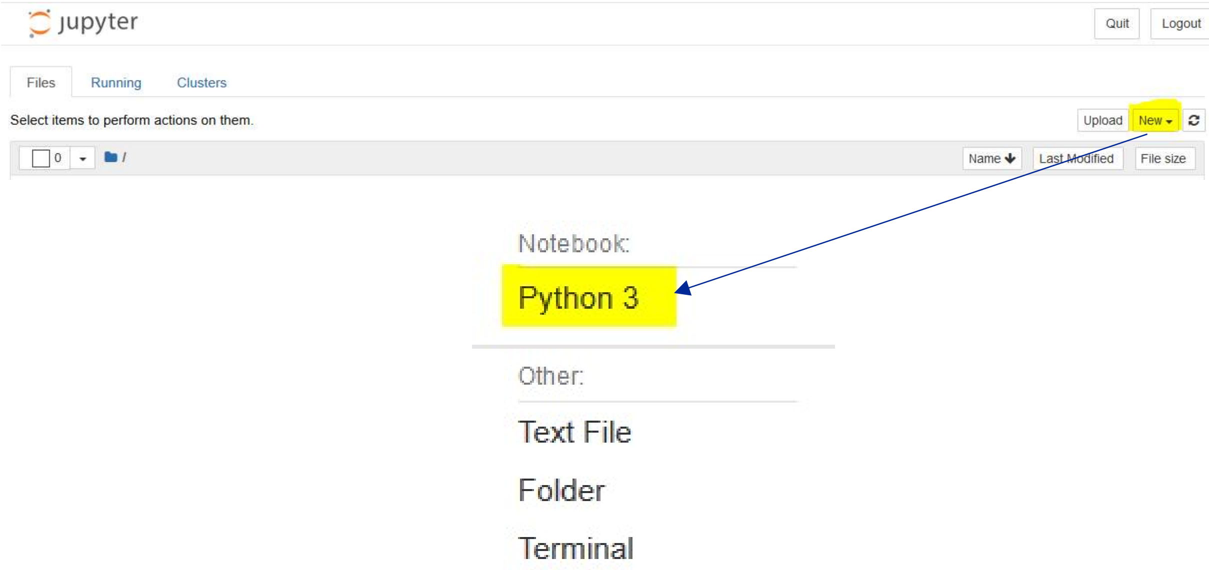
Important remark:

Whenever you start a new notebook, you have to copy the following in the first cell:

```
import httpimport
url='https://raw.githubusercontent.com/ProfKauf/Modules/main/'
with httpimport.remote_repo(url):
    import profK_libraries, profK_statistics
from profK_libraries import *
from profK_statistics import *
```

2 Hello World

Step 1. Create a new python notebook:



Step 2. Create a new cell by the "+" button in the toolbar

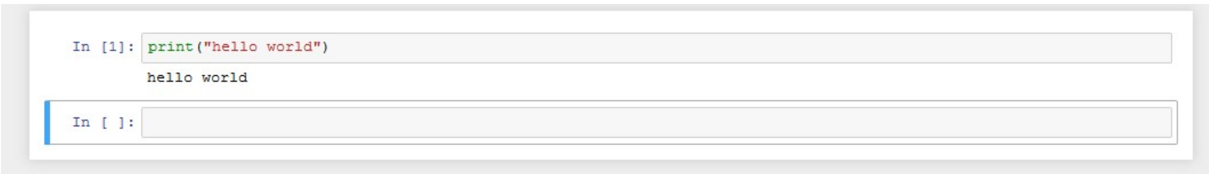
Step 3. Now, the time has come to say hello to the world:

Type

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

and hit 

Result:



Important Information!

If you leave ANACONDA and open your notebook sometime later, you need to rerun the entire notebook: 

3 First Steps with Data

3.1 Code Description

You are supposed to comment and structure your coding by using markdown cells. In order to switch a coding cell into a comment cell hit “cell”:

Then hit “cell type” and pick “markdown cell”.

There are some styling options, for instance:

- Headlines:
  - Headline 1: $\# \; markdown$
  - Headline 2: $\#\# \; markdown$
  - …
- Colored markdown:

$$< div\ class = "alert\ alert - block\ alert - info" > \\ < b > markdown\ colored < /b >$$

Try these commands. You should get the following result:

Please follow the link below to learn more about the options:

https://jupyter-notebook.readthedocs.io/en/stable/examples/Notebook/Working%20With%20Markdown%20Cells.html

3.2 Loading Data

Data is usually stored in an excel or csv file. In order to work with data in your notebook, you need to load it via the following command:

```
data = pd.read_excel (r'path/to/file/file_name.xlsx')
```

Hint 1. The code above is for files in .xlsx format. If you want to load csv files, replace `_excel` by `_csv`

Hint 2. Before you use a .csv file, check if it is separated by commas. If it is separated by, e.g., semicolons, you need to tell python that, see:

https://pandas.pydata.org/docs/reference/api/pandas.read_csv.html

Hint 3. In Anaconda, you may upload your file via

Then, you can omit the path/to/file

3.3 Exercises

Preliminaries

- Open a new notebook
- Copy the preamble in the first cell (see Section 0)
- Load the file YoungPeopleSurvey.xlsx (see previous Section)

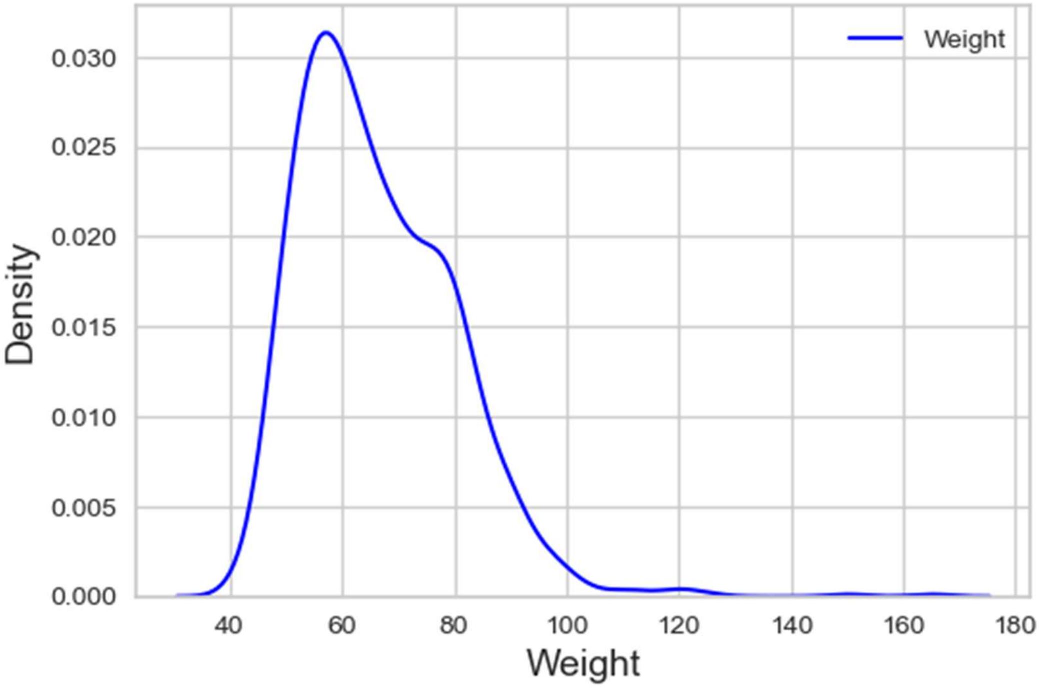
Exercises

The following exercises help you to develop a basic understanding of Python. Notice that the data frame was named data. You may name the data frame differently and adjust the code accordingly.

Exercise 1. Distribution plot.

- Create a new cell. Create a distribution plot of weight:

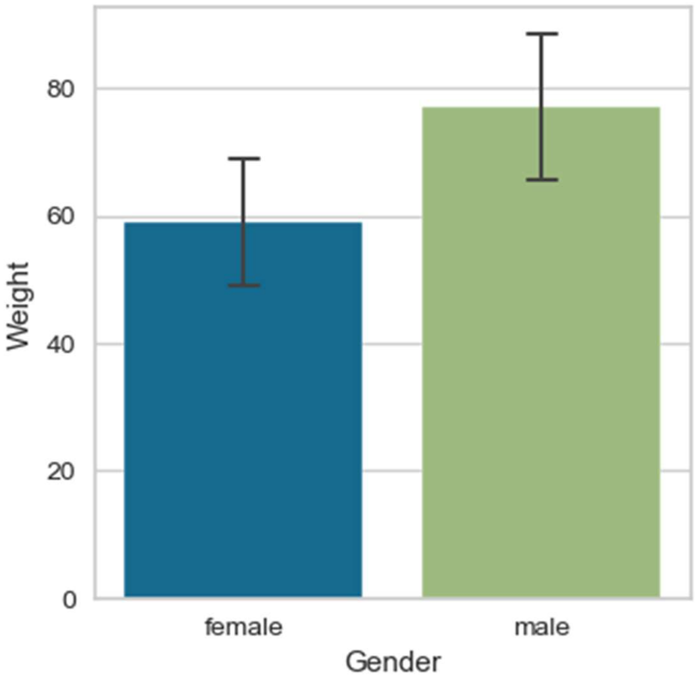
```
plots.dist(data['Weight'],fig=[6,4],labelsize=14,ticksize=10,legsize=10,lin
ewidth=1.5)
```



Exercise 2. Barplot with error bars that shows the mean weight for male and female.

