University of Science, VNU-HCM
Faculty of Information Technology

Introduction to Data Science

Data Visualization

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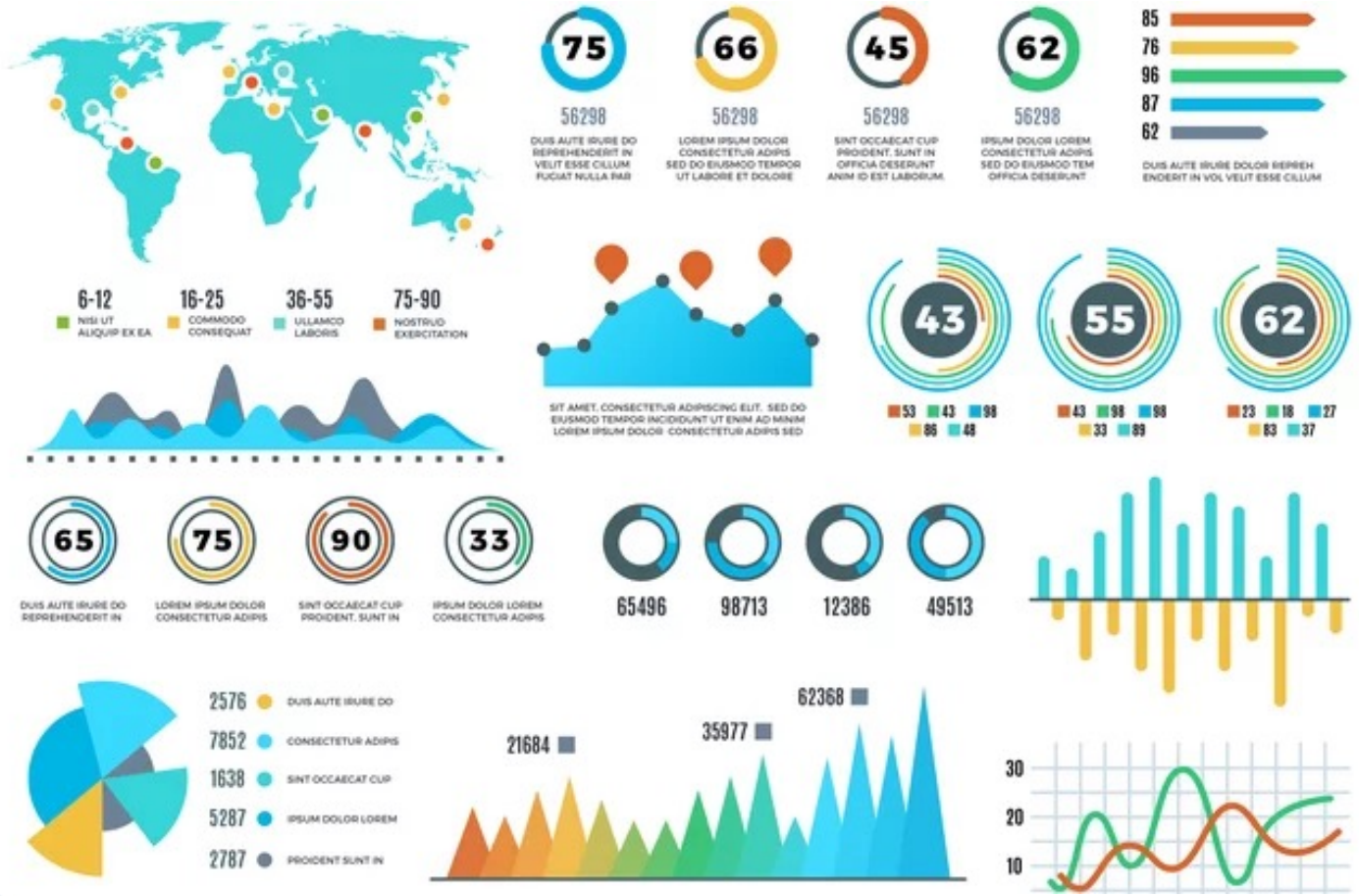
Content

- Introduction
- Types of Visualization
  - Comparison Plots
  - Relation Plots
  - Composition Plots
  - Distribution Plots
  - Geo Plots

What is Data Visualization?

- Data visualization is the graphical representation of information and data.

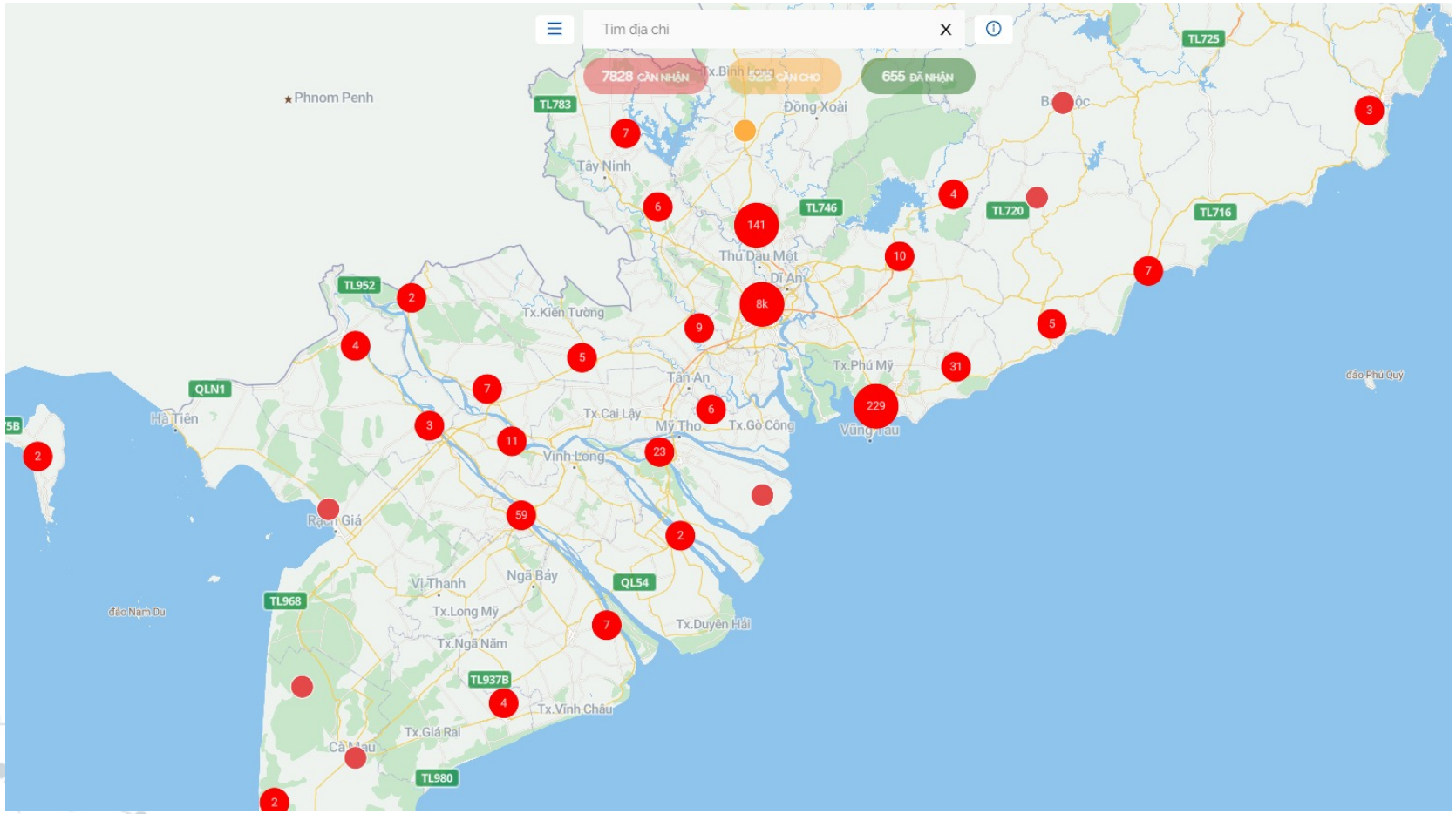


Why is Data Visualization important?

- Visual data is very easy to understand compared to data in any other form.
  - Our brains process images at a rapid pace, according to an MIT study.

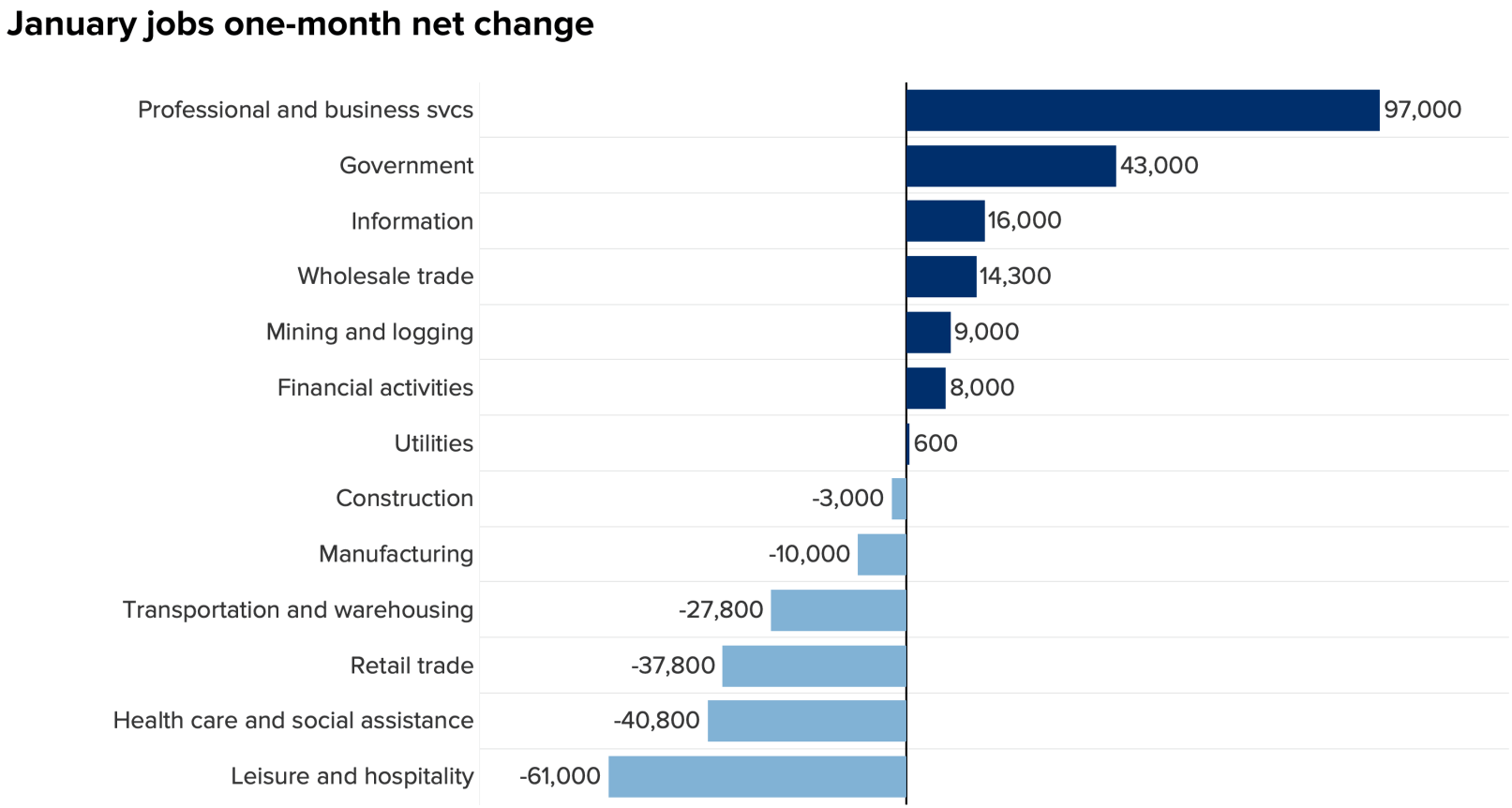
Example of Data Visualization

- Sosmap.net visualizes the covid infected cases with map



Example of Data Visualization

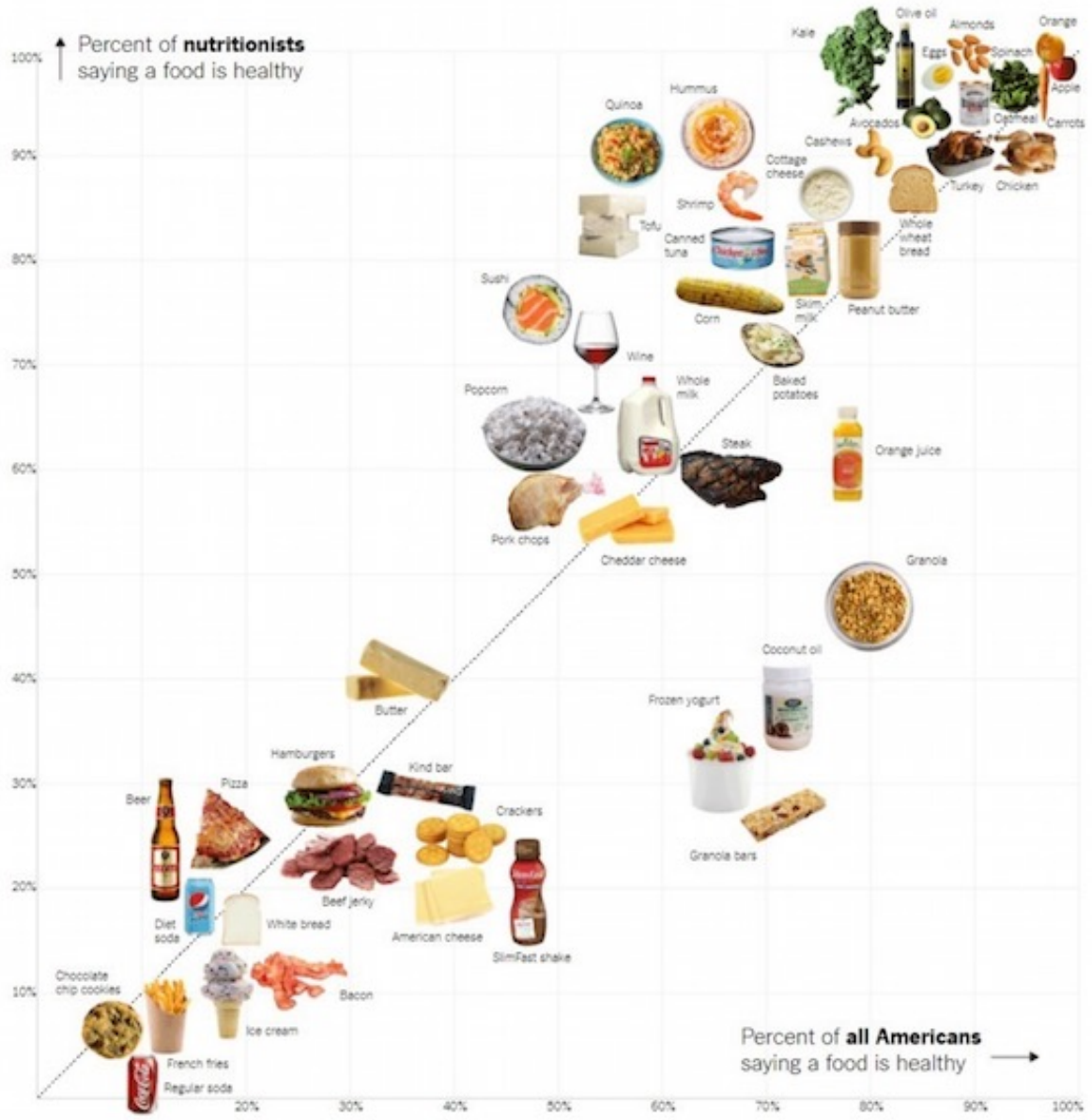
- The visual from CNBC uses a bar graph to visualize the industry-by-industry employment changes in the January 2021 jobs report.



