CSE 5544: Introduction to Data Visualization

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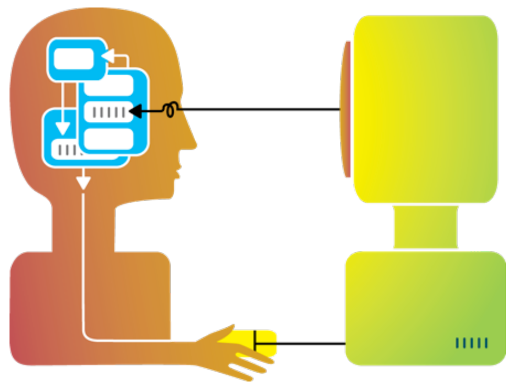
THE OHIO STATE UNIVERSITY

[xkcd]

Many Thanks to

– Alex Lex, University of Utah
– Torsten Moeller, University of Vienna

Interaction



HCI

Why Interaction ?

The MANTRA

Visual Information Seeking Mantra (Shneiderman, 1996)

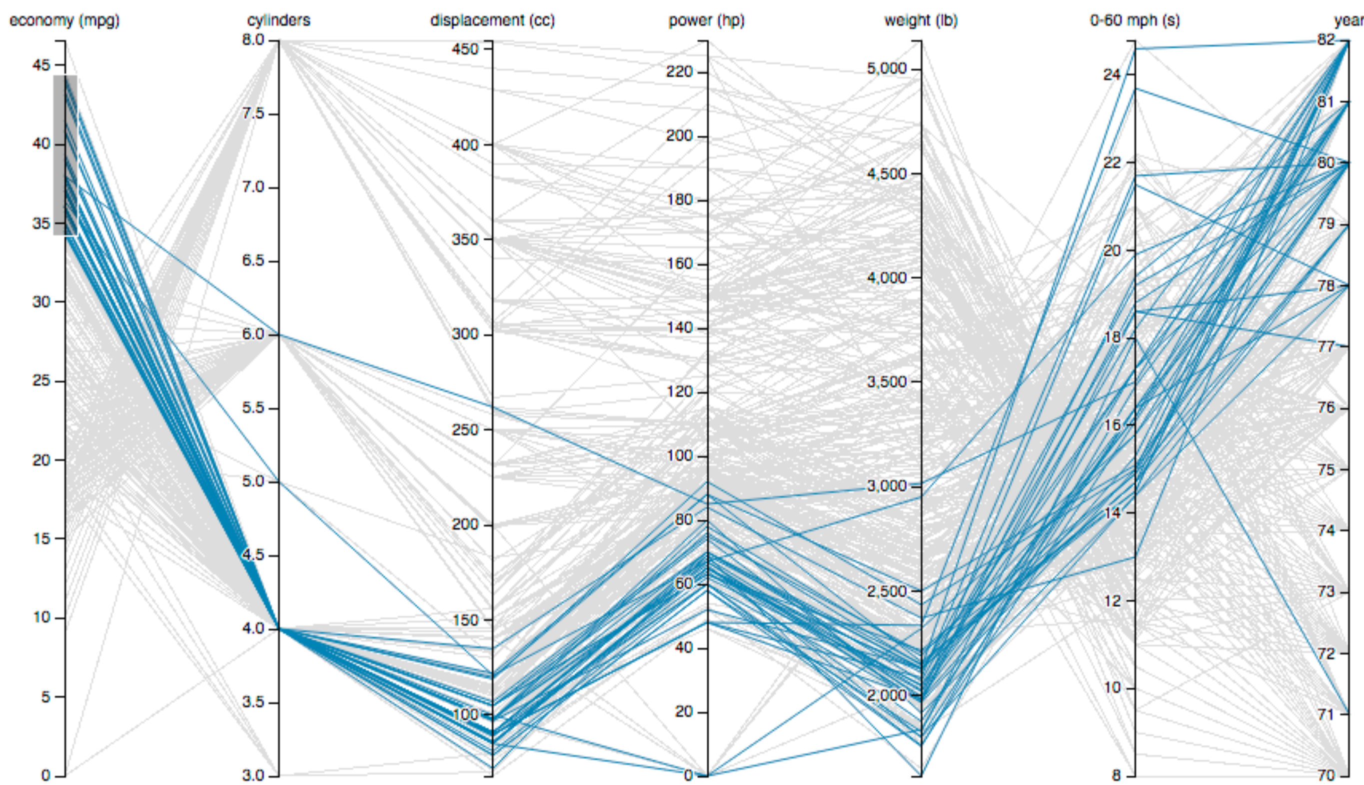
Overview first,

zoom and filter,

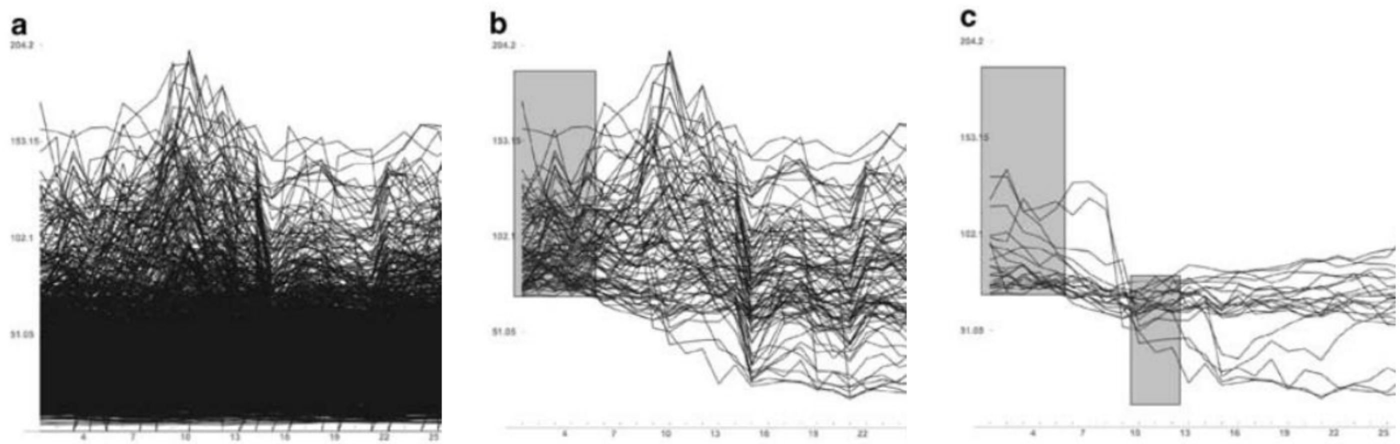
then details on demand

relate, history, extract

Visual Queries

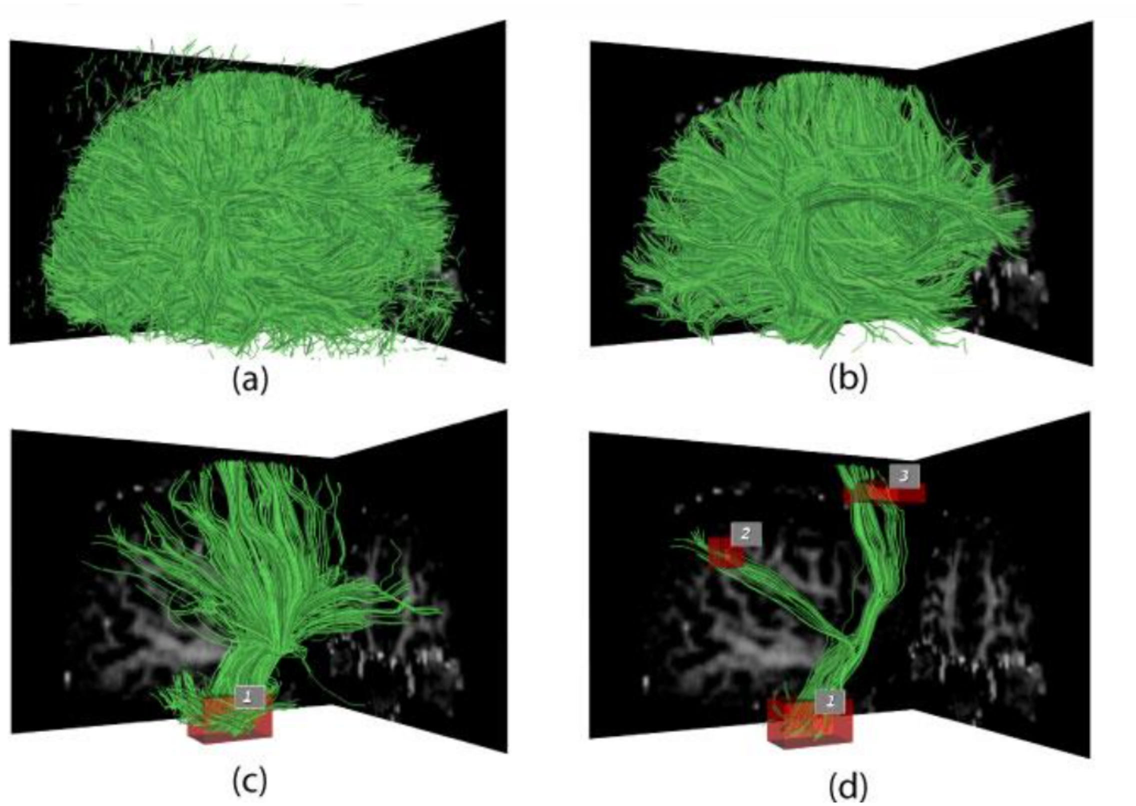


Visual Queries



Time Searcher (Hocheiser, 2003)

Dynamic Queries for Volumetric Data

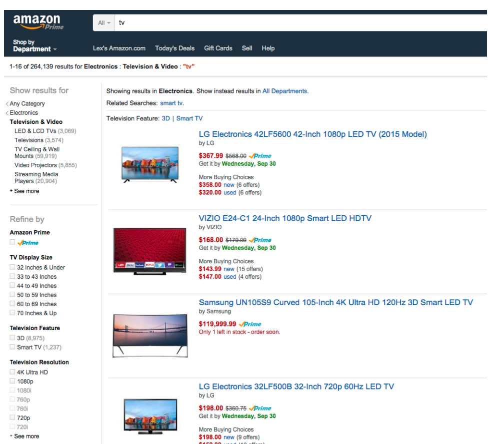


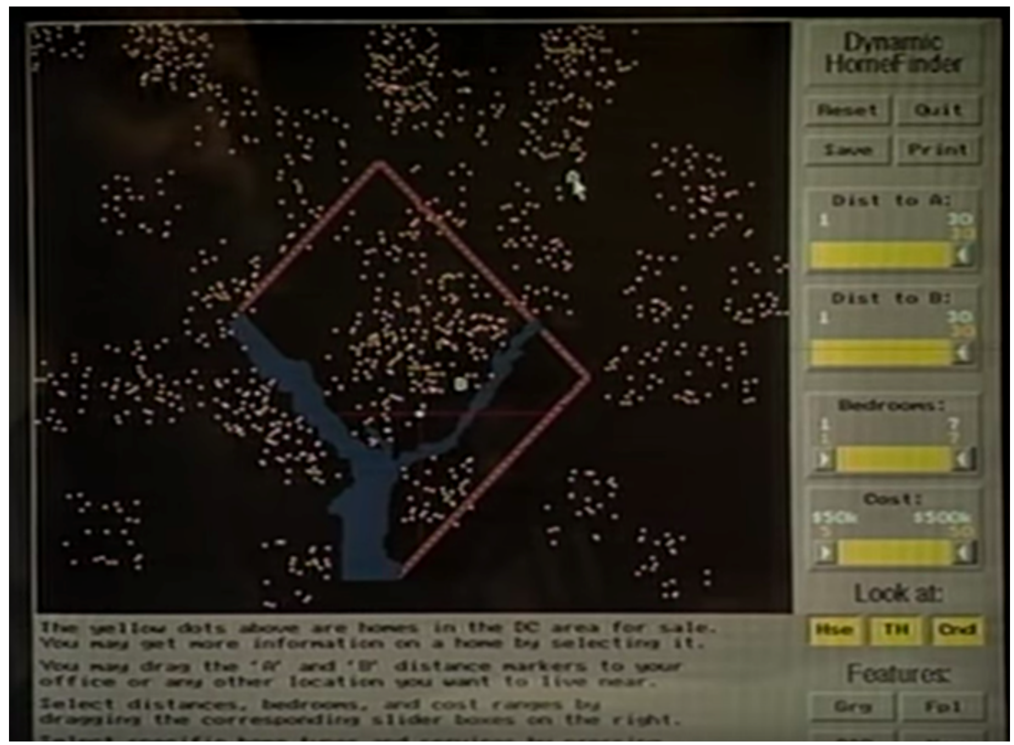
[Sherbondy 2004]

