Information Visualization - Introduction

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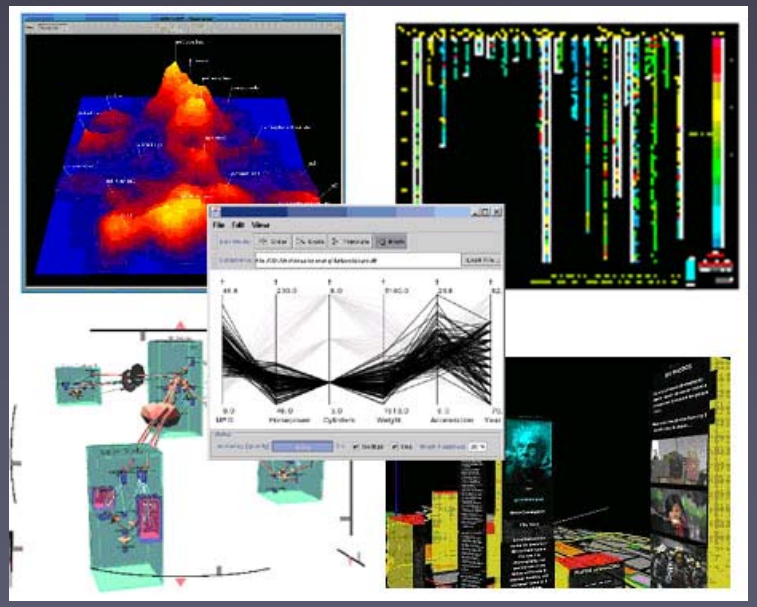
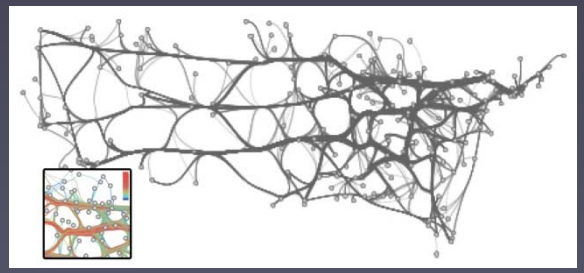
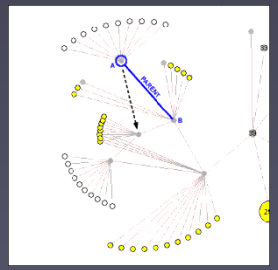
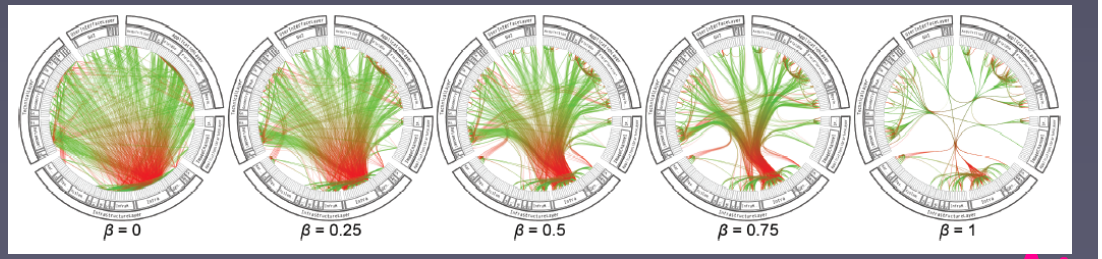
Information Visualization

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









Outline

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

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

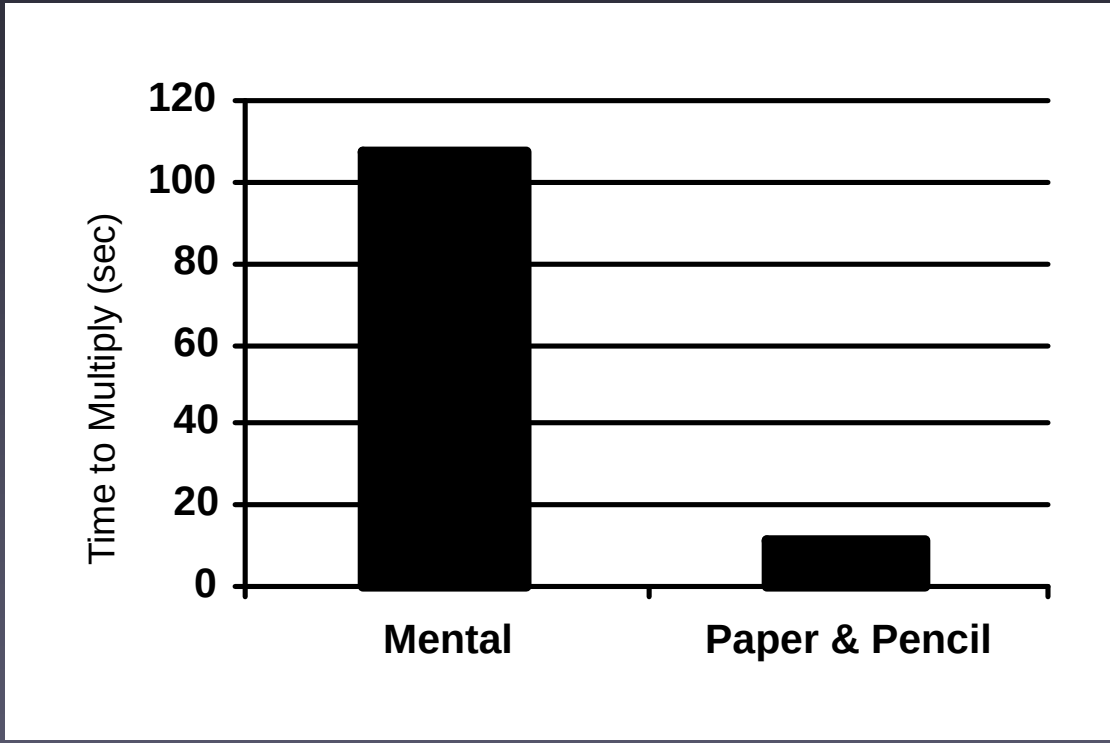
6 2 0 8 9 9 8 6 2 8 0 3 4 8 2

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

Courtesy of Jock Mackinlay

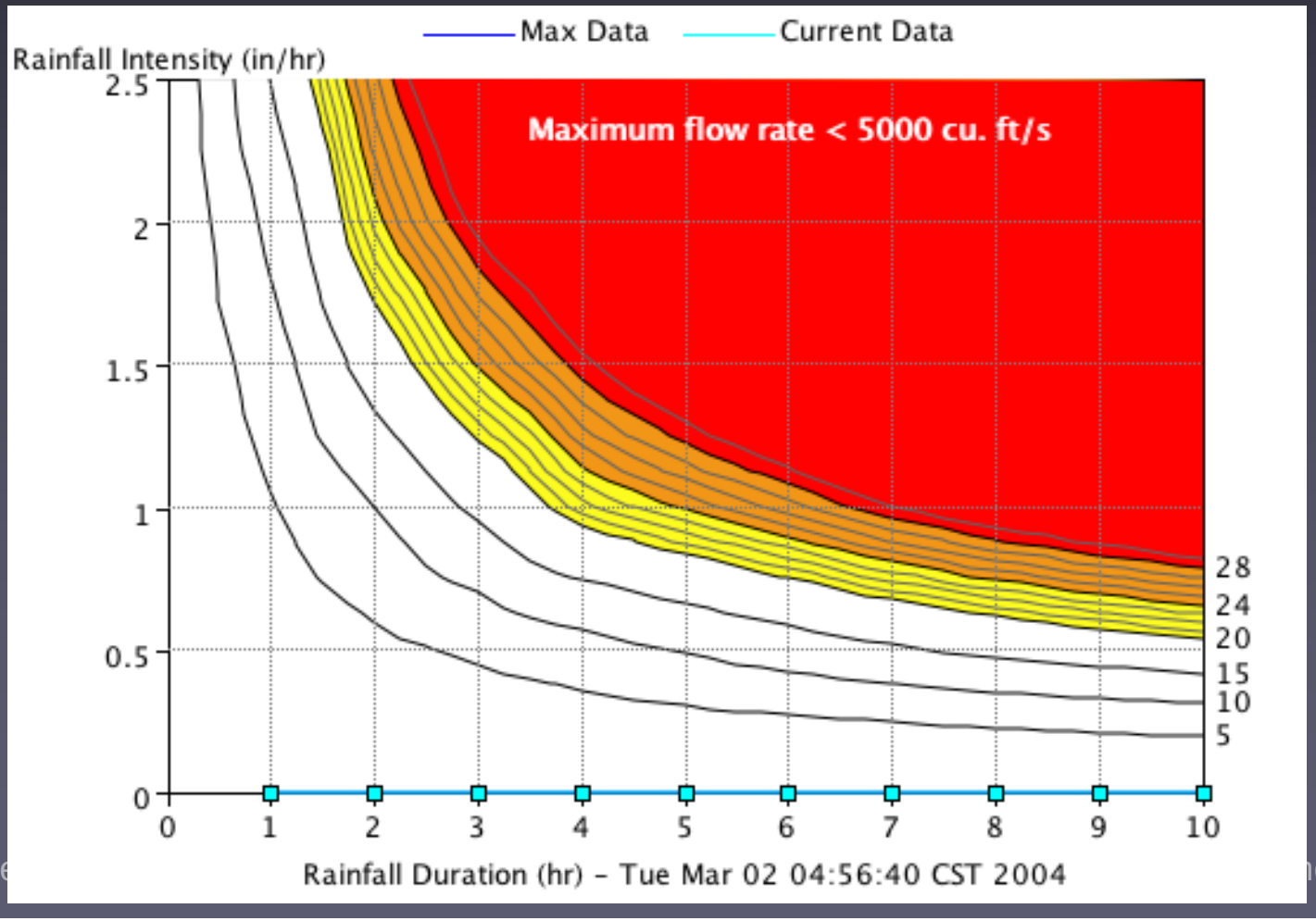
Strategy: Use External World

$$\begin{array}{r} 34 \\ \times\ 72 \\ \hline 68 \\ 23^{2}80 \\ \hline 24^{1}48 \end{array}$$



