Software Visualization

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Roadmap

> Motivation
> Visual Perception
> Information Visualization
> Software Visualization
Roadmap

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> Visual Perception
> Information Visualization
> Software Visualization
A COURT FOR KING CHOLERA.
Anscombe’s Quartet

Number of observations \( n \) = 11
Mean of the \( x \)'s \( \bar{x} \) = 9.0
Mean of the \( y \)'s \( \bar{y} \) = 7.5
Regression coefficient \( (b_1) \) of \( y \) on \( x \) = 0.5
Equation of regression line: \( y = 3 + 0.5 \, x \)
Sum of squares of \( x - \bar{x} \) = 110.0
Regression sum of squares = 27.50 (1 d.f.)
Residual sum of squares of \( y \) = 13.75 (9 d.f.)
Estimated standard error of \( b_1 \) = 0.118

Datasaurus data set

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Vision

We acquire more information through vision than all the other senses combined.
Pre-attentive Processing

“Tasks that can be performed on large multi-element displays in less than 200-250 milliseconds (msec) are considered pre-attentive.”

[Healy and Enns ’12]
size
hue
luminance
Preattentive Processing

- Intersections
- Terminators
- 3D depth
- Flicker
- Direction of motion
- Velocity of motion
- Lighting direction
Preattentive Processing

Pre-attentive Processing: Color
Pre-attentive Processing: Color

878936408237640312876453298473298473209487329084538
9274-0329874-32874-231984750983409834098324098320498
23-09849032814532094810839393947896587436598

22
Gestalt Psychology

> The Gestalt Laws
1. Simplicity
2. Closure
3. Similarity
4. Proximity
5. Continuity
1. Law of Simplicity

> Reality is organized and reduced to the simplest form possible
1. Law of Closure

> The mind completes missing parts so it can see a simple image
2. Law of Similarity

> The mind groups similar elements together
3. Law of Proximity

Spatial (or temporal) proximity induces the mind to see a totality.
4. Law of Continuity

> Lines follow the smoothest and simplest path.
Roadmap

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“The use of computer-supported interactive, *visual representations of abstract data* to amplify cognition.”

[Card et al., 1999]
Data-Driven Principles of Visualization Design

Quantitative

Position
Length
Angle
Area
Gray ramp
Color ramp
Color hue
Shape

Ordinal

Position
Gray ramp
Color ramp
Color hue
Length
Angle
Area

Nominal

Position
Shape
Color hue
Gray ramp
Color ramp
Length
Angle
Area

[Mackinlay, 1986]
Uncovers emergent properties and outliers
Exposes problems with the dataset

“Hippo”
• Industrial System
• 1M LOC
• >10K Files
• >100 Authors

Can you see a certain suspect symmetry in the interaction between the subsystems of this project?
Enhances communication
Uses of Information Visualization

> Supports analysis
  — Uncovers emergent properties and outliers
  — Exposes problems with the data set
> Enhances communication
Roadmap

> Motivation
> Visual Perception
> Information Visualization — Guidelines
> Software Visualization
Guidelines of valuable information visualization can consider style, integrity, and design.
Style: Minimize Non-Data Ink

Removing ink from your graph should remove meaning from it.
Relationship of Actual Rates of Registration to Predicted Rates
(104 cities 1960).
The length of an organism at the time of reproduction in relation to the generation time, plotted on a logarithmic scale.
Design: Choose the appropriate representation

