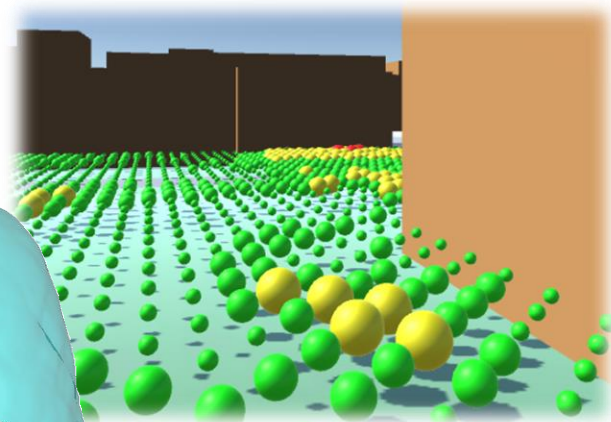
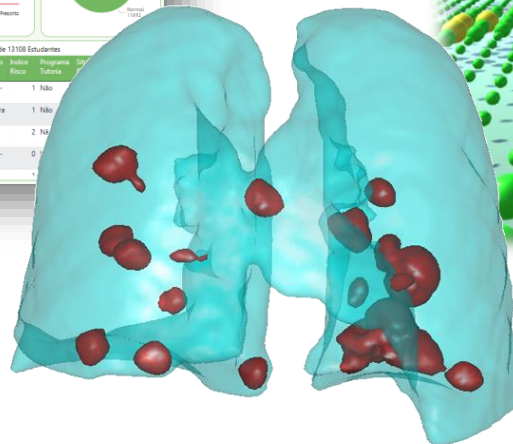




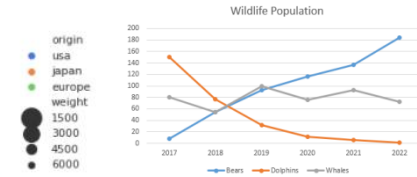
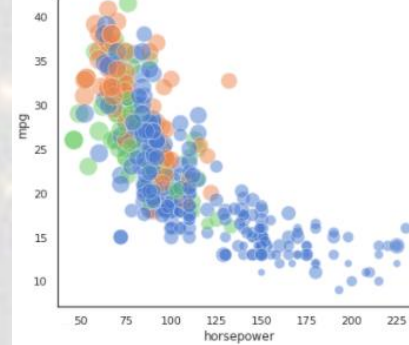
Data Visualization module 2024

Introduction



40	180	0.76	0	0.0	0	7.4193	0.0009	0.009	0	1.200	0.015	1.160	2.07
67	201	0.77	0	0.0	0	8.7669	0.0018	0.022	0	1.166	0.018	1.130	1.78
88	201	3.12	0	0.0	0	11.8279	0.0062	0.072	0	0.421	0.015	0.490	0.85
52	183	-0.15	0	0.0	0	8.2405	0.0011	0.015	0	0.425	0.007	0.490	2.60
02	115	0.28	3	0.0	0	11.0625	0.0035	0.035	0	1.567	0.197	1.490	0.56
25	151	1.82	0	0.0	0	6.6890	0.0006	0.007	0	0.955	0.005	0.940	4.38
48	108	-0.51	0	0.0	0	8.6208	0.0015	0.011	0	0.516	0.015	0.590	1.65
50	105	2.69	0	0.0	0	7.6923	0.0012	0.010	0	1.438	0.017	1.430	1.65
81	203	-0.58	0	0.0	0	8.8563	0.0017	0.024	0	0.962	0.014	0.950	1.68
38	106	1.01	0	0.0	0	7.6626	0.0015	0.011	0	0.456	0.015	0.530	1.92
48	144	0.70	0	0.0	0	9.1657	0.0015	0.017	0	0.520	0.015	0.600	1.30
54	198	7.07	0	0.0	0	6.4211	0.0006	0.008	0	0.763	0.003	0.800	2.87
63	135	-0.37	0	0.0	0	9.2438	0.0018	0.020	0	0.535	0.020	0.610	1.46
86	188	-1.27	0	0.0	0	9.4598	0.0026	0.026	0	0.671	0.017	0.730	1.35
65	184	-0.61	0	0.0	0	8.9385	0.0013	0.016	0	0.468	0.013	0.540	1.66
98	180	-0.35	0	0.0	0	9.3109	0.0019	0.024	0	1.041	0.020	1.010	1.44
40	157	-1.40	0	0.0	0	8.3069	0.0011	0.012	0	0.142	0.010	0.160	2.43
60	87	2.24	0	0.0	0	7.7648	0.0020	0.014	0	1.453	0.018	1.460	1.66
72	165	-0.74	0	0.0	0	9.1842	0.0022	0.024	0	0.848	0.017	0.860	1.33
12	158	0.32	0	0.0	0	8.2076	0.0011	0.010	0	0.466	0.015	0.540	2.00
30	111	6.90	0	0.0	0	6.5466	0.0009	0.007	0	0.514	0.005	0.590	3.55
56	138	2.04	0	0.0	0	9.2353	0.0016	0.020	0	0.916	0.004	0.960	1.20
38	104	-0.25	0	0.0	0	7.8503	0.0015	0.009	0	1.150	0.014	1.110	1.90
93	137	4.22	0	0.0	0	10.5345	0.0037	0.035	0	0.391	0.045	0.460	0.67
55	129	-0.53	0	0.0	0	8.7854	0.0019	0.020	0	0.778	0.015	0.810	1.81
38	114	0.97	0	0.0	0	7.5669	0.0018	0.018	0	0.475	0.009	0.550	2.18
09	134	5.96	1	0.0	0	10.3360	0.0055	0.082	2	0.570	0.042	0.640	0.58
64	177	-0.96	0	0.0	0	8.7201	0.0018	0.021	0	0.026	0.013	0.040	1.75
43	186	0.87	0	0.0	0	8.2910	0.0011	0.010	0	0.387	0.012	0.450	1.68
28	157	1.36	0	0.0	0	6.3456	0.0006	0.007	0	1.032	0.005	1.000	4.16
41	114	1.71	0	0.0	0	8.8825	0.0012	0.009	0	1.104	0.018	1.070	1.57
87	136	-1.30	1	0.0	0	9.7391	0.0025	0.028	0	0.800	0.000	0.800	1.07
50	170	1.94	0	0.0	0	8.7350	0.0013	0.017	0	1.035	0.016	1.010	1.39
69	164	1.13	0	0.0	0	10.8416	0.0044	0.044	0	1.150	0.020	1.250	0.80
44	170	1.65	0	0.0	0	7.4752	0.0008	0.009	0	1.164	0.008	1.130	2.70
68	129	0.76	0	0.0	0	9.6309	0.0020	0.018	0	0.450	0.030	0.520	1.22
34	257	2.90	0	0.0	0	6.6231	0.0006	0.010	0	0.616	0.005	0.680	4.70
65	89	1.42	0	0.0	0	9.1849	0.0022	0.014	0	0.906	0.024	0.910	1.11