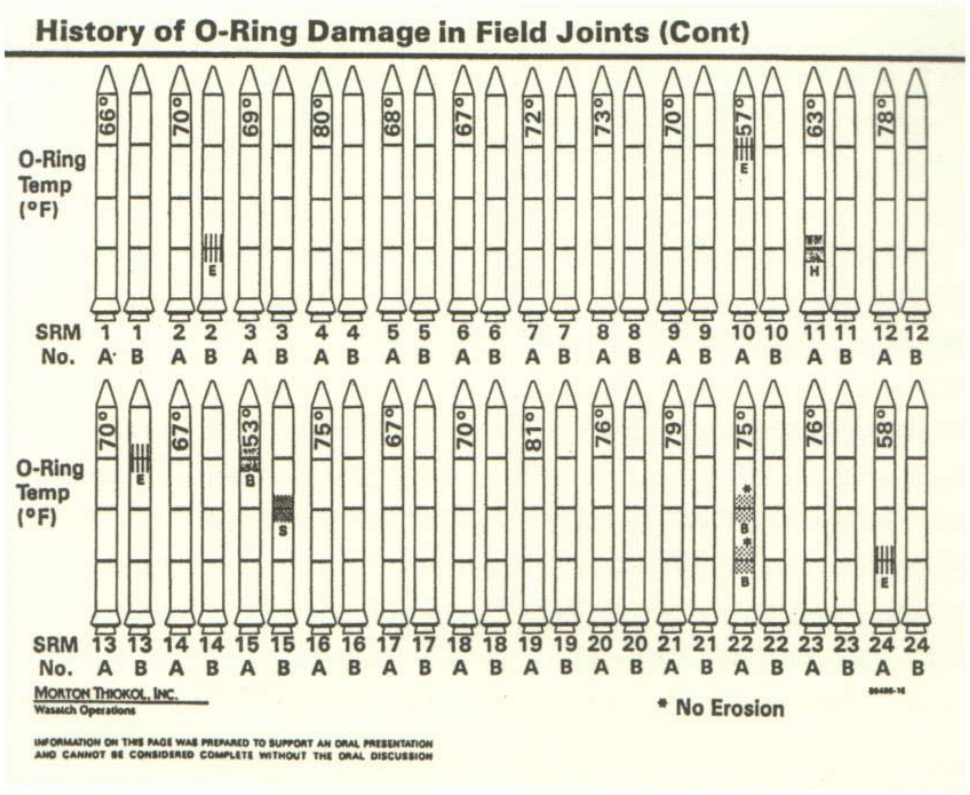
Nomograph

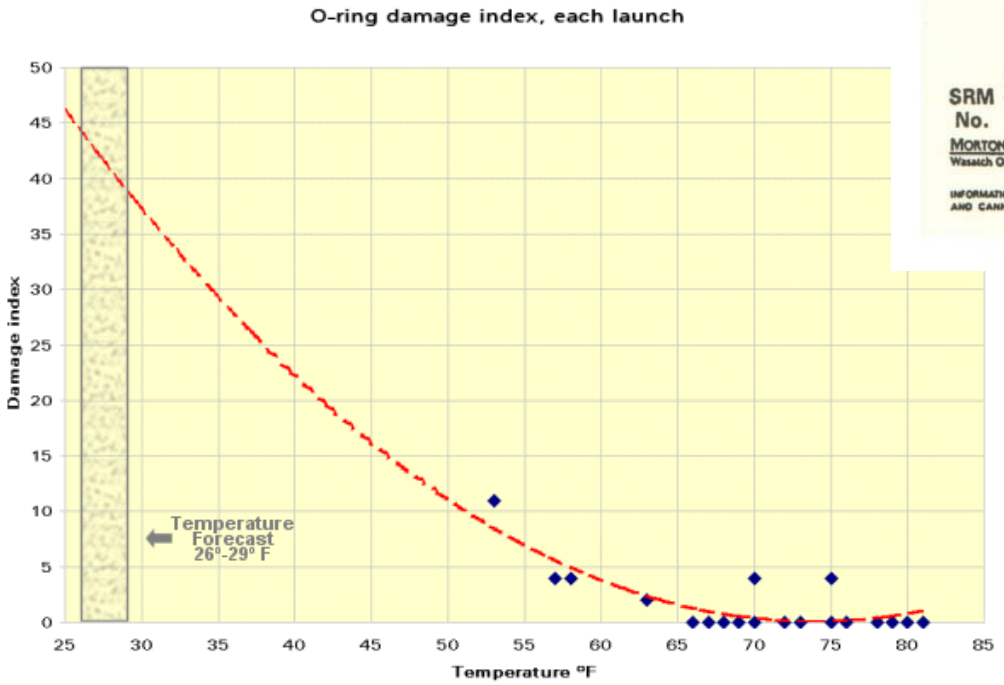
- visual devices for specialized computations
- easy to do „what if“-calculations



Diagrams

Diagram of O-ring damage





Scattergraph of O-ring damage

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

Knowledge Crystallization

Overview
Zoom
Filter
Details
Browse
Search query

forage for data

Extract
Compose
Present

create, decide, or act

Reorder
Cluster
Class
Average
Promote
Detect pattern
Abstract

search for visual structure

develop insight

Create
Delete
Manipulate
Read fact
Read pattern
Read compare

instantiated visual structure

Courtesy of Jock Mackinlay

Dynamic HomeFinder

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

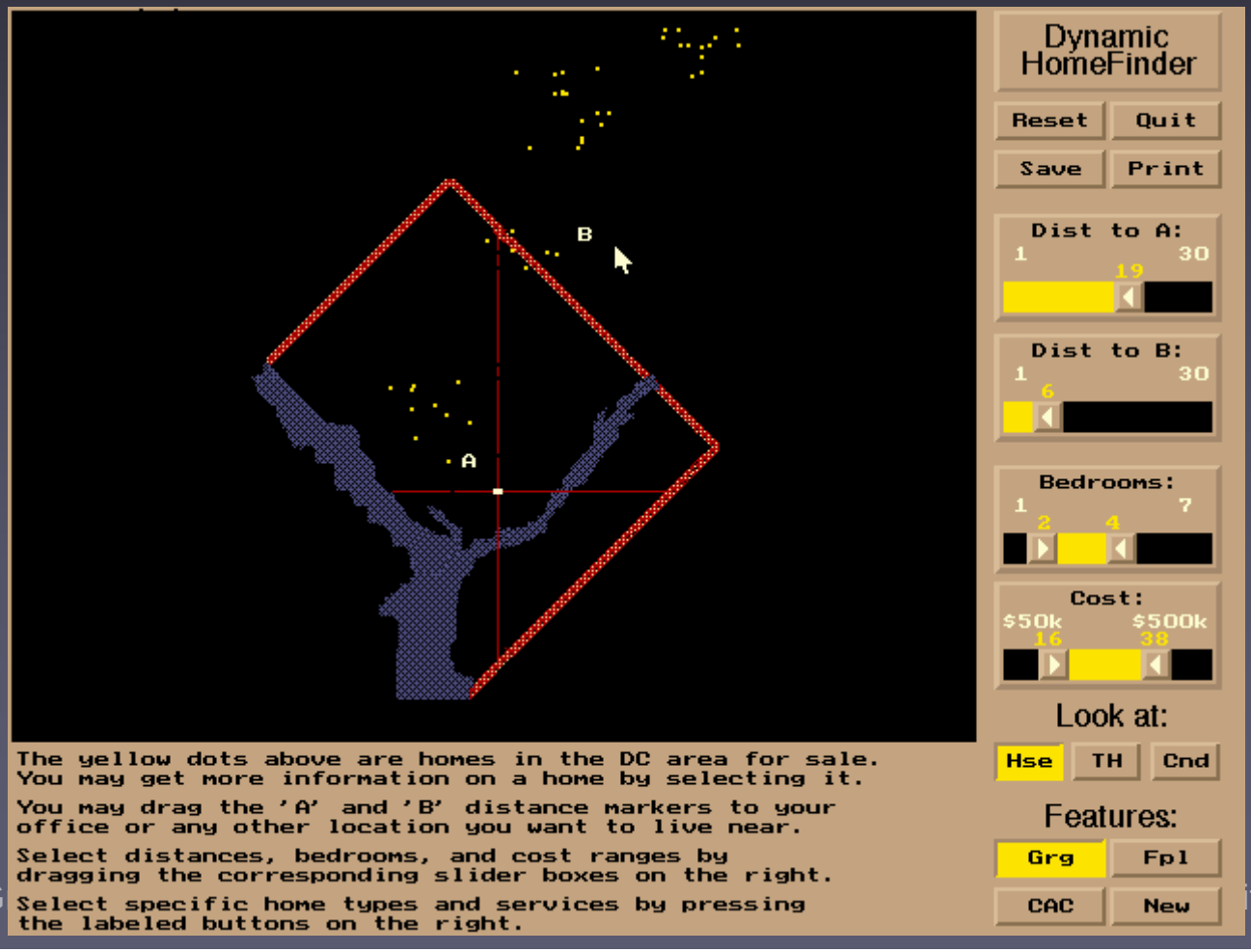
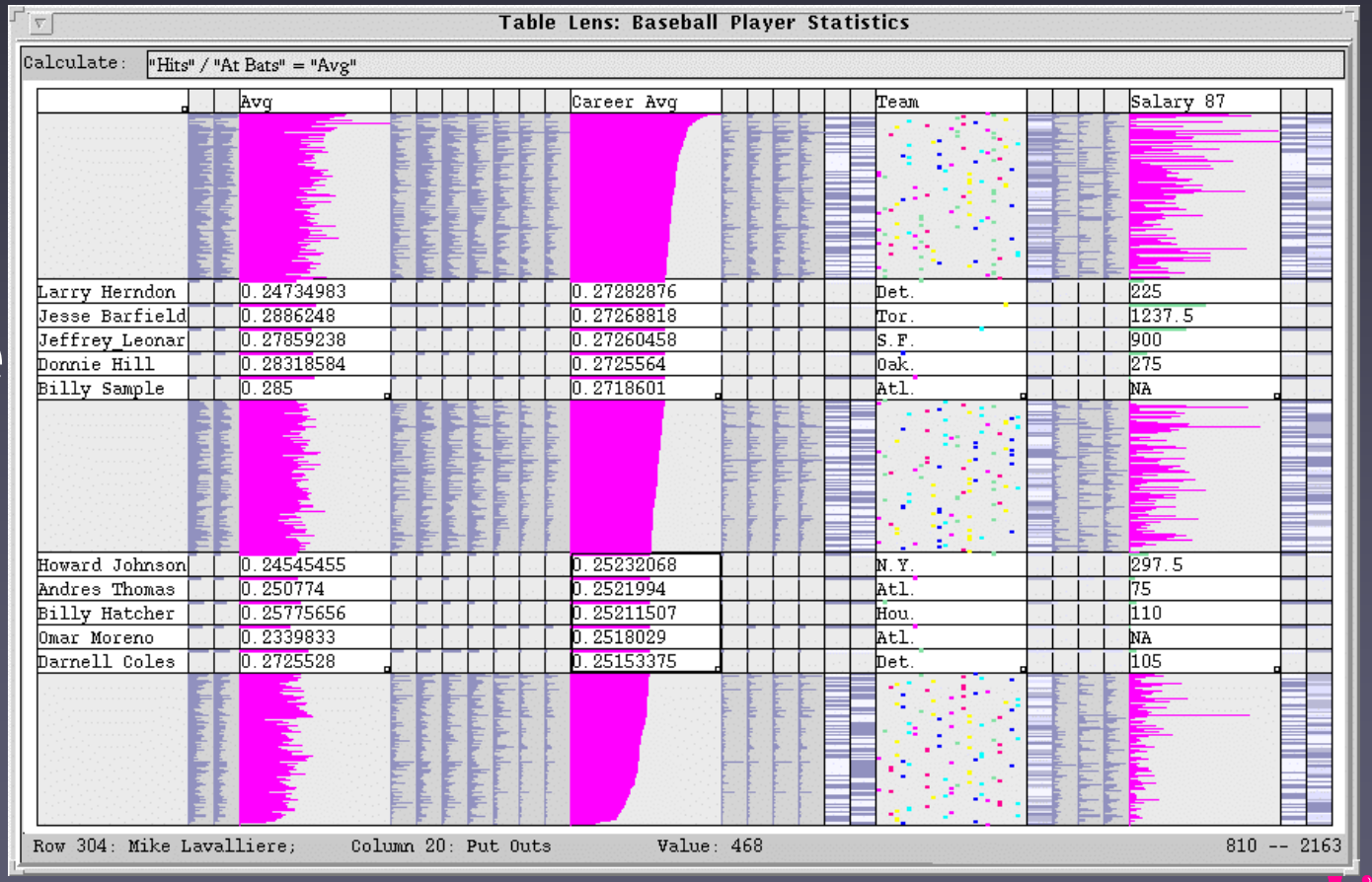


Table Lens Tool

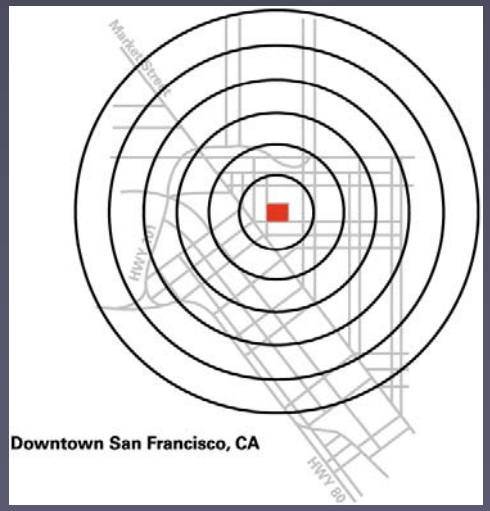
- Table visualization tool
- Instantiate schema
- Manipulate cases, variables



