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Python for IoT Data Analytics

Data Visualization with Matplotlib

EIT4SEMM PHD Program, July 2023

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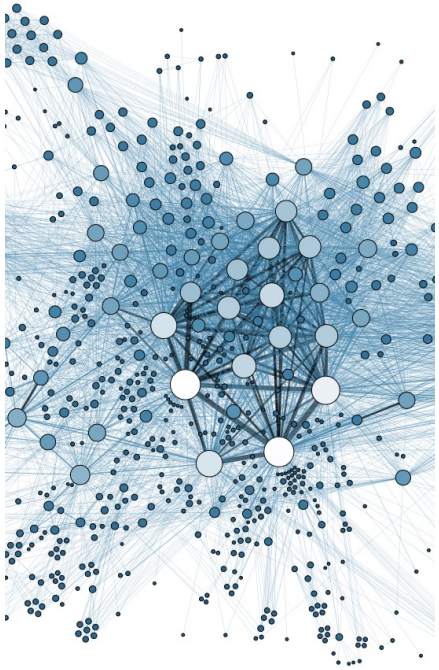
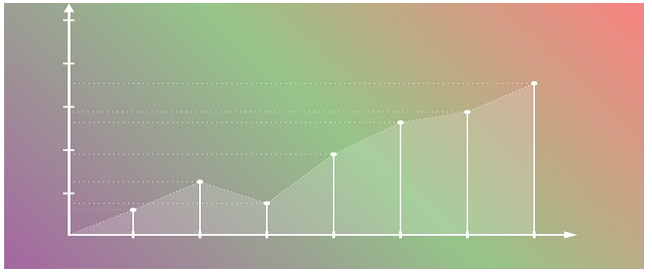
Data Visualization

- **Why data visualization**
- **Basic concepts and tools**
  - Some definitions: marks, channels, separability
  - Dealing with colors
  - Univariate attribute
  - Multivariate attributes
- **Plotting data with Python**
  - Matplotlib library
  - Seaborn library

Data Visualization

- **Data visualization** aims to communicate data clearly and effectively through geometrical representation
  - Effective tool to explore data
  - Help discovering data relationships otherwise not easily observable by looking at row data
  - Can be used to represent the data mining process and patterns/evaluation results obtained from a mining method
- Many different techniques for different kind of data





Data Visualization

	1		2		3		4	
	X	Y	X	Y	X	Y	X	Y
	10.0	8.04	10.0	9.14	10.0	7.46	8.0	6.58
	8.0	6.95	8.0	8.14	8.0	6.77	8.0	5.76
	13.0	7.58	13.0	8.74	13.0	12.74	8.0	7.71
	9.0	8.81	9.0	8.77	9.0	7.11	8.0	8.84
	11.0	8.33	11.0	9.26	11.0	7.81	8.0	8.47
	14.0	9.96	14.0	8.10	14.0	8.84	8.0	7.04
	6.0	7.24	6.0	6.13	6.0	6.08	8.0	5.25
	4.0	4.26	4.0	3.10	4.0	5.39	19.0	12.50
	12.0	10.84	12.0	9.13	12.0	8.15	8.0	5.56
	7.0	4.82	7.0	7.26	7.0	6.42	8.0	7.91
	5.0	5.68	5.0	4.74	5.0	5.73	8.0	6.89
Mean	9.0	7.5	9.0	7.5	9.0	7.5	9.0	7.5
Variance	10.0	3.75	10.0	3.75	10.0	3.75	10.0	3.75
Correlation	0.816		0.816		0.816		0.816	

Credits to: Daniele Loiacono, Data and Results Visualization

Data Visualization

	1		2		3		4	
	X	Y	X	Y	X	Y	X	Y
	10.0	8.04	10.0	9.14	10.0	7.46	8.0	6.58
	8.0	6.95	8.0	8.14	8.0	6.77	8.0	5.76
	13.0	7.58	13.0	8.74	13.0	12.74	8.0	7.71
	9.0	8.81	9.0	8.77	9.0	7.11	8.0	8.84
	11.0	8.33	11.0	9.26	11.0	7.81	8.0	8.47
	14.0	9.96	14.0	8.10	14.0	8.84	8.0	7.04
	6.0	7.24	6.0	6.13	6.0	6.08	8.0	5.25
	4.0	4.26	4.0	3.10	4.0	5.39	19.0	12.50
	12.0	10.84	12.0	9.13	12.0	8.15	8.0	5.56
	7.0	4.82	7.0	7.26	7.0	6.42	8.0	7.91
	5.0	5.68	5.0	4.74	5.0	5.73	8.0	6.89
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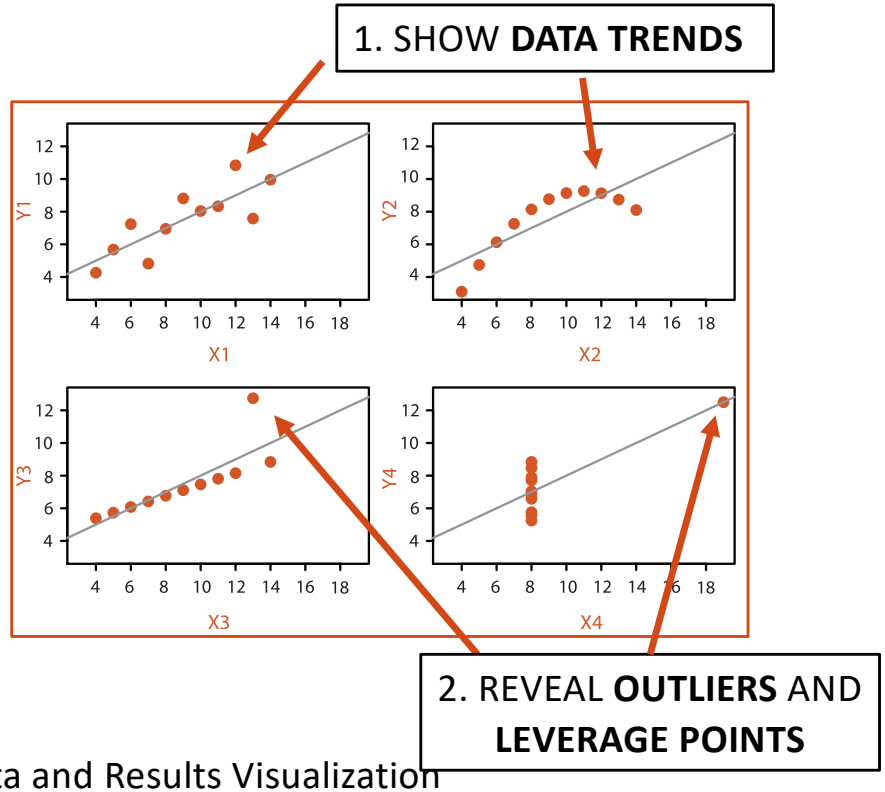
Variance	10.0	3.75	10.0	3.75	10.0	3.75	10.0	3.75
Correlation	0.816		0.816		0.816		0.816	



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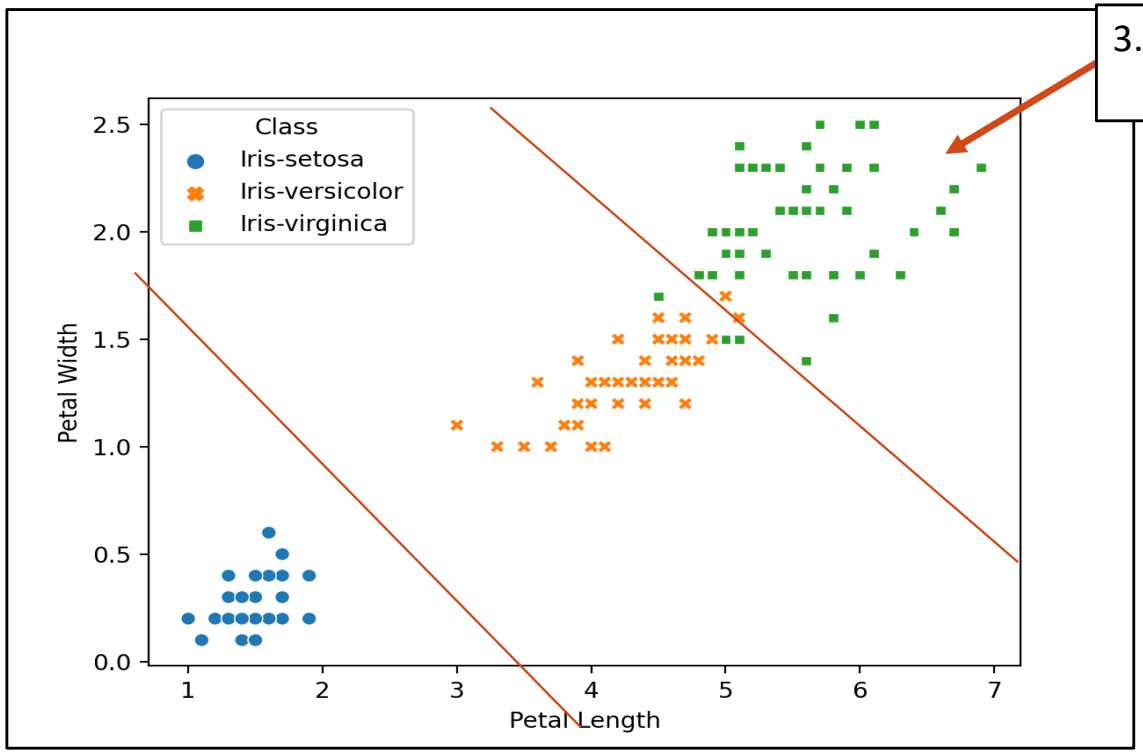
Data Visualization



3. PROVIDE HINTS ABOUT **MODELING TECHNIQUES TO APPLY**

Which conclusions can be derived from this chart?

Data Visualization

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Visualization: concepts

Attribute Types

Nominal/Categorical

hair_color	black, brown, blond
Occupation	teacher, dentist, programmer

Ordinal

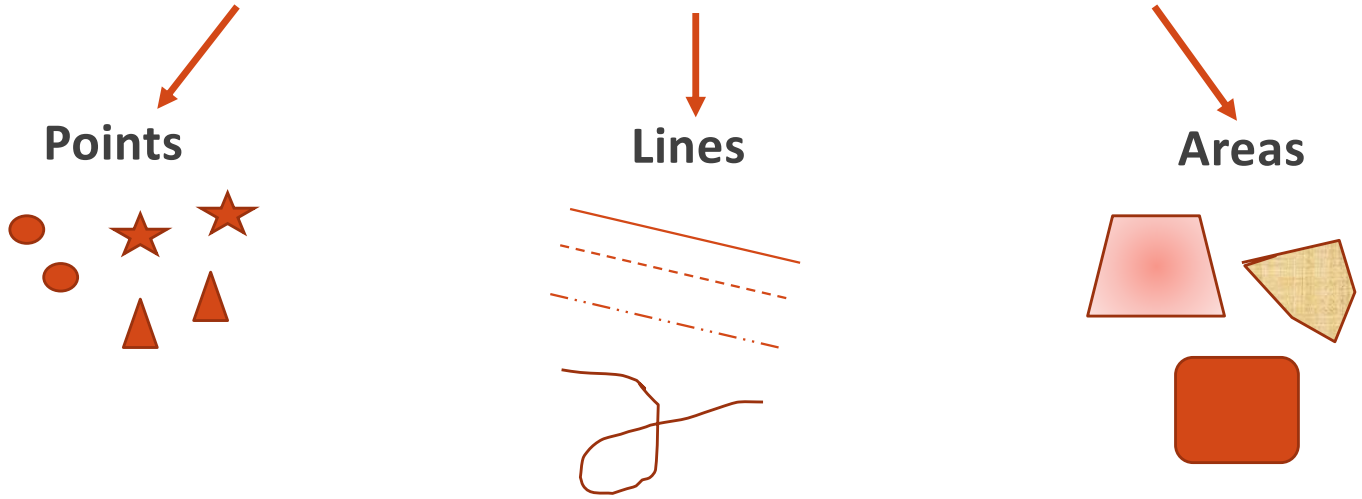
drink_size	Small, Medium, Large
professors rank	assistant, associate, and full

Numeric

e.g.. weight, height, latitude and longitude

Data Visualization

- Building blocks of visual encoding: **Marks** and **Channels**
- **Marks:** geometric elements used to depict the data samples



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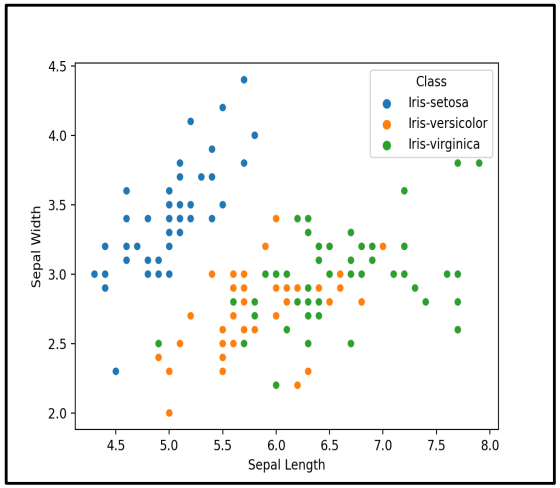
Data Visualization

