INFO 1998: Introduction to Machine Learning

CDS Education

We explore, learn, and educate big minds.

Lecture 3: Data Visualization

INFO 1998: Introduction to Machine Learning

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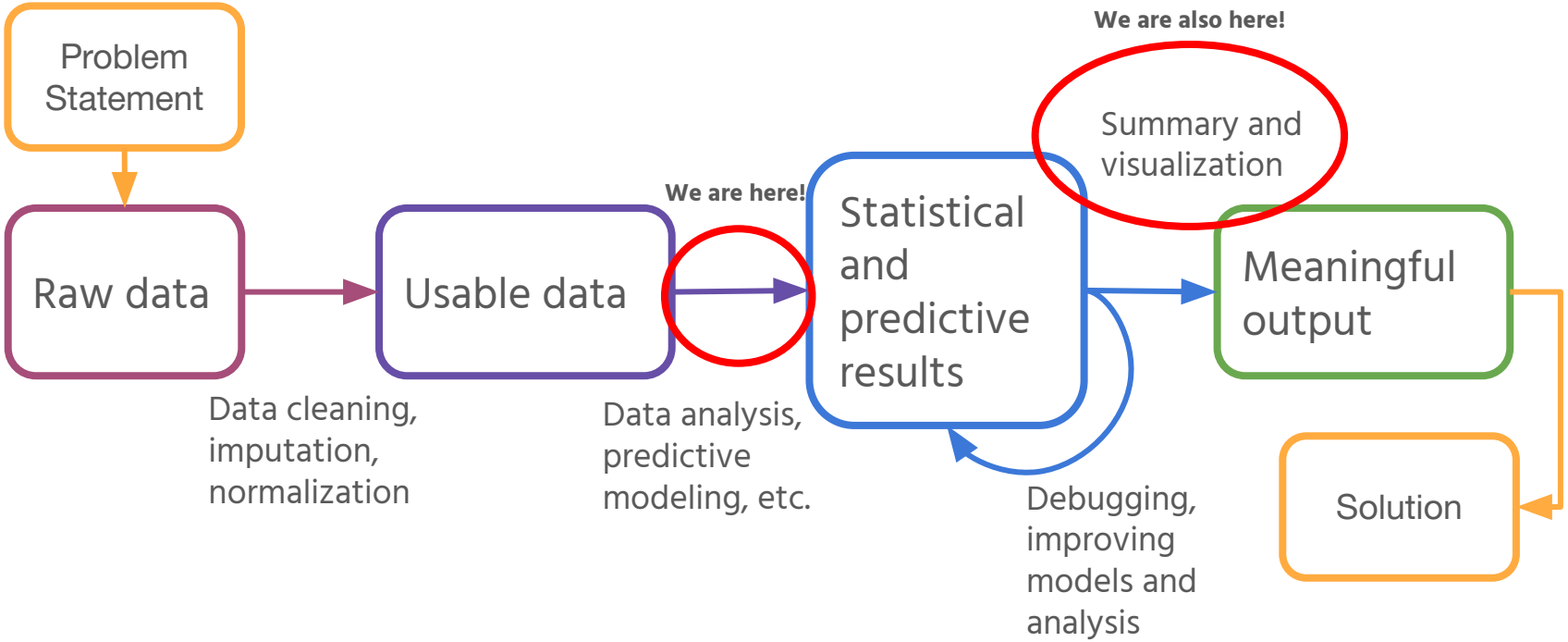
Agenda

1. Why Data Visualization is Important
2. Data Visualization Libraries
3. Basic Visualizations
4. Advanced Visualizations
5. Challenges of Visualization

The Data Pipeline



https://towardsdatascience.com/5-steps-of-a-data-science-project-lifecycle-26c50372b492

This!!!

amphitheaters.csv - Notepad

File Edit Format View Help

```
"Roman","Modern","Country","Year","Length","Notes","Photo","Latitude","Longi
"Dyrrhachium","Durrës","Albania","2nd century AD","61 m","Durrës Amphitheatr
"Lambaesis","Lambèse","Algeria","","64 m","","",35.489247,6.259935
"Colonia Claudia Caesarea","Cherchell","Algeria","","93 m","","",36.60874,2.
"Gemellae","M'lili","Algeria","","37 m","","",34.635409,5.522764
"Theveste","Tébessa","Algeria","4th century AD","45 m","Aerial Photograph","
"Tipasa","Tipaza","Algeria","","","Map of Tipasa","https://en.wikipedia.org/
"Carnuntum","Petronell","Austria","","69 m","2 amphitheatres ","https://en.w
"Carnuntum","Petronell","Austria","","69 m","2 amphitheatres ","https://en.w
"Flavia Solva","Leibnitz","Austria","","","","",46.766744,15.567417
"Virunum","Magdalensberg","Austria","","","","","https://en.wikipedia.org/wiki/
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"Marcianopolis","Devnya","Bulgaria","","","","","",43.222222,27.569444
"Serdica","Sofia","Bulgaria","3rd century AD","","In ground floor of Arena c
"Pietas Iulia Pola","Pula","Croatia","1st century AD","68 m","Pula Arena","h
"Salonae","Solin","Croatia","","65 m","","https://en.wikipedia.org/wiki/File
"Burnum","","Croatia","","46 m","Roman military camp near Šibenik, had a sma
"Augusta Paphus","Paphos","Cyprus","","65 m","","",34.754942,32.405344
"Salamis","","Cyprus","","","Amphitheatre almost vanished ","",35.185522,33
```
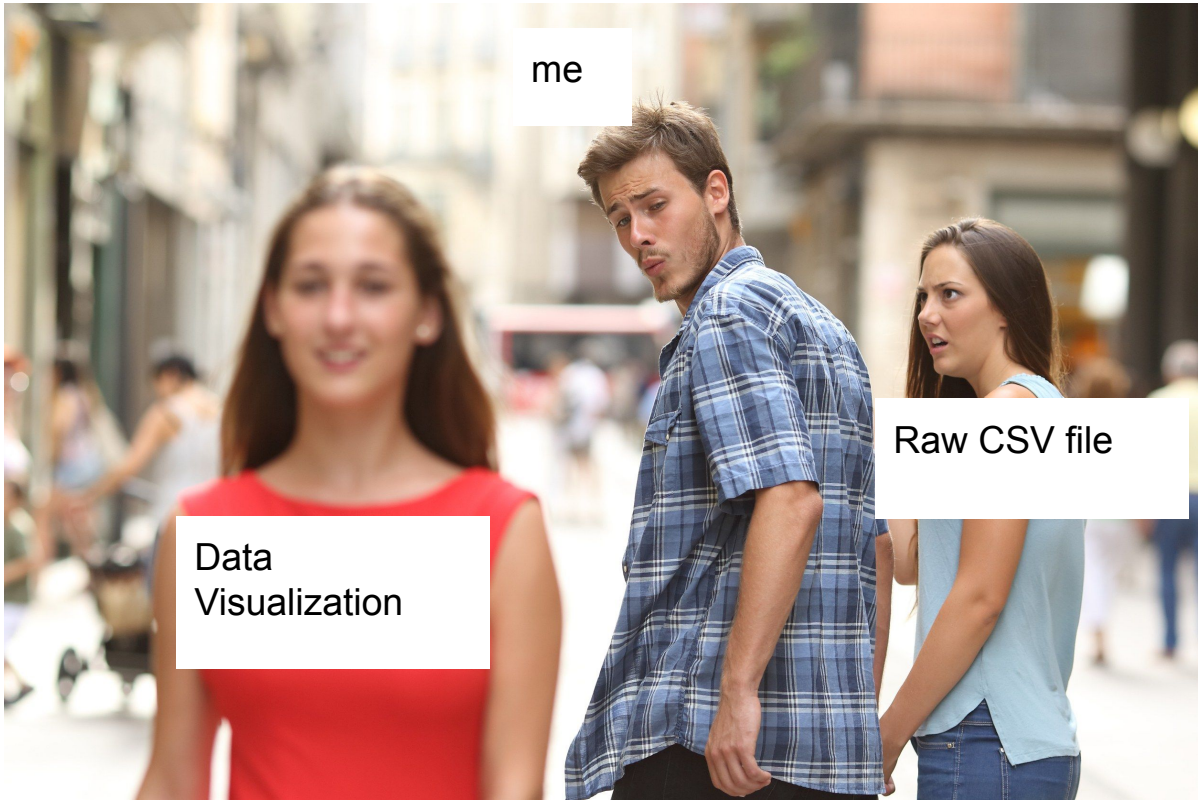

https://manifold.net/doc/mfd9/images/eg_formats_csv01_01.png

Why is Data Visualization Important?