SOURCE: Bureau of Labor Statistics

Example of Data Visualization

- The NY Times uses scatter plots to explain about healthy food

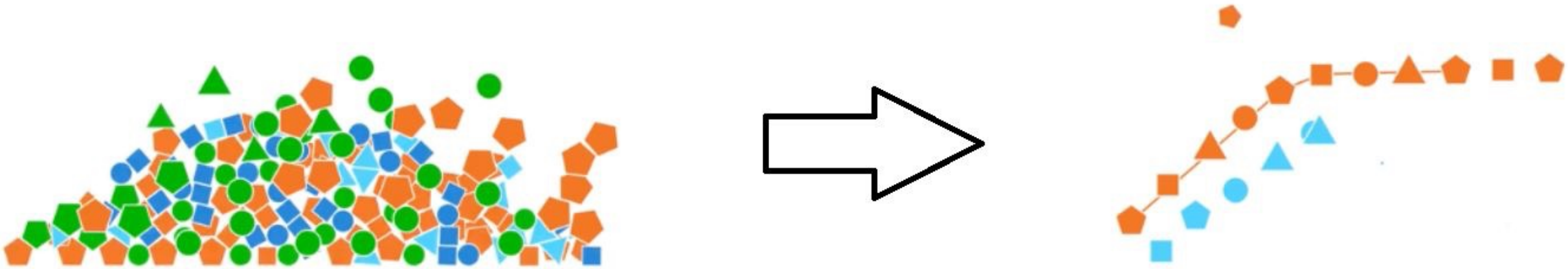


Features of Visualizations

- All of data visualizations include the following features :
  - Indicators: They highlight the most important information.
  - Simplicity: The information is clear. The reader understands the information at hand immediately.
  - Brevity: The message is short and clear, and no unnecessary information is visible.
  - Originality: types of data are collected and displayed in a way that offers readers a new perspective on the subject.
  - Colour: to draw the reader's attention to the most important pieces of information, clear and easy-to-understand color palettes are used.

Data Wrangling

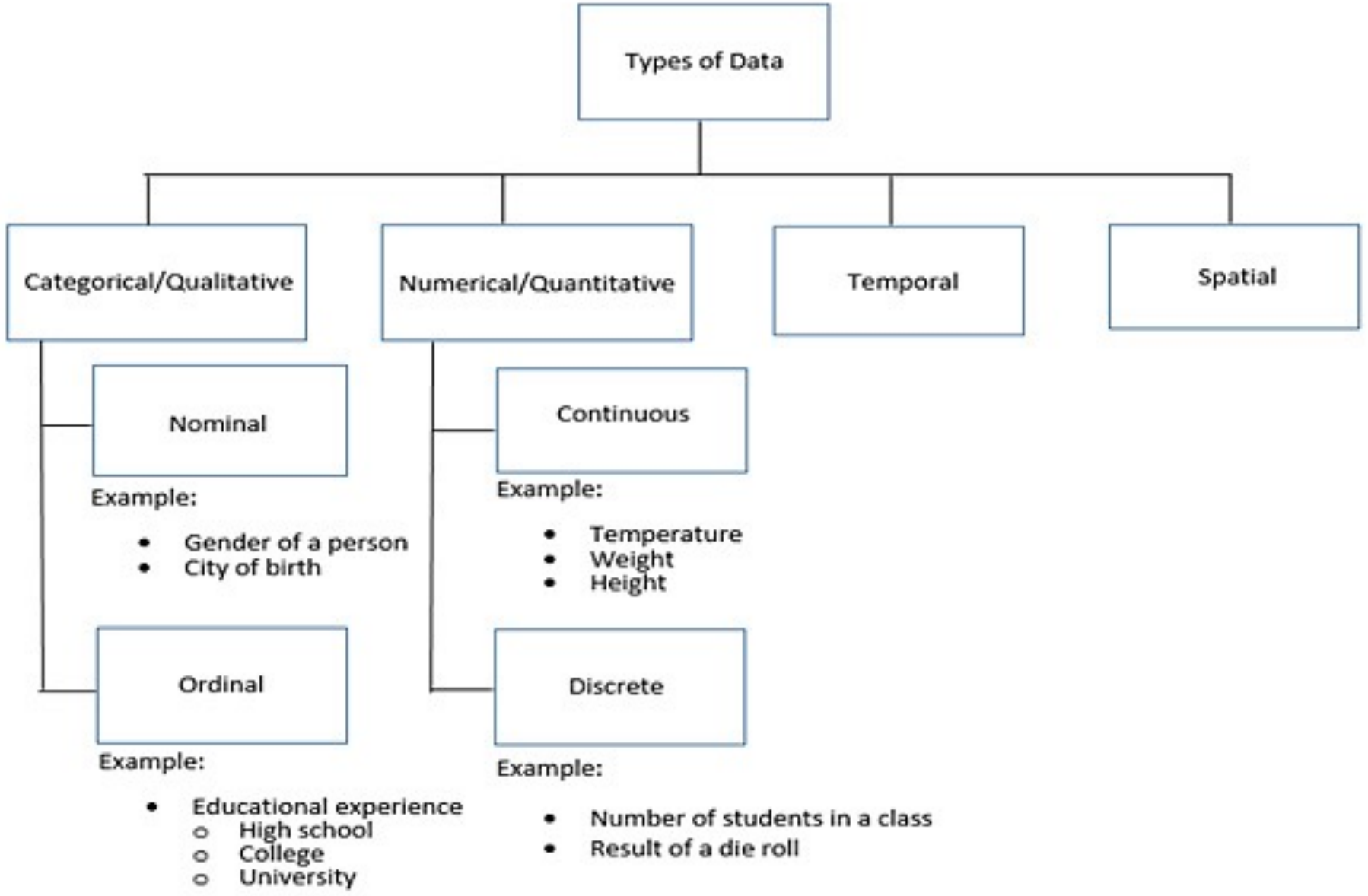
- Data wrangling—also called data munging—is the process of transforming and mapping data from one "raw" data form into the format that is convenient for the consumption of data.



Tools and Libraries for Visualization

- Non-coding tool:
  - Tableau
  - Power BI
- Coding (Python, Matlab, R):
  - Python libraries:
    - Matplotlib
    - Seaborn
    - Geospatial
    - Bokeh

Types of Data



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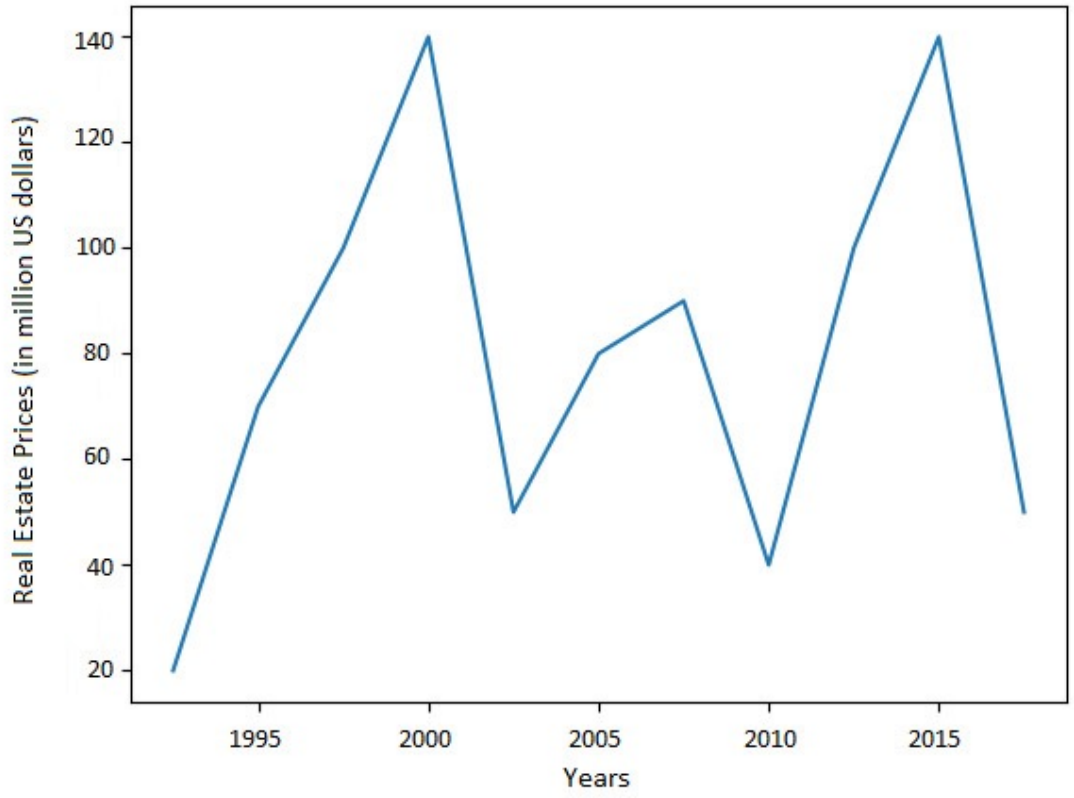
Comparison Plots

- Comparison plots include charts that are well-suited for comparing multiple variables or variables over time.
  - Line chart
  - Bar chart
  - Radar chart

Line Chart

- Line charts are used to display quantitative values over a continuous time period and show information as a series.

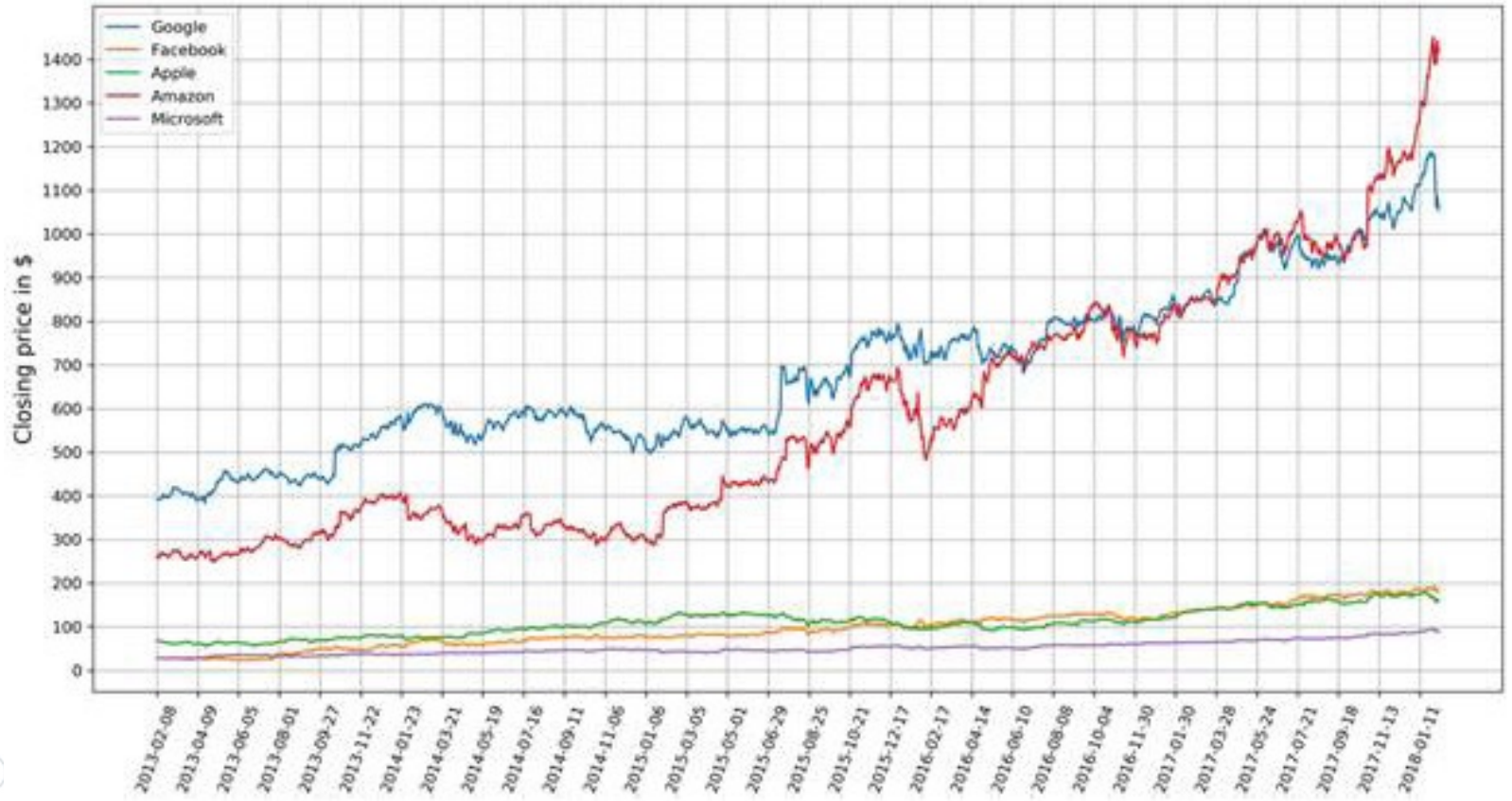


Line Chart

- Uses:
  - Line charts are great for comparing multiple variables and visualizing trends for both single as well as multiple variables, especially if your dataset has many time periods (roughly more than ten).
  - For smaller time periods, vertical bar charts might be the better choice.

Line Chart Example

- Compares the stock-closing prices for Google, Facebook, Apple, Amazon, and Microsoft.



