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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:

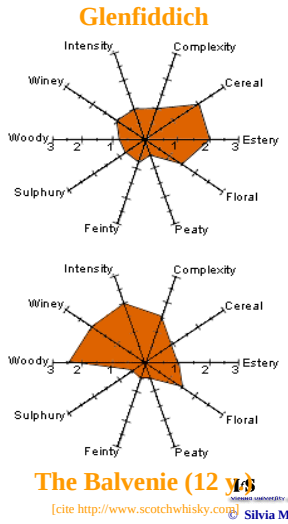
```
317 x 432
 634
 [illegible]0
 12[illegible]0
137.944
```

No Problem!

Example 2 – Taste

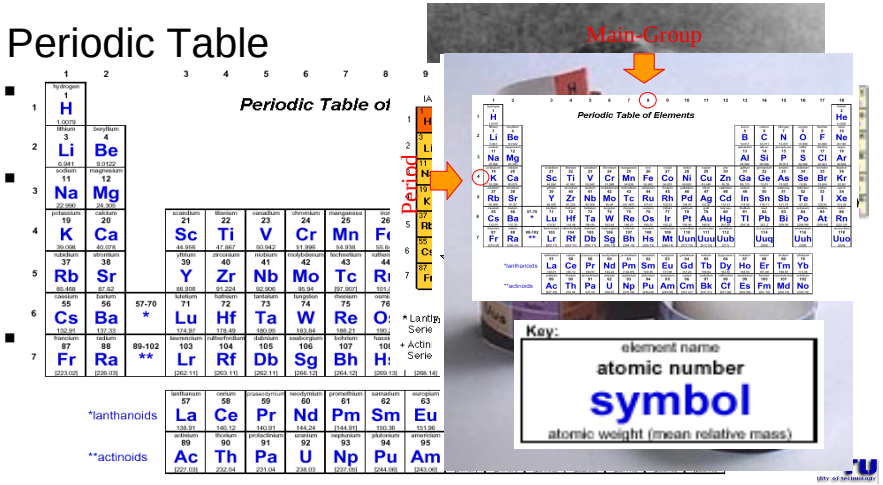
E.g. Whisky-Tasting

- 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

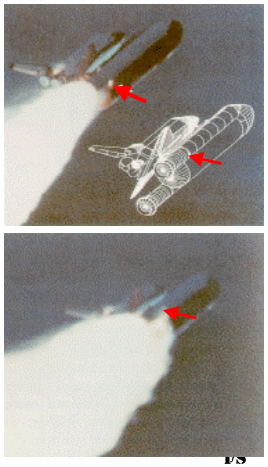
- Periodic Table



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

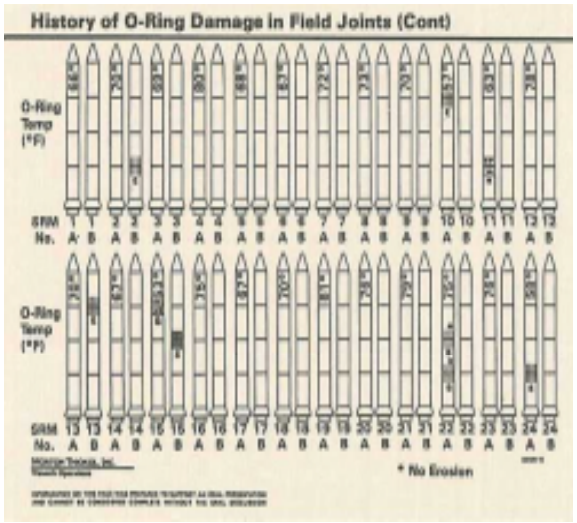
- **The manufacturer of the boosters warned NASA before launch that the expected cold temperatures might be an extra risk.**
- **NASA did not see any correlation between the failing of O-Rings and the temperatures.**
- **This was wrong!**

- 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]

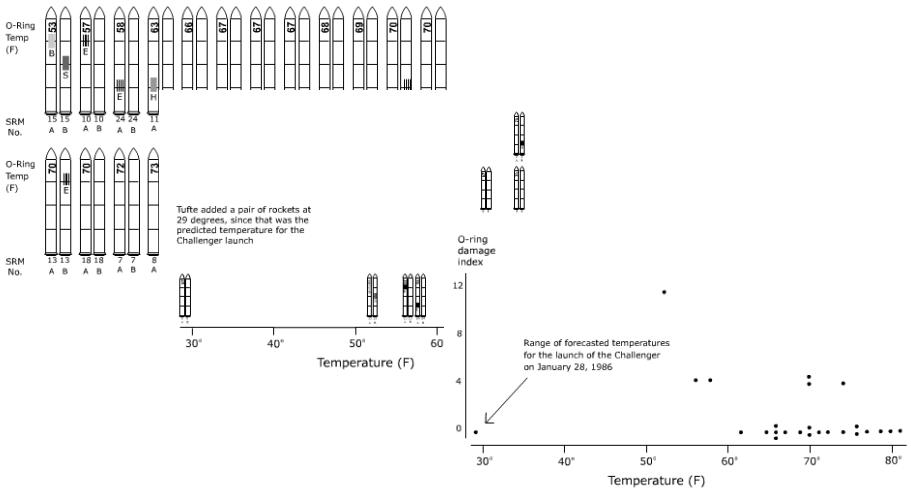
Final Example

Tufte's Re-Visualization



Final Example

Tufte‘s Re-Visualization



Outline

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- Knowledge Crystallization
- Exploration Techniques
- Visual Encoding Techniques
- Summary

Visualization: 3 Areas

Volume Visualization
Flow Visualization ...

} **Scientific Visualization**

Information Visualization

Information vs. Scientific Visualization

- “Abstract” Data
  - Mostly No Inherent Spatial Structure
  - Heterogeneous Data
- nD
- Prime Goals
  - Users & Tasks
  - Visual Metaphor
  - Flexible User Interaction Mechanisms
  - **Exploration**, Analysis, Presentation

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

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

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*.

Kinds of Data

- **High-dimensional**
  - More Simple Structure
  - Many Instances
- **Examples**
  - Medical Monitoring Data
  - Medical Image Data: CTG, MRI
  - Market Research Data
- **High-structural**
  - Complex Structure
  - Few Instances
- **Examples**
  - Performance Measurement System ("Kennzahlensysteme")

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"

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]

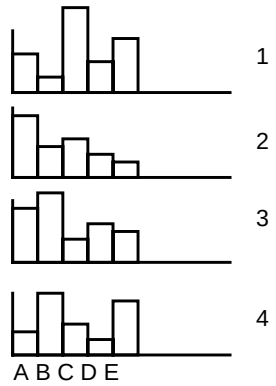
- **Tasks**
  - Overview
  - Zoom
  - Filter
  - Details-on-Demand
  - Relate
  - History
  - Extract
- **Data Types**
  - 1D
  - 2D
  - 3D
  - Temporal
  - Multi-D
  - Tree
  - Network

Approach 1: Multiple Views

[Mackinlay, 2000]