Dynamic Queries

Define criteria for inclusion/exclusion

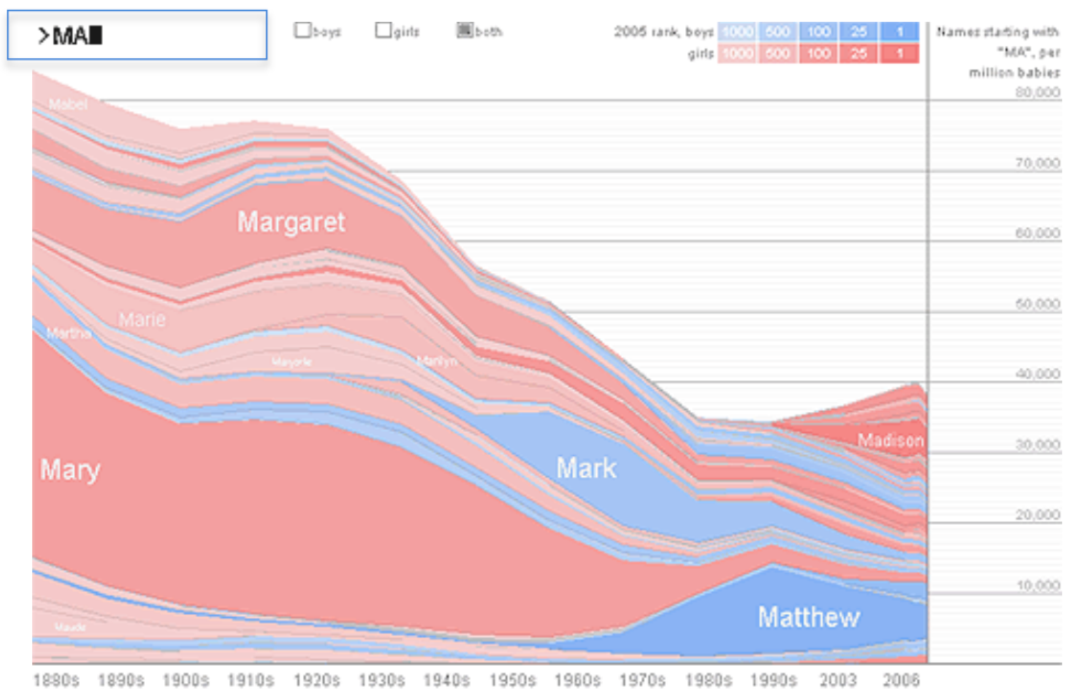
“Faceted Search”



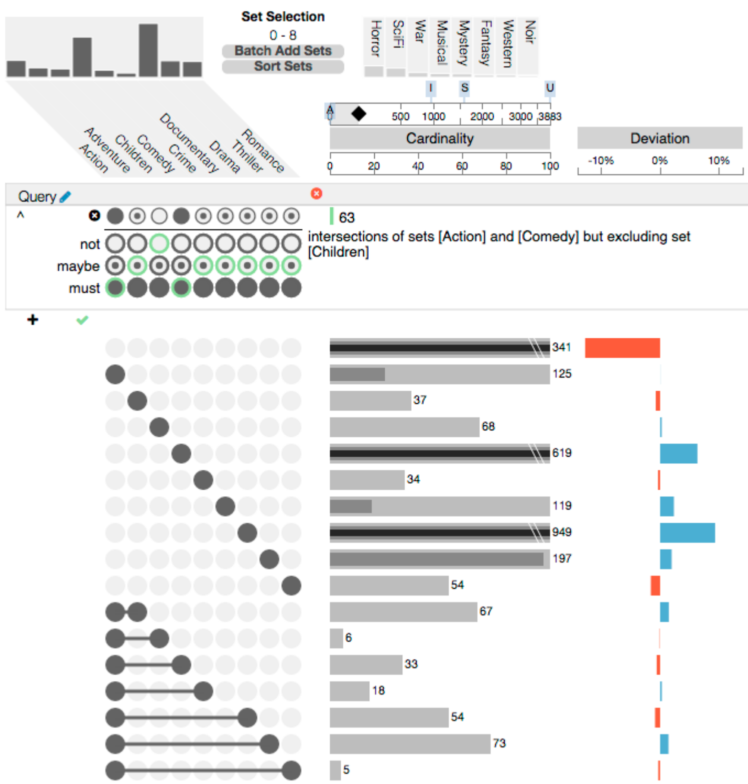


[Ahlberg & Shneiderman, 1994]

Incremental Text Search

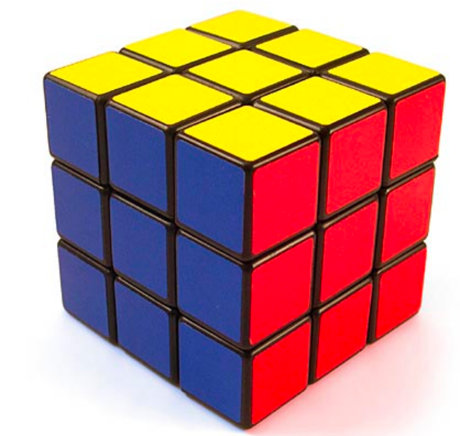


Query Interfaces



Chapter 11

Why Interact with Visualization?



- Explore data that is big / complex
  - too big to show everything at once
  - explore data with different representations
- Interaction amplifies cognition
  - We understand things better if we can touch them
  - If we can observe cause and effect

Types of Interaction

Single View

Change over time

Navigation

Semantic zooming

Filtering and Querying

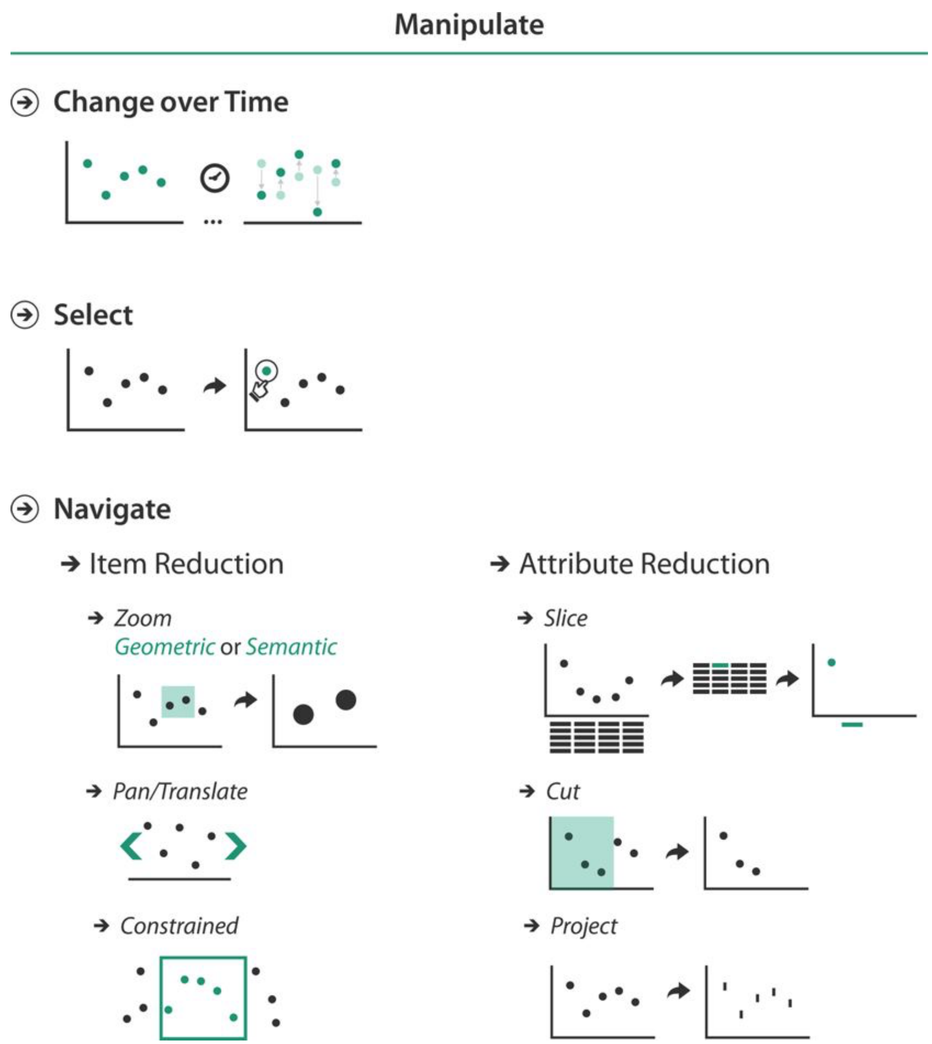
Focus + Context

Multiple Views

Selection (Details on Demand)

Linking & Brushing

Adapting Representations

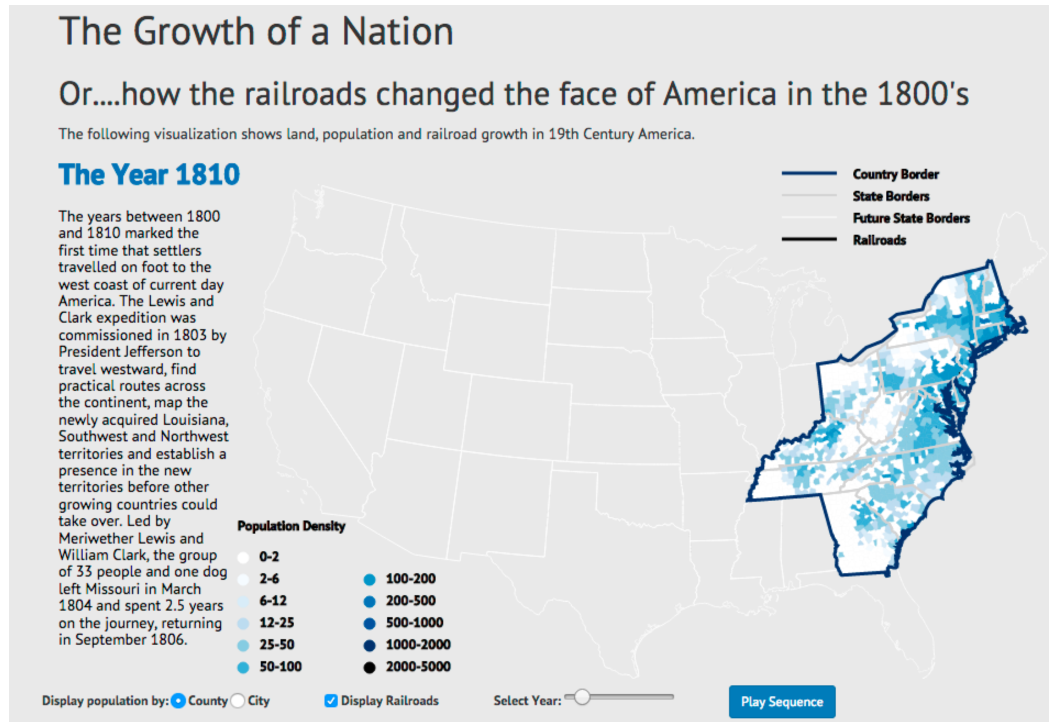

Manipulate
Change over Time
Select
Navigate
Item Reduction
Attribute Reduction
Zoom
Geometric or Semantic
Slice
Pan/Translate
Cut
Constrained
Project

Change over Time / Transitions

Change over Time

Use, e.g., slider to see view with data at different times

Sometimes better to show difference explicitly

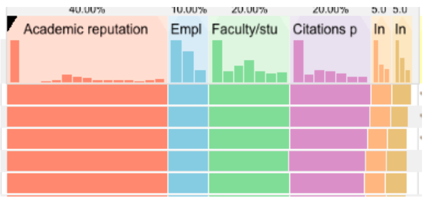


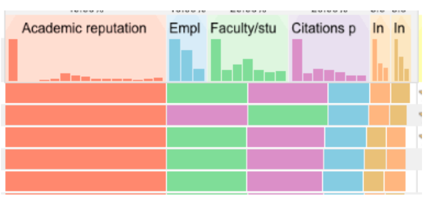
[Lauren Wood]

Change over Time

Doesn't have to be literal time:

- change as you go
- as part of an analysis process





(a) (b) (c) (d)

Tableau supports fluid changes between visual encoding idioms with drag and drop interaction. (a) Data encoded with bars. (b) Data encoded with stacked bars. (c) The user selects a completely different visual encoding. (d) Data encoded using geographic positions.

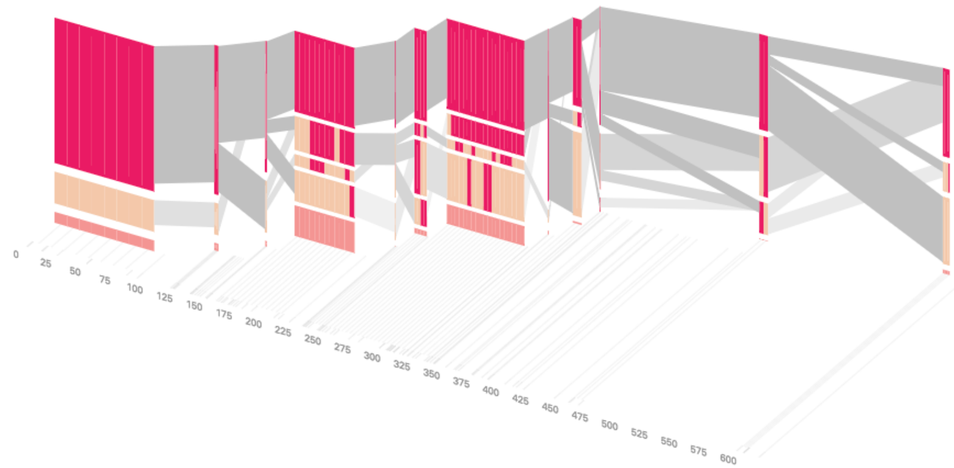
Why Transition?

