Interaction in data visualization

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SCC0672 Visualização Computacional

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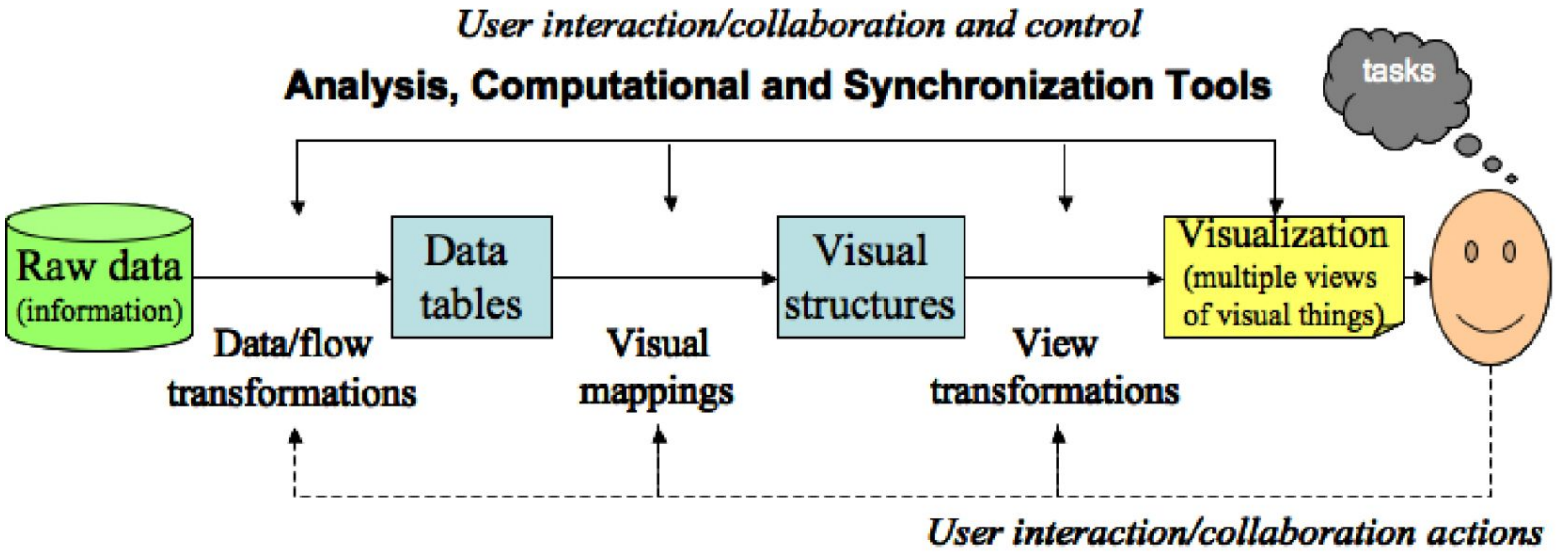
Outline