Give each variable its own display

	A	B	C	D	E
1	4	1	8	3	5
2	6	3	4	2	1
3	5	7	2	4	3
4	2	6	3	1	5

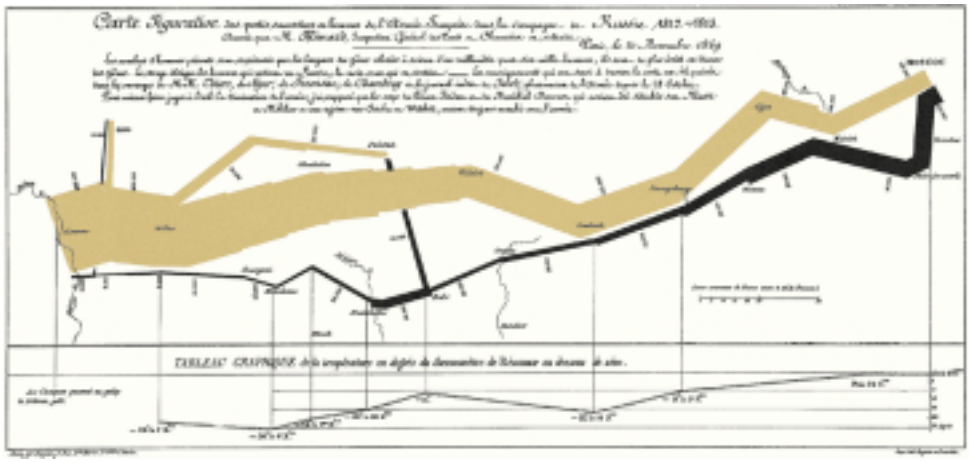


Based on John Stasko slide

Composition/Decomposition

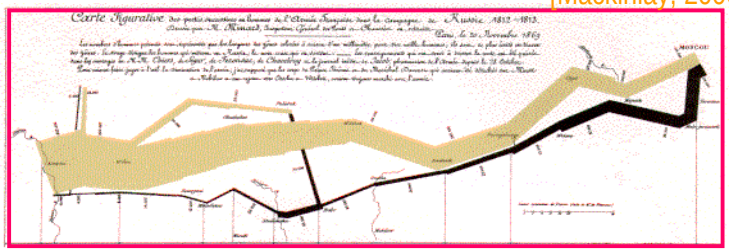
[Mackinlay, 2000]

- Minard's 1869 Napoleon's March

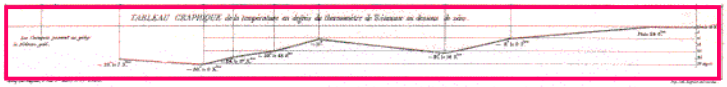


Single Axis Composition

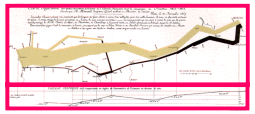
[Mackinlay, 2000]



+



=



Mark Composition

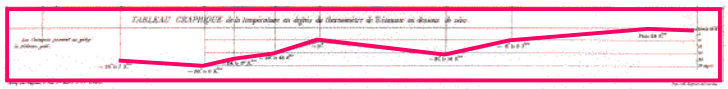
[Mackinlay, 2000]

temperature

\+ time

\+ temp[day]

=



Mark Composition

[Mackinlay, 2000]

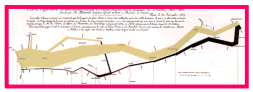
longitude

\+ latitude

\+ army[size, day]

\+ army[position, day]

=

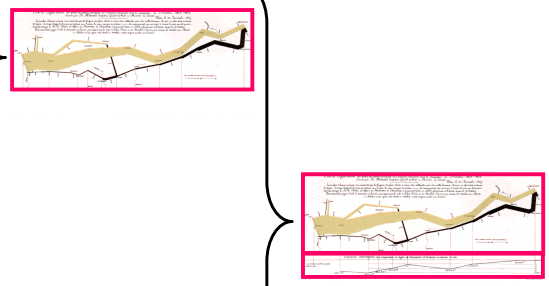


longitude

latitude

army[size, day]

army[position, day]



temperature

time

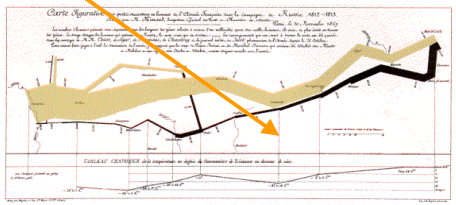
temp[day]

Minard's Data Table and Synoptic

[Mackinlay, 2000]

	Day1	Day2	
Army size			
Army longitude			
Army latitude			
Temperature			

Issue: Seeing the Relationships



Showing Relationships

Brushing a Scatterplot Matrix

[Mackinlay, 2000]

(Figure from Tweedie et al. 96;
See also Cleveland & McGill 84, 88)

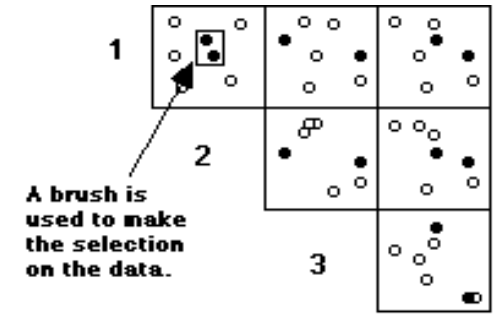
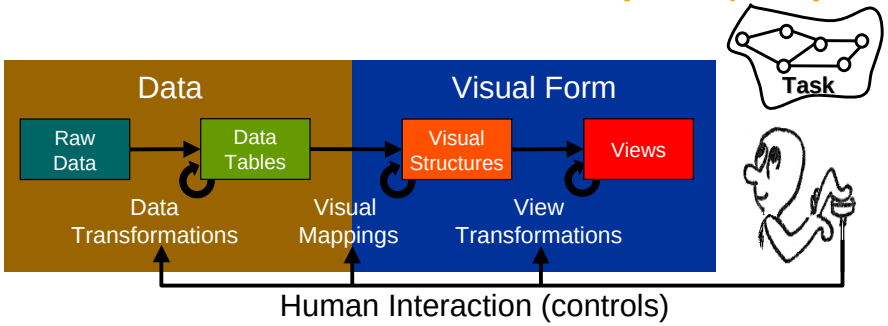


Figure 1: "Brushing" a Scatterplot

Based on Marti Hearst slide

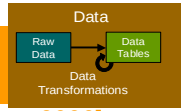
Visualization Reference Model

[Mackinlay, 2000]



- Also Describes the Process for Developing a Visualization.

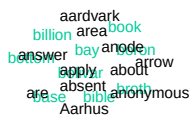
Raw Data



[Mackinlay, 2000]

Documents

Words



Word Vectors

Document	D1	D2	D3	…
aardvark	1	0	0	…
Aarhus	0	1	0	…
about	1	0	1	…
…	…	…	…	…

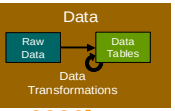
Meta-data

Document	D1	D2	D3	…
Length	4	3	6	…
Author	John	Sally	Lars	…
Date	16/8	11/4	24/7	…
…	…	…	…	…

Other units
- Sentence
- Paragraph
- Section
- Chapter
- Characters
- Pictures

→ Meaning

Raw Data Issues



[Mackinlay, 2000]

- Errors
- Variable formats
- Missing data
- Variable types
- Table Structure

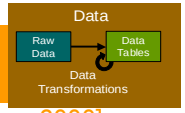
Document	D1	A	D3	…
Length	4	3.5	6	…
Author	John		Lars	…
Date	16/8	Fall	24/7	…
…	…	…	…	…

Document	D1	D2	D3	…
aardvark	1	0	0	…
Aarhus	0	1	0	…
about	1	0	1	…
…	…	…	…	…

VS

aardvark	D1,…
Aarhus	D2,…
about	D1, D3, …
…	…

Data Tables



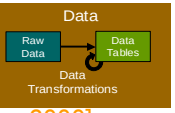
[Mackinlay, 2000]

Variables

Cases

FilmID	230	105	540	…
Title	Goldfinger	Ben Hur	Ben Hur	…
Director	Hamilton	Wyler	Niblo	…
Actor	Connery	Heston	Novarro	…
Actress	Blackman	Harareet	McAvoy	…
Year	1964	1959	1926	…
Length	112	212	133	…
Popularity	7.7	8.2	7.4	…
Rating	PG	G	G	…
Film Type	Action	Action	Drama	…

Data Transformations



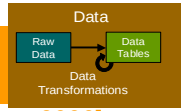
[Mackinlay, 2000]

- Clean raw data
- Calculations

Individual	I1	I2	I3	I4	…
Birth	1908	1952	1964	2000	…
Death	1965				…
Age	53	48	36	1	…

- Structural
  - Demote
  - Promote
  - ….