- Building blocks of visual encoding: **Marks** and **Channels**

- **Channels:** control the appearance of a mark → Encode the attributes
  - Position
  - Hue, saturation, lightness
  - Shape
  - Tilt
  - Size
  - Orientation
  - etc



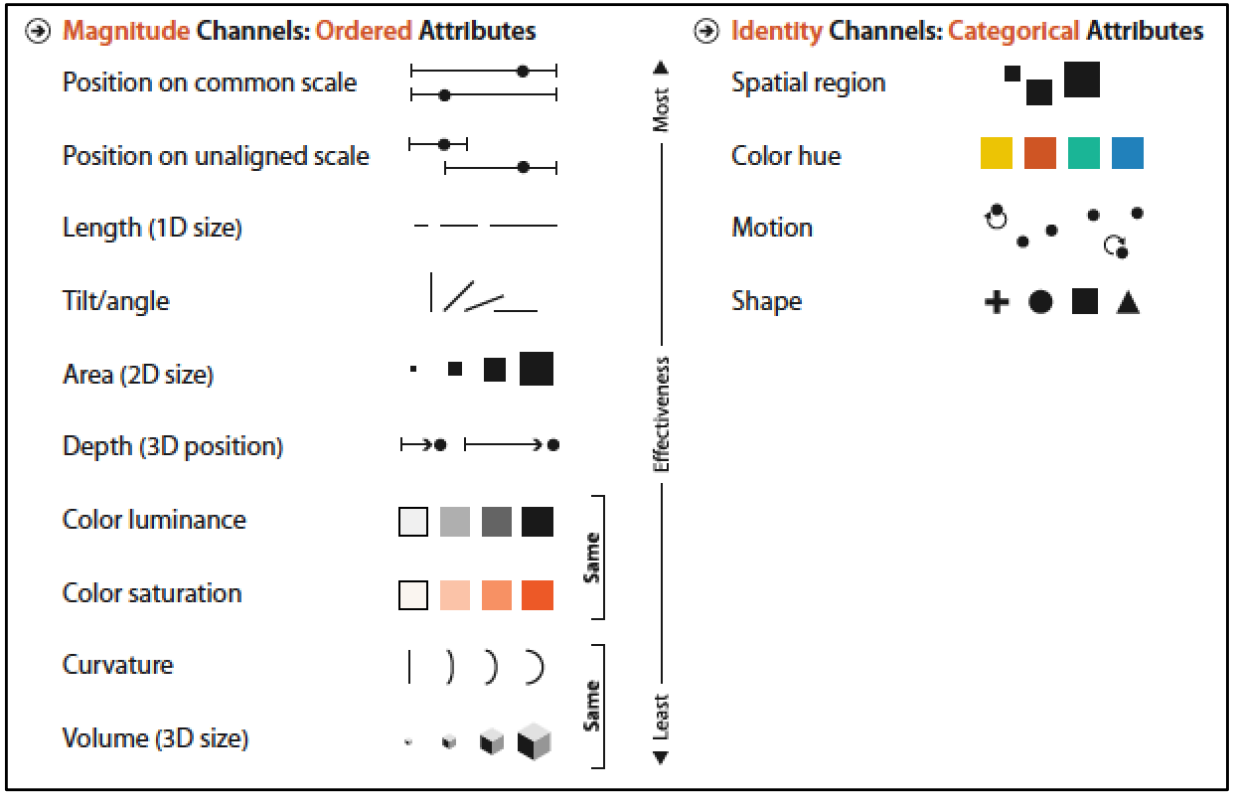
IRIS DATASET VISUALIZATION

- **Marks**
  Points
- **Channels**
  Position(X) → Sepal Length
  Position (Y) → Sepal Width
  Class → Color

Data Visualization

Channel types:

- **Magnitude channels**: enconde Ordinal/Numeric attributes
- **Identify channels**: encode Categorical attributes



Source: Munzner, "Visualization Analysis and Design"

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Data Visualization

- **Why data visualization**
- **Basic concepts and tools**
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Data Visualization

- Our visual system can process signals into three opponent color channels
  - Red – Green
  - Blue – Yellow

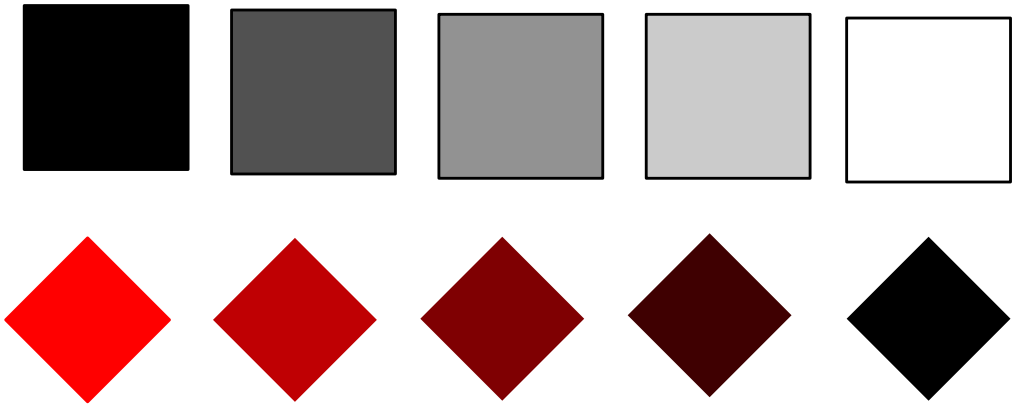
  } Chromaticity → Color
  - Black – White → Luminance → Edge Detection

- Three visual channels to encode data with colors:
  - **Luminance**: how bright is the marker
  - **Saturation**: how colorful is the marker
  - **Hue**: which color is used by the marker

Credits to: Daniele Loiacono, Data and Results Visualization

Data Visualization

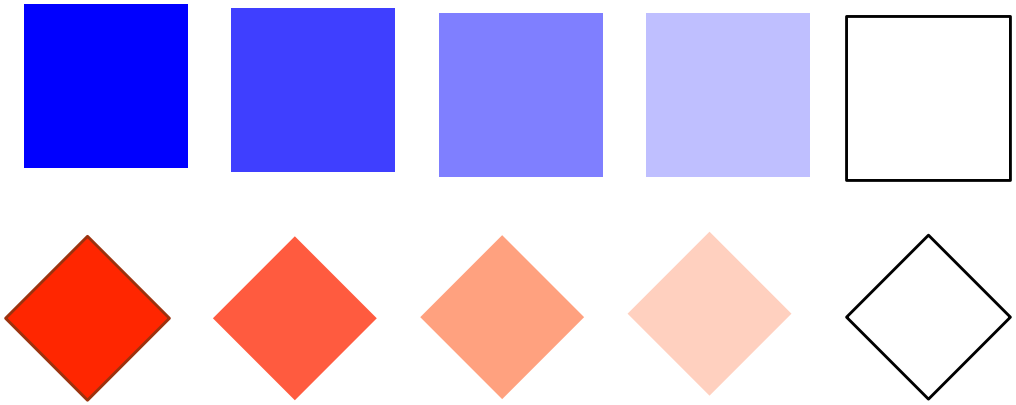
- **Luminance**
  - Magnitude channel, suitable to encode **ordinal** attributes
  - It allows to discriminate up to 5 different (non-contiguous) values



Credits to: Daniele Loiacono, Data and Results Visualization

Data Visualization

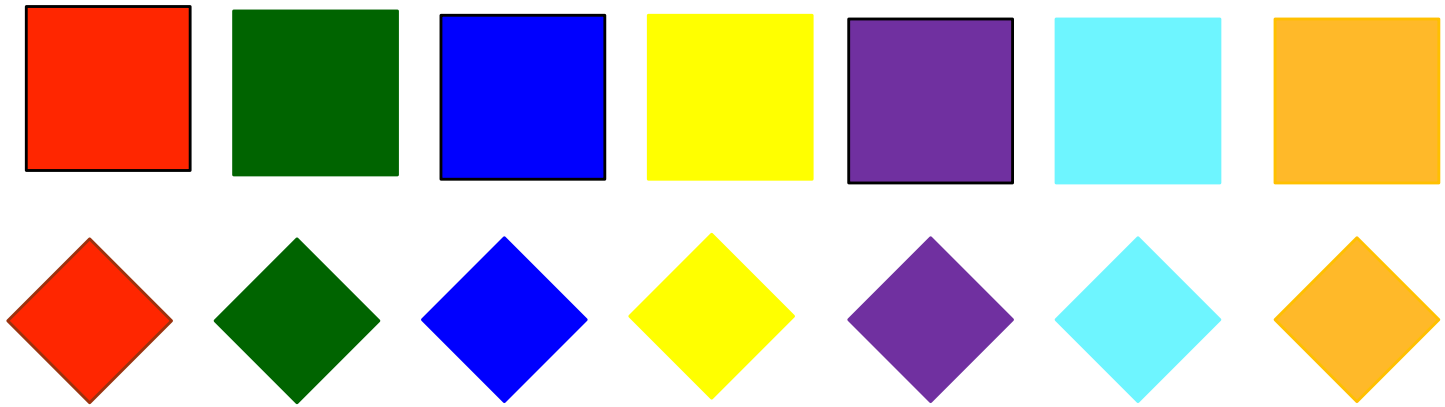
- **Saturation**
  - Magnitude channel, suitable to encode **ordinal** attributes
  - It allows to discriminate up to 3 different (non-contiguous) values (hence it is less effective than the Luminance channel).



Credits to: Daniele Loiacono, Data and Results Visualization

Data Visualization

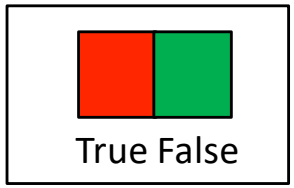
- **Hue**
  - Identity channel, suitable to encode **categorical** attributes
  - It allows to discriminate up to 7 different (non-contiguous) values



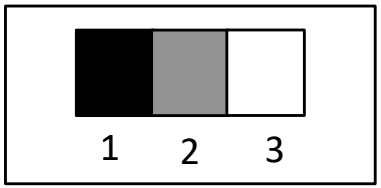
Credits to: Daniele Loiacono, Data and Results Visualization

Data Visualization

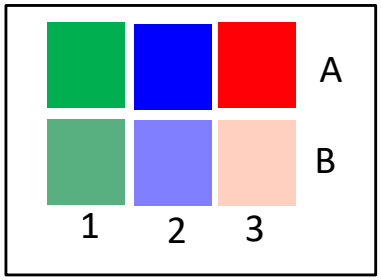
- **Colormap**
  - Mapping chosen to encode one (or two) attributes with color
  - Apply to both categorical and ordinal attributes



Univariate, categorical
(data encoding by Hue)



Univariate, ordinal
(data encoding by Luminance)



Multivariate, ordinal + categorical
(data encoding by Saturation + Hue)

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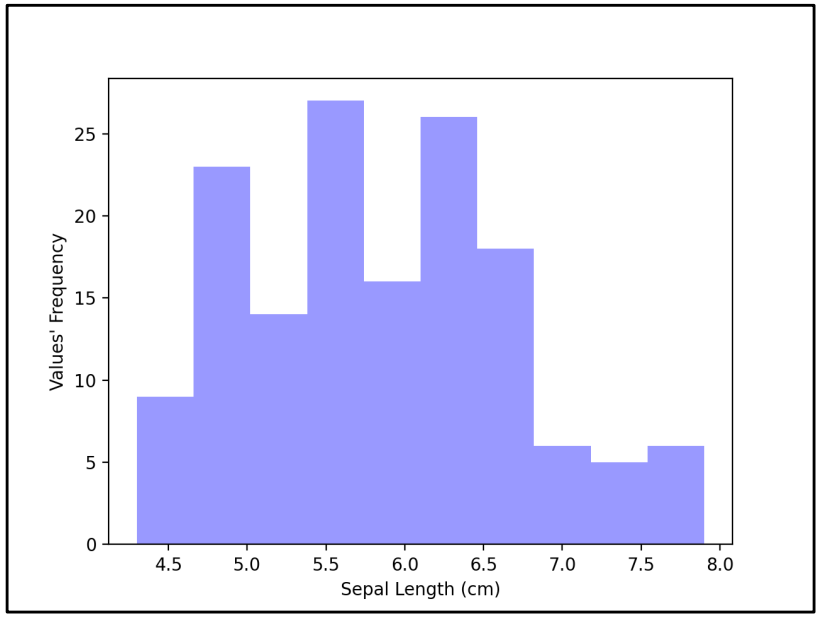
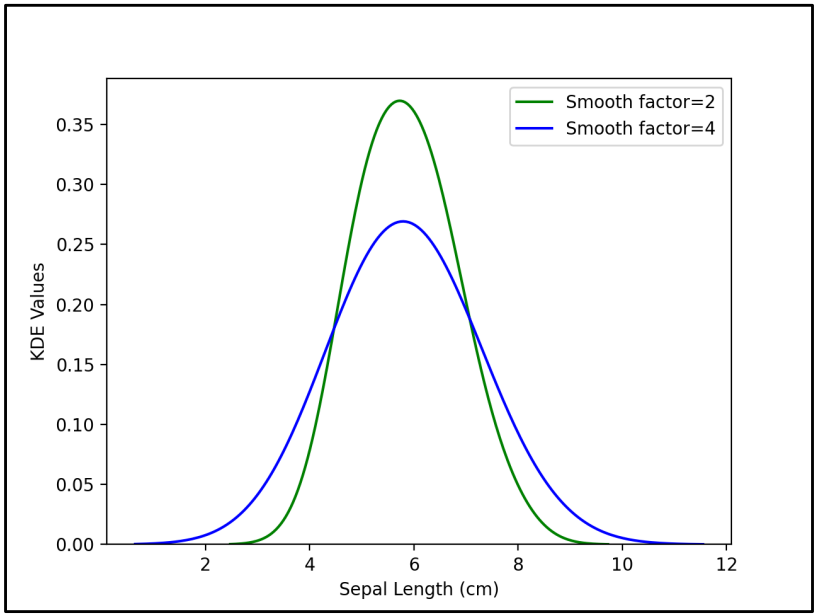
Visualization: tools