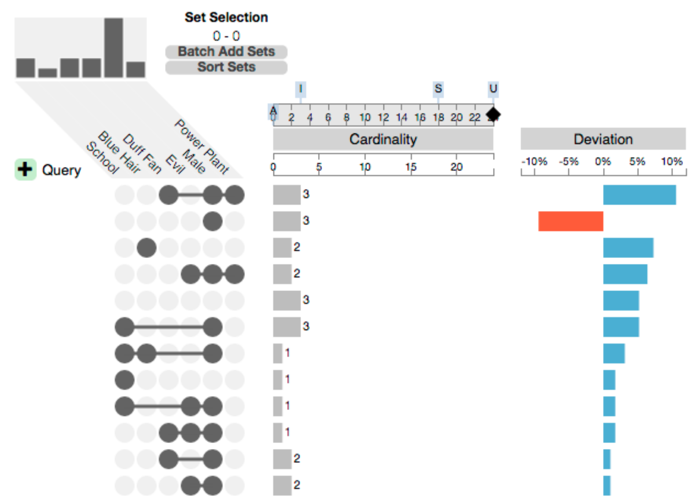
Different representations support different tasks

- bar chart, vs stacked bar chart

Change Ordering

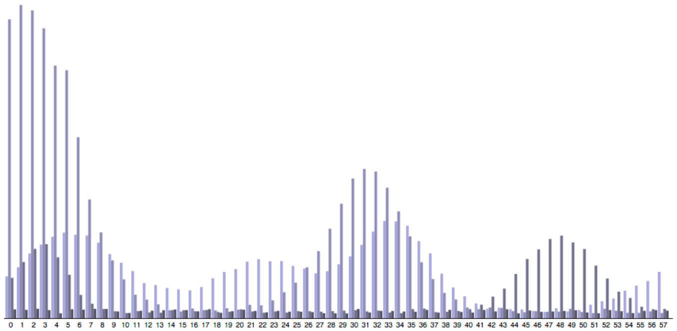
Transition make it possible for users to track what is going on





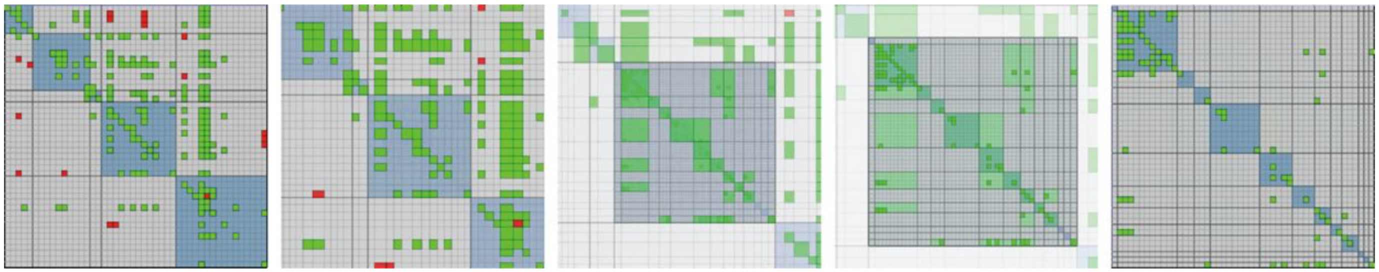
Animated Transitions

Smooth interpolation between states or visualization techniques



[Sunburst by John Stasko, Implementation in Caleydo by Christian Partl]

Animated Transitions

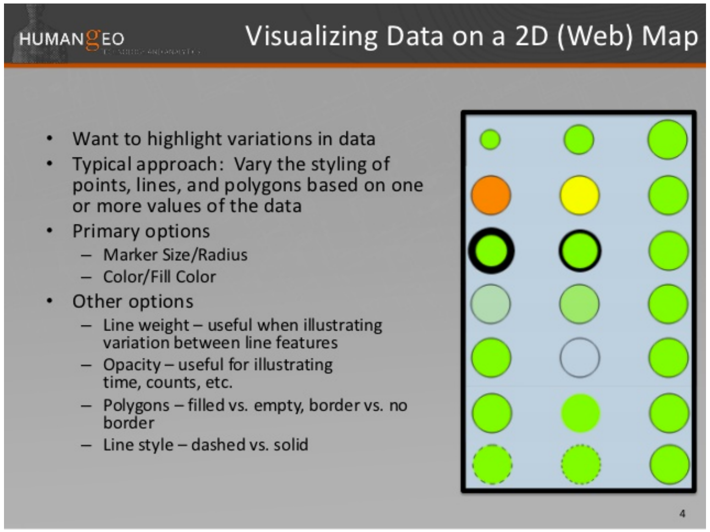


Frames from an animated transition showing zoom between levels in a compound network arranged as an adjacency matrix.

Select

A. Hover

B. Highlighting



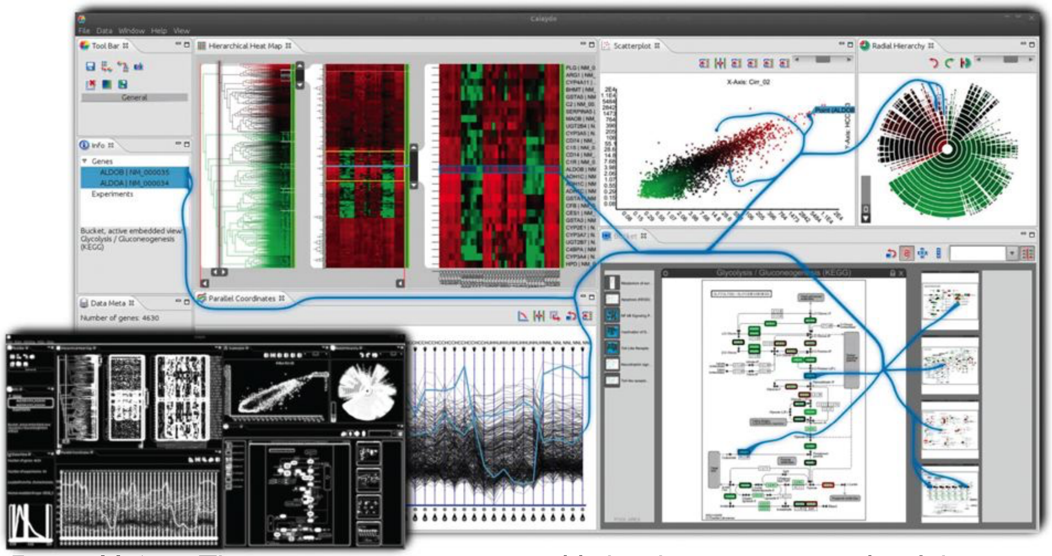
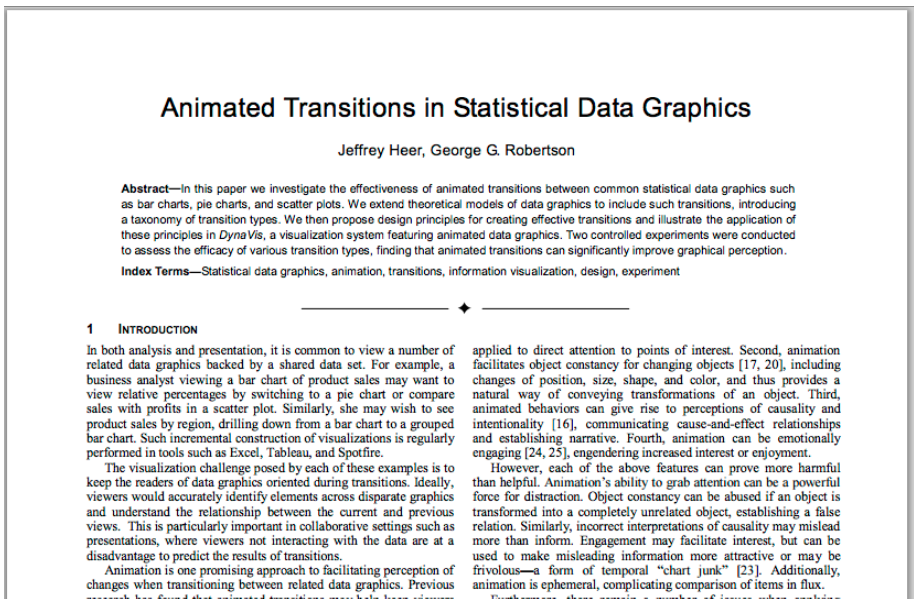


Figure 11.6. The context-preserving visual links idiom is an example of the design choice to coordinate betweeen views by explicitly drawing links as connection marks between items and regions of interest

Why Animated Transition?



Animated Transitions in Statistical Data Graphics

Jeffrey Heer, George G. Robertson

Abstract—In this paper we investigate the effectiveness of animated transitions between common statistical data graphics such as bar charts, pie charts, and scatter plots. We extend theoretical models of data graphics to include such transitions, introducing a taxonomy of transition types. We then propose design principles for creating effective transitions and illustrate the application of these principles in *DynaVis*, a visualization system featuring animated data graphics. Two controlled experiments were conducted to assess the efficacy of various transition types, finding that animated transitions can significantly improve graphical perception.

Index Terms—Statistical data graphics, animation, transitions, information visualization, design, experiment

1 Introduction

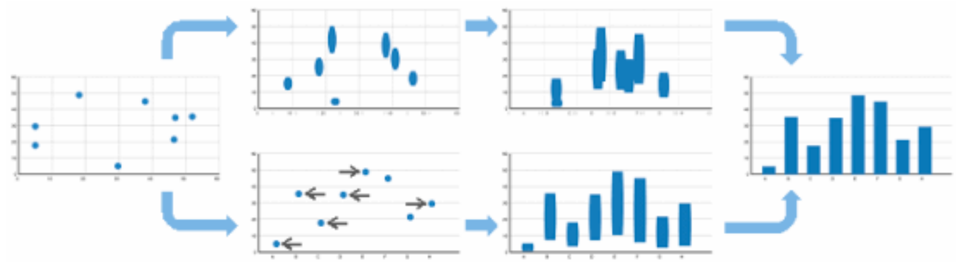
In both analysis and presentation, it is common to view a number of related data graphics backed by a shared data set. For example, a business analyst viewing a bar chart of product sales may want to view relative percentages by switching to a pie chart or compare sales with profits in a scatter plot. Similarly, she may wish to see product sales by region, drilling down from a bar chart to a grouped bar chart. Such incremental construction of visualizations is regularly performed in tools such as Excel, Tableau, and Spotfire.

The visualization challenge posed by each of these examples is to keep the readers of data graphics oriented during transitions. Ideally, viewers would accurately identify elements across disparate graphics and understand the relationship between the current and previous views. This is particularly important in collaborative settings such as presentations, where viewers not interacting with the data are at a disadvantage to predict the results of transitions.

Animation is one promising approach to facilitating perception of changes when transitioning between related data graphics. Previous

applied to direct attention to points of interest. Second, animation facilitates object constancy for changing objects [17, 20], including changes of position, size, shape, and color, and thus provides a natural way of conveying transformations of an object. Third, animated behaviors can give rise to perceptions of causality and intentionality [16], communicating cause-and-effect relationships and establishing narrative. Fourth, animation can be emotionally engaging [24, 25], engendering increased interest or enjoyment.

However, each of the above features can prove more harmful than helpful. Animation's ability to grab attention can be a powerful force for distraction. Object constancy can be abused if an object is transformed into a completely unrelated object, establishing a false relation. Similarly, incorrect interpretations of causality may mislead more than inform. Engagement may facilitate interest, but can be used to make misleading information more attractive or may be frivolous—a form of temporal "chart junk" [23]. Additionally, animation is ephemeral, complicating comparison of items in flux.