The problem...



Data visualization?



Machine learning?

Statistics/ Data analysis?



What is Data Visualization?

- Visualization is focused on how to **visually represent and explore large amounts of data**
- Taking advantage of the **human visual system capacities**
- Providing “**insights**” concerning the phenomenon behind the data

What it **is not**:

- just “pretty pictures”!

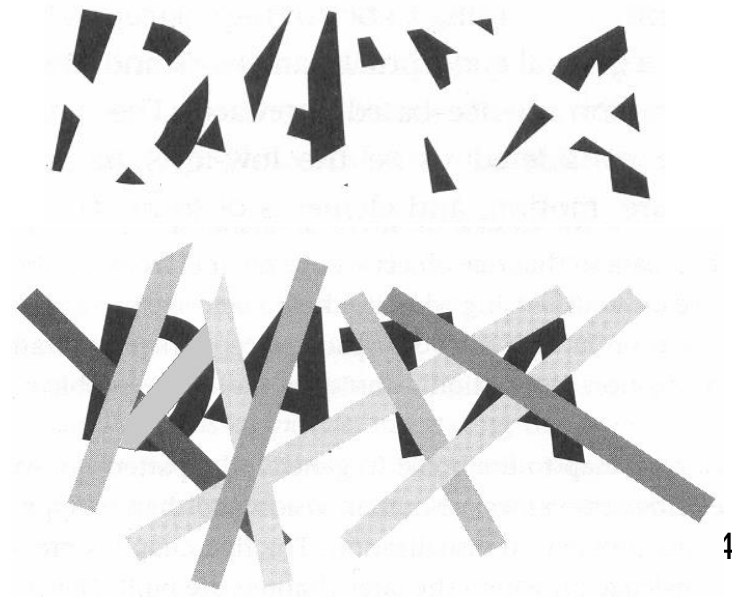
Why and how to represent data visually?

- The human visual system is a most powerful pattern seeker

“seeing is understanding...”

- We easily see patterns displayed in certain ways

but not in others ...



An exercise in preattentive processing: how many “3”?

69704259347493
58728294954642
44396854634235
6658789376

(Nussbaumer Knaflitz, 2015)

69704259347493
58728294954642
44396854634235
6658789376

It is much easier!

How many “7”?

C. Nussbaumer Knaflic, Storytelling with Data ,Talks at Google, 2015
<https://www.youtube.com/watch?v=8EMW7io4rSI>

Why represent data visually?