Source

Why is Data Visualization Important?

Informative

Appealing

Universal

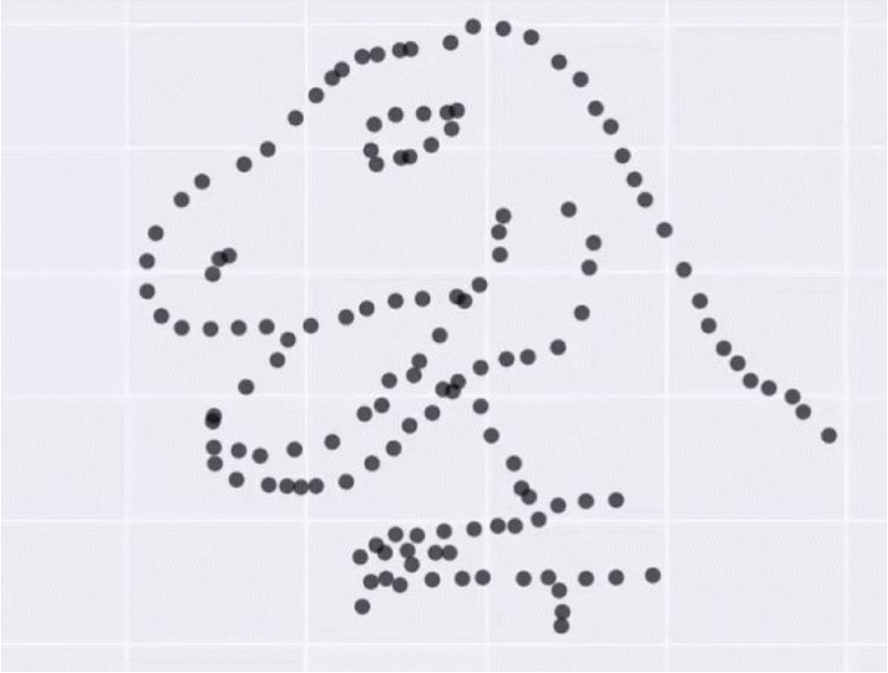
Predictive

Why is Data Visualization Important?

Same summary stats (mean, median, mode) **but different distributions!**

We need to see how the **actual** data looks!

df.describe() is not enough

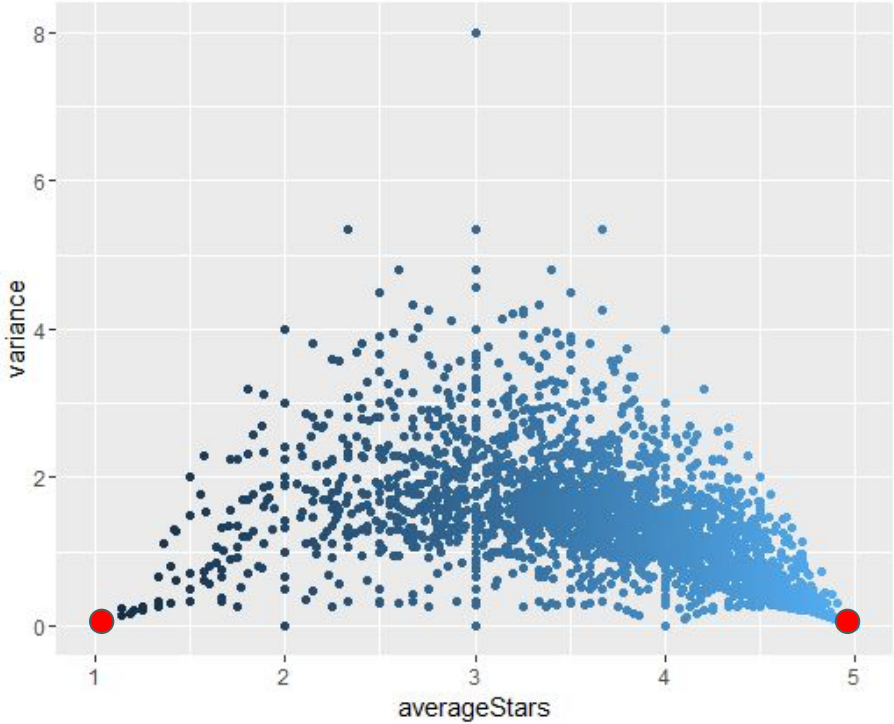


Source

Data Visualization Simple Example: *Ratings on Yelp*

	AVG(stars)	var
AVG(stars)	1.00	-0.43
var	-0.43	1.00

Question: What do you notice? What trends do you see?



Data Visualization Libraries

- **matplotlib**
  - Python data visualization package
  - Capable of handling most data visualization needs
  - Simple object-oriented library inspired from MATLAB
  - Cheatsheet
- **seaborn**
  - Another visualization package built on matplotlib

Seaborn vs Matplot

Seaborn

- Easier syntax
- Built for working with Pandas DF
- High level functions for more robust visualizations
- Superset of matplot

Python libraries for data visualizations!!

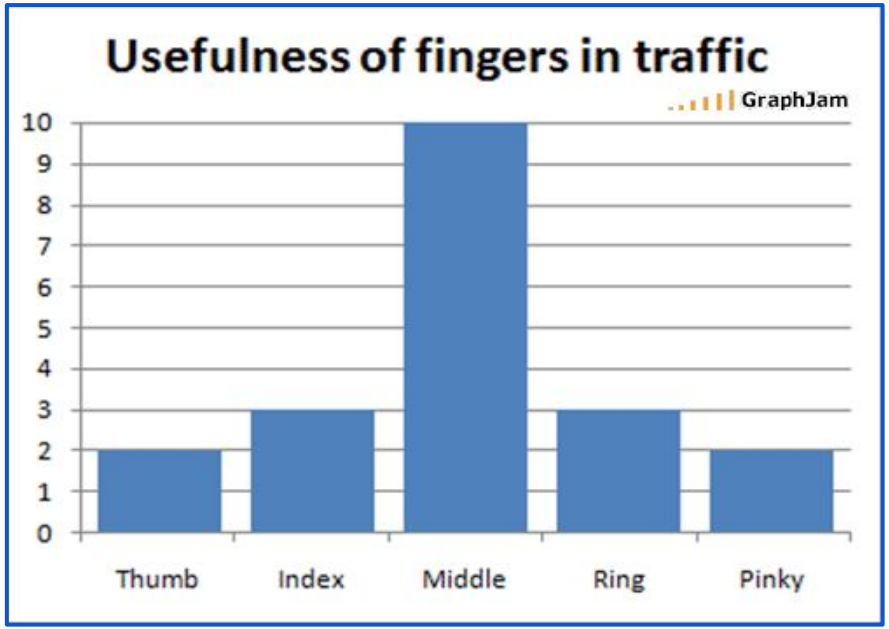
Matplot

- Syntactically more complex
- Harder to work with for DF
- Use for basic graphs

Basic Data Visualizations

Bar Graph

- Represent **magnitude** or **frequency** of discrete variables
- Allows us to compare features



