Part 0

Definitions of
Information Visualization

Outline

- Motivation - Examples
- Definitions and Goals
- Knowledge Crystallization
- Exploration Techniques
- Visual Encoding Techniques
- Summary

Example 1 – Multiplication

- Working Memory of Human Mind is Restricted
  E.g. Mental Multiplication

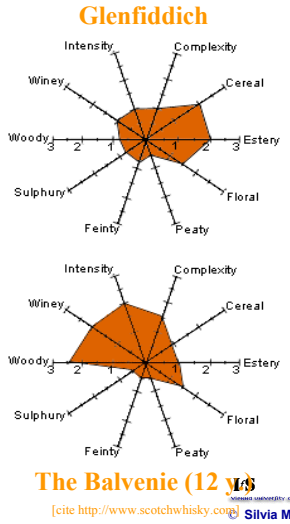
6 X 7 = ? 42 Piece of Cake!
317 x 432 = ? Yuk! No, thanks!
But with pencil and paper:

317 x 432
634
No Problem!
137.944

Example 2 – Taste

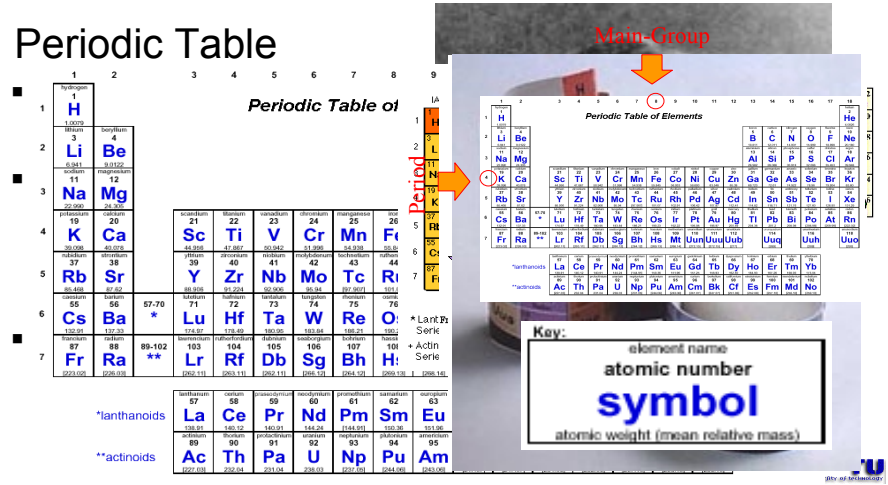
E.g. Whisky-Tasting

- Taste is Very Abstract
- 10 Basic Tastes: Intensity: [0, 3]
- Intensity
  - Wheel Chart
  - Points - Form a Polygon
  - Polygon's Properties Give Quick Access to the Represented Taste



Example 3 – Chemical Elements

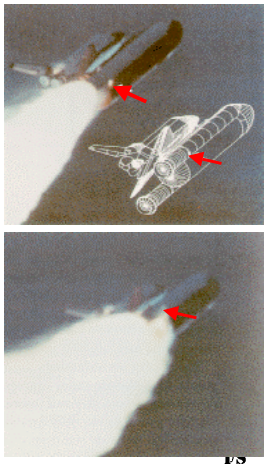
- Periodic Table



Final Example

The Challenger Disaster

January 27, 1986:
US-Space Shuttle *Challenger* Explodes 72 Seconds After Launch



Reason:
Sealing-Rings in the Right Booster Were Damaged Due to Weather Conditions

Reliability-Problems of the so Called O-Rings Were Known

Final Example

The Challenger Disaster

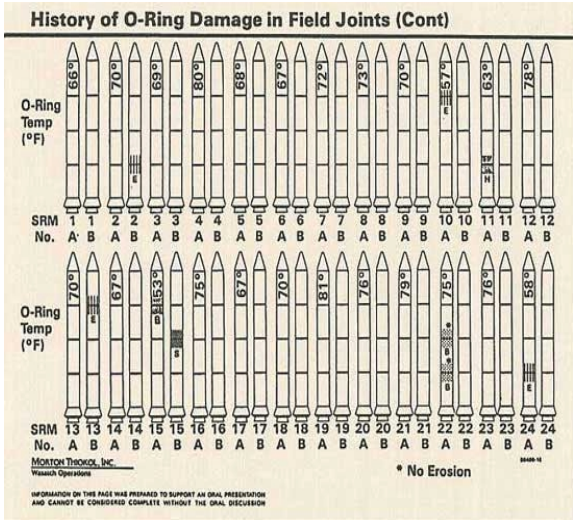
- **The manufacturer of the boosters warned NASA before launch that the expected cold temperatures might be an extra risk.**
- **NASA did not see any correlation between the failing of O-Rings and the temperatures.**
- **This was wrong!**