Data Types

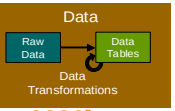


[Mackinlay, 2000]

Nominal | Ordinal | Quantitative

FilmID	230	105	540	…
Title	Goldfinger	Ben Hur	Ben Hur	…
Director	Hamilton	Wyler	Niblo	…
Actor	Connery	Heston	Novarro	…
Actress	Blackman	Harareet	McAvoy	…
Year	1964	1959	1926	…
Length	112	212	133	…
Popularity	7.7	8.2	7.4	…
Rating	PG	G	G	…
Film Type	Action	Action	Drama	…

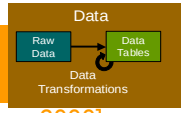
Individuals



[Mackinlay, 2000]

Individual	I1	I2	I3	I4	I5	I6	I7	I8	…
Ages	55	18	22	51	34	50	28	17	…
Income	1	6	8	10	4	7	3	1	…
Professions *P1*	0	0	0	0	1	0	0	0	…
P2	1	1	0	0	0	0	0	0	…
P3	0	0	0	0	0	0	0	0	…
P4	0	0	1	0	0	0	1	0	…
P5	0	0	0	0	0	0	0	1	…
P6	0	0	0	1	0	1	0	0	…
P7	0	0	0	0	0	0	0	0	…
P8	0	0	0	0	0	0	0	0	…

Calculation:

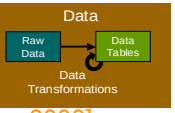


[Mackinlay, 2000]

Individual	I1	I2	I3	I4	I5	I6	I7	I8	…
Age>40	1	0	0	1	0	1	0	0	…
Age20-40	0	0	1	0	1	0	1	0	…
Age0-20	0	1	0	0	0	0	0	1	…
Inc7-10	0	0	1	1	0	1	0	0	…
Inc4-6	0	1	0	0	1	0	0	0	…
Inc2-3	0	0	0	0	0	0	1	0	…
Inc0-1	1	0	0	0	0	0	0	1	…
P1	0	0	0	0	1	0	0	0	…
P2	1	1	0	0	0	0	0	0	…
P3	0	0	0	0	0	0	0	0	…
P4	0	0	1	0	0	0	1	0	…
P5	0	0	0	0	0	0	0	1	…
P6	0	0	0	1	0	1	0	0	…
P7	0	0	0	0	0	0	0	0	…
P8	0	0	0	0	0	0	0	0	…

Classing

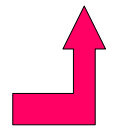
Structural:



[Mackinlay, 2000]

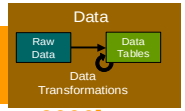
P-ID	P1	P2	P3	P4	P5	P6	P7	P8
Avg Age	33	29	17	34	25	40	58	31
Avg Income	6.3	3.7	3	2.7	3.5	6.6	2	5.7

Individual	I1	I2	I3	I4	I5	I6	I7	I8	…
Ages	55	18	22	51	34	50	28	17	…
Income	1	6	8	10	4	7	3	1	…
P1	0	0	0	0	1	0	0	0	…
P2	1	1	0	0	0	0	0	0	…
P3	0	0	0	0	0	0	0	0	…
P4	0	0	1	0	0	0	1	0	…
P5	0	0	0	0	0	0	0	1	…
P6	0	0	0	1	0	1	0	0	…
P7	0	0	0	0	0	0	0	0	…
P8	0	0	0	0	0	0	0	0	…



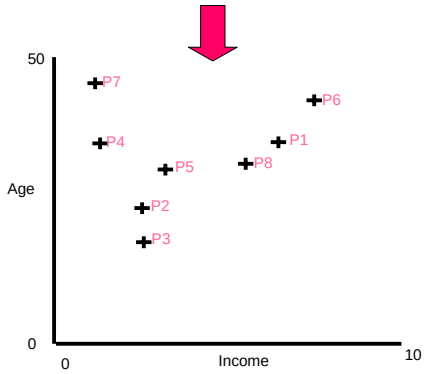
Promote profession

Target: scatterplot



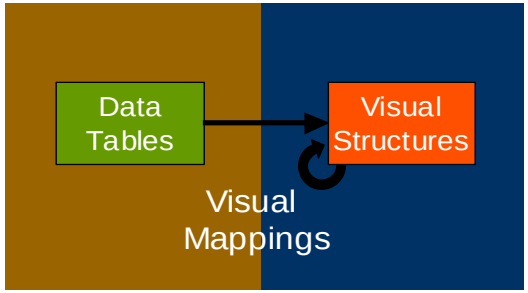
[Mackinlay, 2000]

P-ID	P1	P2	P3	P4	P5	P6	P7	P8
Avg Age	33	29	17	34	25	40	58	31
Avg Income	6.3	3.7	3	2.7	3.5	6.6	2	5.7

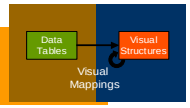


Visual Mappings

[Mackinlay, 2000]



Data Types

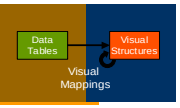


[Mackinlay, 2000]

Nominal Ordinal Quantitative

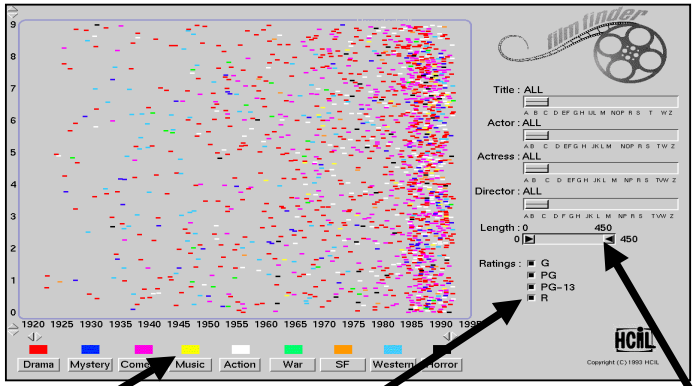
FilmID	230	105	540	…
Title	Goldfinger	Ben Hur	Ben Hur	…
Director	Hamilton	Wyler	Niblo	…
Actor	Connery	Heston	Novarro	…
Actress	Blackman	Harareet	McAvoy	…
Year	1964	1959	1926	…
Length	112	212	133	…
Popularity	7.7	8.2	7.4	…
Rating	PG	G	G	…
Film Type	Action	Action	Drama	…

Visual Structure



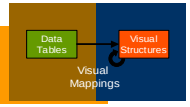
[Mackinlay, 2000]

- Film Finder, University of Maryland



Nominal: Color Ordinal: List Quantitative: Axis

Spatial Substrate



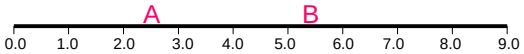
[Mackinlay, 2000]