HISTOGRAM



DENSITY PLOT

Visualization: tools

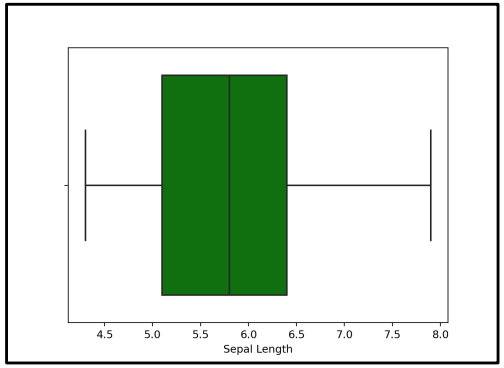
- **Boxplot**
  - Apply to

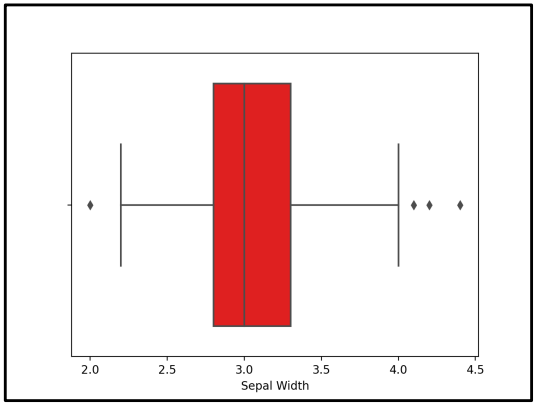
    1 Quantitative Attribute
  - What

    Statistical summary of a data distribution, it shows 5 variables within a single plot
  - How

    Median, first and third quartiles (top/bottom whishers), maximum and minimum values
  - Why

    Identify distribution and range of an attribute, have a quick look to its descriptive analysis





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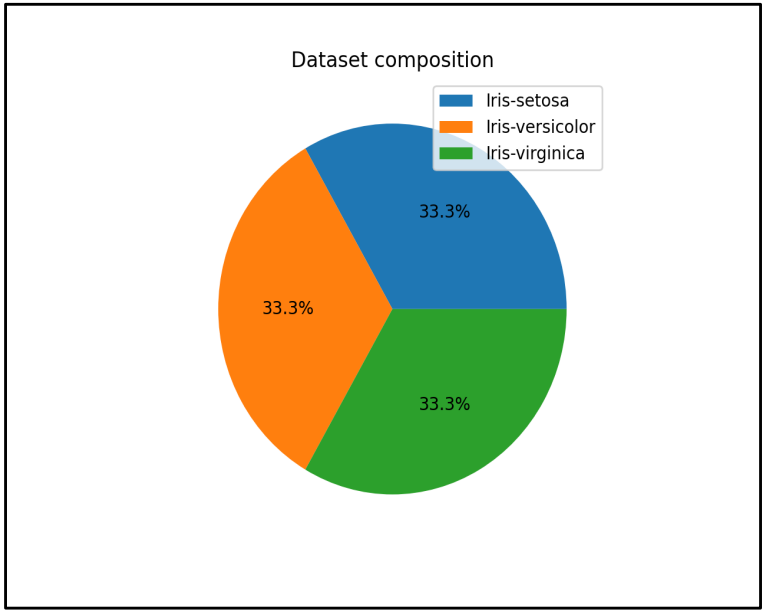
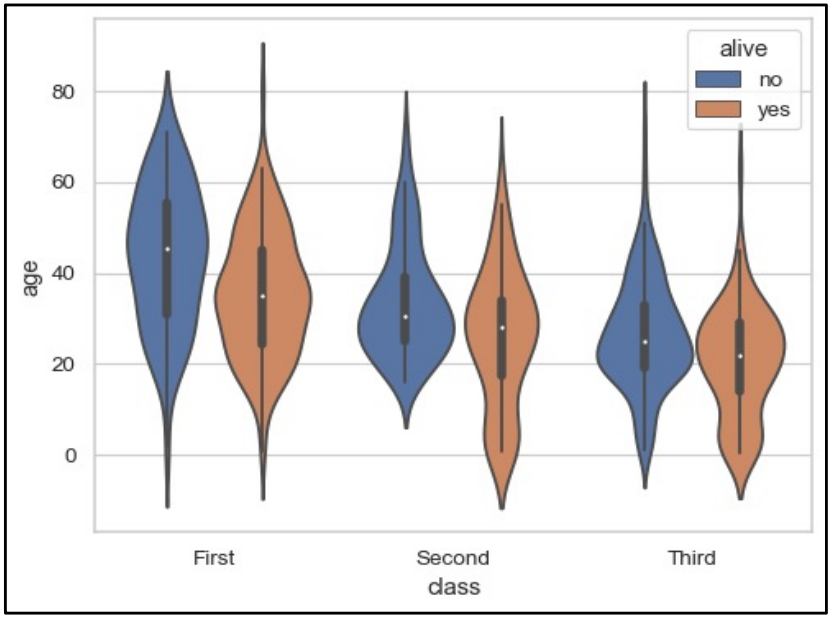
Visualization: tools



PIE CHART



VIOLIN CHART

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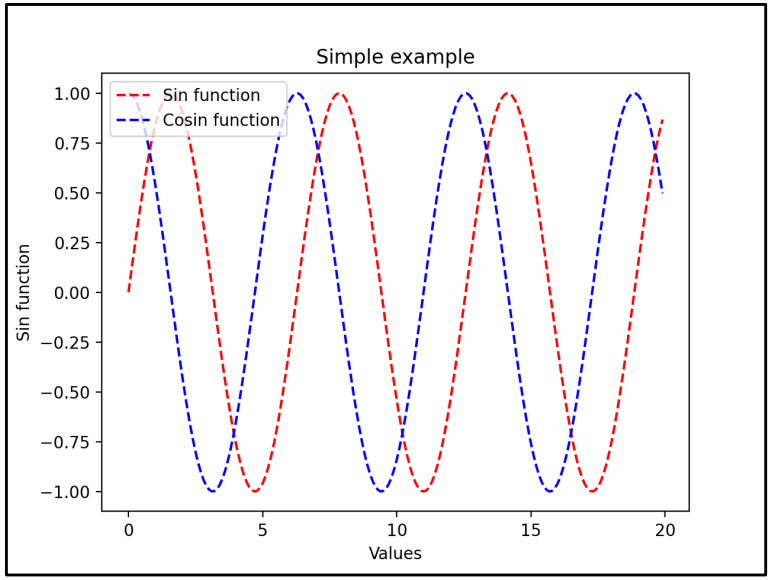
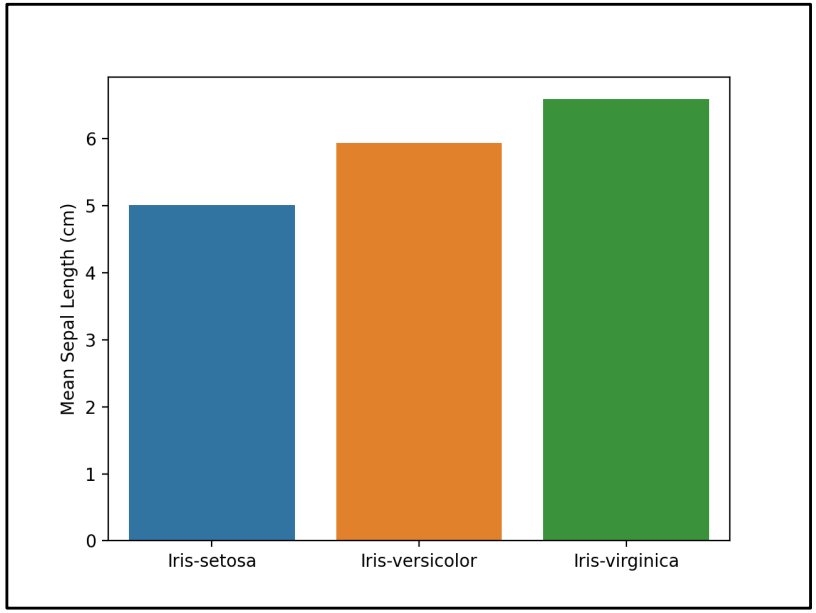
Visualization: tools



LINE PLOT



BAR CHART

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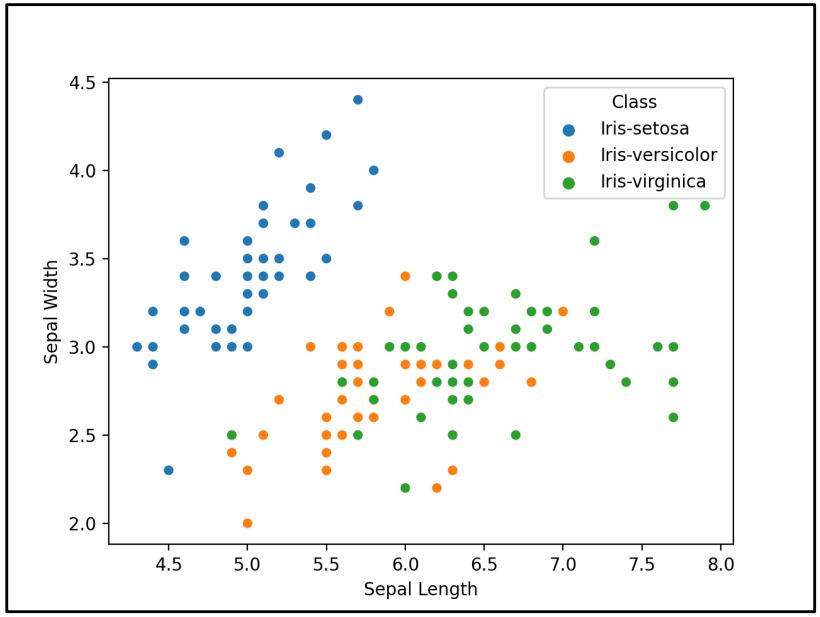
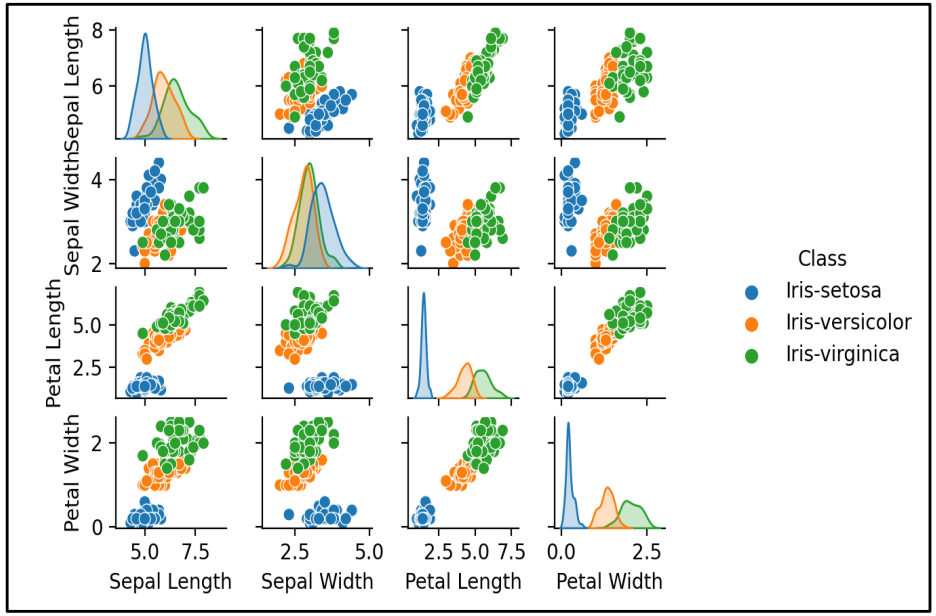
Visualization: tools