- Edward R. Tufte **showed that the risk would have been obvious to NASA engineers if a better visualization would have been used**

[Tufte's Re-Visualization]

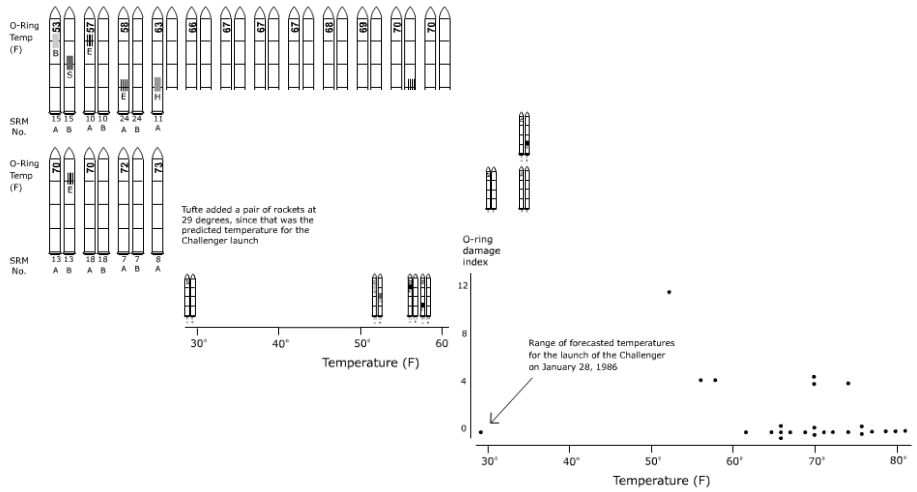
Final Example

Tufte's Re-Visualization



Final Example

Tufte's Re-Visualization



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Visualization: 3 Areas

Volume Visualization
Flow Visualization ...

} **Scientific Visualization**

Information Visualization

Information vs. Scientific Visualization

- "Abstract" Data
  - Mostly No Inherent Spatial Structure
- nD
- Prime Goals
  - Visual Metaphor
  - User Interaction
  - Flexible Interaction Mechanisms
  - **Exploration**, Analysis, Presentation

- Data
  - Inherent Spatial Structure
- 2 or 3D / temporal
- Prime Goals
  - 3D-Rendering
  - Fast Rendering
  - Exploration, **Analysis**, Presentation

Definitions ...

[Card, et al., 2000, Gershon, et al. 1998]

- Visualization
  - "the act or process of interpreting in visual terms or of putting into visual form"
- Information Visualization
  - "the process of transforming *data*, *information*, and *knowledge* into visual form making use of humans' natural visual capabilities"
  - "the computer-assisted use of visual processing to gain understanding"

Definitions ...

[Schreiber, et al., 1999]

- Data
  - "input signals to sensory and cognitive processes"
- Information
  - "data with an associated meaning"
- Knowledge
  - "the whole body of data and information together with cognitive machinery that people are able to exploit to decide how to act, to carry out tasks and to create new information"

Data Exploration

[Keim, 2001]

Definition

Data Exploration is the process of searching and analyzing databases to find implicit but potentially useful information.

more formally:

Data Exploration is the process of finding a

- subset D' of the database D and
- hypotheses $H_U(D', C)$

that a *user U* considers *useful* in an *application context C*.

Visual Information Seeking Mantra

[Shneiderman, 1996]

overview first, zoom and filter, then details-on-demand
overview first, zoom and filter, then details-on-demand
overview first, zoom and filter, then details-on-demand
overview first, zoom and filter, then details-on-demand
overview first, zoom and filter, then details-on-demand
overview first, zoom and filter, then details-on-demand

... 10 times ...

A Task by Data Type Taxonomy

[Shneiderman, 1996]

- **Tasks**
  - Overview
  - Zoom
  - Filter
  - Details-on-Demand
  - Relate
  - History
  - Extract
- **Data Types**
  - 1D
  - 2D
  - 3D
  - Temporal
  - Multi-D
  - Tree
  - Network

Goals

- To Ease *Understanding* and to Facilitate *Cognition*
- To Promote a *Deeper Level of Understanding* of the Data Under Investigation
- To Foster New Insight into the Underlying *Process*

Goals

[Keim, 2001]

