Visualization

Overview

1. What Is Visualization?
2. History of Visualization
3. Relationship between Visualization and Other Fields
4. The Visualization Process
5. The Scatterplot
6. The Role of the User

1. What is Visualization?

Definition of *visualization* in English:

visualization

(*British* **visualisation**)

Pronunciation /vɪzjʊəlʌɪˈzeɪʃ(ə)n/ /vɪʒ(j)ʊəlʌɪˈzeɪʃ(ə)n/

NOUN

[mass noun]

data

1 The representation of an object, situation, or set of information as a chart or other image.
'video systems allow visualization of the entire gastrointestinal tract'
+ More example sentences

1.1 *[count noun]* A chart or other image that is created as a visual representation of an object, situation, or set of information.
'3D visualizations for architectural design'
+ More example sentences

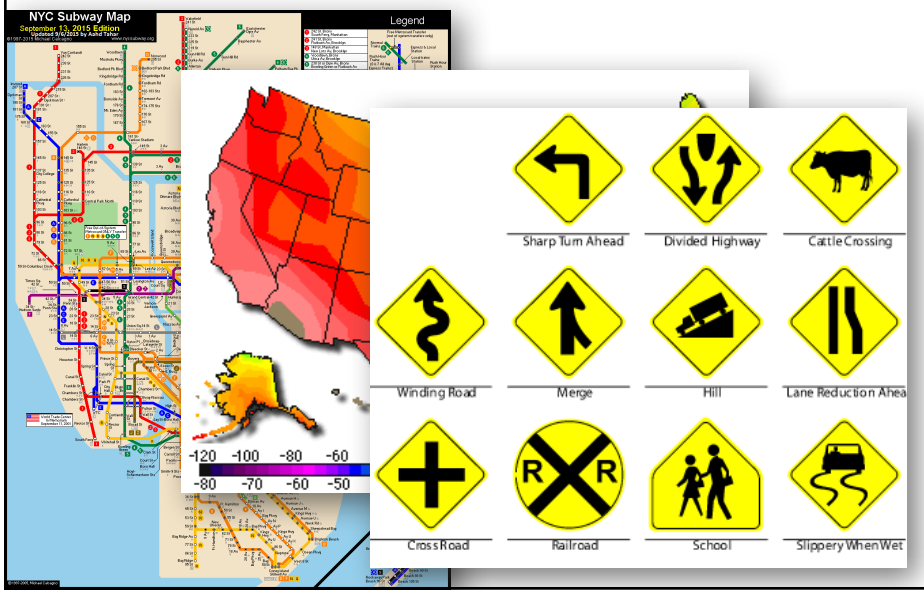
2 The formation of a mental image of something.
'the story uses descriptive language to aid visualization'
'visualization is a helpful technique for relieving stress'
[count noun] 'a powerful visualization of a future dystopia'

https://en.oxforddictionaries.com/definition/visualization

Visualization: From Data to Information

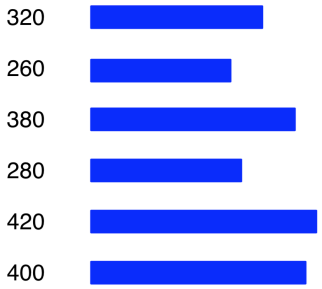
- Data alone are not enough to establish a communicative process.
- To give meaning to data, they must first be processed, organized, and presented in a suitable format.
- This transformation and manipulation of the data produces information that “is accomplished by organizing it into a meaningful form, presenting it in meaningful and appropriate ways, and communicating the context around it”