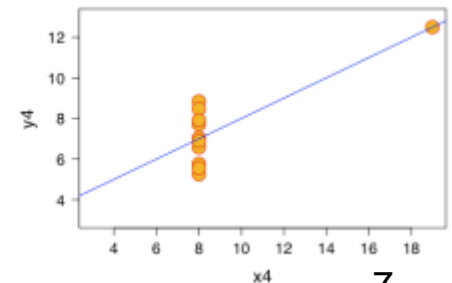
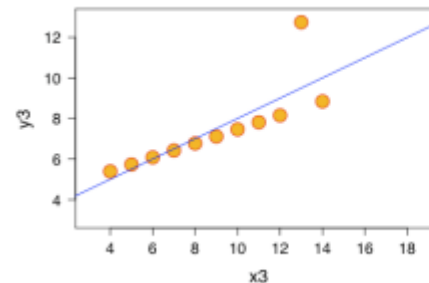
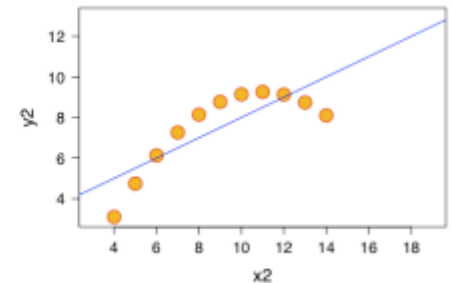
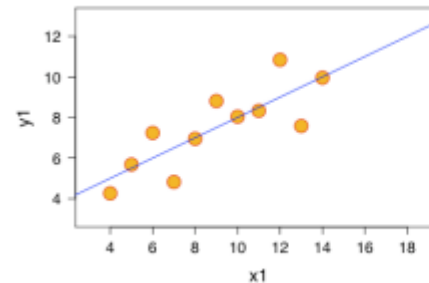
Vis helps in situations where seeing the dataset structure in detail is better than seeing only a brief summary of it.

(Munzner, 2014)

Anscombe's Quartet: Raw Data								
I		II		III		IV		
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
var.	10.0	3.75	10.0	3.75	10.0	3.75	10.0	3.75
corr.	0.816		0.816		0.816		0.816	

Ascombe quartet: data sets with the same simple statistical properties

(Tuft, 1983)



Example of Presentation based on a simple Visualization:

World health by Hans Rosling

200 years of health/income – 120 000 values in 4 min



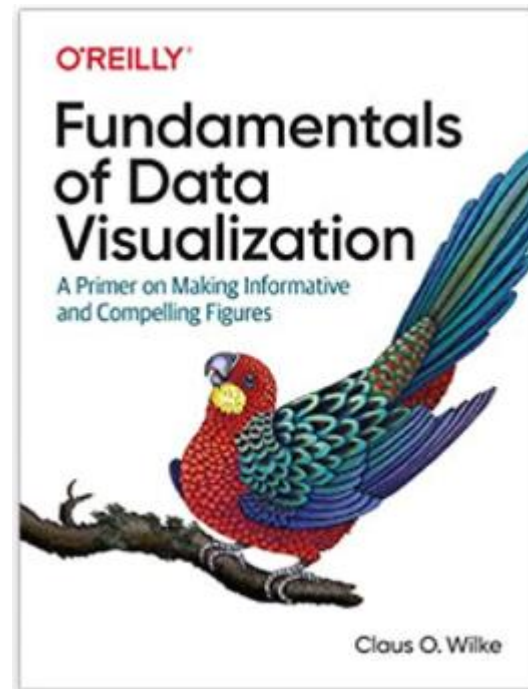
<https://www.youtube.com/watch?v=jbkSRLYSojo>
<https://books.google.pt/books/about/Factfulness>

This module:

- Objective, bibliography and tools
- Introduction to Data Visualization
- Data and phenomena: types and pre-processing
- Human-in-the-loop process: perceptual and cognitive aspects
- Visualization of quantitative data:
 - 1D and 2D Data – main methods; exercises
 - 3D and nD data - main methods; exercises
- Visualization of other types of data
 - networks, hierarchical data, etc.
- Effective Visualization

Bibliography

- Camões, J., *Data at Work : Best practices for creating effective charts and information graphics in Microsoft Excel*, Pearson Education, 2016
<https://learning.oreilly.com/library/view/data-at-work/9780134268798/>
- [Wilke, C., *Fundamentals of Data Visualization: A Primer on Making Informative and Compelling Figures*, O'Reilly, 2019](https://learning.oreilly.com/library/view/fundamentals-of-data/9781492031079/)
<https://learning.oreilly.com/library/view/fundamentals-of-data/9781492031079/>