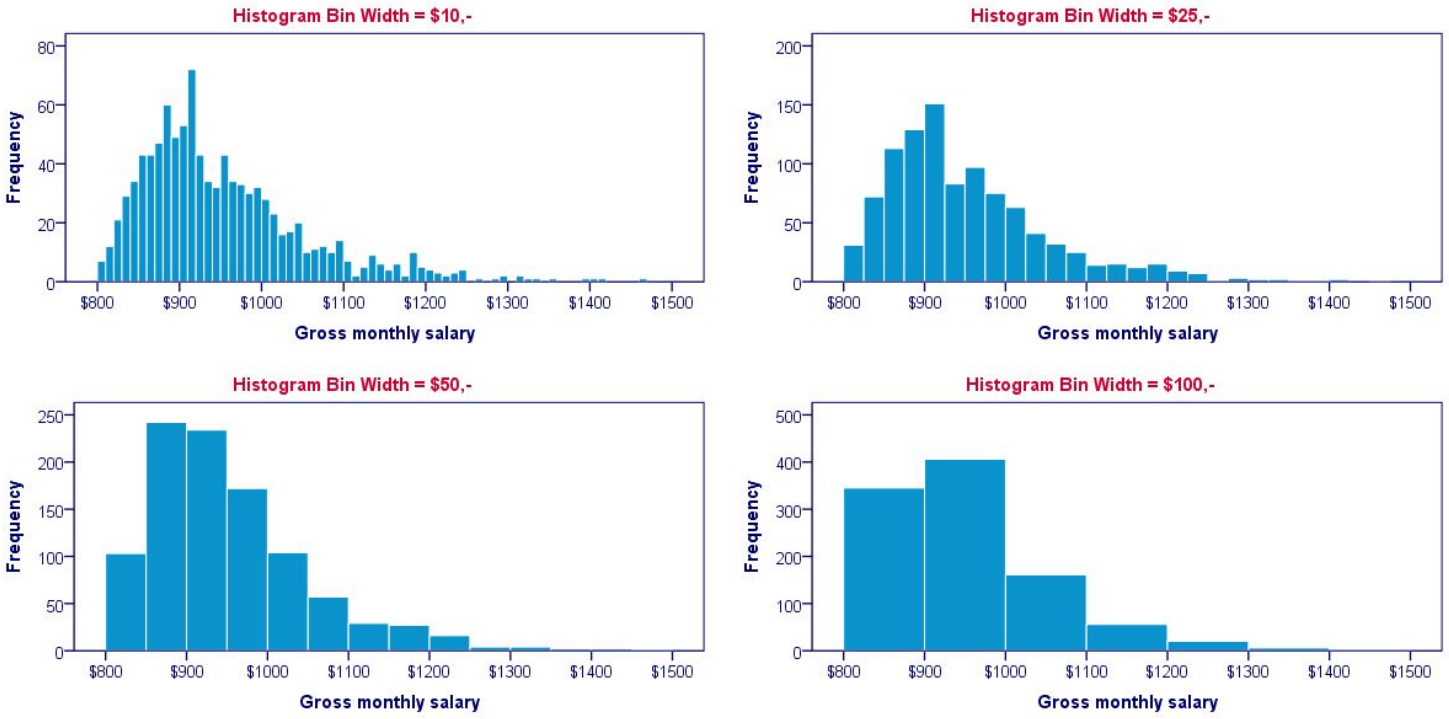
Source

Histograms

Source

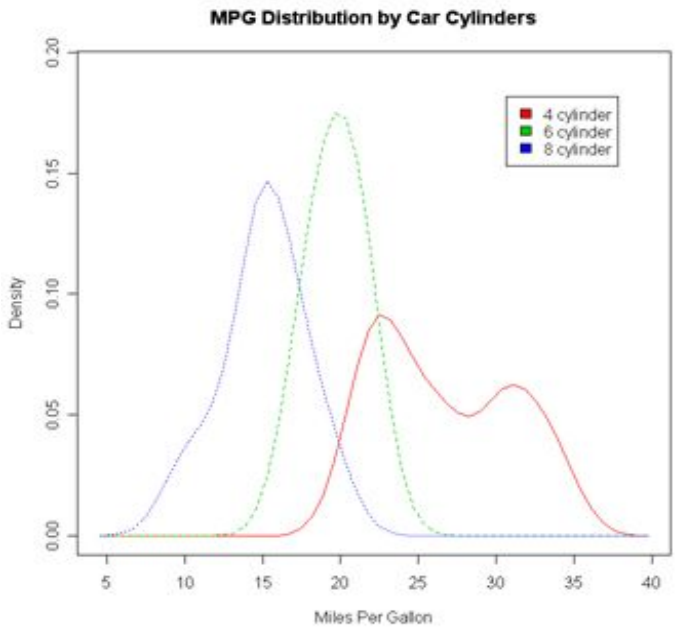
- Used to observe **frequency distribution** of continuous variables
- Data split into **bins**

Histograms: Different Bin Sizes



Source

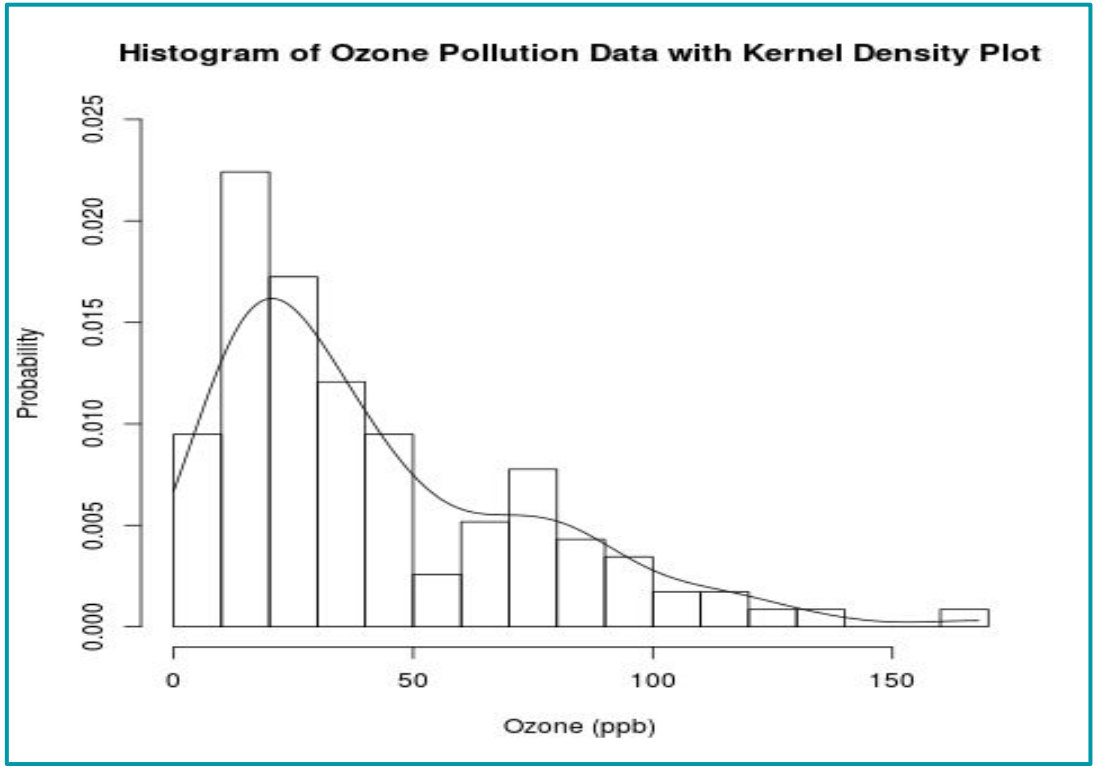
Density Plot



Like a histogram, but **smooths** the shape of the distribution

Source

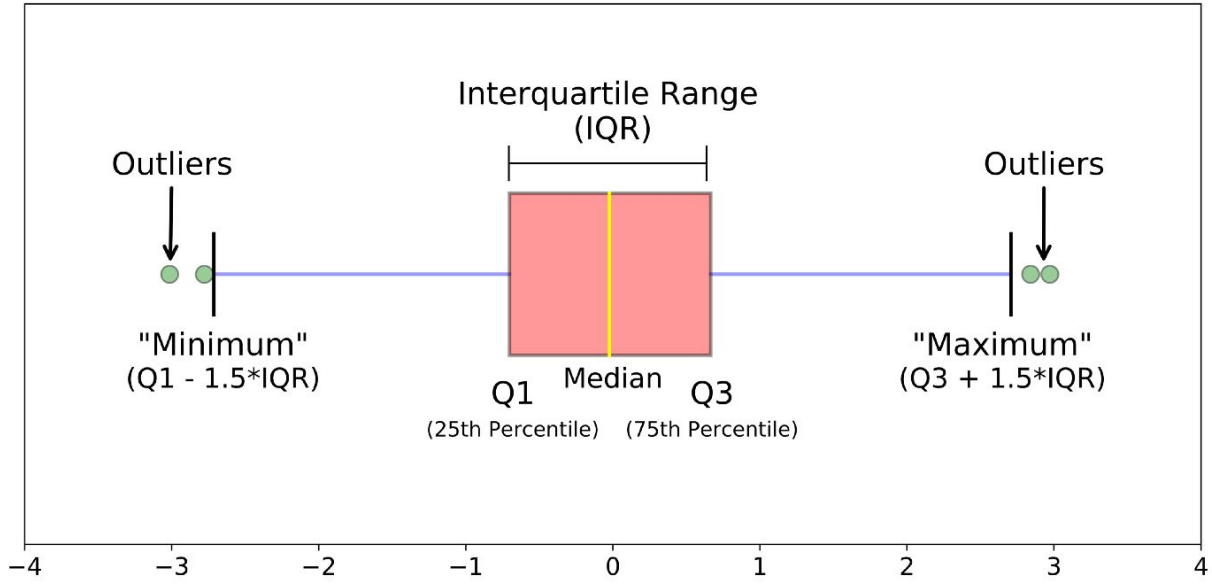
Histogram vs Density Plot



Source

Boxplot (a.k.a box and whisker plot)

