Information Visualization

SS2011, VO 2.0 186.141
SS2011, UE 1.0 186.143
http://www.cg.tuwien.ac.at/courses/InfoVis/index.html

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Information Visualization

"The use of computer-supported, interactive, visual representations of abstract data to amplify cognition"

Course Outline 1/2

2.3.	Vorbesprechung, Vorstellung des Übungsteiles (Martin Haidacher, Thomas Mühlbacher) Grundlagen der InfoVis I (Eduard Gröller)
9.3.	Grundlagen der InfoVis II (Eduard Gröller)
16.3.	Visual Analytics (Eduard Gröller)
23.3.	Präsentationen der Artikel I (StudentInnen)
30.3.	Präsentationen der Artikel II (StudentInnen)
13.4.	Gastvortrag (Philipp Muigg/Harald Piringer)
11.5.	Vorlesung Kresimir Matkovic
18.5.	Vorlesung Kresimir Matkovic
24.5. (Sondertermin)	Gastvortrage (Andreas Kerren)
25.5.	Gastvortrage (Andreas Kerren)
8.6.	Präsentation der Programme I (StudentInnen)
15.6.	Präsentation der Programme II (StudentInnen)
22.6.	Präsentation der Programme III (StudentInnen)
29.6.	UE Abgabegespräche

Course outline 2/2

- Grading I (VO+UE)
  - Registration+Workplan (5%)
  - Presentation of Paper (15%)
  - Implementation (45 %)
  - Presentation of Program (15%)
  - Class attendance (20%)
- Grading II (only VO)
  - Oral exam (80%)
  - Class attendance (20%)

Information Visualization - Introduction

Eduard Gröller

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Outline

- Introduction
- Knowledge crystallization
- InfoVis reference model
  - Visual mappings, visual structures
  - View transformations
  - Interaction

Information Visualization

"The use of computer-supported, interactive, visual representations of abstract data to amplify cognition"

- computer-based - new medium
- interactive - direct manipulation & animation
- visual representations - use human perception
- data - task specific
- amplify cognition - helping people to think

[Jock Mackinlay]

How Many Zeros in 100 Digits of PI?

3.1 4 1 5 9 2 6 5 3 5 8 9 7 9
3 2 3 8 4 6 2 6 4 3 3 8 3 2 7
9 5 0 2 8 8 4 1 9 7 1 6 9 3 9
9 3 7 5 1 0 5 8 2 0 9 7 4 9 4
4 5 9 2 3 0 7 8 1 6 4 0 6 2 8
6 2 0 8 9 9 8 6 2 8 0 3 4 8 2
5 3 4 2 1 1 7 0 6 7 9 8 2 1 4

Courtesy of Jock Mackinlay

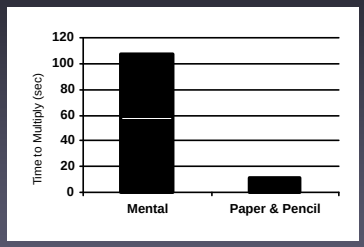
How Many Yellow Objects?

3.1 4 1 5 9 2 6 5 3 5 8 9 7 9
3 2 3 8 4 6 2 6 4 3 3 8 3 2 7
9 5 0 2 8 8 4 1 9 7 1 6 9 3 9
9 3 7 5 1 0 5 8 2 0 9 7 4 9 4
4 5 9 2 3 0 7 8 1 6 4 0 6 2 8
6 2 0 8 9 9 8 6 2 8 0 3 4 8 2
5 3 4 2 1 1 7 0 6 7 9 8 2 1 4

Courtesy of Jock Mackinlay

Strategy: Use External World

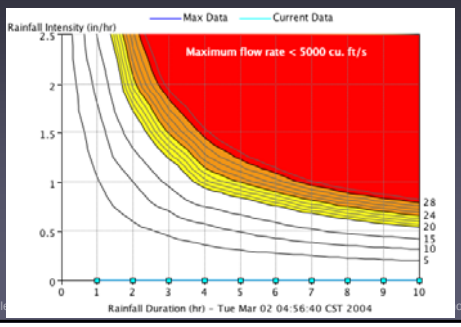
$$\begin{array}{r} 34 \\ \times\ 72 \\ \hline 68 \\ 2380 \\ \hline 2448 \end{array}$$