Line Chart Pratices

- Design practices:
  - Avoid too many lines per chart
  - Adjust the scale so that the trend is clearly visible

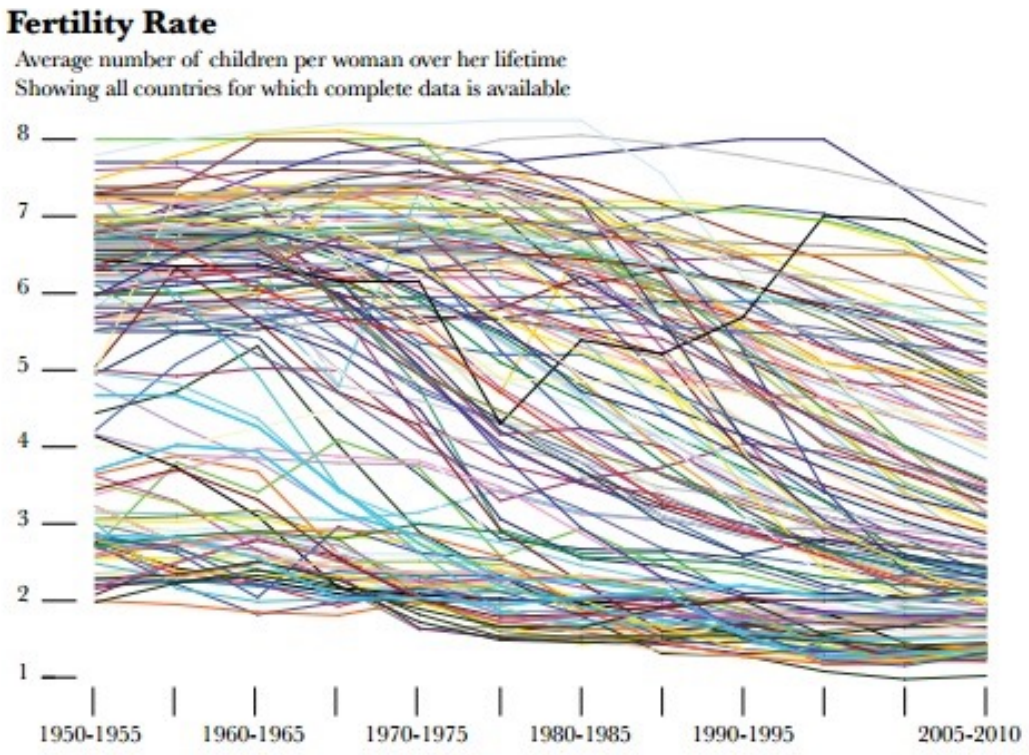


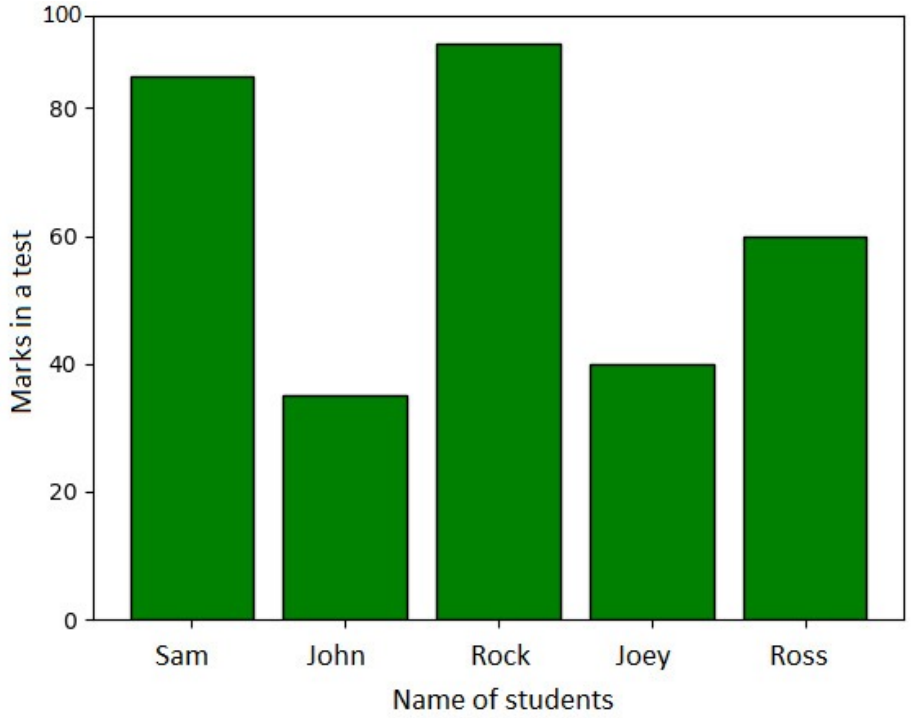
Figure 1.5 Too many lines obscure the message.

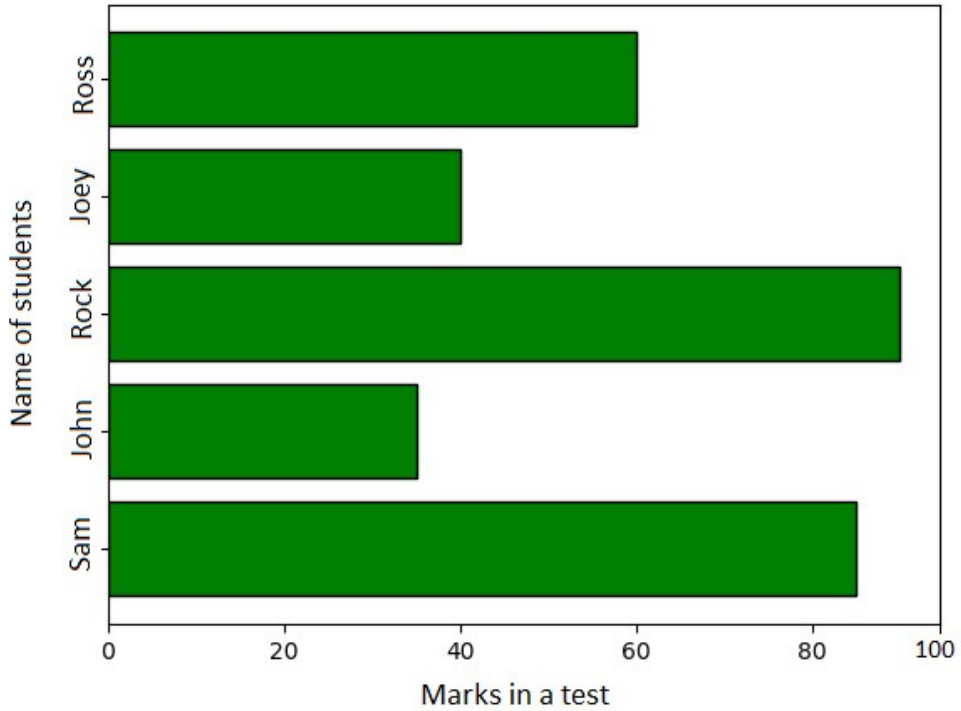
Bar Chart

- The bar length encodes the value.
- There are two variants of bar charts: vertical bar charts and horizontal bar charts.
  - While they are both used to compare numerical values across categories, vertical bar charts are sometimes used to show a single variable over time.
  - Don't confuse vertical bar charts with histograms. Bar charts compare different variables or categories, while histograms show the distribution for a single variable.

Bar Chart Example

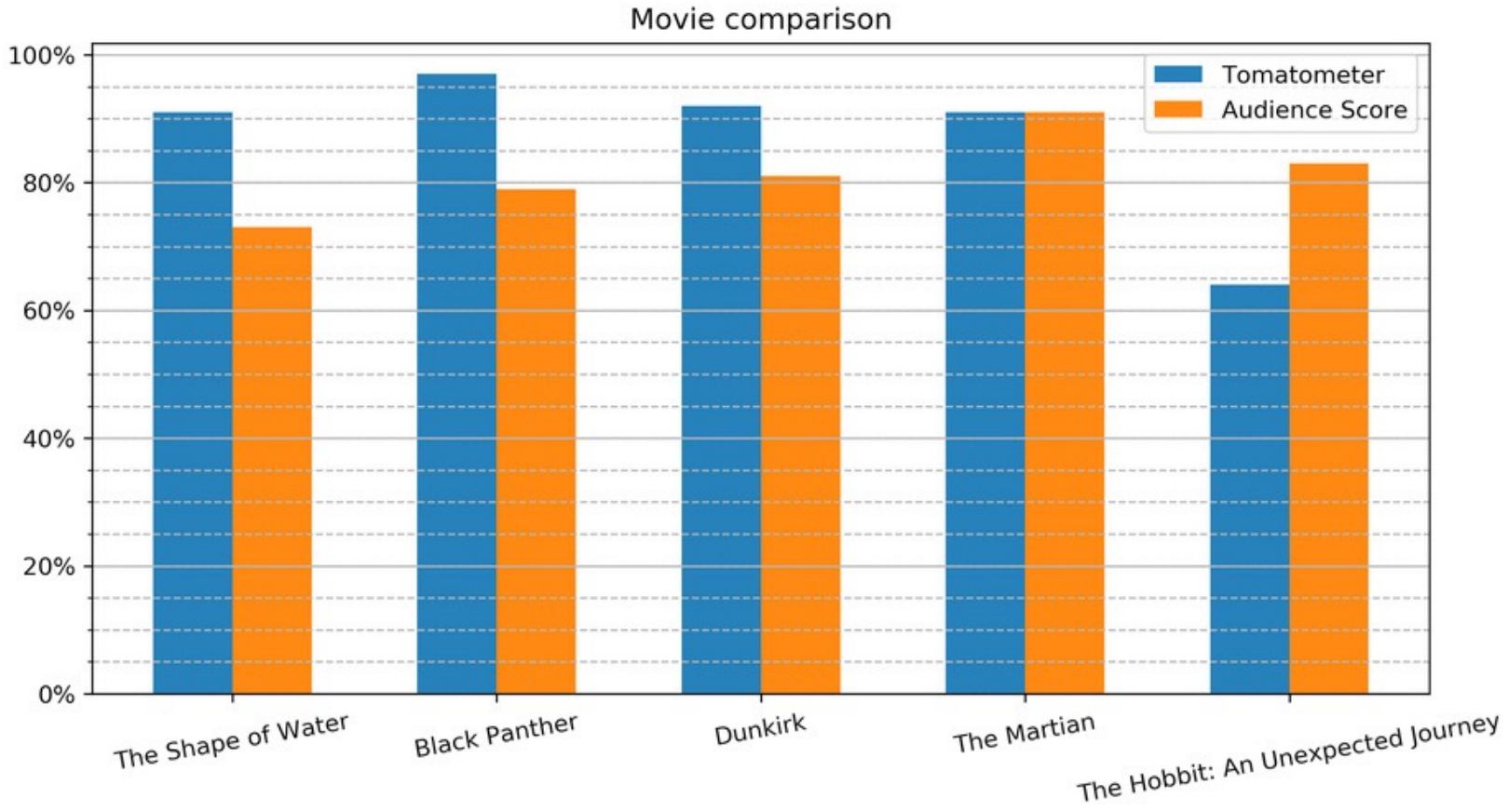
- The marks out of 100 that five students obtained in a test





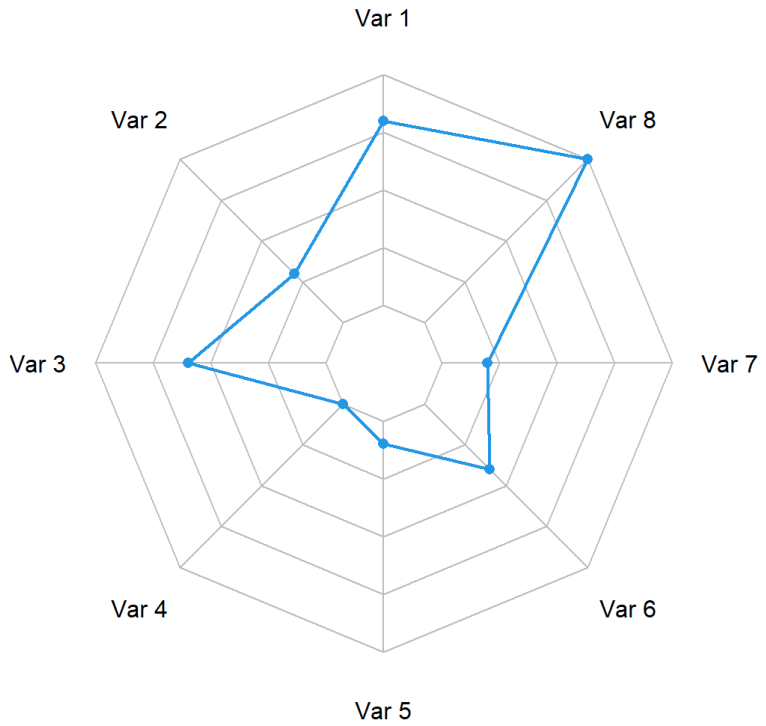
Bar Chart Example

- The following diagram compares movie ratings, giving two different scores:



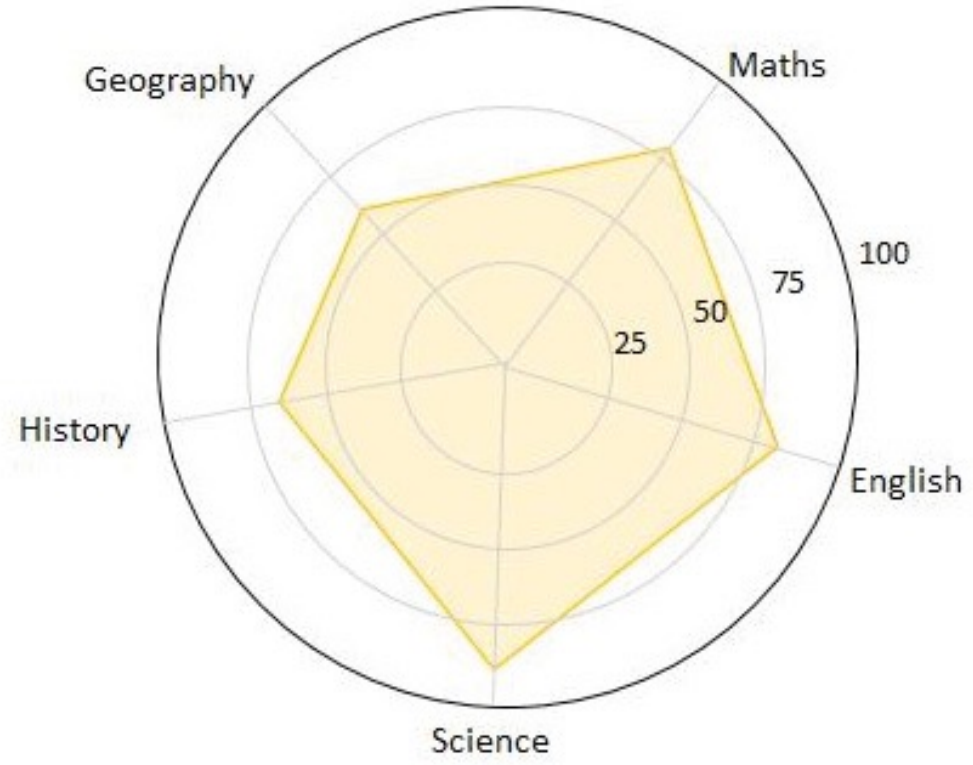
Radar Chart

- Radar charts, also known as spider or web charts, visualize multiple variables with each variable plotted on its own axis, resulting in a polygon.
  - All axes are arranged radially, starting at the center with equal distances between one another and have the same scale.



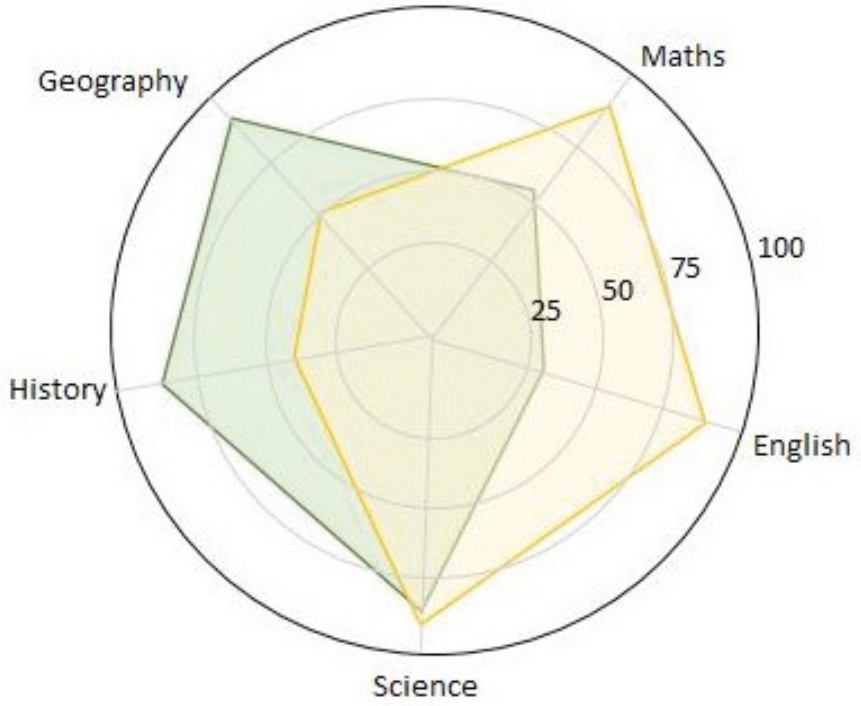
Radar Chart Example

- The following radar chart displays data about a student (a single variable) scoring marks in different subjects.