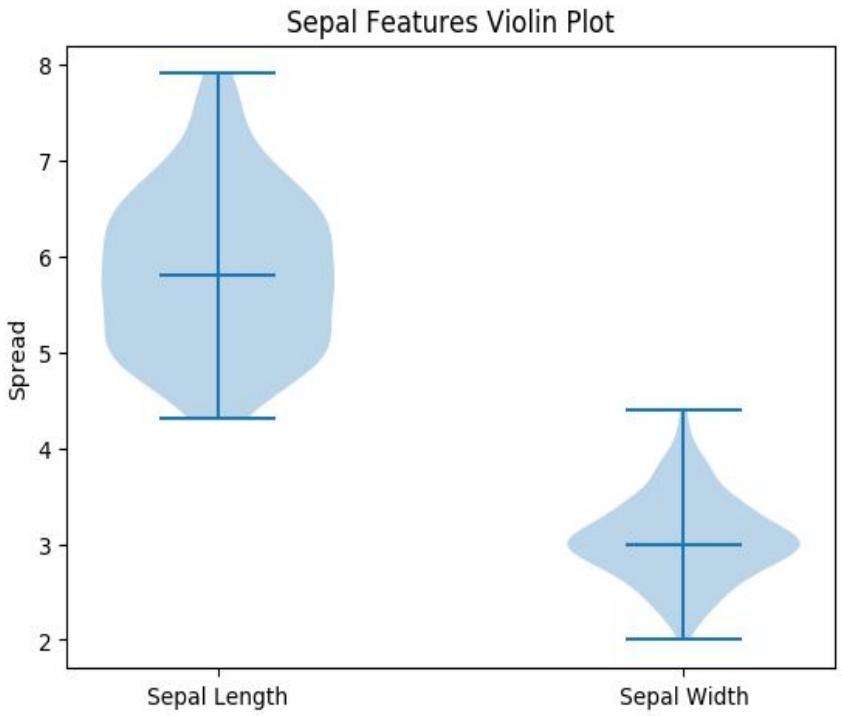
- Summary of data
- Shows **spread** of data
- Gives range, interquartile range, median, and outlier information



Source

Violin Plot

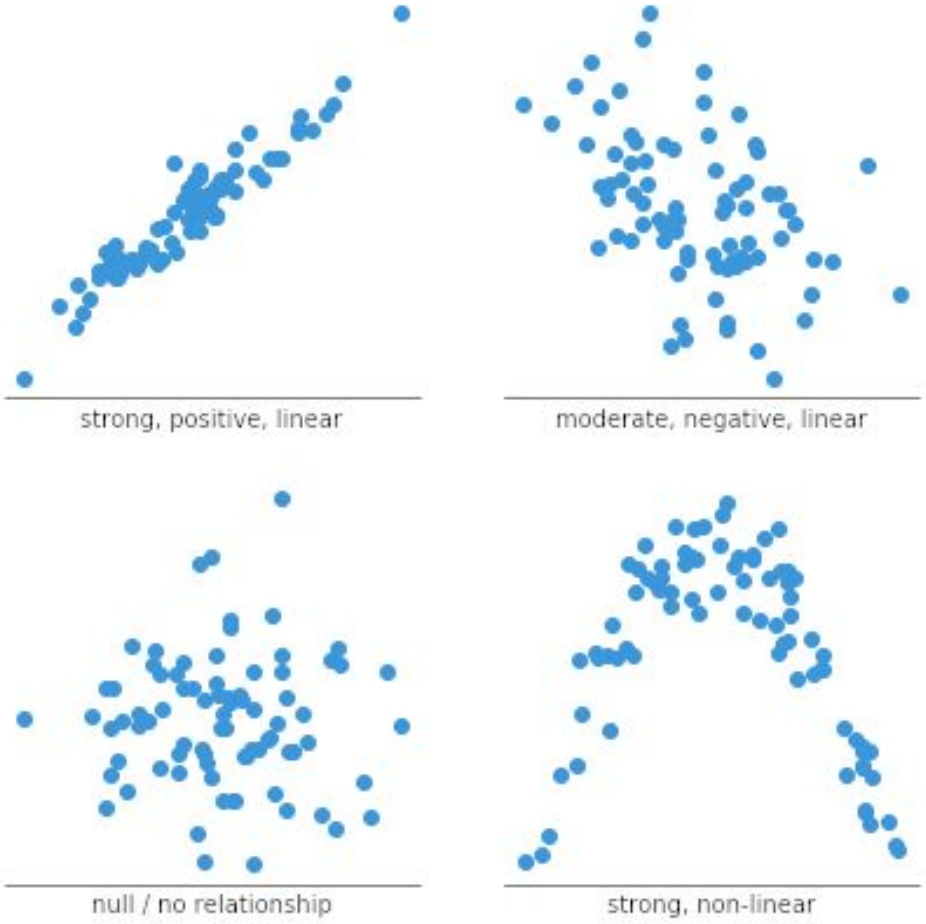
- Combination of **boxplot** and **density plot** to show the **spread** and **shape** of the data
- Can show whether the data is **normal** (i.e. is distributed normally)



Advanced Data Visualizations

Scatterplot

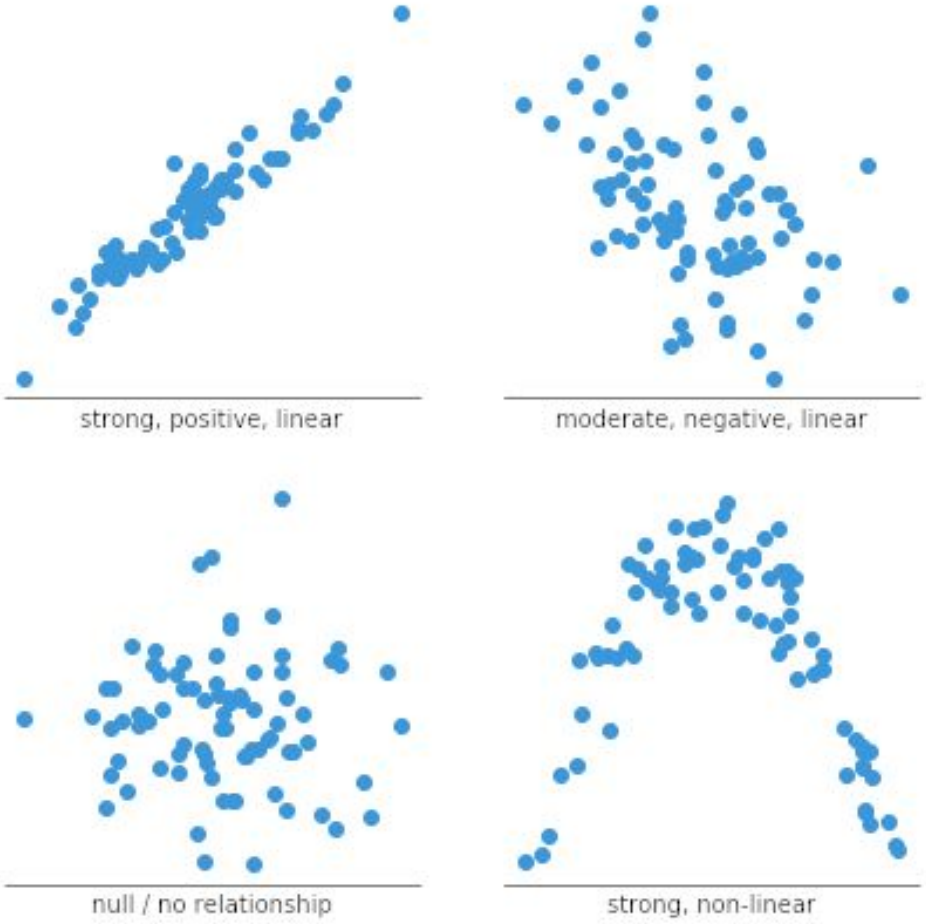
- See **relationship** between two features
- Can be useful for **extrapolating** information