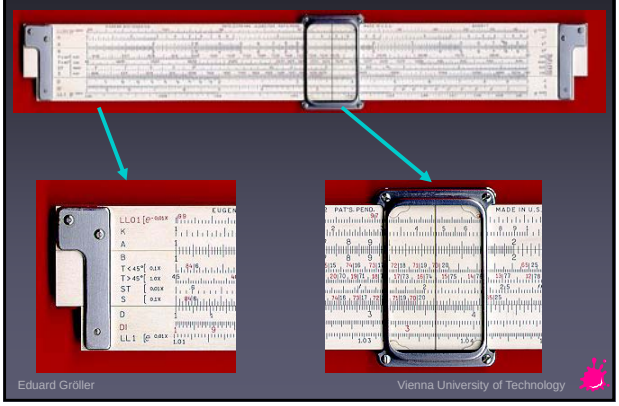
Courtesy of Jock Mackinlay

Nomograph

- visual devices for specialized computations
- easy to do „what if"-calculations

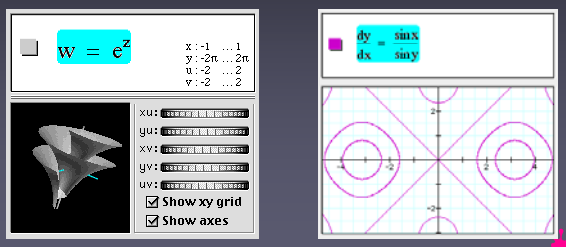


Slide Rules



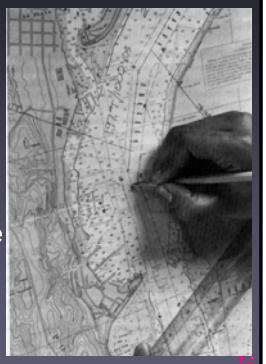
Graphing Calculator

- Slide rules replaced by direct computational device (e.g., pocket calculator)
- Computational device part of more powerful visually based system



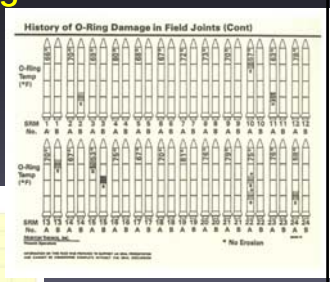
Navigation Charts

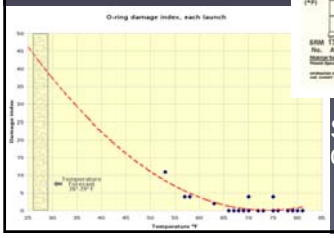
- Visual analogue computing device for navigation
- Cartographic projections
  - Lambert projection
  - Mercator projection
- Calculator and storage device
  - Coastline
  - Ocean depths



Diagrams

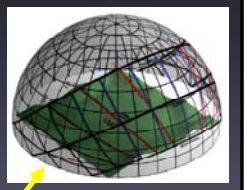
Diagram of O-ring damage

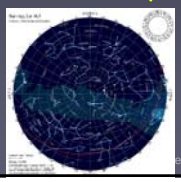


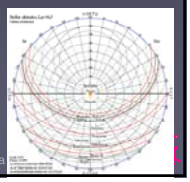


Scattergraph of O-ring damage

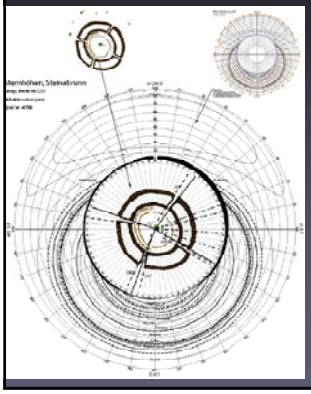
A Sky Dome Visualisation for Identification of Astronomical Orientations