- Create a new cell. Create the barplot as follows:

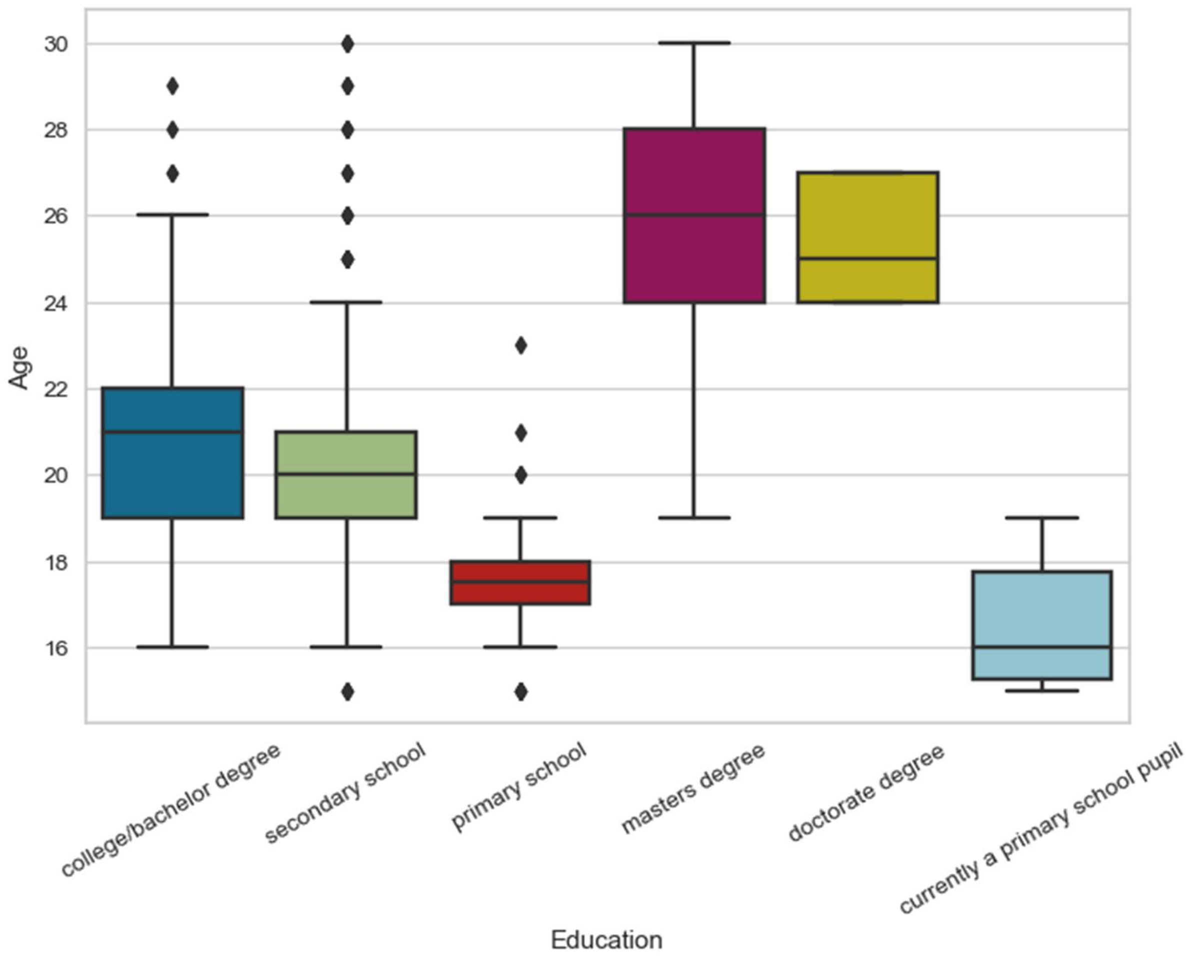
```
plt.figure(figsize=(4,4))
sns.barplot(x='Gender',y='Weight',data=data,ci='sd',capsize=.1,errwidth=1.5
)
```



Exercise 3. Boxplot with quartiles of age for educational levels.

- Create a new cell. Create the boxplot as follows:

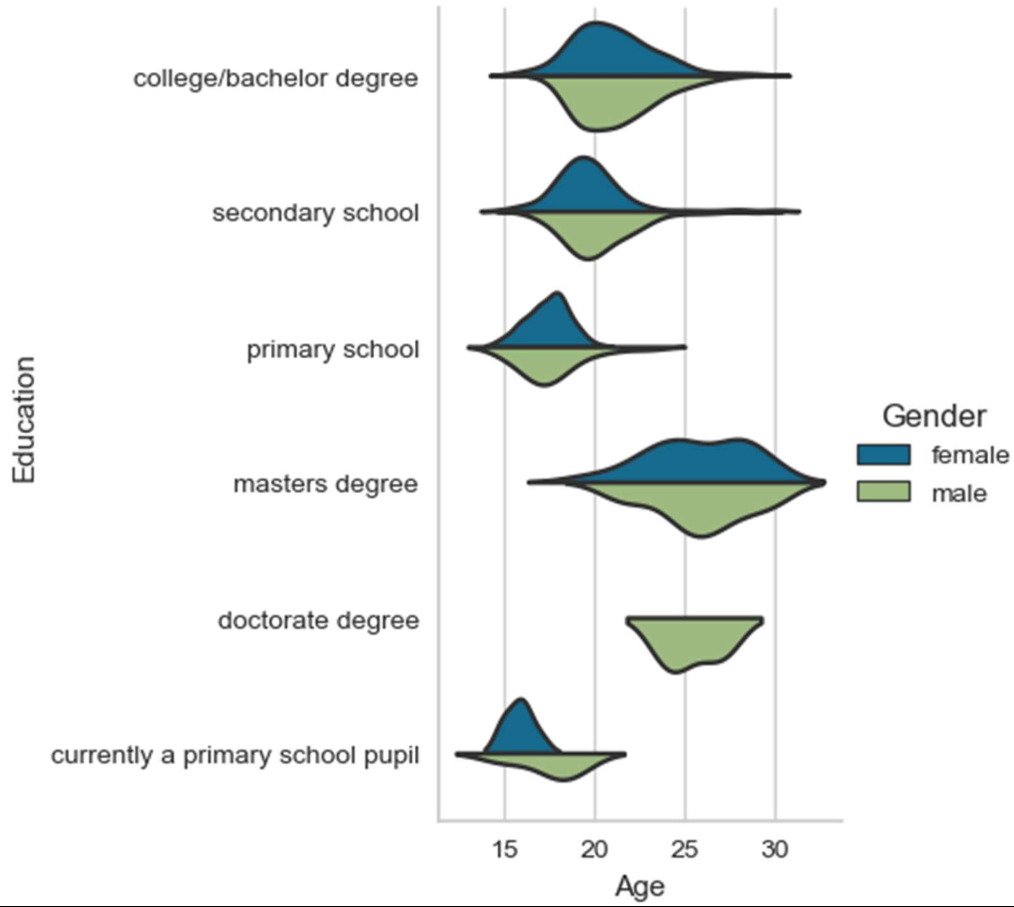
```
sns.boxplot(x='Education',y='Age',data=data)
plt.xticks(rotation=30)
```



Exercise 4. Violin plot with with age for educational levels and gender.

- Create a new cell. Create the violin plot as follows:

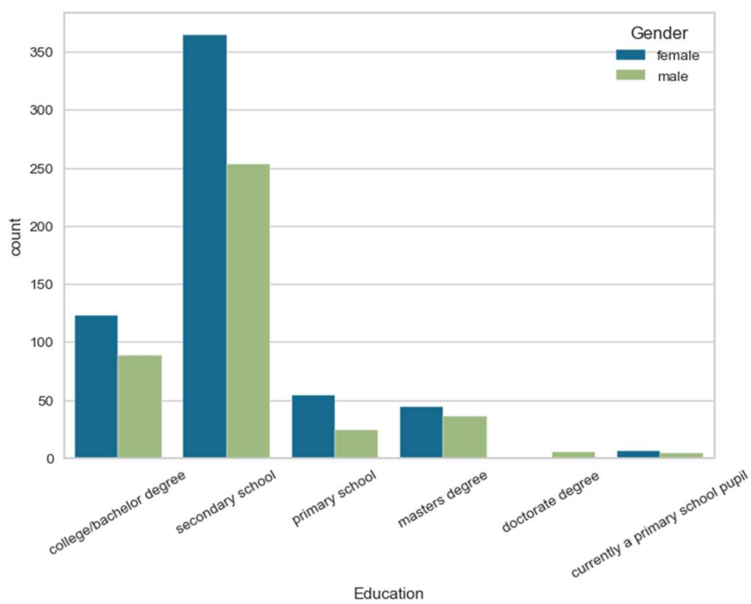
```
sns.catplot(data=data, y="Education", x="Age", hue='Gender',
kind="violin",inner=None, split=True)
```



Exercise 5. Countplot for educational level and gender.