Visualization in Everyday Life

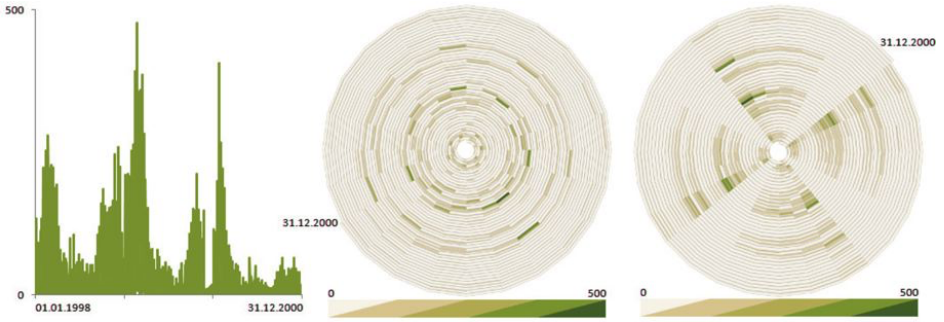


Humans and Visualization

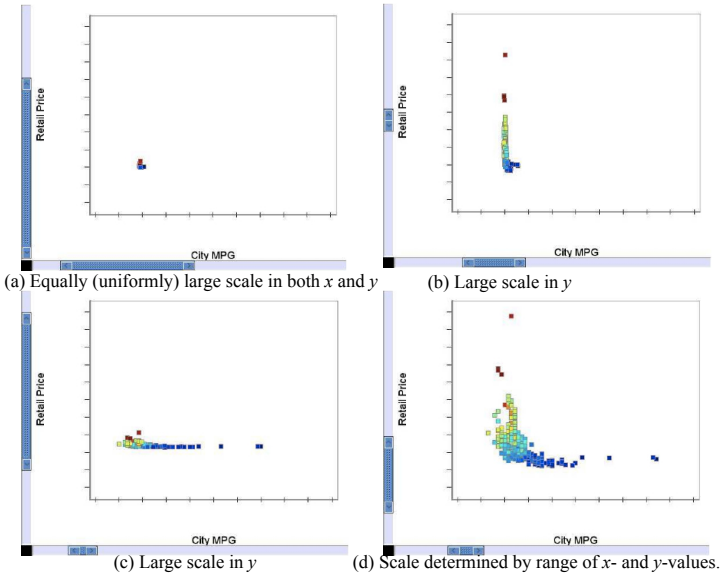
- Humans perceive *visual attributes* very well
- Visual attributes like *color*, *size*, *proximity*, and *movement* are immediately taken in and processed by the perceptual ability of vision
- Even before the complex cognitive processes of the human mind come into play.



Different insights can be gained from different visual representations



The same data plotted with different scales is perceived dramatically differently:



(a) Equally (uniformly) large scale in both *x* and *y*

(b) Large scale in *y*

(c) Large scale in *y*

(d) Scale determined by range of *x*- and *y*-values.

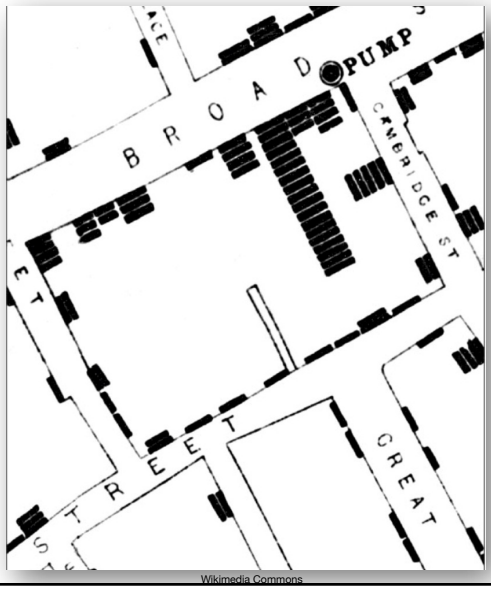
2. History of Visualization

2.1. Early Visualizations

Wikimedia Commons

The famous Hereford map, the largest surviving map of the Middle Ages (1280s).

