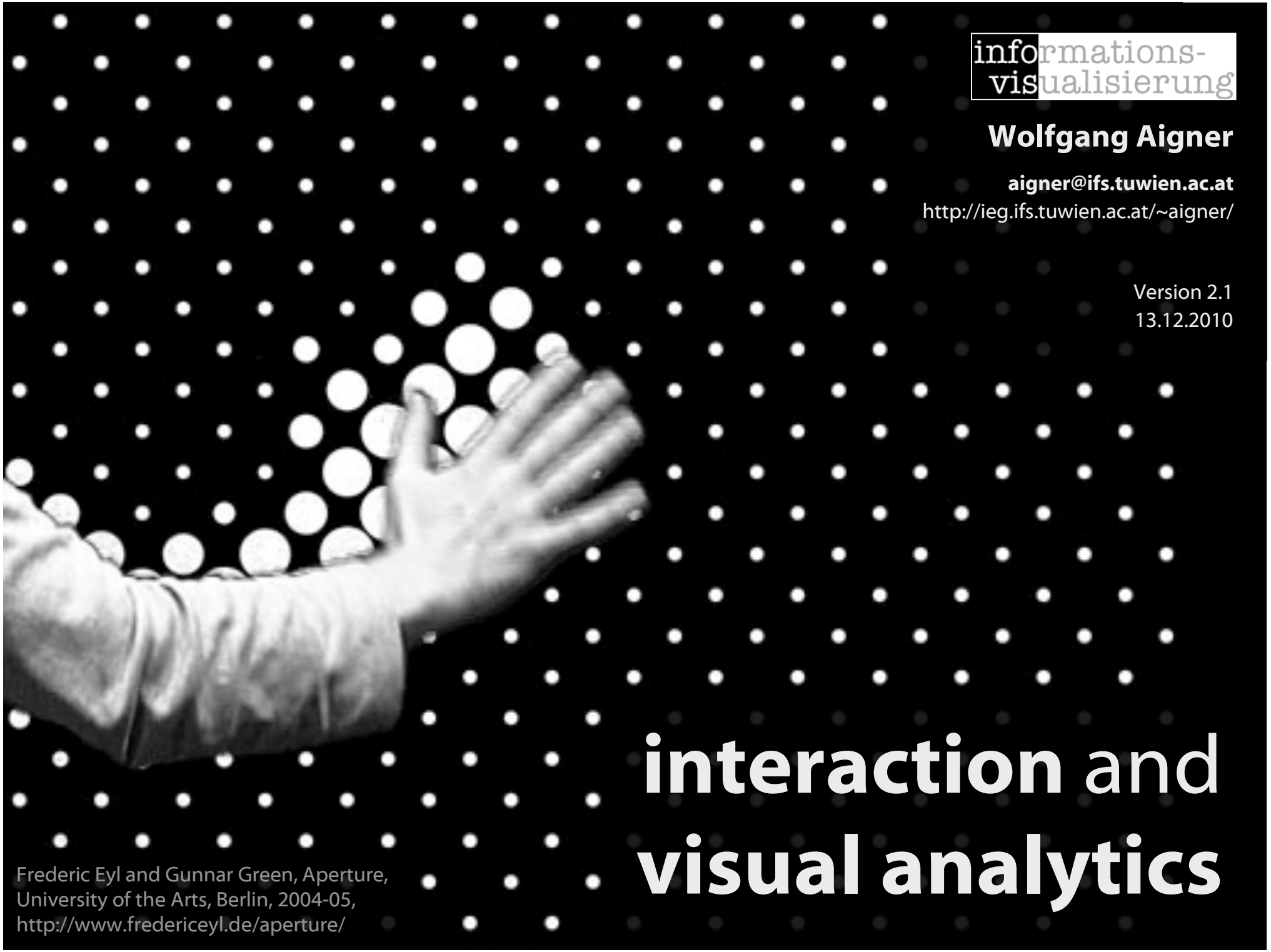

informations-
visualisierung

Wolfgang Aigner

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http://ieg.ifs.tuwien.ac.at/~aigner/

Version 2.1
13.12.2010

interaction and **visual analytics**

Frederic Eyl and Gunnar Green, Aperture,
University of the Arts, Berlin, 2004-05,
http://www.fredericeyl.de/aperture/

Part A
interaction

Motivating Example

Searching for an apartment

1. Newspaper
2. Web Forms - http://www.jobwohnen.at
3. Interactive Applications

   Hotpads - http://hotpads.com

   Attribute Explorer - *DEMO*

InfoVis & Interaction

Two main components:

- Visual representation
- Interaction

Main focus of current research: finding novel visual representations

BUT: Increasing interest in interaction

- Related fields: Human-Computer Interaction (HCI), Interaction Design

InfoVis Reference Model

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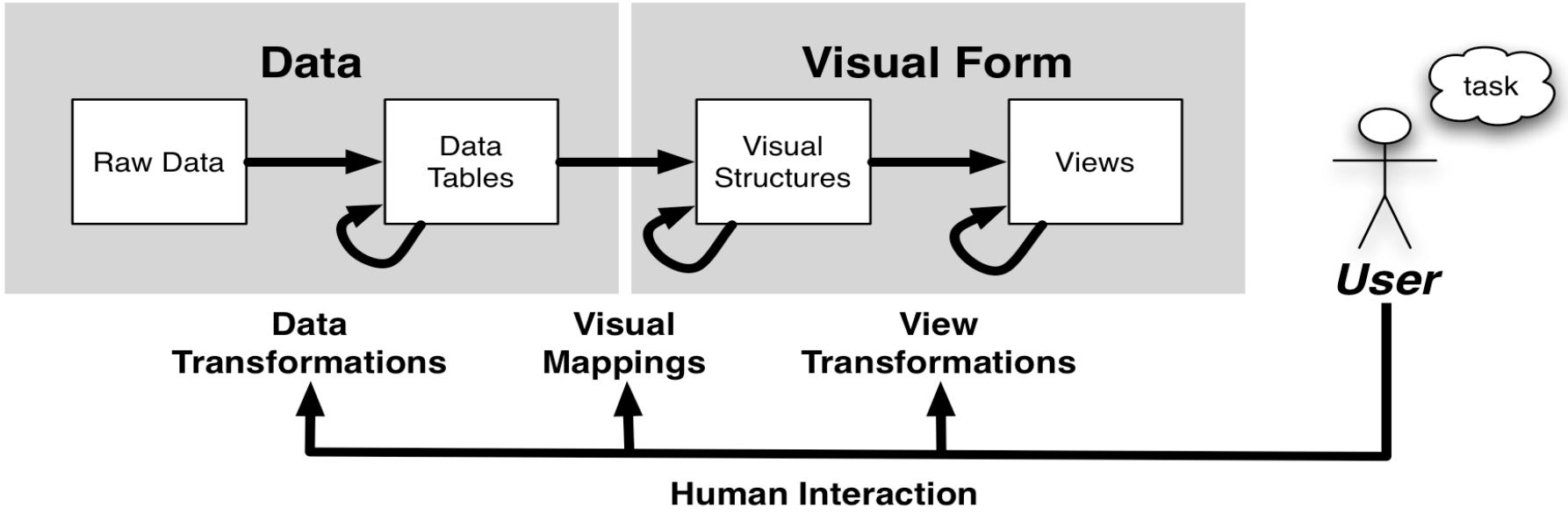
[Card et al., 1999]



Raw Data: idiosyncratic formats
Data Transformations: Mapping raw data into an organization appropriate for visualization
Data Tables: relations (cases by variables) + metadata
Visual Mappings: Encoding abstract data into a visual representation
Visual Structures: spatial substrates + marks + graphical properties
View Transformations: Changing the view or perspective onto the visual presentation
Views: graphical parameters (position, scaling, clipping, ...)
Human Interaction: User influence at any level

User interaction can feed back into any level

Why interaction?

*„Interaction between human and computer is at **the heart of modern information visualization** and for a single overriding reason: the enormous benefit that can accrue from **being able to change one's view** of a corpus of data. Usually that corpus is so large that no single all-inclusive view is likely to lead to insight. Those who wish to acquire insight must **explore, interactively,** subsets of that corpus to find their way towards the view that triggers an 'a ha!' experience.“*

[Spence, 2007]

I hear and I forget.
I see and I remember.
I do and I understand.

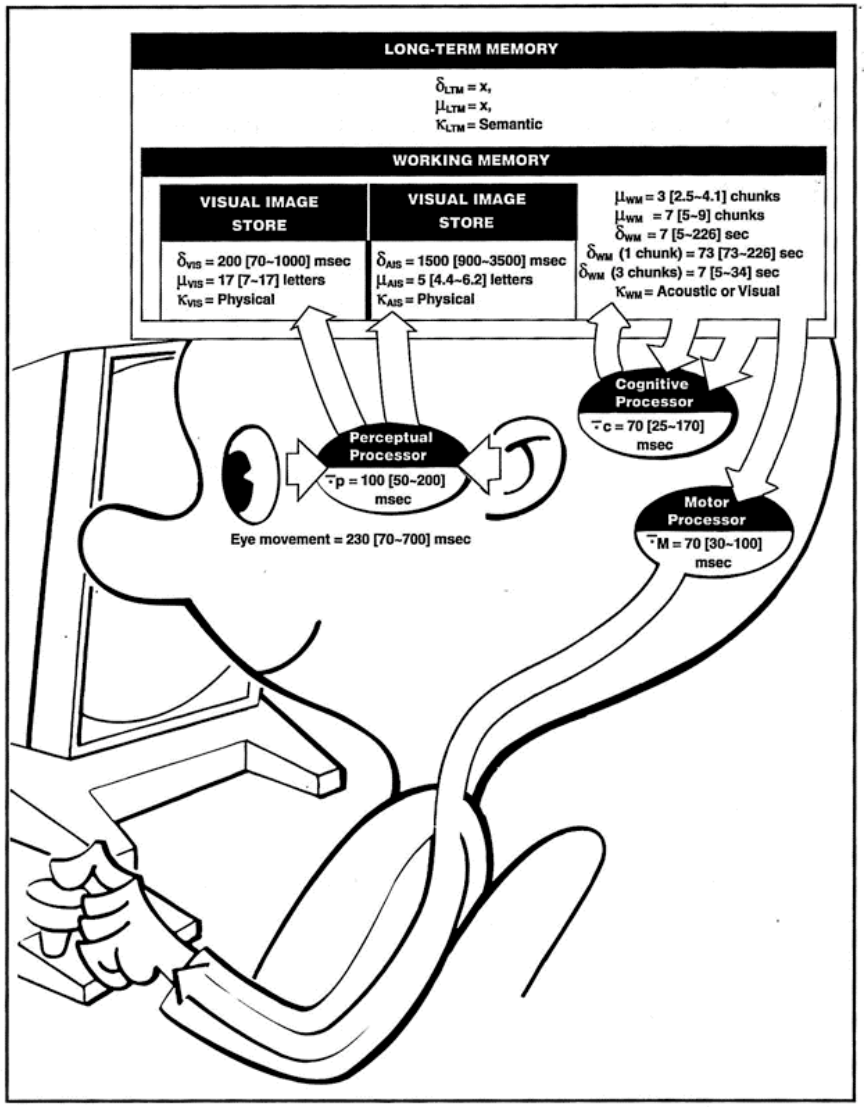
Confucius

Interaction facilitates active discourse with the data

see

think

modify



[Card et al., 1983]

Response Time

.1 sec

Animation, visual continuity, sliders

1 sec

System response, conversation break

10 sec

Cognitive response

[Stasko, 2006, Lecture Slides]

Interaction levels

Conceptual level

What to be done?

e.g. scrolling / navigating

--> Task

Control level

How can it be carried out by the user?

e.g. move scrollbar

--> User interface

Physical level

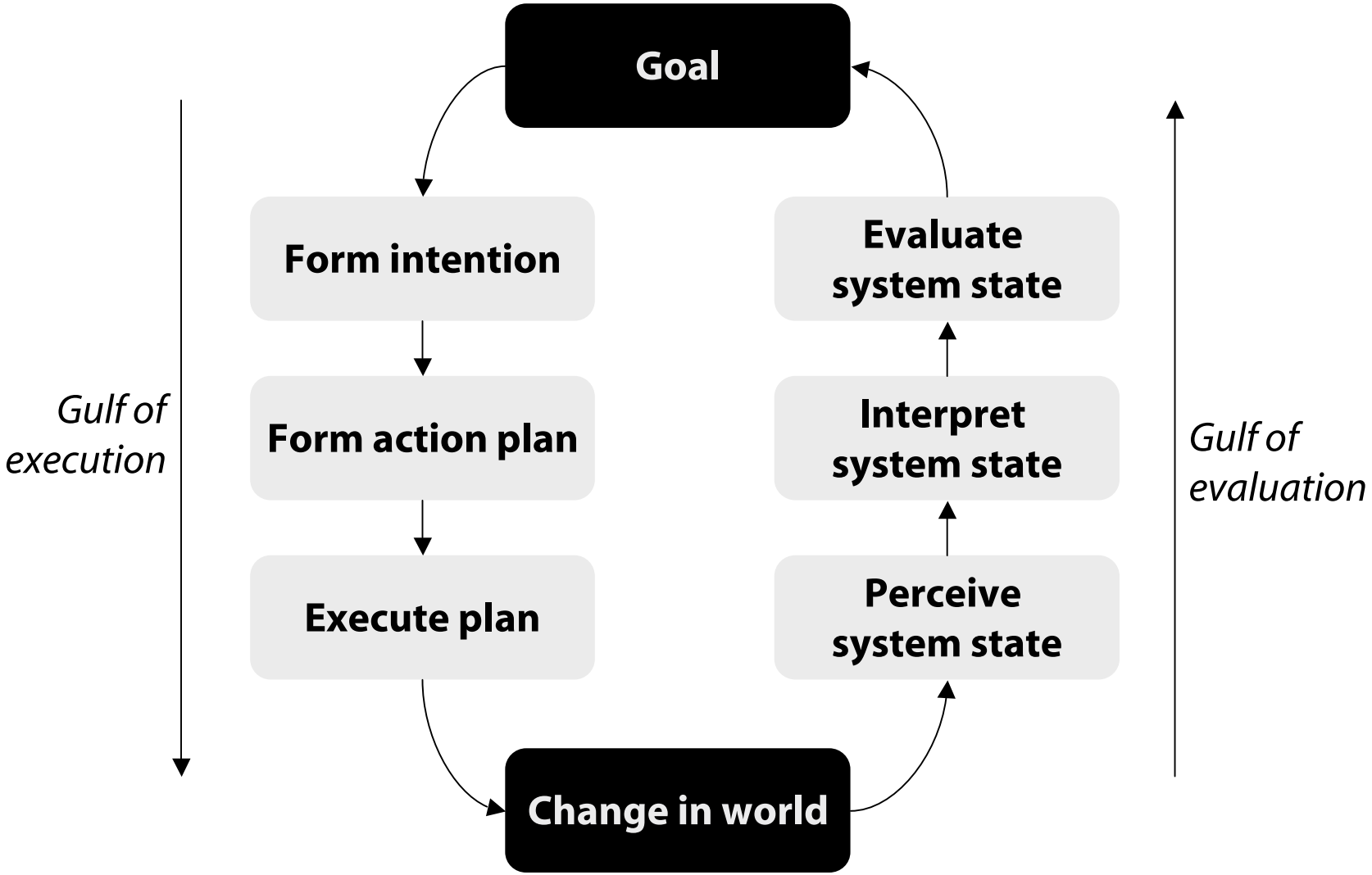
How does the user physically interact?