- Part 1: Overview of techniques
- Part 2: Taxonomies of interaction for Vis

Part 1 – Overview of interaction techniques



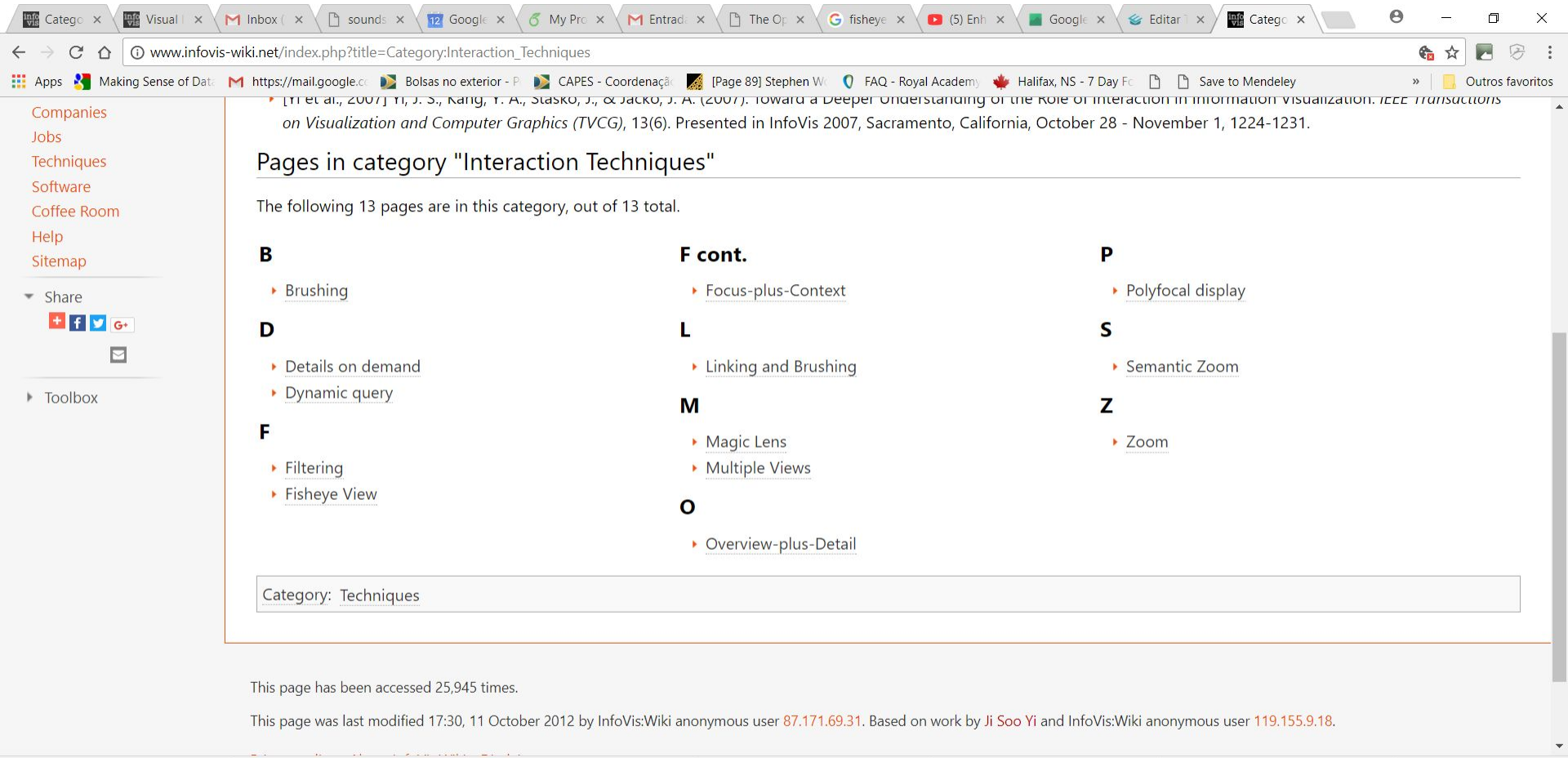
General pipeline model for visual analysis

InfoViz wiki

- http://www.infovis-wiki.net/

- Catalog of interaction techniques
  - https://infovis-wiki.net/wiki/Category:Interaction_Techniques

InfoViz wiki



Linking & Brushing

- ***Linking and brushing*** *are interaction techniques. They can be used to enhance the work with scatterplot matrices, parallel coordinates and many other InfoVis techniques*
- ***Brushing*** *means selecting a subset of the data items with an input device (mouse). This is usually done to highlight this subset, but it can also be done to delete it from the view or to de-emphasize it, if the user wants to focus on the other items. Brushing is most interesting in connection with* ***linking****. For instance in a scatterplot matrix, the user could brush some points in one plot. This causes the brush effect (highlighting, etc.) to be applied on those points in the other plots that represent the same data items.* [Voigt, 2002]

Linking & Brushing examples

- https://bl.ocks.org/mbostock/4063663
- https://www.youtube.com/watch?v=koFm2Rv0rnw
- Ggobi demos: http://www.ggobi.org/demos/

Linking & Brushing

- By linking, we mean showing how a point, or set of points, behaves in each of the plots. This is accomplished by highlighting these points in some fashion. For example, the highlighted points could be drawn as a filled circle while the remaining points could be drawn as unfilled circles. A typical application of this would be to show how an outlier shows up in each of the individual pairwise plots. Brushing extends this concept a bit further. In brushing, the points to be highlighted are interactively selected by a mouse and the scatterplot matrix is dynamically updated (ideally in real time). That is, we can select a rectangular region of points in one plot and see how those points are reflected in the other plots.
- Brushing: discussed in detail by Becker, Cleveland, and Wilks in the paper *"Dynamic Graphics for Data Analysis"* (Cleveland and McGill, 1988).