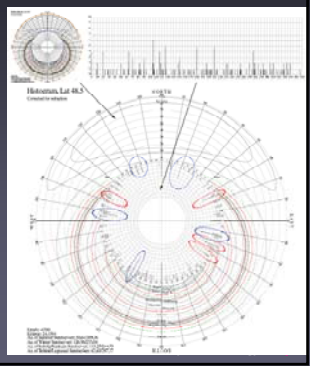






A Sky Dome Visualisation for Identification of Astronomical Orientations





Information Visualization (InfoVis)

External Cognition
use external world to accomplish cognition

↓

Information Design
design external representations to amplify cognition

↓

Visualization
computer-based, interactive

↙ ↘

Scientific Visualization
typically physical data

Information Visualization
abstract, nonphysical data

Courtesy of Jock Mackinlay

Visualization – Three Major Areas

- Three major areas
  - Volume Visualization
  - Flow Visualization

  } Scientific Visualization — Inherent spatial reference

  3D

  nD

  - Information Visualization

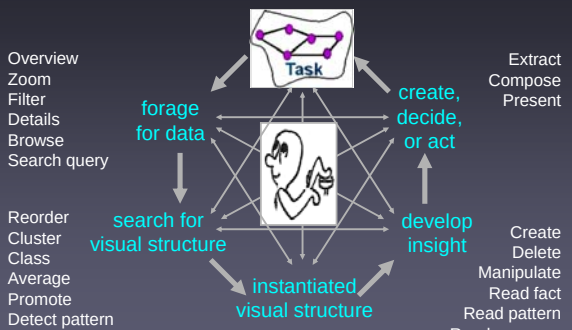
  Usually no spatial reference

InfoViz vs. SciViz

- Abstract data
- n-dimensional
- Very important:
  - Visual metaphor
  - User interaction
  - **Exploration**, Analysis, Presentation

- Concrete Data
- 2- oder 3-dimensional, time related?
- Very important:
  - 3D-rendering
  - Fast rendering
  - **Analysis**, Exploration, Presentation

Knowledge Crystallization



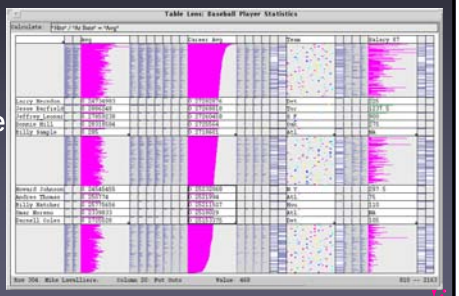
Courtesy of Jock Mackinlay

Dynamic HomeFinder

- Browsing housing market
- Data, schema (structure), task

Table Lens Tool

- Table visualization tool
- Instantiate schema
- Manipulate cases, variables

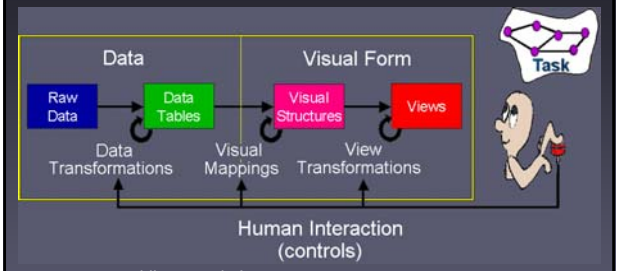


Knowledge Crystallization: Cost Structure

- Information visualization: Improve cost structure of information work
- Representation = data structure + operations + constraints
- Different cost relative to some task

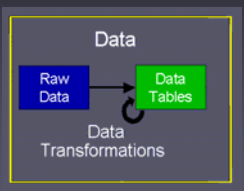
Walking   Driving

InfoVis Reference Model

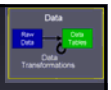


- Raw Data: idiosyncratic formats
- Data Tables: relations(cases by variables)+metadata
- Visual Structures: spatial substrates + marks + graphical properties
- Views: graphical parameters (position, scaling, clipping, zooming,...)

Data

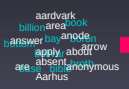


Raw Data



Documents

Words



Word Vectors

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

Other units

- Sentence
- Paragraph
- Section
- Chapter
- Characters
- Pictures

Meta-data

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

Meaning

Jock Mackinlay's Slide

Raw Data Issues

- 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	...
TUWIEN	1	0	0	...
UNIWIEN	0	1	0	...
about	1	0	1	...
...	...	...	...	...