e.g. mouse wheel, touch screen

--> Interaction devices

Norman‘s execution-evaluation cycle

[Norman, 1988]



Direct manipulation

[Shneiderman, 1983, Shneiderman and Plaisant, 2005]

Visual representation (metaphor) of the "world of action"

Objects and actions are shown

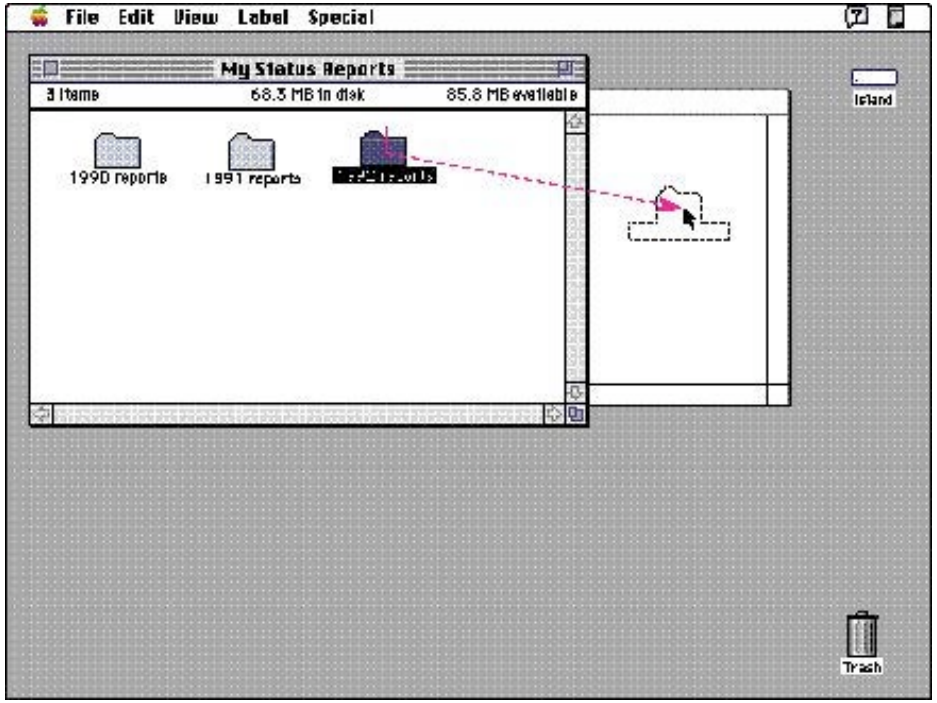
Analogical reasoning is tapped

Rapid, incremental, and reversible actions

Replacement of typing with pointing and selecting

Immediate visibility of results of actions

GOAL:
Allow the user to **directly interact with the object**



[Apple Computer]

Direct manipulation pros/cons

[Shneiderman and Plaisant, 2005]

Benefits over commands

Visibility of the objects of interest

Control/display compatibility

Less syntax reduces error rates

Errors are more preventable

Faster learning and higher retention

Reversibility of all actions

Encourages exploration

Replacement of complex command languages with actions to manipulate directly the visible objects

Immediate visibility of results of actions

Concerns

Increased system resources, possibly

Some actions might be cumbersome; typing commands with the kayboard might be faster

Macro techniques are often weak

History and other tracing may be difficult

Visually impaired users may have more difficulty

Users must learn the graphical representations

Visual Information Seeking Mantra

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[Shneiderman, 1996]

Overview first, zoom and filter, then details-on-demand.

Overview: Gain an overview of the entire collection.

Zoom: Zoom in on items of interest

Filter: Filter out unintetresting items.

Details on demand: Select an item or group and get details when needed.

Relate: View relationships among items.

History: Keep a history of actions to support undo, replay, and progressive refinement.

Extract: Allow extraction of sub-collections and of the query parameters.

Interaction Taxonomy

Indicate: show me where I am pointing at

Select: mark something as interesting

Explore: show me something else

Reconfigure: show me a different arrangement

Encode: show me a different representation

Abstract/Elaborate: show me more or less detail

Filter: show me something conditionally

Connect: show me related items

Activate: trigger action

Modify: manipulate elements

Based on [Soo Yi et al., 2007] and [Raskin, 2000]

Indicate

show me where I am pointing at

Visual Feedback, pop-up tooltips (mouse over)

Hovering mouse cursor brings up details of item

[InfoScope, 2007]

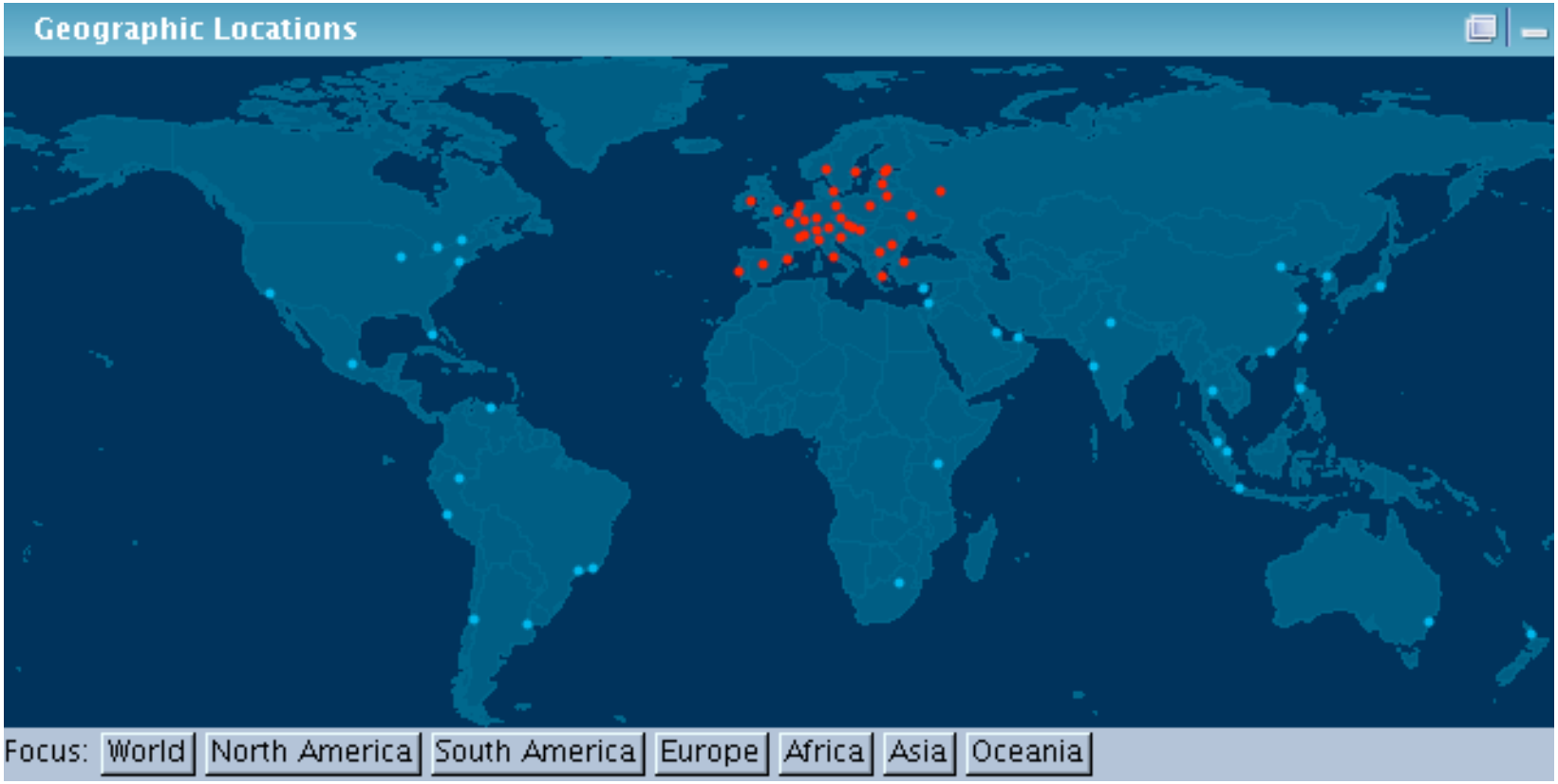
Select

mark something as interesting

Selection / Highlighting

Select or identify one or more elements

e.g. via point + click, region selection (click + drag), etc.



[InfoScope, 2007]

Brushing

[Becker & Cleveland, 1987, Hauser et al., 2002]

More complex than simple selection

Brush is an interactive interface tool to select / mark subsets of data in a single view

- e.g. by sweeping a virtual brush across items of interest

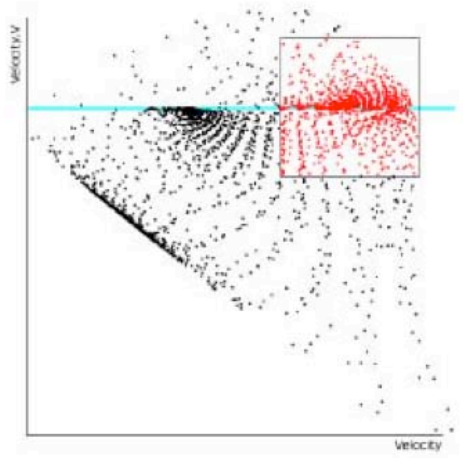
Usually used to visually filter data (via highlighting)

Additional manipulation / operations may be performed on the subsets

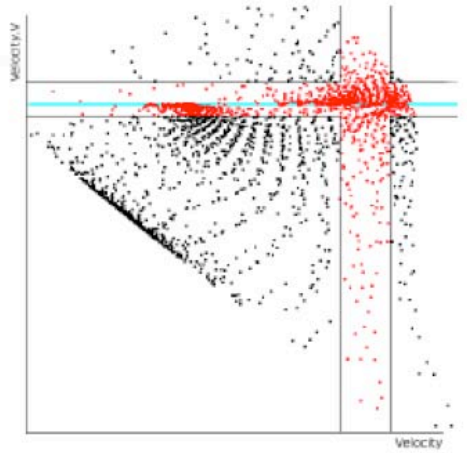
- e.g. masking, magnification, labeling etc.

Different types of brushes [Hauser et al. 2002]

- e.g. simple brush, composite brush, angular brushing, smooth brushing



AND-brush



OR-brush

[Hauser et al., 2002]

Explore

show me something else

Zooming + Panning, Overview + D...

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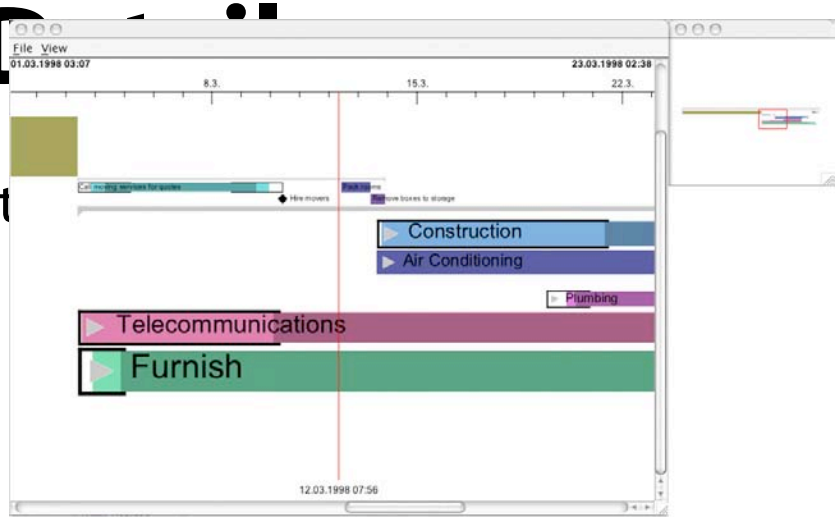
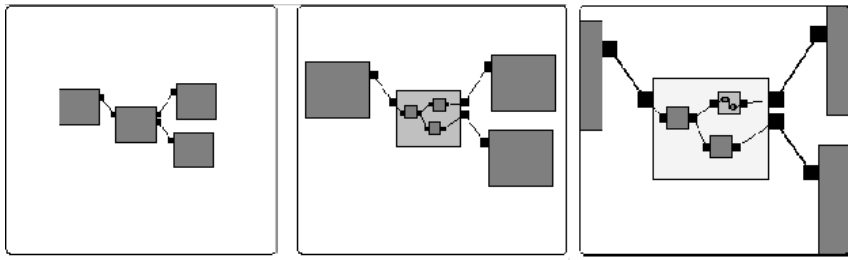
Size + position of viewport