- Create a new cell. Create the countplot as follows:

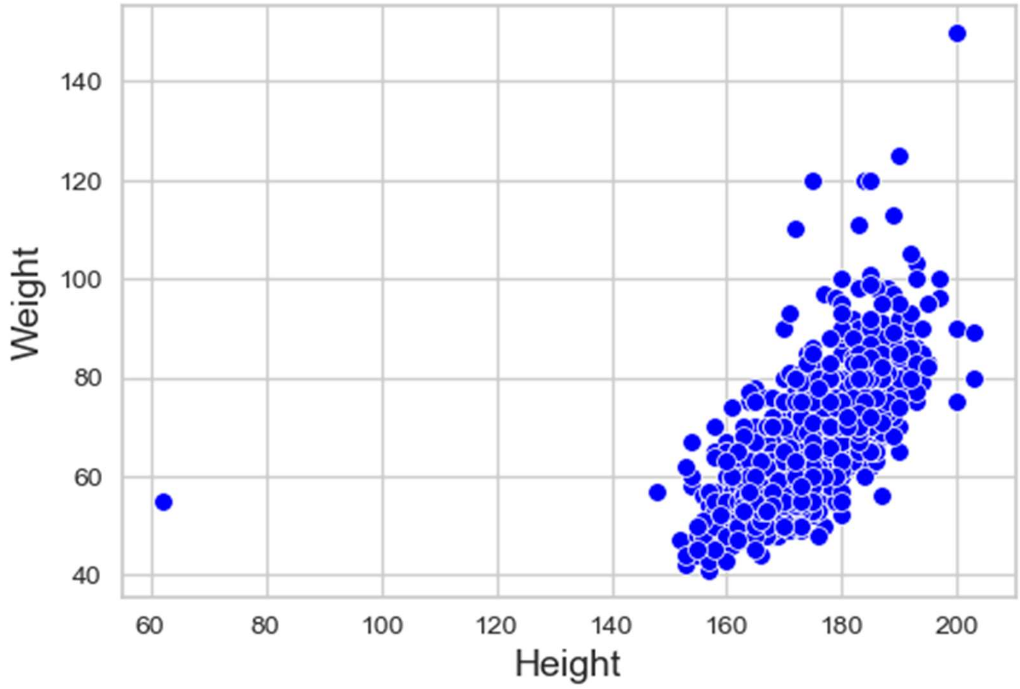
```
sns.countplot(data=data, x='Education',hue='Gender')
plt.xticks(rotation=30)
```



Exercise 6. Scatterplot age vs. height.

- Create a new cell. Create the scatterplot as follows:

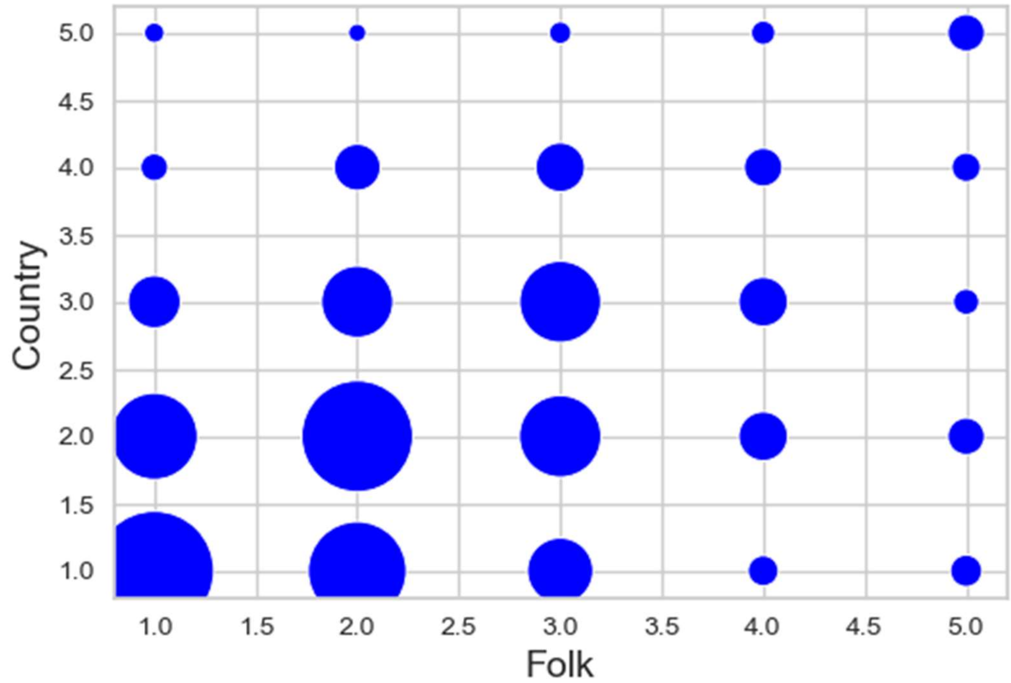
```
plots.scatter(data['Height'],data['Weight'],fig=[6,4],ticksize=10,labelsize=14,dotsize=50)
```



Exercise 7. Bubbleplot Folk vs. Country.

- Create a new cell. Create the bubbleplot as follows:

```
plots.scatter(data['Folk'],data['Country'],fig=[6,4],ticksize=10,labelsize=14,ordinal=True)
```



Exercise 8. Encode Variable Education.

- Have a look at the unique values of the variable:

```
data['Education'].unique()
```

```
array(['college/bachelor degree', 'secondary school', 'primary school',
       'masters degree', 'doctorate degree',
       'currently a primary school pupil', nan], dtype=object)
```

- Define encoder where the values are set in ascending order:

```
enc=dataprep.encoder(order={'Education':['currently a primary school
pupil','primary school','secondary school','college/bachelor
degree','masters degree','doctorate degree']})
```

- Encode the variable:

```
data_encoded=enc.fit_transform(data)
```

- Have a look at the unique values of the encoded variable:

```
data_encoded['Education'].unique()
```

```
array([ 3.,  2.,  1.,  4.,  5.,  0., nan])
```

Exercise 9. Dropping columns.

- Create a new data set that contains only the variables Education, Age and Gender.

```
data_new=data[['Education','Age','Gender']]
```

Exercise 10. Dropping rows I.

- Create a new data set that contains only people who are over 25:

```
data_over25=data[data['Age']>25]
```

- Have a look at the data shapes:

```
print(data.shape)
print(data_over25.shape)
```

```
(1010, 150)
(67, 150)
```

Exercise 11. Dropping rows II.

- Create a new data set that contains only people who hold a masters or doctorate degree.

- Method 1:

```
data_educated=data[(data['Education']=='masters degree') &
(data['Education']=='doctorate degree')]
```

- Method 2:

```
indices=data[(data['Education'].isin(['masters degree','doctorate degree']))].index
data_educated=data.loc[indices]
```

Exercise 12. Create a new column that contains the body mass index (bmi).

$$bmi = \frac{weight}{height\ (in\ m)^2}$$

```
data['bmi']=data['Weight']/(data['Height']/100)**2
```

4 The profK_statistics.py Module

In this section, we use the following abbreviations for types of input objects:

Abbreviation	Meaning
var	Variable
str	String
bool	Boolean Expression (True or False)
int	Integer number (1,2,3,4,…)

In the following, a "grouping variable" refers to a variable that groups your data set in categories.

4.1 Class describe

4.1.1 Summary

```
Class describe
--------------
.data
.contingency
.cormat
```

4.1.2 describe.data

Example:

```
description=describe.data(data=data2[['married','age']],nominal=['married'])
description.table(show='nominal')
```

	married
count	28885
mode	yes
categories	2
least freq	no(37.60%)
most freq	yes(62.40%)

Code Structure:

```
arguments
---------
- data = name of dataframe (var)
- ordinal = list of ordinal variables ([str,str,...])
- nominal = list of nominal variables ([str,str,...])
returns
-------
.table(show) -> descriptive statistics (pd.DataFrame)
    arguments
    ---------
    - show = statistics for which variables ('numeric','ordinal','nominal') (str)
[default='numeric']
```

4.1.3 describe.contingency

Example:

```
describe.contingency(data2['married'],data2['house_own'],show='observed')
```

house_own	no	yes
married		
no	5710	5150
yes	3540	14485

Code Structure:

```
arguments
---------
- x,y = vector of the variables (pd.Series)
- show = what to show ('observed','expected','deviations') (str)
[default='observed']
- decimals = decimal places for percentage deviations (int)
returns
-------
observed or expected frequencies or their deviation
```

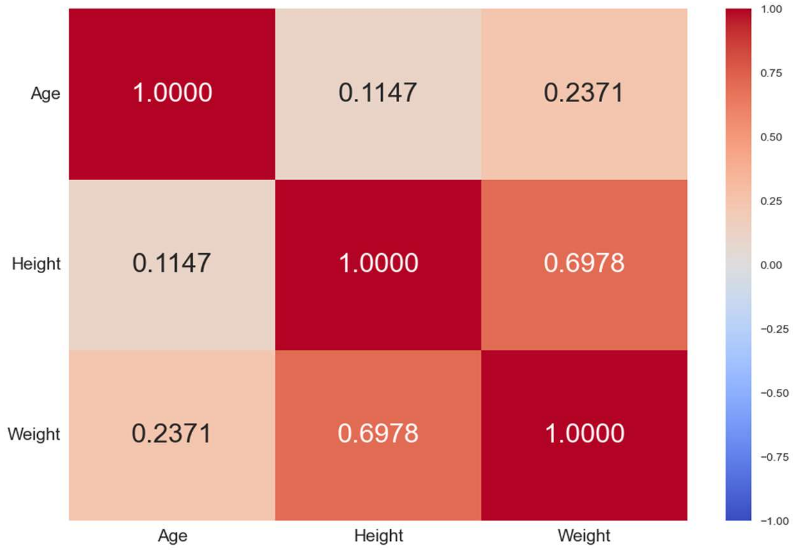
4.1.4 describe.corrmat

Examples:

```
cm=describe.corrmat(data=data_pair2)
cm.table
```

	Age	Height	Weight
Age	1.000000	0.114687	0.237084
Height	0.114687	1.000000	0.697786
Weight	0.237084	0.697786	1.000000

```
cm.heatmap()
```




```
data_pair2=data_pair2.dropna()
cm=describe.corrmat(data=data_pair2,utri=False,stars=True)
```