2.1. Early Visualizations



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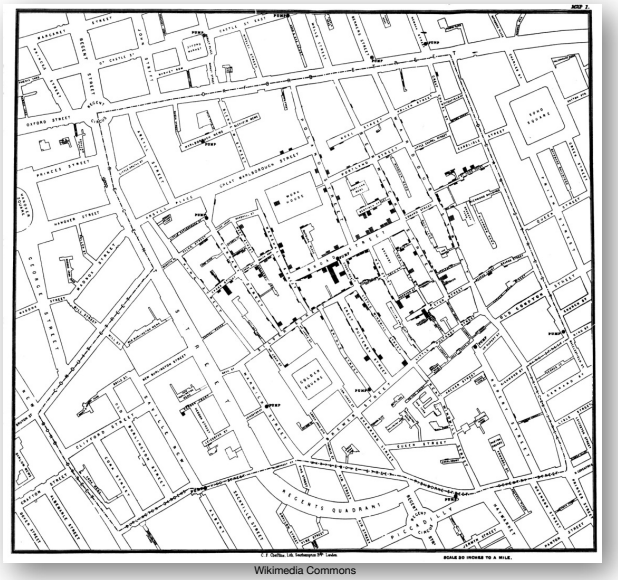
A section of John Snow's map of the deaths from cholera in London in 1663.

Each bar within the houses represents one deceased individual.



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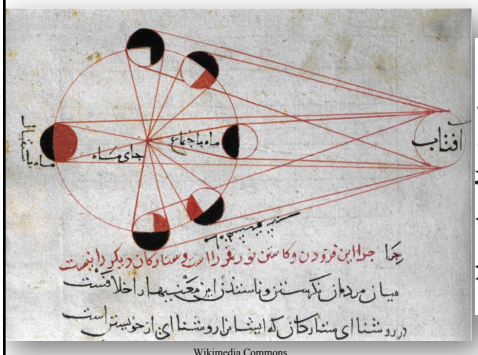
Overview map of the deaths from Cholera in London in 1663.

Note the concentration around the Broad Street Water Pump. Note as well the outliers.

Two early time series visualizations:



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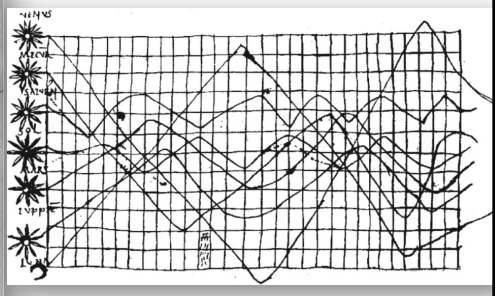
Produced by Biruni circa 1030.

Shows the phases of the moon in orbit.



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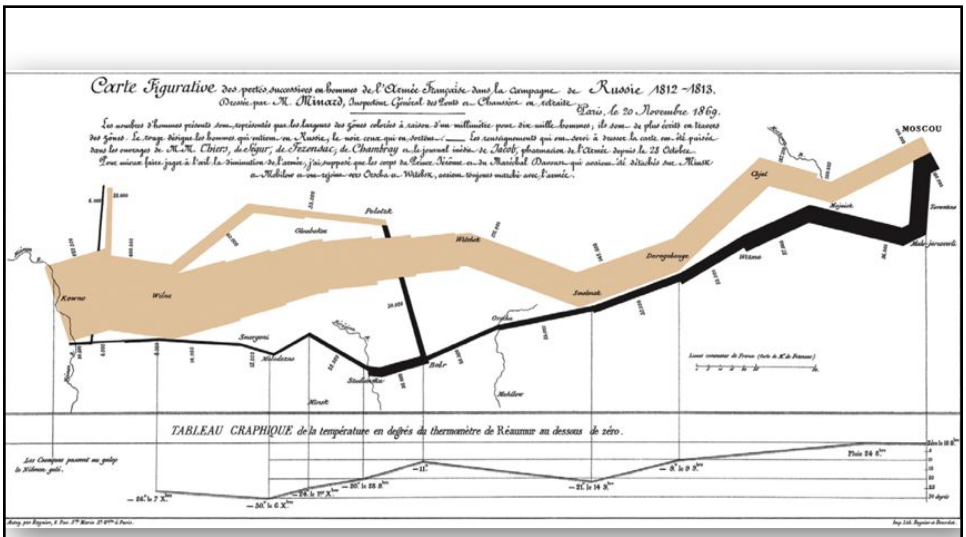
Shows planetary motion