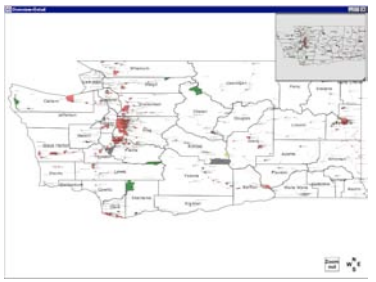
Geometric zoom

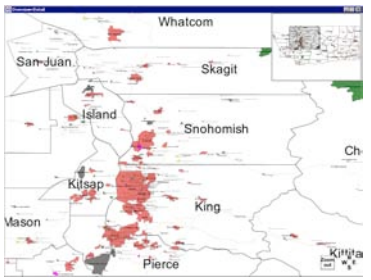
e.g. Photoshop

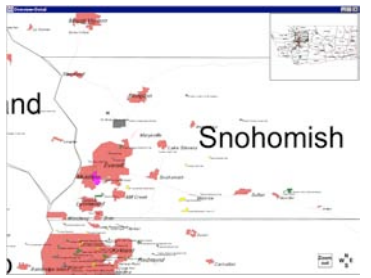


Semantic zoom

e.g. Google Maps

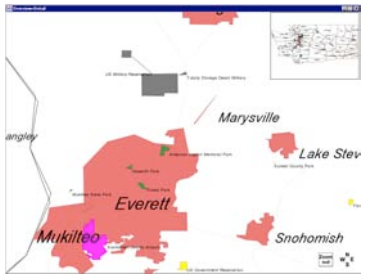






Focus+Context

e.g. Fisheye zoom



Navigation & Browsing

in space

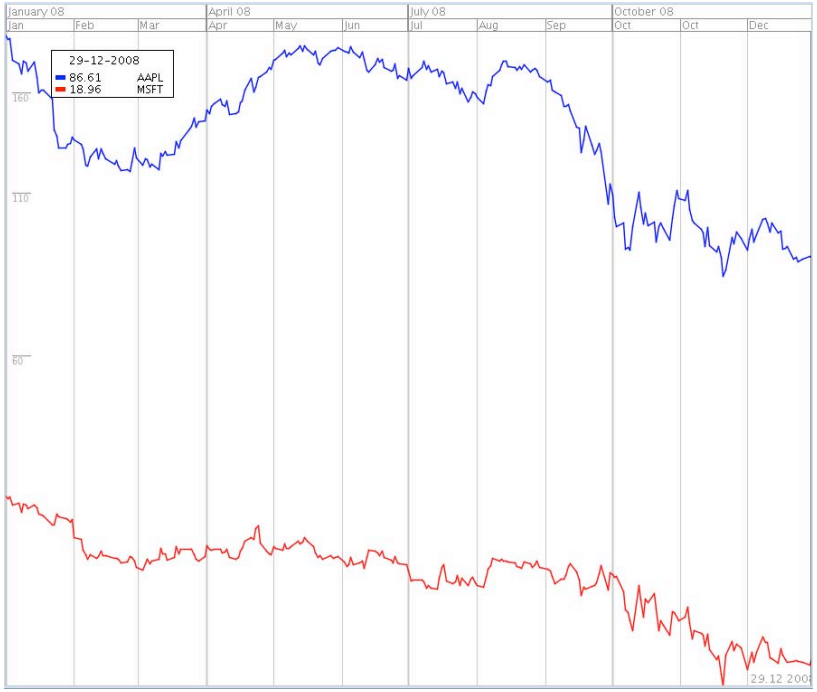
in **time**

[InfoScope, 2007]

Reconfigure

show me a different arrangement

Reconfigure



e.g., move view position, sorting items in a table, switch scale on axes

[InfoScope, 2007]

Encode

show me a different representation

Encode

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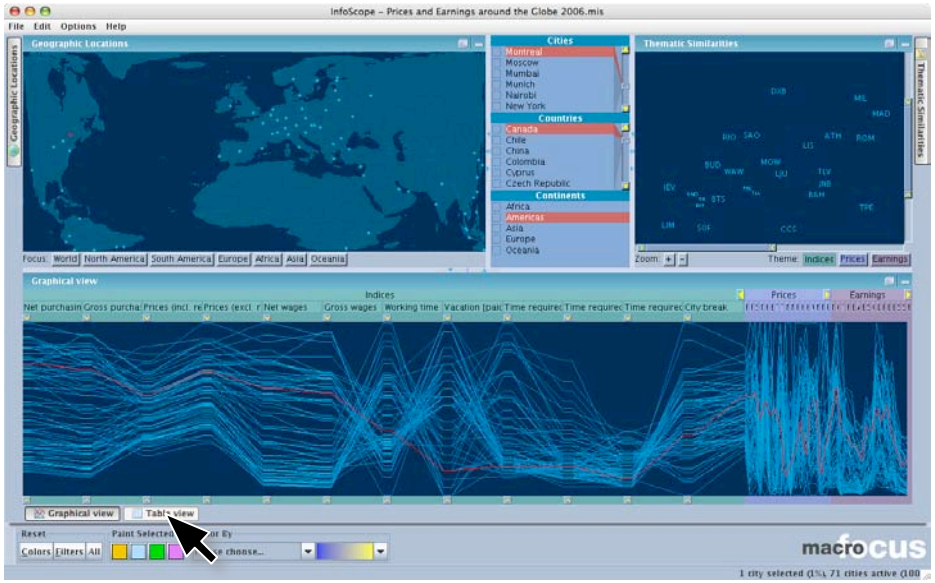
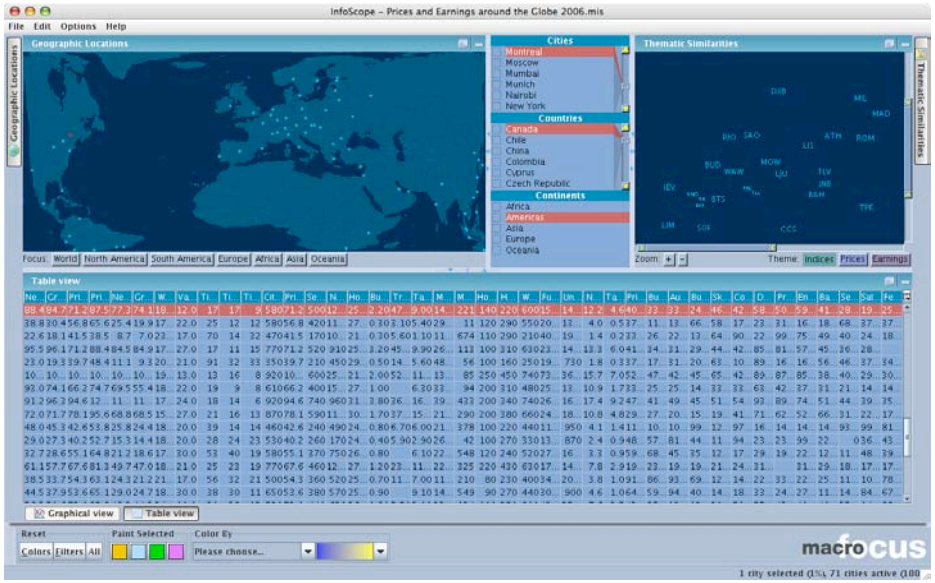
Change representation

e.g., from histogram to scatterplot



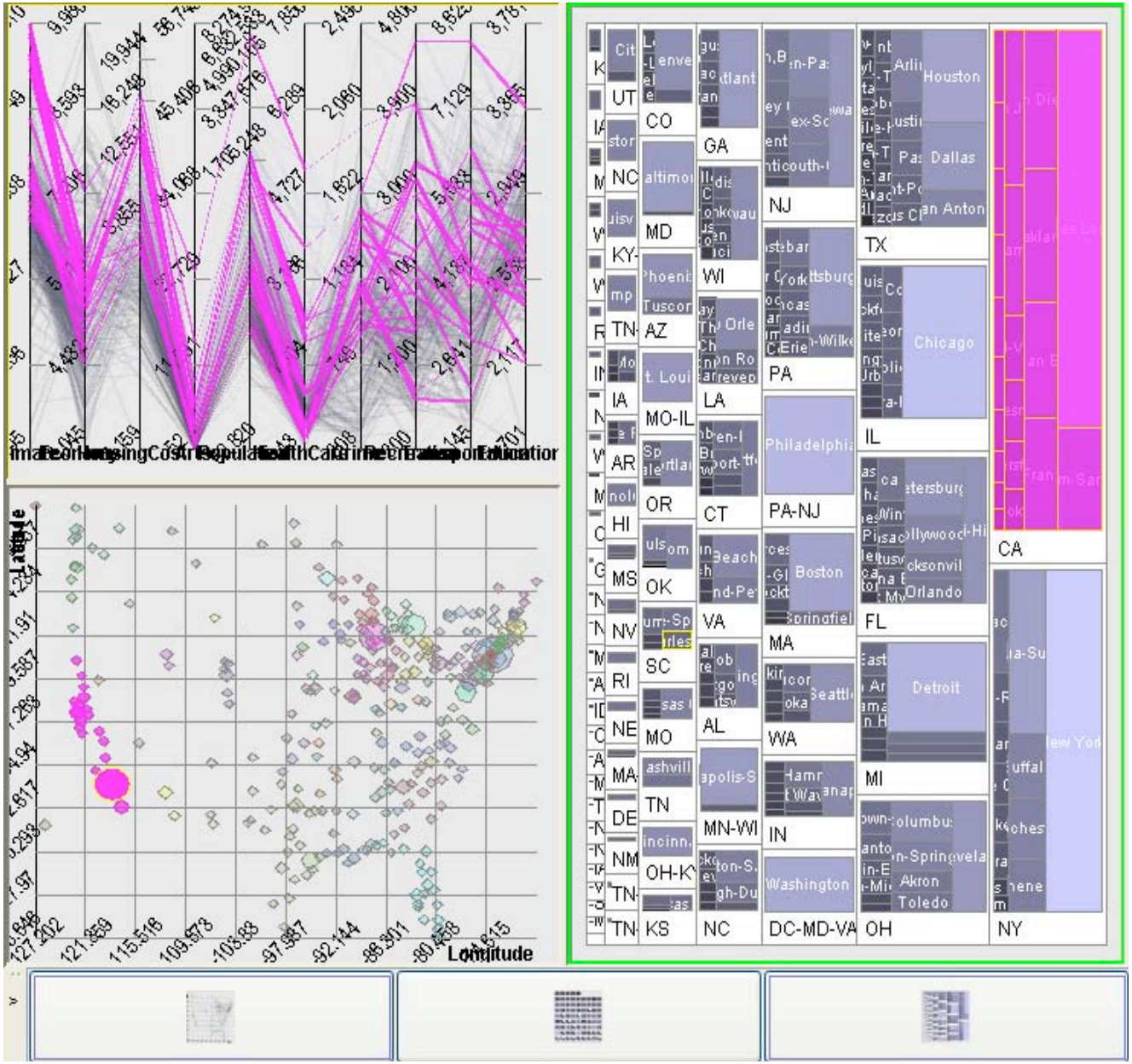


[InfoScope, 2007]

Multiple Views: Brushing & Linking

A multiple view–system uses two or more distinct views to support the investigation of a single conceptual entity.

[Baldonado et al., 2000]



Magic Lenses, Movable Filters

[Bier et al., 1993, Stone et al, 1994]

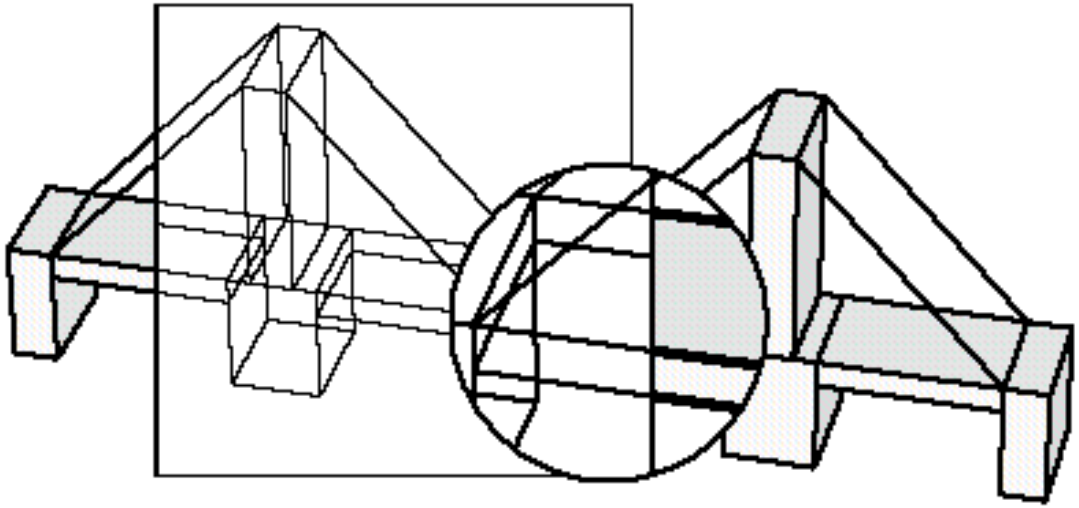
Arbitrarily shaped area of an object and to manipulate this area with specific operators

cover only a part of the object

Can be overlaid and combined

Combination with Dynamic Queries [Fishkin & Stone 1995]