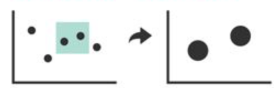
Navigation

Navigate

→ Item Reduction

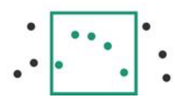
→ *Zoom*

Geometric or *Semantic*



→ *Pan/Translate*

→ *Constrained*



Navigation

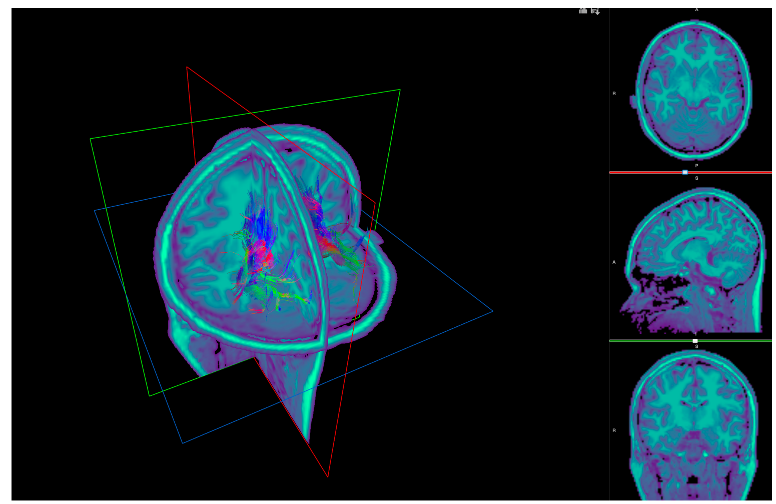
Pan

move around

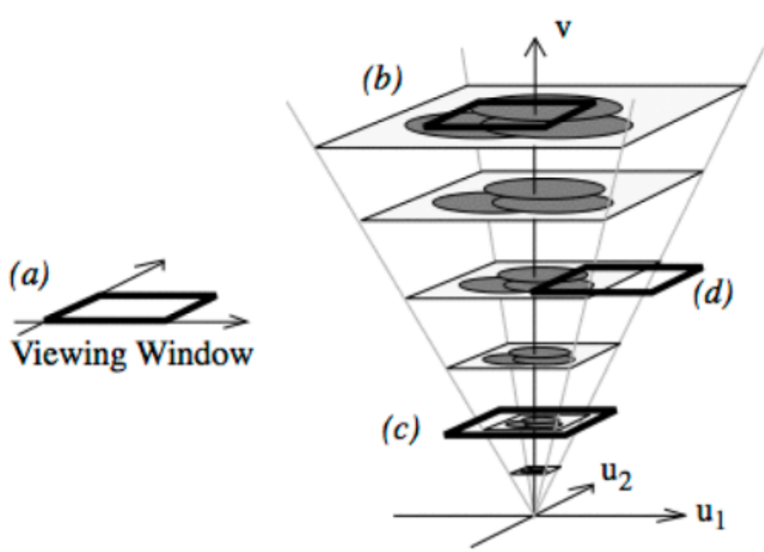
Zoom

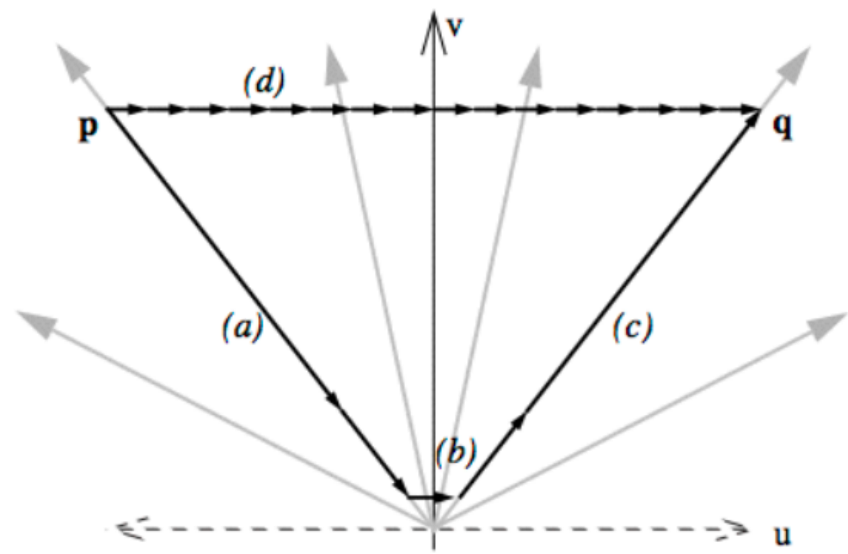
enlarge/ make smaller (move camera)

Rotate

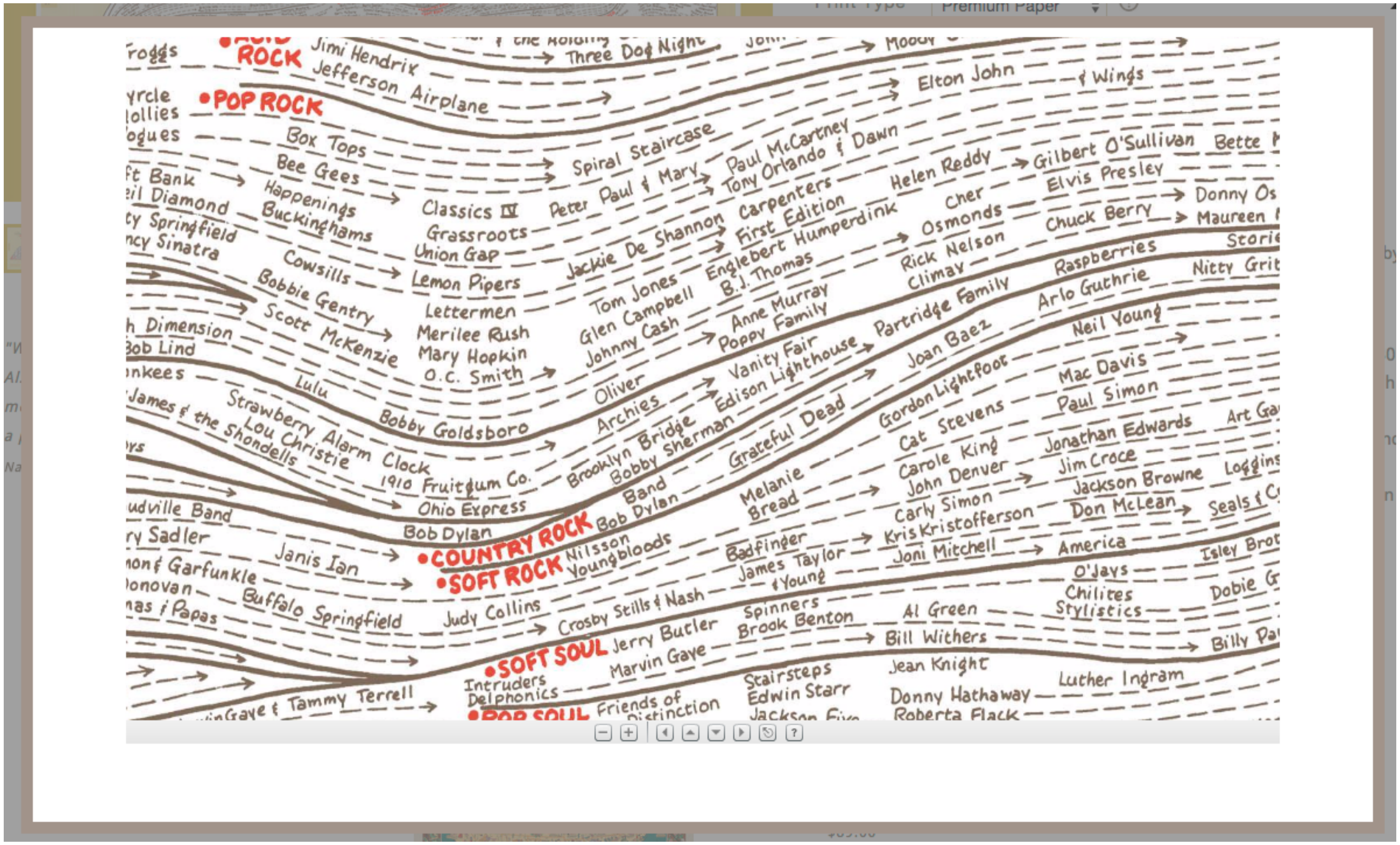


Space-Scale Diagrams





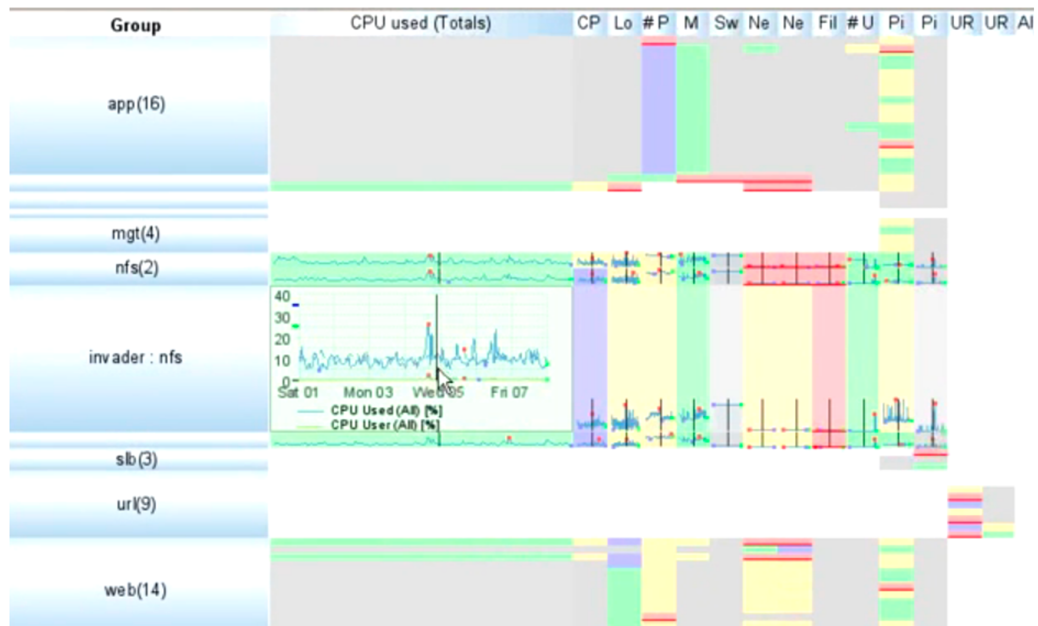
[Furnas & Bederson 1995]


ROCK
Jimi Hendrix
Jefferson Airplane
Three Dog Night
Elton John
& Wings
POP ROCK
Box Tops
Bee Gees
Spiral Staircase
Paul McCartney
Tony Orlando & Dawn
Helen Reddy
Gilbert O'Sullivan
Elvis Presley
Happenings
Buckinghams
Classics IV
Peter Paul & Mary
Carpenters
First Edition
Cher
Grassroots
Union Gap
Jackie De Shannon
Englebert Humperdink
Osmonds
Chuck Berry
Cowsills
Lemon Pipers
Tom Jones
B.J. Thomas
Rick Nelson
Climax
Raspberries
Bobbie Gentry
Lettermen
Glen Campbell
Anne Murray
Partridge Family
Arlo Guthrie
Scott McKenzie
Merilee Rush
Johnny Cash
Poppy Family
Neil Young
Mary Hopkin
O.C. Smith
Vanity Fair
Joan Baez
Oliver
Edison Lighthouse
Mac Davis
Lulu
Archies
Gordon Lightfoot
Paul Simon
Strawberry Alarm Clock
Lou Christie
Bobby Goldsboro
Brooklyn Bridge
Bobby Sherman
Grateful Dead
Cat Stevens
Jonathan Edwards
Carole King
Jim Croce
1910 Fruitgum Co.
Band
Melanie
John Denver
Jackson Browne
Ohio Express
Bob Dylan
Bread
Carly Simon
Don McLean
Bob Dylan
COUNTRY ROCK
Kris Kristofferson
Janis Ian
Nilsson
Badfinger
SOFT ROCK
Youngbloods
James Taylor
& Young
Joni Mitchell
America
O'Jays
Buffalo Springfield
Judy Collins
Crosby Stills & Nash
Spinners
Chilites
Stylistics
Brook Benton
Al Green
Jerry Butler
Bill Withers
SOFT SOUL
Marvin Gaye
Jean Knight
Stairsteps
Intruders
Delphonics
Luther Ingram
Friends of Distinction
Edwin Starr
Donny Hathaway
Tammy Terrell
Roberta Flack

Semantic Zooming

Semantic Zooming

- As you zoom in, content is updated
- More detail as more space becomes available
- Ideally readable at multiple resolutions
- Changing Representation



[McLachlan 2008]

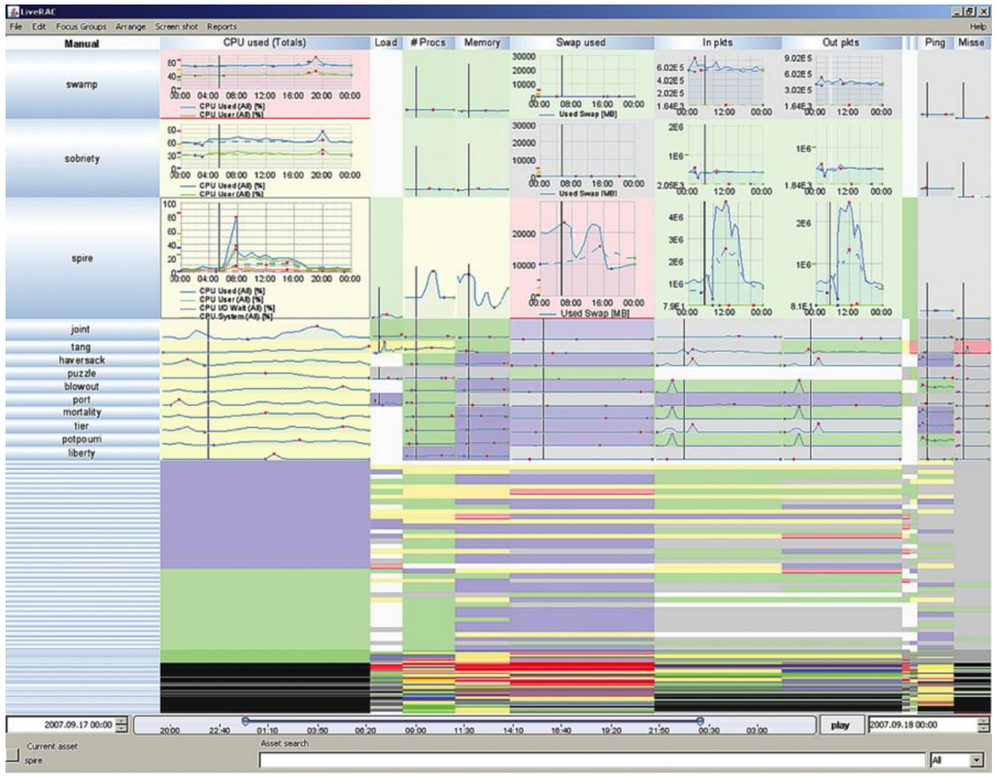
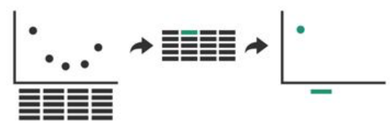


Figure 11.7. LiveRAC uses semantic zooming within a stretchable grid of time-series line charts.