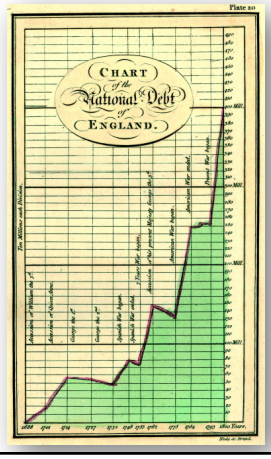


Wikimedia Commons

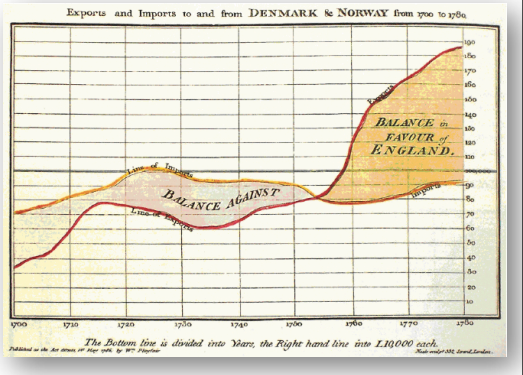
Minard's map, showing Napoleon's march on Moscow. The width of the line conveys the size of the army at that location. Color indicates the direction of movement. The temperature is plotted at different points along the retreat at the bottom.

Early visualizations of William Playfair:

A plot of the national debt over time.



A display of the balance of trade between England and Norway/Denmark (1786).



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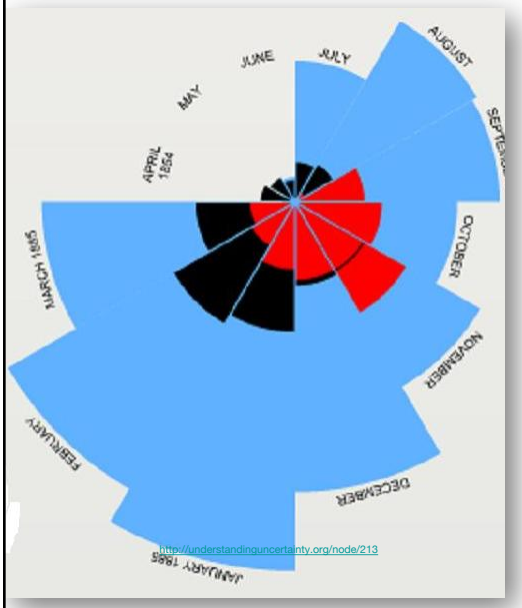
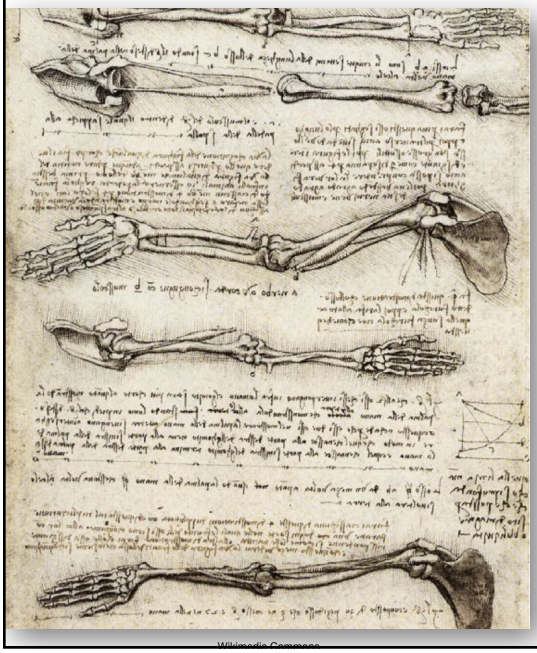


Florence Nightingale's coxcomb chart showing monthly deaths from battle and other causes.