Nominal Presence
N

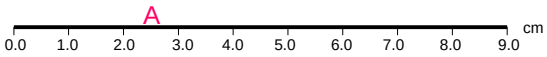
Nominal Grid
N

Ordinal Grid
O (A<B)

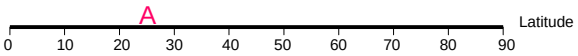
Quantitative Scale
Q (B/A=2.2)



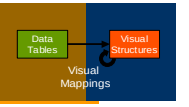
Spatial Coordinates
Qs (A=2.5 cm)



Geographical Scale
Qg (A=24 ° 5' W)

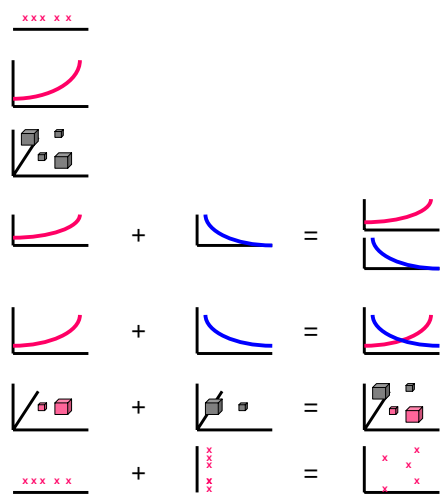


Composition of space

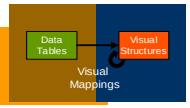


[Mackinlay, 2000]

- 1D axis
- 2D axis
- 3D axis
- Single axis
- Double axis
- Triple axis
- Mark composition

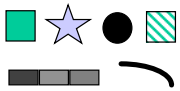


Marks

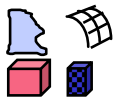


[Mackinlay, 2000]

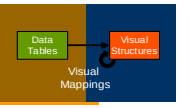
- Simple
  - Points
  - Lines



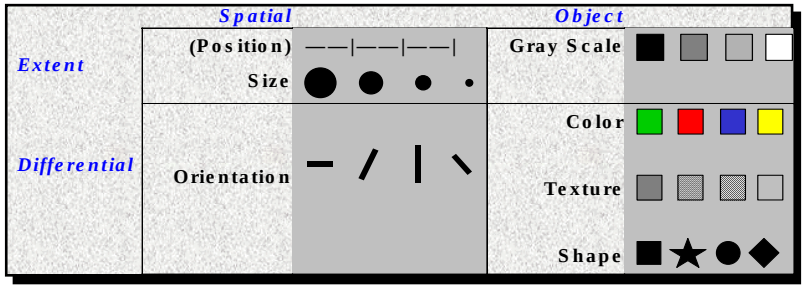
- Sub spaces
  - Areas
  - Volumes



Retinal Variables

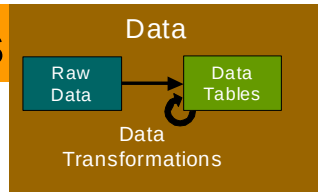


[Mackinlay, 2000]



Data Transformations

[Mackinlay, 2000]

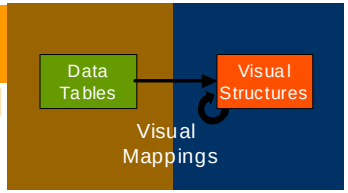


- Data Tables
  - Cases
  - Variables
  - Values
  - Metadata
    - Nominal
    - Ordinal
    - Quantitative

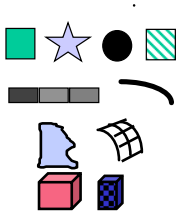
- Data Types
  - Spatial (Scientific)
  - Geographic
  - Database
  - Time
  - Hierarchies
  - Networks
  - World Wide Web
  - Documents

Visual Mappings

[Mackinlay, 2000]

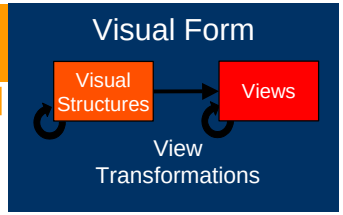


- Spatial Substrate
  - Nominal
  - Ordinal
  - Quantitative
- Marks
  - Type: Point, Line, Area Volume
  - Connection and Enclosure
  - Retinal: Color, Size, Shape, …
- Axes
  - Composition
  - Overloading



View Transformations

[Mackinlay, 2000]



- **Tasks** [Shneiderman, 1996]
  - Overview
  - Zoom
  - Filter
  - Details-on-Demand
  - Relate
  - History
  - Extract

- **Tree Other Approaches**
  - Overview + Detail
  - Zooming
  - Focus + Context

1. Detail-Only Window

[Mackinlay, 2000]

- Single window with horizontal and vertical panning
- Works only when zoom factor is relatively small

- Example: Windows

Slide adapted from John Stasko

2. One Window With Zoom & Replace

[Mackinlay, 2000]

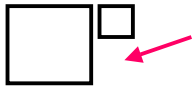
- Global view with selectable zoom area which then becomes entire view
- Variations can let users pan and adjust zoomed area and adjust levels of magnification
- Context switch can be disorienting
- Example: CAD/CAM

Slide adapted from John Stasko

3. Single Coordinated Pair

[Mackinlay, 2000]

- Combined display of the overview and local magnified view (separate views)
- Some implementations reserve large space for overview; others for detail
- Issue: How big are different views and where do they go?



Slide adapted from John Stasko

4. Tiled multilevel browser

[Mackinlay, 2000]

- Combined global, intermediate, and detail views
- Views do not overlap
- Good implementations closely relate the views, allowing panning in one view to affect others

Slide adapted from John Stasko

5. Free Zoom and Multiple Overlap

[Mackinlay, 2000]

- Overview presented first; user selects area to zoom and area in which to create detailed view
- Flexible layout, but users must perform manual window management

Slide adapted from John Stasko

6. Bifocal Magnified

[Mackinlay, 2000]

- "Magnifying glass" zoomed image floats over overview image
- Neighboring objects are obscured by the zoomed window
- More on lens later

Slide adapted from John Stasko

7. Fish-Eye View

[Mackinlay, 2000]

- Magnified image is distorted so that focus is at high magnification, periphery at low
- All in one view
- Distortion can be disorienting
- This is focus + context More later...

Slide adapted from John Stasko

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]

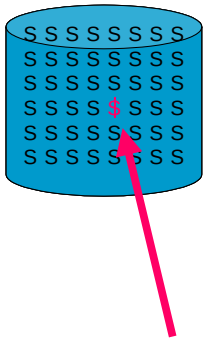
- **Explorative Analysis**
  - starting point: data without hypotheses about the data
  - process: interactive, usually undirected search for structures, trends, etc.
  - result: visualization of the data, which provides hypotheses about the data
- Confirmative Analysis
  - starting point: hypotheses 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

Outline

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

Motivation: An Information Gap

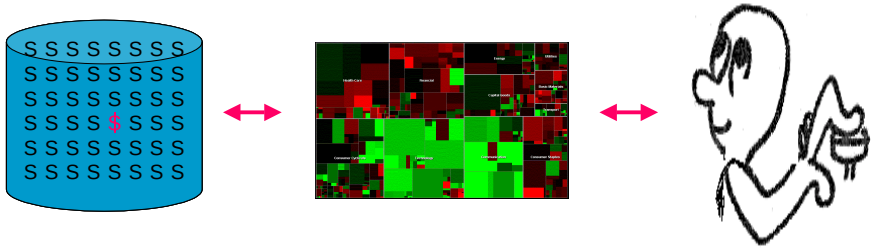
[Card, et al. 1999]



Somewhere in the data there is valuable information.