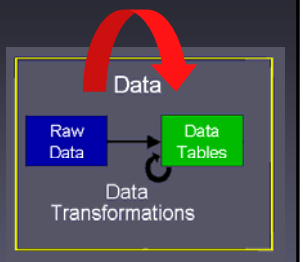
VS

TUWIEN	D1,...
UNIWIEN	D2,...
about	D1, D3, ...
...	...

Courtesy of Jock Mackinlay

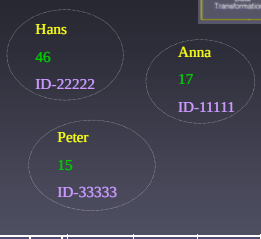
Data Transformations

- Process of converting Raw Data into Data Tables.
- Used to build and improve Data Tables



Data Tables

- Data Tables:
  - Cases/Items
  - Variables
    - Nominal
    - Quantitative
    - Ordinal
  - Values
  - Metadata



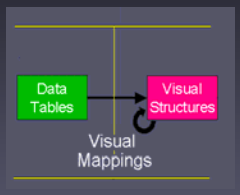
Name	N	Anna	Hans	Peter
Age	Q	17	46	15
ID	O	11111	22222	33333

Data Transformations

- Values → Derived Values
- Structure → Derived Structure
- Values → Derived Structure
- Structure → Derived Values

	Derived value	Derived structure
Value	Mean	Sort Class Promote
Structure	Demote	X,Y,Z→P xzy

Visual Mappings



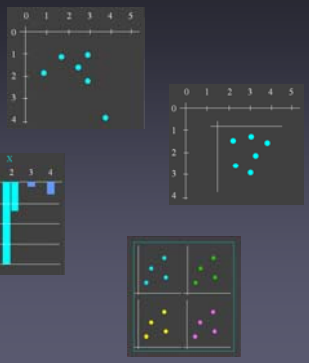
- Expressiveness
- Effectiveness

Visual Mappings

- Spatial Substrate (Type of Axes)
  - Nominal
  - Ordinal
  - Quantitative
- Marks
  - Type: Point, Line, Area, Volume
  - Connection and Enclosure
- Axes Location
  - Composition
  - Overloading
  - Folding
  - Recursion

Axes Location

- Composition
- Overloading
- Folding
- Recursion

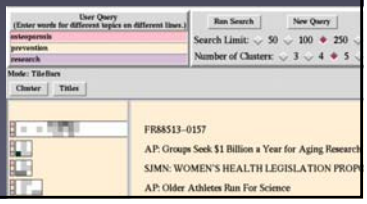


Visual Structures

- Classification by use of space:
  - 1D, 2D, 3D
    - Refers to visualizations that encode information by positioning marks on orthogonal axes
  - Multivariable >3D
    - Data Tables have so many variables that orthogonal Visual Structures are not sufficient
    - Multiple Axes, Complex Axes
  - Trees
  - Networks

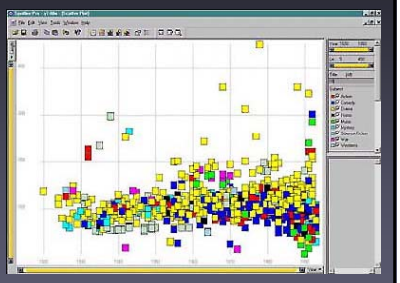
1D Visual Structures

- Typically used for documents and timelines, particularly as part of a larger Visual Structure
- Often embedded in the use of more axes, second or third axis, to accommodate large axes
- Example:
  - TileBars



2D Visual Structures

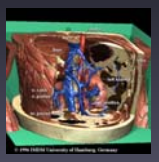
- Chart, geographic data
- Document collections
- Example:
  - Spotfire: 2D scattered graph



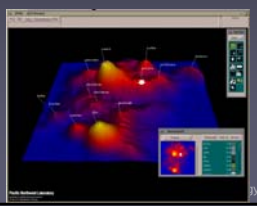
[Ahlberg, 1995]