Blue represents the deaths from disease

Red represents deaths from wounds

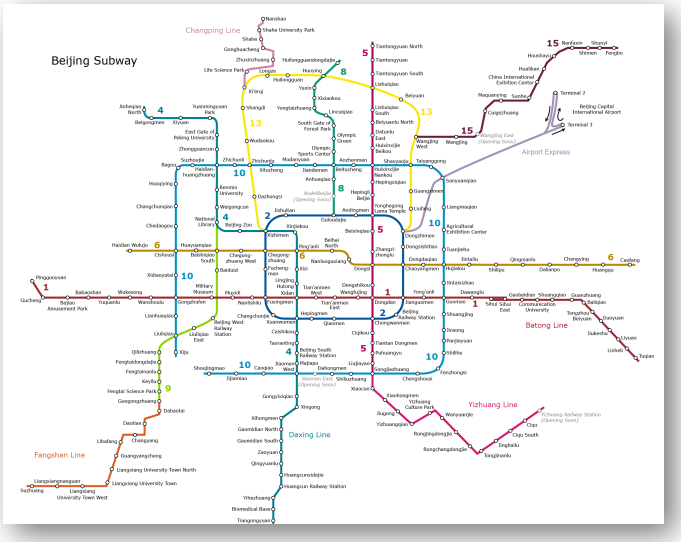
Black represents all other deaths.



Leonardo Da Vinci's study of the motion of the human arm (1510).

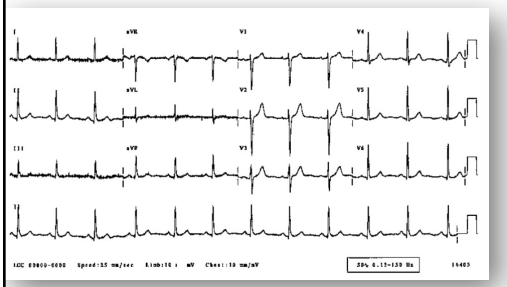
2.2. Visualization Today

The Beijing Underground map. A logical representation of the metro highlighting qualitative relationships between the stops.

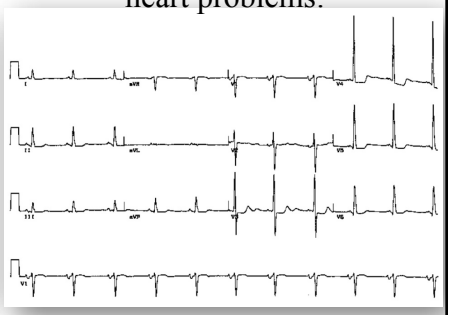


Two examples of 12-lead ECGs:

A normal adult:

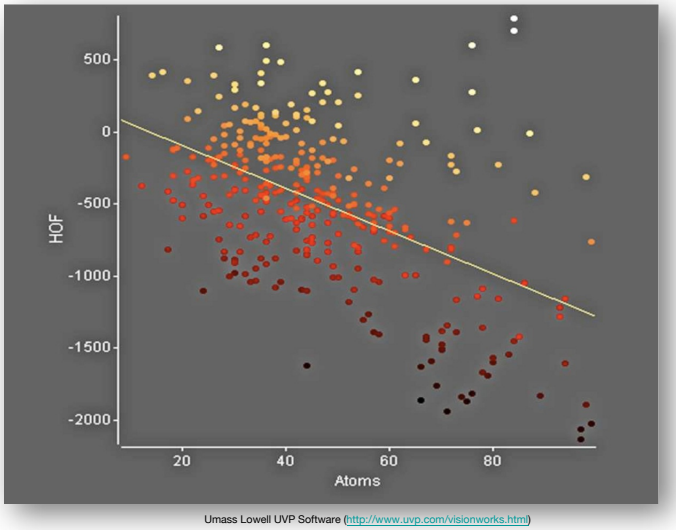


An 83-year-old adult with heart problems:



http://www.ecglibrary.com/ecghome.html

Yeast mechanism of action data with regression line.