SCATTER PLOT



SCATTER PLOT MATRIX

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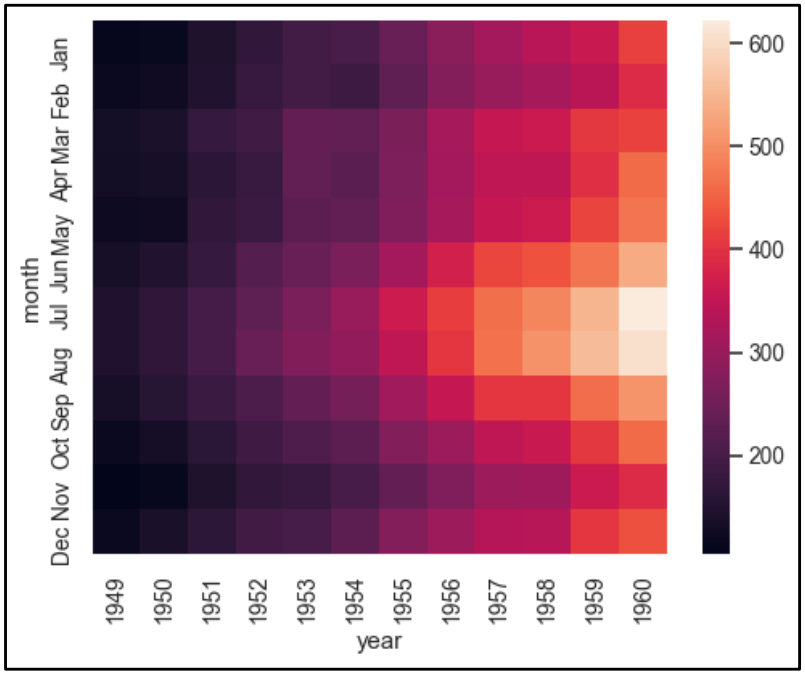
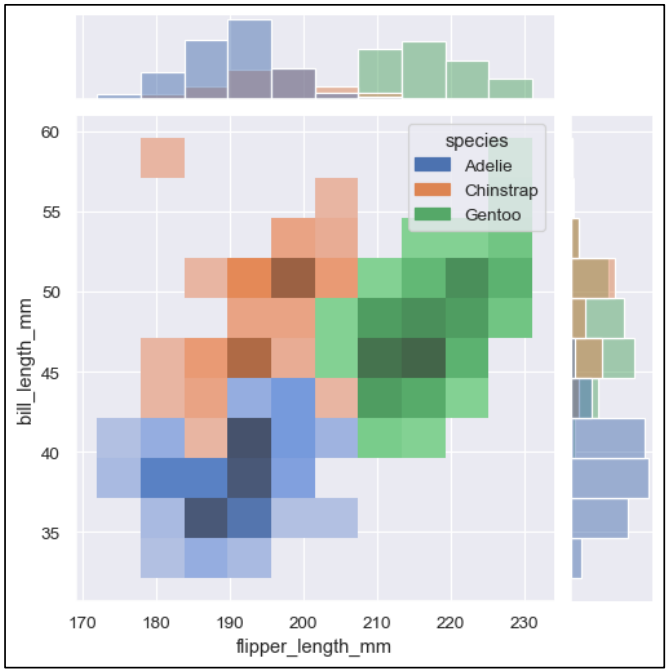
Visualization: tools



HEATMAP



HEATMAP+DISTPLOT

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Matplotlib

- **Python 2D/3D plotting library**
  - Initially developed by J. Hunter in 2003
  - Object-oriented API (`pyplot`)
- **MATLAB-like interface**
  - plots, histograms, power spectra, bar charts, errorcharts, scatterplots, etc.
- **Official (introductory, intermediate, advanced) tutorials:**
  - https://matplotlib.org/3.1.1/tutorials/index.html


```
pip install -U matplotlib
```

```
import matplotlib.pyplot as plt
```

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Matplotlib

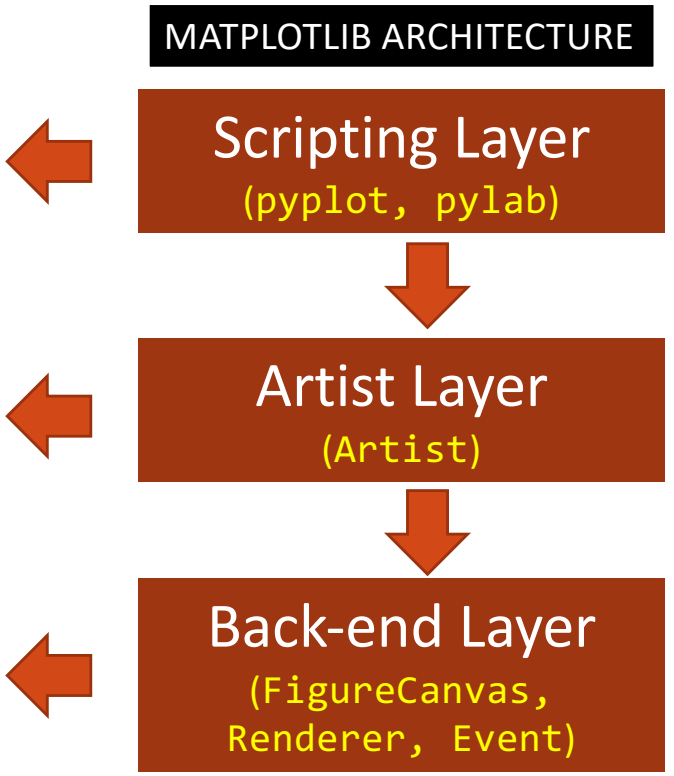
State-machine interface to the underlying Python libraries

- Object Oriented (OO) interface
- Procedural interface (discouraged)

Additional primitives for the fine-grained customization of each figure

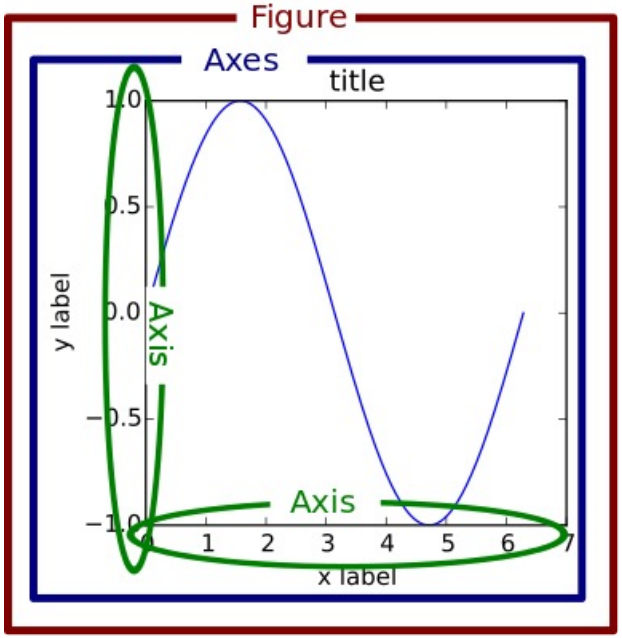
Hard work behind-the-scenes to **render** the figure and ro **export** it

- User interface rendering library (e.g. QT)
- Hardcopy backends to make files (e.g. PNG)

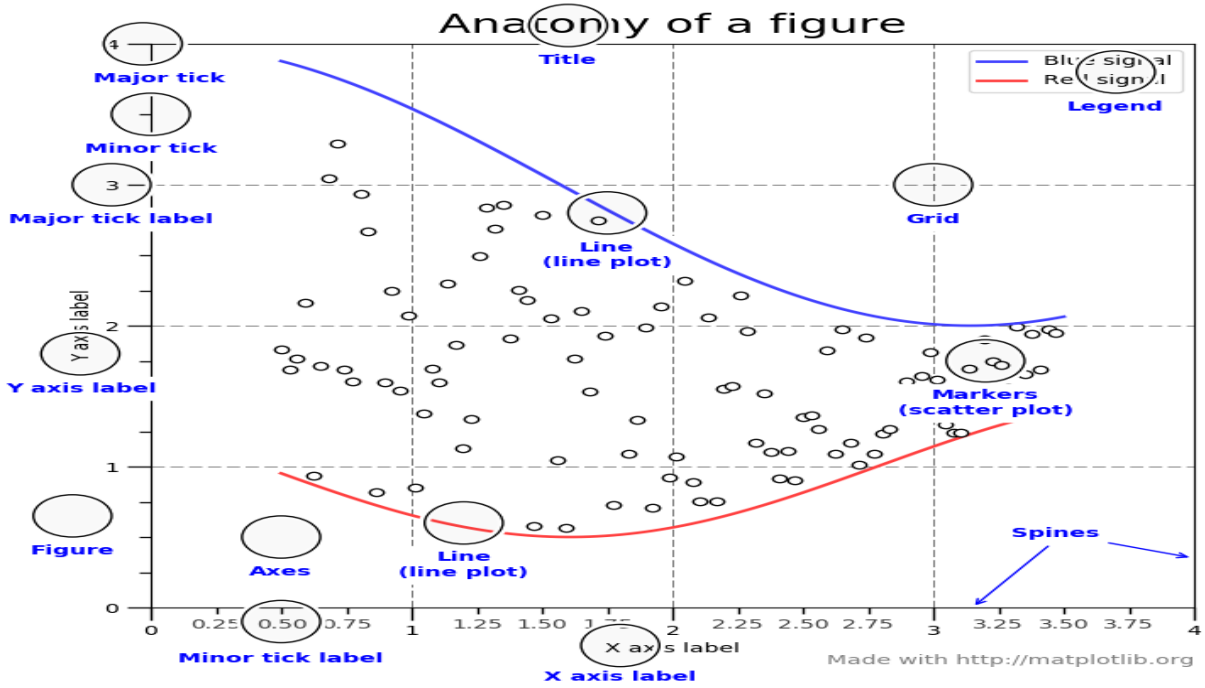


Matplotlib

- **Figure**
  - Overall window or page that everything is drawn on
  - Top-level component
- **Axes**
  - area on which data is plotted (e.g. via the `plot(…)` function)
  - A Figure contains at least one Axes, but it might contain more than one (e.g. subplots)
- **Axis**
  - Take care of setting the graph limits and generating the ticks (visual marks) and ticklabels (strings)



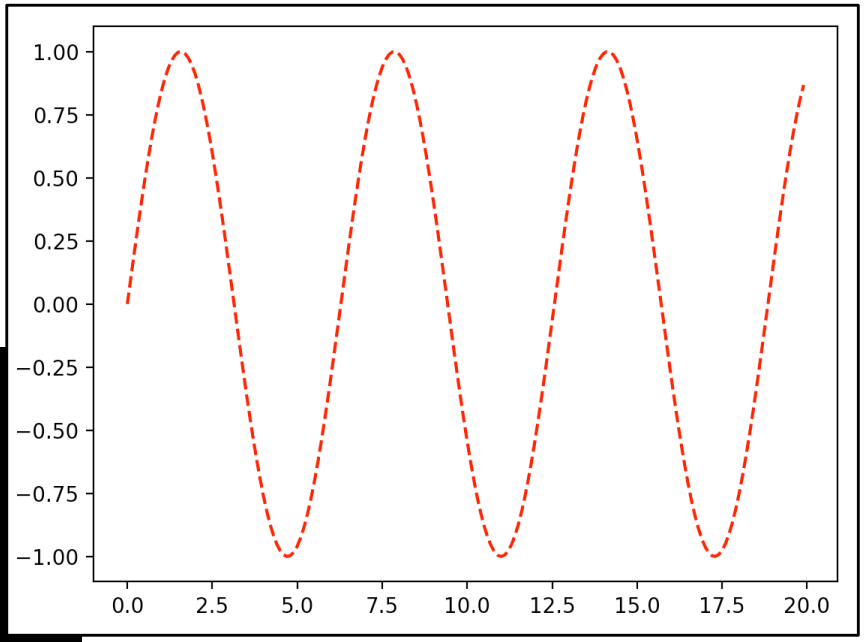
Matplotlib


Anatomy of a figure
Title
Major tick
Minor tick
Major tick label
Y axis label
Figure
Axes
Minor tick label
X axis label
Line
(line plot)
Grid
Legend
Markers
(scatter plot)
Spines
Made with http://matplotlib.org

Matplotlib

- **matplotlib.pyplot.plot()**
  - Plot one or multiple data series with linespoints
  - Argument: any list of data, including Numpy arrays
- **matplotlib.pyplot.show()**
  - Display the Figure

```
import matplotlib.pyplot as plt
data=np.arange(0.0, 20.0, 0.1)
plt.plot(data,np.sin(data),'r--')
plt.show()
```