Knowledge Crystallization: Cost Structure

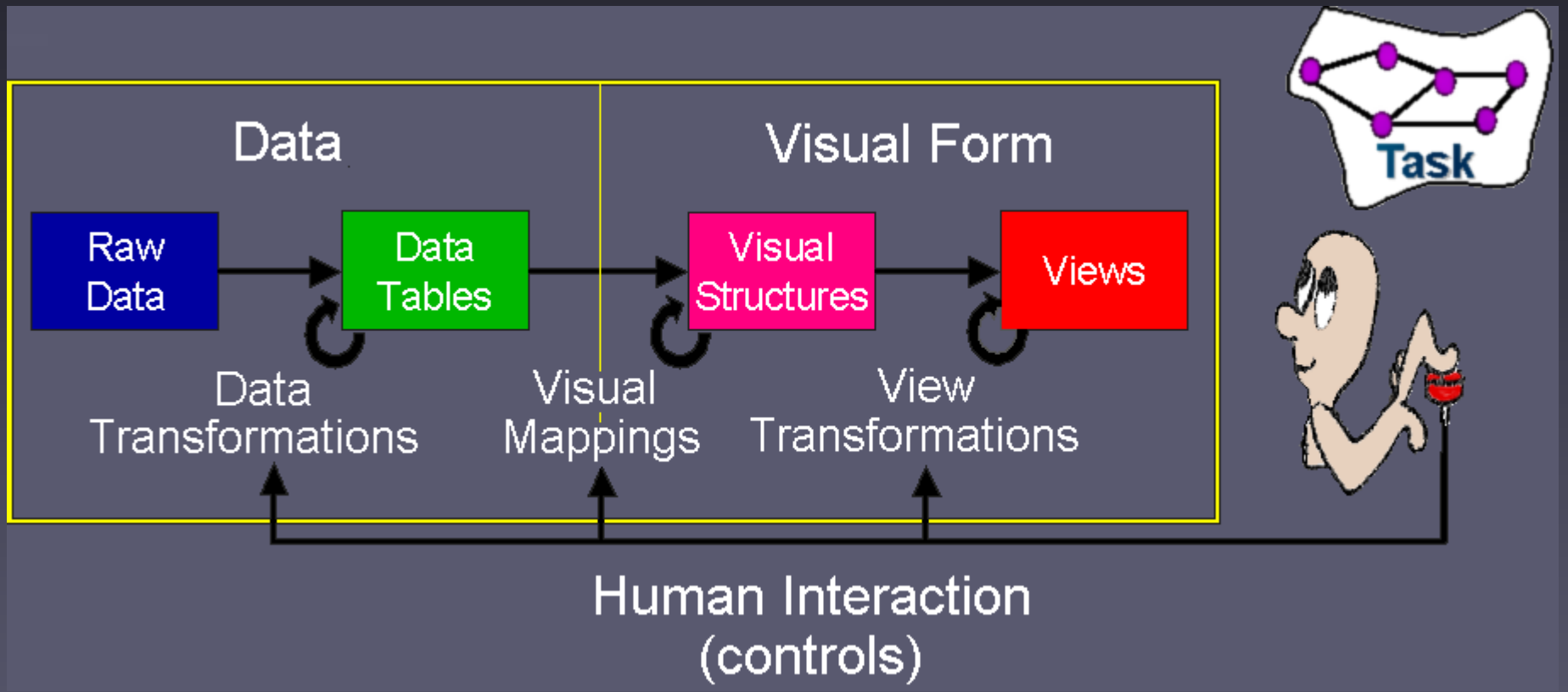
- Information visualization: Improve cost structure of information work
- Representation = data structure + operations + constraints
- Different cost relative to some task

Walking



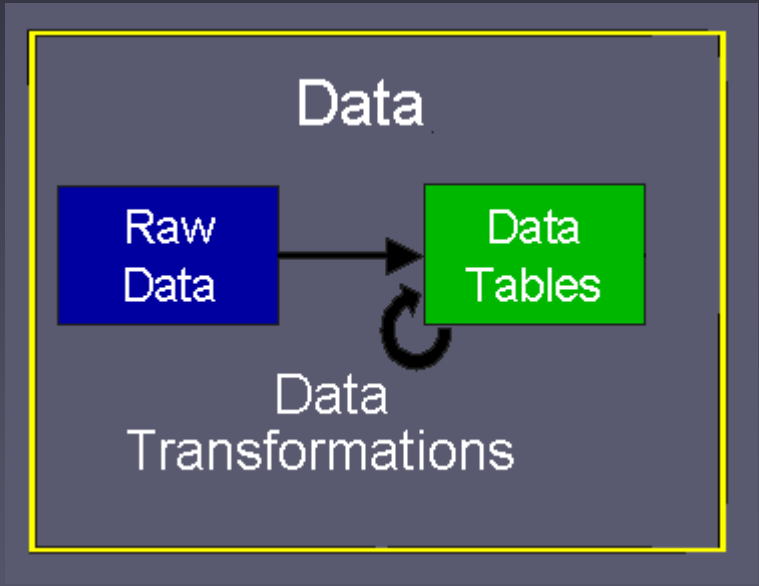
Driving

InfoVis Reference Model

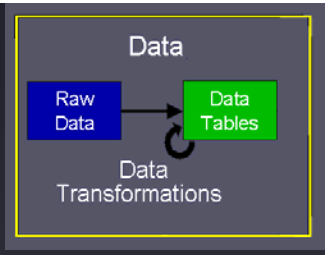


- Raw Data: idiosyncratic formats
- Data Tables: relations(cases by variables)+metadata
- Visual Structures: spatial substrates + marks + graphical properties
- Views: graphical parameters (position, scaling, clipping, zooming,...)

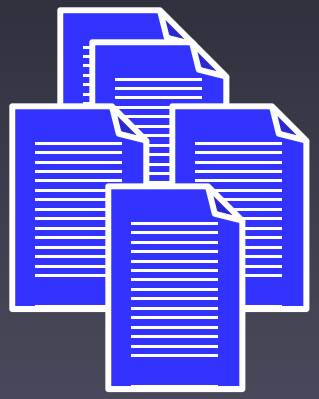
Data



Raw Data



Documents



Words

aardvark
billion area book
anode
answer bay boron
arrow
apply about
absent
are anonymous
base bible broth
Aarhus

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

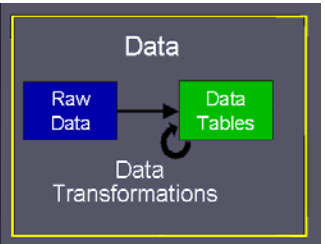
Meta-data

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	…
…	…	…	…	…

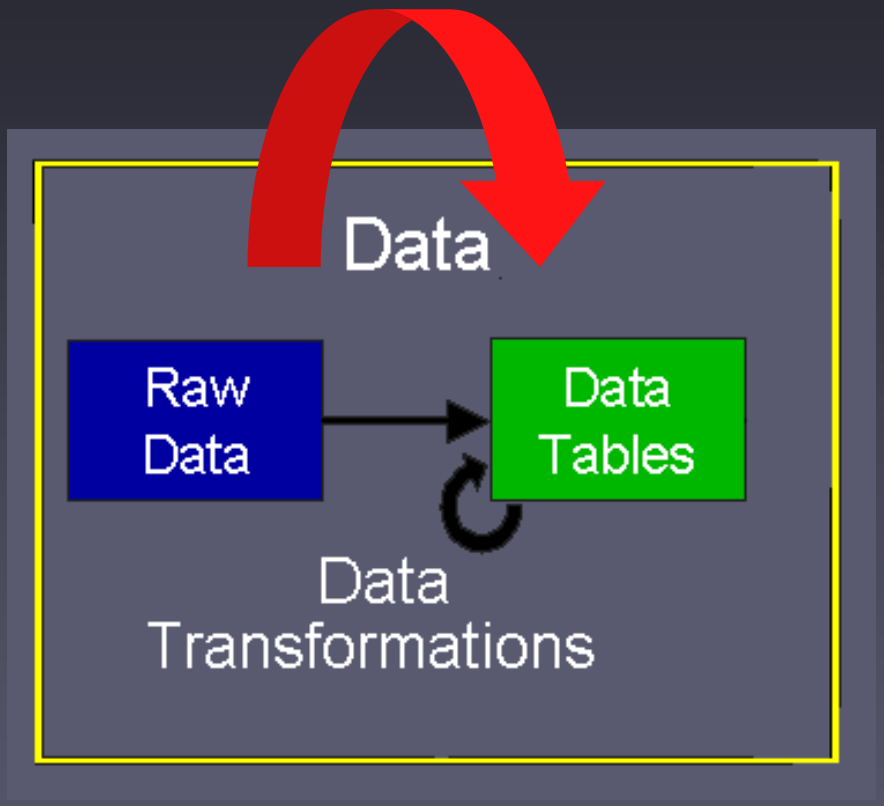
VS

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

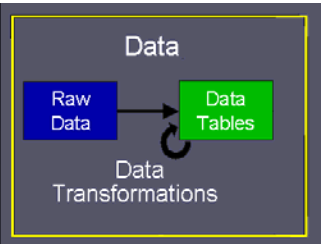
Courtesy of Jock Mackinlay

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

Hans
46
ID-22222

Anna
17
ID-11111

Peter
15
ID-33333

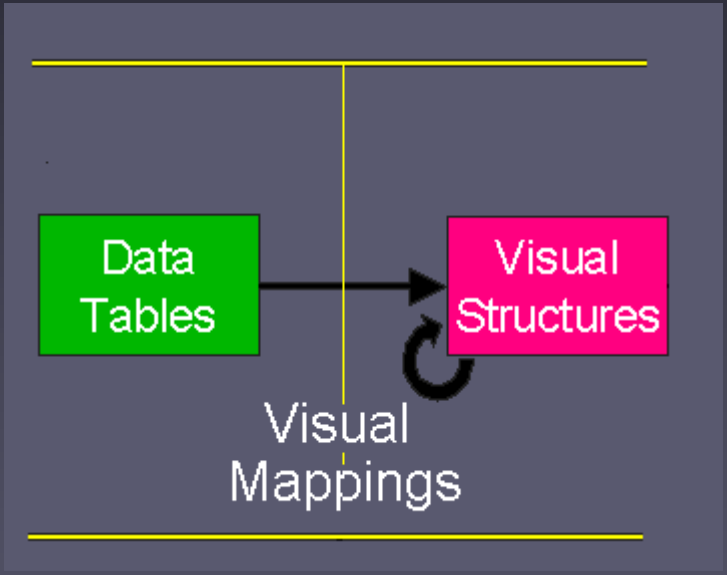
Name	N	Anna	Hans	Peter
Age	Q	17	46	15
ID	O	11111	22222	33333

Data Transformations

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

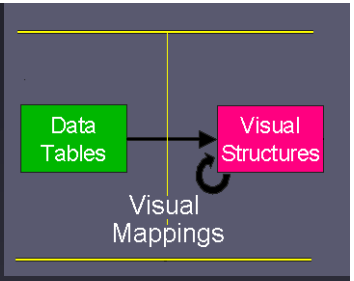
	Derived value	Derived structure
Value	Mean	Sort Class Promote
Structure	Demote	X,Y,Z→P xzy

Visual Mappings

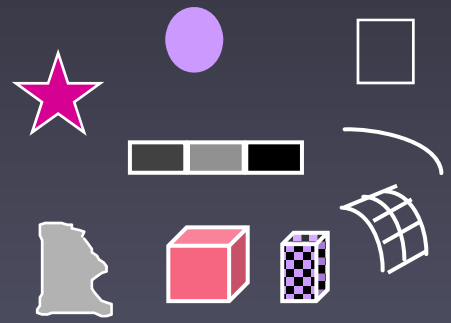


- Expressiveness
- Effectiveness

Visual Mappings

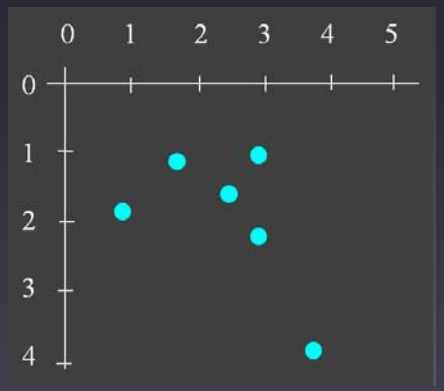


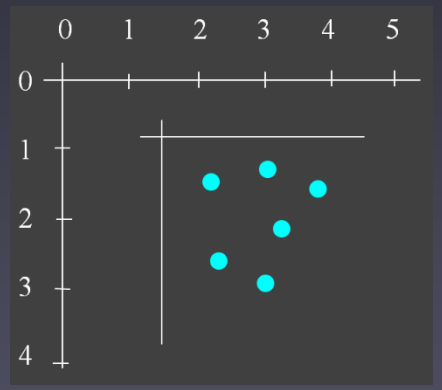
- Spatial Substrate (Type of Axes)
  - Nominal
  - Ordinal
  - Quantitative
- Marks
  - Type: Point, Line, Area, Volume
  - Connection and Enclosure
- Axes Location
  - Composition
  - Overloading
  - Folding
  - Recursion