https://chartio.com/learn/charts/what-is-a-scatter-plot/

Scatterplot

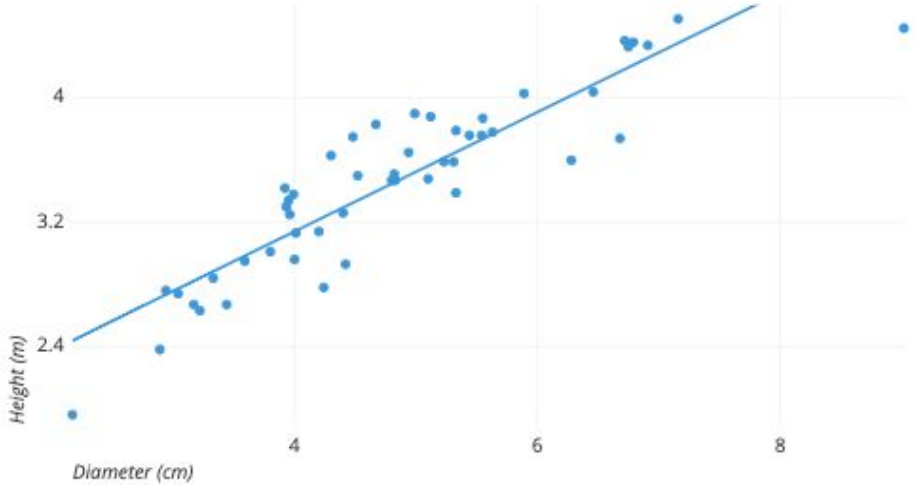
- See **relationship** between two features
- Can be useful for **extrapolating** information
- **Correlation ≠ Causation!**

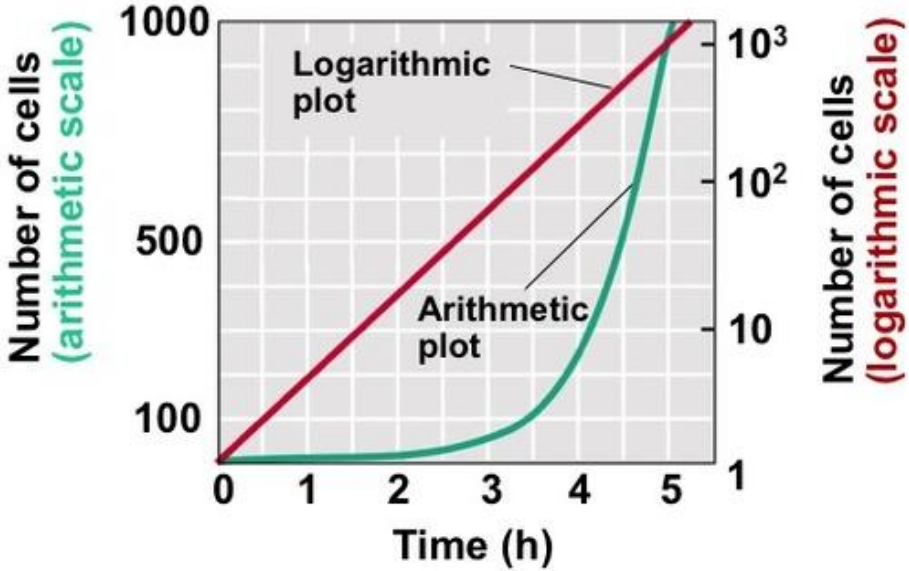


https://chartio.com/learn/charts/what-is-a-scatter-plot/

Scatterplot – more ways

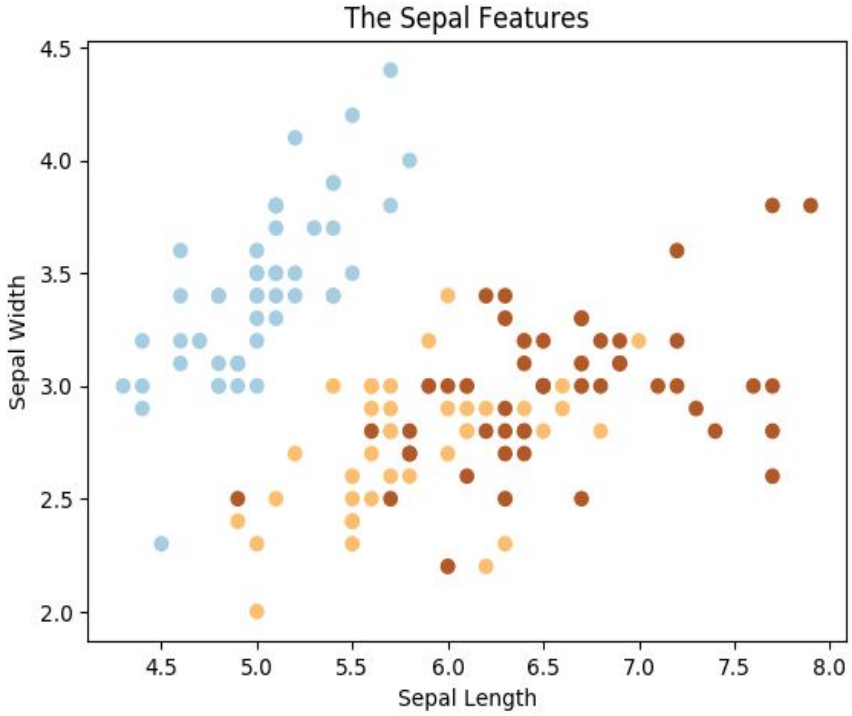
- Line of best fit

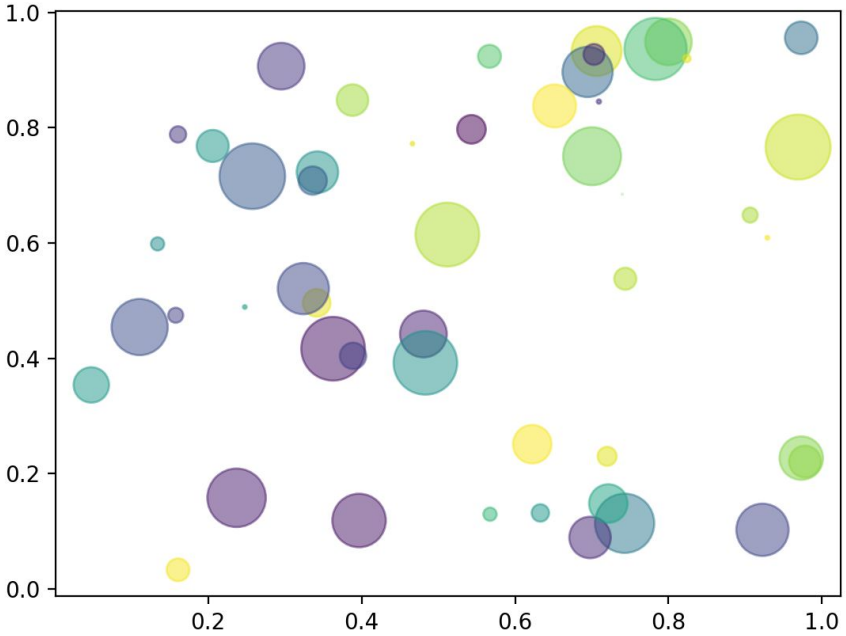




Scatterplot – more ways

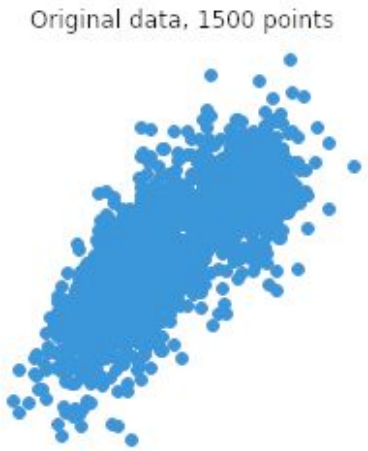
- Line of best fit
- Demonstrate clusters
- Bubble chart