One Approach: Visualization

[Card, et al. 1999]

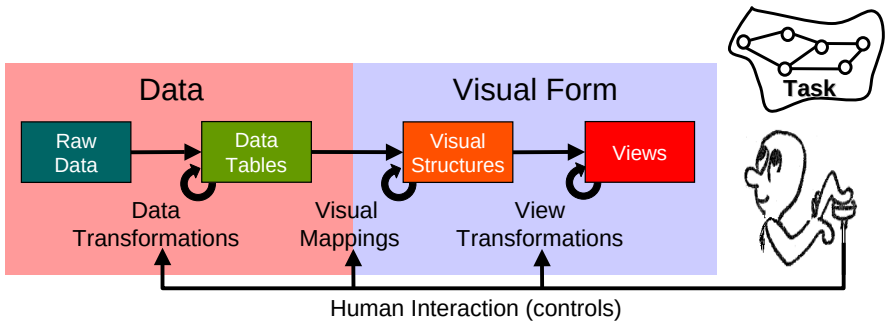


- Tap the Power of Human Perception
  - Complex View of the Data
  - Interactive Controls to Explore Data and See Patterns

Image courtesy Martin Wattenburg, SmartMoney.com

Visualization Controls

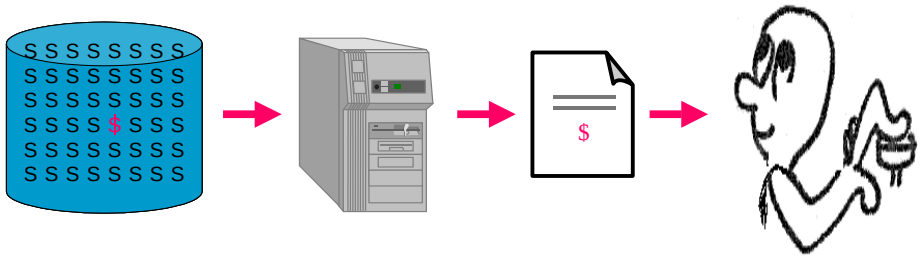
[Card, et al. 1999]



Can Require Specialist Training

Competing Approach: Data Mining

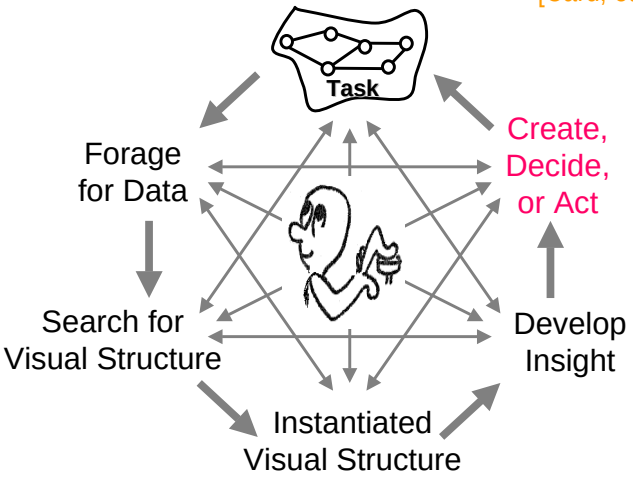
[Card, et al. 1999]



- Tap the Power of the Computer
  - Complex Statistical Analysis
  - Simple Report

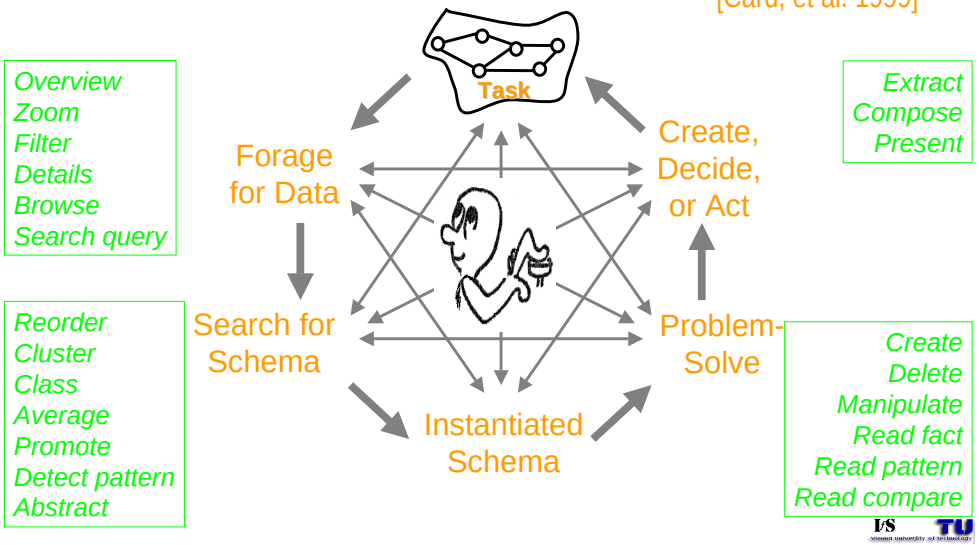
Knowledge Crystallization Loop

[Card, et al. 1999]



Knowledge Crystallization Sub-tasks

[Card, et al. 1999]



Knowledge Crystallization 1

The Task

- You want to buy a new Computer!
- But where?
- Which Model?
- Aaaargh... HELP!

Solution

- What do you do?

>> Knowledge Crystallization <<

Knowledge Crystallization 2

- Information Foraging
  - Collect Information about the Task, i.e.:
    - Articles
    - Tests
    - Advertising
    - etc.
    ... About Computers

Knowledge Crystallization 3

- Search for a Schema
  - Identify Attributes of Computers You Want to Use for Comparison, e.g.:
    - MHz
    - RAM
    - Disc-Space
    - CD-Rom/DVD-Rom Speed
    - Brand
    - Warranty
    - or Even Color?

Knowledge Crystallization 4

- Instantiate Schema
  - Make a Table
    - List Computers and Their Attributes
  - Information That Does Not Fit into Schema:
    - If Not Essential
      ➔ Remove
    - If Essential
      ➔ Go to Step Two and Find Better Schema
  - In General
    - Remove Redundant Information

Knowledge Crystallization 5

- Problem-Solving / Find Trade-off
  - Set Priorities in the Features You Want
  - Re-order the Columns and Rows of Your Table, Respectively
  - Remove Computers That Are Already Out of the Running

Knowledge Crystallization 6

- Search for a More Compact Schema
  - Simplify Your Trade-off
    - E.g., Group the Computers Regarding to Attributes You Are Interested in
    - Remove All These Computers but the Best One or Two in Each Group