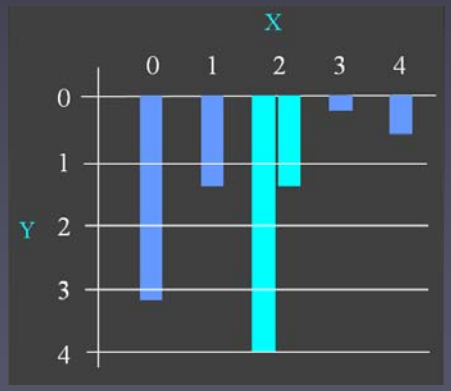


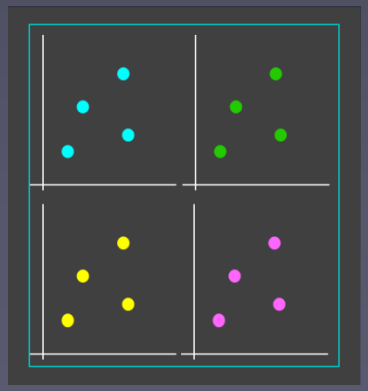
Axes Location

- Composition
- Overloading
- Folding
- Recursion

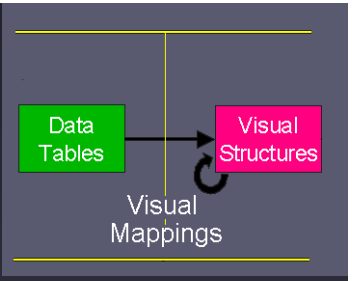






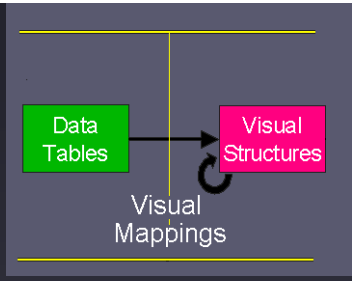


Visual Structures

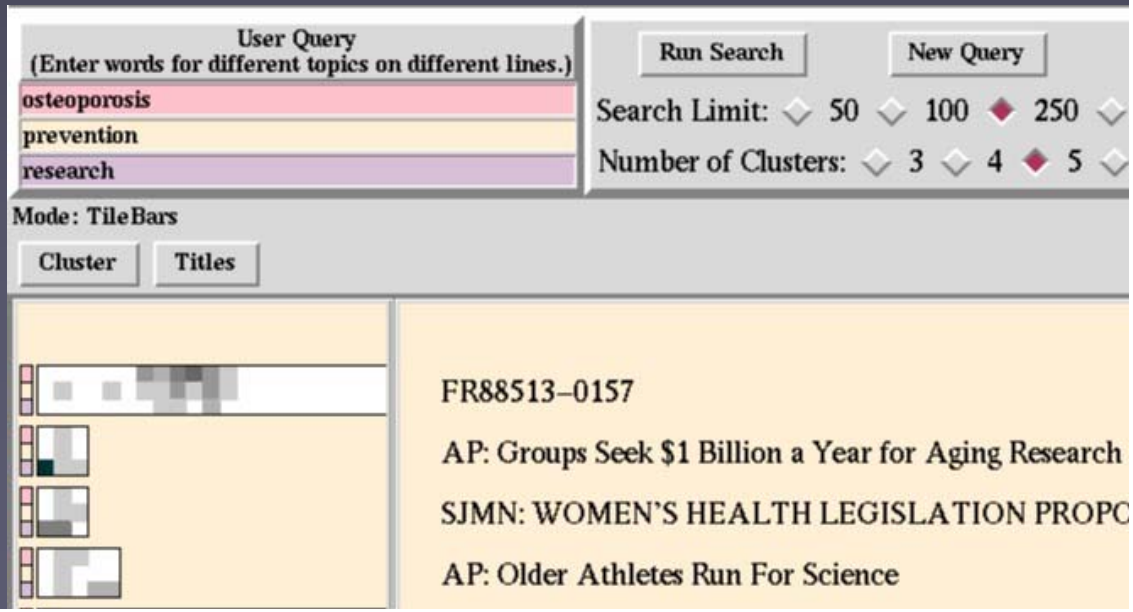


- Classification by use of space:
  - 1D, 2D, 3D
    - Refers to visualizations that encode information by positioning marks on orthogonal axes
  - Multivariable >3D
    - Data Tables have so many variables that orthogonal Visual Structures are not sufficient
    - Multiple Axes, Complex Axes
  - Trees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

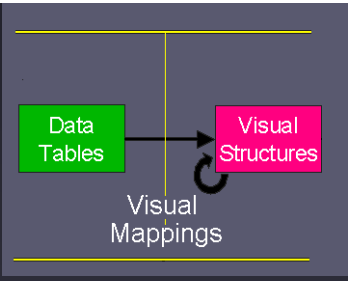
1D Visual Structures



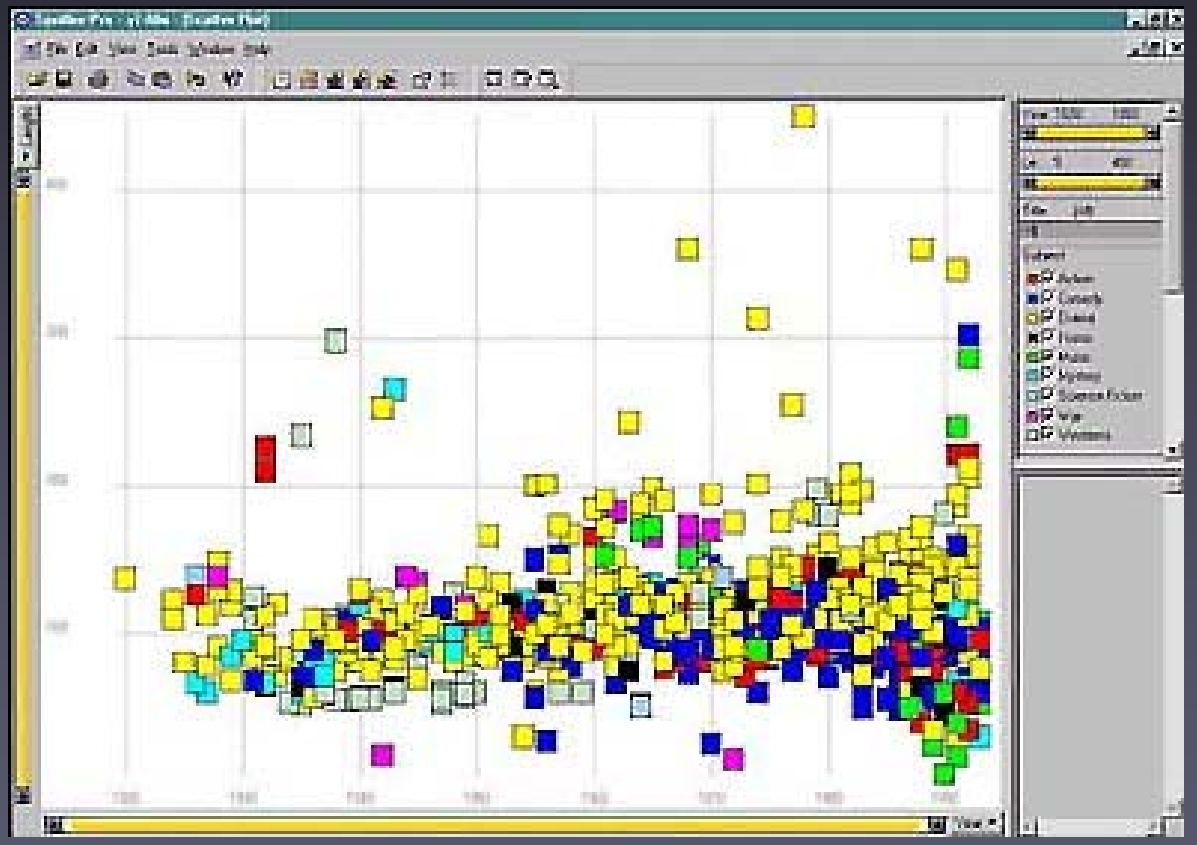
- Typically used for documents and timelines, particularly as part of a larger Visual Structure
- Often embedded in the use of more axes, second or third axis, to accommodate large axes
- Example:
  - TileBars



2D Visual Structures

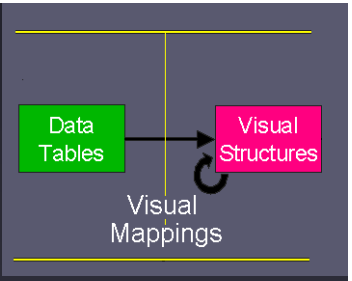


- Chart, geographic data
- Document collections
- Example:
  - Spotfire: 2D scattered graph

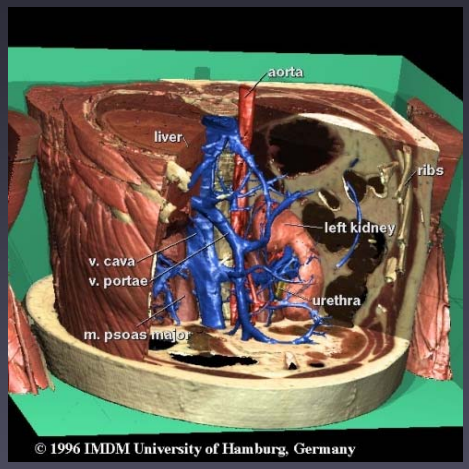


[Ahlberg, 1995]

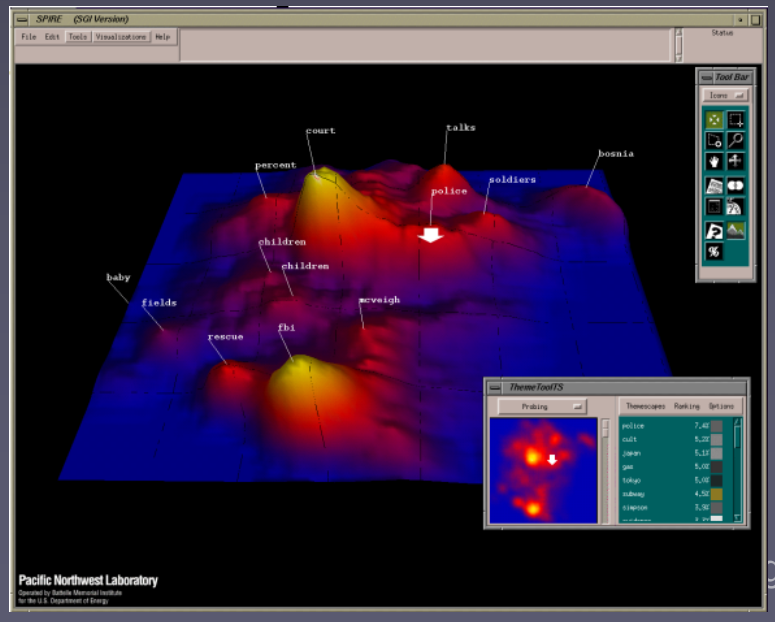
3D Visual Structures



- Usually represent real world objects

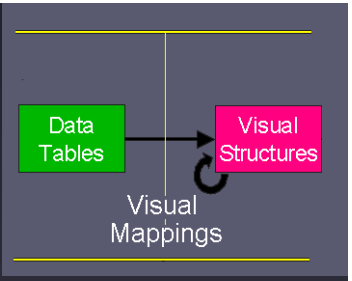


- 3D Physical Data
  - E.g., VoxelMan



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

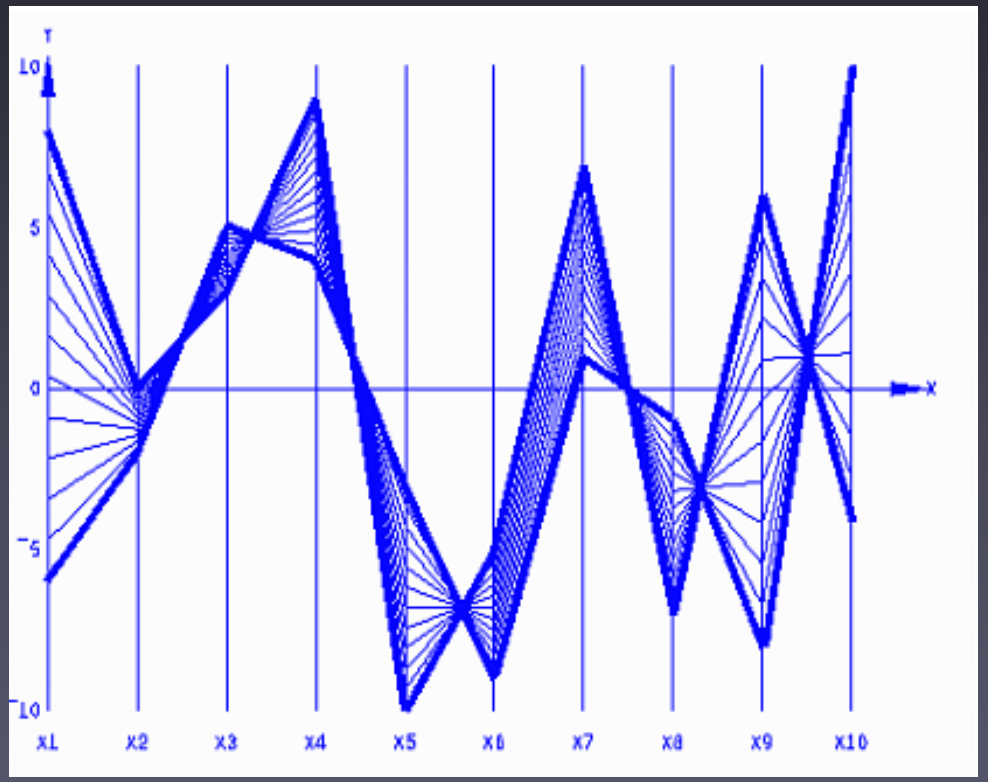
Multivariable >3D



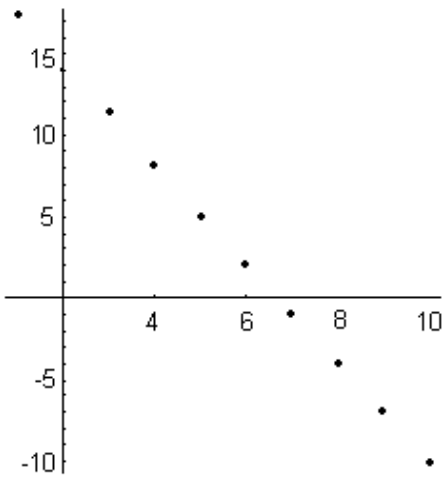
- Data Tables have so many variables that orthogonal Visual Structures are not sufficient.
- Example:
  - Parallel Coordinates