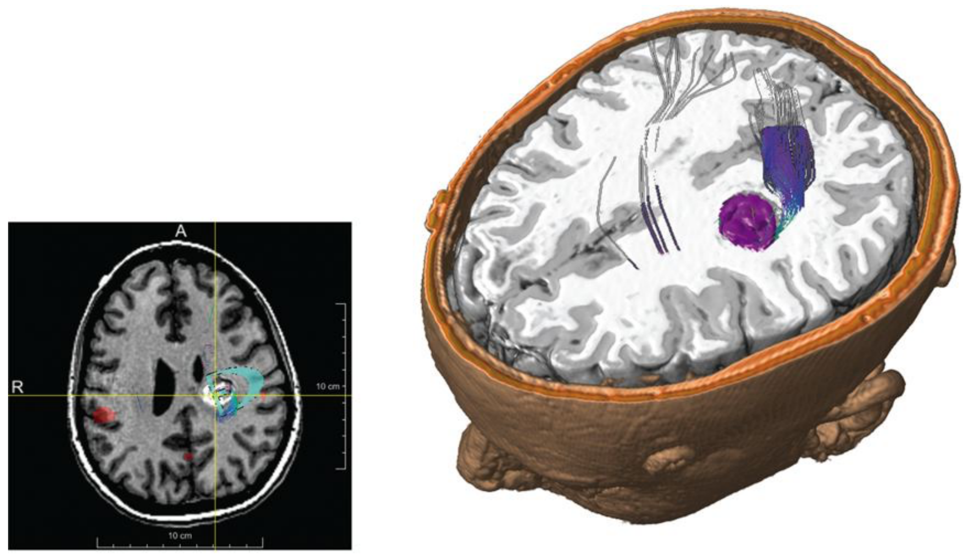
→ Attribute Reduction

→ *Slice*



→ *Cut*

→ *Project*



(a) (b)

Figure 11.8. The *slice* choice eliminates a dimension/attribute by extracting only the items with a chosen value in that dimension. The *cut* choice eliminates all data on one side of a spatial cutting plane. (a) Axis-aligned slice. (b) Axis-aligned cut.

Chapter 12

Faceting

Facet

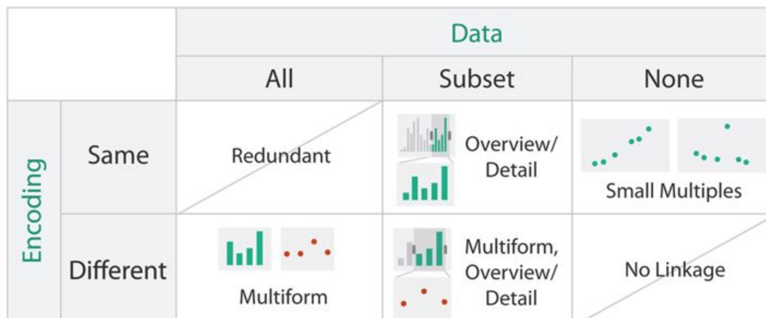
Juxtapose and Coordinate Multiple Side-by-Side Views

→ Share Encoding: Same/Different

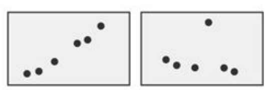
→ *Linked Highlighting*

→ Share Data: All/Subset/None

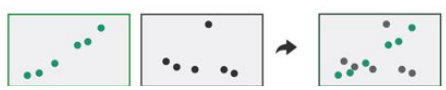
→ Share Navigation



Partition into Side-by-Side Views



Superimpose Layers



Linked Highlighting

Facet

Juxtapose and Coordinate Multiple Side-by-Side Views

→ Share Encoding: Same/Different

→ *Linked Highlighting*

(a) (b)

inked highlighting between views shows how regions that are contiguous in one view are distributed within another. (a) Selecting the high salaries in the upper right window shows different distributions in the other views. (b) Selecting the bottom group in the *Assists-PutOuts* window shows that the clump corresponds to specific positions played.

(Munzner)

Munzner, Tamara. *Visualization Analysis and Design*. A K Peters/CRC Press, 20140929. VitalBook file.

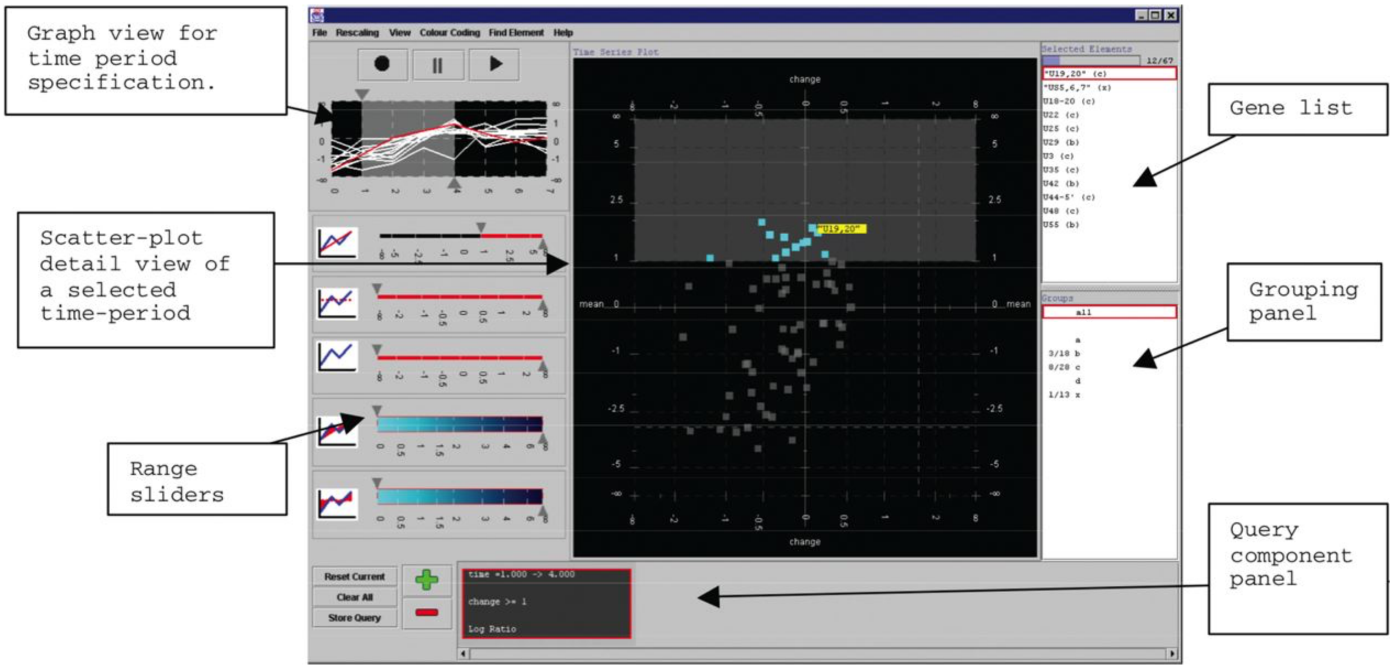
➔ Share Data: All/Subset/None

Same Encoding, Different Data

Overview–detail example with geographic maps, where the views have the same encoding and dataset; they differ in viewpoint and size.

→ Share Navigation

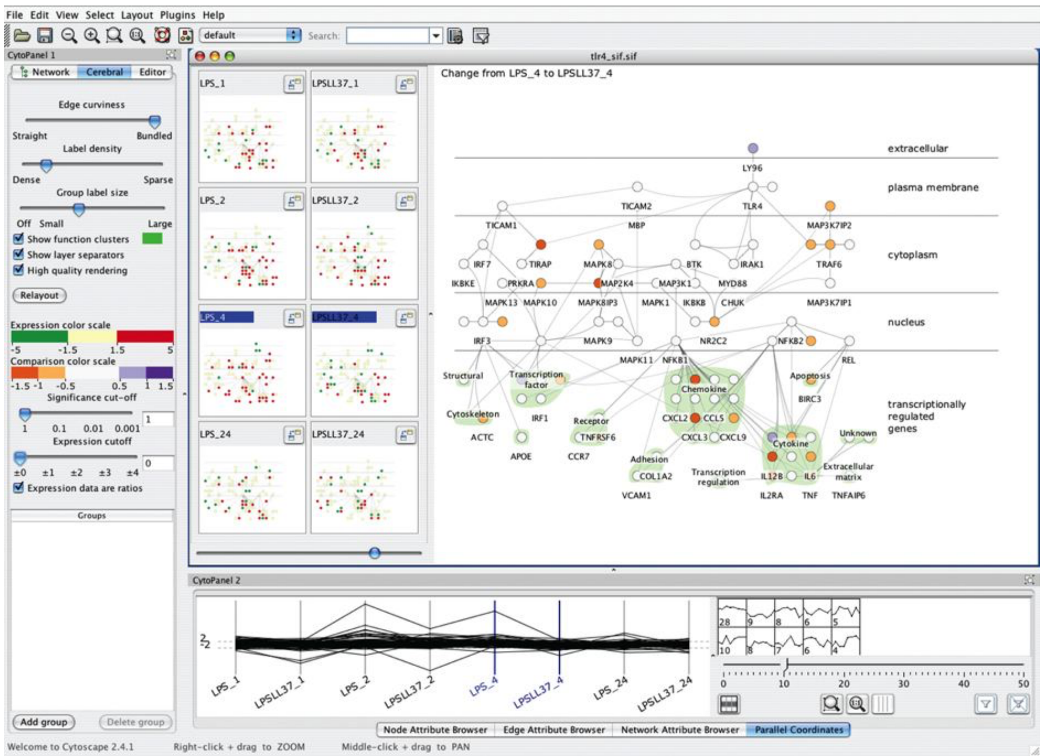
Detail on Demand



Multiform overview–detail vis tool for microarray exploration features a central scatterplot linked with the graph view in the upper left.

Single View, Navigation

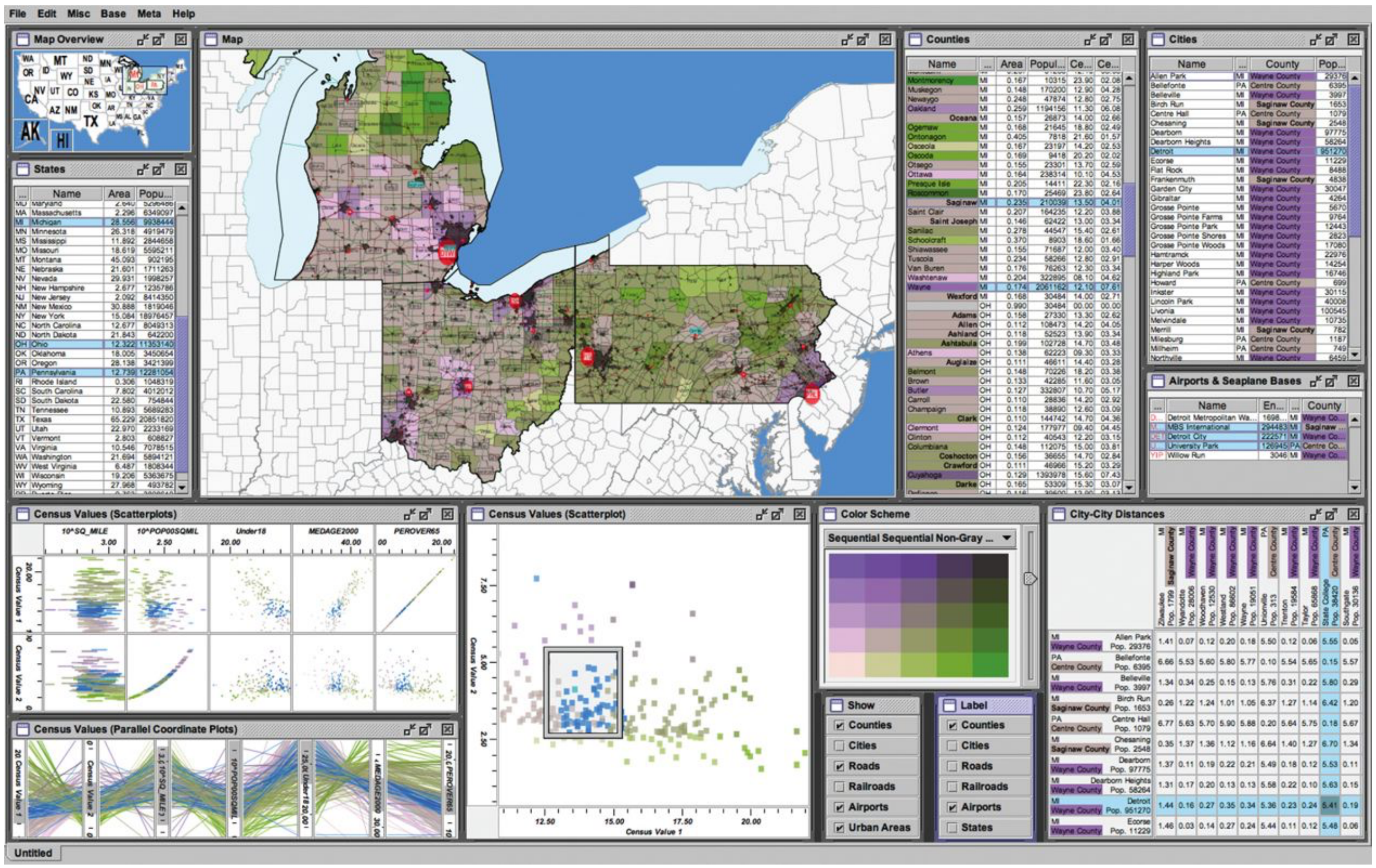
Multiple Views, Single Navigation



Cerebral uses small-multiple views to show the same base graph of gene interactions colored according to microarray measurements made at different times. The coloring in the main view uses the derived attribute of the difference in values between the two chosen views.