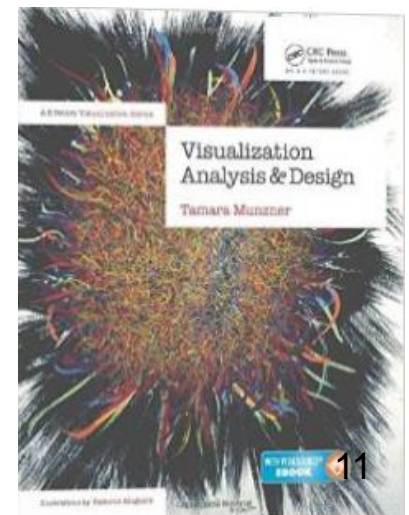
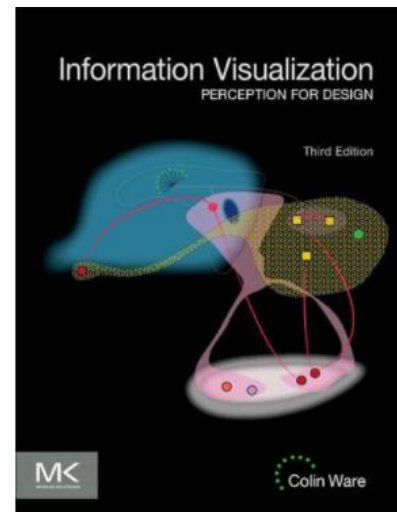
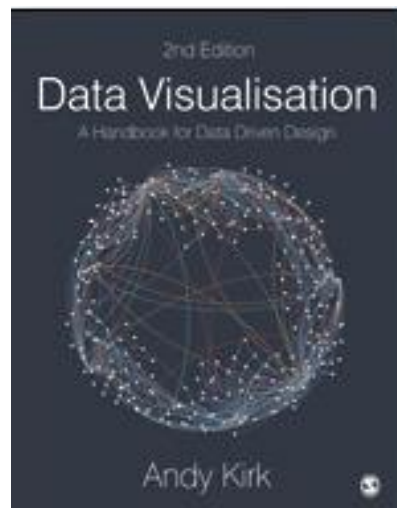
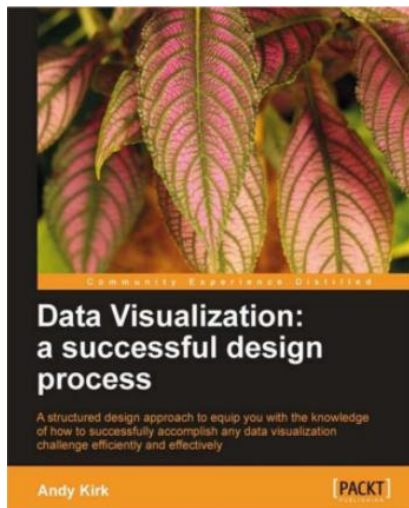


More advanced bibliography

- Kirk, A., Data Visualisation A Handbook for Data Driven Design, 2nd. Ed., Sage, 2019
- Ware, C., Information Visualization, Perception for Design, 3rd ed., Morgan Kaufman, 2012
- Munzner, T., *Visualization Analysis and Design*, A K Peters/CRC Press, 2014
- [Kirk, A., *Data Visualization: A successful design process*, Pack Publishing, 2012](#)

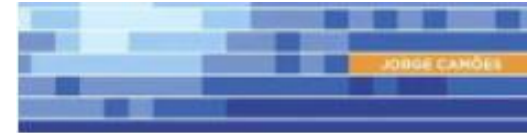
Explore other books available at the playlist:

<https://learning.oreilly.com/playlists/74bfec5e-4346-48ff-82b4-657fda6922b6>



Interesting links

- <https://excelcharts.com/author/jorge-camoes/>



- <https://eagereyes.org/>



- <http://www.perceptualedge.com/>

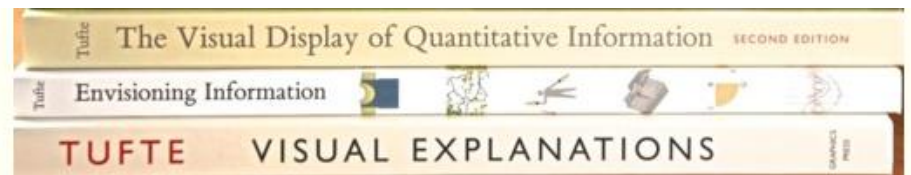


Visual Business Intelligence
for enlightening analysis and communication

- <http://www.thefunctionalart.com/>



- <https://www.edwardtufte.com/tufte>



Interesting links



- <https://medium.com/multiple-views-visualization-research-explained>

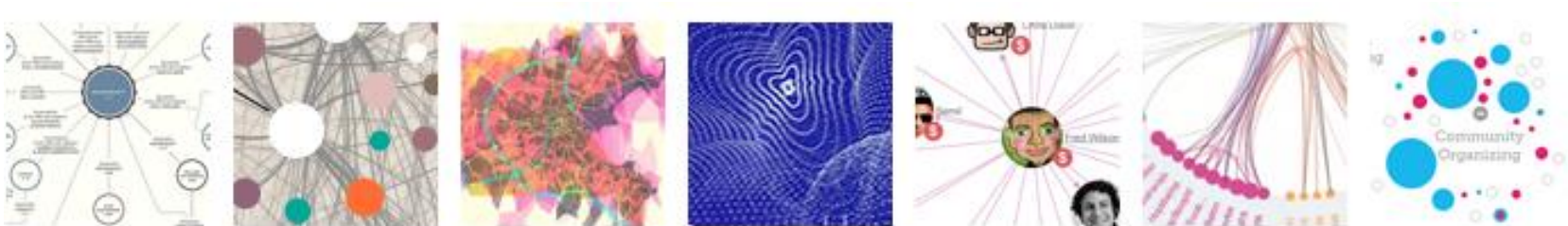
- <http://seeingdata.org/>



- <https://flowingdata.com/about>








- <http://www.visualcomplexity.com/vc/>



Moodle

▼ Slides

-  Introduction to the module
-  Introduction to Visualization
-  Data
-  Creating a Visualization
-  Effective Visualization