Parallel Coordinates

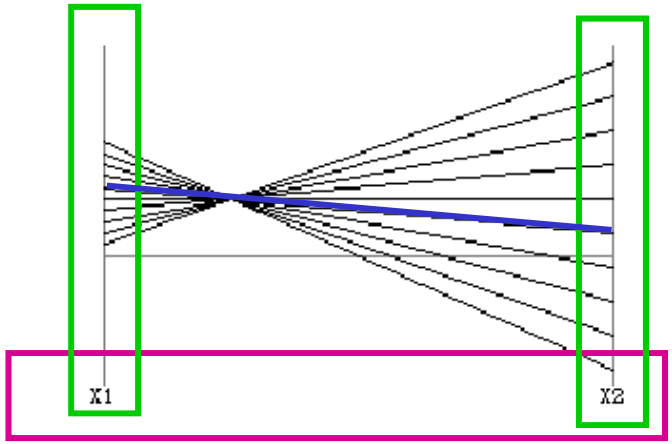
- Parallel 2D axes.
- Add/Remove data
  - Establish Patterns
  - Examine interactions.
- Useful for recognizing patterns between the axes
- Skilled user



Parallel Coordinates [Inselberg]



Dataset in a Cartesian graph



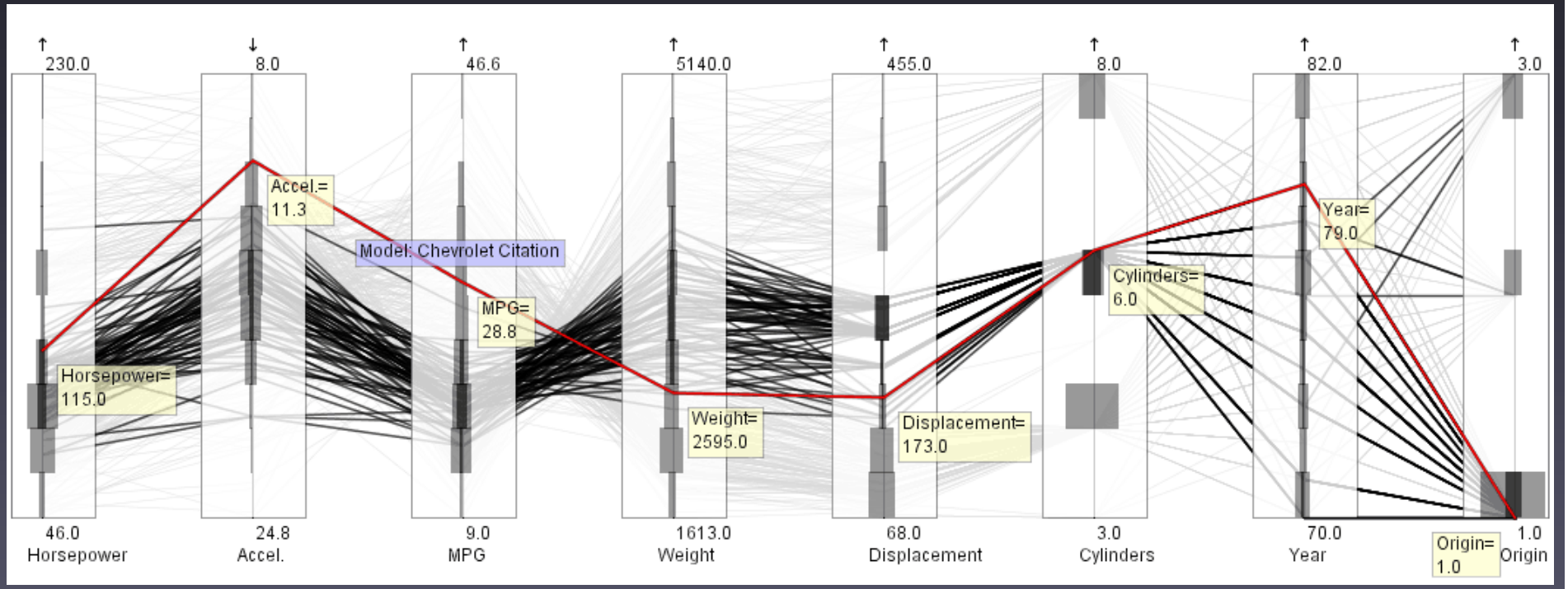
Same dataset in parallel coordinates

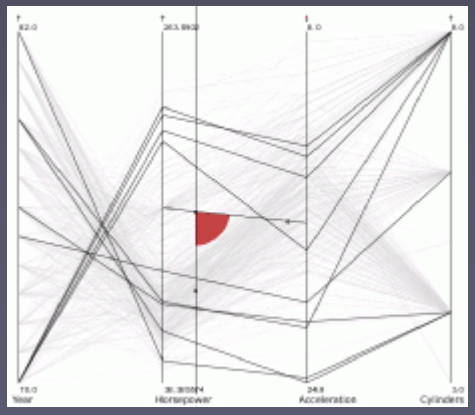
Encode variables along a horizontal row

Vertical line specifies single variable

Blue line specifies a case

Extended Parallel Coordinates

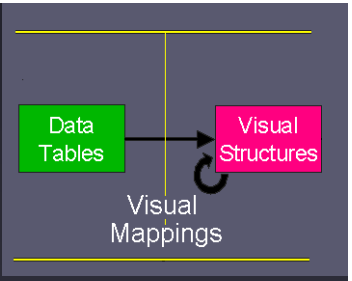




- Greyscale, color
- Histogram information on axes
- Smooth brushing
- Angular brushing

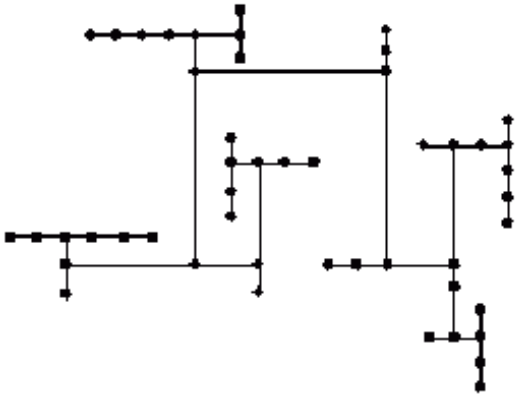
vrvis

Trees

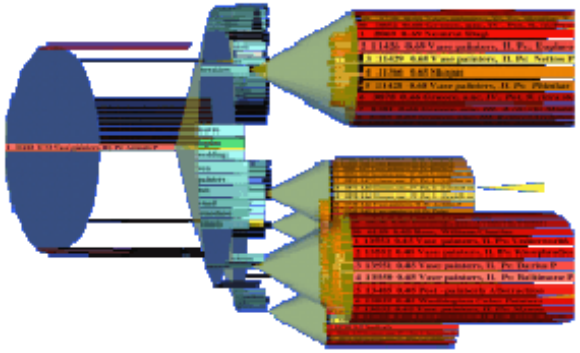


- Visual Structures that refer to use of connection and enclosure to encode relationships among cases
- Desirable Features
  - Planarity (no crossing edges)
  - Clarity in reflecting the relationships among the nodes
  - Clean, non-convoluted design
  - Hierarchical relationships should be drawn directional

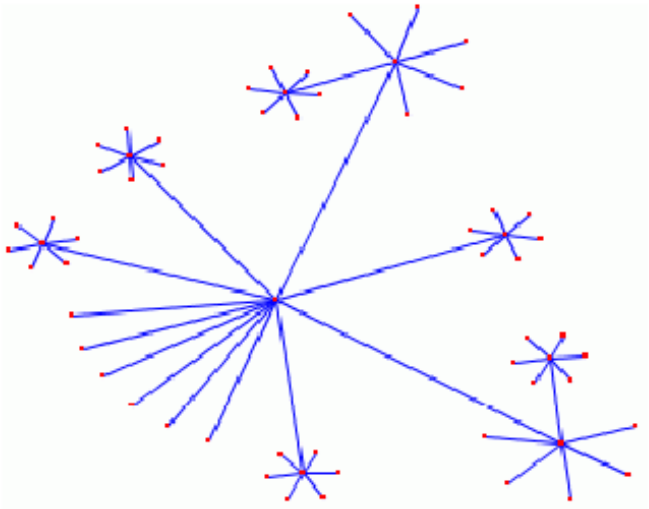
Trees



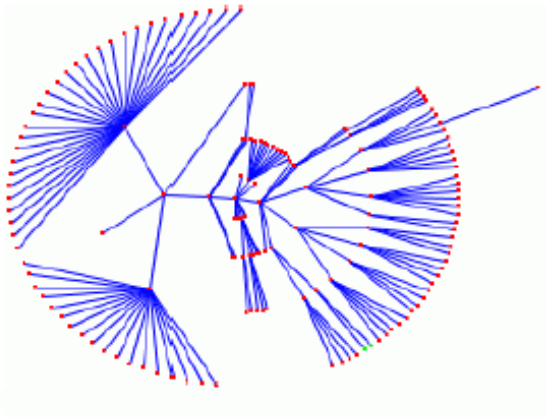
H-Tree Layout



Cone Tree (3D)



Balloon View



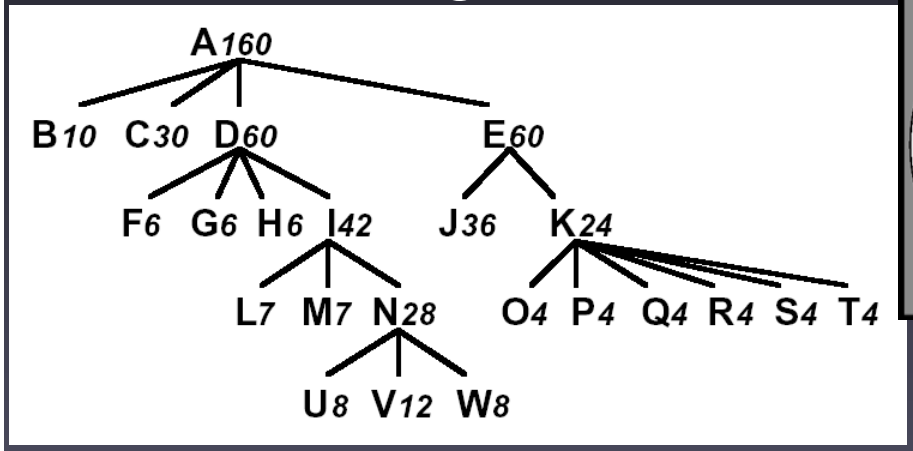
Radial Layout

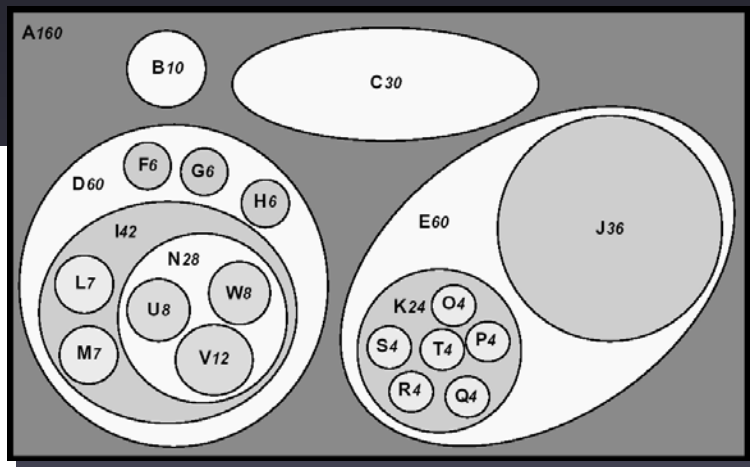
Tree Maps [Johnson, Shneiderman, 1991]