	Age	Height	Weight
Age		***	****
Height	0.1147***		****
Weight	0.2371****	0.6978****	

Code Structure:

```
arguments
---------
- data = name of dataframe (var)
- nominal,ordinal = list of names of nominal,ordinal variables ([str,str,...])
- ordvsord = correlation coefficient for ordinal vs ordinal/numerical
('spearman','kendall','gk_gamma') (str) [default = 'spearman']
- nomvsnom = correlation coefficient for nominal vs nominal/ordinal ('cramer')
(str)
- numvsnom = correlation coeffient for numerical vs nominal ('eta','pbc') (str)
[default = 'eta']
- stars = do you want to flag significant correlations with stars (bool) [default
= False]
- padjust = method to correct for multiple testing
('none','bonf','sidak','holm','fdr_bh','fdr_by') (str) [default='bonf']
- utri = do you want to show the upper triangle of the matrix (bool) [default =
True]
- ltri = do you want to show the upper triangle of the matrix (bool) [default =
True]
- fill = how to fill the empty spaces if upper/lower triangle is masked (str)
[default = '']
- decimals = how many decimal places to show in case a triangle is masked or stars
is True (int) [default = 4]
- percent = display the correlations as percentages (bool) [default = False]
- force_biserial = always use rank-biserial resp. point-biserial coefficent when
ordinal/numerical vs binary nominal (bool) [default = True]
```

```
returns
-------
.table -> correlation matrix (pd.DataFrame)
.def
heatmap(self,cmap='coolwarm',roty=0,rotx=0,lsize=15,tsize=20,annot=True,fsize=70,f
ig=[12,8],down=0): -> matrix as heatmap
    arguments
    ---------
    - cmap = palette for heatmap (str) [default = 'coolwarm']
    - rotx, roty = rotate x or y labels (int) [default: rotx, roty = 0, 0]
    - lsize = labelsize (int) [default = 15]
    - tsize = ticksize (int) [default = 20]
    - annot = show numbers in cells (bool) [default = True]
    - fsize = fontsize in cells (int) [default = 70]
    - fig = size of figure ([int,int]) [default = [12,8]]
    - down = shift the caption down only relevant when stars = True (dec) [default
= 0]
```

4.2 Class dataprep

Examples:

- Separate a data set, e.g., married from not married people:

```
groups=dataprep.group_sep(data=data2[['married','age','income']],groupvar='
married')

groups[0].head()
```

	married	age	income
0	no	75	67195.781504
1	no	75	57014.602488
2	no	75	51924.012980
3	no	75	41742.833964
4	no	75	50905.895078

```
groups[1].head()
```

	married	age	income
5	yes	50	38688.480260
6	yes	50	37670.362358
7	yes	50	38688.480260
8	yes	50	38688.480260
9	yes	50	38688.480260

- One-hot-/Dummy-Encoding of data, e.g., ethnicity.

Original data:

	ethnicity	income
0	white	67195.781504
1	white	57014.602488
2	white	51924.012980
3	white	41742.833964
4	white	50905.895078

One-hot-Encoding:

```
enc=dataprep.onehot(cats=['ethnicity'])
data_encoded=enc.fit_transform(data2[['ethnicity','income']])
```

Encoded Data:

	dummy__ethnicity_hispanic	dummy__ethnicity_other	dummy__ethnicity_white	income
0	0.0	0.0	1.0	67195.781504
1	0.0	0.0	1.0	57014.602488
2	0.0	0.0	1.0	51924.012980
3	0.0	0.0	1.0	41742.833964
4	0.0	0.0	1.0	50905.895078

- Standard encoding of an ordinal variable, e.g., happiness:

Original data:

	happy_study_program	income	year	level
0	very unhappy	1100.0	2023	Bachelor
1	happy	650.0	2023	Bachelor
2	unhappy	1000.0	2023	Bachelor
3	so,so	500.0	2023	Bachelor
4	unhappy	1000.0	2023	Bachelor

Standard encoding:

```
enc=dataprep.encoder(order={'happy_study_program':['very
unhappy','unhappy','so,so','happy', 'very happy']})
data_encoded=enc.fit_transform(data)
```

Encoded data:

	happy_study_program	income	year	level
0	0.0	1100.0	2023	Bachelor
1	3.0	650.0	2023	Bachelor
2	1.0	1000.0	2023	Bachelor
3	2.0	500.0	2023	Bachelor
4	1.0	1000.0	2023	Bachelor

Remark: in case of nominal variables, the order can be omitted.

Code Structure:

```
.group_sep
    arguments
    ---------
    - data = name of dataframe (var)
    - groupvar = name of the grouping variable (str)
    returns
    -------
    list of groupwise dataframes (list of pd.DataFrame)
.nan
    arguments
    ---------
    - data = name of dataframe (var)
    - cols = list of column names that should be examined ([str,str,...])
    returns
    -------
    .analysis -> summary table for the analysis of nans (pd.DataFrame)
    .drop -> a dataframe where nans are removed (pd.DataFrame)
.onehot
    arguments
    ---------
    - drop = string that indicates which dummies should be dropped, can be set to
None (str) [defaul='first']
    returns
    -------
    .fit(X,y)
    .transform(X,y,sparse) -> a dataframe where nans are removed (pd.DataFrame)
        arguments
        ---------
        - X = a dataframe (pd.DataFrame)
        - y = target variable (pd.Series) [optional, default = None]
        - sparse = whether output should be returned in sparse format (bool)
[default=False]
.encoder
    arguments
    ---------
    - cols = nominal columns to encoder [default=None]
    - order = a dictionary of the format {colname:order of categories} to encode
ordinal variables [default=None]
    if cols and order are both none the encoder treats all columns with strings as
nominal variables
```

```
    returns
    -------
    .transform(data,sparse) -> an encoded dataframe
        arguments
        ---------
        - data = a dataframe (pd.DataFrame) or a vector (pd.Series)
        - sparse = whether output should be returned in sparse format (bool)
[default=False]
```

4.3 Class plots

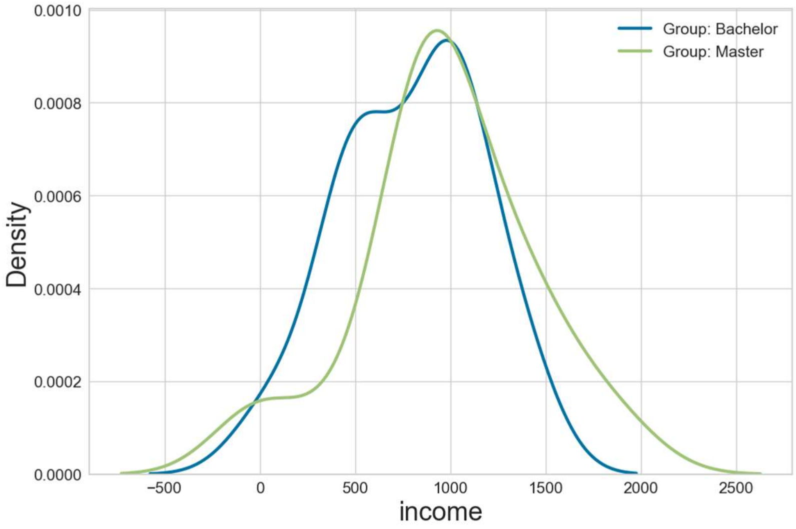
4.3.1 Summary

```
Class plots
--------------
.dist
.qq
.scatter
.scatter3d
.outlier
```

4.3.2 plots.dist

Example:

```
plots.dist(data,var='income',groupvar='level',fig=[12,8],ticksize=15,
       labelsize=25,legsize=15,dark=False,linewidth=3,lineclr='blue',xlabel=None,s
       harediagram=True)
```



Code Structure:

```
arguments
---------
- data = either name of dataframe (var) or vector (pd.Series)
- var, groupvar = name of variable and grouping variable (str) -> only relevant
when data is name of a dataframe
- fig = figure size ([int,int]) [default=[12,8]]
- ticksize = size of ticks (int) [default=15]
```