▼ Examples and Practical assignments

-  Assignment - How Visualization was used in a specific research/development work
-  Example: Using Visualization in the development of Multilayer radiating structures for mm Waves
-  Template for the assignment - presenting how Visualization was used

▼ Bibliography

-  Camões, J., Data at Work : Best practices for creating effective charts and information graphics in Microsoft Excel, Pearson Education, 2016
-  Wilke, C., Fundamentals of Data Visualization: A Primer on Making Informative and Compelling Figures, O'Reilly, 2019
-  Healy, K., Data Visualization a Practical Introduction, Princeton, 2019
-  Kirk, A., Data Visualization: A successful design process, Pack Publishing, 2012
-  Spence, R., Design for Interaction (2nd Edition), Pearson, 2007
-  More Advanced Bibliography- playlist

Sessions

(subject to minor adjustments)

- 1** - Introduction to the module, bibliography, and S/W
- 2** - Data Visualization - definition, history, model, critical analysis of examples
Visualization Literacy Quiz
- 3** - Data - different types, phenomena they represent and pre-processing
- 4/5** – Human-in the loop process - introduction to the visual and cognitive system
Visualization of 1D and 2D, 3D Data, beyond quantitative data – main
methods; application exercises
- 6** – Effective Visualization; application examples
- 7/8** – Assignment presentation and discussion
- 9** – Test

Assessment Module 3

During the semester:

Test – 60%

Practical Assignment - 30%

Attendance and participation – 10%

Alternative at the end of semester:

Exam – 90%

Attendance and participation – 10%

Test – last session of the module – June, 3rd

Assignment submission (via Moodle) – May, 22th

Assignment presentation and discussion – May 23th, 27th

Practical activities

Next lecture bring your own laptop!

Assignment (team work)

- Prepare and present an example illustrating the usage of visualization in a specific engineering field
(e.g. chemical, computer, electrical, mechanical, etc.)

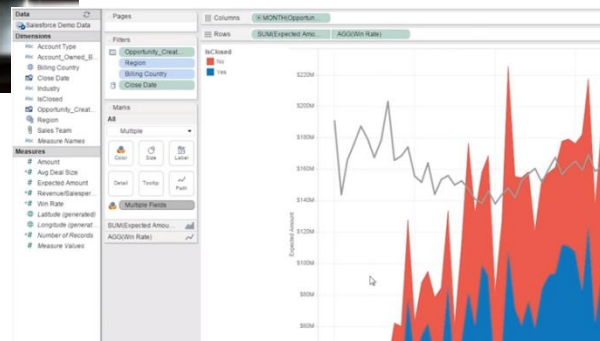
or

- Select and present a Visualization paper

Questions regarding the module?



Visualization S/W



Which Visualization Tool?

It depends ...

- Exploratory (discover pattern, multiple views)
or Explanatory (View of the data presenting discovered highlights)?
- Type of data (Maps, Charts, Data,...)
- Developer or non-developer?
- Scientific or information Visualization (2D,3D, structured or not?)
- Interactive or Static?
- Web or local?
- Easy to use or Flexible?
- Protection of data?...

Visualization Tools – Some possible choices

- If you want to produce a few simple charts for a report or paper: Excel, ...
- If you want to produce some charts and have some programming skills: MATLAB, R, python libraries, ...
- If you use some statistics/analytics S/W: Statistica, SPSS, ...
- If you are in a large company: Tableau or Qlickview may be adequate (very powerful and expensive business intelligence S/W)
- If you just want to make a few simple charts for your web page and have programming skills: google charts
- If you want to develop an interactive visualization Web application to visually explore data: D3.js

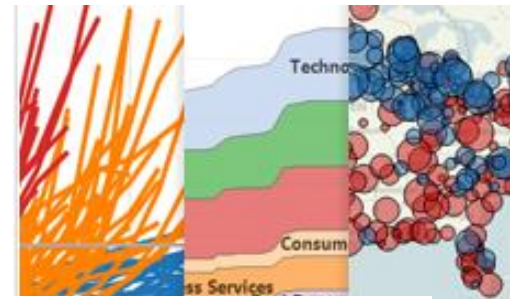
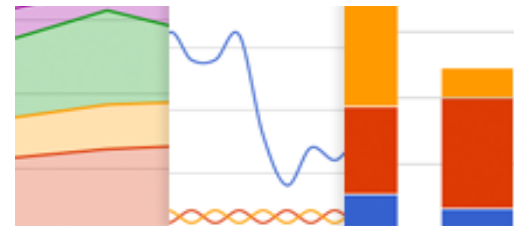


Tableau Public

A desktop application to build and post interactive graphs, dashboards, maps and tables to the web.



Google Chart Tools

A collection of simple to use, customizable and free to use interactive charts and data tools.

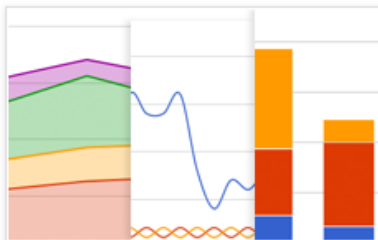


D3.js

An small, flexible and efficient library to create and manipulate interactive documents based on data.