Outline

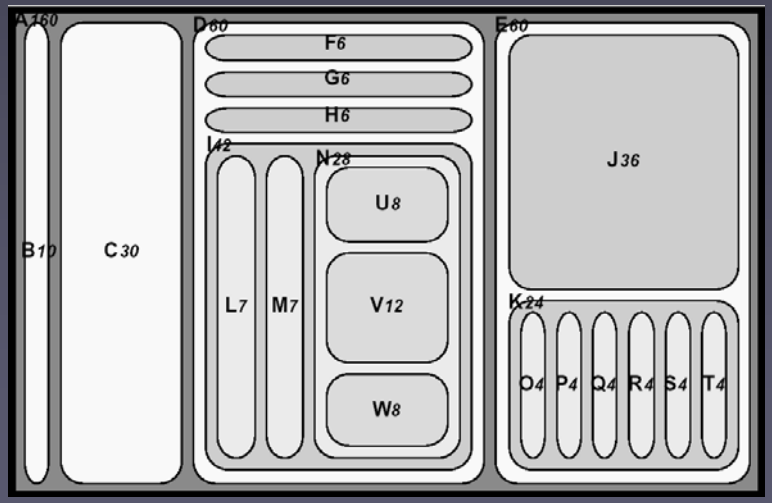
- A160
  - B10
  - C30
  - D60
    - F6
    - G6
    - H6
    - I42
      - L7
      - M7
      - N28
        - U8
        - V12
        - W8
  - E60
    - J36
    - K24
      - O4
      - P4
      - Q4
      - R4
      - S4
      - T4

Tree diagram

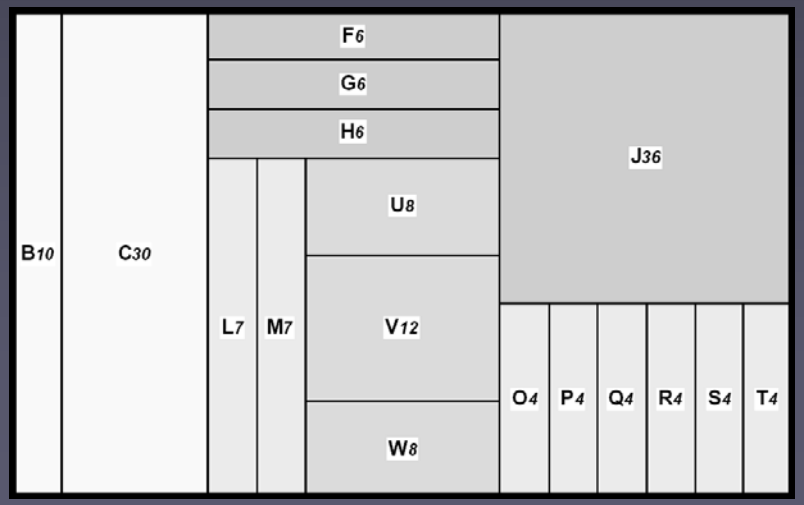




Venn diagram



Nested treemap

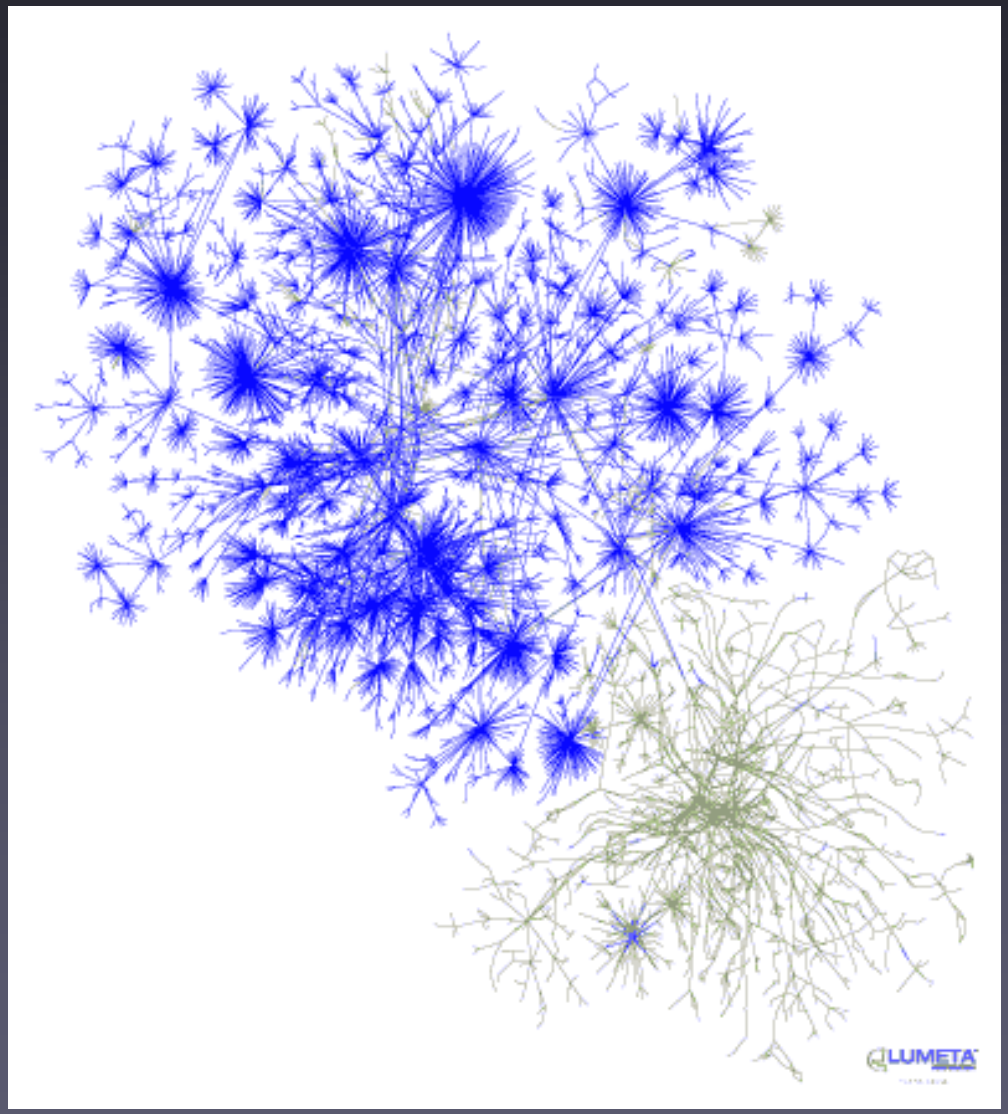


Treemap

Eduard Gröller
Vienna University of Technology

Networks

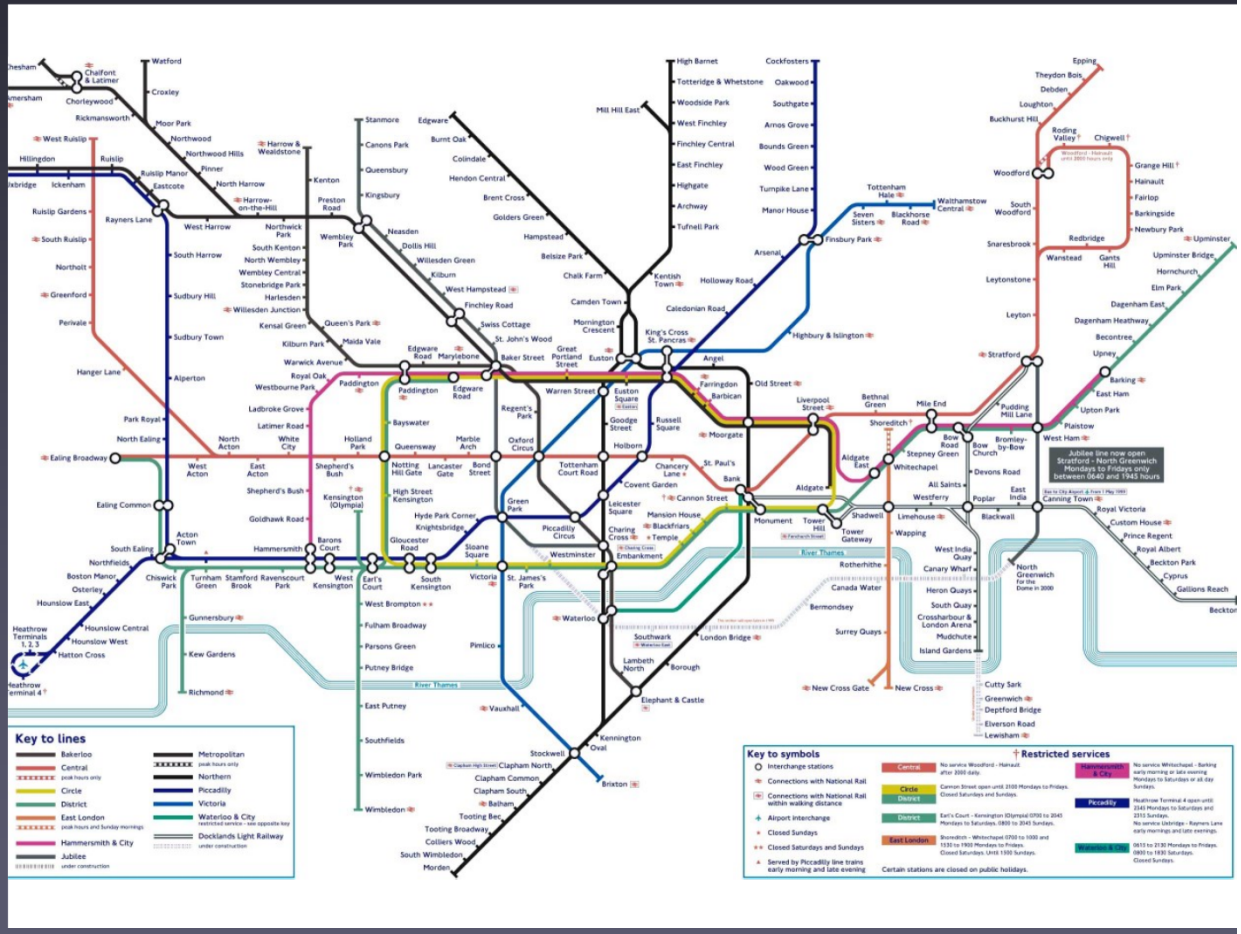
- Used to describe Communication Networks, Telephone Systems, Internet
- Nodes
  - Unstructured
  - Nominal
  - Ordinal
  - Quantity
- Links
  - Directed
  - Undirected



[Branigan et al, 2001]

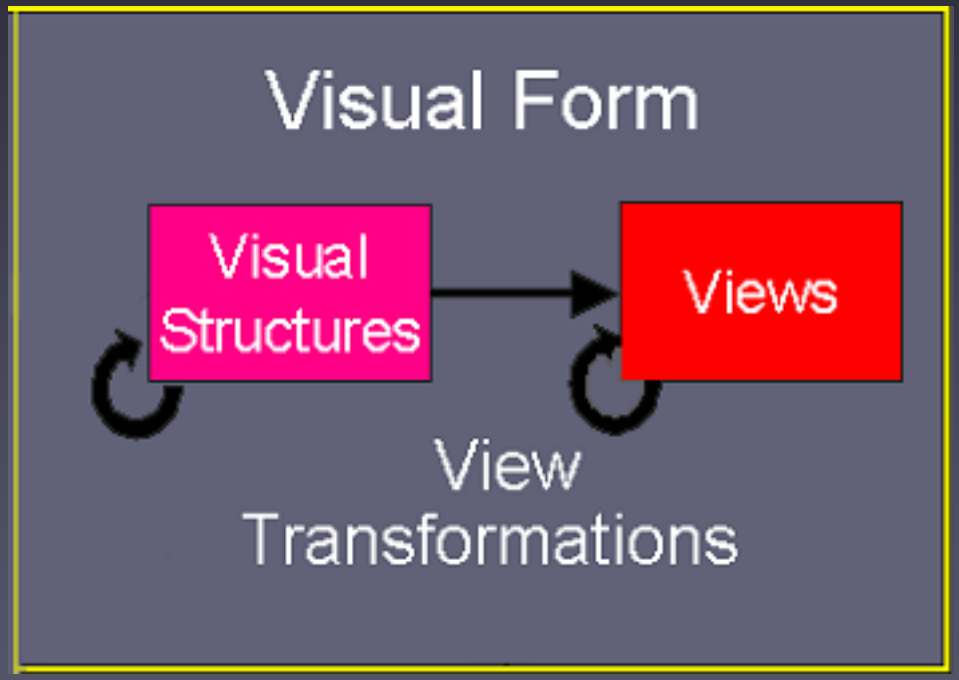
Networks

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



[London Subway]