<table>
<thead>
<tr>
<th>Cancer Site</th>
<th>% Survival Rates and Standard Errors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5 year</td>
</tr>
<tr>
<td>Prostate</td>
<td>98.8 0.4</td>
</tr>
<tr>
<td>Thyroid</td>
<td>96.0 0.8</td>
</tr>
<tr>
<td>Testis</td>
<td>94.7 1.1</td>
</tr>
<tr>
<td>Melanomas</td>
<td>89.0 0.8</td>
</tr>
<tr>
<td>Breast</td>
<td>86.4 0.4</td>
</tr>
<tr>
<td>Hodgkin's disease</td>
<td>85.1 1.7</td>
</tr>
<tr>
<td>Corpus uteri, uterus</td>
<td>84.3 1.0</td>
</tr>
<tr>
<td>Urinary, bladder</td>
<td>82.1 1.3</td>
</tr>
<tr>
<td>Cervix, uterus</td>
<td>70.5 1.6</td>
</tr>
<tr>
<td>Larynx</td>
<td>68.9 2.1</td>
</tr>
<tr>
<td>Rectum</td>
<td>62.6 1.2</td>
</tr>
<tr>
<td>Kidney, renal pelvis</td>
<td>61.8 1.3</td>
</tr>
<tr>
<td>Colon</td>
<td>61.7 0.8</td>
</tr>
<tr>
<td>Non-Hodgkin's</td>
<td>57.8 1.0</td>
</tr>
<tr>
<td>Oral cavity, pharynx</td>
<td>56.7 1.3</td>
</tr>
<tr>
<td>Ovary</td>
<td>55.0 1.3</td>
</tr>
<tr>
<td>Leukemia</td>
<td>42.5 1.2</td>
</tr>
<tr>
<td>Brain, nervous system</td>
<td>32.0 1.4</td>
</tr>
<tr>
<td>Multiple myeloma</td>
<td>29.5 1.6</td>
</tr>
<tr>
<td>Stomach</td>
<td>23.8 1.3</td>
</tr>
<tr>
<td>Lung and bronchus</td>
<td>15.0 0.4</td>
</tr>
<tr>
<td>Esophagus</td>
<td>14.2 1.4</td>
</tr>
<tr>
<td>Liver, bile duct</td>
<td>7.5 1.1</td>
</tr>
<tr>
<td>Pancreas</td>
<td>4.0 0.5</td>
</tr>
</tbody>
</table>
Estimates of relative survival rates, by cancer site

<table>
<thead>
<tr>
<th>Cancer Site</th>
<th>5 year</th>
<th>10 year</th>
<th>15 year</th>
<th>20 year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prostate</td>
<td>99</td>
<td>96</td>
<td>94</td>
<td>91</td>
</tr>
<tr>
<td>Thyroid</td>
<td>86</td>
<td>94</td>
<td>91</td>
<td>88</td>
</tr>
<tr>
<td>Melanoma</td>
<td>80</td>
<td>82</td>
<td>81</td>
<td>79</td>
</tr>
<tr>
<td>Breast</td>
<td>86</td>
<td>78</td>
<td>71</td>
<td>68</td>
</tr>
<tr>
<td>Hodgkin's disease</td>
<td>71</td>
<td>63</td>
<td>57</td>
<td>52</td>
</tr>
<tr>
<td>Non-Hodgkin's</td>
<td>63</td>
<td>57</td>
<td>49</td>
<td>47</td>
</tr>
<tr>
<td>Kidney, renal pelvis</td>
<td>57</td>
<td>52</td>
<td>46</td>
<td>43</td>
</tr>
<tr>
<td>Ovary</td>
<td>54</td>
<td>50</td>
<td>46</td>
<td>40</td>
</tr>
<tr>
<td>Leukemia</td>
<td>44</td>
<td>46</td>
<td>44</td>
<td>38</td>
</tr>
<tr>
<td>Brain, nervous system</td>
<td>41</td>
<td>42</td>
<td>38</td>
<td>33</td>
</tr>
<tr>
<td>Multiple myeloma</td>
<td>34</td>
<td>33</td>
<td>30</td>
<td>29</td>
</tr>
<tr>
<td>Stomach</td>
<td>32</td>
<td>29</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>Lung and bronchus</td>
<td>23</td>
<td>20</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Esophagus</td>
<td>15</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Liver, bile duct</td>
<td>8</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Pancreas</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>
Integrity: Present only the data

This cluster of type emphasizes and stretches out the low value for 1966–1967, encouraging the impression that recent years have shot up from a small, stable base. Horizontal arrows provide similar emphasis.

This squeezed-down block of type contributes to an image of small, squeezed-down budgets back in the good old days.