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Matplotlib

- **DATA INPUT (1): Lists**

```
import matplotlib.pyplot as plt
x = [0,1,2,3,4,5,6,7,8,9]
y = [0,2,4,6,8,10,12,14,16,18]
plt.plot(x,y,'r--')
plt.show()
```

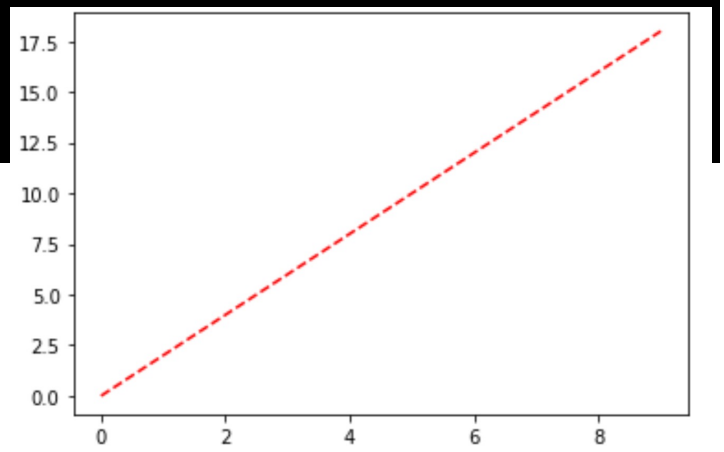
- **DATA INPUT (2): Numpy arrays**

```
import numpy as np
x = np.array([0,1,2,3,4,5,6,7,8,9])
y = np.array([0,2,4,6,8,10,12,14,16,18])
plt.plot(x,y,'r--')
plt.show()
```

Matplotlib

- **DATA INPUT (3): Dataframe Pandas**

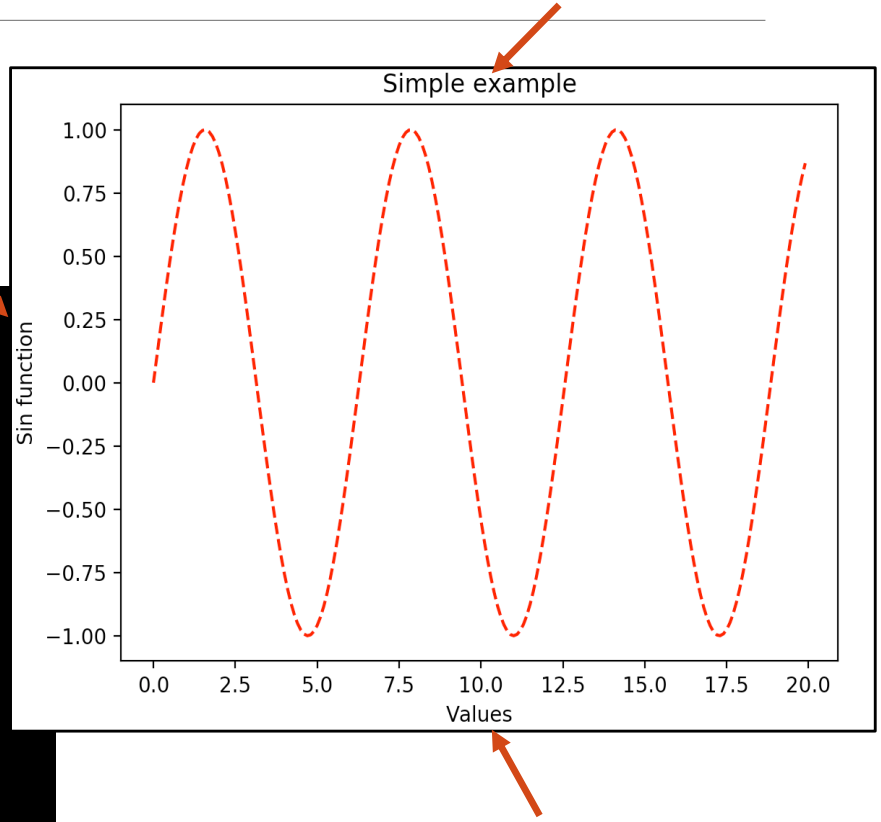
```
import matplotlib.pyplot as plt
import pandas as pd
df = pd.DataFrame({"x":[0,1,2,3,4,5,6,7,8,9],
                   "y":[0,2,4,6,8,10,12,14,16,18] })
plt.plot(df["x"],df["y"],'r--')
plt.show()
```



Matplotlib

- **Customize the title and labels**
  - matplotlib.pyplot.xlabel(str)
  - matplotlib.pyplot.ylabel(str)
  - matplotlib.pyplot.title(str)

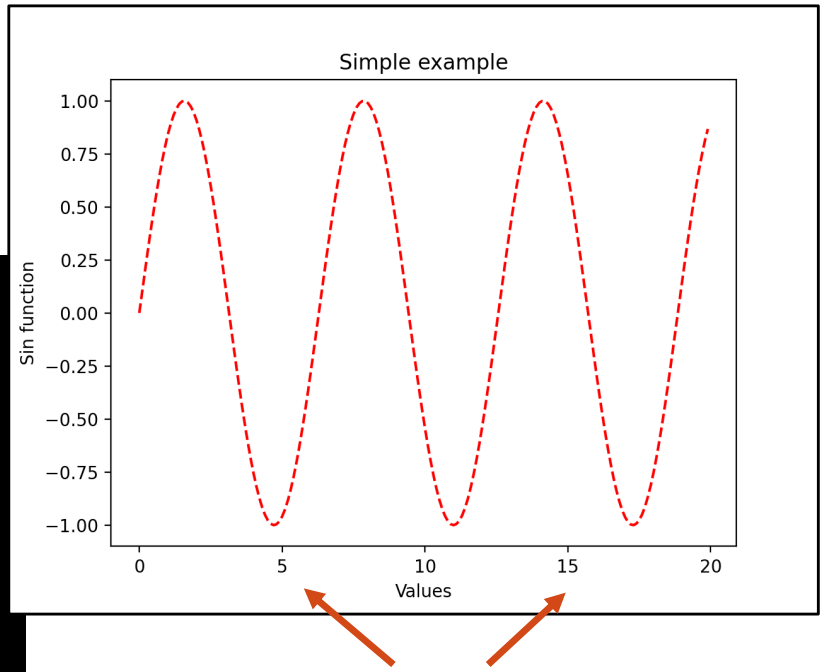
```
import matplotlib.pyplot as plt
data=np.arange(0.0, 20.0, 0.1)
plt.plot(data,np.sin(data),'r--')
plt.xlabel('Values')
plt.ylabel('Sin function')
plt.title('Simple example')
plt.show()
plt.savefig('example.png')
```



Matplotlib

- **Customize the tics on the x/y axis**
  - `matplotlib.pyplot.xtics(location, labels)`
  - `matplotlib.pyplot.ytics(location, labels)`

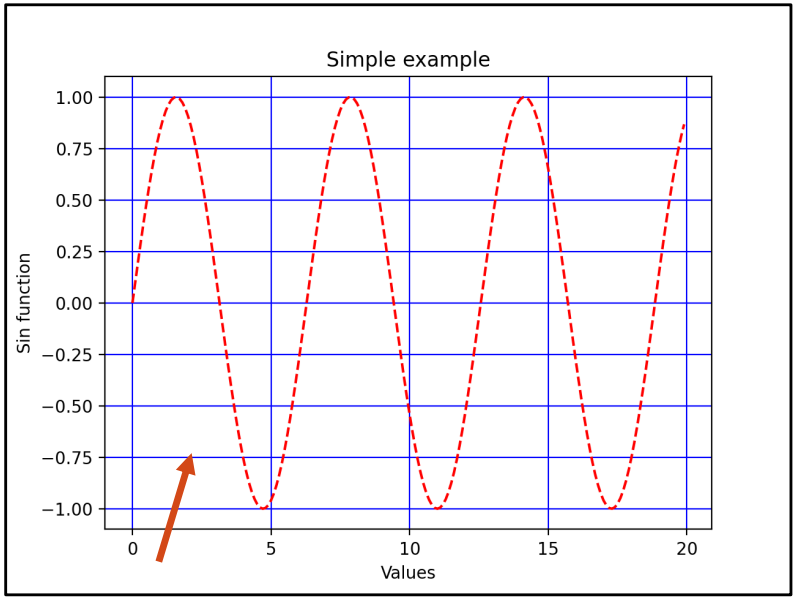
```
import matplotlib.pyplot as plt
data=np.arange(0.0, 20.0, 0.1)
plt.plot(data,np.sin(data),'r--')
plt.xlabel('Values')
plt.ylabel('Sin function')
plt.title('Simple example')
plt.xticks([0,5,10,15,20])
plt.show()
```



Matplotlib

- **Set the grid**
  - `matplotlib.pyplot.grid(color, linewidth)`

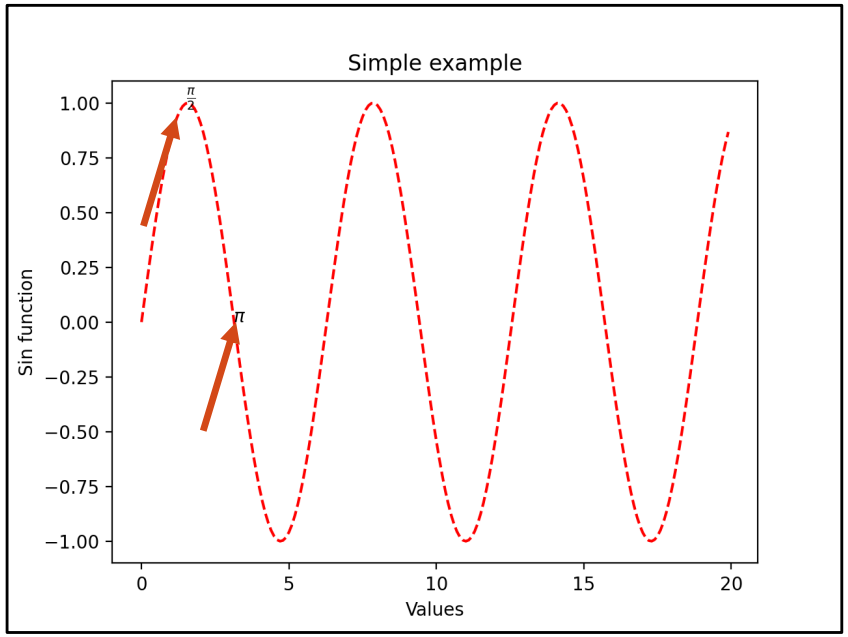
```
data = np.arange(0.0, 20.0, 0.1)
plt.plot(data, np.sin(data), 'r--')
plt.xlabel('Values')
plt.grid(color='b')
plt.ylabel('Sin function')
plt.title('Simple example')
plt.xticks([0, 5, 10, 15, 20])
plt.show()
```



Matplotlib

- **Add text at arbitratry positions**
  - `matplotlib.pyplot.text(x,y, str)`

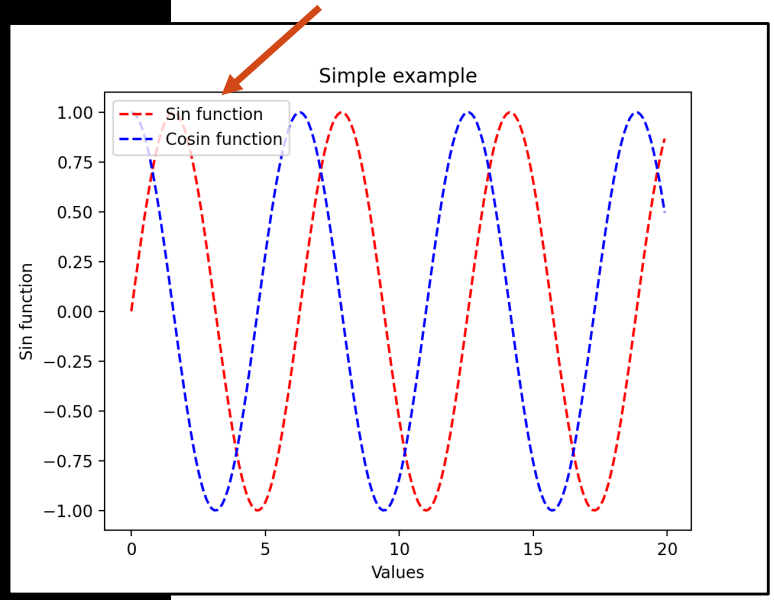
```
data = np.arange(0.0, 20.0, 0.1)
plt.plot(data, np.sin(data), 'r--')
plt.xlabel('Values')
plt.text(1.52,1,r'$\frac{\pi}{2}$')
plt.text(3.10, 0, r'$\pi$')
plt.ylabel('Sin function')
plt.title('Simple example')
plt.xticks([0, 5, 10, 15, 20])
plt.show()
```



Matplotlib

- **Add a legend**
  - `matplotlib.pyplot.legend(position)`

```
data = np.arange(0.0, 20.0, 0.1)

plt.plot(data, np.sin(data), 'r--', label='Sin function')

plt.plot(data, np.cos(data), 'b--', label='Cosin function')

plt.xlabel('Values')

plt.ylabel('Sin function')

plt.title('Simple example')

plt.xticks([0,5,10,15,20])

plt.legend(loc='upper left')

plt.show()
```



Matplotlib

- **Line plot**
  - `matplotlib.pyplot.plot(x,y, fmt,args)`
  - `fmt:` compact notation to define [color][marker][line]. Some examples:
    - `go--` → color=green, marker='o', linestyle='dashed'
    - `ro` → color=red, marker='o'
    - `b*-` → color=blue, marker='*', linestyle='solid'
  - Optional parameters (some examples):
    - linewidth: float number
    - antialiased: boolean value
    - label: object value
    - alpha: float value
    - ….