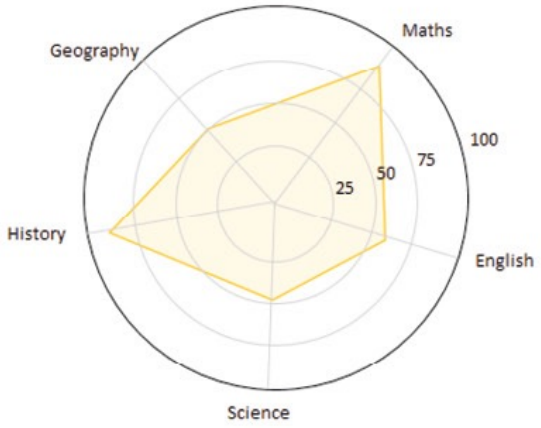
Radar Chart Example

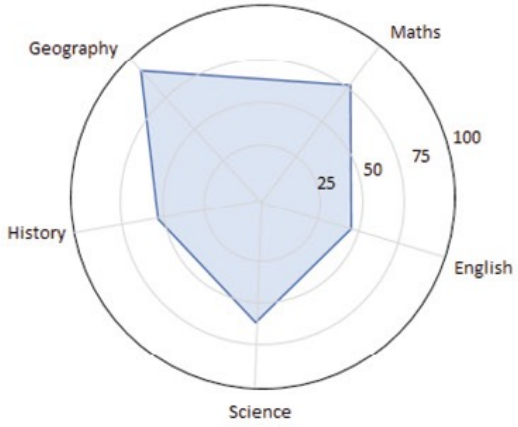
- The following diagram shows a radar chart for two variables/groups:

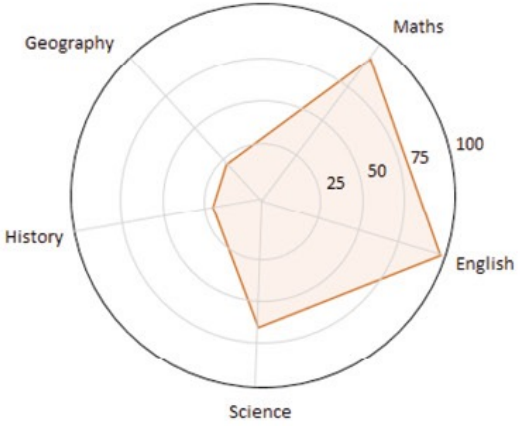


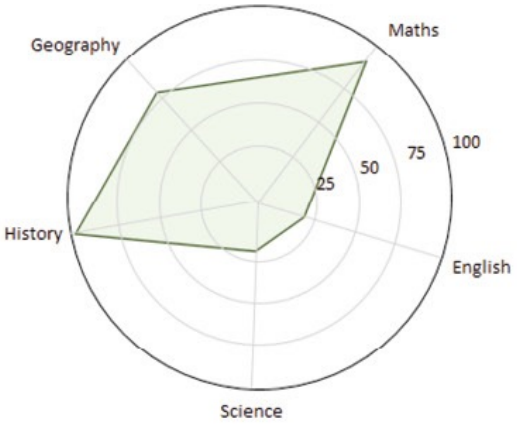
Radar Chart Example

- Radar chart with faceting for multiple variables (multiple subjects)



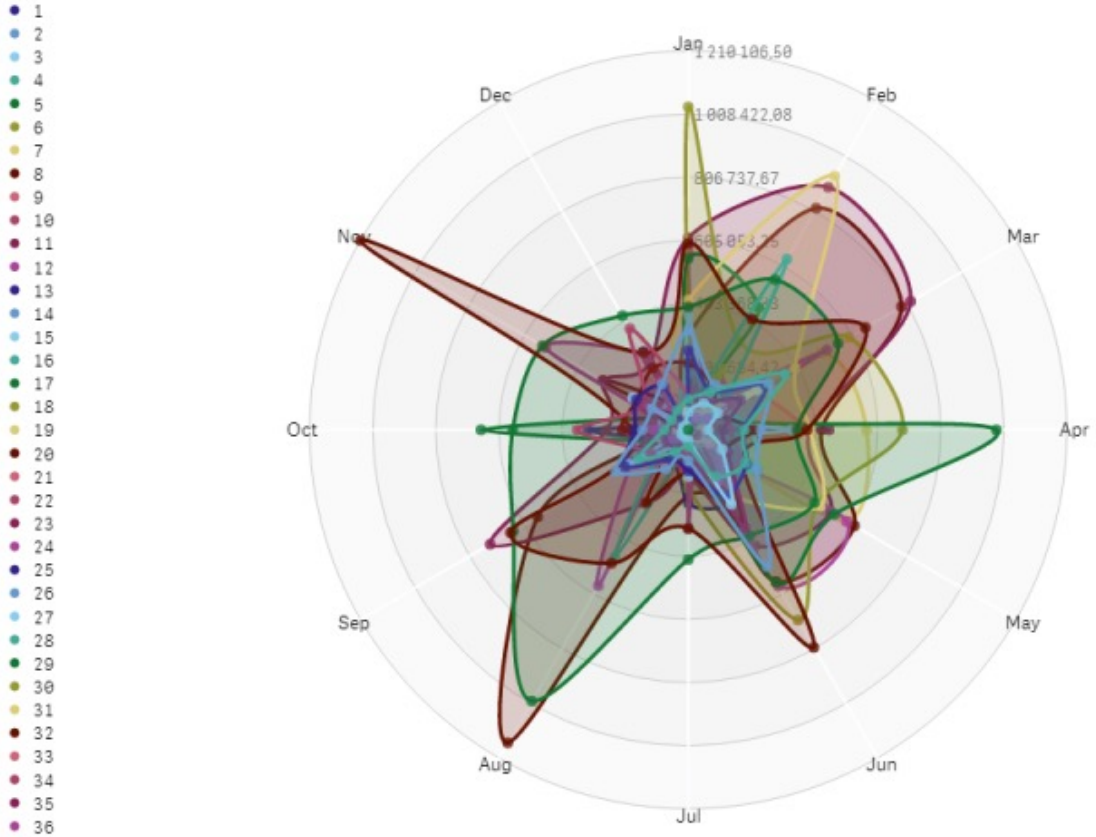






Radar Chart Pratices

- Design practices:
  - Display ten factors or fewer on one radar chart to make it easier to read.



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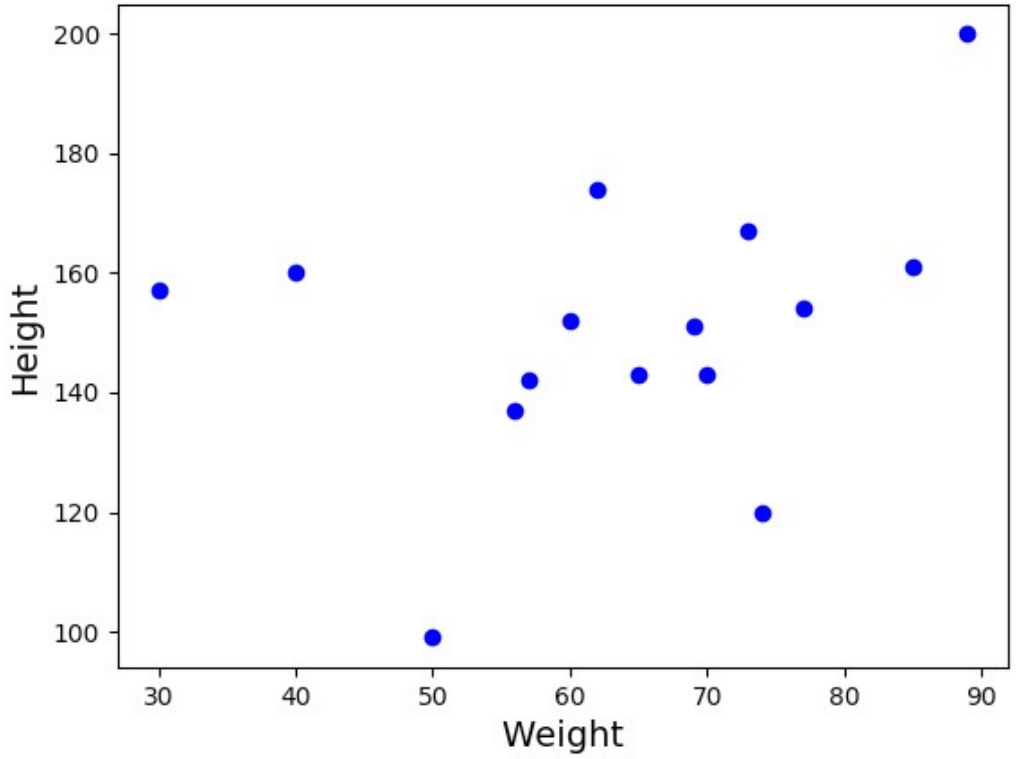
Relation Plots

- Relation plots are perfectly suited to show relationships among variables.
  - Scatter plot
  - Bubble plot
  - Correlogram
  - Heatmap

Scatter Plot

- Scatter plots show data points for two numerical variables, displaying a variable on both axes.



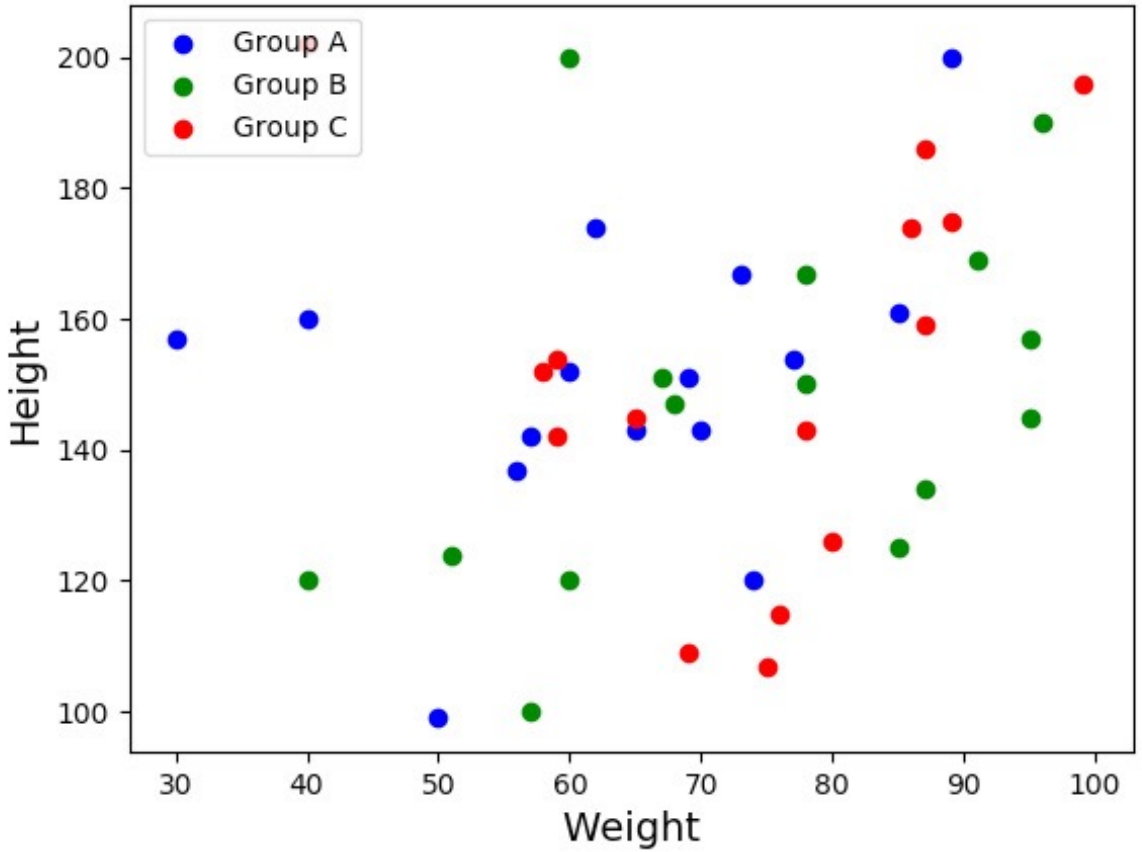
A scatter plot of height and weight of persons belonging to a single group

Scatter Plot

- With scatter plot:
  - Can detect whether a correlation (relationship) exists between two variables.
  - Can plot the relationship for multiple groups or categories using different colors.
  - A bubble plot, which is a variation of the scatter plot, is an excellent tool for visualizing the correlation of a third variable.