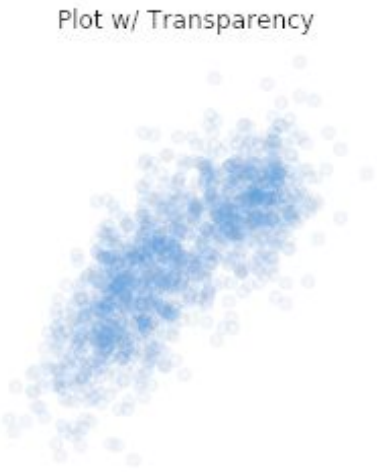


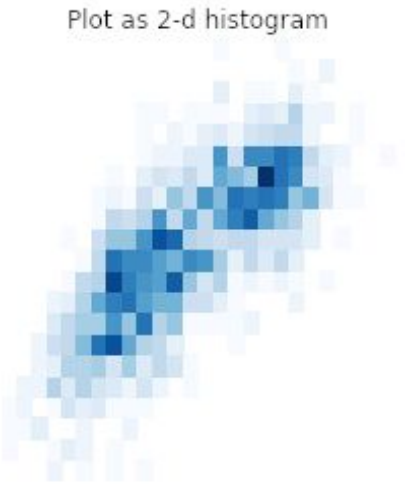


Scatterplot - Overplotting

- Only sample a random selection
- Change dot form (eg. add transparency)
- Use heatmap

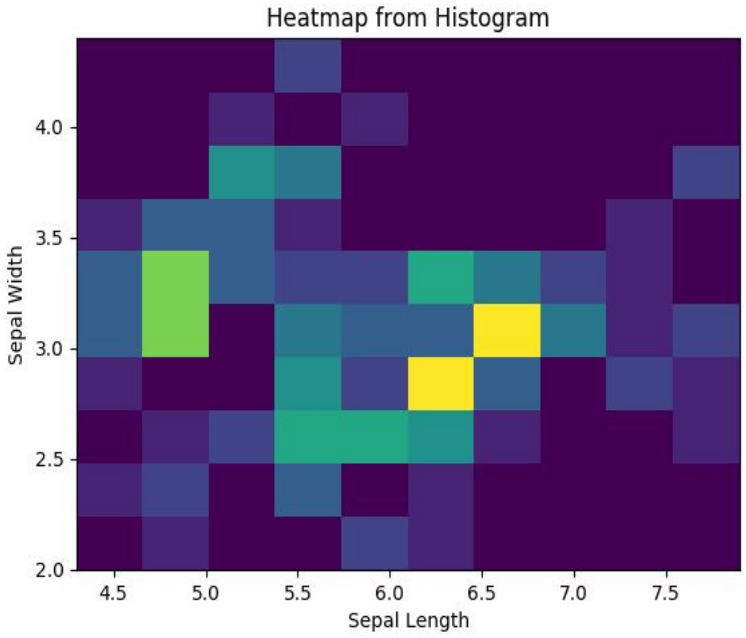






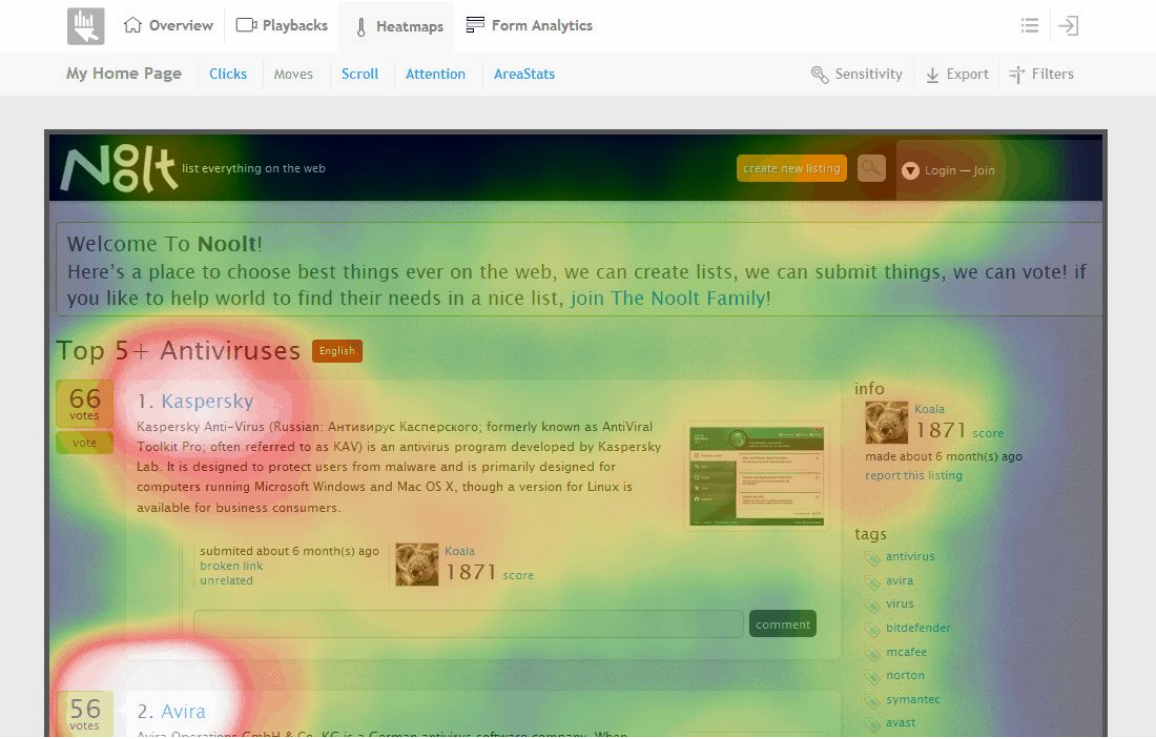
https://chartio.com/learn/charts/what-is-a-scatter-plot/

Heatmap



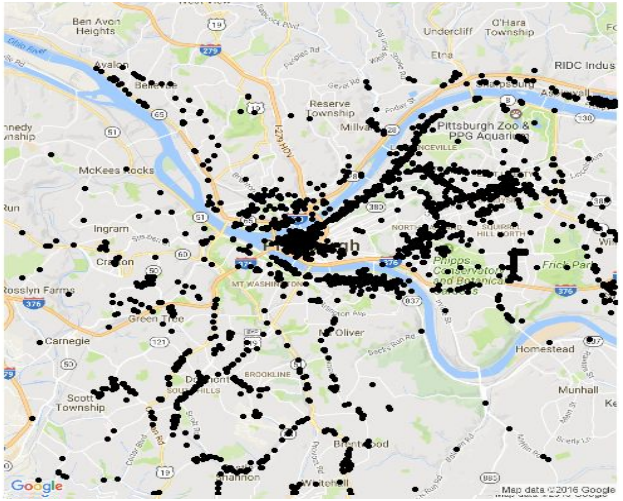
- Varying degrees of one metric are represented using **color**
- Especially useful in the context of **maps** to show geographical variation

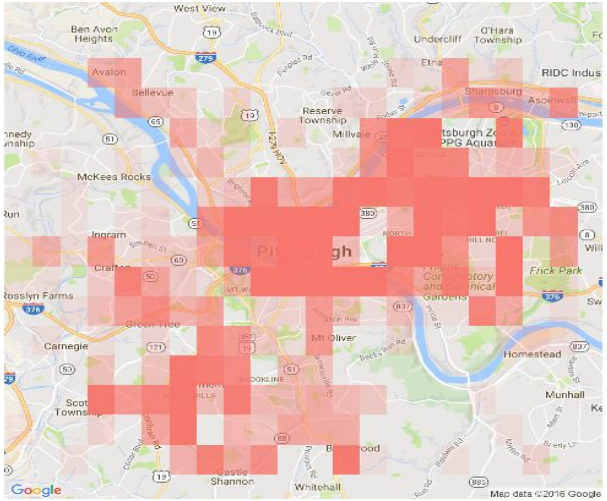
Heatmap - Click Density / Website Heatmaps



Using Maps

- **Map visualization → contextual information**
  - **Trends are not always apparent in the data itself**
  - Eg. Longitudes + Latitudes → *Geographical Map*