Visualization S/W

- There are a lot of tools, of different types and with different purposes from very simple to very complex ...
- Some interesting and widely used tools:



Google Chart Tools

A collection of simple to use, customizable and free to use interactive charts and data tools.



D3.js

A small, flexible and efficient library to create and manipulate interactive documents based on data.



R

A software environment for statistical computing and graphical techniques.

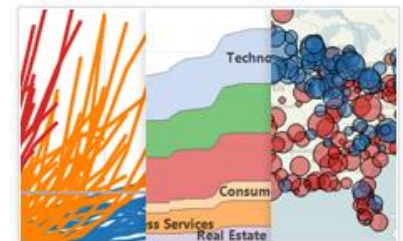


Tableau Public

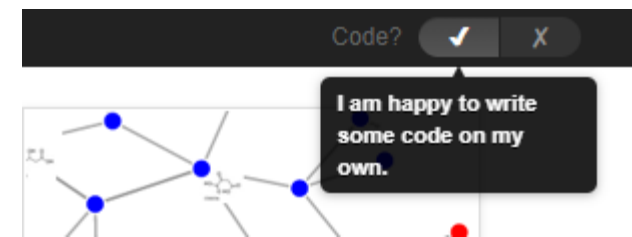
A desktop application to build and post interactive graphs, dashboards, maps and tables to the web.

see e.g.

<https://www.kdnuggets.com/2020/05/top-10-data-visualization-tools-every-data-scientist.html>

<https://www.kdnuggets.com/2019/04/7-qualities-big-data-visualization-tools.html>

<http://selection.datavisualization.ch/>



Visualization Tools

- There are a lot, of different types and with different purposes

(see e.g. <http://selection.datavisualization.ch/>)

+ DATAVISUALIZATION.CH

SELECTED TOOLS

Search...

All


Maps

Charts

Data


Color

Code? ✓




Arbor.js

A library of force-directed layout algorithms plus abstractions for graph organization and refresh handling.




CartoDB

A web service for mapping, analyzing and building applications with data.




Chroma.js

Interactive color space explorer that allows to preview a set of linear interpolated equidistant colors.



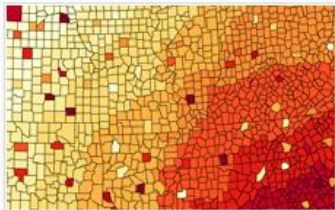
Circos

A software package for visualizing data in a circular layout.



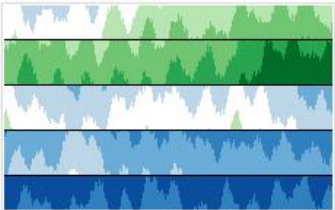
Cola.js

A library for arranging networks using constraint-based optimization techniques.



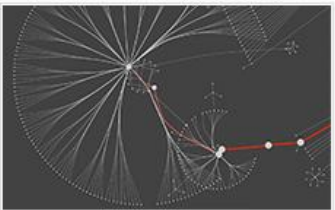
ColorBrewer

A web tool for selecting colors for maps.



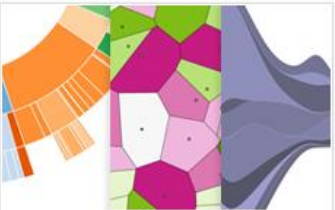
Cubism.js

A library for creating interactive time series and horizon graphs based on D3.js



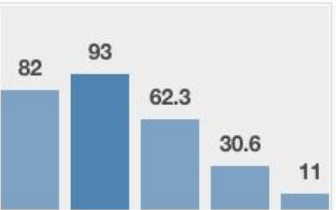
Cytoscape

An application for visualizing complex networks and integrating these with any type of attribute data.



D3.js

An small, flexible and efficient library to create and manipulate interactive documents based on data.