Umass Lowell UVP Software (http://www.uvp.com/visionworks.html)

3. Relationship between Visualization and Other Fields

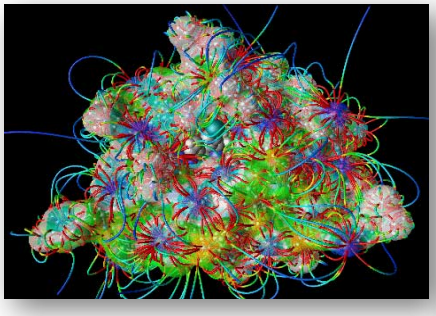
3.1. Visualization vs. Computer Graphics

- The most important aspect of all visualizations is their **connection to data**. Computer graphics focuses primarily on graphical objects (points, lines, areas, and volumes) and the organization of graphic primitives; visualizations go one step further and are based on the underlying data, and may include spatial positions, populations, or physical measures.
- Visualization is the application of graphics to display data by mapping data to graphical primitives and rendering the display.

3.2. Scientific Visualization (SciViz) vs. Information Visualization (InfoViz)

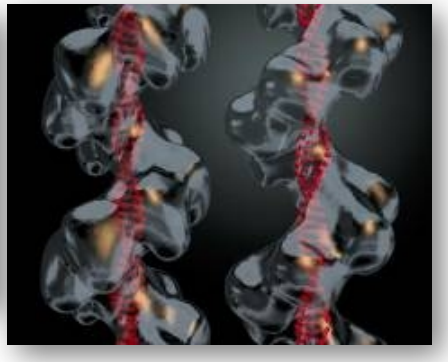
- Initially, scientific visualization and information visualization were differentiated, although some no longer differentiate the two.
- Both provide representations of data. However the data sets are most often different.
- ScientificViz – typically concerned with objects.
- InfoViz – typically concerned with abstract data.

An example of a drug that targets HIV-I reverse transcriptase:



OpenDX (http://www.opendx.org/)

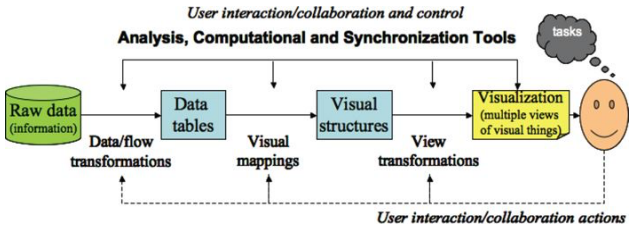
Electron microscopic image of filaments of DNA:



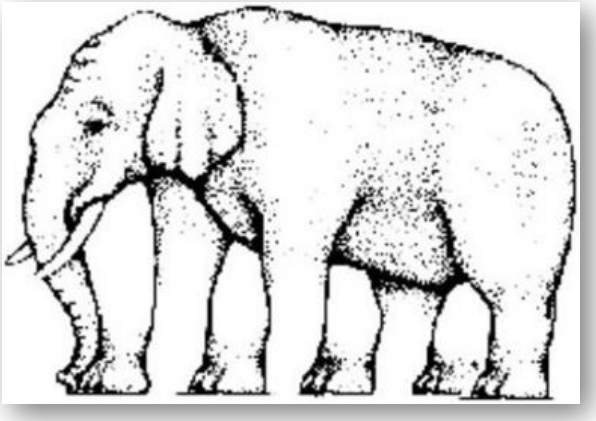
Alias/Wavefront Visualizer & OpenDX (http://www.opendx.org/)

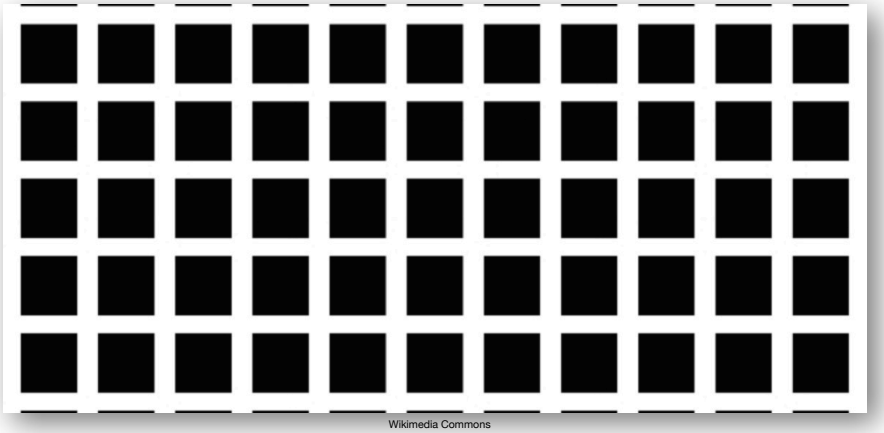
4. The Visualization Process & Human Considerations