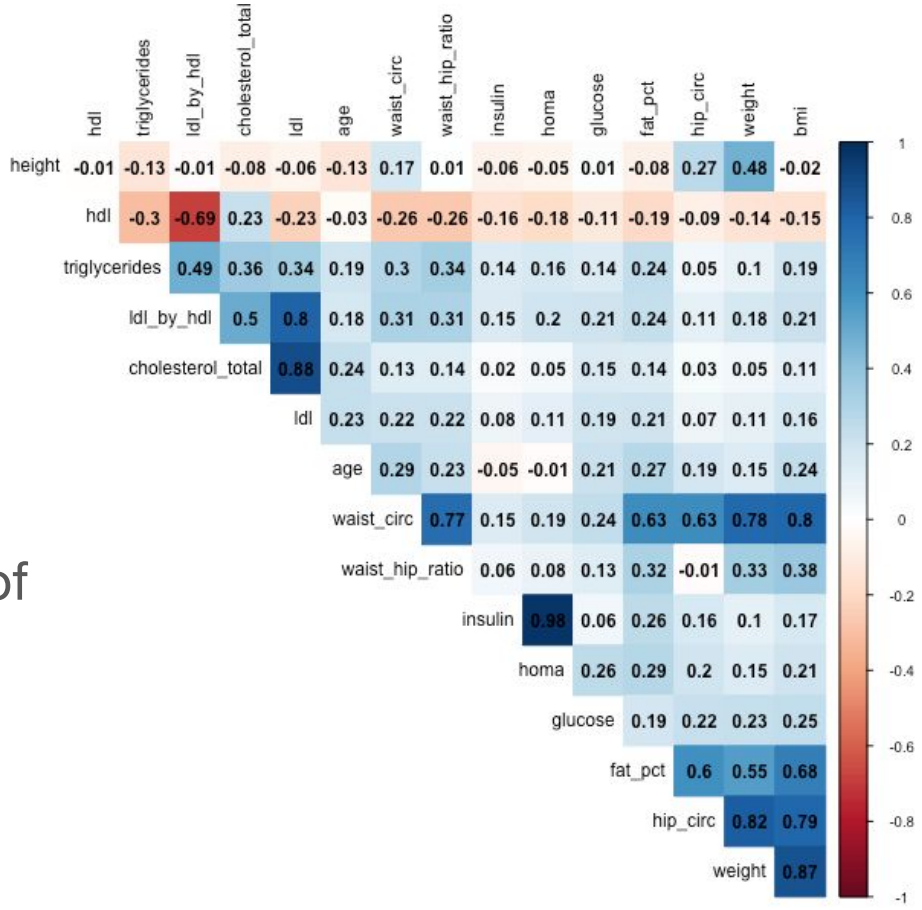


Correlation Plots

- 2D matrix with all variables on each axis
- Entries represent the **correlation coefficients** between each pair of variables

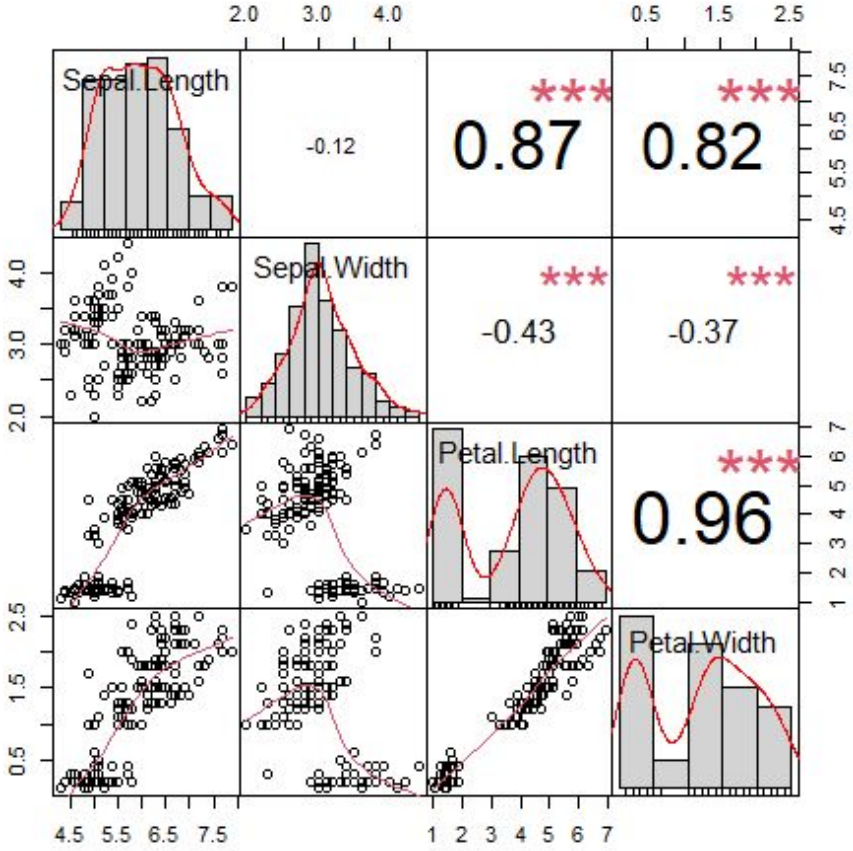
```
[[ 1.         -0.10936925  0.87175416  0.81795363]
 [-0.10936925  1.         -0.4205161  -0.35654409]
 [ 0.87175416 -0.4205161   1.          0.9627571 ]
 [ 0.81795363 -0.35654409  0.9627571   1.        ]]
```

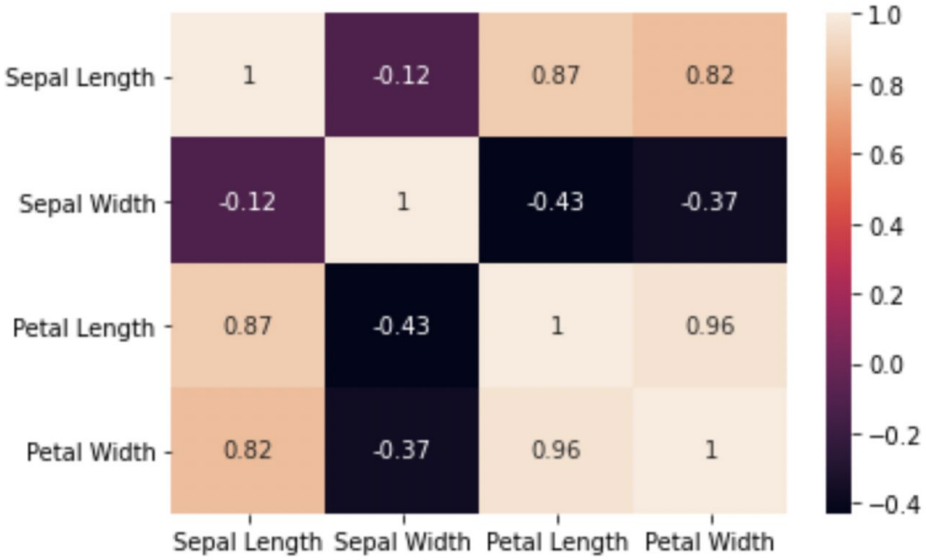
Why are all entries on the diagonal '1'?



Source

Correlation Plots





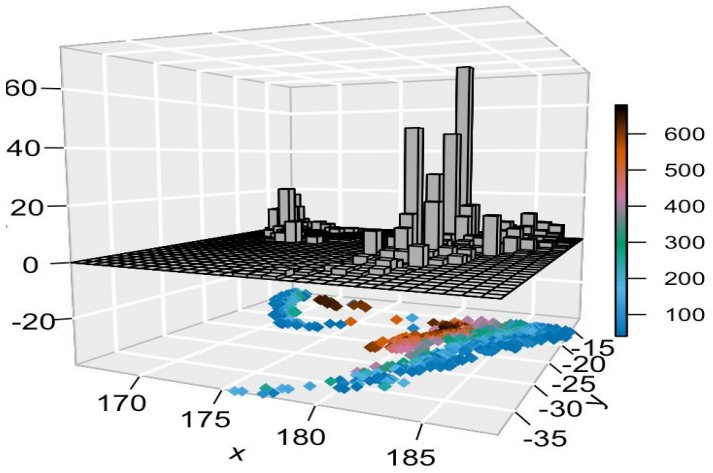
https://r-coder.com/correlation-plot-r/

Demo

Challenges of Visualization

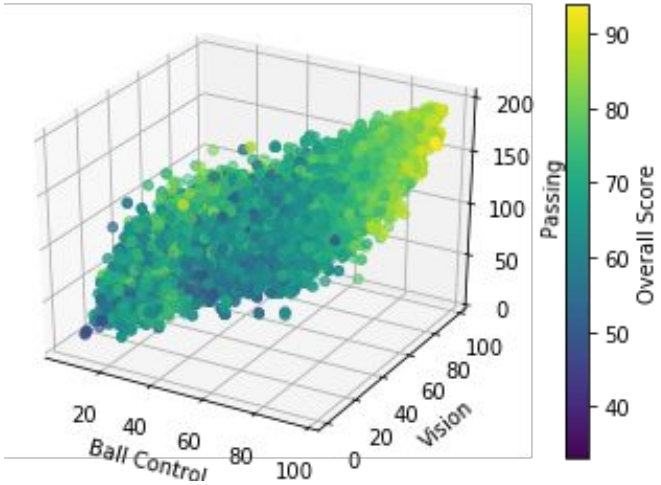
Higher Dimension	**Non-Trivial**
Time Consuming	**Hard to Show Uncertainty**