Knowledge Crystallization 7

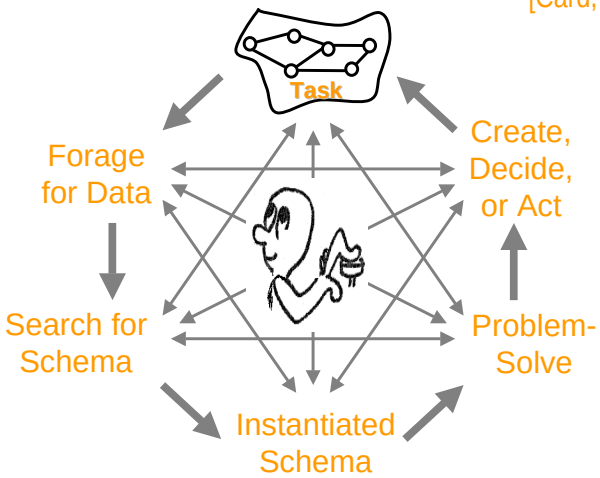
- Communicate Found Pattern or Act Resp.
  - You Found a Pattern in Your Input Data

    i.e. You Found a Compromise or Several Alternatives
  - Bring It in a More „Crystallized“ Form of Representation
  - Use this Representation to Communicate Your Result to Others...
  - ... or To Make a Decision on Your Own

➔ **Your Task Is Solved**

Knowledge Crystallization Loop

[Card, et al. 1999]



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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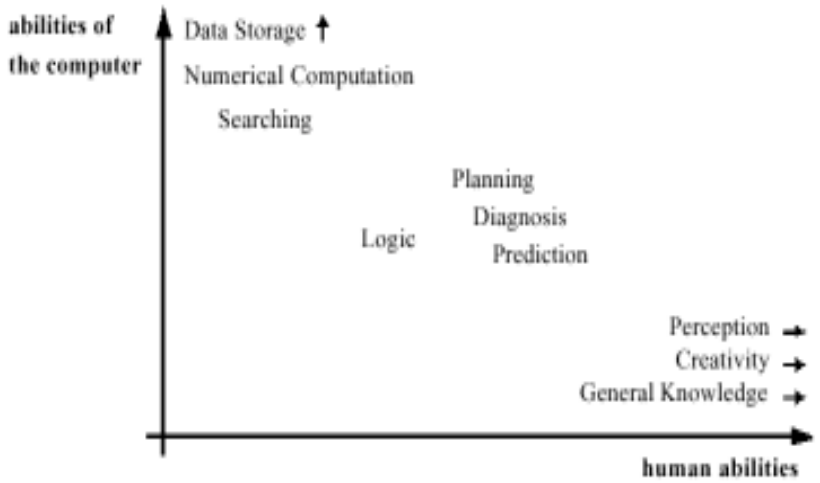
Intro: Comparison

[Keim, 2001]



Historical Overview

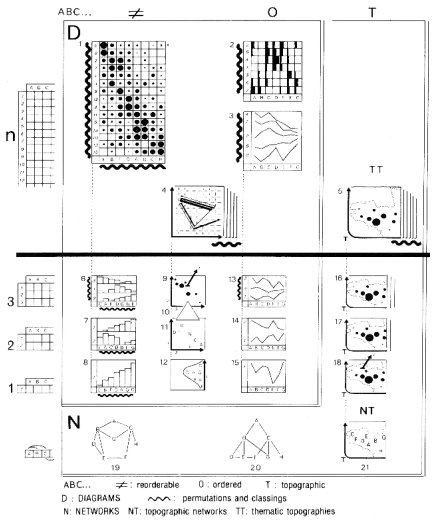
[Keim, 2001]

- 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.

Jacques Bertin

[Card, et al. 1999]

Semiology of Graphics



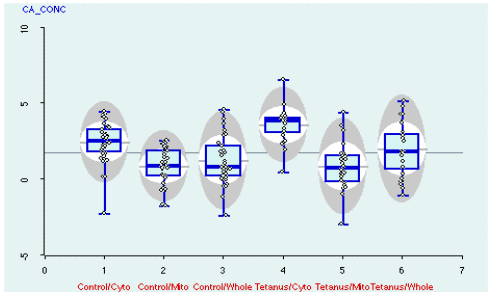
- 1967

John Tukey

Exploratory Data Analysis

[Card, et al. 1999]

3	4
4	0
5	7 2 7
6	0 7 9 0 3 9 9
7	1
8	9



- 1977 Stem&Leaf, Box&Whisker

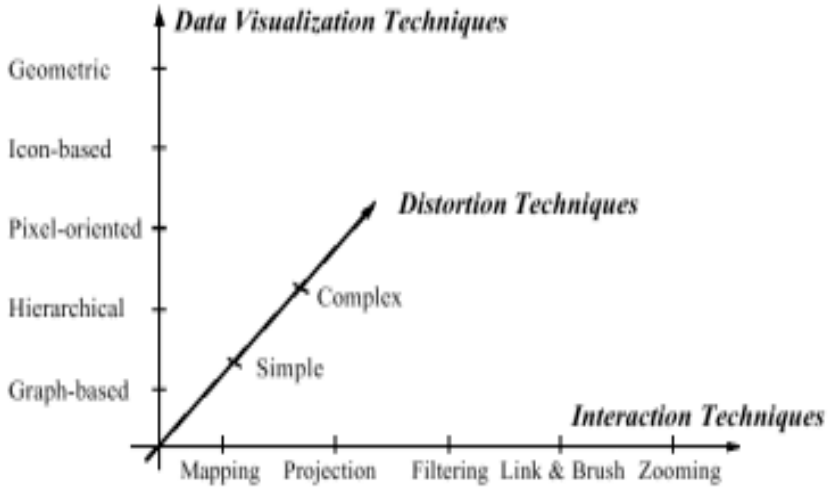
Historical Overview (cont'd)

[Keim, 2001]

- Development of Visualization Techniques for Arbitrary Multidimensional Data <u>without</u> any Underlying Physical Model
  - Applicable to Databases and Other Information Resources

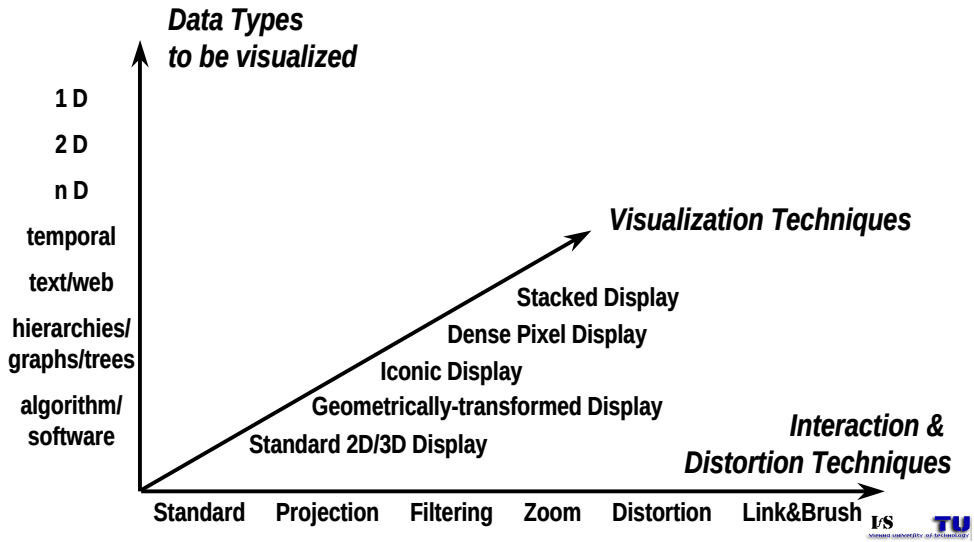
Dimensions of Exploratory Data Visualizations

[Keim, 2001]