3D Visual Structures

- Usually represent real world objects



- 3D Physical Data
  - E.g., VoxelMan
- 3D Abstract Data
  - E.g., Themescapes

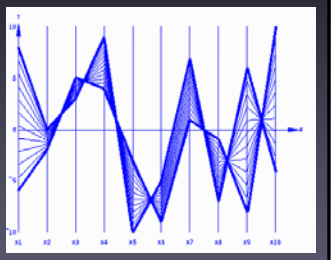


Multivariable >3D

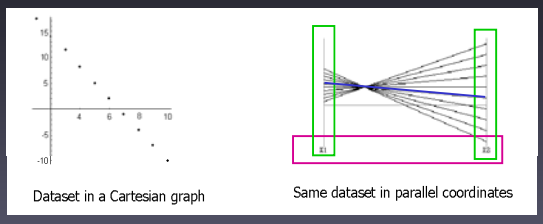
- Data Tables have so many variables that orthogonal Visual Structures are not sufficient.
- Example:
  - Parallel Coordinates

Parallel Coordinates

- Parallel 2D axes.
- Add/Remove data
  - Establish Patterns
  - Examine interactions.
- Useful for recognizing patterns between the axes
- Skilled user

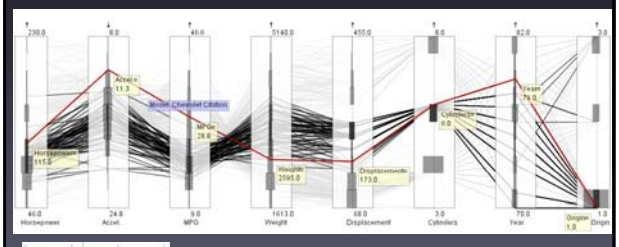


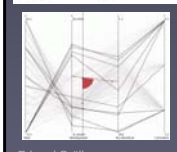
Parallel Coordinates [Inselberg]



Encode variables along a horizontal row
Vertical line specifies single variable
Blue line specifies a case

Extended Parallel Coordinates



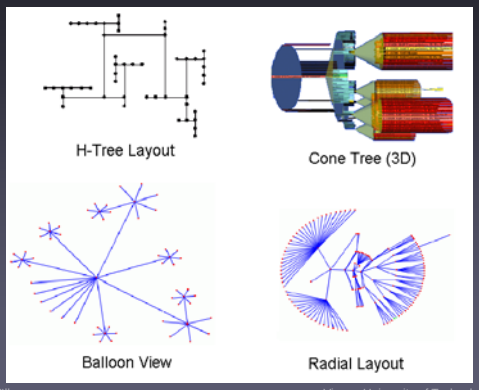


- Greyscale, color
- Histogram information on axes
- Smooth brushing
- Angular brushing

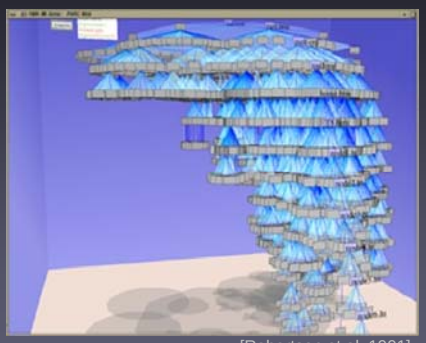
Trees

- Visual Structures that refer to use of connection and enclosure to encode relationships among cases
- Desirable Features
  - Planarity (no crossing edges)
  - Clarity in reflecting the relationships among the nodes
  - Clean, non-convoluted design
  - Hierarchical relationships should be drawn directional

Trees

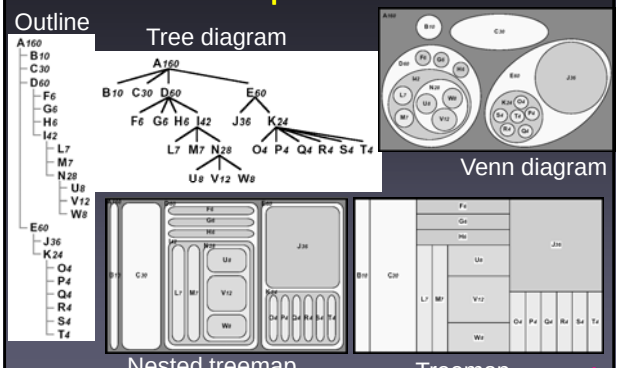


ConeTree



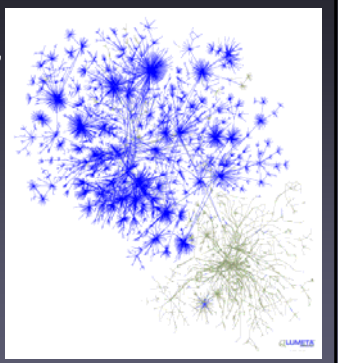
[Robertson et al, 1991]