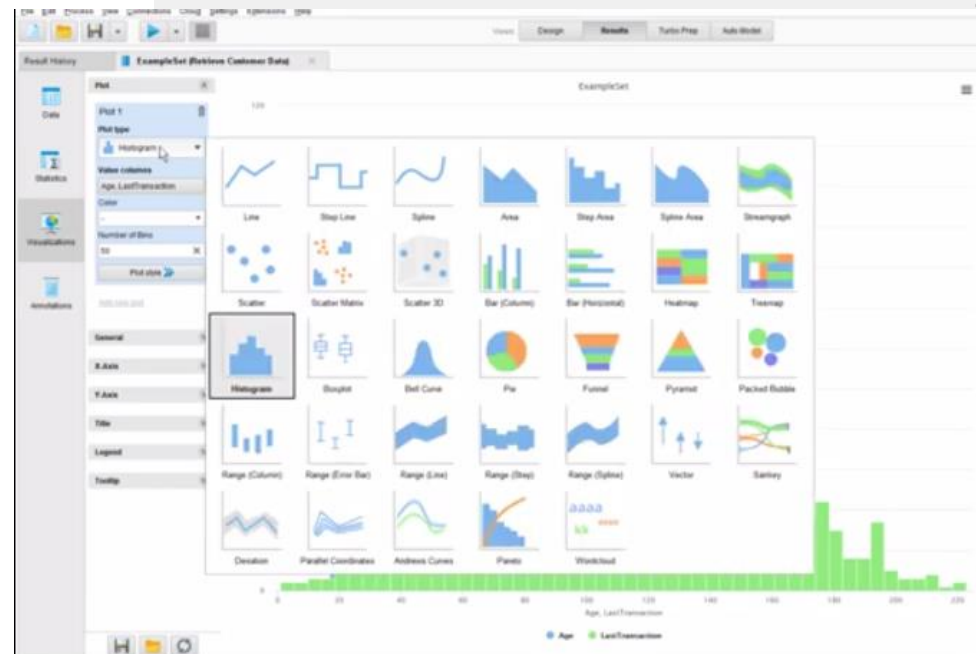
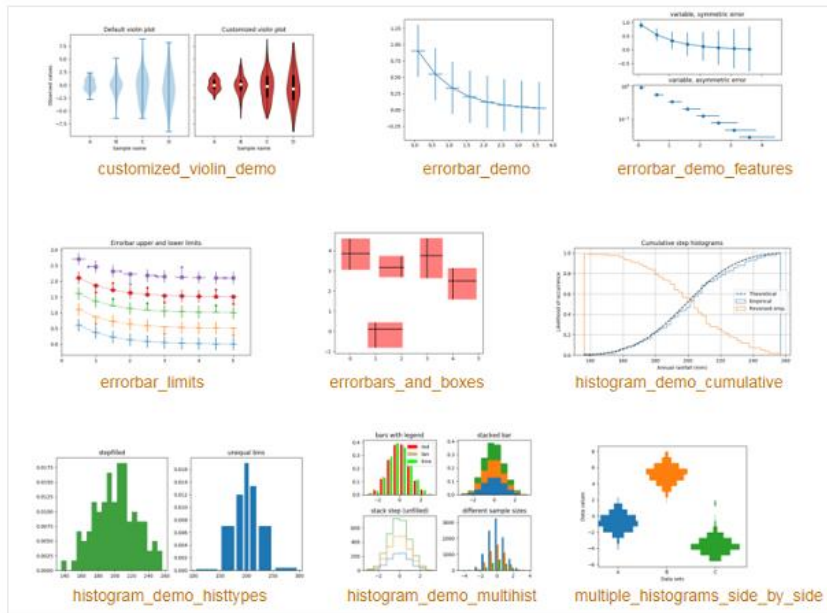
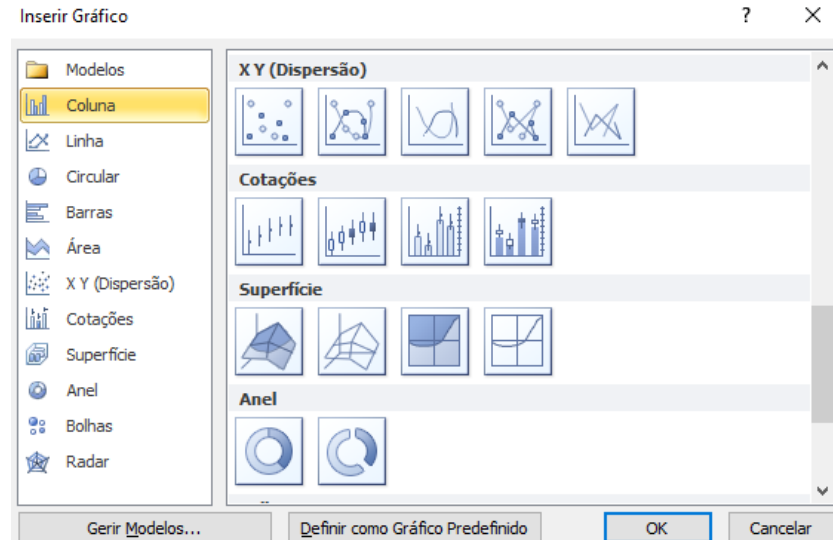


Dance.js

A simple data-driven visualization framework based on Data.js and Underscore.js

We may use the Visualization capabilities of other S/W or online tools

- Excel
- SPSS
- Rapidminer
- Weka
-
- Python graphics libraries (e.g. Bokeh)
- ...