Matplotlib

Markers

character	description
`'.'`	point marker
`','`	pixel marker
`'o'`	circle marker
`'v'`	triangle_down marker
`'^'`	triangle_up marker
`'<'`	triangle_left marker
`'>'`	triangle_right marker
`'1'`	tri_down marker
`'2'`	tri_up marker
`'3'`	tri_left marker
`'4'`	tri_right marker
`'s'`	square marker
`'p'`	pentagon marker
`'*'`	star marker
`'h'`	hexagon1 marker
`'H'`	hexagon2 marker
`'+'`	plus marker
`'x'`	x marker
`'D'`	diamond marker
`'d'`	thin_diamond marker
`'|'`	vline marker
`'_'`	hline marker

Line Styles

character	description
`'-'`	solid line style
`'--'`	dashed line style
`'-.'`	dash-dot line style
`':'`	dotted line style

character	color
`'b'`	blue
`'g'`	green
`'r'`	red
`'c'`	cyan
`'m'`	magenta
`'y'`	yellow
`'k'`	black
`'w'`	white

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Matplotlib

- **Line plot**

```
data = np.arange(0.0, 20.0, 0.5)
plt.plot(data, np.power(data,2), 'ro-', linewidth=0.1, label='Sqr function')
plt.plot(data, np.sqrt(data), 'b*-', linewidth=2, label='Sqrt function')
plt.xlabel('Input values (X)')
plt.ylabel('F(X)')
plt.title('Line example')
plt.legend(loc='upper left')
plt.show()
```

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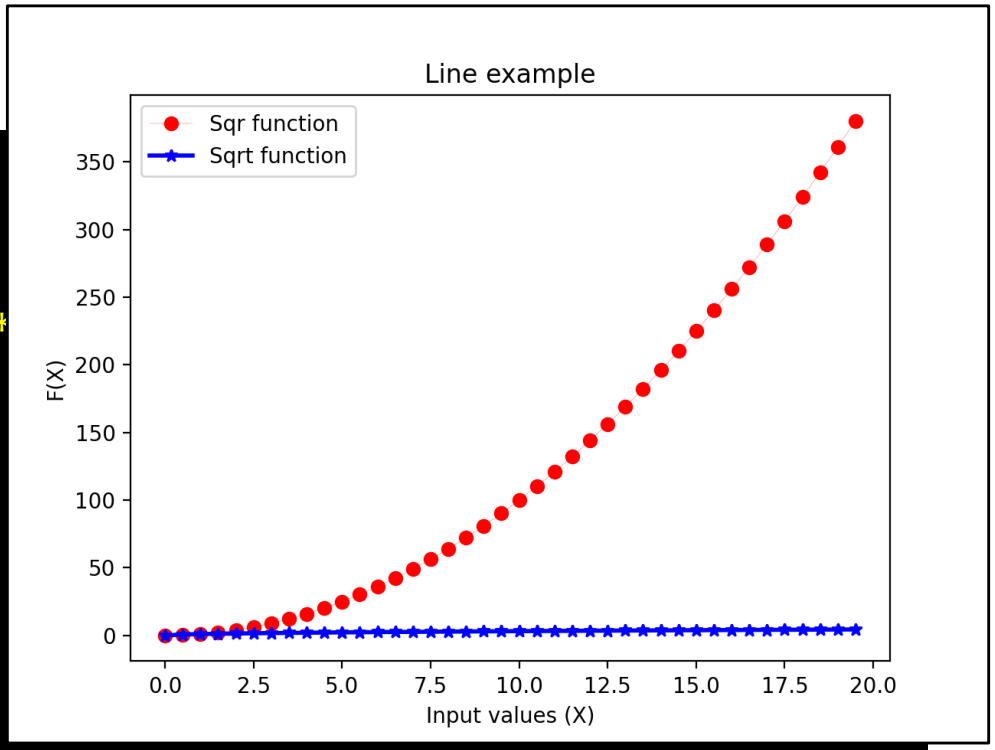
Matplotlib

- **Line plot**

```
data = np.arange(0.0, 20.0, 0.5)
plt.plot(data, np.power(data,2), 'r^', label='Sqr function')
plt.plot(data, np.sqrt(data), 'b*', label='Sqrt function')
plt.xlabel('Input values (X)')
plt.ylabel('F(X)')
plt.title('Line example')
plt.legend(loc='upper left')
plt.show()
```



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Matplotlib

- **Histogram plot**
  - `matplotlib.pyplot.hist(x, bins, arguments)`
  - It approximates the probability density function (PDF) of the underlying variable
  - `x`: single or sequence of arrays
  - `bins`: if a single integer value, it defines the number of equal-width bins in the range. If is a sequence, it defines the bin edges, including the left edge of the first bin and the right edge of the last bin
  - Optional parameters. Some examples:
    - `rwidth`: The relative width of the bars
    - `color`: Color or sequence of colors, one per dataset.
  - Returns:
    - `<n, bins>`: values and edges of the bins

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Matplotlib

- **Histogram plot**
  - matplotlib.pyplot.hist(x, bins, arguments)

```
data = np.random.normal(0, 0.1, 500)
result= plt.hist(data, 5)
print(result)
plt.xlabel('Input values (X)')
plt.ylabel('CDF')
plt.title('Histogram example')
plt.show()
```

```
(array([  6.,  82., 266., 130.,
16.]), array([-0.36652272, -0.22773513,
-0.08894754,  0.04984004,  0.18862763,
0.32741522])
```

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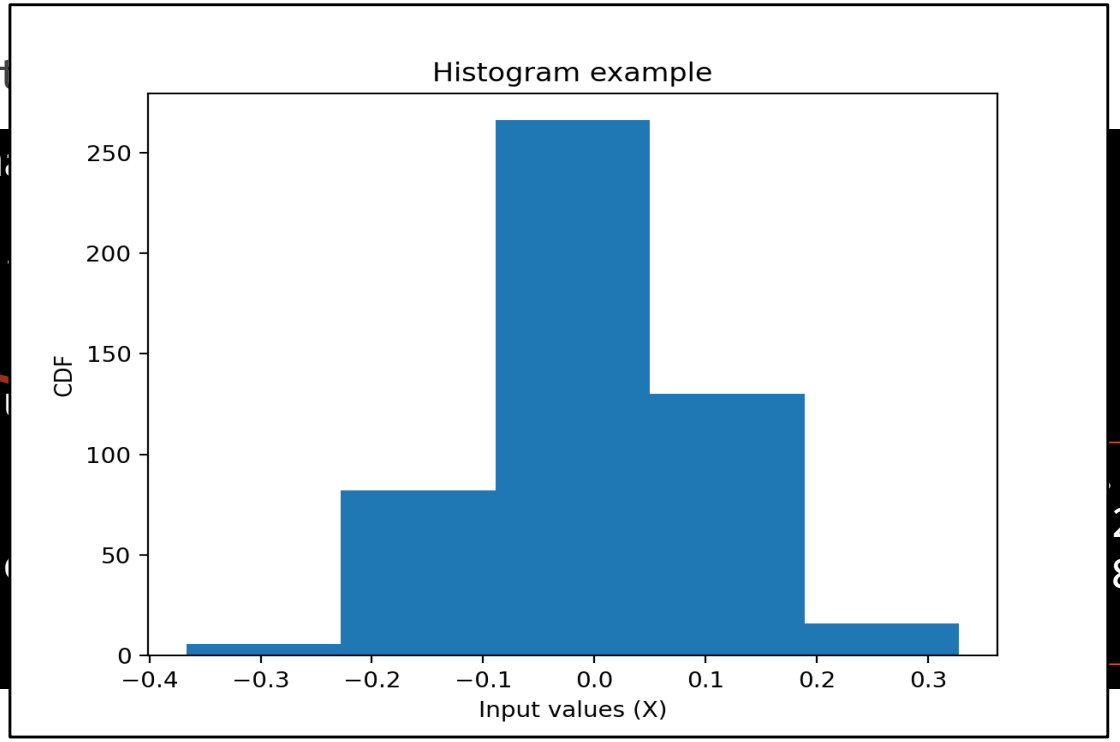
Matplotlib

- **Histogram plot**
  - matplotlib.pyplot.hist

```
data = np.random.norm
result= plt.hist(data
print(result)
plt.xlabel('Input val
plt.ylabel('CDF')
plt.title('Histogram
plt.show()
```




```
,
22773513,
8862763,
```

Matplotlib

- **Boxplot**
  - `matplotlib.pyplot.boxplot(x, arguments)`
  - `x`: Array or a sequence of vectors
  - Optional parameters. Some examples:
    - `sym`: The default symbol for flier points
    - `widths`: Sets the width of each box either with a scalar or a sequence
    - `whis`: reach of the whiskers to the beyond the first and third quartiles
    - `labels`: Labels for each dataset. Length must be compatible with dimensions of x
  - It returns a dictionary including the plot information in numeric format:
    - boxes, median, mean, whiskers, fliers

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Matplotlib

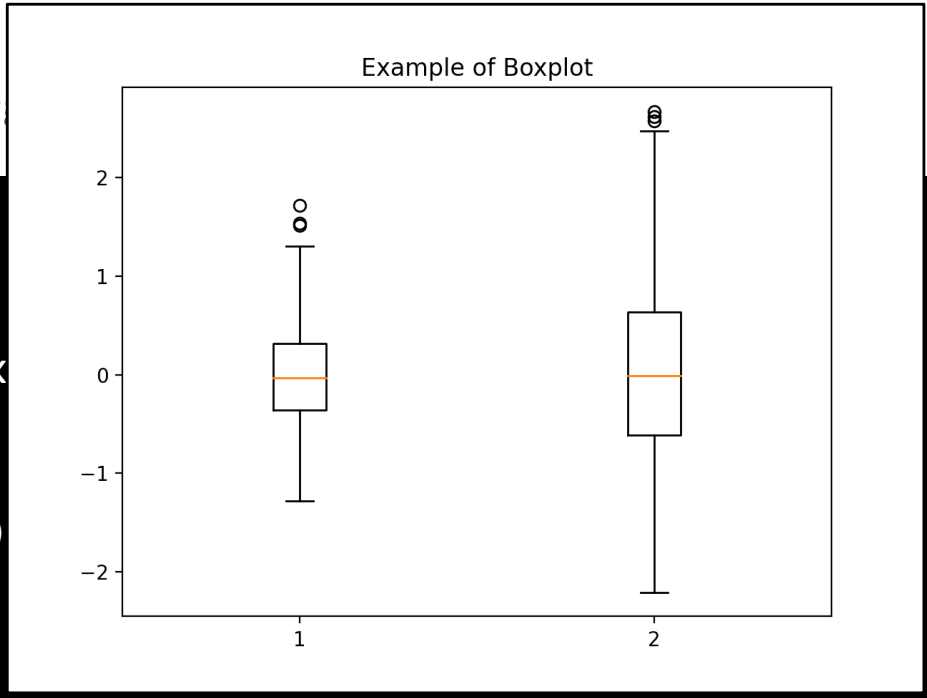
- **Boxplot**
  - `matplotlib.pyplot.boxplot(x, arguments)`

```
data0=np.random.normal(0, 0.5, size=(500,))
data1= np.random.normal(0, 1.0, size=(500,))
data=np.stack((data0,data1), axis=1)
plt.boxplot(data,  whis=1.5)
plt.title('Example of Boxplot')
plt.show()
```

Matplotlib

- **Boxplot**
  - matplotlib.pyplot.boxplot(x, ar

```
data0=np.random.normal(0, 0.5,
data1= np.random.normal(0, 1.0,
data=np.stack((data0,data1), ax
plt.boxplot(data,  whis=1.5)
plt.title('Example of Boxplot')
plt.show()
```



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Matplotlib

- **Scatter plot**
  - `matplotlib.pyplot.scatter(x, y, arguments)`
  - `x,y`: data positions, array of shape (n,)
  - Optional parameters. Some examples:
    - `s`: marker size, flot of array of floats with shape (n,)
    - `c`: array-like or list of colors or color,
    - `marker`: marker style, default ‘o’
    - `alpha`: The alpha blending value, between 0 (transparent) and 1 (opaque).
    - `norm`: scale the color data `c` in the range 0 to 1