View Transformations



View Transformations

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

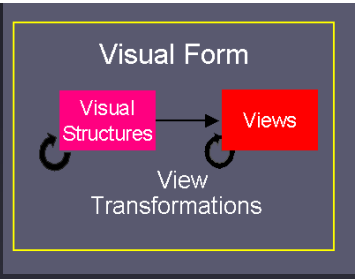
Overview + Detail

Zooming

Focus + Context

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

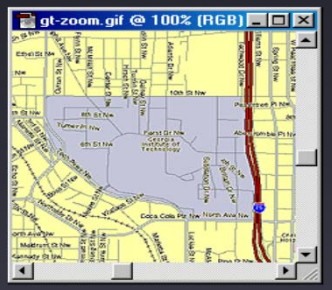
Overview + Detail

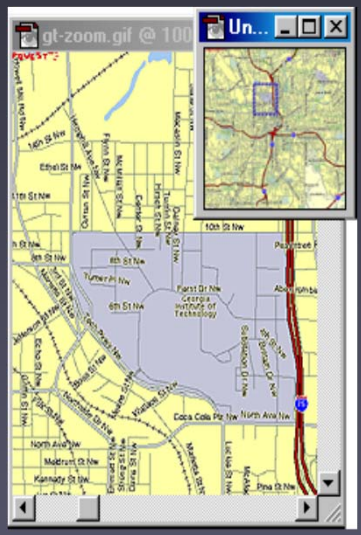


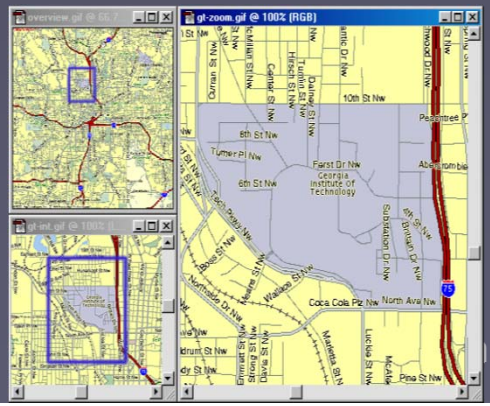
- Provide both overview and detail displays
- Two ways to combine:
  - Time - Alternate between overview and detail sequentially
  - Space - Use different portions of the screen

Overview+Detail - Examples

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

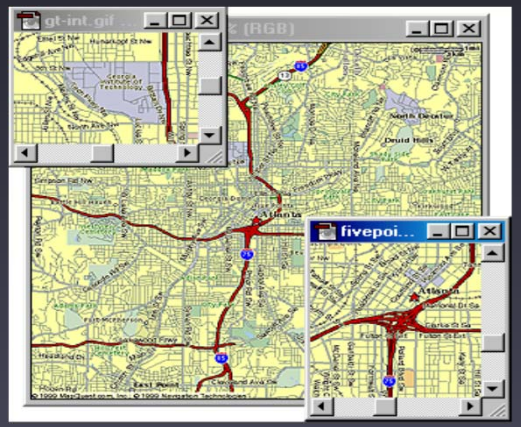




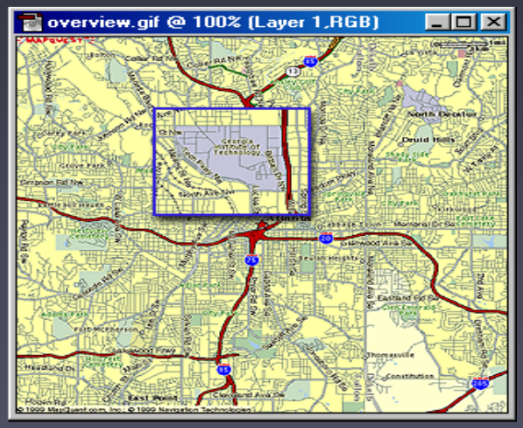


Overview+Detail - Examples

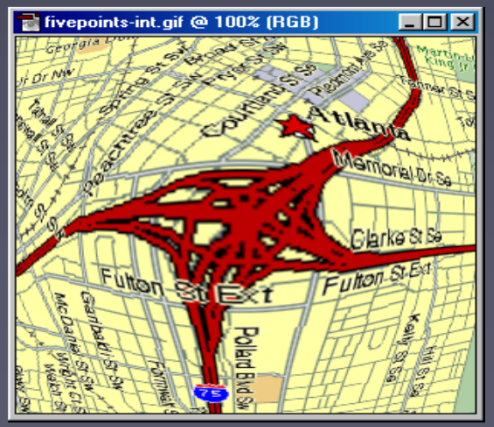
- Free zoom and multiple overlap



- Bifocal magnified

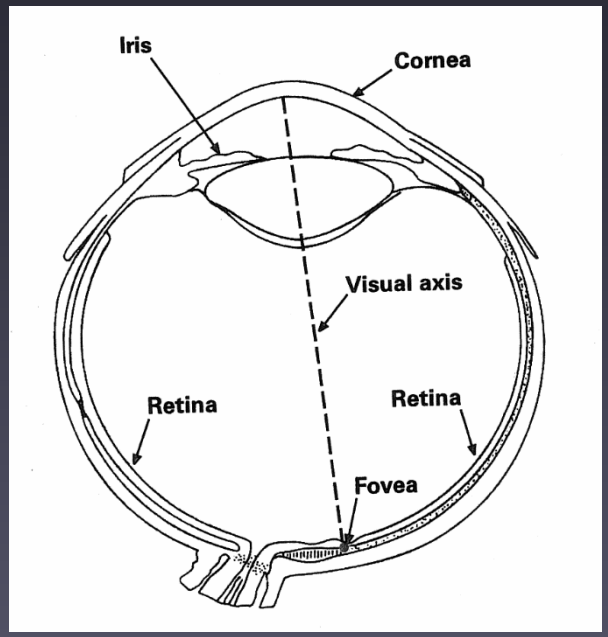


- Fish-eye view (Focus+Context)



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

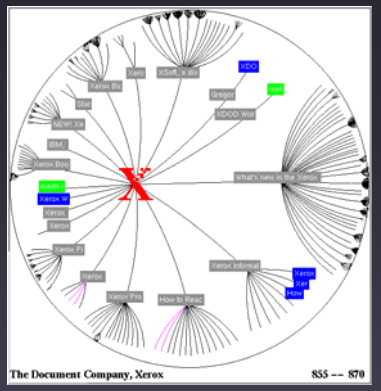
Courtesy of Jock Mackinlay

Focus + Context

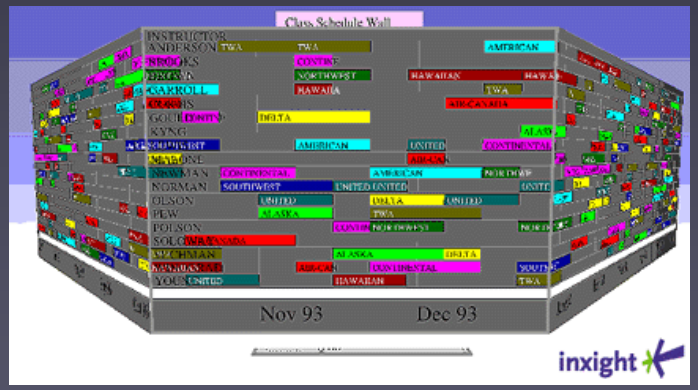
- Filtering
  - Selection of cases
  - Manually or dynamically
- Selective aggregation
  - New cases
- Distortion
  - Relative changes in the number of pixels devoted to objects in the space
  - Types of distortion:
    - Size of the objects representing cases
    - Size due to perspective
    - Size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