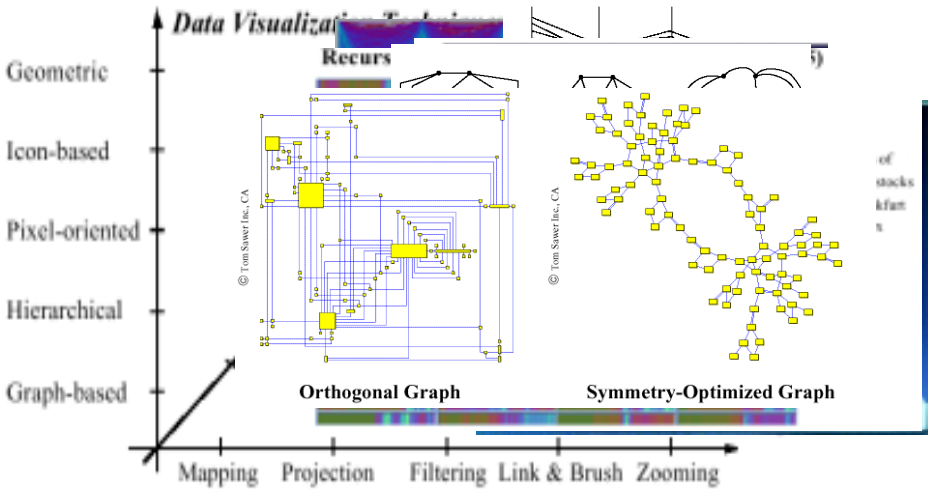
Dimensions of Exploratory Data Visualizations

adapted from [Keim, 2001]



Dimensions of Exploratory Data Visualizations

[Keim, 2001]

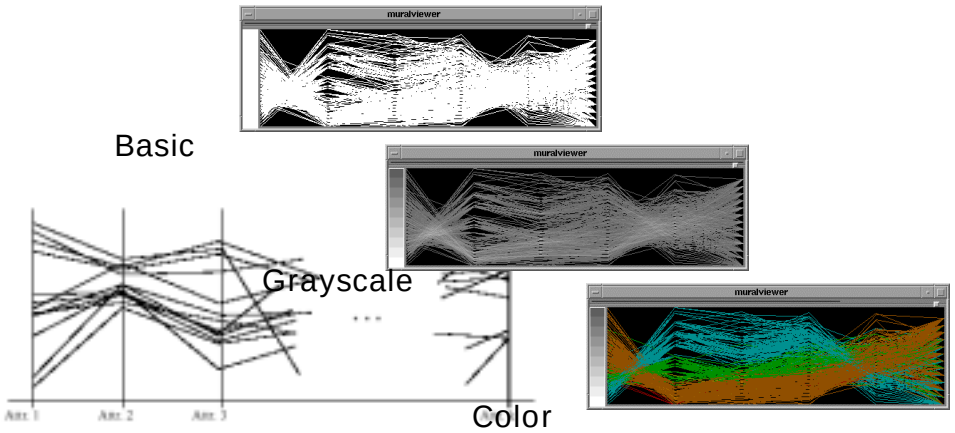


Exploration Techniques

- **Geometric Techniques**
  - Scatterplots, Parallel Coordinates, ...
- **Icon-based Techniques**
  - Glyphs, Chernoff Faces, Stick Figures, ...
- **Pixel-based Techniques**
  - Recursive Pattern Techniques, Circle Segments, ...
- **Hierarchical Techniques**
  - Cone/Cam Trees, Treemap, ...
- **Graph-based Techniques**
  - Polyline, Curved Line, ...
- **Distortion Techniques**
  - Perspective Wall, Fisheye View, ...
- **Dynamic/Interactive Techniques**
  - Filtering, Zooming, ...
- **Focus + Context**
  - → Distortion Techniques
  - → Dynamic/Interactive Techniques
- **Hybrid Techniques**

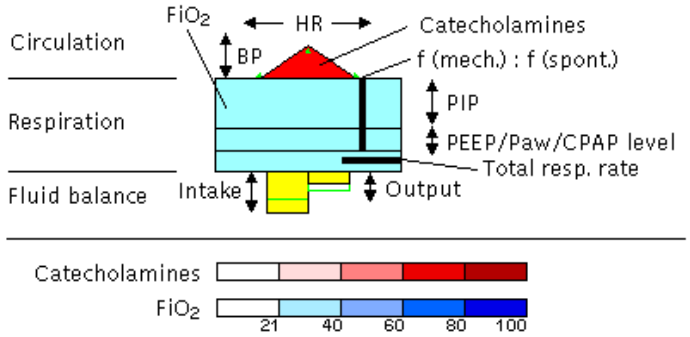
Geometric Techniques

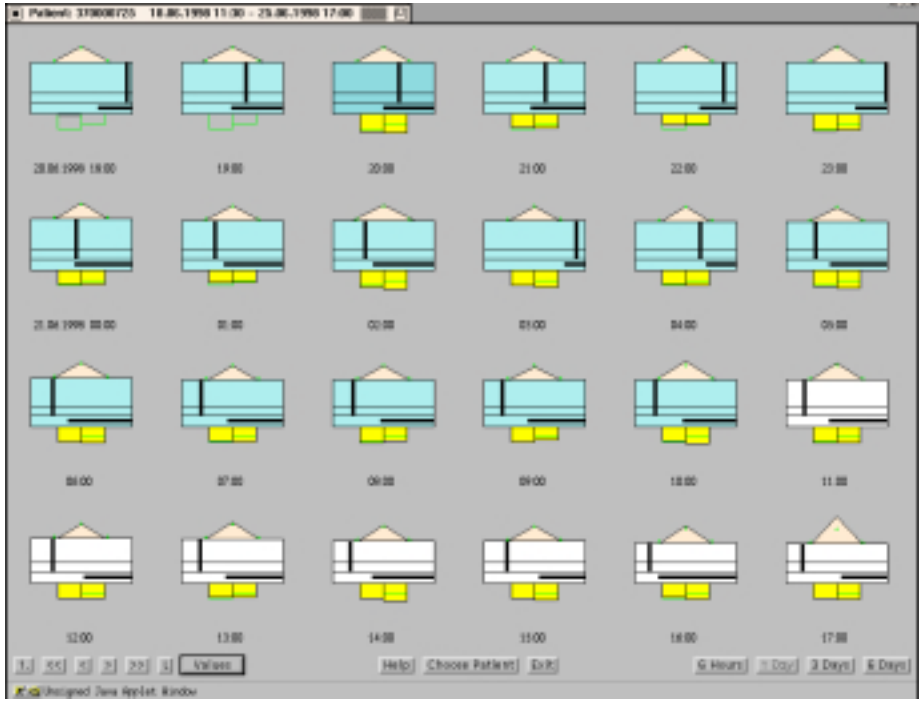
- Parallel Coordinates



Icon-based Techniques

- VIE-Visu ***[Horn, et al. 1998]***



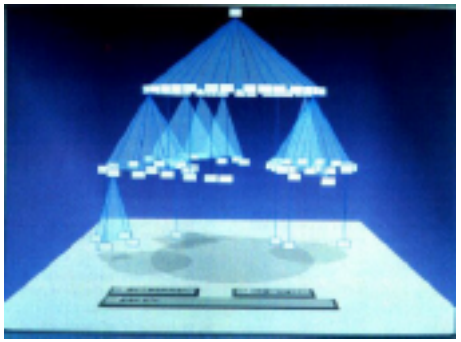


Hierarchical Techniques

[Robertson et al. 1991]