MOVIE



Midgaard - Semantic Zoom

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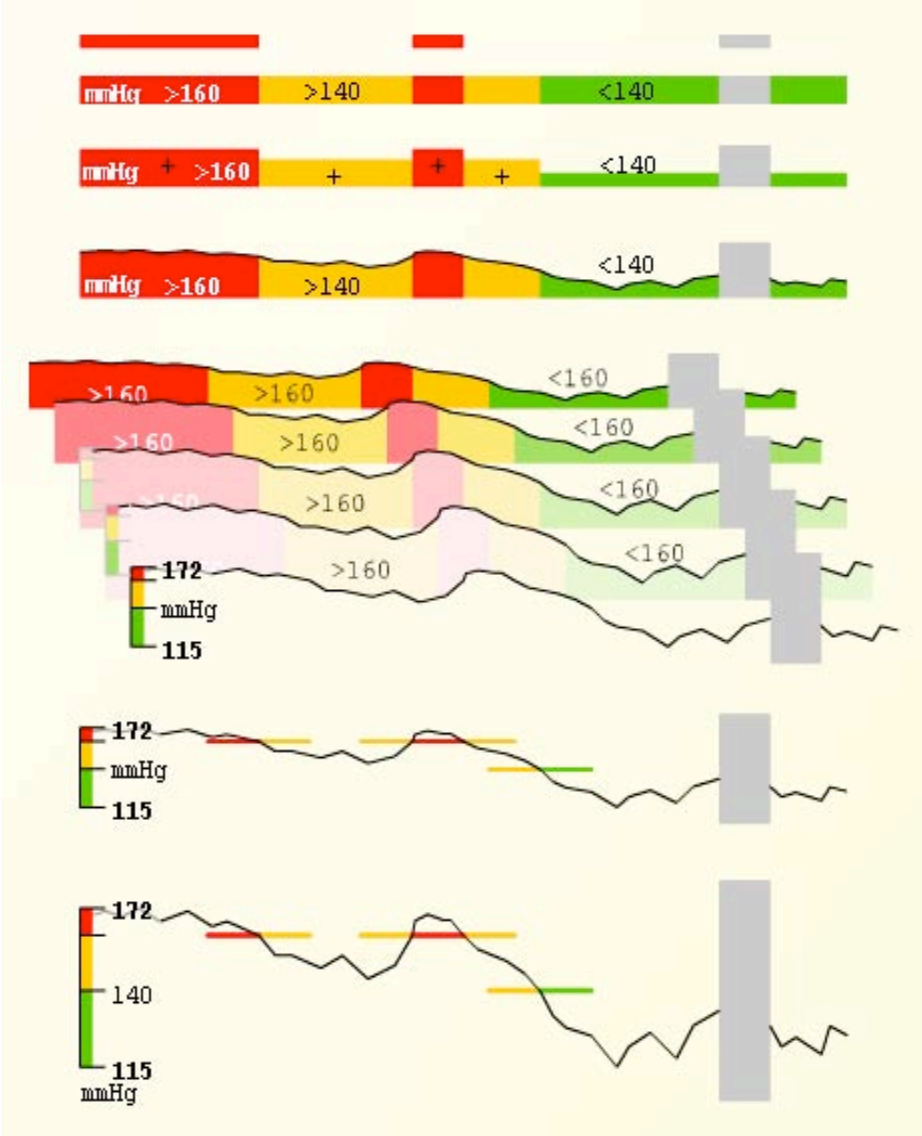
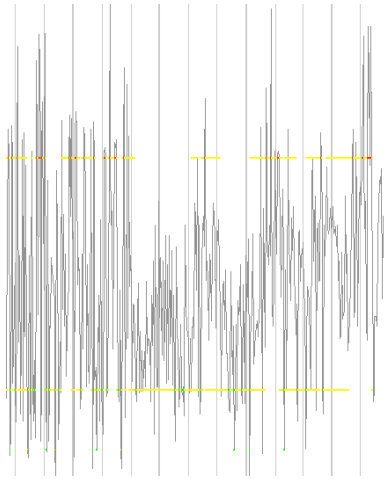
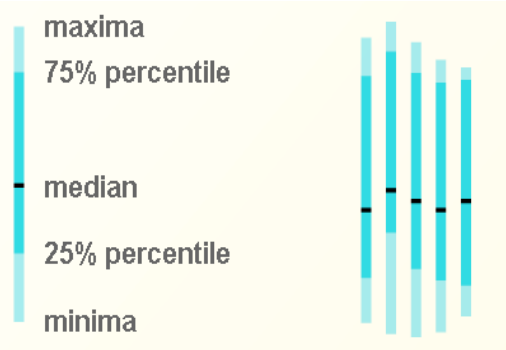
[Bade et al., 2004]

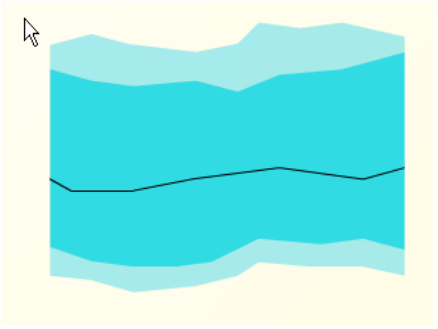
Quantitative/qualitative hybrids



High-frequency data







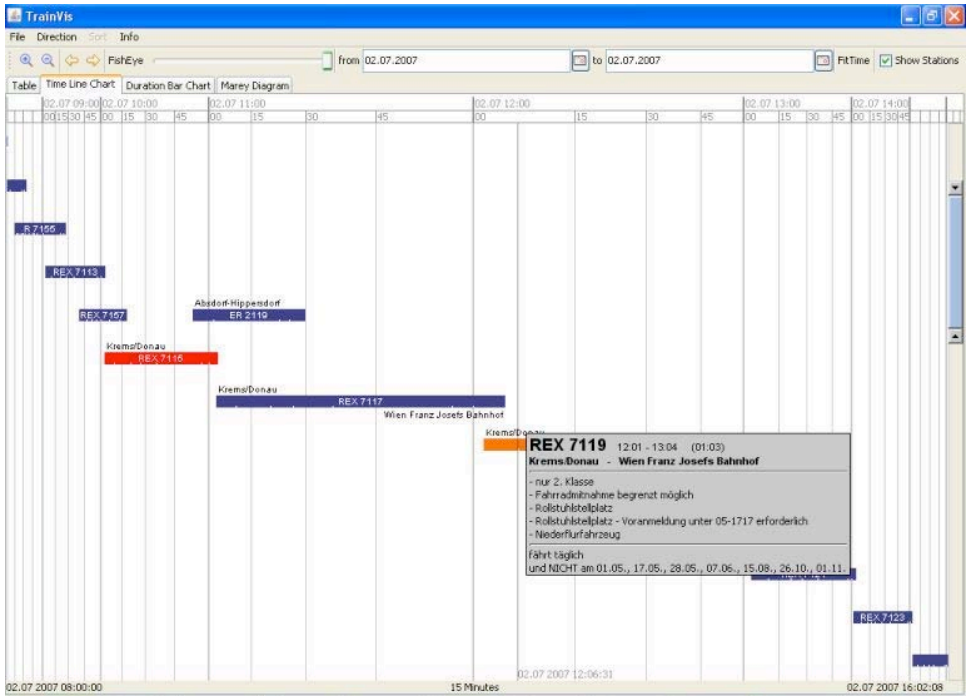
Abstract/Elaborate

show me more or less detail

Details on Demand

Displaying detailed information about data case(s) on demand to the user

- May just be more info about a case
- May be moving from aggregation view to individual view



Filter

show me something conditionally

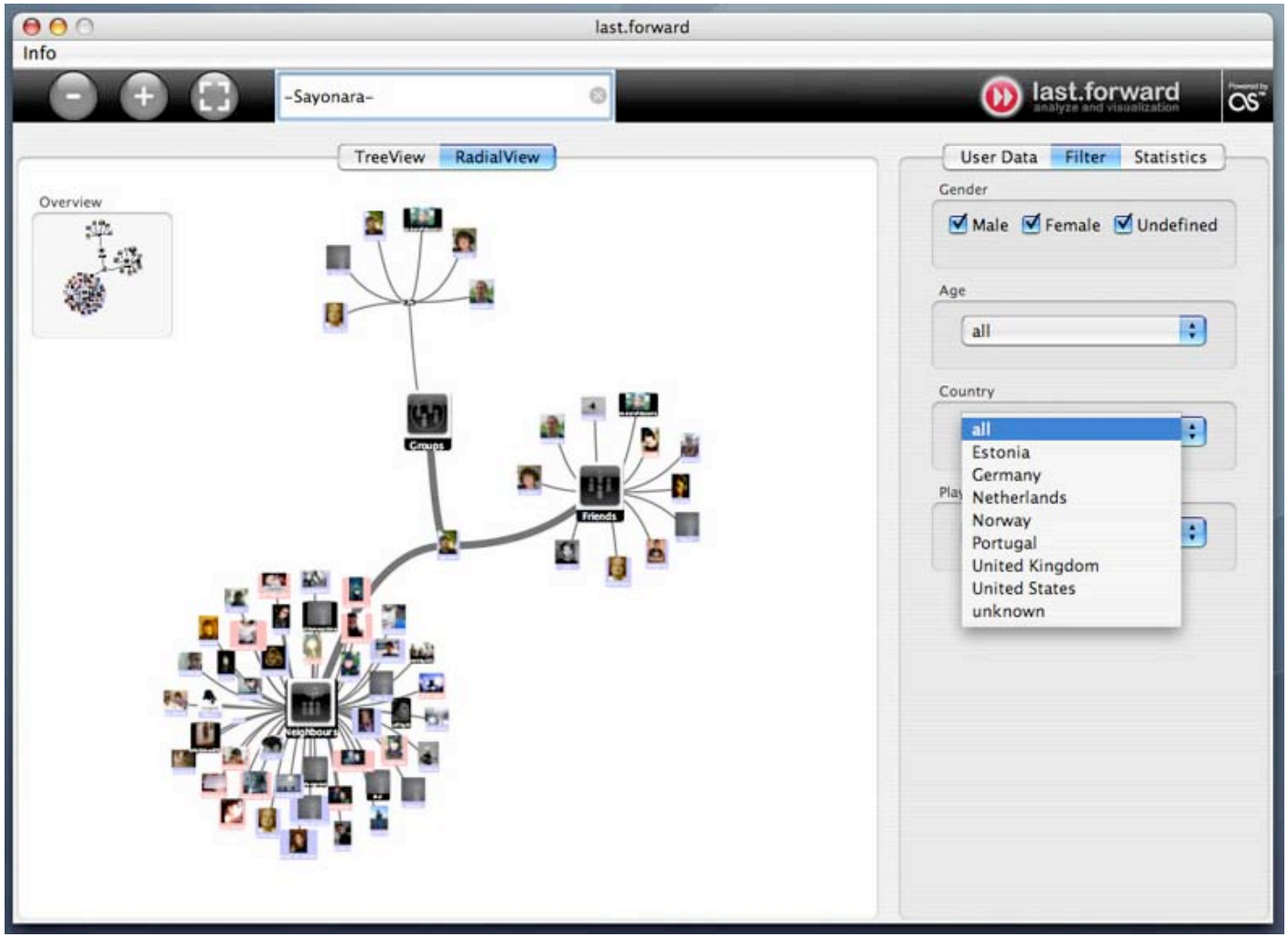
Node-Link

Images as nodes

Weighted edges

Overview + Detail

Filtering



Dynamic Queries

[Shneiderman, 1994 ff, Miksch LVA]

Selecting value ranges of variables via controls with real time feedback in the display.

Principles:

Visual Presentation of Query's Components

Visual Presentation of Results

Rapid, Incremental, and Reversible Control

Selection by Pointing, not Typing

Immediate and Continuous Feedback

Support Browsing

Details on Demand

Dynamic Queries

informations-visualisierung

[Shneiderman, 1994 ff]

Interactive Search

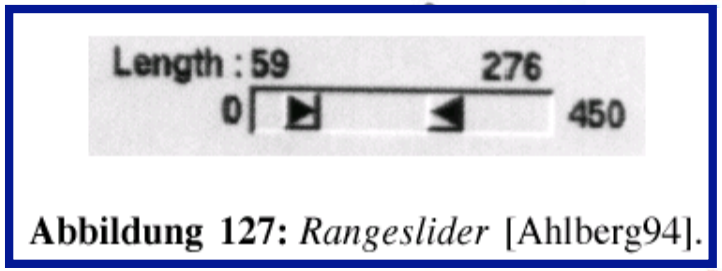
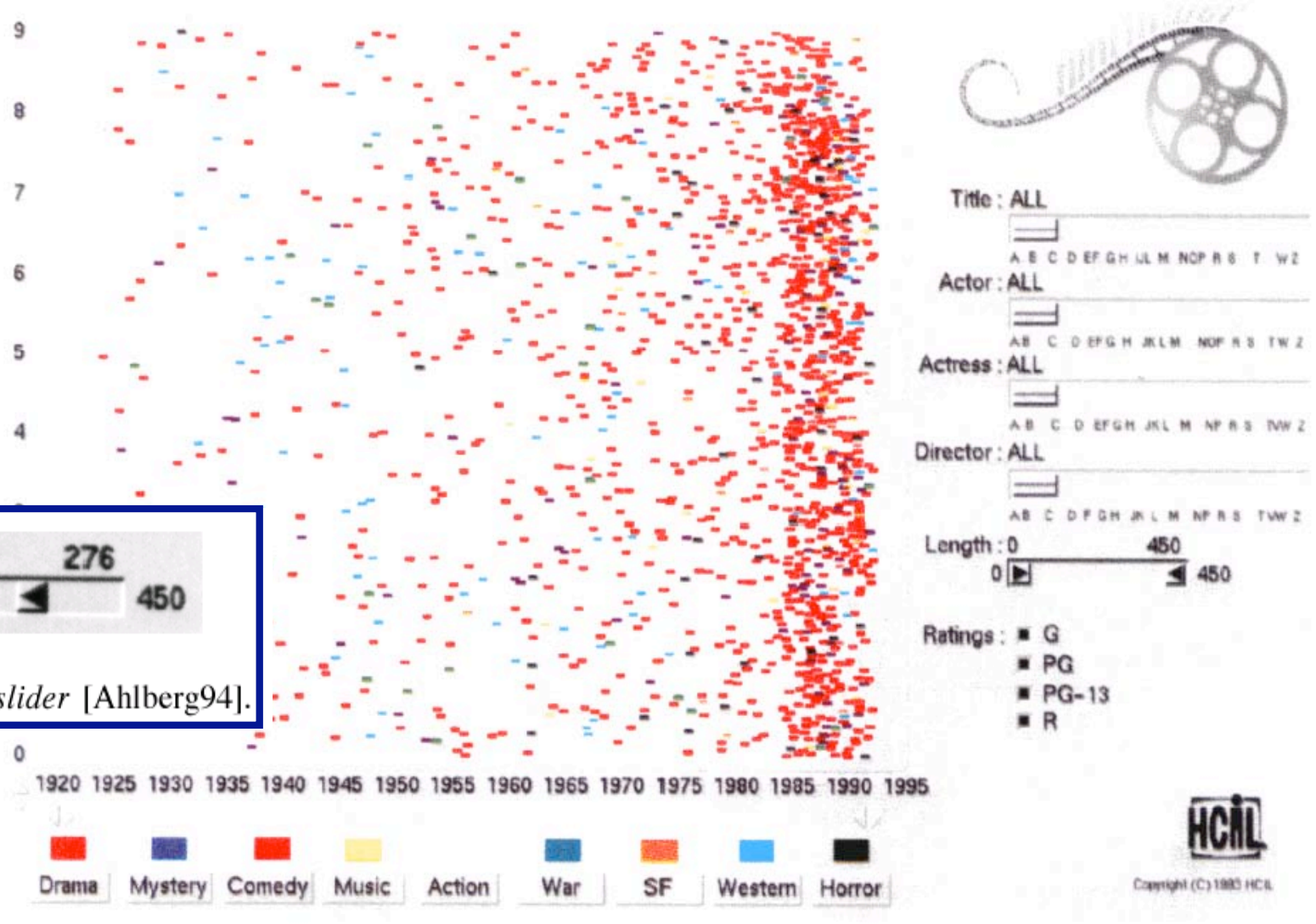


Abbildung 127: *Rangeslider* [Ahlberg94].