➔ Share Navigation

Multiform Views



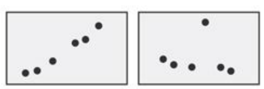
The Improvise toolkit [Weaver 04] was used to create this census vis that has many forms of coordination between views. It has many multiform views, some of which use small multiples, and some of which provide additional detail information.

		Data		
		All	Subset	None
Encoding	Same	Redundant	Overview/ Detail	Small Multiples
	Different	Multiform	Multiform, Overview/ Detail	No Linkage

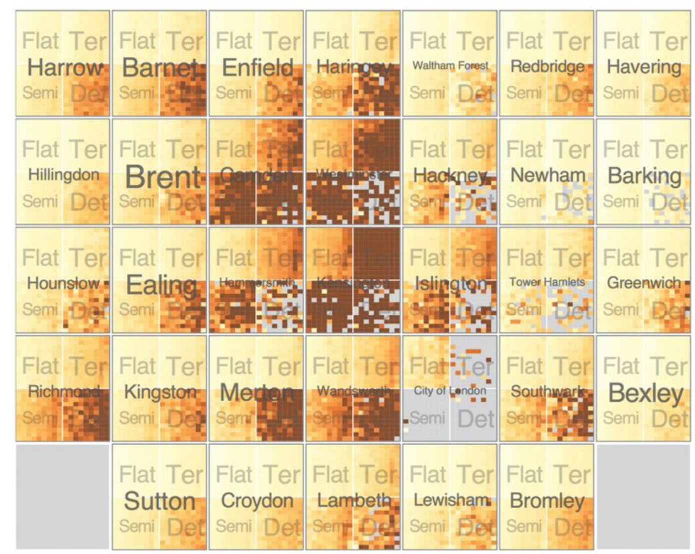
Partition Choices

HiVE with different arrangements. (a) Sizing regions according to sale counts yields a treemap. (b) Arranging the second-level regions as choropleth ma

Partition into Side-by-Side Views



(a)

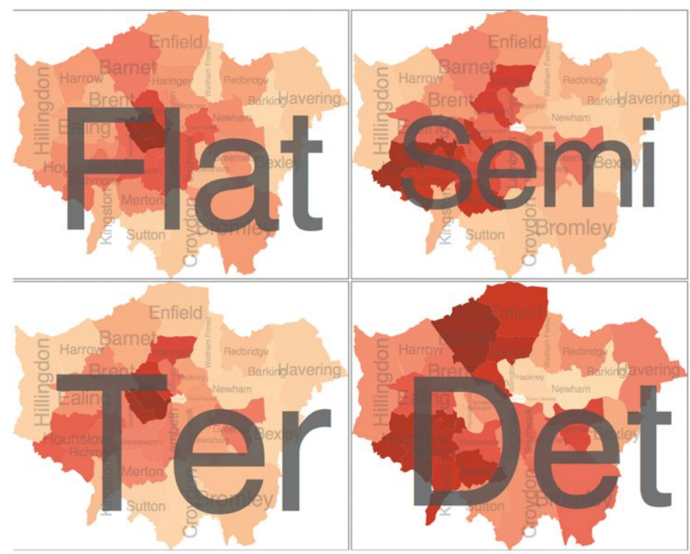


(b)

Partition Choices

The HiVE system supports exploration through different partitioning choices. (a) Recursive matrix alignment where the first split is by the house type attribute, and the second by neighborhood. The lowest levels show time with years as rows and months as columns. (b) Switching the order of the first and second splits shows radically different patterns.

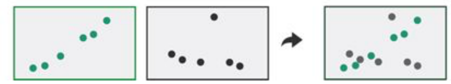
(a)

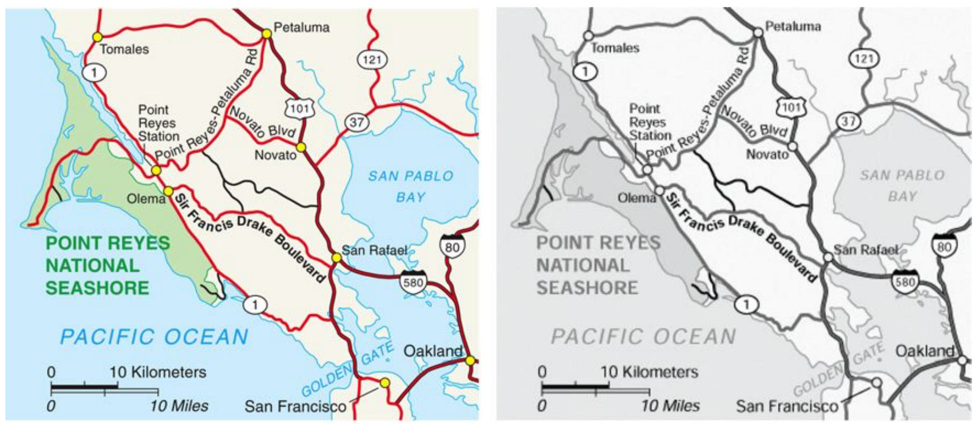


(b)

Layering

Superimpose Layers

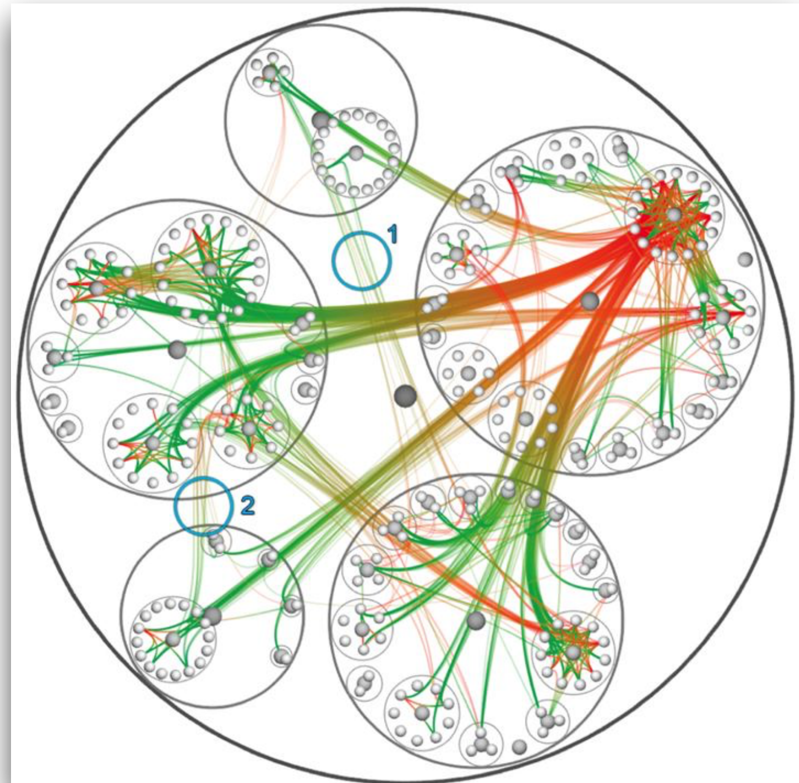




(a) (b)

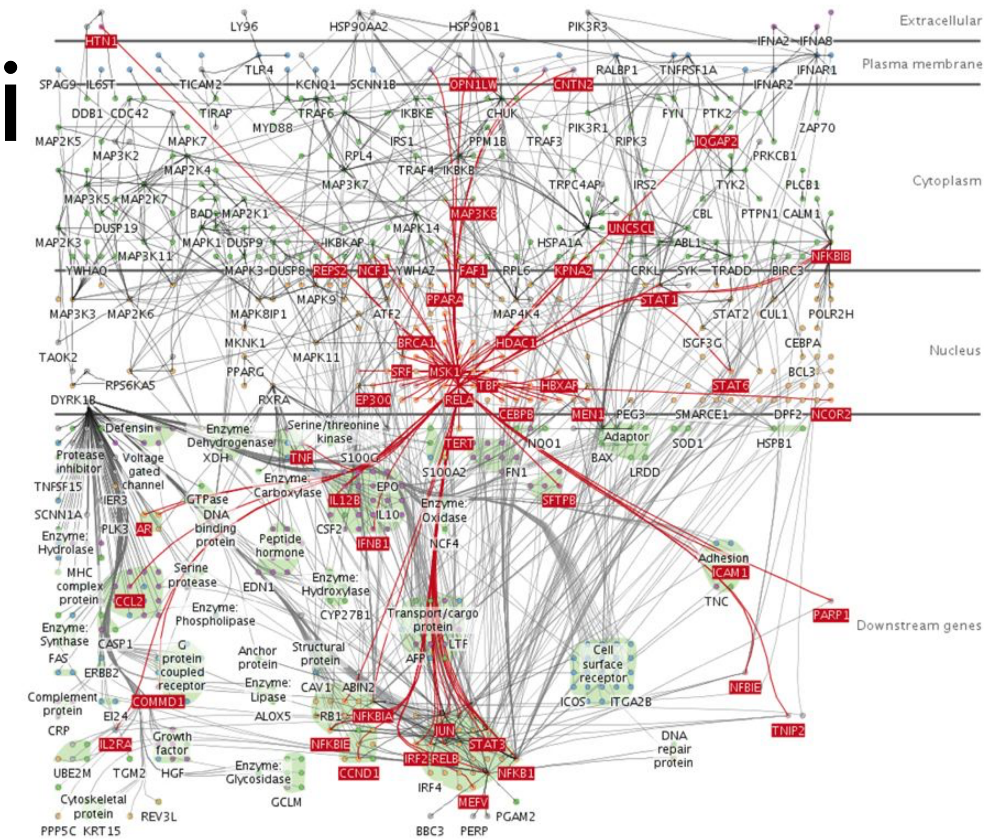
Static visual layering in maps. (a) The map layers are created by differences in the hue, saturation, luminance, and size channels on both area and line marks. (b) The grayscale view shows that each layer uses a different range in the luminance channel, providing luminance contrast.

Layering



The hierarchical edge bundles idiom shows a compound network in three layers: the tree structure in back with containment circle marks, the red–green graph edges with connection marks in a middle layer, and the graph nodes in a front layer

Dynamic Layeri



Cerebral dynamically creates a foreground visual layer of all nodes one topological hop away in the network from the node underneath the cursor.

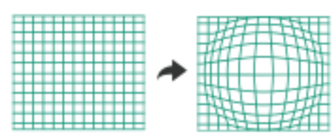
Chapter 13

Embed

Elide Data

Superimpose Layer

Distort Geometry



Focus + Context

Focus + Context

carefully pick what to show

hint at what you are not showing

Focus + Context

synthesis of **visual encoding and interaction**

user selects region of interest (focus)
through navigation or selection

provide context through

- aggregation
- reduction
- layering

Elision

e·li·sion
/iˈliZHən/
noun

the omission of a sound or syllable when speaking (as in *I'm*, *let's*, *e ' en*).