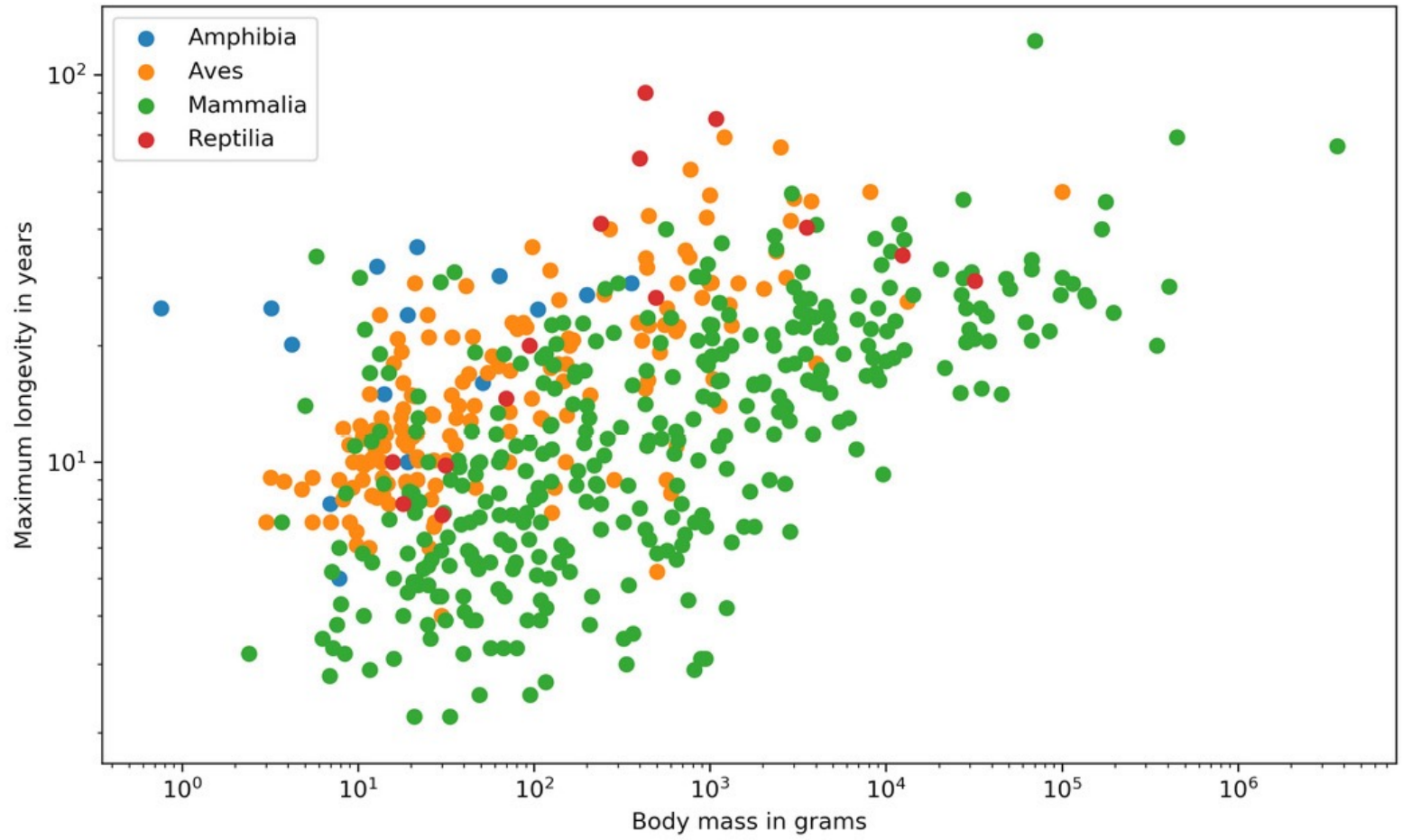
Scatter Plot Example

- Scatter plot with multiple variables (three groups)



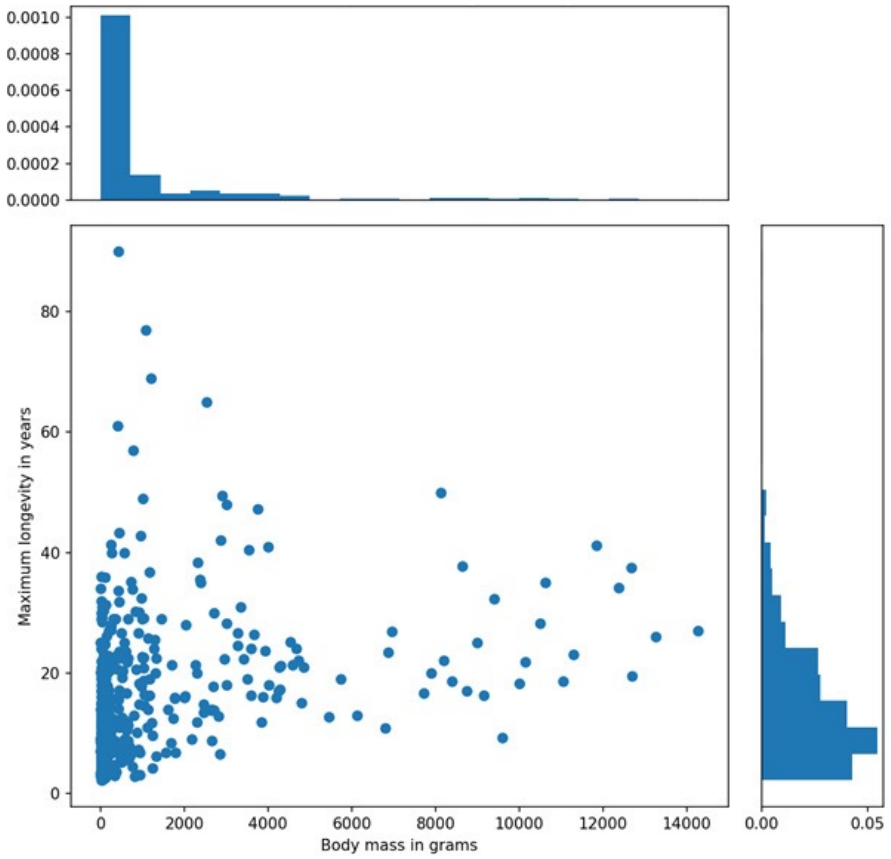
Scatter Plot Example

- The following diagram shows the correlation between the body mass and the maximum longevity for various animals grouped by their classes.
  - There is a positive correlation between the body mass and the maximum longevity



Variants: scatter plots with marginal histograms

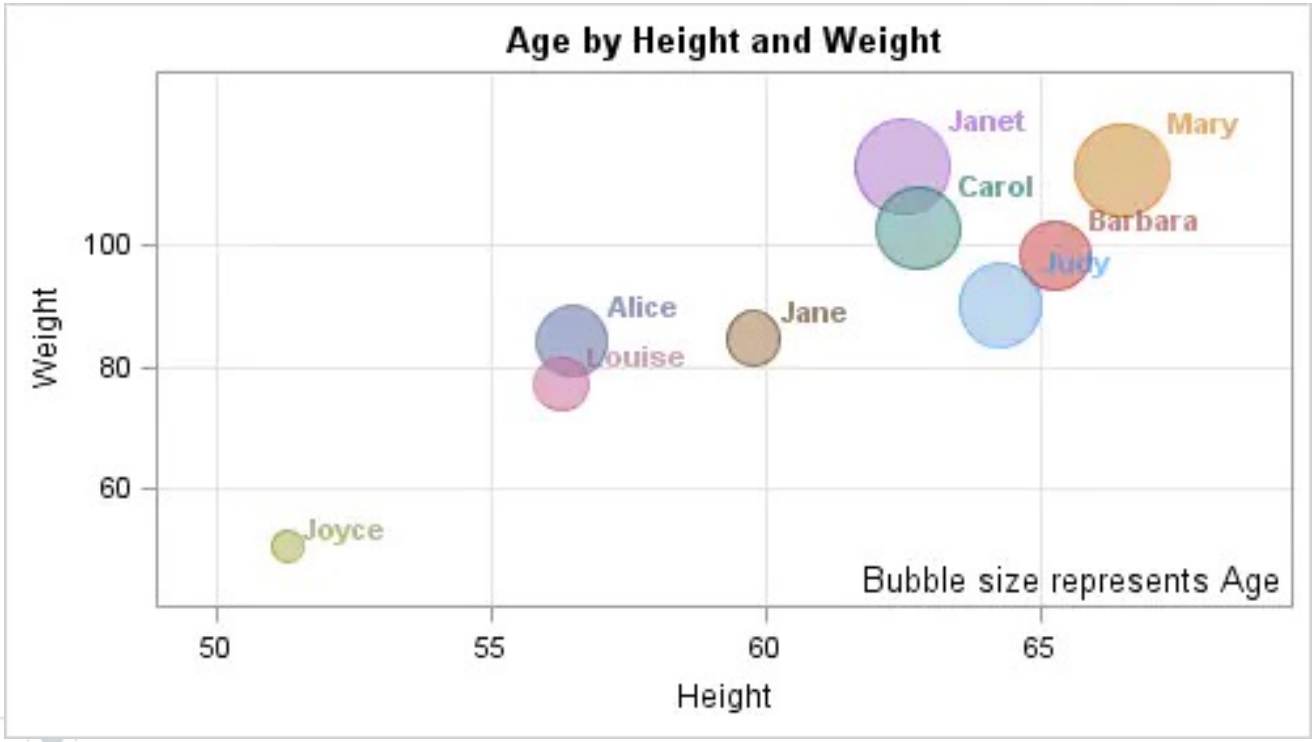
- In addition to the scatter plot, you can plot the marginal distribution for each variable in the form of histograms to give better insight into how each variable is distributed.



Correlation between body mass and maximum longevity of the Aves class with marginal histograms

Bubble Plot

- A bubble plot extends a scatter plot by introducing a third numerical variable.
  - To show a correlation between three variables.
  - The value of the variable is represented by the size of the dots. The area of the dots is proportional to the value.
  - A legend is used to link the size of the dot to an actual numerical value.

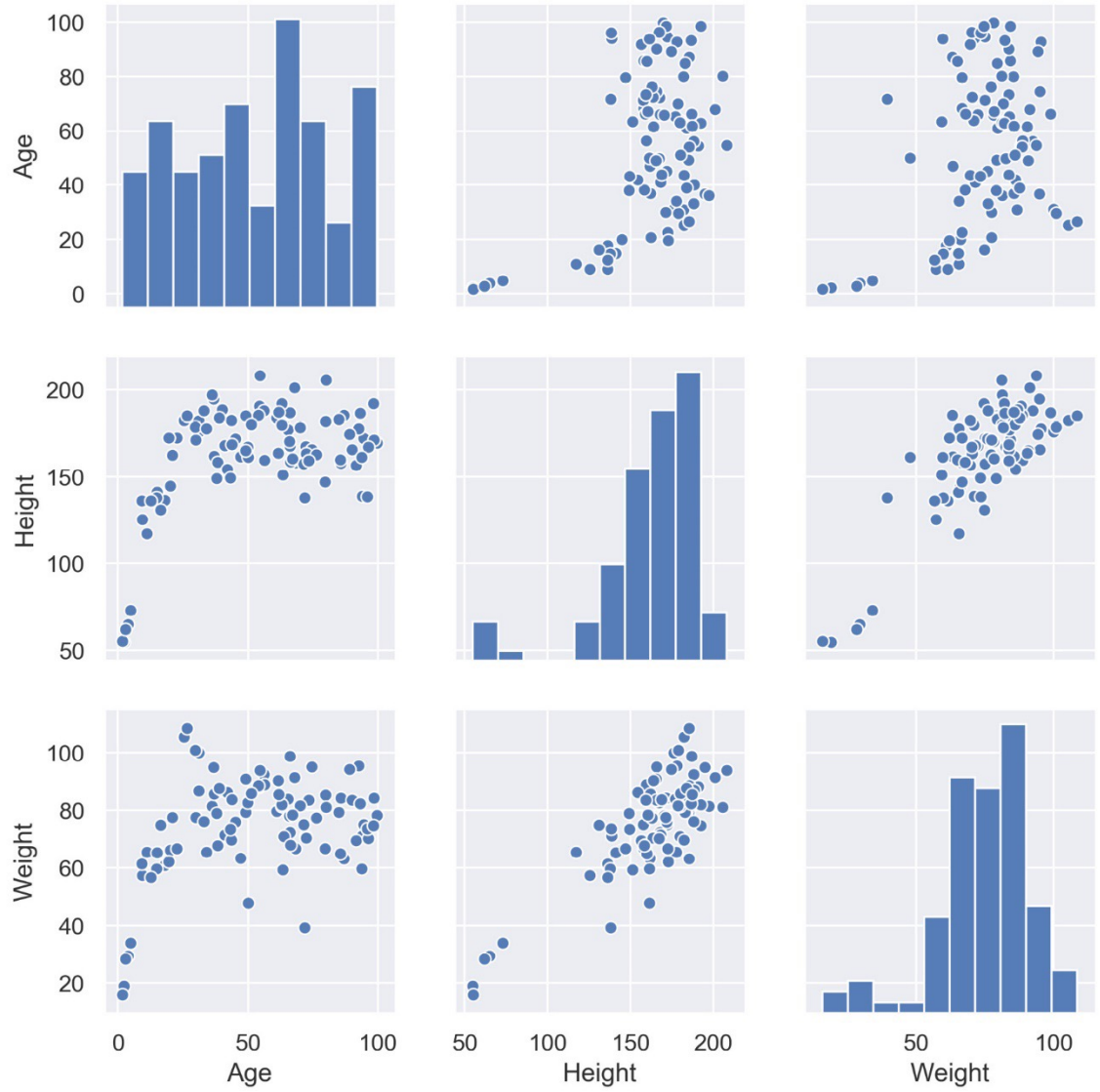


Correlogram

- A correlogram is a combination of scatter plots and histograms.
  - A correlogram or correlation matrix visualizes the relationship between each pair of numerical variables using a scatter plot.
  - The diagonals of the correlation matrix represent the distribution of each variable in the form of a histogram.

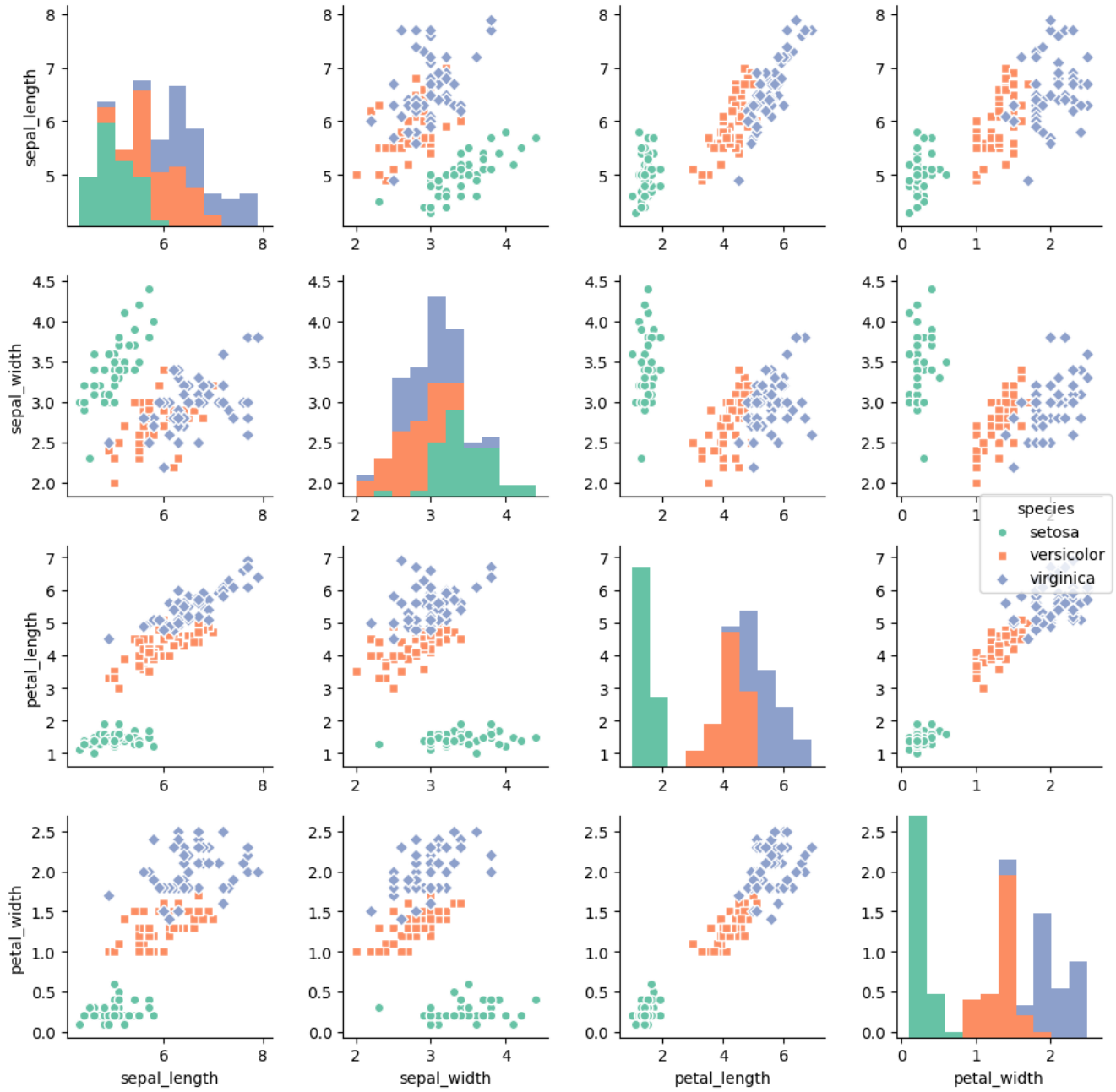
Correlogram Example

- The following diagram shows a correlogram for height, weight, and age of humans.