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Matplotlib

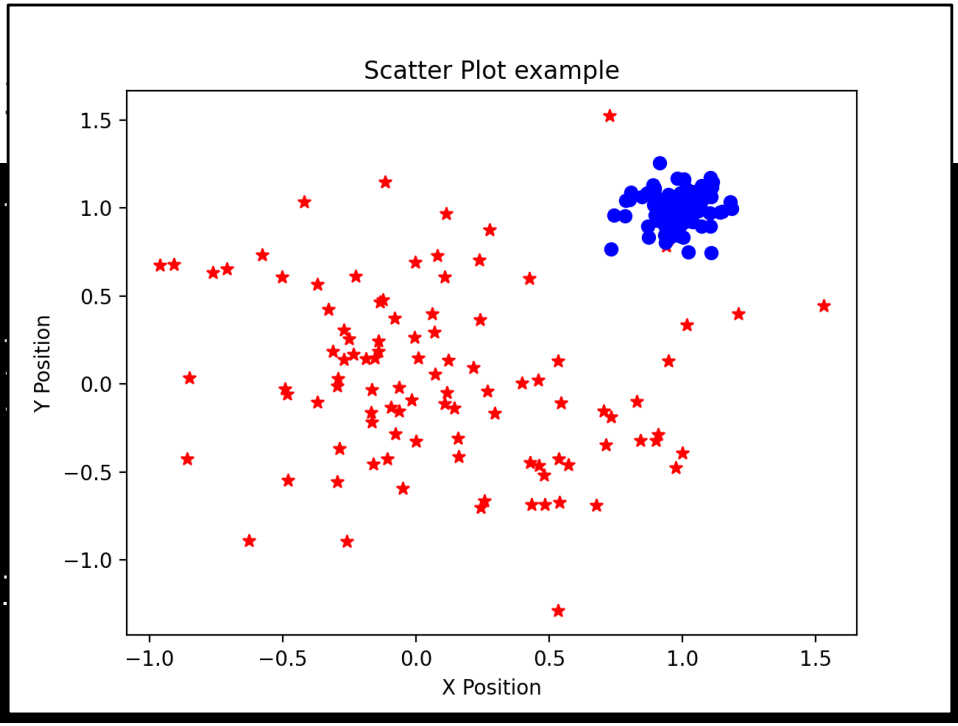
- **Scatter plot**
  - `matplotlib.pyplot.scatter(x, y, arguments)`

```
data0=np.random.normal(0, 0.5, size=(2,100))
data1 = np.random.normal(1.0, 0.1, size=(2, 100))
plt.scatter(data0[0],data0[1],c='r',marker='*')
plt.scatter(data1[0], data1[1], c='b', marker='o')
plt.xlabel('X Position')
plt.ylabel('Y Position')
plt.title('Scatter Plot example')
plt.show()
```

Matplotlib

- **Scatter plot**
  - matplotlib.pyplot.scatter(x,

```
data0=np.random.normal(0, 0.5
data1 = np.random.normal(1.0,
plt.scatter(data0[0],data0[1]
plt.scatter(data1[0], data1[1
plt.xlabel('X Position')
plt.ylabel('Y Position')
plt.title('Scatter Plot examp
plt.show()
```



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Matplotlib

- **Bar plot**
  - `matplotlib.pyplot.bar(x, height, arguments)`
  - `x`: float or array of x coordinates of the bars
  - `height`: float or array of y coordinates of the bar
  - Optional parameters. Some examples:
    - `width`: float of array of float numbers
    - `bottom`: float of array of y coordinates of the bottom
    - `color`: color or array of colors of the bar faces
    - `edgecolor`: color or array of colors of the bar edges
    - `hatch`: filling pattern {'/', '\', '|', '-', '+', 'x', 'o', 'O', '.', '*'}

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Matplotlib

- **Bar plot**
  - matplotlib.pyplot.bar(x, height, arguments)

```
xvalue=[2.873,2.148,8.98,6.642,3.769]
yvalue=["Rome","Paris","London", "Madrid", "Berlin"]
plt.bar(yvalue,xvalue, color=['m','r','g','b','y'], hatch='/')
plt.xlabel('EU Capitals')
plt.ylabel('Population (millions)')
plt.title('Bar example')
plt.show()
```

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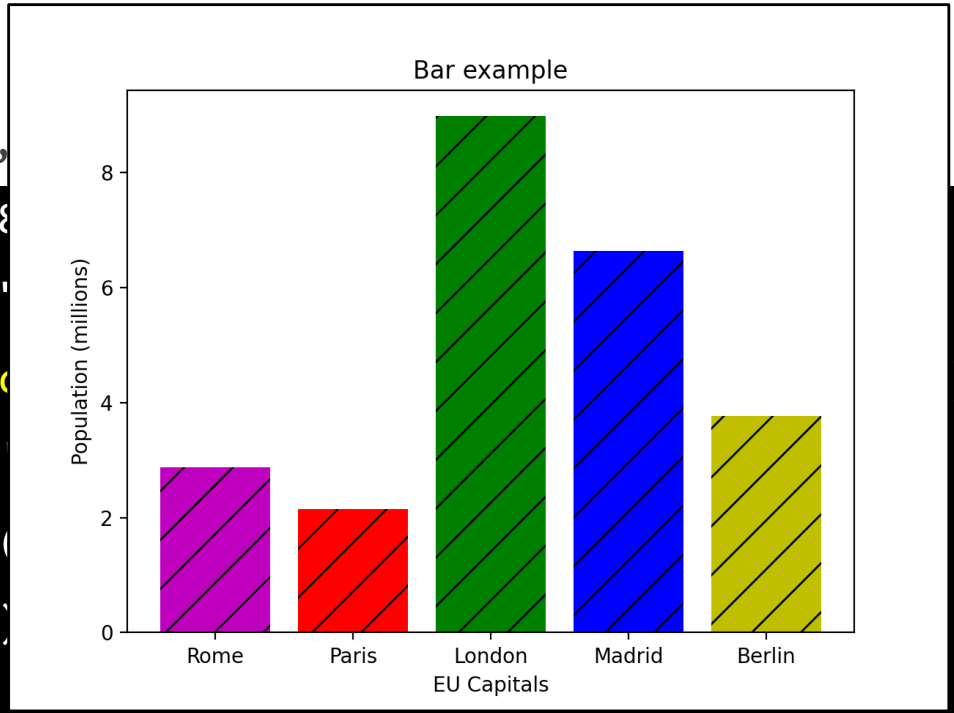
Matplotlib

- **Bar plot**
  - matplotlib.pyplot.bar(x,

```
xvalue=[2.873,2.148,8.98
yvalue=["Rome","Paris",'
plt.bar(yvalue,xvalue, c
plt.xlabel('EU Capitals'
plt.ylabel('Population (
plt.title('Bar example')
plt.show()
```



Matplotlib

- **Bar plot (MULTI-BAR)**
  - matplotlib.pyplot.bar(x, height, arguments)

```
data = [[2.638, 2.23, 8.42],
            [2.864, 2.19, 8.77],
            [2.856, 2.14, 8.96]]
X = np.arange(3)
plt.xticks([0.25,1.25,2.25],['Rome','Paris','London'])
plt.bar(X + 0.00, data[0], color='b', width=0.25, label='2013')
plt.bar(X + 0.25, data[1], color='g', width=0.25, label='2016')
plt.bar(X + 0.50, data[2], color='r', width=0.25, label='2019')
plt.xlabel('EU Capitals')
plt.ylabel('Population (millions)')
plt.title('Multi-Bar example')
plt.legend()
plt.show()
```

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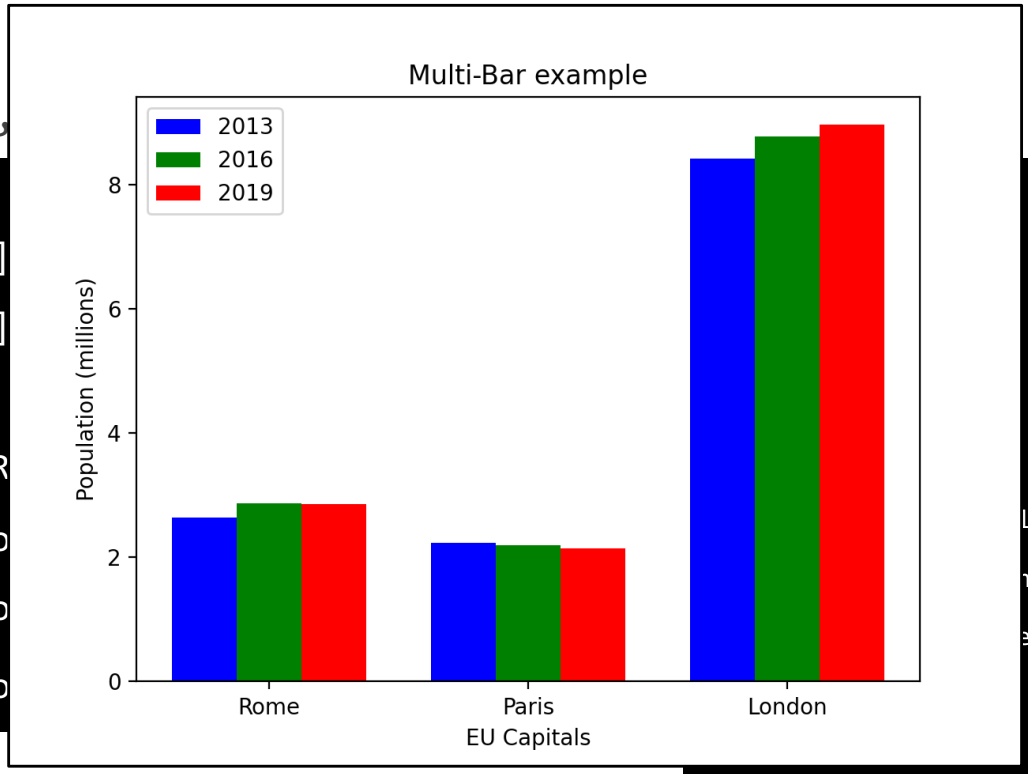
Matplotlib

- **Bar plot (MULTI-BAR)**
  - matplotlib.pyplot.bar(x,

```
data = [[2.638, 2.23, 8.42],
        [2.864, 2.19, 8.77]
        [2.856, 2.14, 8.96]
X = np.arange(3)
plt.xticks([0.25,1.25,2.25],['R
plt.bar(X + 0.00, data[0], colo
plt.bar(X + 0.25, data[1], colo
plt.bar(X + 0.50, data[2], colo
```




```
ls')
 (millions)')
example')
```

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Matplotlib

- **Pie Chart**
  - `matplotlib.pyplot.pie(x, arguments)`
  - `x`: The wedge sizes. The fractional area of each wedge is given by x/sum(x)
  - Optional parameters. Some examples:
    - `labels`: A sequence of strings providing the labels for each wedge
    - `colors`: A sequence of matplotlib color args through which the pie chart will cycle
    - `radius`: The radius of the pie
    - `startangle`: rotates the start of the pie chart counterclockwise from the x-axis
    - `shadow`: boolean, draw a shadow beneath the pie

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Matplotlib

- **Pie Chart**
  - `matplotlib.pyplot.pie(x, arguments)`

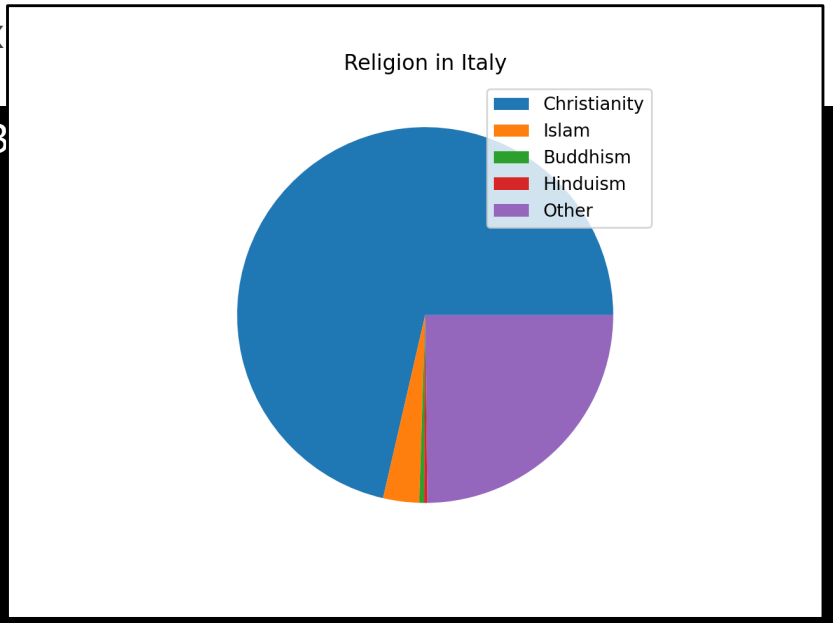
```
data1=np.array([71.4, 3.1, 0.4, 0.3, 24.8])
label=['Christianity', 'Islam', 'Buddhism', 'Hinduism', 'Other']
plt.pie(data1)
plt.legend(label)
plt.title('Religion in Italy')
plt.show()
```