- an omission of a passage in a book, speech, or film.
  "the movie's elisions and distortions have been carefully thought out"
- the process of joining together or merging things, especially abstract ideas.
  "unease at the elision of so many vital questions"

focus items shown in detail,

other items summarized for context

Superimpose

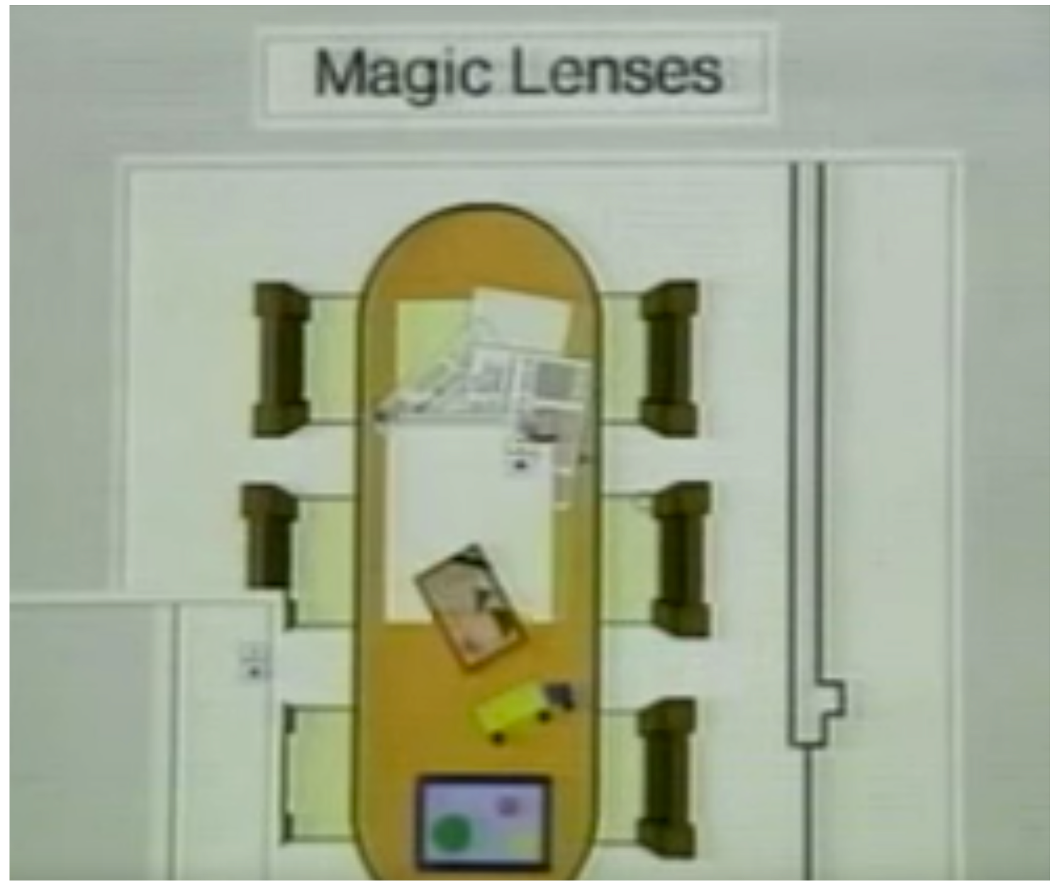
focus layer limited to a local region of view,
instead of stretching across the entire view

Toolglass & Magic Lens

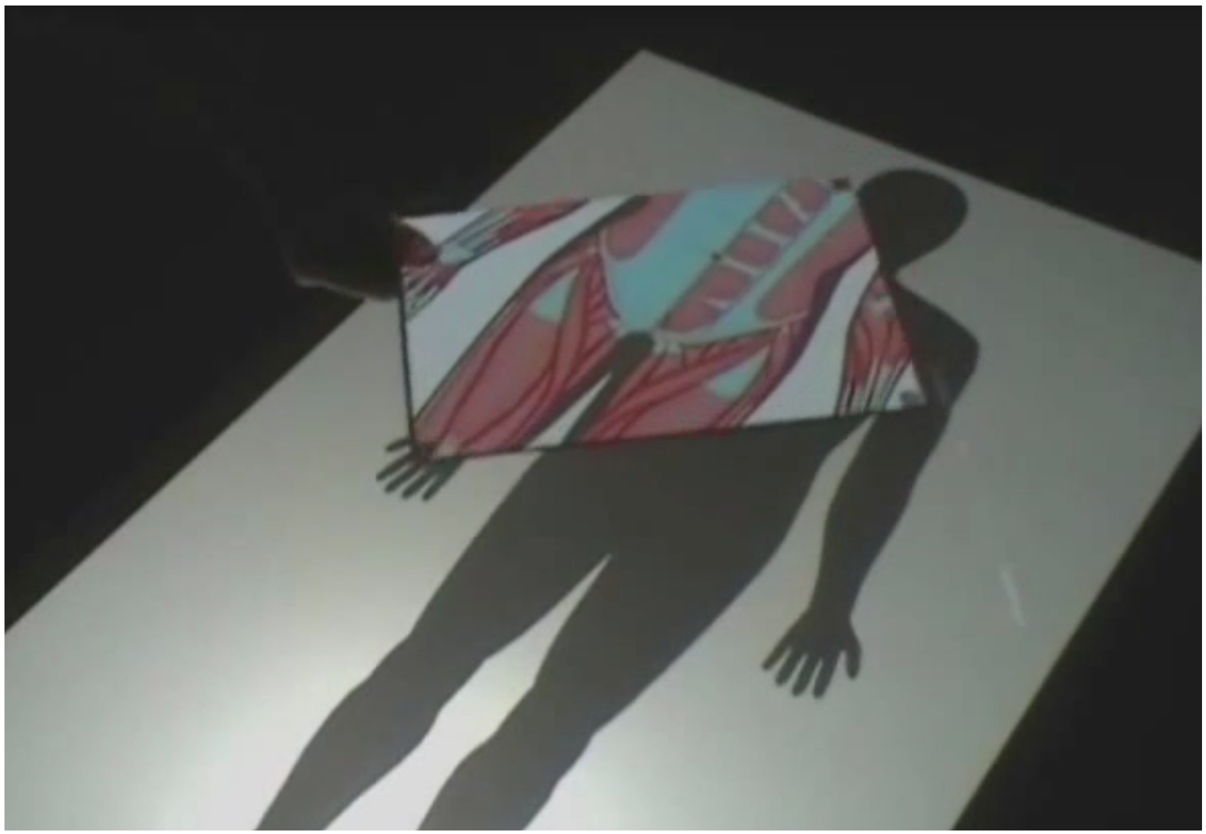
Magic Lens:

details/different data is shown
when moving a lens
over a scene

[Bier, Siggraph 1993]

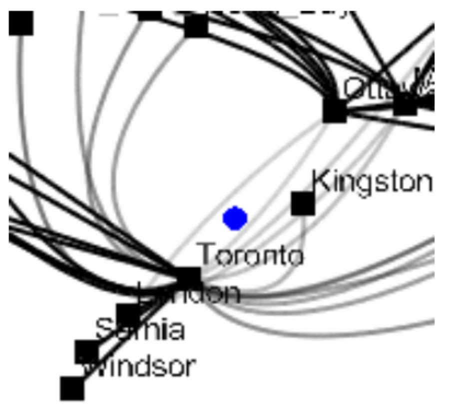


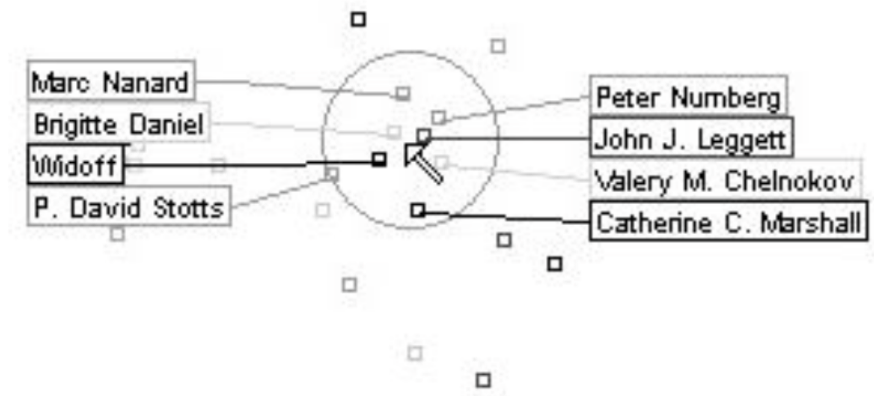
Magic Lense with Tangible Interface



[Spindler, CHI 2010]

Magic Lens: Edges & Labeling





[Fekete and Plaisant, 1999]

Distortion

use geometric distortion of the contextual regions to make room for the details in the focus region(s)

Distortion - Perspective

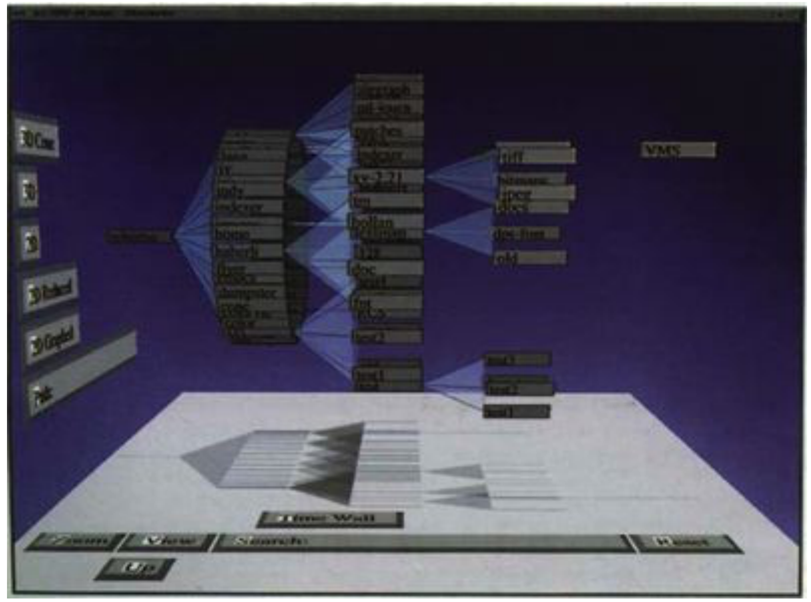
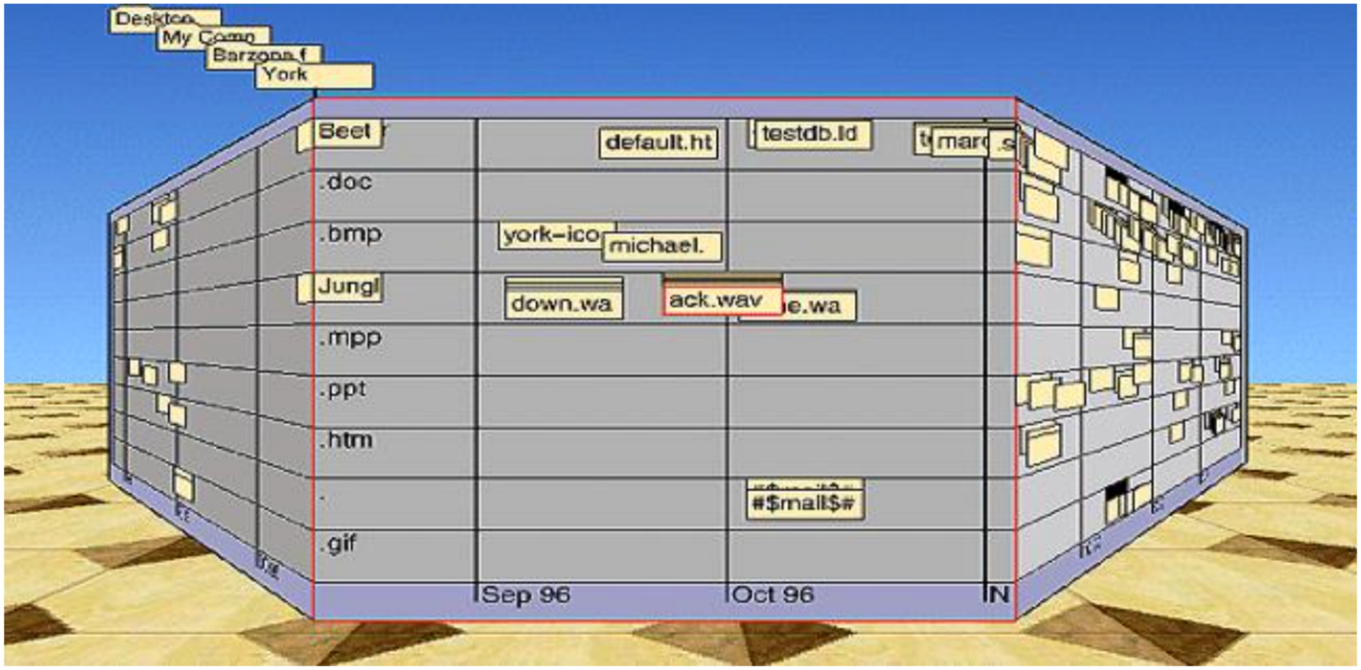


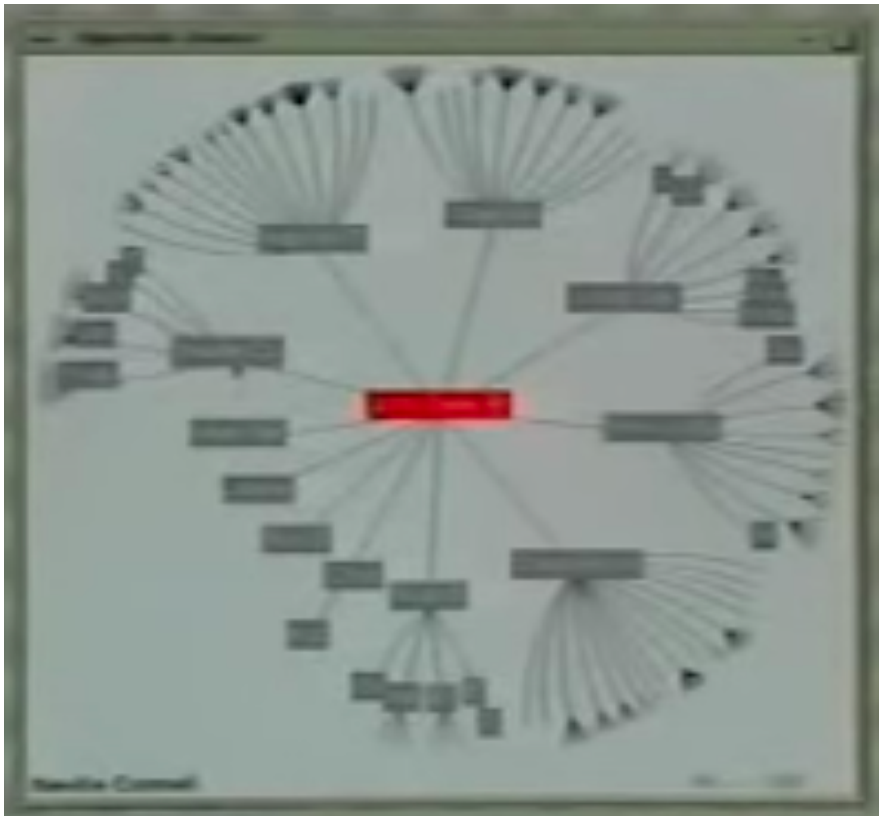
Figure 14.4. The Cone Tree system used 3D perspective for focus+context, providing a global distortion region with a single focus point, and using standard geometric navigation for interaction.