Arrows pointing straight up emphasize recent growth. Compare with horizontal arrows at left.
Improvement 1: Eliminate Chart Junk

Leaving behind the distortion in the chartjunk heap at the left yields a calmer view:
Improvement 2: Adjust the underlying information...
Roadmap

> Motivation
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> Information Visualization
> **Software Visualization**
“SV is the use of interactive computer graphics to enhance the interface between users and their programs.”

[Price, 1992]
Roadmap

> Motivation
> Visual Perception
> Information Visualization
> Software Visualization
  — Structure
  — Evolution
  — Behavior
Space Filling Techniques

> Use of pre-attentive processing features of
  — Locality
  — Size
> Techniques
  — Treemaps
  — Voronoi diagrams
Providing an overview of size distribution
Polymetric Views

> Use of pre-attentive processing features
  — Size
  — Color
  — Connectedness

> Available tools
  — Roassal, Mondrian, XRay
Providing an overview of inheritance
Metaphor: City

> Use of pre-attentive processing features of
  — Size
  — Color
  — 3D spatial locality

> Available tools
  — CodeCity
  — CityVR
Detecting Outliers

LOC  ->  Color
NOM  ->  Height
NOA  ->  Area
Communicating the locality of problems

Marcel Bruch @MarcelBruch · 2h

 Wanna know which parts of your code cause loads of errors? This is the new 'Sin City of Code':

![Image of a map with code-related locations marked]
Hierarchical Visualization

> Use of pre-attentive processing features of
  — Size
  — Spatial locality
  — Connectedness
  — Color

> Available tools
  — Softwareaut, Rigi, Shrimp, etc.
Structure — Summary

> Visualized software aspects
  — Inheritance
  — Containment
  — Dependencies

> Visualization techniques
  — Space filling techniques
  — Polymetric Views
  — Metaphors
  — Hierarchical Visualization
Roadmap

> Visual Perception
> Information Visualization
> **Software Visualization**
  — Structure
  — Evolution
  — Behavior
CODE_SWARM
SeeSoft mapped time on color to visualize churn

The SeeSoft system maps each line of code into a thin row. The color of each row indicates a statistic of interest, e.g., red rows are those most recently changed, and blue are those least recently changed.
Mapping evolution on space (the x-axis)
Y-axis represents individual files sorted alphabetically
Map authors on colors and kill alphabetical order
Alphabetical order must die (J. Nielsen)
System evolution can be mapped on

time  color  space
Roadmap

> Visual Perception
> Information Visualization

Software Visualization
— Structure
— Evolution
— Behavior
Zinsight is a visualization of large event traces using a pixel based representation.
Massively reliant on visual pattern recognition and interactivity
Visual detection of bugs
Present and Future of Software Visualization

> Novel interaction techniques
Present and Future of Software Visualization
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Present and Future of Software Visualization

> Novel interaction techniques
> 3D Software Visualization
Present and Future of Software Visualization

> Novel interaction techniques

> 3D Software Visualization

Present and Future of Software Visualization

> Novel interaction techniques
> 3D Software Visualization
> Multiple media to display visualizations
  - 2D: Wall displays, Tabletops, Mobile devices
Present and Future of Software Visualization

- Novel interaction techniques
- 3D Software Visualization
- Multiple media to display visualizations
  - 2D: Wall displays, Tabletops, Mobile devices
  - 3D: AR, VR, CAVE, Stereo glasses, 3D prints
- Focus on evaluation of software visualizations
  - Beyond time & Correctness
  - Replicability & Reproducibility
- AR & VR & AV
Present and Future of Software Visualization

> Novel interaction techniques
> 3D Software Visualization

> **Multiple media to display visualizations**
  - 2D: Wall displays, Tabletops, Mobile devices
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Present and Future of Software Visualization

http://evaluate.inf.usi.ch/artifacts
https://www.artifact-eval.org/

https://www.acm.org/publications/policies/artifact-review-badging

http://oavis.steveharoz.com/
Inheritance

Ceci n’est pas une visualization
What you should know

> What is pre-attentive processing?
> What are the laws of Gestalt psychology?
> What is information visualization?
> Which aspects of software are usually visualized?
> Which techniques allow to visualize software structure?
> On what visualization features can we map evolution?
> What kinds of problems can be solved with software visualization?
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