Focus + Context - Examples

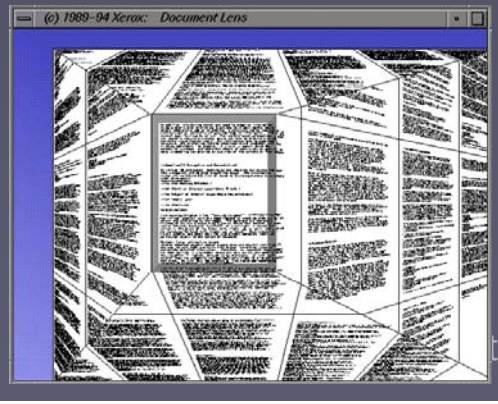
- Hyperbolic tree



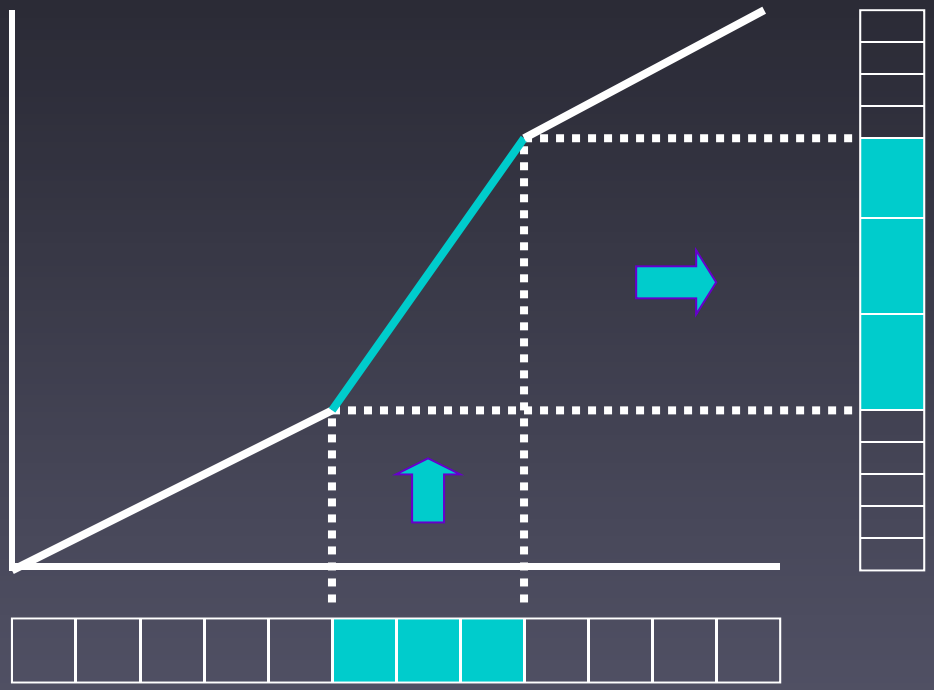
- Perspective Wall



- Document Lens

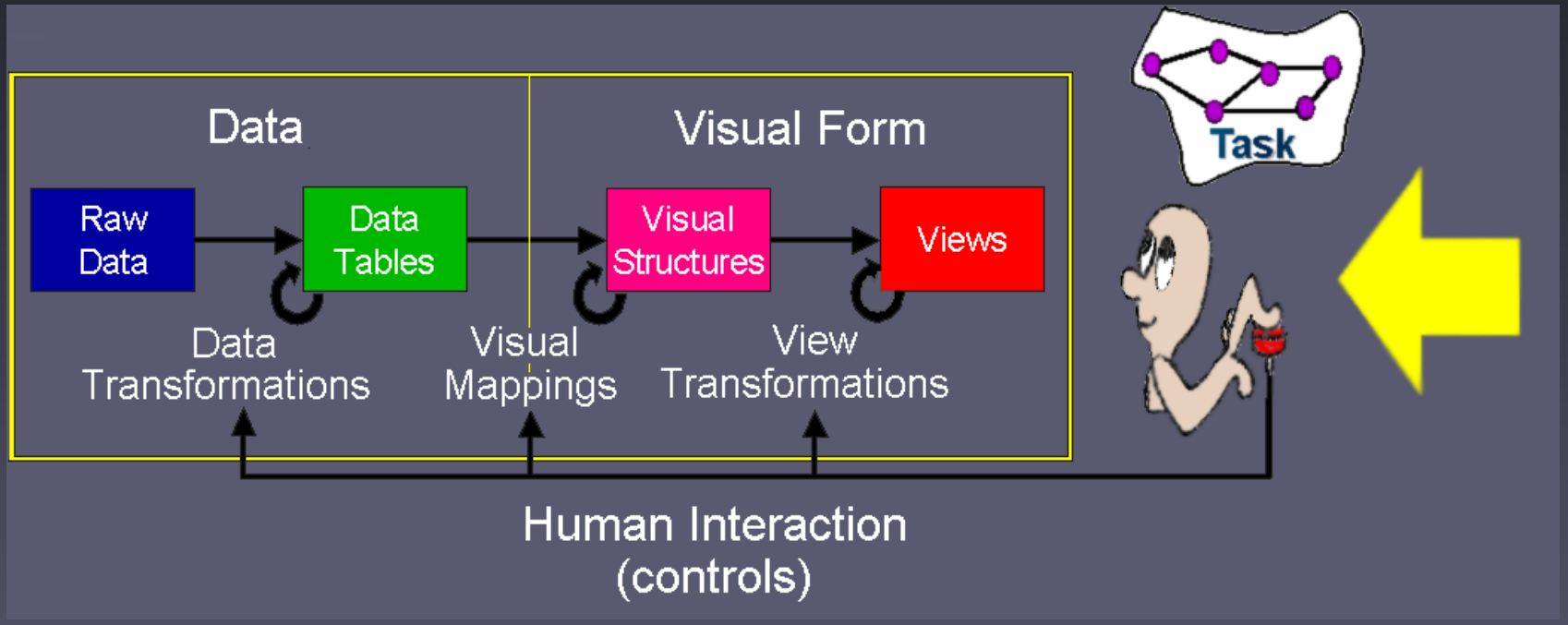


Visual Transfer Function



- 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

Rooms: 5

Conference Room: Yes

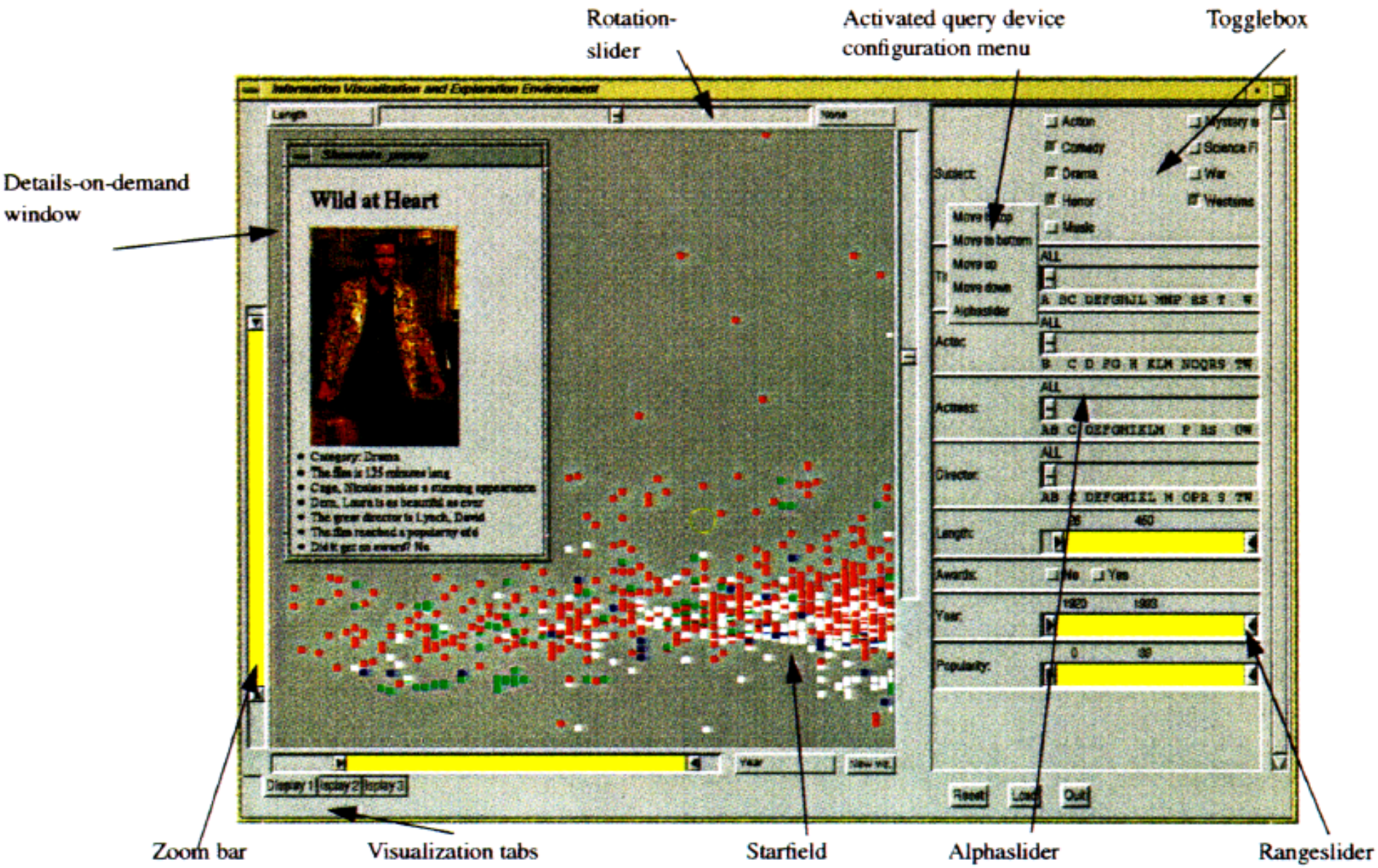
Availability: Under Construction

Location: Favoriten Strasse 9

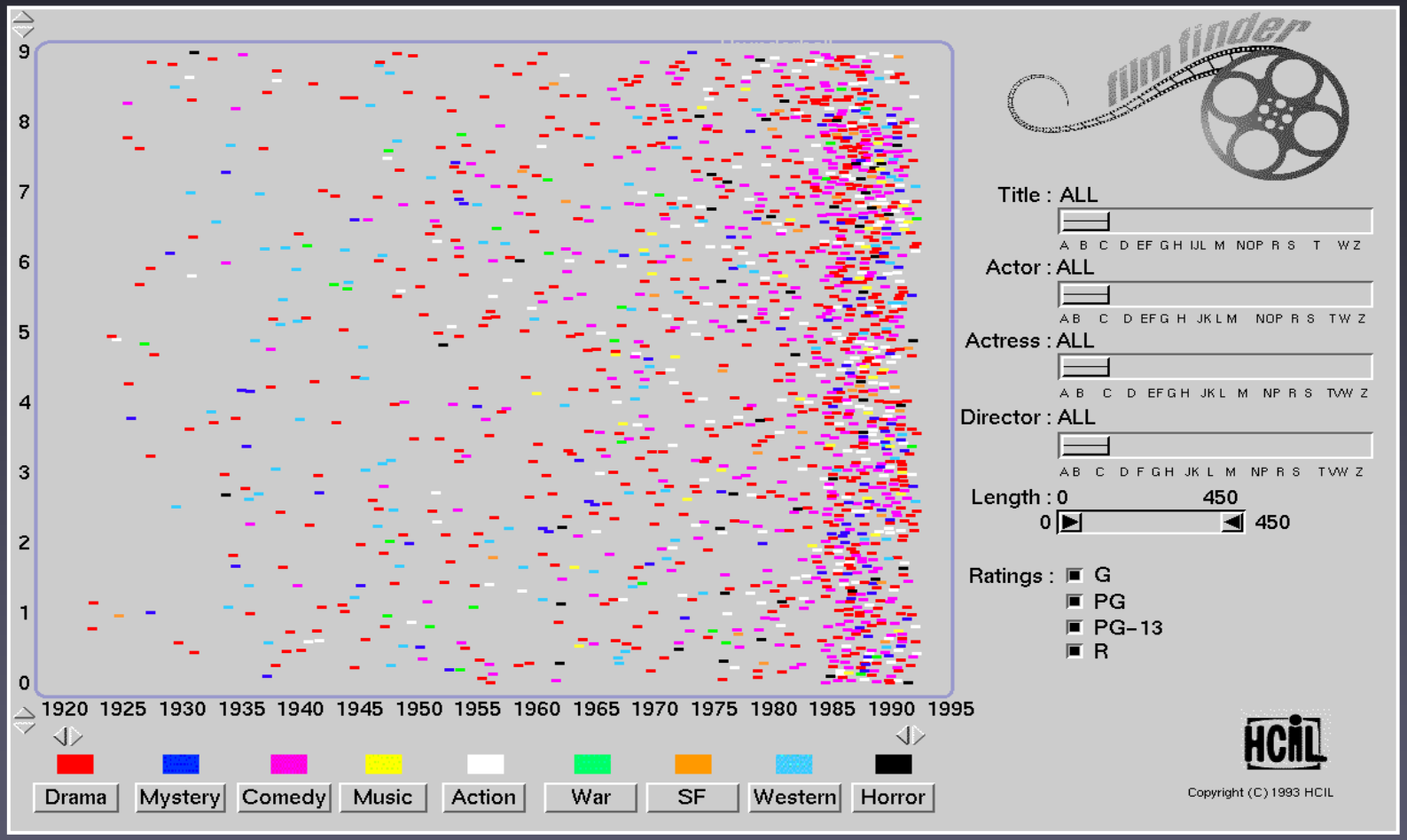
Rooms: 20

Conference Room: Yes

Availability: Occupied


Rotation-slider
Activated query device configuration menu
Togglebox
Details-on-demand window
Information Visualization and Exploration Environment
Wild at Heart
Zoom bar
Visualization tabs
Starfield
Alphaslider
Rangeslider

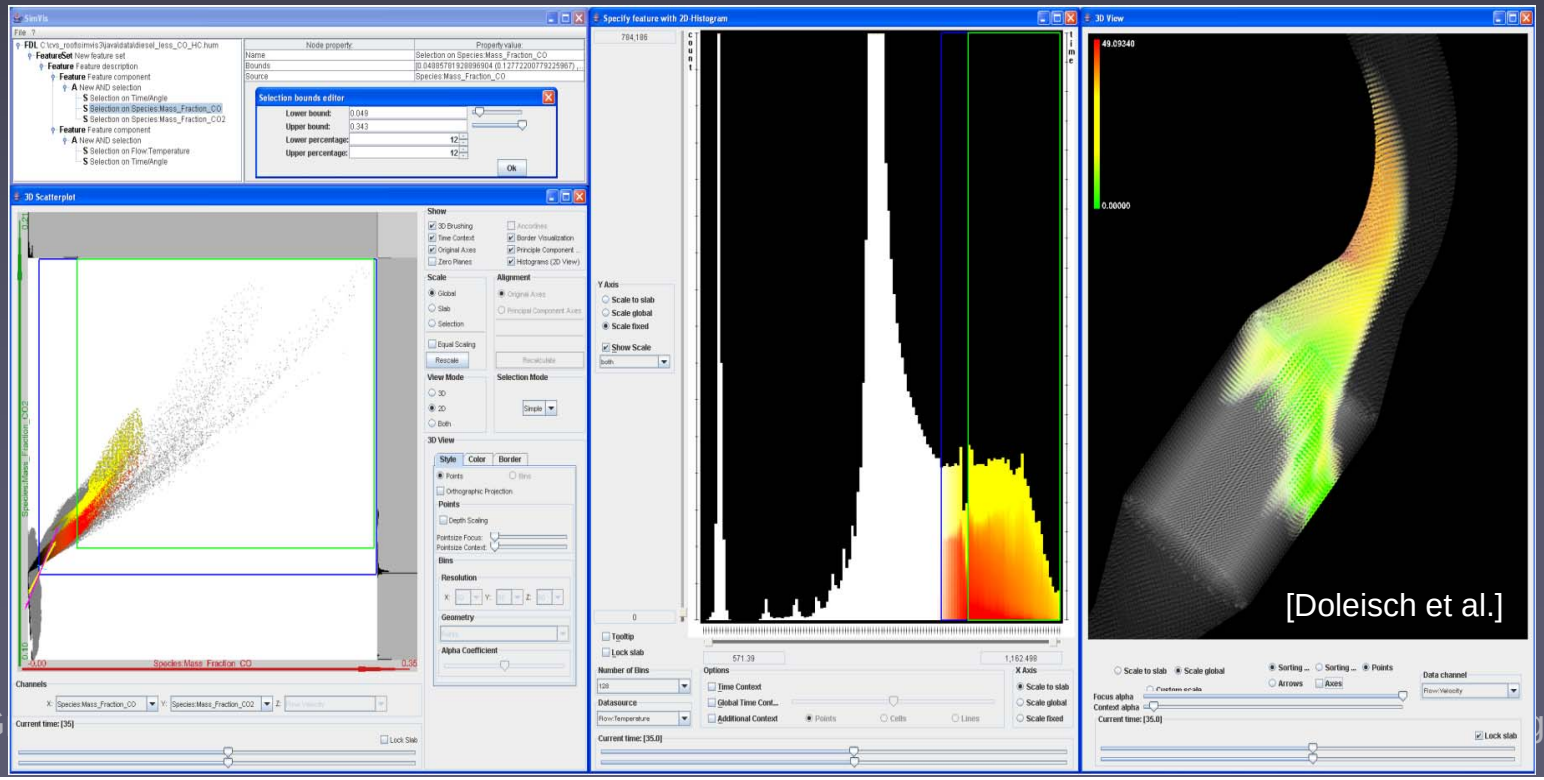
Dynamic Queries



- 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://many-eyes.com/
- Visual Complexity
  - http://www.visualcomplexity.com/
- Further Links - External Links
  - http://www.cg.tuwien.ac.at/courses/InfoVis/index.html