Tree Maps [Johnson, Shneiderman, 1991]



Networks

- Used to describe Communication Networks, Telephone Systems, Internet
- Nodes
  - Unstructured
  - Nominal
  - Ordinal
  - Quantity
- Links
  - Directed
  - Undirected



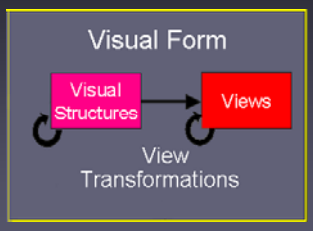
[Branigan et al, 2001]

Networks

- Problems Visualizing Networks:
  - Positioning of Nodes
  - Managing links so they convey the actual information
  - Handling the scale of graphs with large amounts of nodes
  - Interaction
  - Navigation

[London Subway]

View Transformations



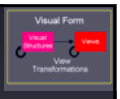
View Transformations

- Problems:
  - Scale
  - Region of Interest
  - How to specify focus?
    - Find new focus
    - Stay oriented

→ Overview + Detail
→ Zooming
→ Focus + Context

- Ability to interactively modify and augment visual structures, turning static presentations into visualizations

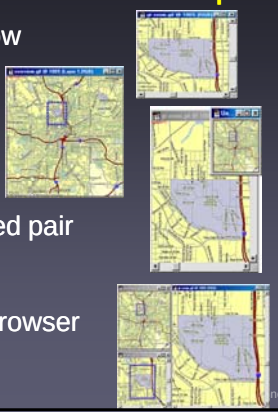
Overview + Detail



- Provide both overview and detail displays
- Two ways to combine:
  - Time - Alternate between overview and detail sequentially
  - Space - Use different portions of the screen

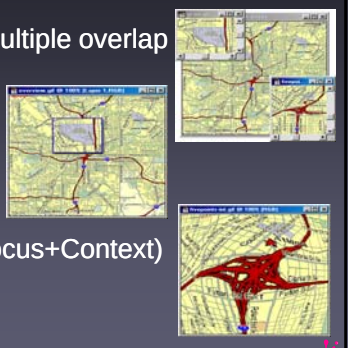
Overview+Detail - Examples

- Detail only window
- Zoom & replace
- Single coordinated pair
- Tiled multilevel browser



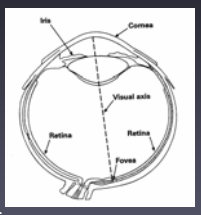
Overview+Detail - Examples

- Free zoom and multiple overlap
- Bifocal magnified
- Fish-eye view (Focus+Context)



Focus + Context

- Overview Content
- Detail Content
- Dynamical Integration



Rationale
- Zooming hides the context
- Two separate displays split attention
- Human vision has both fovea and retina

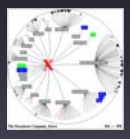
Courtesy of Jock Mackinlay

Focus + Context

- Filtering
  - Selection of cases
  - Manually or dynamically
- Selective aggregation
  - New cases
- Distortion
  - Relative changes in the number of pixels devoted to objects in the space
  - Types of distortion:
    - Size of the objects representing cases
    - Size due to perspective
    - Size of the space itself