Farbabbildung 22: Der *FilmFinder* [Ahlberg94].

Dynamic Queries (cont.)

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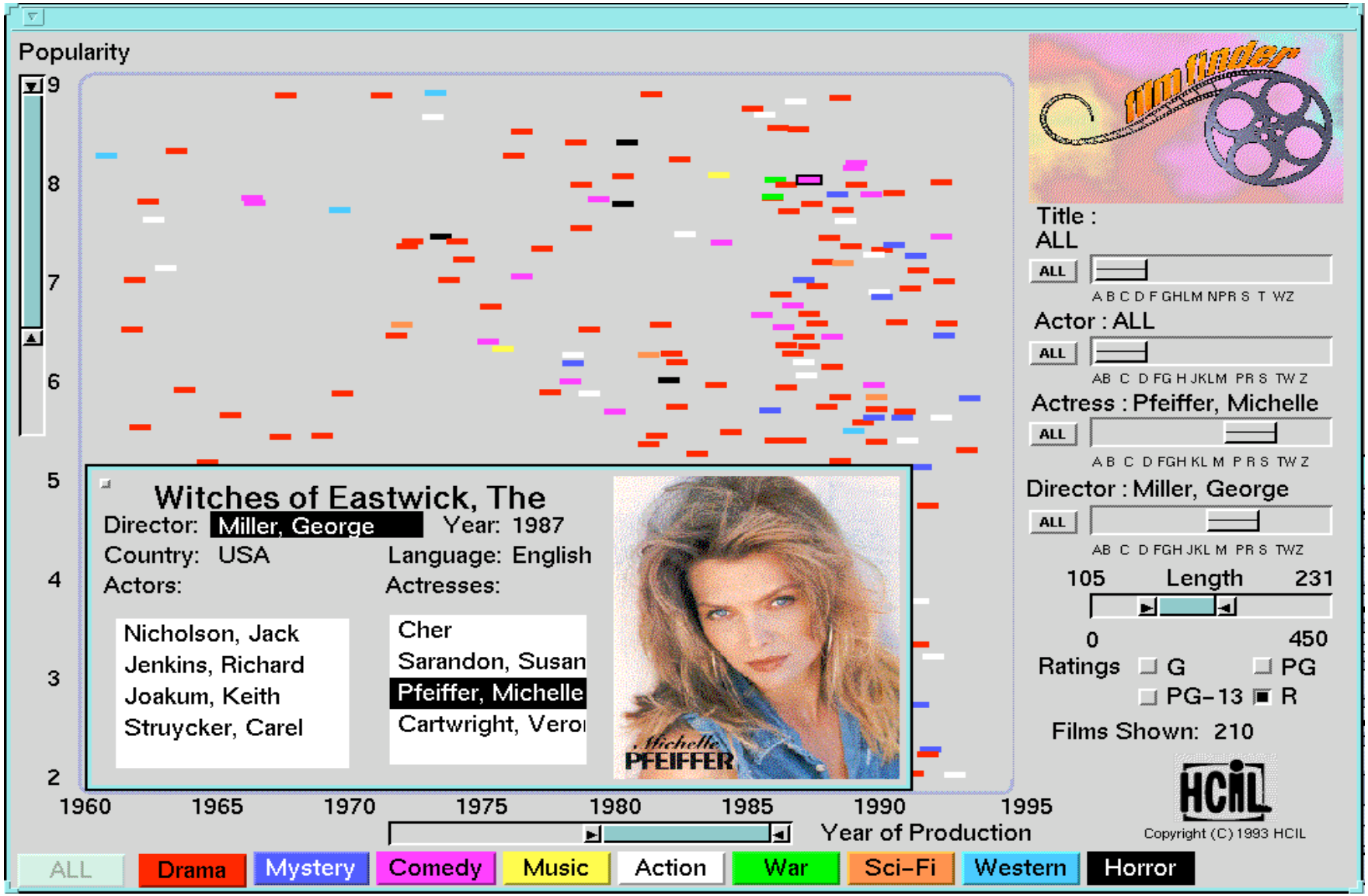
[Shneiderman, 1994 ff]



Details on Demand

RangeSlider

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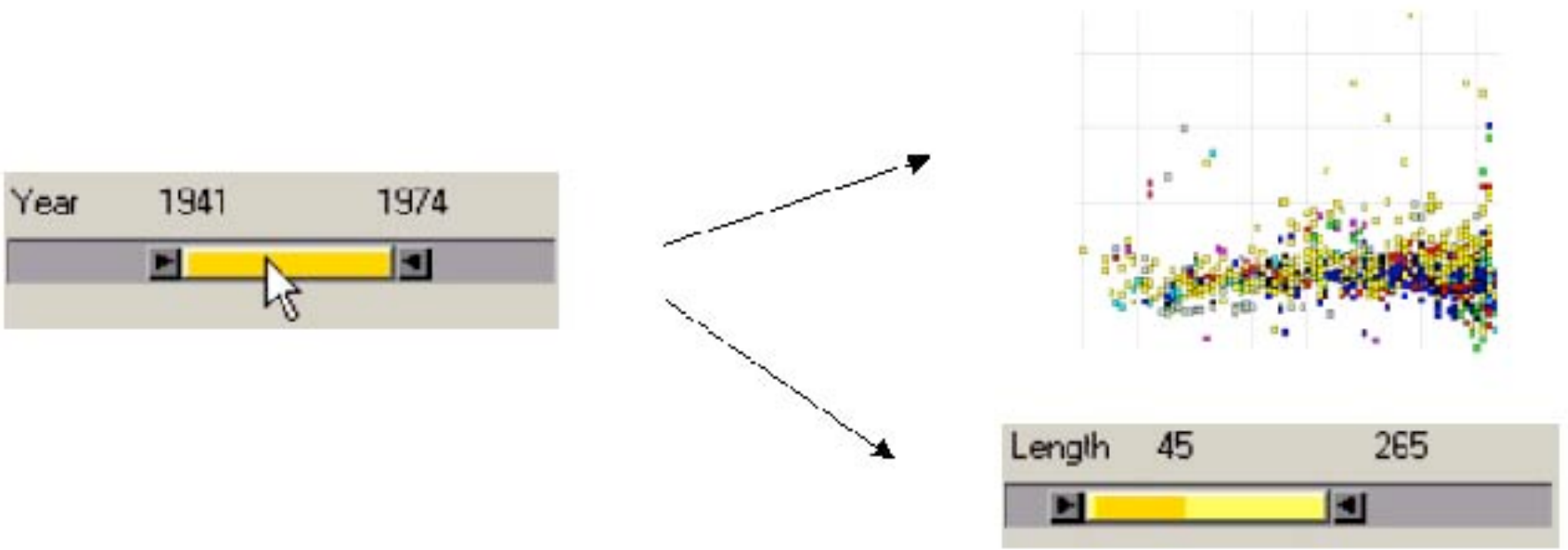
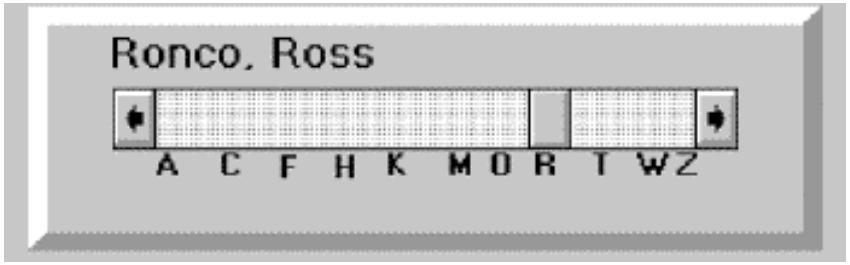
[Shneiderman, 1994 ff]



AlphaSlider

[Ahlberg and Shneiderman, 1994]



Used to rapidly scan through and select from lists of alphanumeric data

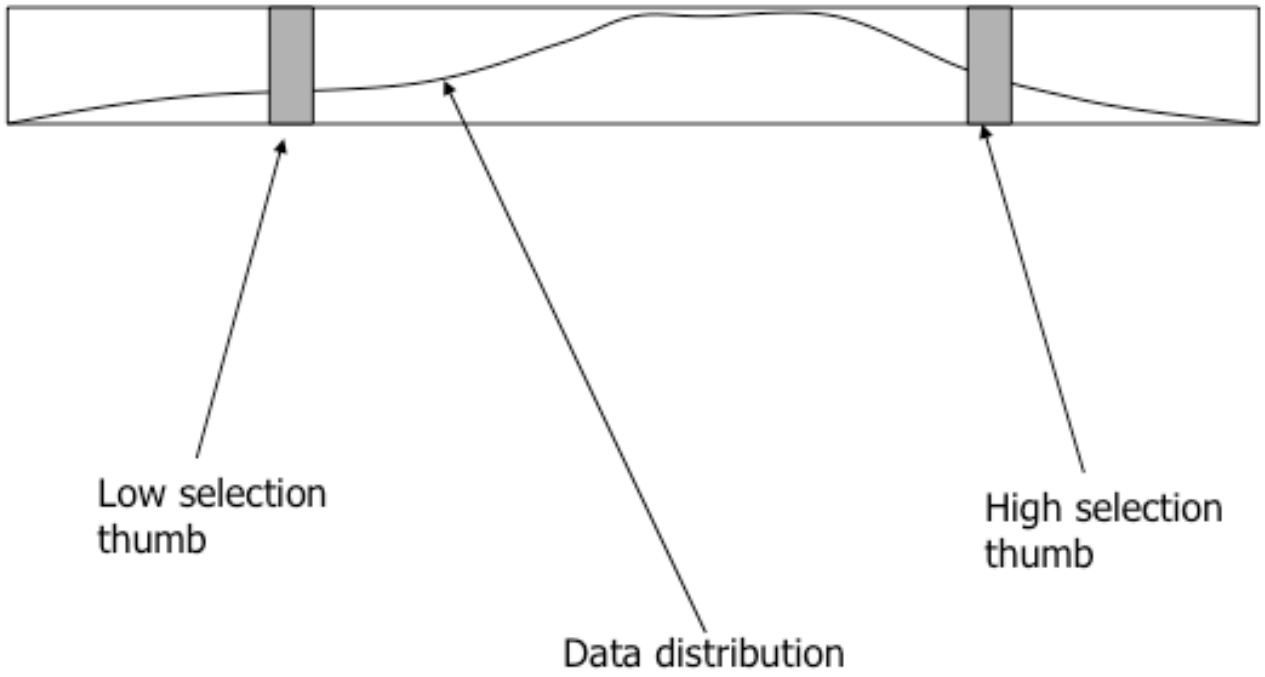
Small-sized widget to search sorted lists

Letter index visualizing the distribution of initial letters - jump to a position in the slider