2023 Gartner Magic Quadrant for Analytics and Business Intelligence Platforms

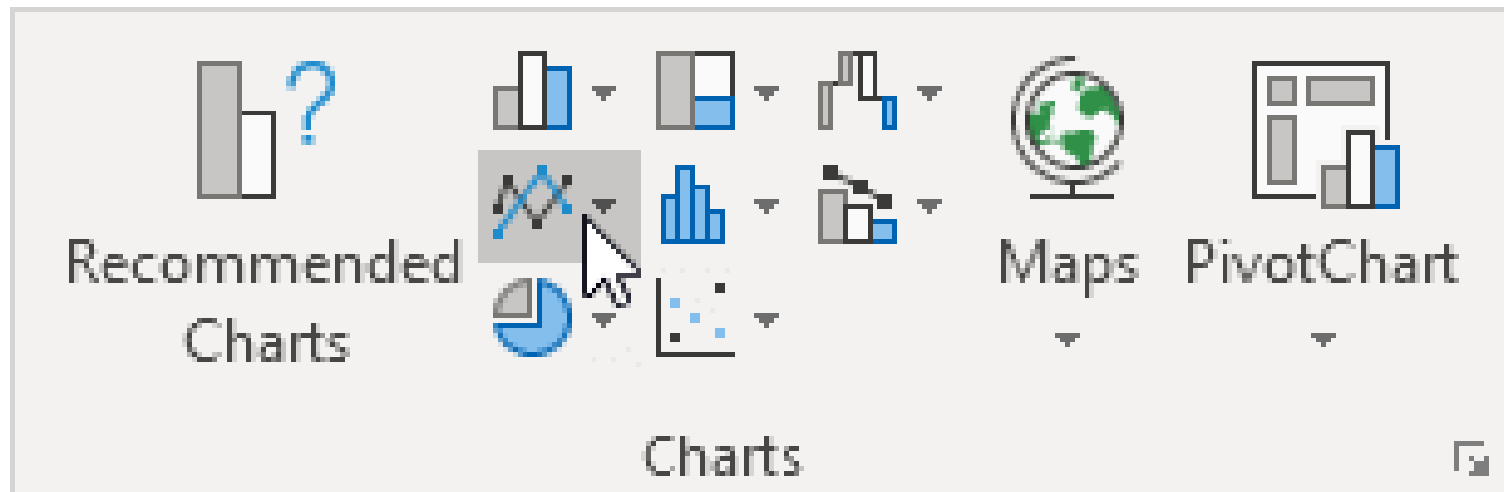


Note: the report is
available upon request

We will use

- Excel
- Python + Matplotlib

(but you may use also other S/W if you master it)



Suggestion for more advanced programmers...

- Python + Bokeh (<https://bokeh.org/>)



Bokeh at a Glance

Flexible

Interactive

Shareable

Bokeh

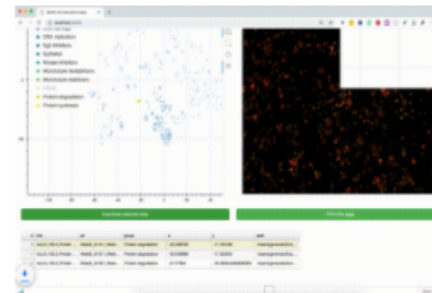
(bokeh.org)

User Showcase

Dask

Dask is a tool for scaling out PyData projects like **NumPy**, **Pandas**, **Scikit-Learn**, and **RAPIDS**. It is supported by **Nvidia**, **Quansight**, and **Anaconda**.

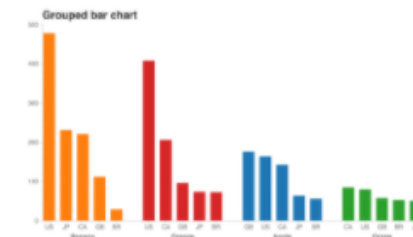
The **Dask Dashboard** is a diagnostic tool that helps you monitor and debug live cluster performance.



Microscopium

Microscopium is a project maintained by researchers at **Monash University**.

It allows researchers to discover new gene or drug functions by exploring large image datasets with Bokeh's interactive tools.



Chartify

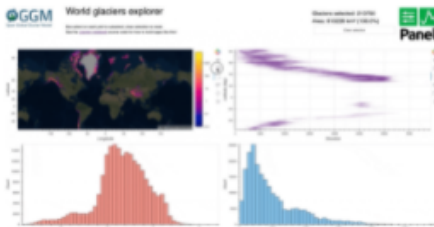
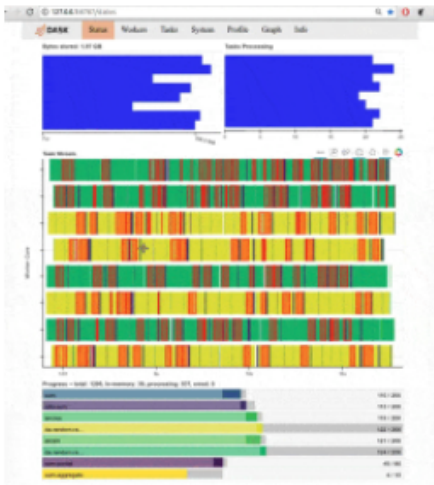
Chartify is an opinionated high-level charting API built on top of Bokeh, created by **Spotify**.

With smart default styles, consistent tidy data format, and a simple API, it's easy for you to concentrate on your work.

Panel

Panel is a tool for polished data presentation that utilizes the Bokeh server. It is created and supported by **Anaconda**.

Panel makes it simple to create custom interactive web apps and dashboards by connecting user-defined widgets to plots, images, tables, or text.



For next session:

- Select assessment mode:
 - (along semester/ final)
- If you selected along the semester:
 - Organize groups (5 students)
 - Select assignment topic

And bring your laptop!