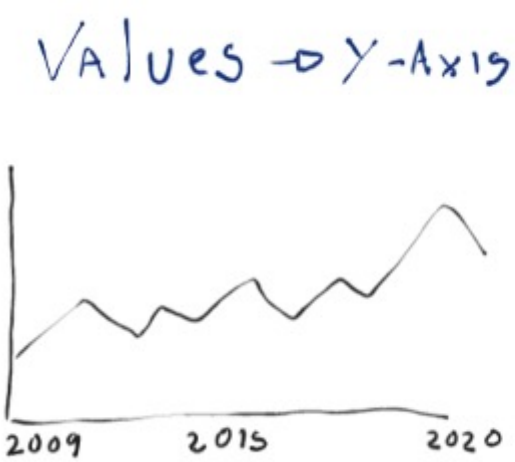
Correlogram Example

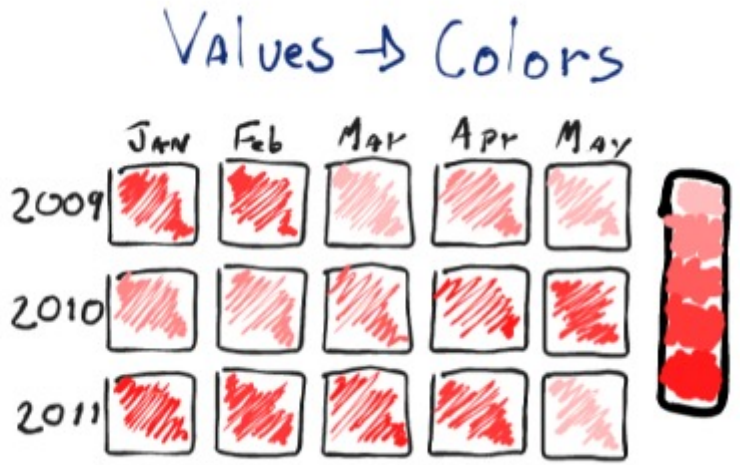
- Correlogram with multiple categories



Heatmap

- A heatmap is a visualization where values contained in a matrix are represented as colors or color saturation.
- Heatmaps are great for visualizing multivariate data
  - categorical variables are placed in the rows and columns
  - numerical or categorical variable is represented as colors or color saturation.





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Composition Plots

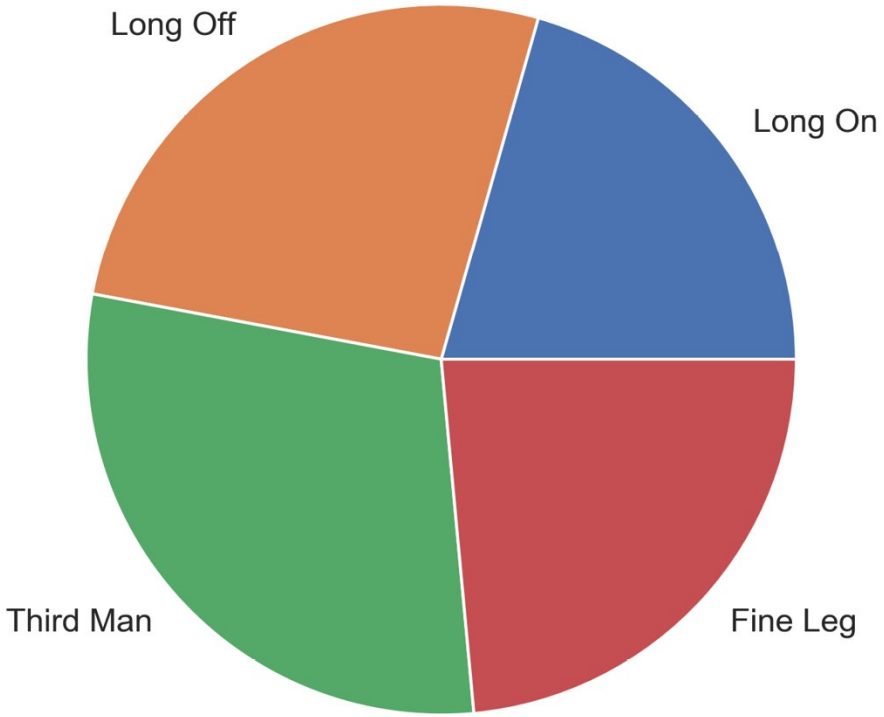
- Composition plots are ideal if you think about something as a part of a whole.
  - Pie chart
  - Stacked bar chart
  - Venn diagram

Pie Chart

- Pie charts illustrate numerical proportion by dividing a circle into slices.
  - Each arc length represents a proportion of a category.
  - The full circle equals to 100%.
  - For humans, it is easier to compare bars than arc lengths; therefore, it is recommended to use bar charts or stacked bar charts most of the time.

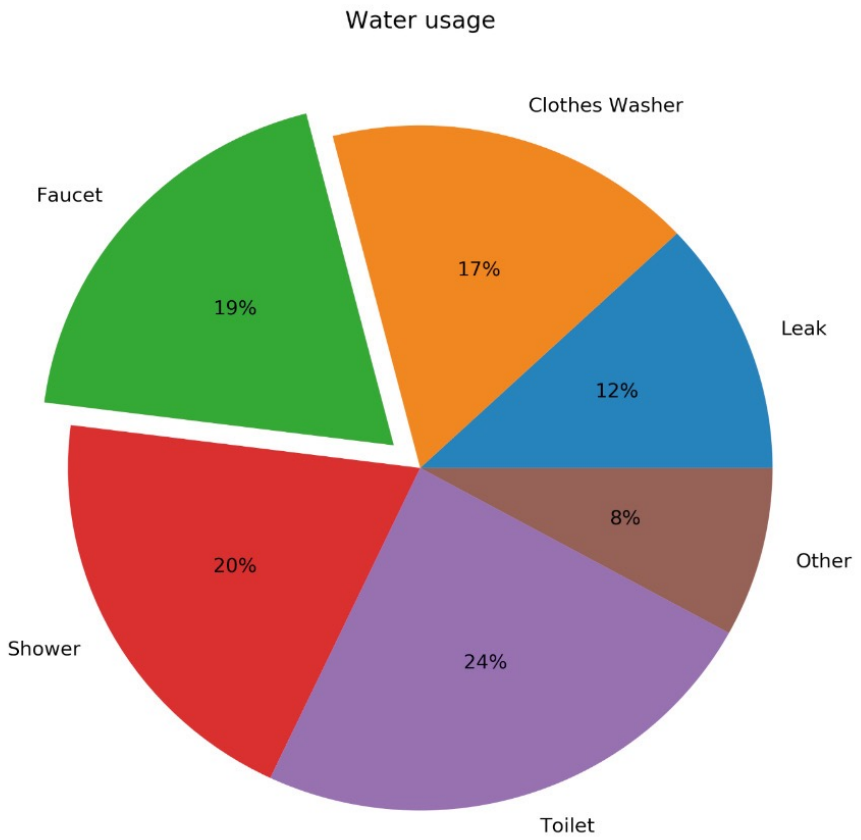
Pie Chart Example

- The following diagram shows a pie chart that shows different fielding positions of the cricket ground, such as long on, long off, third man, and fine leg.



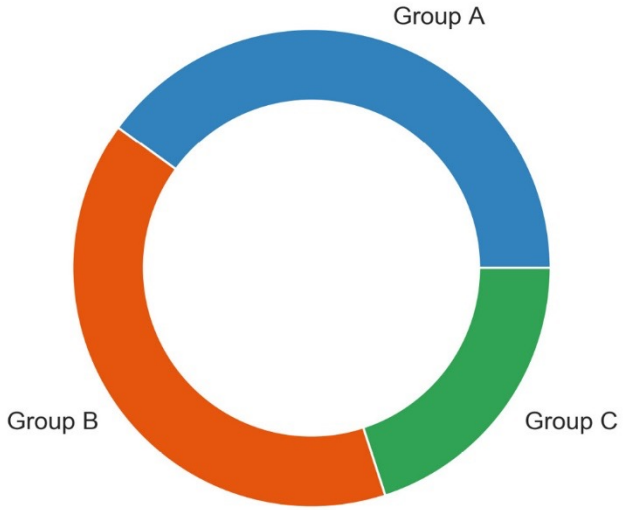
Pie Chart Example

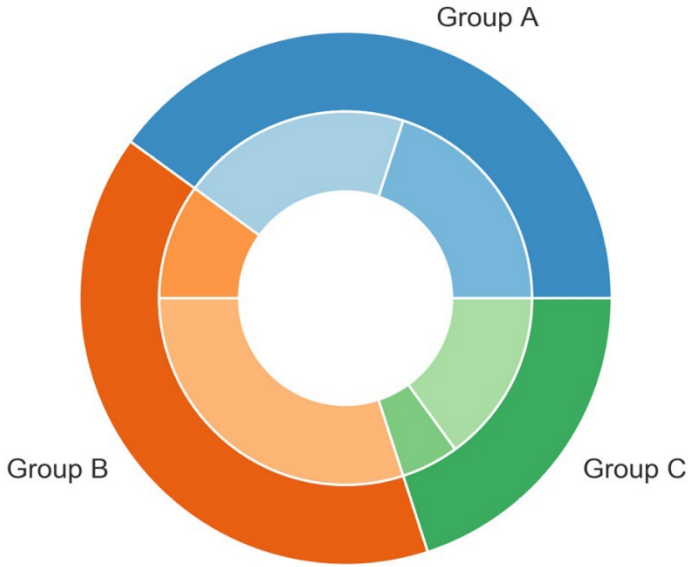
- The following diagram shows water usage around the world:



Pie Chart Variants: Donut Chart

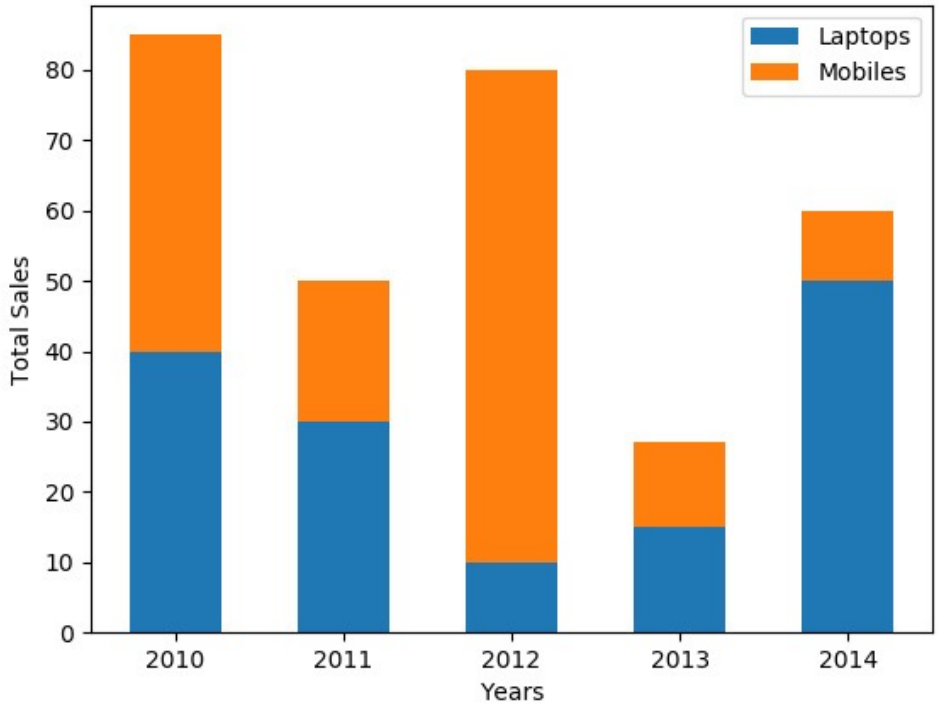
- Donut charts are more space-efficient because the center is cut out, so it can be used to display information or further divide groups into sub-groups.





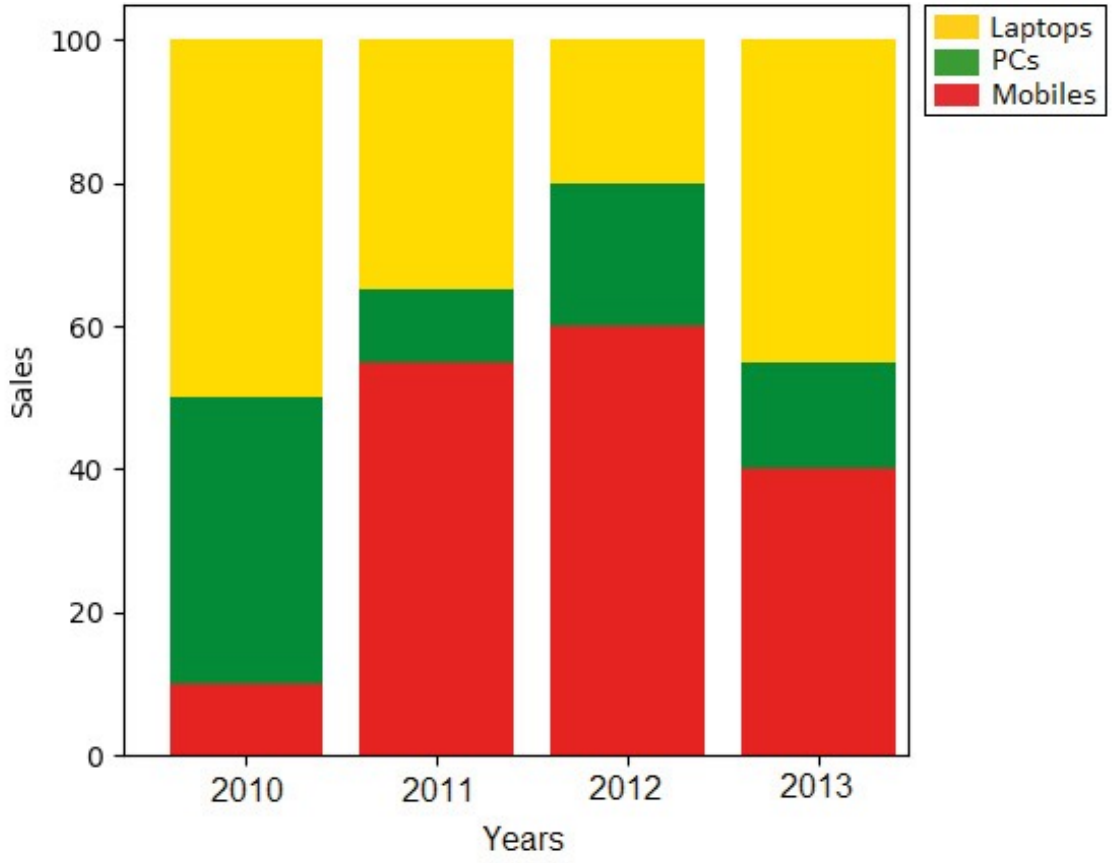
Stacked Bar Chart

- Stacked bar charts are used to show how a category is divided into sub-categories and the proportion of the sub-category, in comparison to the overall category.
  - You can either compare total amounts across each bar or show a percentage of each group.