Locating an items out of a list of 10,000 items ~ 28s for novice users

Data Visualization Sliders

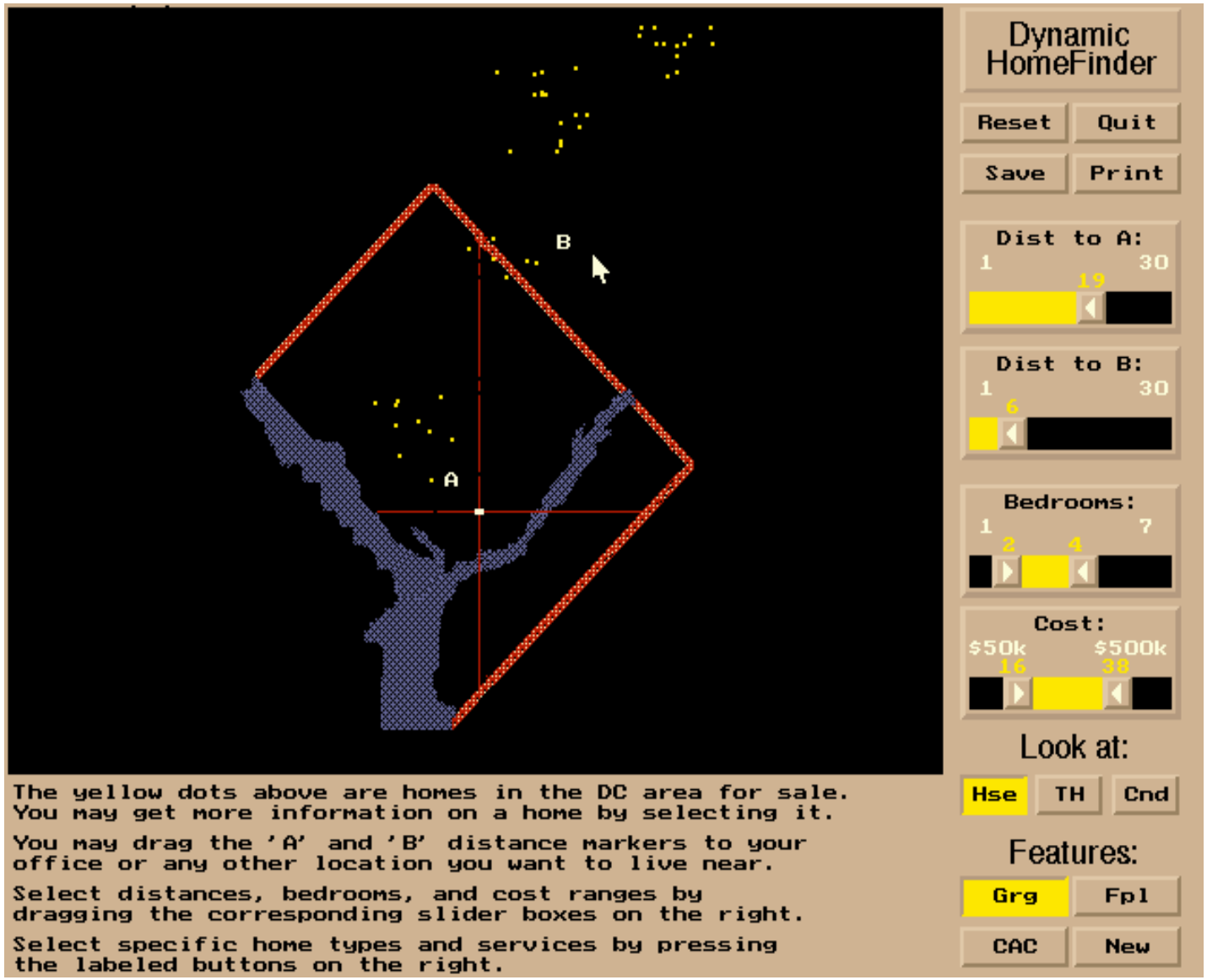
[Eick, 1994]



Data distribution is shown within control

Dynamic HomeFinder

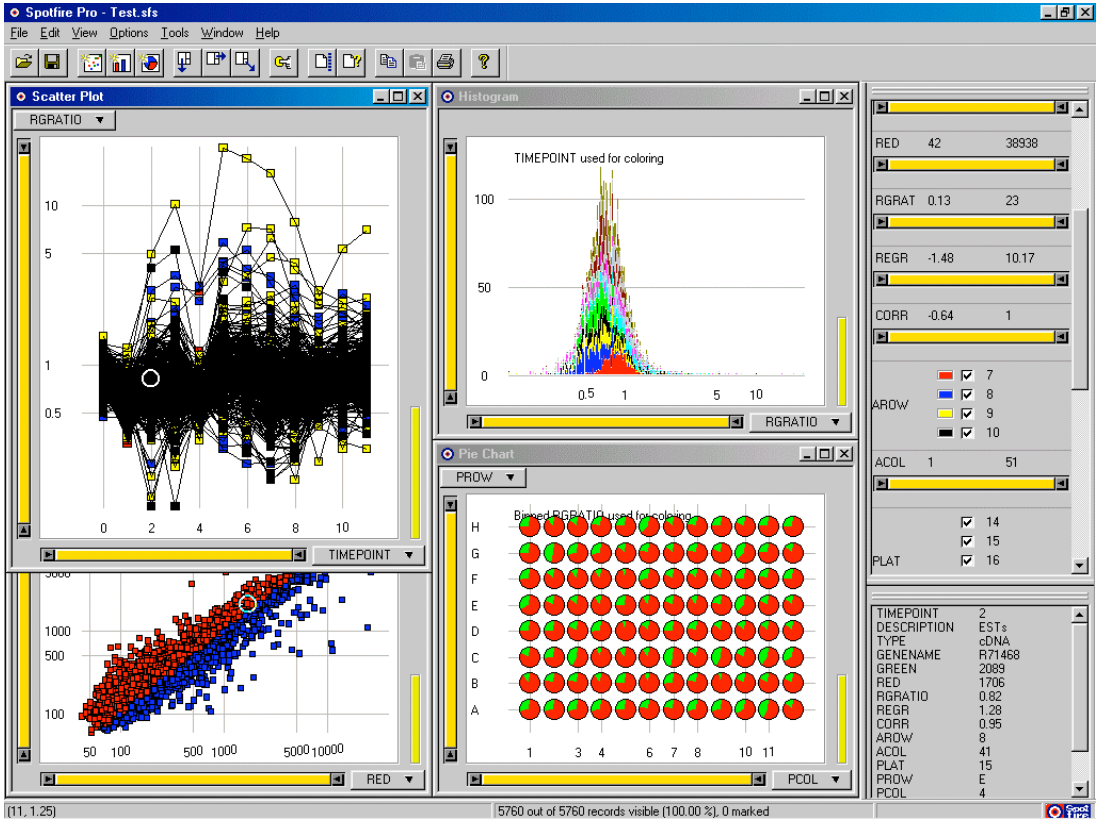
[Shneiderman, 1994 ff]



Spotfire

Christopher Ahlberg

- 1991: Visiting student from Sweden at the HCIL University of Maryland
- 1996: Founder of Spotfire
- 2007: Spotfire was sold for 195 Mio. $



Online examples

Immobilien Suche

http://immo.search.ch/

Diamond Search

http://www.bluenile.com

Amazon.com search via Treemap (Hive Group)

http://www.hivegroup.com/gallery/galleryapps_amazon.html

Spotfire Holiday Gift Finder

http://spotfire.tibco.com/testdrive/holidays/

Dynamic Queries Summary

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[Büring LVA, 2007]

Users can rapidly, safely playfully explore a data space - no false input possible

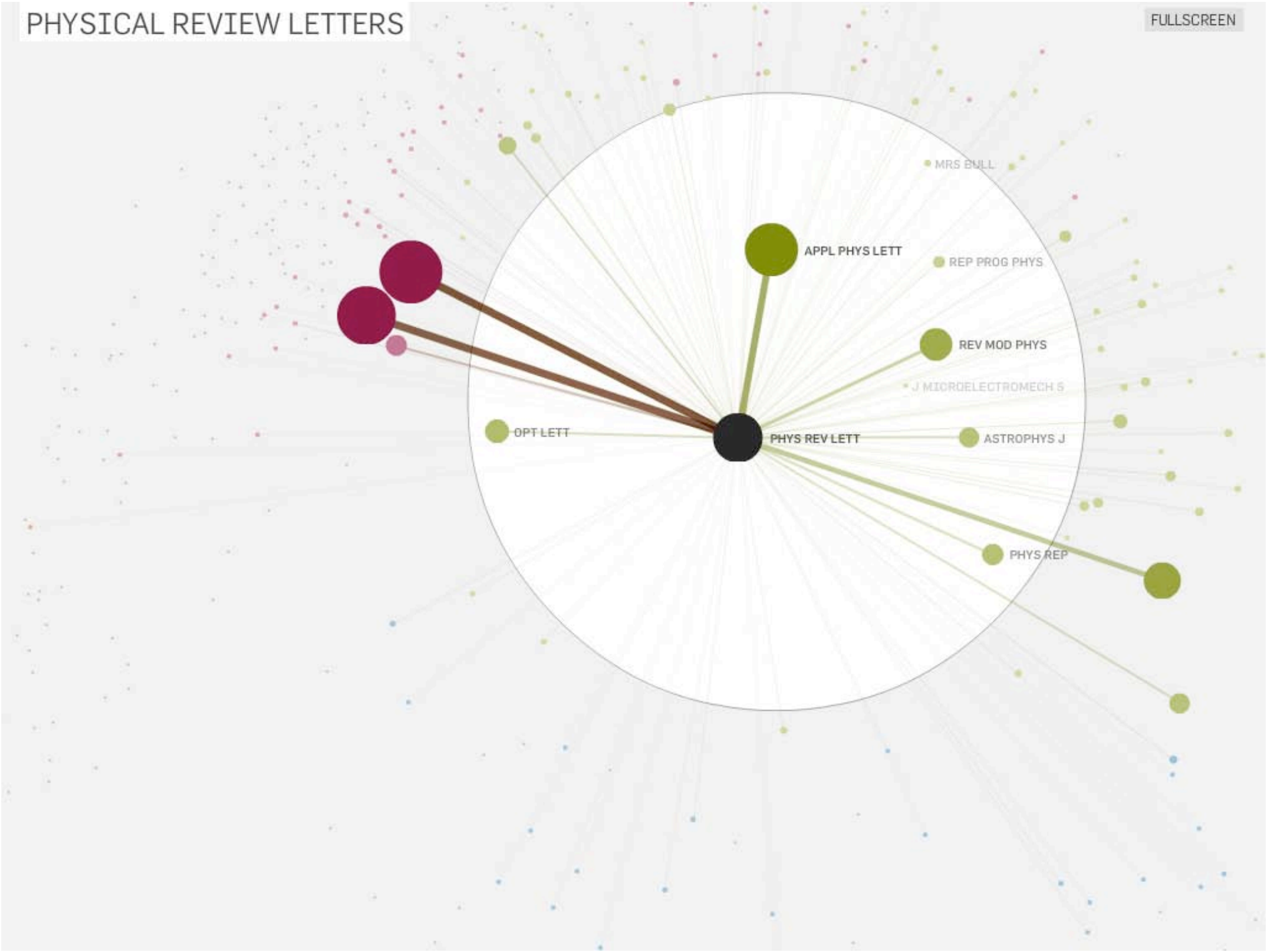
- Users can rapidly generate new queries based on incidental learning
- Visual representation of data supports data exploration
- Analysis by continuously developing and testing hypotheses (detect clusters, outliers, trends in multivariate data)
- Provides straightforward undo and reversing of actions

Potential problems

- Limit of query complexity - filters are always conjunctive
- Performance is limited for very large data sets and client / server applications
- Controls require valuable display space
- Controls must be fixed in advance
- Information is pruned
- Only single range queries and single selection in the Alphaslider
- Operations are global in scope

Connect

show me related items

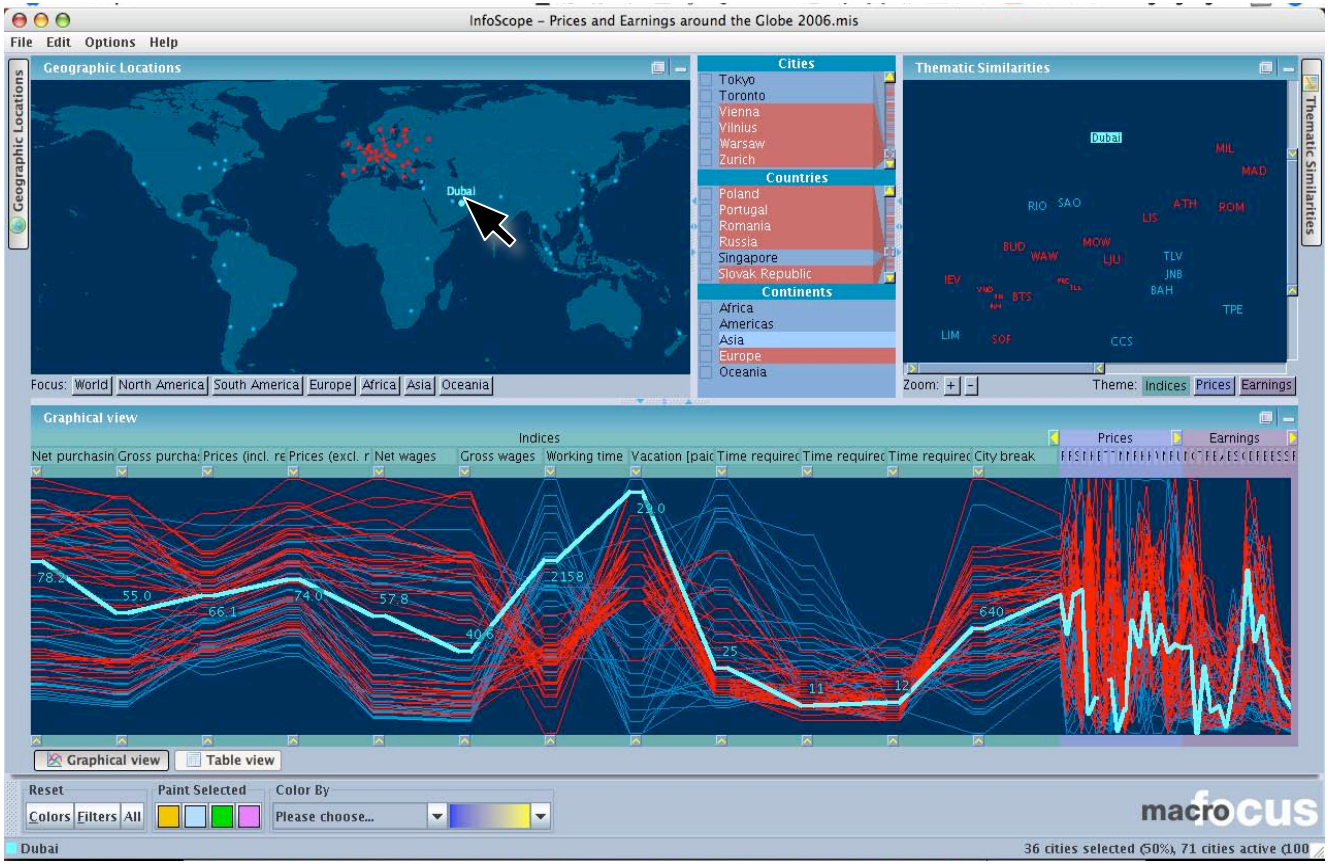

PHYSICAL REVIEW LETTERS
FULLSCREEN
MRS BULL
APPL PHYS LETT
REP PROG PHYS
REV MOD PHYS
J MICROELECTROMECH S
OPT LETT
PHYS REV LETT
ASTROPHYS J
PHYS REP