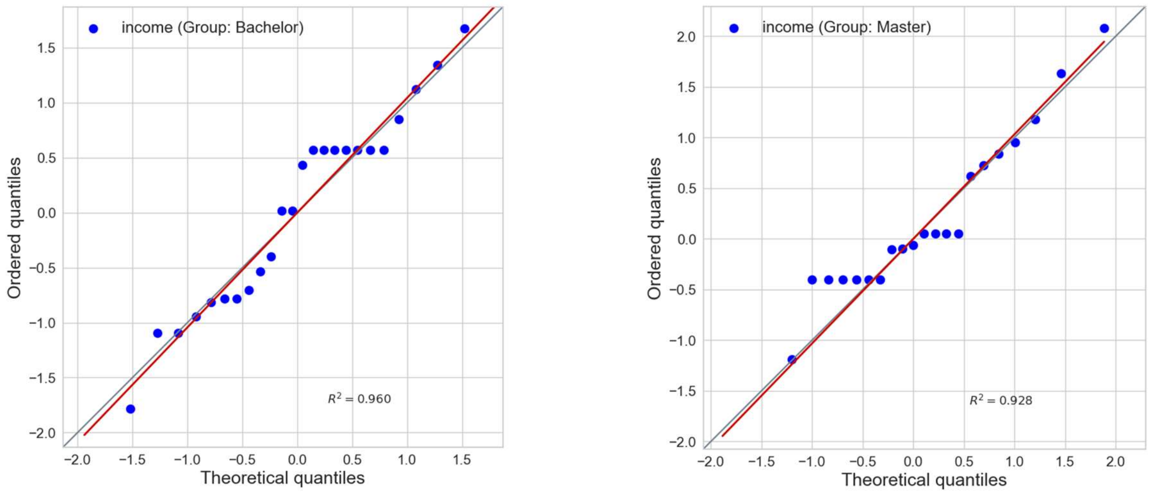
```
- labelsize = size of labels (int) [default=25]
- legsize = size of legend (int) [default=15]
- dark = dark background (bool) [default=False]
- linewidth = line width (int) [default=3]
- lineclr = line color (str) [default='blue']
- xlabel = custom x-axis label (str) [default=None]
- sharediagram = whether plots should be done in the same diagram (bool) [default
= True]

returns
-------
Distribution plot
```

4.3.3 plots.qq

Example:

```
plots.qq(data,var='income',groupvar='level',fig=[12,8],ticksize=14,labelsize=18,le
gsize=16,dark=False,rotx=0,roty=90,dotsize=80,confidence=False)
```



Code Structure:

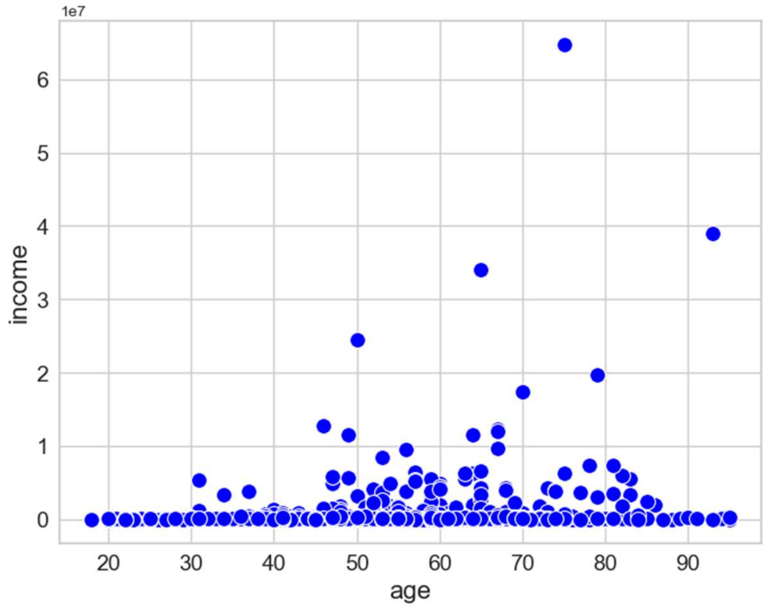
```
arguments
---------
- data = either name of dataframe (var) or vector (pd.Series)
- var, groupvar = name of variable and grouping variable (str) -> only relevant
when data is name of a dataframe
- fig = figure size ([int,int]) [default=[12,8]]
- ticksize = size of ticks (int) [default=15]
- labelsize = size of labels (int) [default = 18]
- legsize = size of legend [default = 16]
- dark = dark background? (bool) [default = False]
- rotx, roty = rotate x and y (int between 0 and 360) [default: rotx=0, roty=90]
- dotsize = size of dots (int) [default = 80]
- confidence = whether to plot a confidence interval (dec between 0 and 1)
[default = False]

returns
-------
QQ Plot
```

4.3.4 plots.scatter

Example:

```
plots.scatter(data3['age'],data3['income'],data=None,fig=[8,6],ticksize=14,labelsize=16,dark=False,dotsize=100,dotclr=['blue'],hue=None,hueclr='tab10',hue_norm=None, namexy=[],rotx=0,roty=90, ordinal=False,bubsize=(20, 2000), regression=None, linewidth=2, lineclr='red', poly_deg=3,legend=False,legendfont=12, legendcol=1, legendspaceh=3, legendspacev=2,intext=False,pos=[0,0],txtclr='red',txtsize=12)
```



Code Structure:

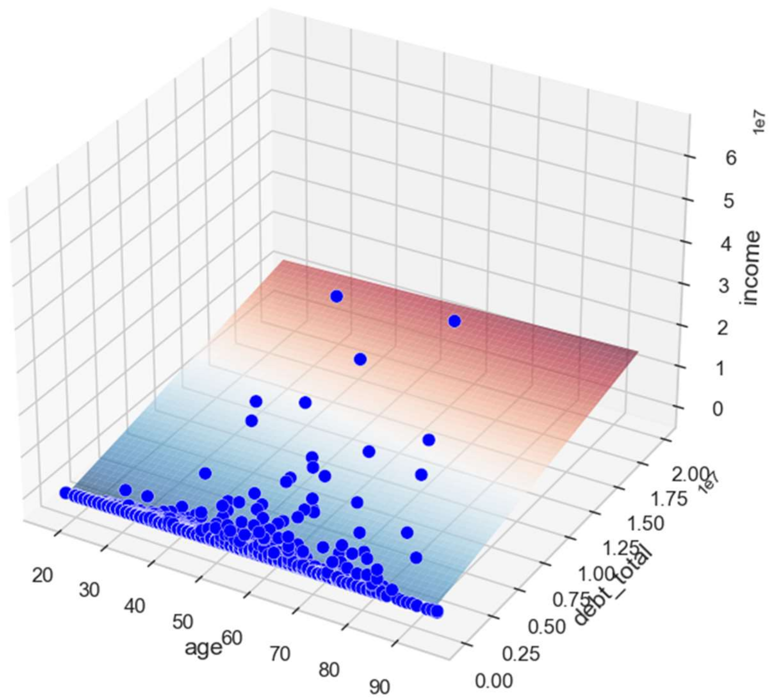
```
arguments
---------
- data = name of dataframe (var)
- x,y = names of variables (str)
- fig = figure size ([int,int]) [default = [8,6]]
- ticksize = size of ticks (int) [default = 14]
- labelsize = size of labels (int) [default = 16]
- dark = dark background? (bool) [default = False]
- dotsize = size of dots (int) [default = 100]
- dotclr = color of dots (str) [default = ['blue']]
- hue = name of third variable whose values are used to color the dots (str)
[default = None]
- hueclr = palette for colors of hue variable (str) [default = 'tab10']
- namexy = names of variables (list) [default = None]
- rotx, roty = rotate x and y (int between 0 and 360) [default: rotx=0, roty=90]
- ordinal = enable bubble plot (bool) [default = False]
- bubsize = size of dots in bubble plot ((int,int)) [default = (20,2000)]
- regression = plot a regression ('linear','logistic','poly') (str) [default =
False]
- linewidth = width of regression line (int) [default = 2]
- lineclr = color of regression line (str) [default = 'red']
- poly_deg = polynomial degrees only relevant if regression = 'poly' (int)
[default = 3]
- legend = enable legend (bool) [default = False]
- legendfont = size of legend (int) [default = 12]
- legendcol = number of legend cols (int) [default = 1]
```

```
- legendspaceh = horizontal space between legend items (int) [default = 3]
- legendspacev = vertical space between legend items (int) [default = 2]
- intext = whether to plot the regression description inside plot (bool) [default
= False]
- pos = position of intext [x,y] ([int,int]) [default = [0,0]]
- txtclr = color of intext (str) [default = 'red']
- txtsize = size of intext [default = 12]
returns
-------
Scatter Plot
```

4.3.5 plots.scatter3d

Example:

```
plots.scatter3d(data3[['age','debt_total']],data3['income'],fig=[12,8],ticksize=12
,labelsize=14,dotsize=60,dotclr='blue',
linreg=True,regpal=plt.cm.RdBu_r,regclr='red',intext=False,pos=[0,0,60],
txtclr='red',txtsize=10)
```



Code Structure:

```
arguments
---------
- X = feature matrix with 2 variables (pd.DataFrame)
- y = dependent variable (pd.Series)
- fig = figure size ([int,int]) [default = [8,6]]
- ticksize = size of ticks (int) [default = 14]
- labelsize = size of labels (int) [default = 16]
- dotsize = size of dots (int) [default = 60]
- dotclr = color of dots (str) [default = 'blue']
- linreg = whether to plot regression plane (bool) [default = True]
```