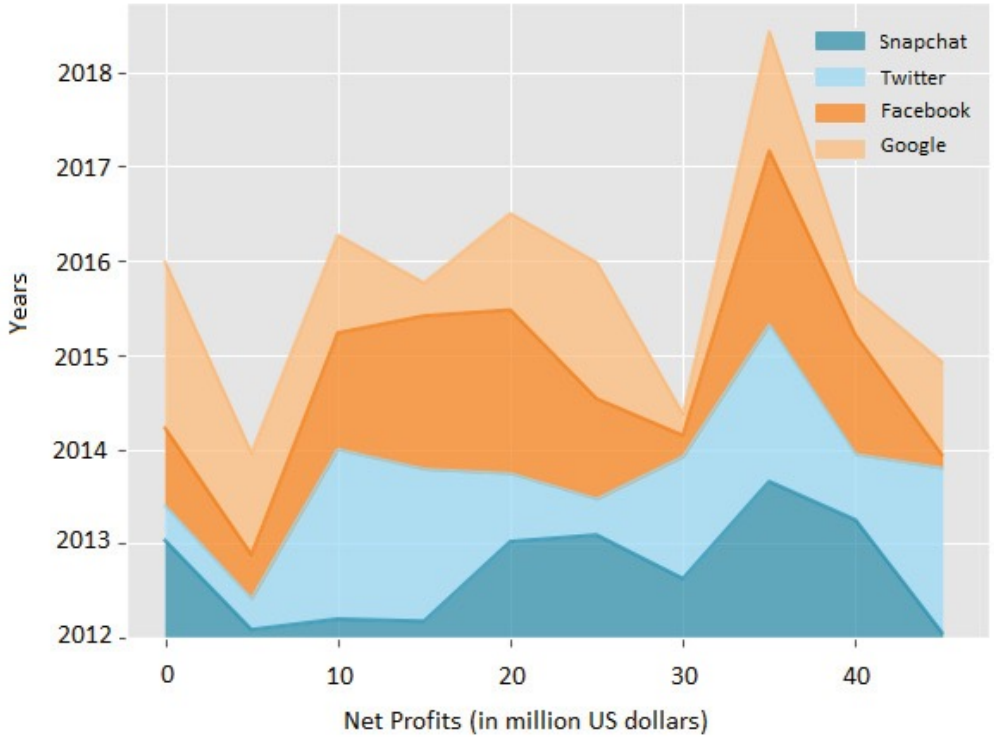
Stacked Bar Chart

- A 100% stacked bar chart makes it easier to see relative differences between quantities in each group.



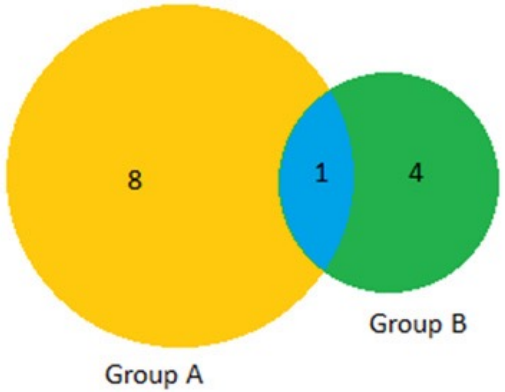
Stacked Area Chart

- Stacked area charts show trends for part-of-a-whole relations.
  - The values of several groups are illustrated on top of one another.
  - It helps to analyze both individual and overall trend information.



Venn Diagram

- Venn diagrams, also known as set diagrams, show all possible logical relations between a finite collections of different sets.
  - Each set is represented by a circle.
  - The circle size illustrates the importance of a group.
  - The size of an overlap represents the intersection between multiple groups.



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Distribution Plots

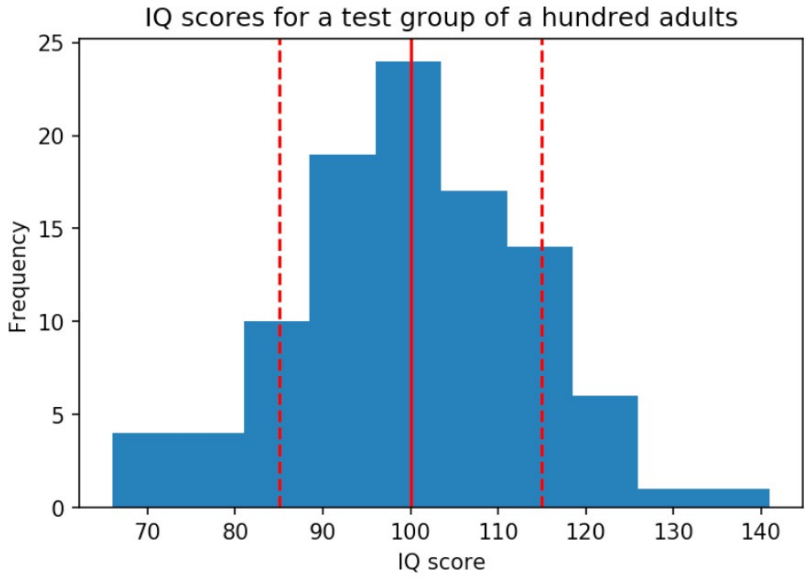
- Distribution plots give a deep insight into how your data is distributed.
  - Histogram
  - Density plot
  - Box plot
  - Violin plot

Histogram

- A histogram visualizes the distribution of a single numerical variable.
  - Each bar represents the frequency for a certain interval.
  - Either plot a histogram with absolute frequency values or alternatively normalize your histogram.
  - To compare distributions of multiple variables, use different colors for the bars.
- Histograms help get an estimate of statistical measures.
  - Identify where values are concentrated
  - Easily detect outliers.

Histogram Example

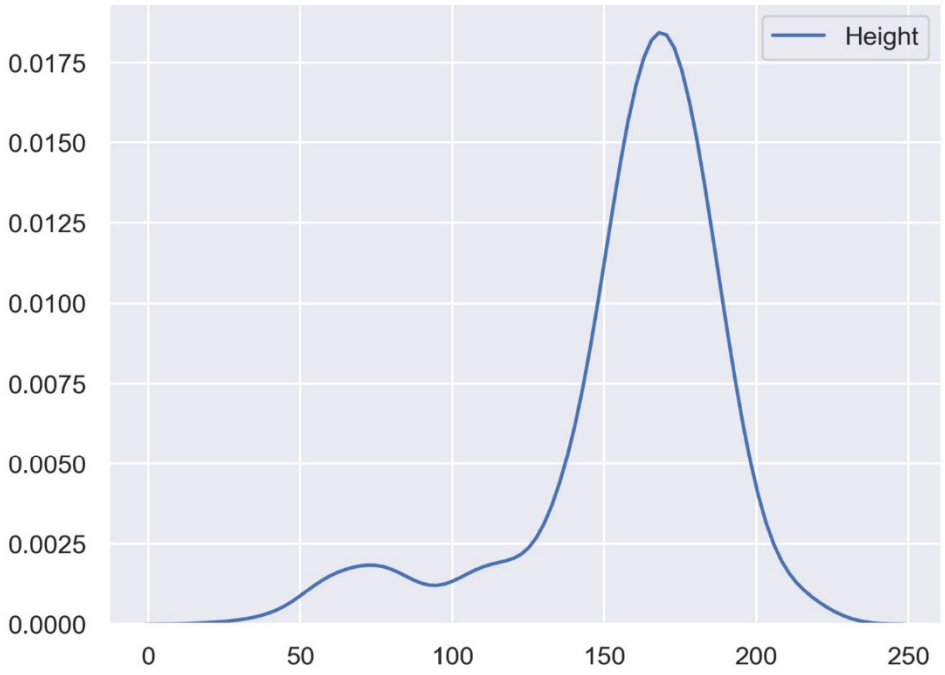
- The distribution of the Intelligence Quotient (IQ) for a test group.
  - The solid line indicates the mean and the dashed lines indicate the standard deviation

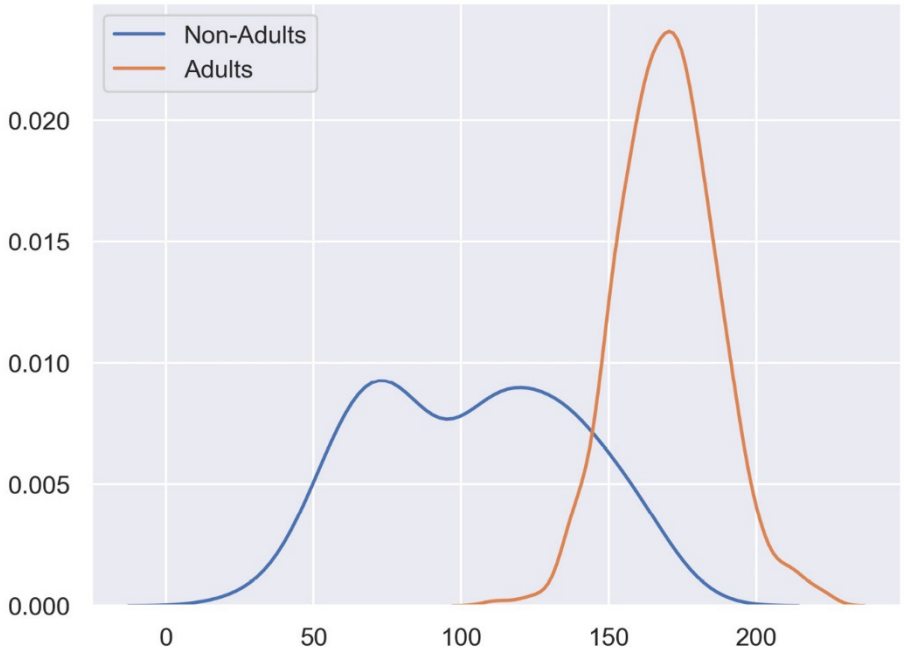


Density Plot

- A density plot shows the distribution of a numerical variable.
  - It is a variation of a histogram that uses kernel smoothing, allowing for smoother distributions.
  - An advantage they have over histograms is that density plots are better at determining the distribution shape, since the distribution shape for histograms heavily depends on the number of bins (data intervals).

Density Plot Example

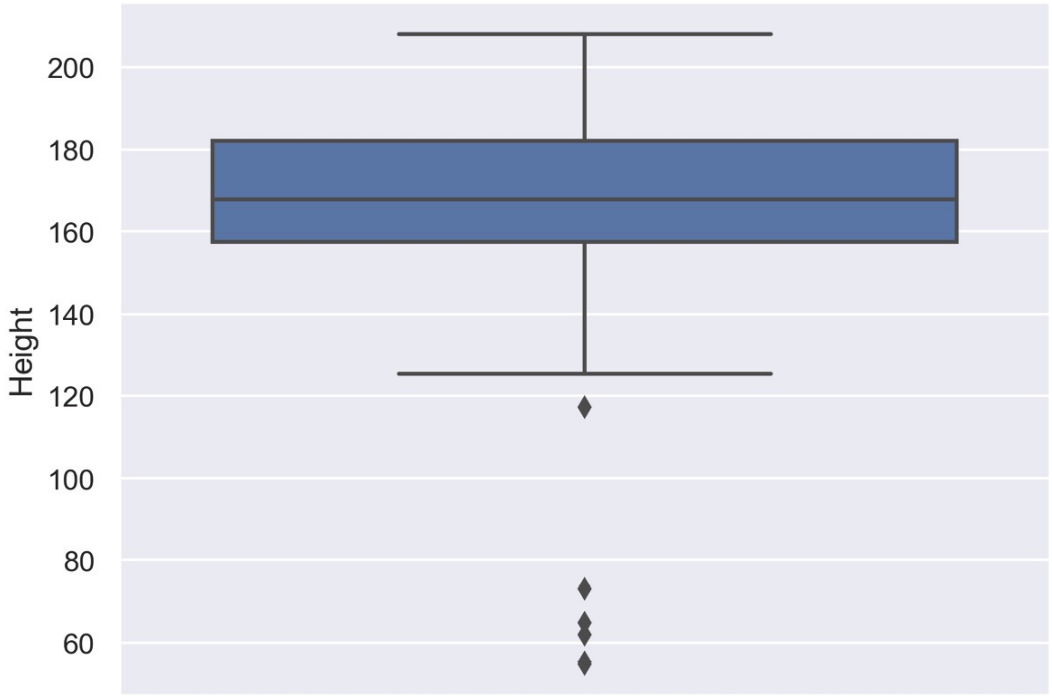


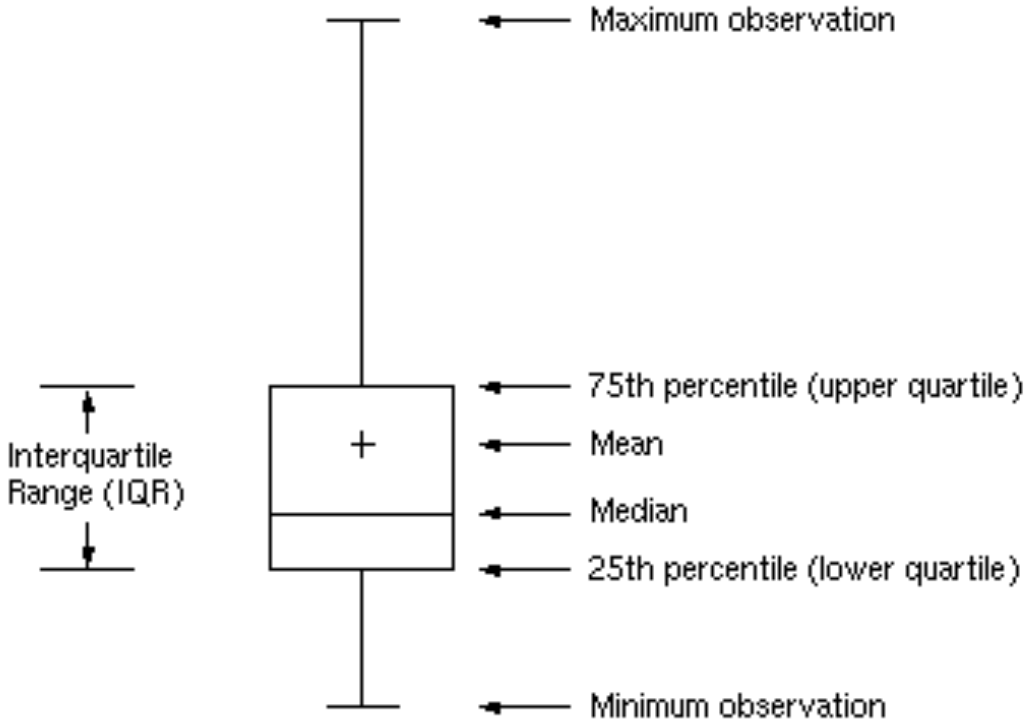


Box Plot

- The box plot shows multiple statistical measurements.
  - The box extends from the lower to the upper quartile values of the data, thus allowing us to visualize the interquartile range.
  - The horizontal line within the box denotes the median.
  - The whiskers extending from the box show the range of the data. It is also an option to show data outliers, usually as circles or diamonds, past the end of the whiskers.