Linking

Connection between multiple views of the same data space

Updating one view means updating all

Often mentioned in conjunction with “brushing” (Linking + Brushing)



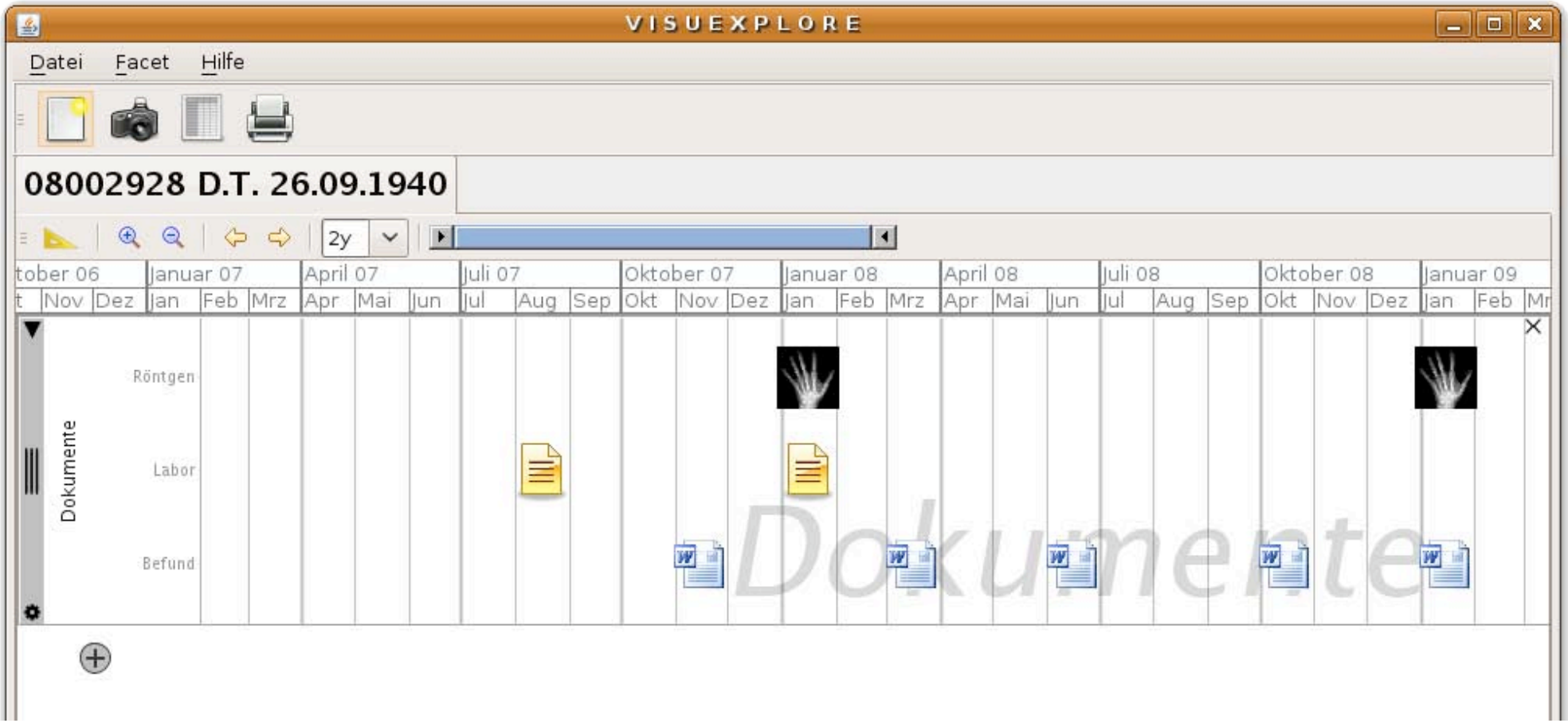
[InfoScope, 2007]

Activate

trigger action

Activate

e.g., open document, go to webpage



Modify

manipulate elements

Modify: manipulate elements

generate

delete

move

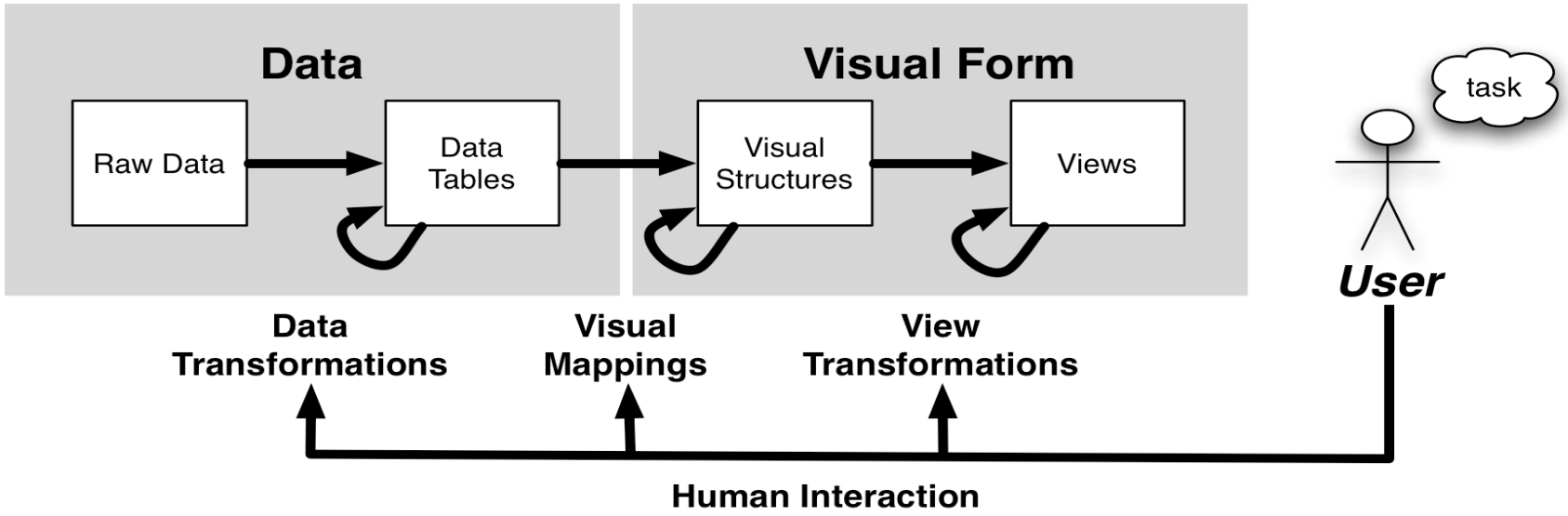
transform

copy

Revisiting the InfoVis Reference Model

informations-visualisierung

[Card et al., 1999]



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Data Transformations: Mapping raw data into an organization appropriate for visualization
Data Tables: relations (cases by variables) + metadata
Visual Mappings: Encoding abstract data into a visual representation
Visual Structures: spatial substrates + marks + graphical properties
View Transformations: Changing the view or perspective onto the visual presentation
Views: graphical parameters (position, scaling, clipping, ...)
Human Interaction: User influence at any level

User interaction can feed back into any level

Interaction devices

[Shneiderman and Plaisant, 2005]

Keyboard devices

Pointing devices

- Direct control devices
  - easy to learn and use, but hand may obscure display
  - *e.g. Lightpen; Touchscreen; Stylus*
- Indirect control devices
  - takes time to learn
  - *e.g. Mouse; Trackball; Joystick;Touchpad; Graphics tablet*
- Novel devices and strategies
  - special purposes
  - *e.g. Foot controls; Eye tracking; 3D trackers; DataGloves; Boom Chameleon; Haptic feedback; Tangible user interfaces; Digital paper*

Speech and auditory interfaces

Displays

Printers

Part B
visual analytics

Motivation: Main Problems

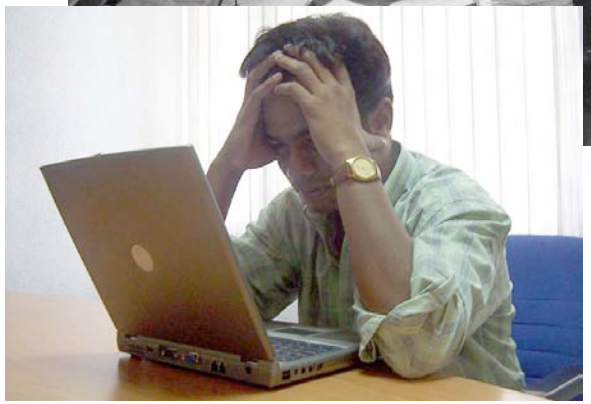
informations-visualisierung

Data Unmanageable –
Loss of Overview

Missing Integration of

Various (Heterogeneous)
Information Sources

Various
Interdisciplinary Methods



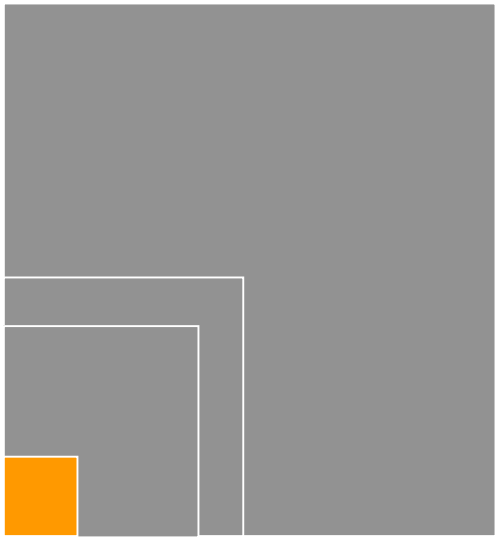
Missing Involvement of

Users and their Tasks

Analytical Methods

informations-visualisierung

Screen Resolution:	1024 * 768 = **786.432**
Measurements of Water Level in LA Every Year:[1]	**5.256.000**
Number of Cellular Phones in Austria (2005):[2]	**8.160.000**
Transmitted Emails Every Hours (World-Wide):[3]	**35.388.000**



Whole Data often not Presentable

Applying Analytical Methods
(*Data Reduction*)

Visualization of Most Important Data
and Information

Analytical Methods

Statistics, Machine Learning & Data Mining

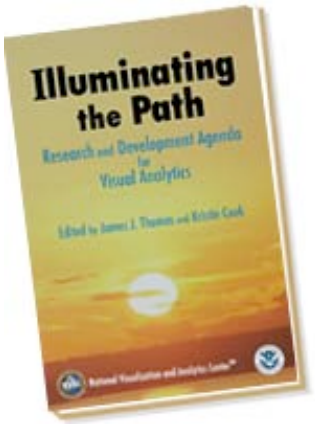
1 ... Amt der NÖ Landesregierung, Abt. WA5 - Hydrologie, http://www.noel.gv.at/SERVICE/WA/WA5/htm/wnd.htm, Accessed: 11.1.2007
2 ... CIA Factbook, https://www.cia.gov/cia/publications/factbook/, Accessed: 11.1.2007
3 ... How Much Information?, UC Berkeley, http://www2.sims.berkeley.edu/research/projects/how-much-info-2003/, Accessed: 11.1.2007

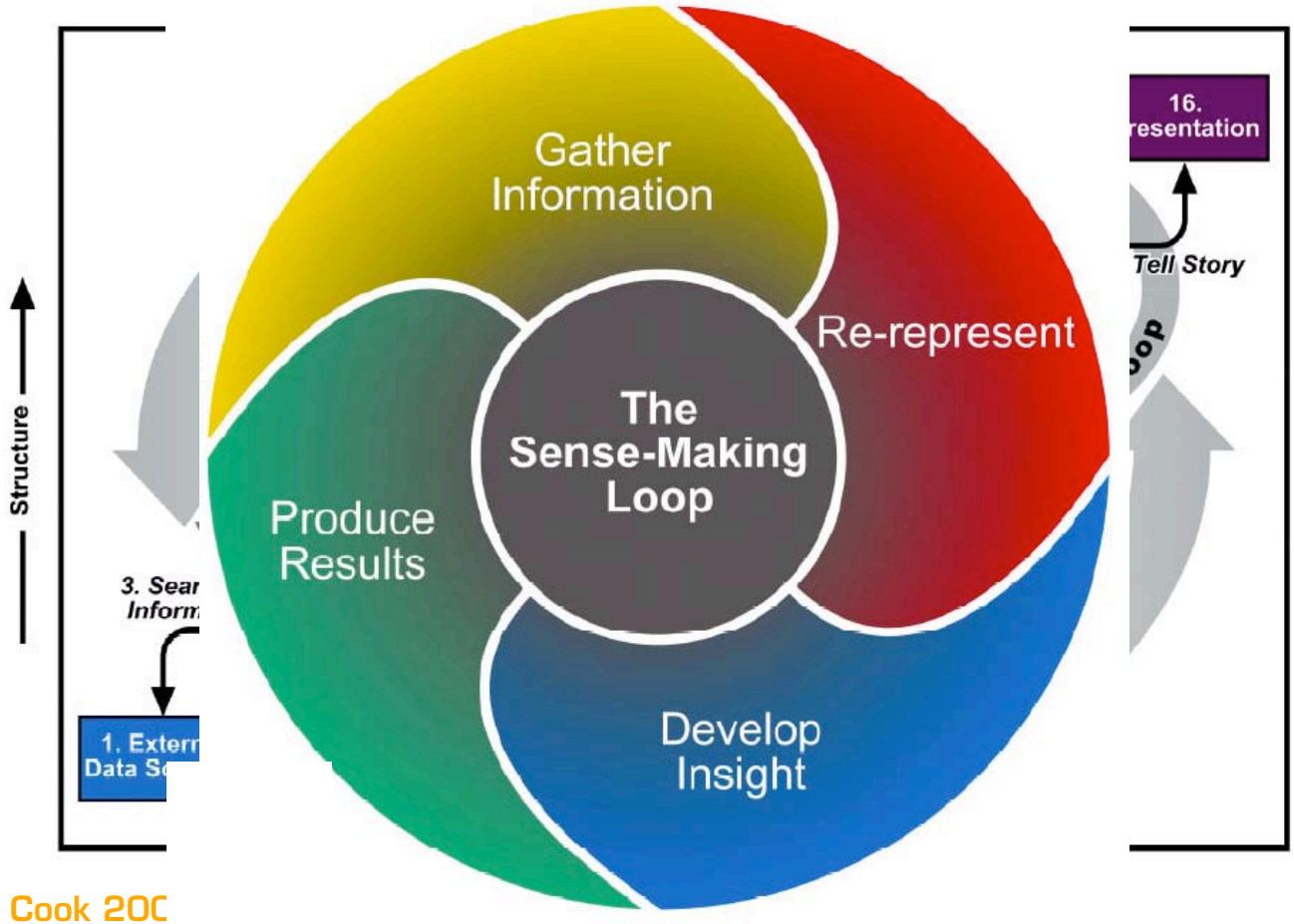
Visual Analytics – What is it?