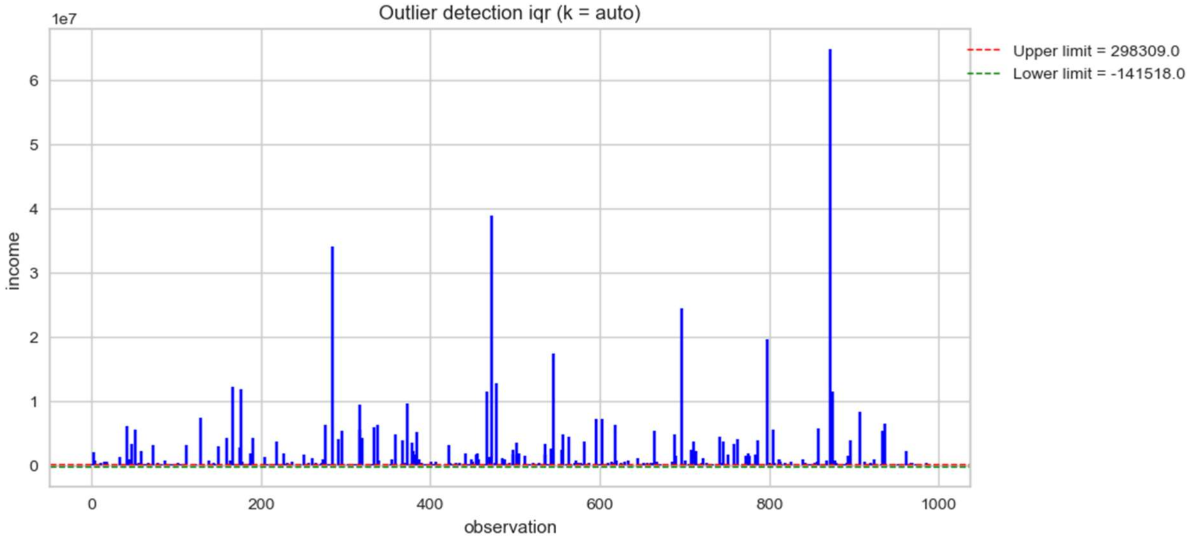
```
- regpal = palette for regression plane, can be None (obj) [default =
plt.cm.RdBu_r]
- regclr = color of regression plan used only if regpal=None (str) [default =
'red']
- intext = whether to plot the regression description inside plot (bool) [default
= False]
- pos = position of intext [x,y] ([int,int]) [default = [0,0]]
- txtclr = color of intext (str) [default = 'red']
- txtsize = size of intext [default = 12]
returns
-------
3D Scatter Plot
```

4.3.6 plots.outlier

Examples:

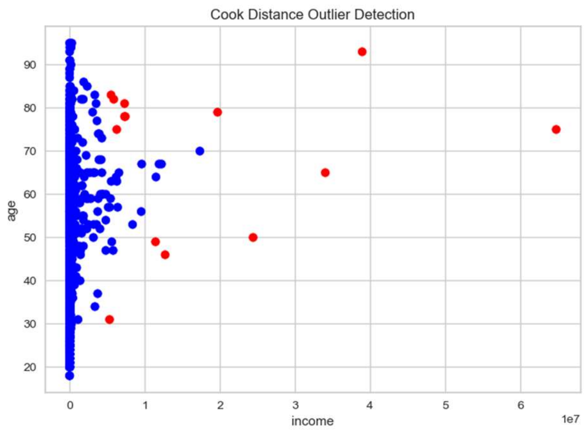
- Visualize potential univariate outliers, e.g., for age:

```
plots.outlier(data3['income'],k='auto',method='iqr',limround=0,dtype='univariate')
```

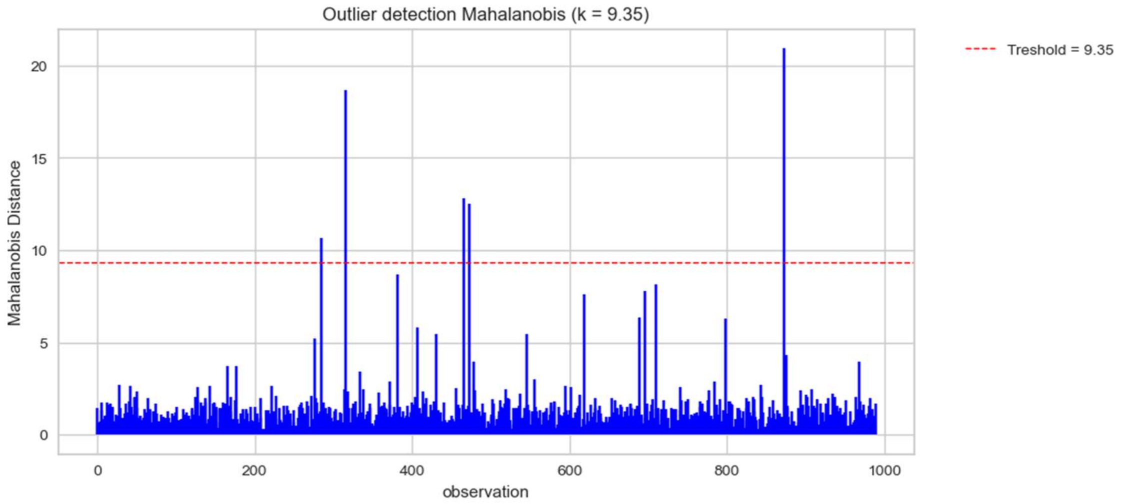


- Visualize potential bivariate outliers, e.g., for age+income:

```
plots.outlier(data3[['income']],data3['age'],k='auto',method='Cook',limround=0,dtype='bivariate')
```



- Visualize potential multivariate outliers, e.g., for age+income+debt:



Code Structure:

```
arguments
---------
- x = either feature matrix with variables (pd.DataFrame) or variable (pd.Series)
- y = dependent variable (pd.Series) or None if univariate
- k = outlier detection factor either 'auto' (str) or a dictionary containing
methods and factors (dic) [default='auto']
- method = outlier detection method ('iqr','zscore','mad','Cook','Mahalanobis')
(str) [default = iqr]
- limround = decimal places to round tresholds (int) [default = 0]
- dtype = data type ('univariate','bivariate','multivariate') (str) [default =
'univariate']
returns
-------
uni- and multivariate return a observation vs distance/values plot with tresholds
bivariate returns a scatterplot where outliers are flagged red
```

4.4 Class tests

4.4.1 Summary

```
Class tests
------------
.t
.nonparametric
.independence
.correlation
.association
.equal_var
```

tests.t

Examples:

- One-sample t-test:

```
tests.t.one_sample(data=data3,var='income',nullmean=600).round(4)
```

	var	mean	null mean	t	dof	alternative	p-val	CI95%	cohen-d	BF10	power
One-Sample t-Test	income	674574.7795	600	6.7	988	two-sided	0.0	[477173.42, 871976.14]	0.213	1.146e+08	1.0

- Two-sample t-test:

```
tests.t.two_sample(data=data3,var='income',groupvar='gender').round(4)
```

	var	group	mean	variances	t	dof	alternative	p-val	CI95%	cohen-d	BF10	power
Two-Sample	income	female	67440.0837	equal	-3.2533	987.0000	two-sided	0.0012	[-1253444.17, -310243.89]	0.2483	14.809	0.9015
t-Test		male	849284.1126	unequal	-6.0454	778.8207		0.0000	[-1035718.7, -527969.35]	0.2483	3.821e+06	0.9015

- Paired t-Test

```
tests.t.paired(data_time['income 2019'],data_time['income 2020']).round(4)
```

	var	mean diff	correlation	t	dof	alternative	p-val	CI95%	cohen-d	BF10	power
Paired Sample t-Test	income 2019-income 2020	-227248.599	-0.0482	-0.983	199	two-sided	0.3268	[-683122.89, 228625.7]	0.1003	0.127	0.292

Code Structure:

```
Class t
------------
.one_sample
    arguments
    ---------
    - data = name of dataframe (var)
    - var = name of the variable in the dataframe (str)
    - nullmean = mean under null hypothesis (int)
    - alternative = direction of the test ('two-sided', 'left', 'right') (str)
    returns
    -------
    table of one-sample t-test (pd.DataFrame)
.two_sample
    arguments
    ---------
    - data = name of dataframe (var)
    - var = name of the variable in the dataframe (str)
    - groupvar = name of the grouping variable (str)
    - alternative = direction of the test ('two-sided', 'left', 'right') (str)
    returns
    -------
    table of two-sample t-test (pd.DataFrame)
.paired
    arguments
    ---------
```

```
    - data = name of dataframe (var) [optional]
    - var1, var2 = names of the variables in the dataframe (str) or vectors
(pd.Series) if data is None
    - alternative = direction of the test ('two-sided', 'left', 'right') (str)
    returns
    -------
    table of paired t-test (pd.DataFrame)

Remarks:
-------
- Missing values are automatically removed from the data.
```

4.4.2 tests.nonparametric

Examples:

- Sign test:

```
tests.nonparametric.sign(data=data3,var='income',nullmedian=60000).round(4)
```

	var	median	null median	n(-)	n(+)	n	M	alternative	p-val
Sign Test	income	78395.0784	60000	402	587	989	92.5	two-sided	0.0

- Mann-Whitney U test:

```
tests.nonparametric.mwu(data=data3,var='income',groupvar='gender').round(4)
```

	var	groups	n	median	U-val	alternative	p-val	RBC	CLES
Mann–Whitney U test	income	female/male	221/768	38688.48026/100793.67226	39015.5	two-sided	0.0	0.5403	0.2299

- Wilcoxon test:

```
tests.nonparametric.wilcoxon(data_time['income 2019'],data_time['income
2020']).round(4)
```

	var	n	median	ranksum (+)	ranksum (-)	W-val	alternative	p-val	RBC	CLES
Wilcoxon signed-rank Test	income 2019-income 2020	200	85012.84478099999/87863.574905	9401.5	10498.5	9401.5	two-sided	0.5005	-0.0551	0.486