- **Explorative Analysis**
  - starting point: data without hypotheses about the data
  - process: interactive, usually undirected search for structures, trends, etc.
  - result: visualization of the data, which provides hypotheses about the data
- Confirmative Analysis
  - starting point: hypotheses about the data
  - process: goal-oriented examination of the hypotheses
  - result: visualization of the data, which allows the confirmation or rejection of the hypotheses
- Presentation
  - starting point: facts to be presented are fixed a priori
  - process: choice of an appropriate presentation technique
  - result: high-quality visualization of the data presenting the facts

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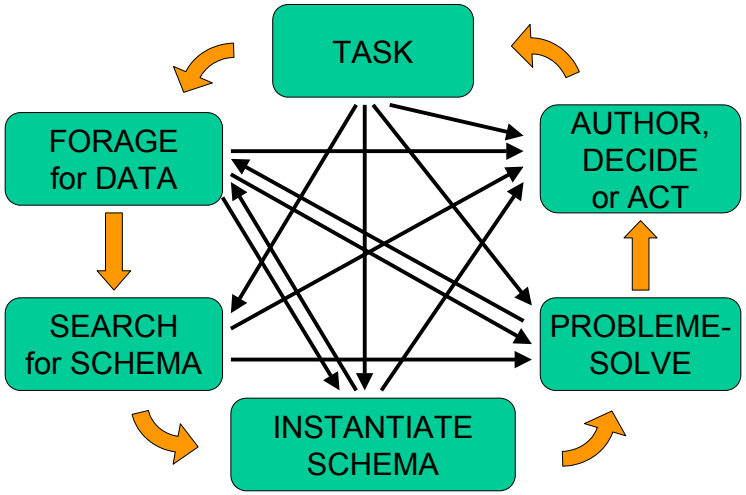
Knowledge Crystallization



Facilitation of Cognition

[Card, Mackinlay & Shneiderman 1999]

- There are six ways how visualization can facilitate cognition
  - By increasing the memory and processing resources available to the user
  - By reducing the search for information
  - By using visual representations to enhance the detection of patterns
  - By enabling perceptual inference operations
  - By using perceptual attention mechanisms for monitoring
  - By encoding information in a manipulable medium

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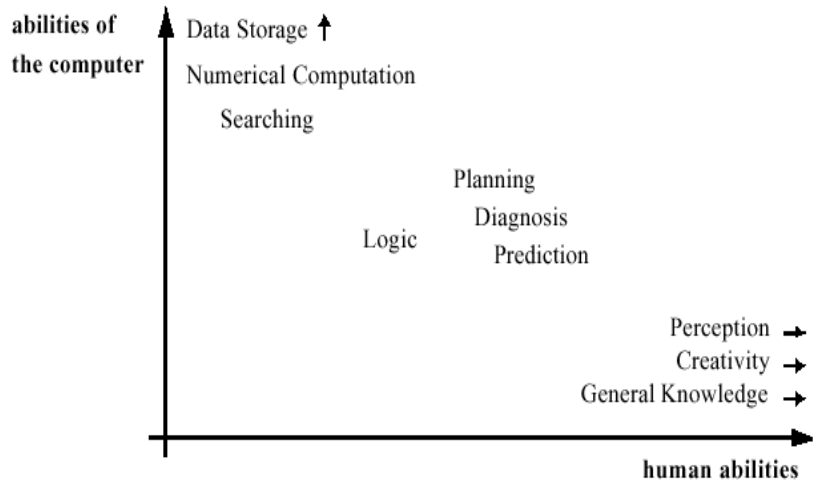
Exploration Techniques

- **Geometric Techniques**
  - Scatterplots, Parallel Coordinates, ...
- **Icon-based Techniques**
  - Glyphs, ...
- **Pixel-based Techniques**
  - Circle Segments, ...
- **Hierarchical Techniques**
  - Cone/Cam Trees, Treemap, Dimensional Stacking, Hierarchy Visualizations, ...
- **Distortion Techniques**
  - Perspective Wall, Fisheye View, ...
- **Dynamic/Interactive Techniques**
  - Filtering, Zooming, LifeLines ...
- **Focus + Context**
  - → Distortion Techniques
  - → Dynamic/Interactive Techniques
- **Hybrid Techniques**

Intro: Comparison

[Keim, 2001]



Historical Overview 1/2

[Keim, 2001]

- Pioneering Work of Tufte and Bertin
  - visualization of data with inherent 2D/3D-semantics
  - general rules for layout, color composition, attribute mapping, etc.
- Development of Visualization Techniques of Different Types of Data with an Underlying Physical Model
  - geographic data, CAD data, flow data, image data, voxel data, etc.

Historical Overview 2/2

[Keim, 2001]

- Development of Visualization Techniques for Arbitrary Multidimensional Data without any Underlying Physical Model
  - applicable to databases and other information resources