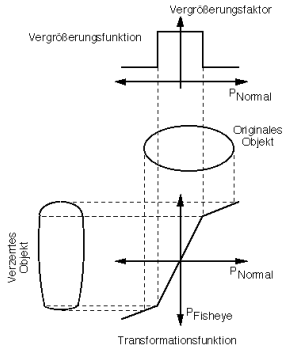
Cone Trees

Cam Trees



Distortion Techniques

- Fisheye View ***[Furnas, 1986]***



Dynamic/Interaktive Techniques

- Linking & Brushing

Adapted from J. Mackinlay slide

Baseball Data

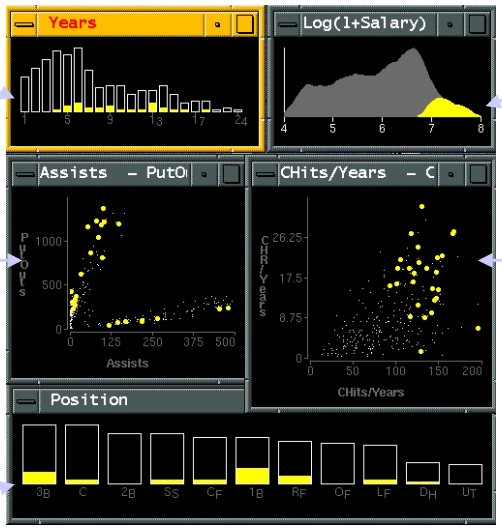
how long in majors

select high salaries

avg assists vs avg putouts (fielding ability)

avg career HRs vs avg career hits (batting ability)

distribution of positions played



What Was Learned from interaction with this Baseball Data?

- Seems impossible to earn a high salary in the first three years
- High salaried players have a bimodal distribution (peaking around 7 & 13 yrs)
- Hits/Year a better indicator of salary than HR/Year
- High paid outlier with low HR and medium hits/year. Reason: person is player-coach
- There seem to be two differentiated groups in the put-outs/assists category (but not correlated with salary) Why?

Based on Marti Hearst slide

Focus and Context: Covers?

[Kosara, et al. 2001]

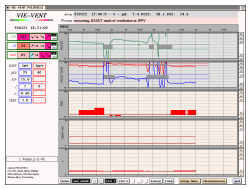
Overview: Research Projects

ViCo: Metric for the Complexity

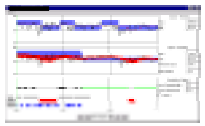
VIE-PNN

VIE-Nmed

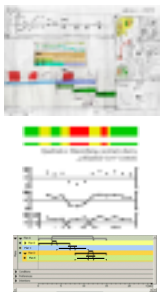
VIE-VENT



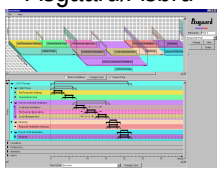
Pulsoximetry



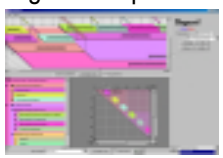
Interactions



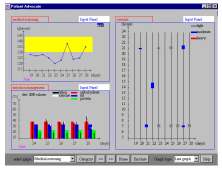
Asgaard/Asbru



Asgaard/SopoView



Patient Advocate



Semantic Depth of Field (SDOF)

Comparison

[Keim, 1996/2001]

Criteria for Comparison [KK 96]

comparison of the described information visualization techniques based on their suitability for certain

- **data characteristics**
  (e.g., no. of variates, no. of data items, categorical data, ...)
- **task characteristics**
  (e.g., clustering, multi variate hot spots, ...)
- **visualization characteristics**
  (e.g., visual overlap, learning curve, ...)

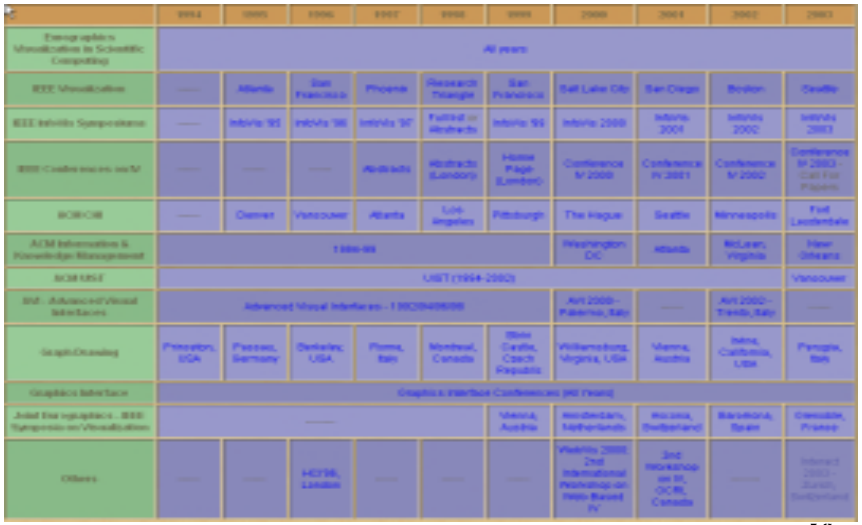
Disclaimer: The following comparison table expresses my personal opinion obtained from reading the literature and experimenting with several of the described techniques. Many of the ratings are arguable and largely depend on the considered data, the exploration task, experience of the user, etc. In addition, implementations of the techniques in real systems usually avoid the drawbacks of a single technique by combining it with other techniques, which is also not reflected in the ratings.

Comparison

[Keim, 1996/2001]

		cluster-ing	multi-variate hot spot	no. of variates	no. of data items	cate-gorical data	visual overlap	learning curve
Geometric Techniques	Scatterplot Matrices	++	++	+	+	-	o	++
	Landscapes	+	+	-	o	o	+	+
	Prosection Views	++	++	+	+	-	o	+
	Hyperslice	+	+	+	+	-	o	o
	Parallel Coordinates	o	++	++	-	o	--	o
Icon-based Techniques	Stick Figure	o	o	+	-	-	-	o
	Shape Coding	o	-	++	+	-	+	-
	Color Icon	o	-	++	+	-	+	-
Pixel-oriented Techniques	Query-Independent	+	+	++	++	-	++	+
	Query-Dependent	+	+	++	++	-	++	-
Hierarchical Techniques	Dimensional Stacking	+	+	o	o	++	o	o
	Worlds-within-Worlds	o	o	o	+	o	o	o
	Treemap	+	o	+	o	++	+	o
	Cone Trees	+	+	o	+	o	+	+
	InfoCube	o	o	-	-	o	o	+

Conferences on InfoVis



http://www.dcs.napier.ac.uk/~marting/IVconf.html

Outline

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

Visual Encoding Techniques 1

[Card, Mackinlay & Shneiderman 1999]

- Different ways in encoding information visually:
  - space (absolute dominant)
  - marks (in space)
  - connections & enclosures
  - retinal properties
  - temporal changes
  - viewpoint transformations

five main techniques, we will talk about later

- points
- lines
- areas
- volumes

crispness
shape
resolution
transparency
color (value, hue & saturation)
grayscale

Visual Encoding Techniques 2

[Card, Mackinlay & Shneiderman 1999]

- Five major spatial encoding techniques:
  - Composition — The orthogonal placement of axes, creating a 2D metric space
  - Alignment — The repetition of an axis at a different position in the space
  - Folding — The continuation of an axis in an orthogonal direction
  - Recursion — The repeated subdivision of space
  - Overloading — The reuse of the same space for the same Data Table

Outline

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Summary: InfoVis...

- ... is a very complex task
- ... can help to get insight into data more quickly
- ... requires preparation and sensible handling of the information
- ... should make use of the properties of human visual perception
- ... requires sensible handling, relative to the task
- ... is a big challenge, if you want to do it good