Code Structure:

```
Class nonparametric
-------------------
.sign
    arguments
    ---------
    - data = name of dataframe (var or pd.Series)
    - var = name of the variable in the dataframe (str) or None if data =
pd.Series
    - nullmedian = median under null hypothesis (int) [if nullmedian=None ->
nullmedian=median of variable]
```

```
    - alternative = direction of the test ('two-sided', 'left', 'right') (str)
    returns
    -------
    table of one-sample sign test (pd.DataFrame)
.mwu
    arguments
    ---------
    - data = name of dataframe (var)
    - var = name of the variable in the dataframe (str)
    - groupvar = name of the grouping variable (str)
    - alternative = direction of the test ('two-sided', 'left', 'right') (str)
    returns
    -------
    table of Mann-Whitney U test (pd.DataFrame)
.wilcoxon
    arguments
    ---------
    - data = name of dataframe (var) [optional]
    - var1, var2 = names of the variables in the dataframe (str) or vectors
(pd.Series) if data is None
    - alternative = direction of the test ('two-sided', 'left', 'right') (str)
    returns
    -------
    table of Wilcoxon signed-rank test (pd.DataFrame)
```

4.4.3 tests.independence

Examples:

- Chi2 tests:

```
tests.independence.chi2(data=data3,var1='gender',var2='expenses_last12')
```

	vars	no. categories	test	chi2	dof	p-val	cramer	power
Chi2 Tests	gender	2	pearson	12.068362	2.0	0.002395	0.110465	0.885033
of Independence	expenses_last12	3	cressie-read	11.737415	2.0	0.002827	0.108940	0.875730
			G(log-likelihood)	11.182538	2.0	0.003730	0.106334	0.858654
			freeman-tukey	10.846742	2.0	0.004412	0.104725	0.847363
			mod-log-likelihood	10.569450	2.0	0.005068	0.103378	0.837466
			neyman	10.161636	2.0	0.006215	0.101364	0.821920

- Exact tests:

```
tests.independence.exact(data['gender'],data['married']).round(4)
```

	vars	test	statistic	p-val
Exact Tests	gender	fisher	123.8947	0.0
of Independence	married	barnard	20.9032	0.0
		boschloo	0.0000	0.0

Code Structure:

```
Class independence
-------------------
.chi2
    arguments
    ---------
    - data = name of dataframe (var) [optional]
    - var1, var2 = names of the variables in the dataframe (str) or vectors
(pd.Series) if data is None
    - yates = whether to apply the yates correction (bool) [default = False]
    returns
    -------
    table of chi2 independence test (pd.DataFrame)
.exact
    arguments
    ---------
    - data = name of dataframe (var) [optional]
    - var1, var2 = names of the variables in the dataframe (str) or vectors
(pd.Series) if data is None
    returns
    -------
    table of containing Fisher, Barnard, and Boschloo Exact Test (pd.DataFrame)
```

4.4.4 tests.correlation

Examples:

- Simple Correlation with Kendall correlation coefficient:

```
tests.correlation.simple(data['income'],data['age'],method='kendall').round(4)
```

	var1	var2	n	r (kendall)	CI95%	alternative	p-val	power
kendall Test of Correlation	income	age	989	0.1277	[0.07, 0.19]	two-sided	0.0	0.981

- Partial Correlation with Pearson correlation coefficient:

```
tests.correlation.partial(data=data,var1='income',var2='age',covar=['debt_total']).round(4)
```

	var1	var2	covar	n	r (pearson)	CI95%	alternative	p-val
pearson Partial Correation Test	income	age	[debt_total]	989	0.1503	[0.09, 0.21]	two-sided	0.0

Code Structure:

```
Class correlation
-----------------
.simple
    arguments
    ---------
    - data = name of dataframe (var) [optional]
```

```
    - var1, var2 = names of the variables in the dataframe (str) or vectors
(pd.Series) if data is None
    - alternative = direction of the test ('two-sided', 'left', 'right') (str)
    - method = correlation coefficient ('pearson','spearman','kendall') (str)
[default = 'pearson']
    returns
    -------
    table of simple correlation test (pd.DataFrame)
.partial
    arguments
    ---------
    - data = name of dataframe (var)
    - var1,var2 = name of the variable in the dataframe (str)
    - covar = list of names of the covariates ([str,str,...])
    - groupvar = name of the grouping variable (str)
    - method = correlation coefficient ('pearson','spearman','kendall') (str)
[default = 'pearson']
    returns
    -------
    table of partial correlation test (pd.DataFrame)
.pbc
    arguments
    ---------
    - x = vector of the numerical variable (pd.Series)
    - nom = vector of the nominal variable (pd.Series)
    returns
    -------
    (point-biserial correlation coefficient, p-value) (tup)
.rbc
    - x = vector of the ordinal variable (pd.Series)
    - nom = vector of the nominal variable (pd.Series)
    returns
    -------
    (rank-biserial correlation coefficient, p-value) (tup)

.eta
    - x = vector of the numerical variable (pd.Series)
    - nom = vector of the nominal variable (pd.Series)
    returns
    -------
    (eta, p-value) (tup)

.gk_gamma
    arguments
    ---------
    - x,y = vectors of the variables (pd.Series)
    - alternative = direction of the test ('two-sided', 'left', 'right') (str)
    returns
    -------
    (Goodman and Kruskal's gamma, asymptotic pvalue under null, asymptotic pvalue
under alternative,pvalue standard) (tup)
.cramer
    arguments
    ---------
    - x,y = vectors of the variables (pd.Series)
    returns
    -------
    (Cramer's V, p-value) (tup)
```

4.4.5 tests.equal_var

Examples:

- Levene's Test of equal variances:

```
tests.equal_var.levene(data=data,var='income',groupvar='education').round(4)
```

	var	group		f	dof1	dof2	p-val
Levenes Test	income	education	Mean	18.0211	3	985	0.0000
of Equal Variances			Median	7.4110	3	985	0.0001
			Trimmed	118.0536	3	985	0.0000

- Bartlett's Test of equal variances:

```
tests.equal_var.bartlett(data=data,var='income',groupvar='education').round(4)
```

	var	group	T	dof1	dof2	pval
Bartletts Test of Equal Variances	income	education	781.5386	3	985	0.0

Code Structure:

```
Class equal_var
-----------------
.levene
    arguments
    ---------
    - data = name of dataframe (var)
    - var = name of the variable in the dataframe (str)
    - groupvar = name of the grouping variable in the dataframe (str)
    - rem = whether or not to show explanatory remarks (bool) [defaul = False]
    returns
    -------
    table of Levene's test (pd.DataFrame)
.bartlett
    arguments
    ---------
    - data = name of dataframe (var)
    - var = name of the variable in the dataframe (str)
    - groupvar = name of the grouping variable in the dataframe (str)
    returns
    -------
    table of Bartlett test (pd.DataFrame)
```

4.5 Class regression

Examples:

- Multiple linear regression:

```
X=data[['age','social_pension_income']]
y=data['income']
reg=regression(X,y)
reg.coef.round(4)
```

		coef	stand. coef	std err	t	P>|t|	[0.025	0.975]
linear reg.	intercept	-601800.0000	-1.4135	361000.000	-1.665	0.096	-1310000.000	107000.000
coefficients	age	22410.0000	0.7455	7004.086	3.199	0.001	8663.452	36200.000
	social_pension_income	5.8039	0.6680	2.683	2.163	0.031	0.539	11.069

```
reg.datafit.round(4)
```

	dv	dof resid	dof model	R2	adj. R2	omnibus (F)	omnibus (p-val)	LL
linear reg. fit	income	986.0	2.0	0.0277	0.0258	14.0628	0.0	-16191.4723

```
reg.asstest.round(2)
```

	test	statistic	p-val
linear reg.	Jarque-Bera	1816978.14	0.0
assumptions	Breusch-Pagan	7.96	0.0187
	Durbin-Watson	2.06	
	Ramsey RESET	41.56	0.0

- Multiple logistic regression:

```
X=data[['age','income']]
y=data['gender']
reg=regression(X,y,regression='logistic')
reg.coef.round(4)
```

		coef	exp(coef)	std err	z	P>|z|	[0.025	0.975]
logistic reg.	intercept	-1.1406	0.3196	0.269	-4.247	0.000	-1.667	-0.614
coefficients	age	0.0120	1.0121	0.005	2.508	0.012	0.003	0.021
	income	-0.0000	1.0000	0.000	-5.690	0.000	-0.000	-0.000

Code Structure:

```
Class regression
-----------------
arguments
---------
- X = matrix of independent variables (pd.DataFrame)
- y = dependent variable (pd.Series)
- method = type of regression ('linear','logistic','multinomial','ordinal') (str)
[default = 'linear']
- var = name of the variable in the dataframe (str)
returns
-------
.resid -> (pseudo) residuals of the regression
.pred -> predictions of the regression
.datafit -> general information and goodness of fit of the regression
.coef -> table with coefficients
.vif -> variance inflation factors
.asstest -> tests to check assumptions
.summary -> summary of regression analysis
```

4.6 Class outlier

Examples:

- Detecting univariate outliers:

```
out=outlier.univariate(data['income'])
out.analysis
```

	method	pot. outlier	proportion
extreme value analysis	zscore	11	1.11%
	iqr	184	18.6%
	mad	240	24.27%
	E[ND] (>3 std from mean)	2	0.27%

```
out.show(method='zscore')
```

[166, 177, 285, 466, 472, 478, 545, 696, 798, 872, 875]

```
data.loc[out.show(method='zscore')][['income']].head()
```

	income
166	1.224796e+07
177	1.192216e+07
285	3.405604e+07
466	1.145383e+07
472	3.896337e+07