James Thomas & Kristin A. Cook:

NVAC (National Visualization and Analytics Center), Seattle, USA

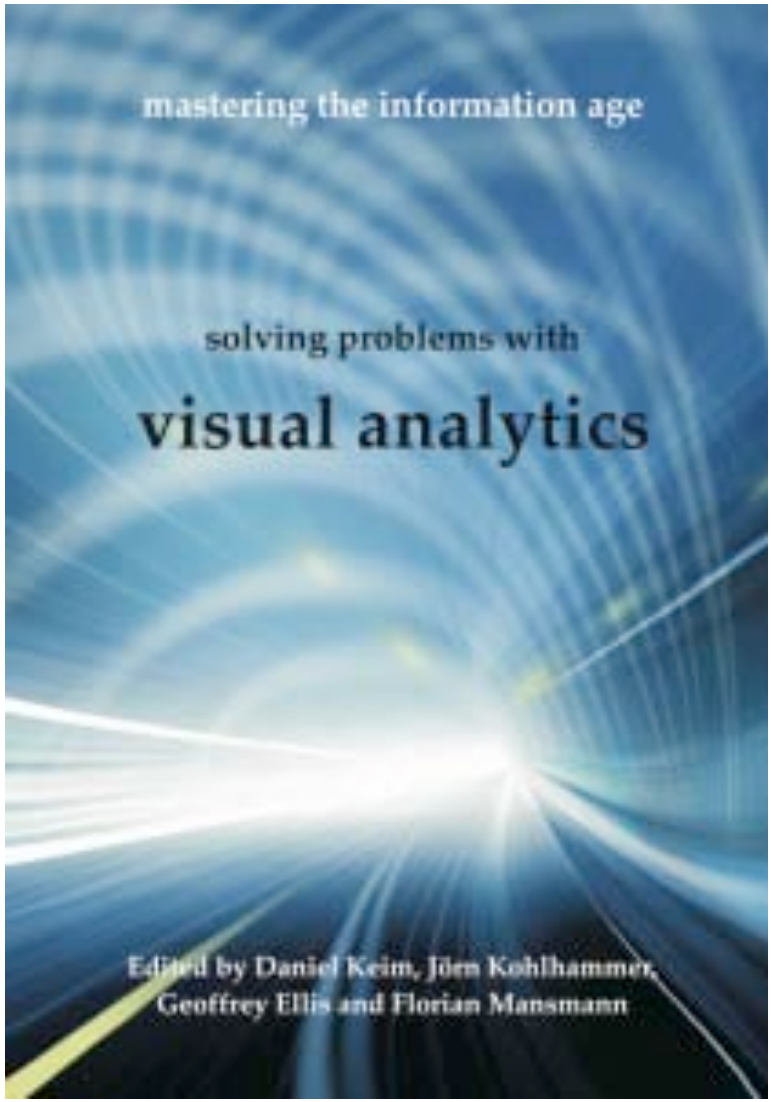
„Visual Analytics is the science of analytical reasonin facilitated by interactive visual interfaces"





[Thomas & Cook 20C

VisMaster Roadmap



http://www.vismaster.eu/

Visual Information Seeking Mantra

informations-visualisierung

[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 ...

Visual Analytics Mantra

informations-visualisierung

[Keim, 2005, presentation]

Analyze first,
show the important,
zoom filter & analyze,
then details-on-demand

Analyze first,
show the important,
zoom filter & analyze,
then details-on-demand

Analyze first,
show the important, …

… 10 times …

Application Areas

Economic & Business Data

- Business Intelligence
- Market Analysis

Medicine & Biotechnology

- Patients' Data Management
- Epidemiology
- Genetics

Security & Risk Management

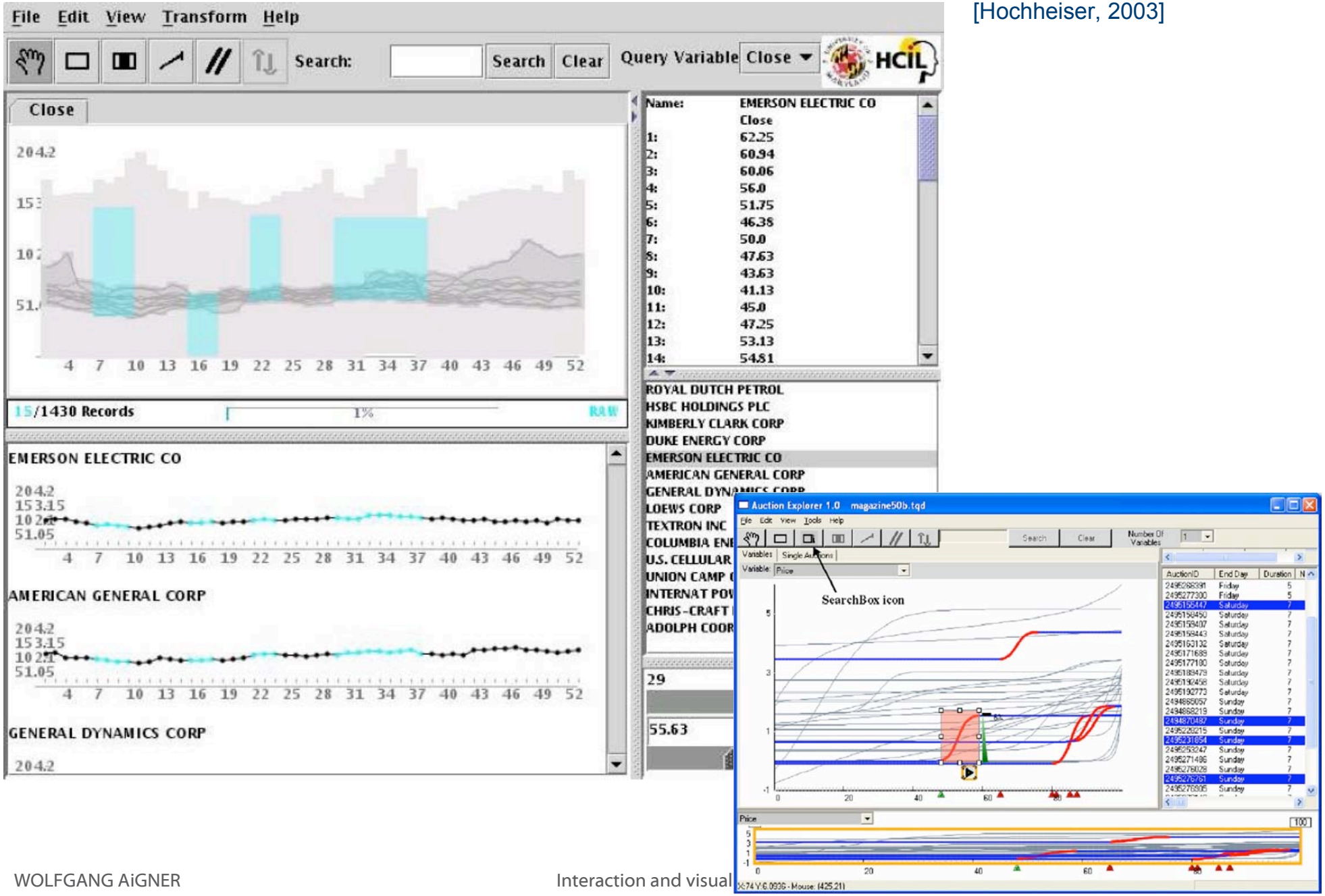
- Disaster Management
- Computer Networks
- Transportation
- Reducing Crime and Terror Rate
- Fraud Detection

Environment & Climate Research

etc.

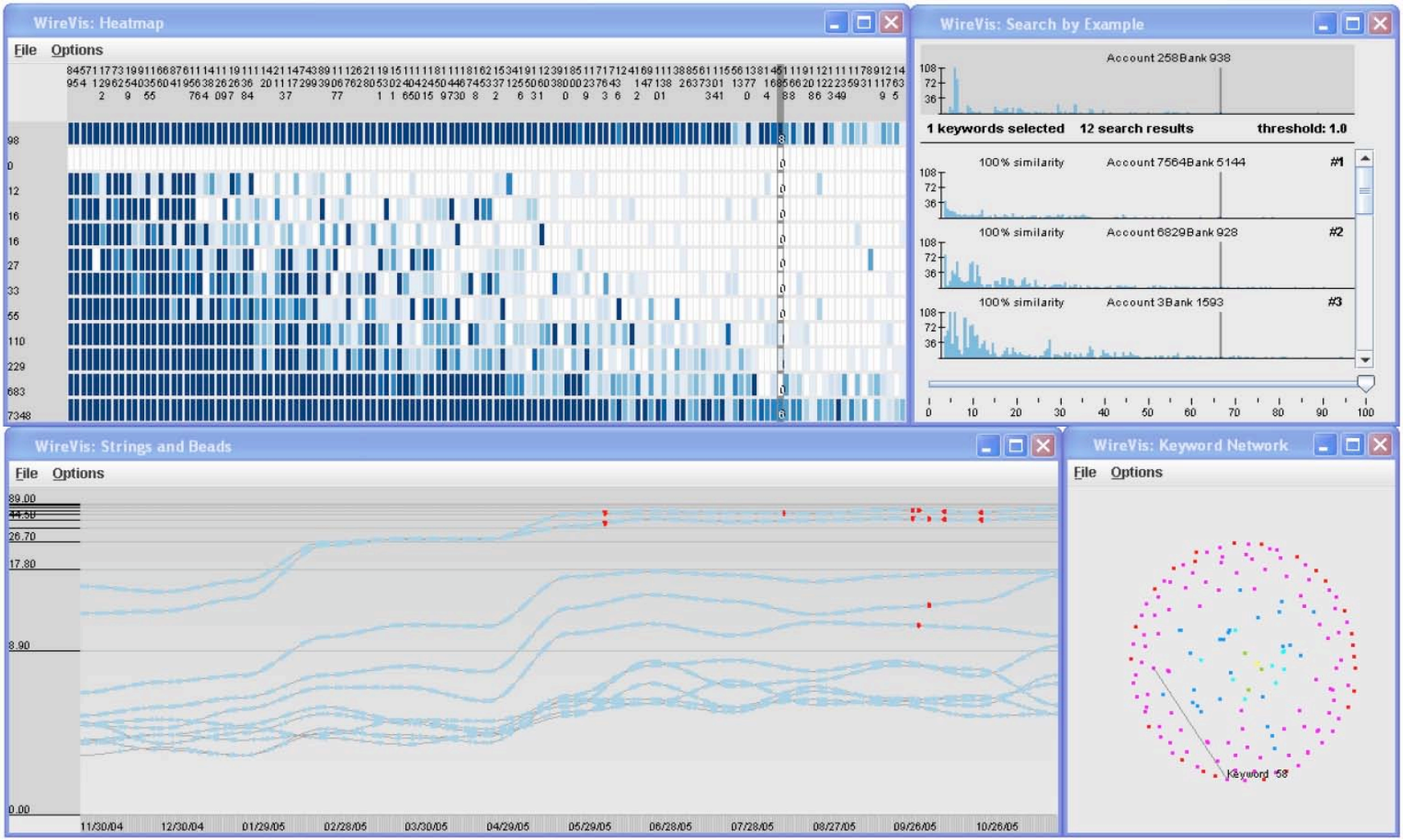
Stock Prices

[Hochheiser, 2003]



WireVis - Anti Money Laundering

[Chang et al., 2007]



WireVis.wmv

Useful resources

Books

[Shneiderman and Plaisant, 2005] Ben Shneiderman and Catherine Plaisant, *Designing the User Interface*, 4th Edition, Pearson Education, 2005.

[Spence, 2007] Robert Spence, *Information Visualization - Design for Interaction*, 2nd Edition, Pearson Education Limited, Essex, UK, 2007

[Cooper et al., 2007] Alan Cooper, Robert Reimann, and David Cronin, *About Face 3 - The Essentials of Interaction Design*, Wiley Publishing, Indianapolis, IN, USA, 2007.

[Sharp et al., 2007] Helen Sharp, Yvonne Rogers, and Jenny Preece, *Interaction Design - beyond human-computer interaction*, 2nd Edition, John Wiley & Sons, West Sussex, UK, 2007.

[Tidwell, 2006] Jenifer Tidwell, *Designing Interfaces - Patterns for Effective Interaction Design*, O'Reilly Media, Sebastopol, CA, USA, 2006.

Web Lecture by John Stasko ★

http://weblectures.cc.gatech.edu/videolectures/7450_Interaction_files/intro.htm

References

[Card, 2008] Stuart Card, Information visualization, in A. Sears and J.A. Jacko (eds.), The Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies, and Emerging Applications, Lawrence Erlbaum Assoc Inc, 2007.

[Cleveland & McGill, 1984] William Cleveland , R. McGill, Graphical Perception: Theory, Experimentation, and Application to the Development of Graphical Methods. Journal of the American Statistical Association 79:531–554, 1984.

[Mackinlay 1986] Jock Mackinlay. Automating the Design of Graphical Presentations of Relational Information. ACM Transactions on Graphics, 5(2):110-141, 1986.

[Schumann and Müller, 2000] Heidrun Schumann and Wolfgang Müller, Visualisierung - Grundlagen und allgemeine Methoden. Springer-Verlag, Berlin, 2000.

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