4.1. The Visualization Pipeline



4.2. The Role of Perception





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The strength of the eye's saccadic movement is hard to overcome.

5. The Scatterplot – An example

The Data

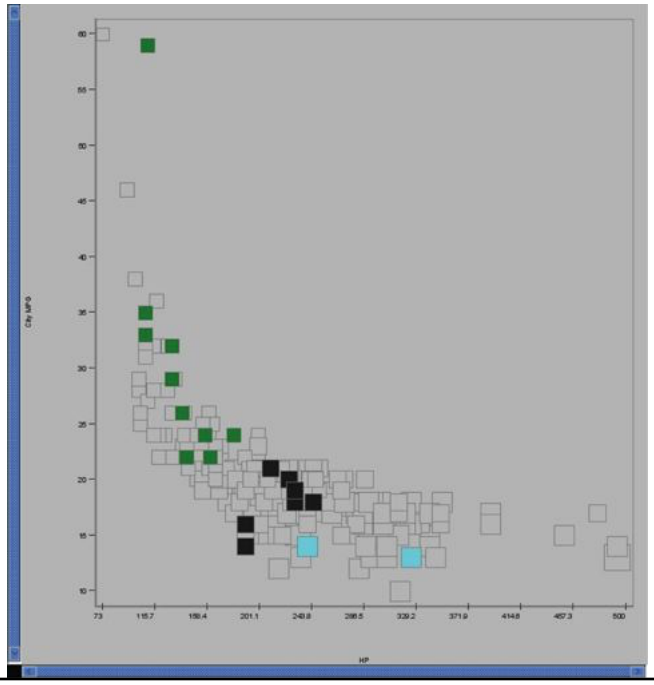
Vehicle Name	Sedan	Sports	SUV	Wagon	Minivan	Pickup	AWD	RWD	Price
Acura 3.5 RL 4dr	1	0	0	0	0	0	0	0	43755
Acura MDX	0	0	1	0	0	0	1	0	36945
Suzuki XL-7 EX	0	0	1	0	0	0	0	0	23699

A simple partial table of car and truck data. Note that you can think of this as a row-based table (cars and trucks) or a column-based table (car attributes). Note: 1=yes; 0=no.