- Detecting multivariate outliers:

```
out=outlier.multivariate(data[['income']],data['debt_total'])
out.analysis
```

	method	pot. outlier	proportion
extreme value	Cook	18	1.82%
analysis	Mahalanobis	9	0.91%

```
out.show(method=' Mahalanobis')
```

```
[285, 316, 382, 466, 472, 618, 696, 710, 872]
```

Code Structure:

```
Class outlier
-----------------
.univariate
    arguments
    ---------
    - x = vector (pd.Series)
    - k = detection factor either 'auto' (str) or [(dec,dec,dec)] for
zscore,iqr,mad [default = 'auto']
    returns
    -------
    .analysis -> outlier analysis summary
    .show -> indices of outliers detected by the specified method
        arguments
        ---------
        - method = outlier detection method ('zscore','iqr','mad') (str) [default
= 'iqr']
.multivariate
    arguments
    ---------
    - x = matrix of independent variables (pd.DataFrame)
    - y = dependent variable (pd.Series)
    - k = detection factor either 'auto' (str) or [(dec,dec)] for Cook,Mahalanobis
[default = 'auto']
    returns
    -------
    .analysis -> outlier analysis summary
    .show -> indices of outliers detected by the specified method
        arguments
        ---------
        - method = outlier detection method ('Cook','Mahalanobis') (str) [default
= 'Cook']
```

5 Working with Data

5.1 Data Structures

5.1.1 Types

Python mainly processes data by the following structures

- **Series Object.** A series is a vector-like object (a one-dimensional column array) with index. Link:

  https://pandas.pydata.org/pandas-docs/stable/reference/api/pandas.Series.html
- **List.** A list object is a one-dimensional row array without index. Link:

  https://www.w3schools.com/python/python_lists.asp
- **Array Object.** An array is a matrix-like object. Link:

  https://www.w3schools.com/python/python_arrays.asp
- **Pandas Dataframe.** A data frame is like an array embedded within a table. Link:
  https://pandas.pydata.org/pandas-docs/stable/reference/api/pandas.DataFrame.html
- **Dictionary.** A dictionary is a mapping from keys to values {key:value}. Link:

  https://www.w3schools.com/python/python_dictionaries.asp

5.1.2 Converting Data Structures

Convert series to
(let ser be the name of the object)
	• list
	`list(ser)`
	• array
	`ser.array`
	• dataframe
	`pd.DataFrame(ser)`

Convert list to
(let li be the name of the object)
	• series
	`pd.Series(li)`
	• array
	`np.array(li)`
	• dataframe
	`pd.DataFrame(li)`

Convert array to (let ar be the name of the object)	• series `pd.Series(ar)` • list

	`ar.tolist()`
	• dataframe
	`pd.DataFrame(ar)`

Convert dataframe to
(let df be the name of the object)
	• series (column with name c)
	`df['c']`
	`or`
	`df.c`
	• list (column with name c)
	`df['c'].to_list()`
	`or`
	`df.c.to_list()`
	• array
	`df.to_numpy()`

5.1.3 Selecting Cells, Columns an Rows

- **Series/Lists.** Select ith item:

```
ser[i]
li[i]
```

- **Array.** Select cell with row index i and column index j:

```
ar[i,j]
```

- **Dataframe.**
    - Select column with name c:

```
df['c']
```

    - Select row with index i:

```
df.loc[i]
```

    - Select cell with column name c and row index i:

```
df.loc[i,'c']
```

    - Select cell with column index j and row index i:

```
df.iloc[i,j]
```

- **Dictionary.** Select value for key k:

```
dic[k]
```

5.2 Data Frames

5.2.1 Dropping Columns

Suppose your data frame is named df.

- The following command drops the column named c. Only one column can be dropped:

```
del df['c']
```

- The following command drops all columns whose names are in [] (c1,c2,…):

```
df=df.drop(['c1','c2',...],axis=1)
```

- The following command <u>keeps</u> all columns whose names are in [[]] (c1,c2,…):

```
df=df[['c1','c2',...]]
```

5.2.2 Dropping Rows

Suppose your data frame is named df.

- The following command drops all rows whose numbers are in [] (r1,r2,…):

```
df=df.drop([r1,r2,...])
```

- The following command <u>keeps</u> all rows whose names are in [[]] (r1,r2,…):

```
df=df.loc[[r1,r2,...]]
```

- The following command drops all rows where the values in column c are greater or equal x (x = a number):

```
df=df[df['c']<x]
```

  - Similarly, you may use a greater (>), a equal (==) or an unequal (!=) statement in this code.

- The following command <u>keeps</u> all rows where the values in column named c1 < x and, at the same time, those in column named c2 are > y:

```
df=df[(df['c1']<x) & (df['c2']>y)]
```

  - Instead of an and (&) you may also use an and/or operator (|) in this code.

- The following commands drop all rows where the values in column c take on the values in [] (v1,v2,…):

```
indices = df[df['c'].isin([v1,v2,…])].index
df=df.drop(indices)
```

5.2.3 Creating new Columns

Suppose your data frame is named df.

- The following code creates a column named new that contains only one value x (which can be a number or a text string):

```
df['new']=x
```

- The following command creates a new column named new whose values are the sum of the values of the columns named c1 and c2:

```
df['new']=df['c1']+df['c2']
```

- The following command creates a new column with name new that assumes value v1 if the column with name c equals value v2 and, otherwise, value v3:

```
df['new']=df['c'].apply(lambda x: v1 if x==v2 else v3)
```

- Create a column conditional on the values of several other columns.
    - Step 1. Define a function. The following function assigns 'yes' if column c1 equals x and c2 is greater than y. It assigns 'no' if c1 equals x and y is less or equal y. Otherwise (if c1 unequal x), it assigns 'maybe':

```
def f(a):
    if a(c1) == x and a(c2)>y:
        return 'yes'
    elif a(c1) == x and a(c2)<=y:
        return 'no'
    else:
        return 'maybe'
```

    - Step 2. Apply the function:

```
df.apply(f,axis=1)
```

5.2.4 Rename Columns and and Replace Values

- The following command renames the old columns with new names (old_name: new_name):

```
df=df.rename(columns={'colname1_old':'colname1_new','colname2_old':'colname
1_new',…})
```

- The following command replaces value x in column c1 by 1 and the value y in column c2 by 'a':

```
df.replace({'c1': {x: 1}, 'c2':{y:'a'}})
```

5.2.5 Merging Data Frames

Data frames (df1, df2) can be merged as follows:

- Append:

```
df1.append(df2)
```

    - Link: https://www.geeksforgeeks.org/python-pandas-dataframe-append/

- Concat:

```
frames=[df1,df2]
df_merged = pd.concat(frames)
```

    - Remark: The data frames are stacked vertically and need to have exactly the same number of columns with identical names.
    - However, you may set an inner join (horizontal merge) by adding join='inner':

```
frames=[df1,df2]
df_merged = pd.concat(frames,axis=1,join='inner')
```

- Link: https://pandas.pydata.org/pandas-docs/stable/reference/api/pandas.concat.html

5.2.6 Some Useful Commands

Command	**Description**
`df.describe()`	returns the descriptive statistics of the data frame
`df.dropna()`	eliminates all missing values from your data frame
`df._get_numeric_data()`	eliminates all columns from df that do not contain numeric data
`df.groupby('colname')`	groups your data frame w.r.t. the grouping variable named colname
`df.head(i)`	shows the first i rows of the data frame
`df.round(i)`	rounds your data frame to i decimal places
`df.shape`	returns a list tuple: (number of columns, number of rows)
`df.sort_values(by=['colname'])`	sorts the data frame w.r.t. to the values of the column named colname
`df['colname'].count()`	shows the number of rows of the column named colname
`df['colname'].cumsum()`	returns a series object containing the cumulated sum of the entries of the column named colname
`df['colname'].mean()`	returns the mean of the column named colname
`df['colname'].std()`	returns the standard deviation of the column named colname

`df['colname'].sum()`	shows the sum of the entries of the column named colname
`df['colname'].unique()`	returns a list of the unique values in the column named colname
`df['colname'].value_counts()`	returns a list of all values of the column named colname and the number of observations per value

5.3 Data Visualization

In Python, it is very easy to create a plot based on two columns of a data frame:

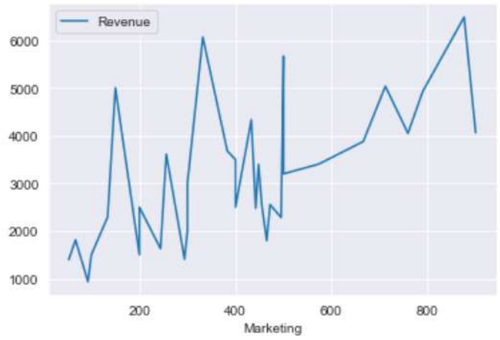
```
df.plot(x='colname1',y='colname2')
```

Example.

```
df=df[['Marketing','Revenue']]
df=df.sort_values(by=['Marketing'])
```

```
df.plot(x='Marketing', y='Revenue')
```

```
<AxesSubplot:xlabel='Marketing'>
```



5.4 Programing Functions

Python allows to easily program functions. In order to program a function use the command $def\ f(a1, a2, \ldots)\colon syntax\ return\ y$. The arguments of the function are $a1, a2, \ldots$ and y is the output of the function.

Example.

```
def f(x,a,b):
    return a*x+b
```

```
f(2,3,1)
```

```
7
```

We hope that this brief introduction showed you some abilities of python and helped you to do some steps on your own.

Enjoy the program!

Florian Kauffeldt

Please report any typos/errors in this document to florian.kauffeldt@hs-heilbronn.de