Matplotlib

- **Pie Chart**
  - matplotlib.pyplot.pie(x

```
data1=np.array([71.4, 3
label=['Christianity',
plt.pie(data1)
plt.legend(label)
plt.title('Religion in
plt.show()
```

```
'Other']
```



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Data Visualization

- **Why data visualization**
- **Basic concepts and tools**
  - Some definitions: marks, channels, separability
  - Dealing with colors
  - Univariate attribute
  - Multivariate attributes
- **Plotting data with Python**
  - Matplotlib library
  - *Seaborn library*

Seaborn

- **Python 2D/3D plotting library**
  - Built on top of matplotlib
  - Object-oriented API

- **Integrated with Pandas library**
  - Same Matplotlib plot types (e.g. bar plots) + additional plot styles (e.g. heatmaps) and customization effects
- **Official (introductory, intermediate, advanced) tutorials:**
  - https://seaborn.pydata.org/tutorial.html

```
pip install -U seaborn
```

```
import seaborn as sns
```

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Seaborn

- **Histogram plot**
  - `sns.displot(x, bins, other_arguments)`
- **Box plot**
  - `sns.boxplot(df['age'], whis, other_arguments)`
- **Scatter plot**
  - `sns.scatterplot(x, y, hue, other_arguments)`
- **Line plot**
  - `sns.lineplot(x, y, , other_arguments)`

Seaborn

- **Density plot**
  - `seaborn.kdeplot(x,y,arguments)`
  - `x,y:` Variables that specify positions on the x and y axes.
  - Optional parameters. Some examples:
    - `kernel`: function that defines the kernel (default: Gaussian)
    - `bw`: smoothing factor
    - `cumulative`: If True, computes the compulative function
    - `clip`: do not evaluate the density outside of these limits.

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Seaborn

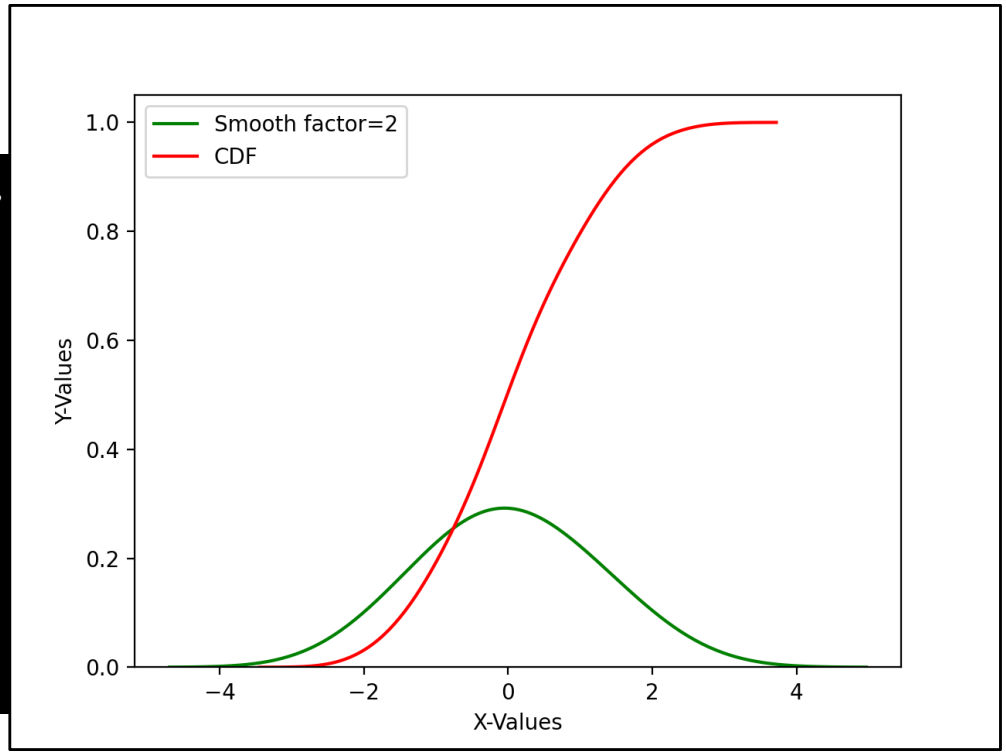
- **Density plot**
  - `seaborn.kdeplot(x,y,arguments)`

```
data0 = np.random.normal(0, 1.0, size=(100,))
sns.kdeplot(data0, color='g', bw_adjust=2, label='Smooth factor=2')
sns.kdeplot(data0, color='r', cumulative=True, label='CDF')
plt.legend()
plt.xlabel("X-Values")
plt.ylabel("Y-Values")
plt.show()
```

Seaborn

- **Density plot**
  - seaborn.kdeplot(x,y,arguments)

```
data0 = np.random.normal(0, 1.
sns.kdeplot(data0, color='g',
sns.kdeplot(data0, color='r',
plt.legend()
plt.xlabel("X-Values")
plt.ylabel("Y-Values")
plt.show()
```



Seaborn

Heatmap

- `seaborn.heatmap(data, arguments)`
- `data:` 2D dataset that can be coerced into an ndarray. If a Pandas DataFrame is provided, the index/column information will be used to label the columns and rows.
- Optional parameters. Some examples:
  - `cmap`: mapping from data values to color space
  - `vmin, vmax`: values to anchor the colormap, otherwise they are inferred from the data
  - `annot`: If True, write the data value in each cell
  - `cbar`: boolean, whether to show the colorbar
  - `linewidths`: Width of the lines that will divide each cell

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Matplotlib

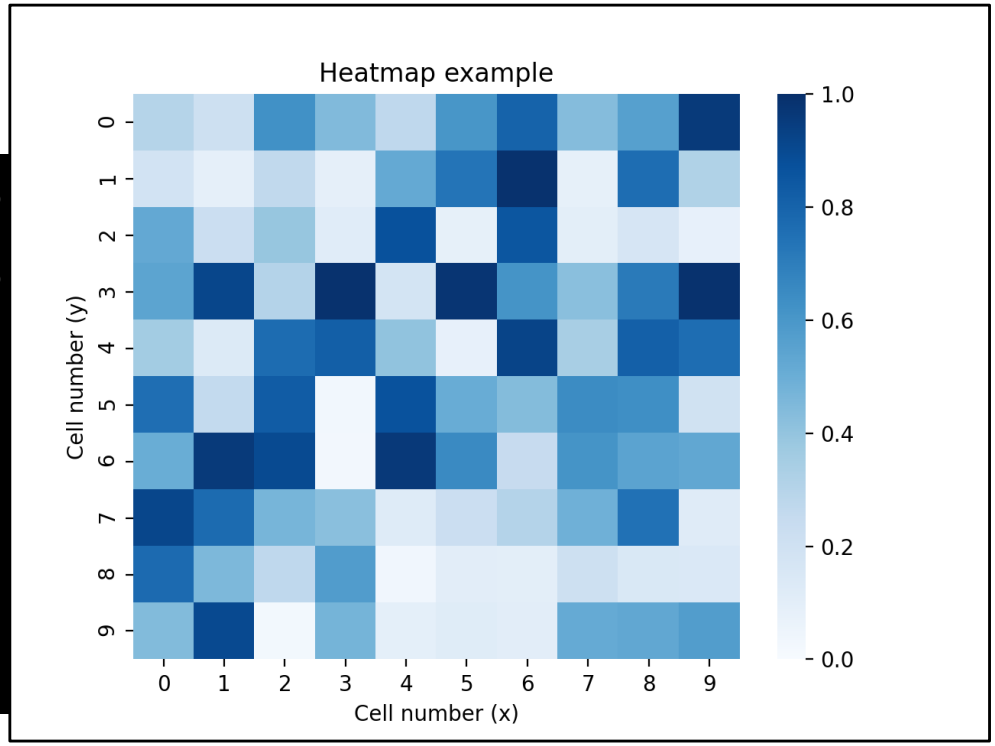
- **Heatmap**
  - seaborn.heatmap(map, arguments)

```
normal_data = np.random.rand(10, 10)
sns.heatmap(normal_data, vmin=0, vmax=1, cmap='Blues')
plt.xlabel('Cell number (x)')
plt.ylabel('Cell number (y)')
plt.title('Heatmap example')
plt.show()
```

Matplotlib

- **Heatmap**
  - seaborn.heatmap(map, arguments)

```
normal_data = np.random.rand(10,
sns.heatmap(normal_data, vmin=0,
plt.xlabel('Cell number (x)')
plt.ylabel('Cell number (y)')
plt.title('Heatmap example')
plt.show()
```



Seaborn

- **Scatter Plot Matrix**
  - `seaborn.pairplot(data, arguments)`
  - `data:` dataframe where each column is a variable and each row is an observation.
  - Optional parameters. Some examples:
    - `hue`: Variable in data to map plot aspects to different colors
    - `kind`: Kind of plot to make {‘scatter’, ‘kde’, ‘hist’, ‘reg’}
    - `height`: Height of each facet
    - `palette`: Set of color for the Hue variable

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Seaborn

- **Scatter Plot Matrix**
  - `seaborn.pairplot(data, arguments)`

```
data = np.random.normal(0, 0.5, size=(100,3))

category=np.random.randint(1,4, size=(100,))

df=pd.DataFrame({'Attribute1': data[:, 0], 'Attribute2': data[:, 1],
'Attribute3': data[:, 2],'Class': category})

sns.pairplot(df, height=1, hue='Class')

plt.show()
```

Seaborn

- **Scatter Plot Matrix**
  - `seaborn.pairplot(dat`

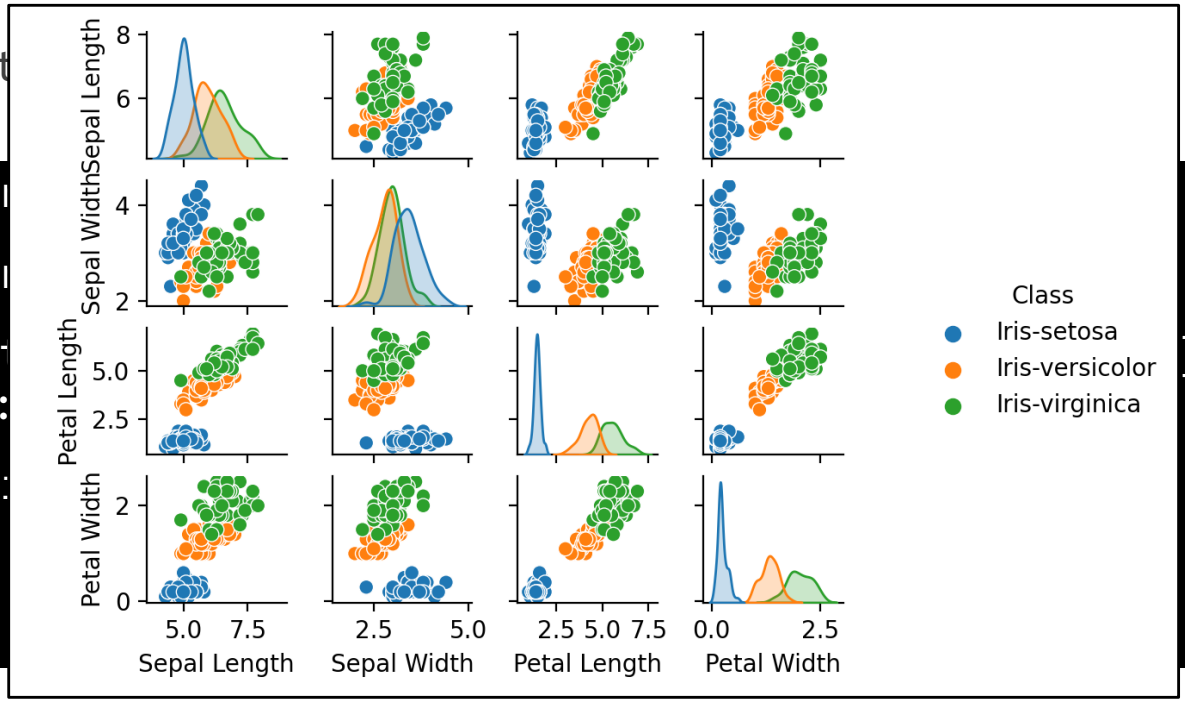
```
data = np.random.nor

category=np.random.r

df=pd.DataFrame({'A
'Attribute3': data[:

sns.pairplot(df, he

plt.show()
```



Seaborn

Subplots with Seaborn

```
fig, axs = plt.subplots(2, figsize=(18, 10))

sns.kdeplot(df['age'], ax=axs[0], color='g', bw_adjust=2,
label='Smooth factor=2')

sns.kdeplot(df['age'], ax=axs[1], color='r', cumulative=True,
label='CDF')

plt.show()
```