Perspective Wall



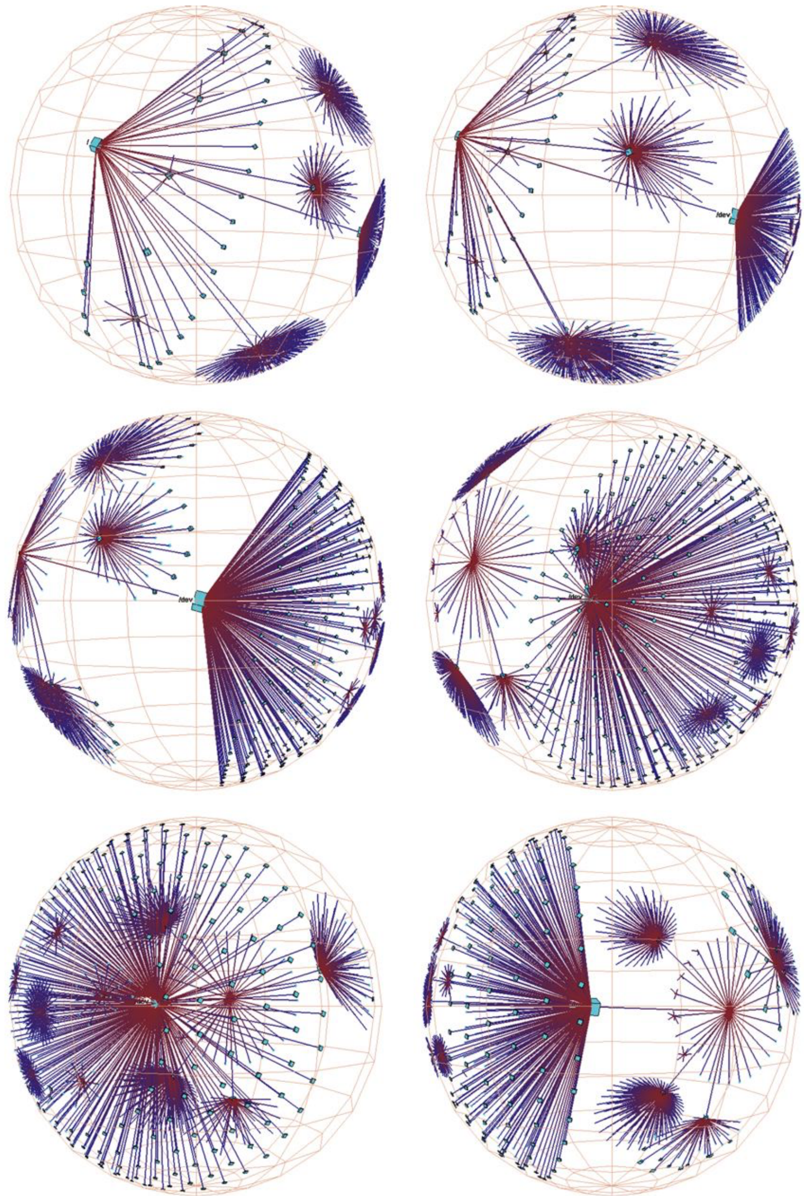
[Mackinlay, 1991]

Hyperbolic Geometry

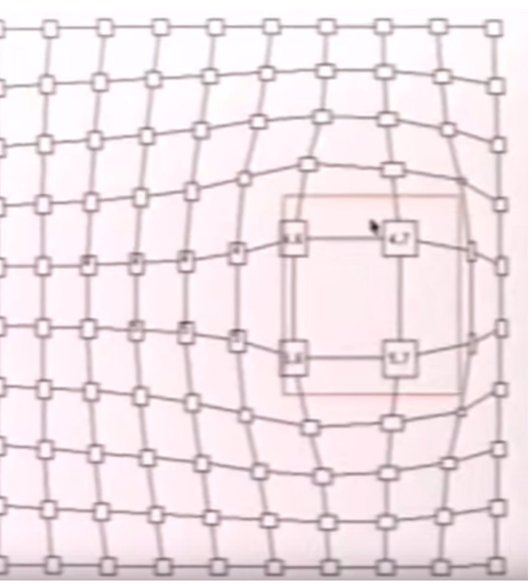


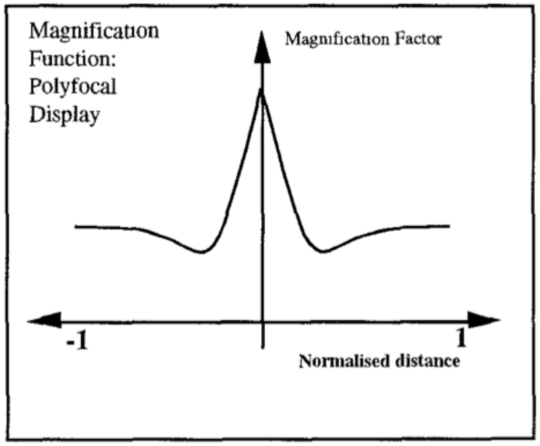
[Lamping, 1995]

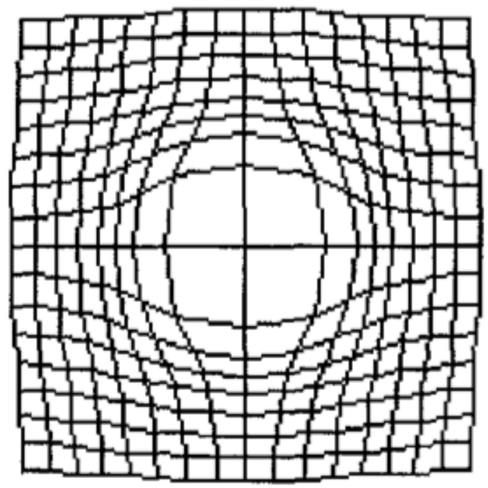
Munzner

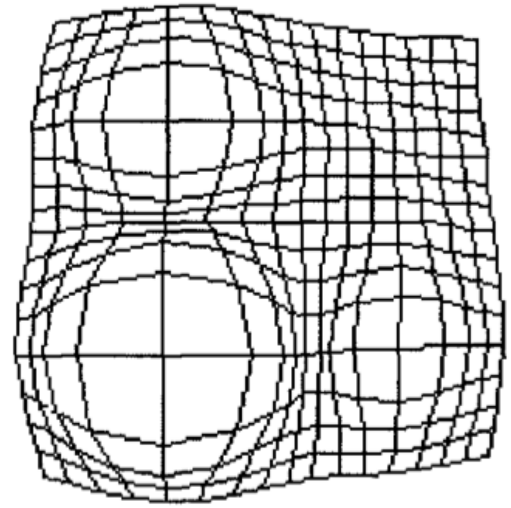


Fisheye



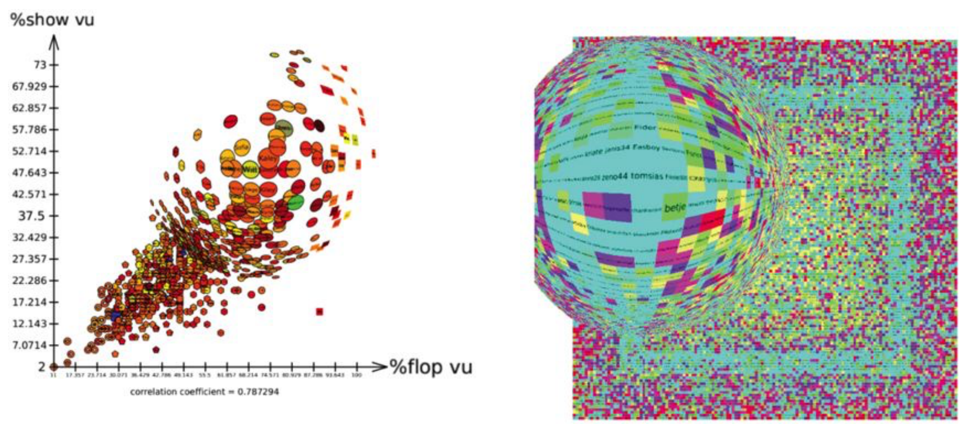






[Sarkar, 1993]

Leung 1994

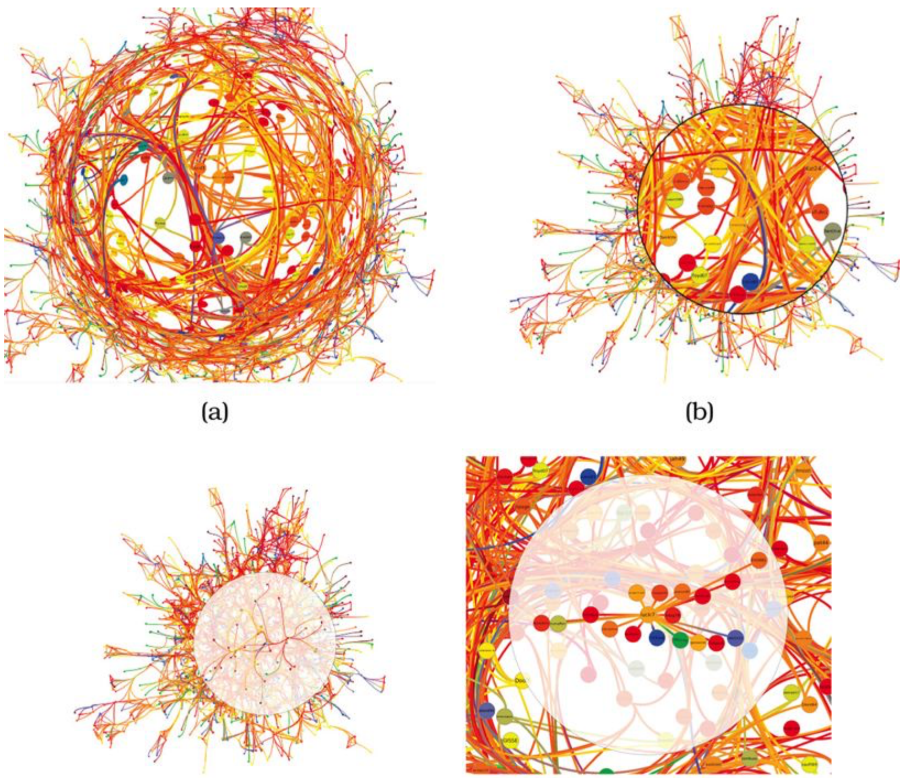


(a) (b)

Figure 14.5. Focus+context with interactive fisheye lens, with poker player dataset. (a) Scatterplot showing correlation between two strategies. (b) Dense matrix view showing correlation between a specific complex strategy and the player's winning rate, encoded by color.


Saskatchewan
Edmonton
Calgary
Winnipeg
Ontario
Quebec
Vancouver
Seattle
Spokane
Washington
Portland
Oregon
Montana
Idaho
Wyoming
North Dakota
South Dakota
Minnesota
Minneapolis
Wisconsin
Michigan
Madison
Milwaukee
Detroit
Chicago
Toledo
Iowa
Nebraska
Omaha
Lincoln
Illinois
Indiana
Ohio
Salt Lake City
Nevada
Utah
Colorado
United States
Kansas
Kansas City
St. Louis
Missouri
Sacramento
Stockton
California
Las Vegas
Bakersfield
Los Angeles
Riverside
Mexicali
Tijuana
Ensenada
Arizona
Phoenix
Tucson
Albuquerque
New Mexico
Ciudad Juarez
Wichita
Tulsa
Oklahoma
Arkansas
Tennessee
Memphis
Mississippi
Dallas
Texas
San Antonio
Houston
Louisiana
Alabama
Mobile
Atlanta
Georgia
Kentucky
Ottawa
Montreal
Toronto
Buffalo
New York
Cleveland
Pennsylvania
Philadelphia
Columbus
West Virginia
Virginia
North Carolina
South Carolina
Maine
Rhode Island
Connecticut
New Jersey
Delaware
Maryland
District of Columbia
Jacksonville
Orlando
Florida
Miami
Gulf of Mexico
Gulf of California
Hermosillo
Chihuahua
Ciudad Obregón
Los Mochis
La Paz
Culiacán
Mazatlán
Monclova
Nuevo Laredo
Corpus Christi
Matamoros
Saltillo
Monterrey
Ciudad Victoria
México
Aguascalientes
San Luis

http://pmcruz.com/information-visualization/data-lenses



(a) (b)

(c) (d)

Distortion Concerns

- unsuitable for relative spatial judgements
- overhead of tracking distortion
- visual communication of distortion
  - gridlines, shading
- target acquisition problem
  - lens displacing items away from screen location
- mixed results compared to separate views and temporal navigation
- fisheye follow-up: concern with enthusiasm over distortion
  - what is being shown: selective filtering
  - how it is being shown: distortion as one possibility

Read Chapter 15

for inspiration