Vehicle Name	Small/Sporty/ Compact/Large Sedan	Sports Car	SUV	Wagon	Minivan	Pickup	AWD	RWD	Retail Price	Dealer Cost	Engine Size (l)	Cyl	HP	City MPG	Hwy MPG	Weight	Wheel Base	Len	Width
Toyota 4Runner SR5 V6	0	0	1	0	0	0	0	0	27710	24801	4	6	245	18	21	4035	110	189	74
Toyota Avalon XL 4dr	1	0	0	0	0	0	0	0	26560	23693	3	6	210	21	29	3417	107	192	72
Toyota Avalon XLS 4dr	1	0	0	0	0	0	0	0	30920	27271	3	6	210	21	29	3439	107	192	72
Toyota Camry LE 4dr	1	0	0	0	0	0	0	0	19560	17558	2.4	4	157	24	33	3086	107	189	71
Toyota Camry LE V6 4dr	1	0	0	0	0	0	0	0	22775	20325	3	6	210	21	29	3296	107	189	71
Toyota Camry Solara SE 2dr	1	0	0	0	0	0	0	0	19635	17722	2.4	4	157	24	33	3175	107	193	72
Toyota Camry Solara SE V6 2dr	1	0	0	0	0	0	0	0	21965	19819	3.3	6	225	20	29	3417	107	193	72
Toyota Camry Solara SLE V6 2dr	1	0	0	0	0	0	0	0	26510	23908	3.3	6	225	20	29	3439	107	193	72
Toyota Camry XLE V6 4dr	1	0	0	0	0	0	0	0	25920	23125	3	6	210	21	29	3362	107	189	71
Toyota Celica GT-S 2dr	0	1	0	0	0	0	0	0	22570	20363	1.8	4	180	24	33	2500	102	171	68
Toyota Corolla CE 4dr	1	0	0	0	0	0	0	0	14085	13065	1.8	4	130	32	40	2502	102	178	67
Toyota Corolla LE 4dr	1	0	0	0	0	0	0	0	15295	13889	1.8	4	130	32	40	2524	102	178	67
Toyota Corolla S 4dr	1	0	0	0	0	0	0	0	15030	13650	1.8	4	130	32	40	2524	102	178	67
Toyota Echo 2dr auto	1	0	0	0	0	0	0	0	11560	10896	1.5	4	108	33	39	2085	93	163	65
Toyota Echo 2dr manual	1	0	0	0	0	0	0	0	10760	10144	1.5	4	108	35	43	2035	93	163	65
Toyota Echo 4dr	1	0	0	0	0	0	0	0	11290	10642	1.5	4	108	35	43	2055	93	163	65
Toyota Highlander V6	0	0	1	0	0	0	1	0	27930	24915	3.3	6	230	18	24	3935	107	185	72
Toyota Land Cruiser	0	0	1	0	0	0	1	0	54765	47986	4.7	8	325	13	17	5390	112	193	76
Toyota Matrix XR	0	0	0	1	0	0	0	0	16695	15156	1.8	4	130	29	36	2679	102	171	70
Toyota MR2 Spyder convertible 2dr	0	1	0	0	0	0	0	1	25130	22787	1.8	4	138	26	32	2195	97	153	67
Toyota Prius 4dr (gas/electric)	1	0	0	0	0	0	0	0	20510	18926	1.5	4	110	59	51	2890	106	175	68
Toyota RAV4	0	0	1	0	0	0	1	0	20290	18553	2.4	4	161	22	27	3119	98	167	68
Toyota Sequoia SR5	0	0	1	0	0	0	1	0	35695	31827	4.7	8	240	14	17	5270	118	204	78
Toyota Sienna CE	0	0	0	0	1	0	0	0	23495	21198	3.3	6	230	19	27	4120	119	200	77
Toyota Sienna XLE Limited	0	0	0	0	1	0	0	0	28800	25690	3.3	6	230	19	27	4165	119	200	77
Toyota Tacoma	0	0	0	0	0	1	0	1	12800	11879	2.4	4	142	22	27	2750	103	*	*
Toyota Tundra Access Cab V6 SR5	0	0	0	0	0	1	1	0	25935	23520	3.4	6	190	14	17	4435	128	*	*
Toyota Tundra Regular Cab V6	0	0	0	0	0	1	0	1	16495	14978	3.4	6	190	16	20	3925	128	*	*

Toyota vehicle table. All variables are shown. Notice that there are a few missing values.

A scatterplot of horsepower versus city MPG for Toyota vehicles. The vehicle class is mapped to color.



6. The Role of the User

Goals/Activities

- **Presentation**: The user is trying to convey some concept or set of facts to an audience.
- **Interactive Presentation**: The user is providing a presentation as above but one that is interactive typically for an individual to explore.
- **Exploration**: The user possesses a data set and wants to examine it to ascertain its contents and/or whether a particular feature or set of features is present or absent.
- **Confirmation**: The user has determined or hypothesized that a given feature is present in the data and wants to use the visualization to verify this fact or hypothesis.

7. Creating Visualizations

Example libraries/toolkits/APIs

- **D3.js** (JavaScript)
  - https://d3js.org
- **Shiny** (R)
  - https://shiny.rstudio.com
- **Pandas** plotting (Python)
  - https://pandas.pydata.org/pandas-docs/stable/visualization.html
- **Google Charts** (JavaScript)
  - https://developers.google.com/chart/