Focus + Context - Examples

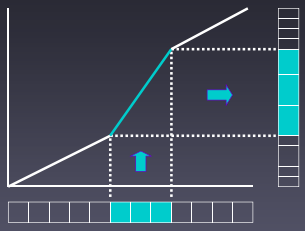
- Hyperbolic tree



- Perspective Wall

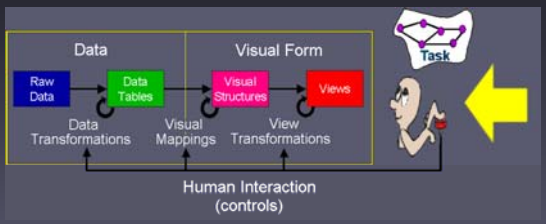
- Document Lens

Visual Transfer Function



- Functions that distort visualizations by stretching or compressing them, giving the portion of visualization attended to more visual detail
- DOI - Degree Of Interest Function

Interaction



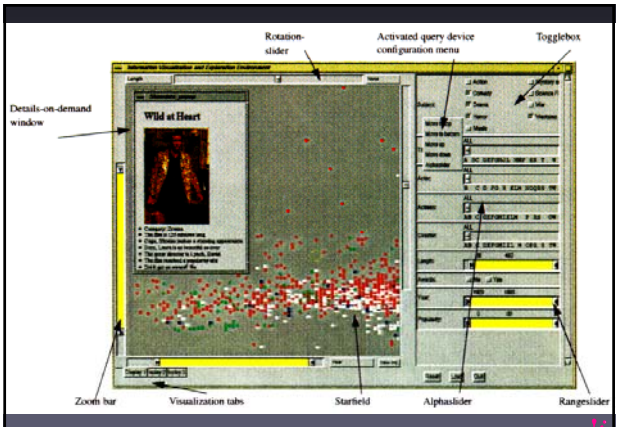
- Details-on-Demand
- Dynamic Queries
- Brushing

Details-on-Demand

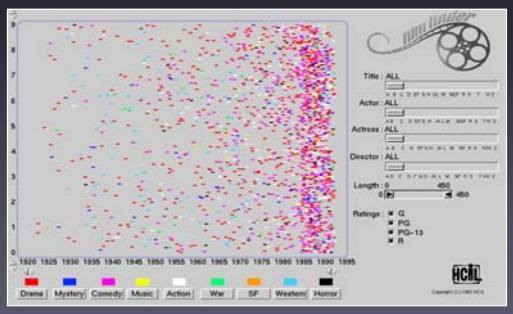
- Expands a set of small objects to reveal more of their variables
- Allows more variables to be mapped to the visualization

Looking for new office HQs???

Location: Michaelerstrasse 1	Location: Favoriten Strasse 9
Rooms: 5	Rooms: 20
Conference Room: Yes	Conference Room: Yes
Availability: Under Construction	Availability: Occupied



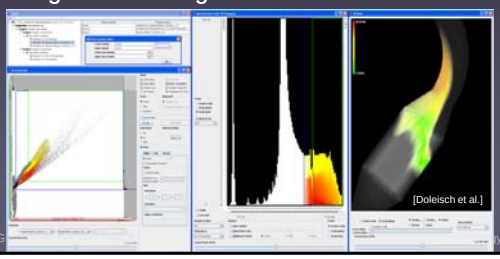
Dynamic Queries



- FilmFinder : Visual means of specifying conjunctions

Brushing

- Used with multiple visualizations of the same objects
- Highlighting one case from the Data Table selects the same case in other views
- Linking and Brushing



Further Readings

- The **Information Visualization** community platform http://www.infovis-wiki.net/index.php/Main_Page
- Card, S., Mackinlay, J., Shneiderman B., ***Readings in Information Visualization***, Morgan Kaufmann, 1999.
- Shneiderman, B., ***The eyes have it: A task by data type taxonomy for information visualizations***, Proc. IEEE Visual Languages 1996, 336-343.
- Ware, C., Information Visualization - Perception for Design, second edition 2004, Morgan Kaufmann
- Tufte, E., The Visual Disply of Quantitative Information, second edition, 2001, Graphics Press
- *North, C., http://infovis.cs.vt.edu/cs5764/readings.html*

Interesting Links

- Google Public Data Explorer
  - http://www.google.com/publicdata/home
- Hans Rosling – Gapminder
  - http://www.ted.com/speakers/hans_rosling.html
- IBM – Many Eyes
  - http://manyeyes.alphaworks.ibm.com/manyeyes/
- Visual Complexity
  - http://www.visualcomplexity.com/