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 /ˌvɪziˈɔːləˌzeɪʃən/ • /ˌvɪzəˈleɪʒən/ • /ˌvɪzəˈleɪʃən/

<table>
<thead>
<tr>
<th>NOUN</th>
<th>data</th>
</tr>
</thead>
<tbody>
<tr>
<td>[mass noun]</td>
<td>The representation of an object, situation, or set of information as a chart or other image.</td>
</tr>
<tr>
<td>&quot;video systems allow visualization of the entire gastrointestinal tract&quot;</td>
<td></td>
</tr>
<tr>
<td>[count noun]</td>
<td>A chart or other image that is created as a visual representation of an object, situation, or set of information.</td>
</tr>
<tr>
<td>&quot;3D visualizations for architectural design&quot;</td>
<td></td>
</tr>
<tr>
<td>2. The formation of a mental image of something.</td>
<td></td>
</tr>
<tr>
<td>&quot;the story uses descriptive language to aid visualization&quot;</td>
<td></td>
</tr>
<tr>
<td>&quot;visualization is a helpful technique for relieving stress&quot;</td>
<td></td>
</tr>
<tr>
<td>[count noun]</td>
<td>&quot;a powerful visualization of a future dystopia&quot;</td>
</tr>
</tbody>
</table>

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.

![Bar chart](image)

Different insights can be gained from different visual representations.

![Graphs](image)
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

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

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.
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:

Produced by Biruni circa 1030. Shows the phases of the moon in orbit.

Shows planetary motion.
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).
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:
Yeast mechanism of action data with regression line.

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: 

Electron microscopic image of filaments of DNA:


4. **The Visualization Process & Human Considerations**
4.1. The Visualization Pipeline

4.2. The Role of Perception
The strength of the eye’s saccadic movement is hard to overcome.

5. The Scatterplot – An example
The Data

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.

<table>
<thead>
<tr>
<th>Vehicle Name</th>
<th>Sedan</th>
<th>Sports</th>
<th>SU</th>
<th>Wagon</th>
<th>Minivan</th>
<th>Pickup</th>
<th>AWD</th>
<th>RWD</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acura 3.5 RL 4dr</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>43755</td>
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<tr>
<td>Acura MDX</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>36945</td>
</tr>
<tr>
<td>Suzuki XL-7 EX</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>23699</td>
</tr>
</tbody>
</table>

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](https://d3js.org)
- **Shiny** (R)
  - [https://shiny.rstudio.com](https://shiny.rstudio.com)
- **Pandas** plotting (Python)
- **Google Charts** (JavaScript)
  - [https://developers.google.com/chart/](https://developers.google.com/chart/)