High Dimensional Data



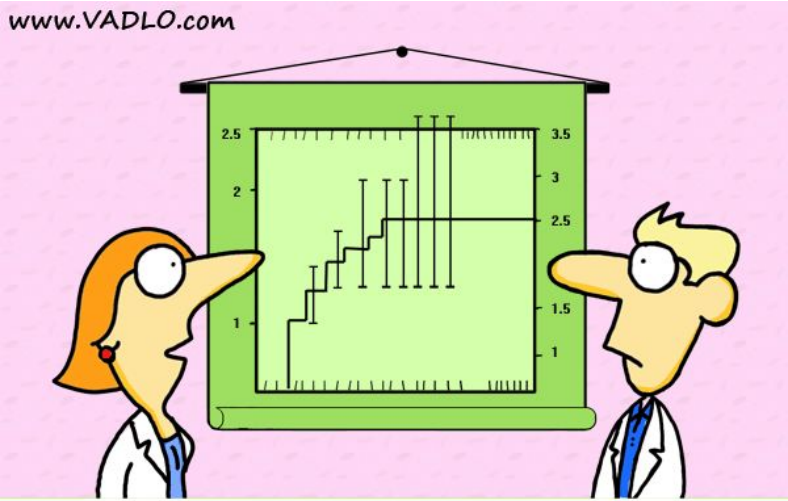
4D Plot For Earthquake Data

- Color, time animations, or point shape can be used for higher dimensions
- There is a limit to the number of features that can be displayed

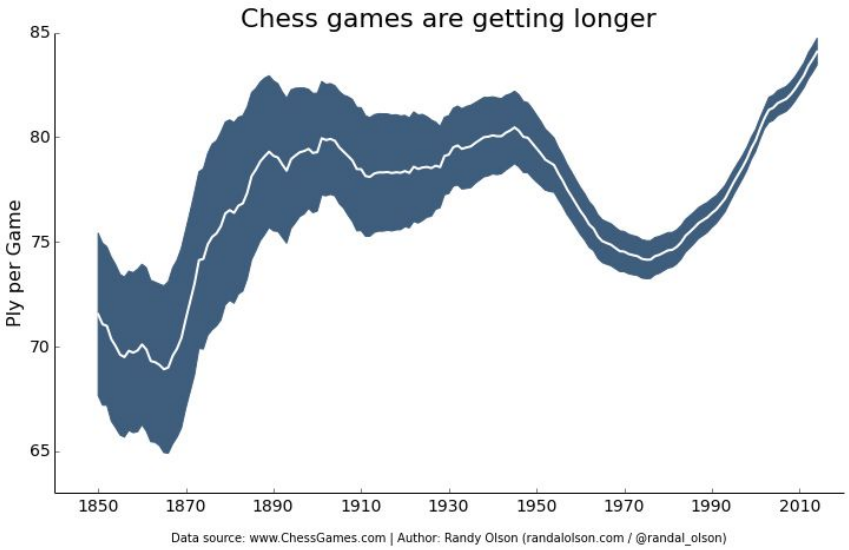


Error Bars

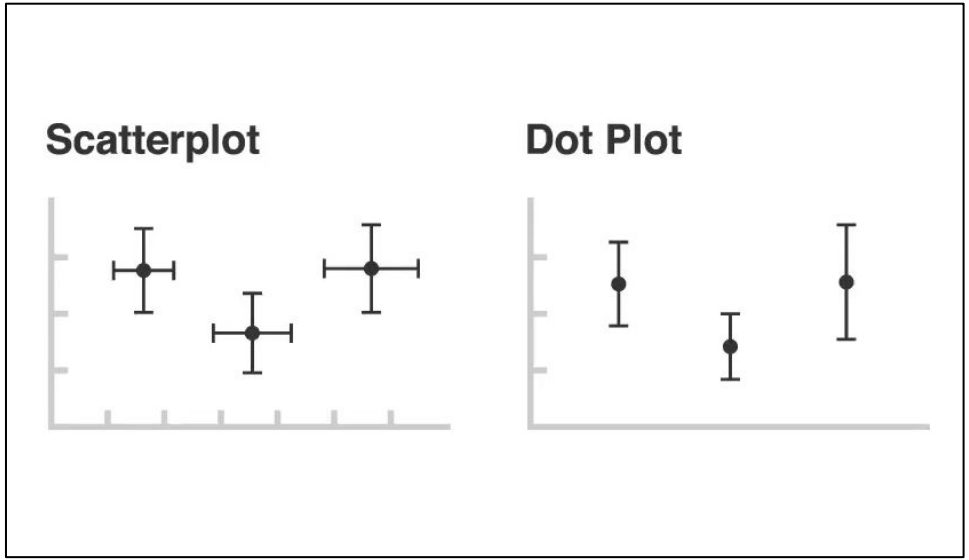
- Show uncertainty
- Usually display 95 percent confidence interval

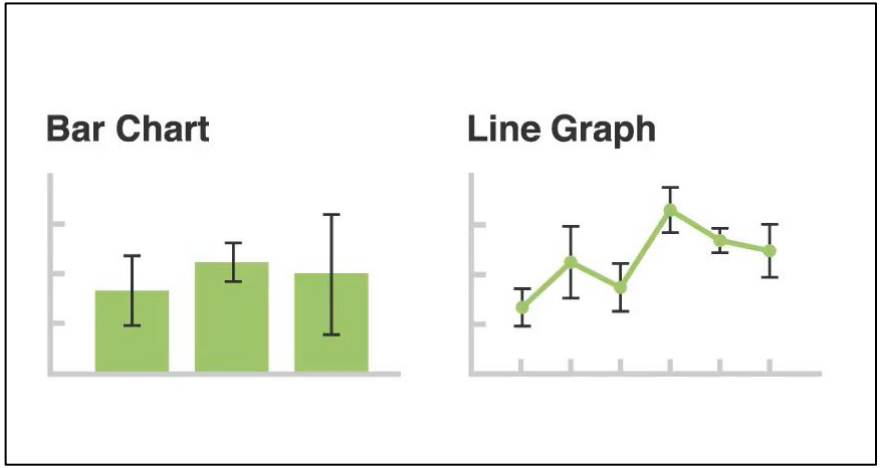


"Did you really have to show the error bars?"



Error Bars

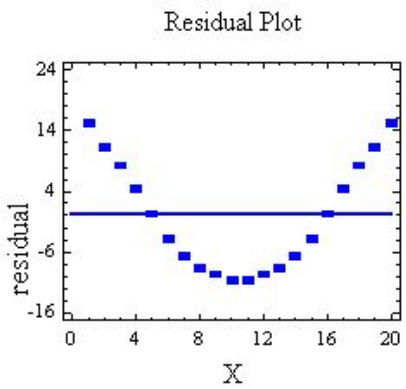




https://www.geeksforgeeks.org/errorbar-graph-in-python-using-matplotlib/

Residual Plot

- Values should be equally and randomly spaced on horizontal axis
- Regression line is called line of best fit
- Not optimal if data has outliers or is non-linear



Coming Up

- **Assignment 2**: Due Tonight at 11:59 PM
- **Assignment 3**: Due next Wednesday at 11:59 PM
- **Next Lecture**: Fundamentals of Machine Learning

Check ED before writing emails! Post Questions on ED!

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