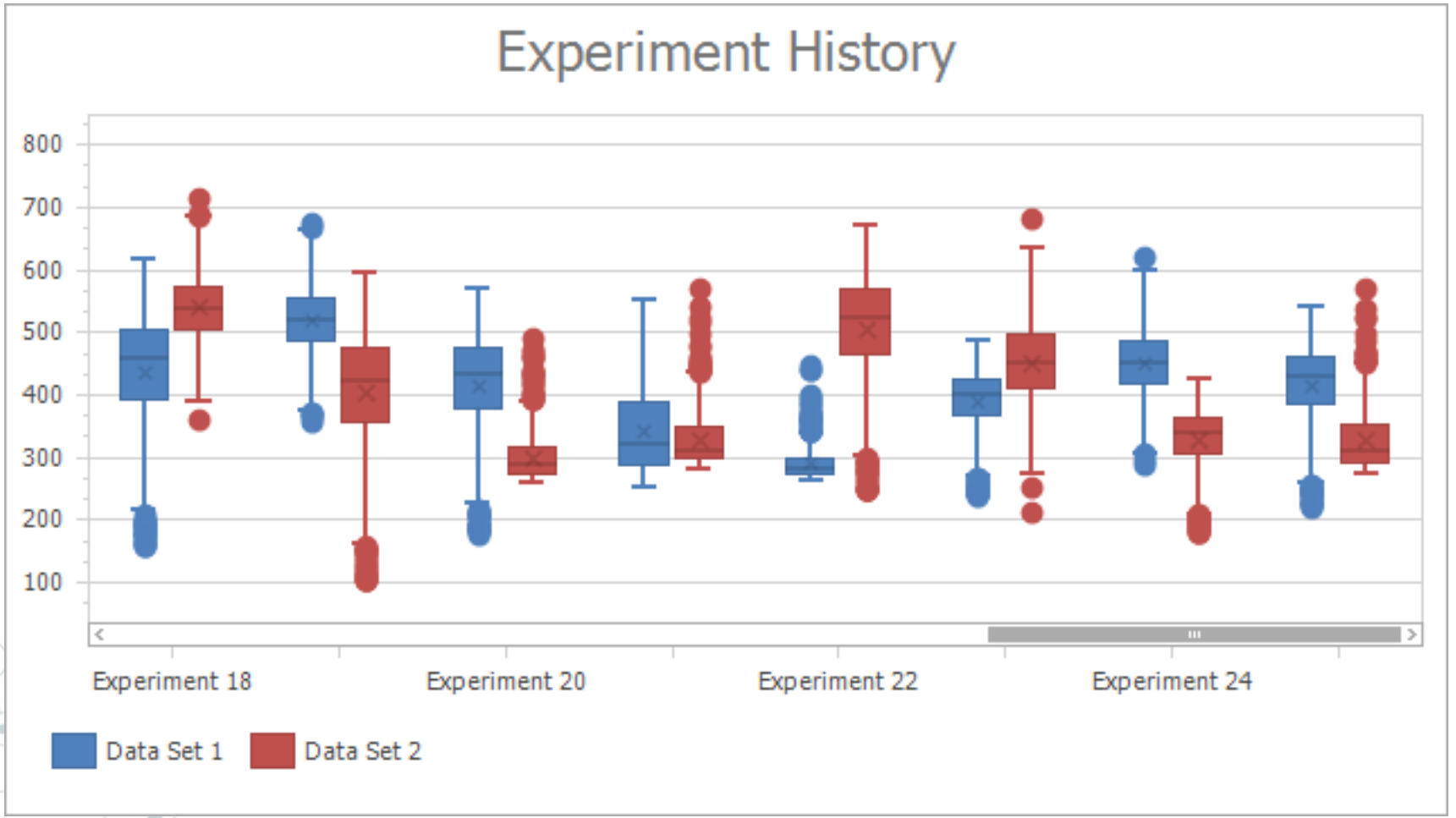
Box Plot Example





Box Plot Example

- If you want to compare statistical measures for multiple variables or groups, simply plot multiple boxes next to one another.

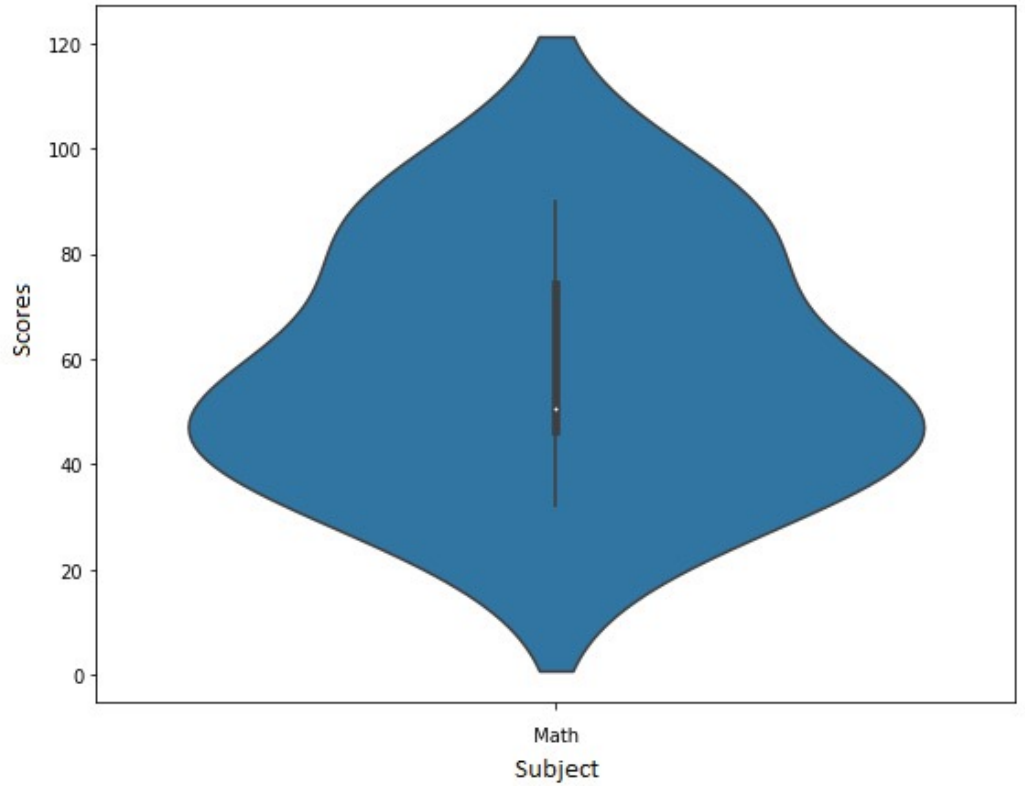


Violin Plot

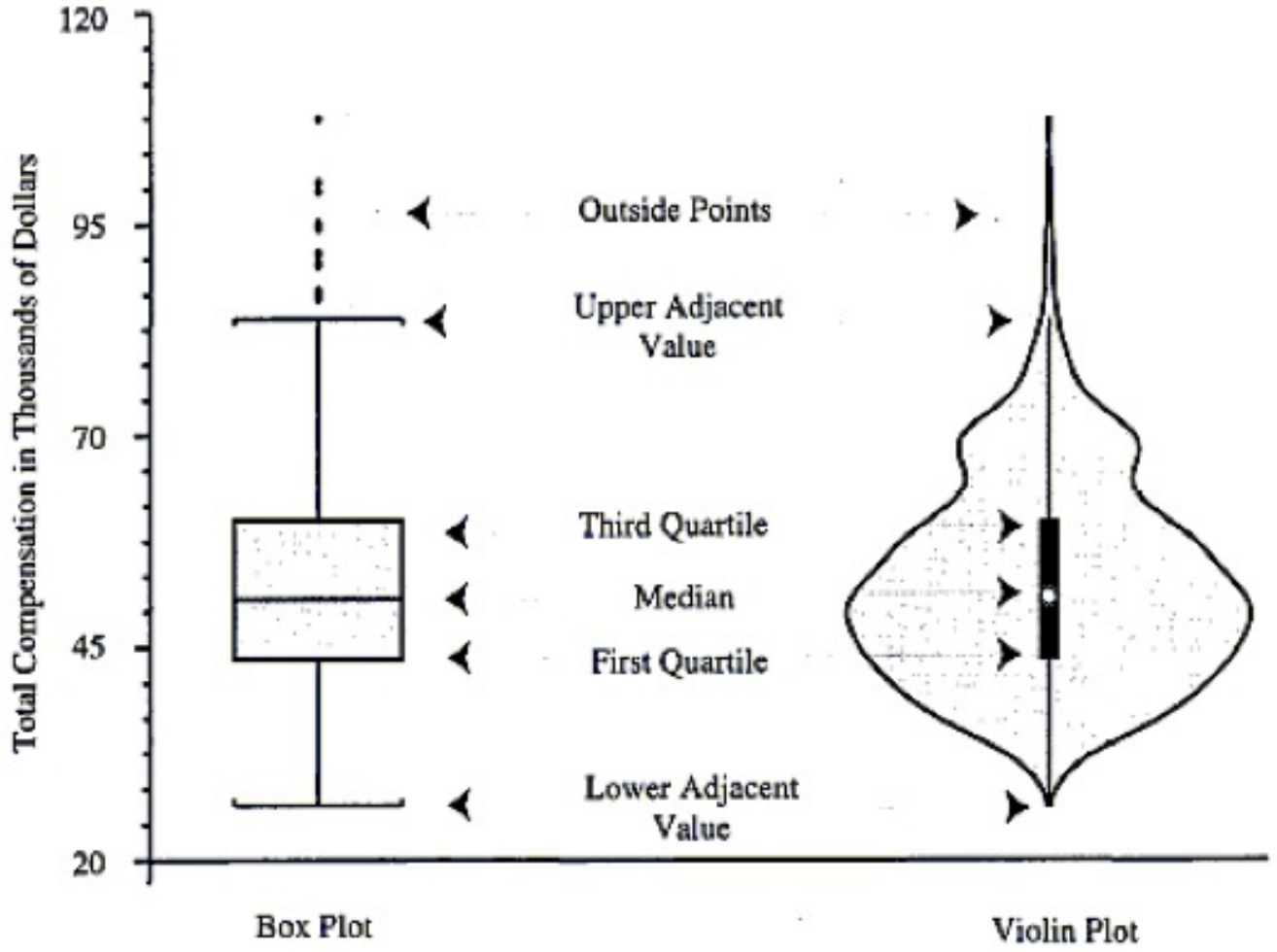
- Violin plots are a combination of box plots and density plots.
  - Both the statistical measures and the distribution are visualized.
  - The thick black bar in the center represents the interquartile range, the thin black line shows the 95% confidence interval, and the white dot shows the median.
  - On both sides of the center-line, the density is visualized.

Violin Plot Example

- The following diagram shows a violin plot for a single variable and shows how students have performed in Math:



Box plot vs Violin Plot



Content

- Introduction
- **Types of Visualization**
  - Comparison Plots
  - Relation Plots
  - Composition Plots
  - Distribution Plots
  - Geo Plots

Geo Plots

- Geological plots are a great way to visualize geospatial data.
  - Dot map
  - Choropleth map
  - Connection map

Dot Map

- In a dot map, each dot represents a certain number of observations.
  - Each dot has the same size and value (the number of observations each dot represents).
  - The dots are not meant to be counted—they are only intended to give an impression of magnitude.
  - The size and value are important factors for the effectiveness and impression of the visualization.
  - You can use different colors or symbols for the dots to show multiple categories or groups.

Dot Map Example

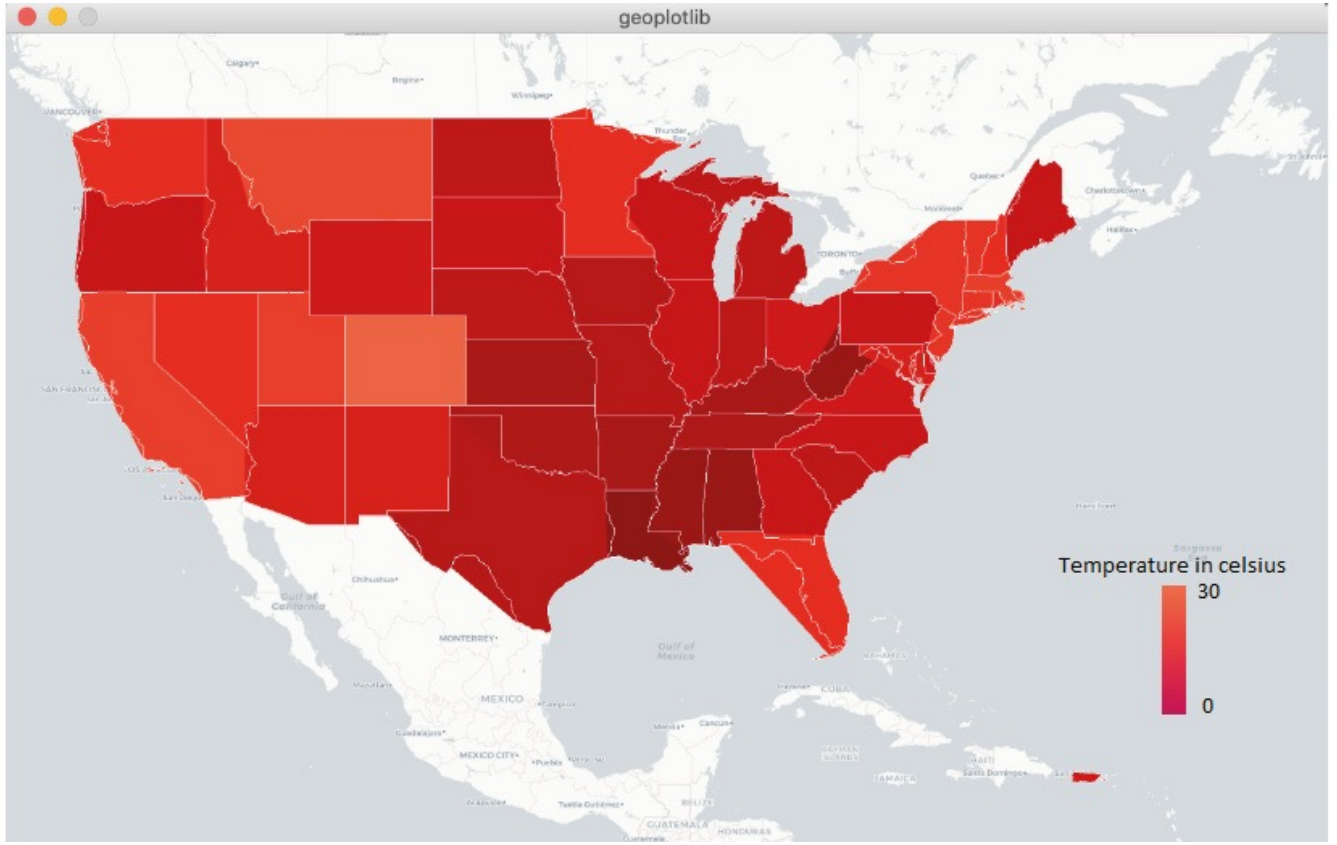
- The following diagram shows a dot map where each dot represents a certain amount of bus stops throughout the world

Choropleth Map

- In a choropleth map, each tile is colored to encode a variable.
  - A tile represents a geographic region for, for example, counties and countries.
- Choropleth maps provide a good way to show how a variable varies across a geographic area.

Choropleth Map Example

- The following diagram shows a choropleth map of a weather forecast in the USA:



Connection Map

- In a connection map, each line represents a certain number of connections between two locations.
  - The link between the locations can be drawn with a straight or rounded line representing the shortest distance between them.

Thank you for listening