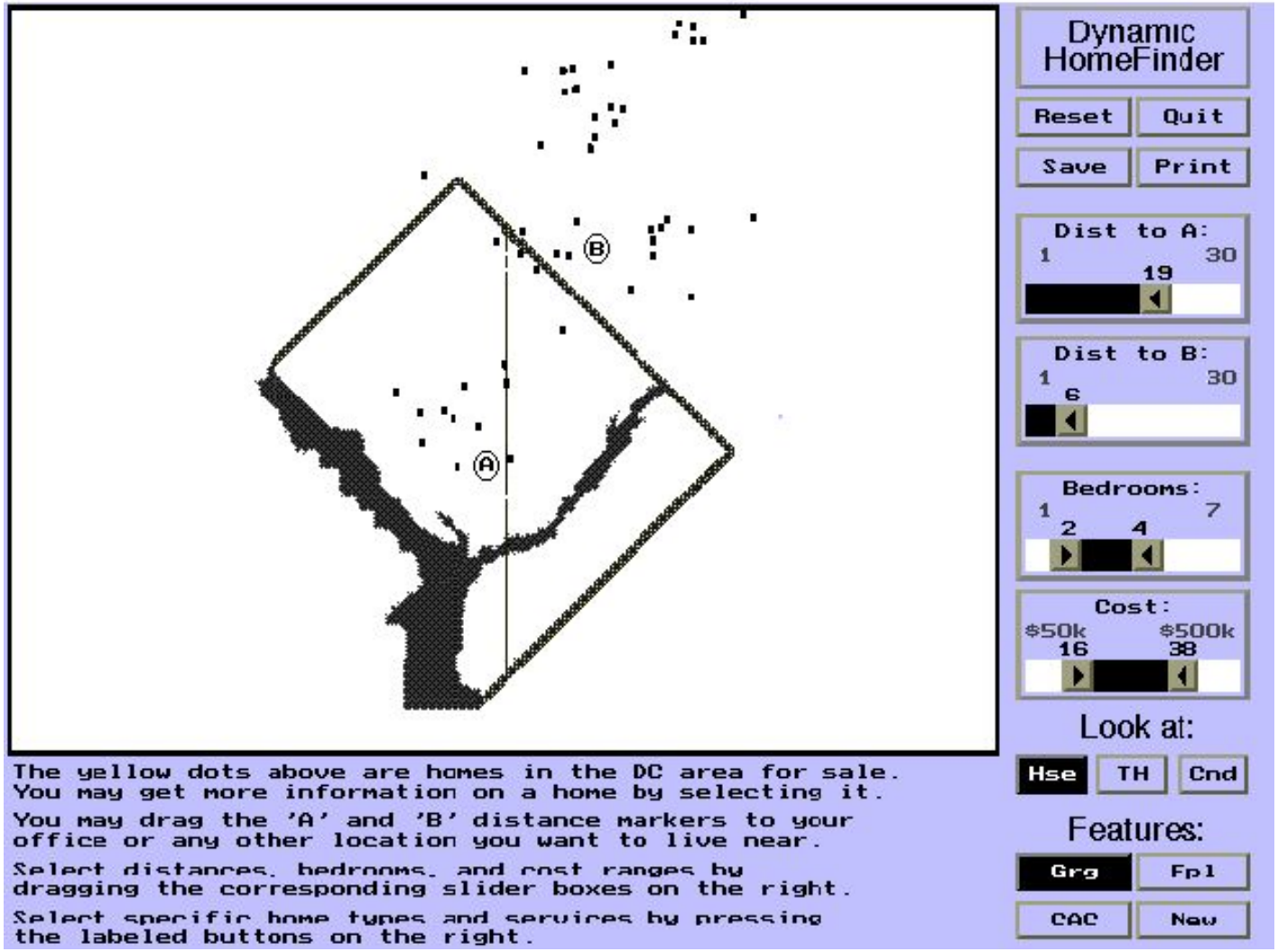
Dynamic query

- Visual widgets for querying a database
- Constantly need to update queries as users adjust sliders or select buttons
  - Visual representation of query
  - Visual representation of results
  - Rapid and incremental control of query
  - Immediate and continuous feedback
- Highly innovative in early 90's!

Dynamic query

- Video HomeFinder: https://www.youtube.com/watch?v=5X8XY9430fM
- Video CHI collection: Visual Information Seeking
- B. Shneiderman's Overview, filter, then details-on-demand

HomeFinder


Dynamic HomeFinder
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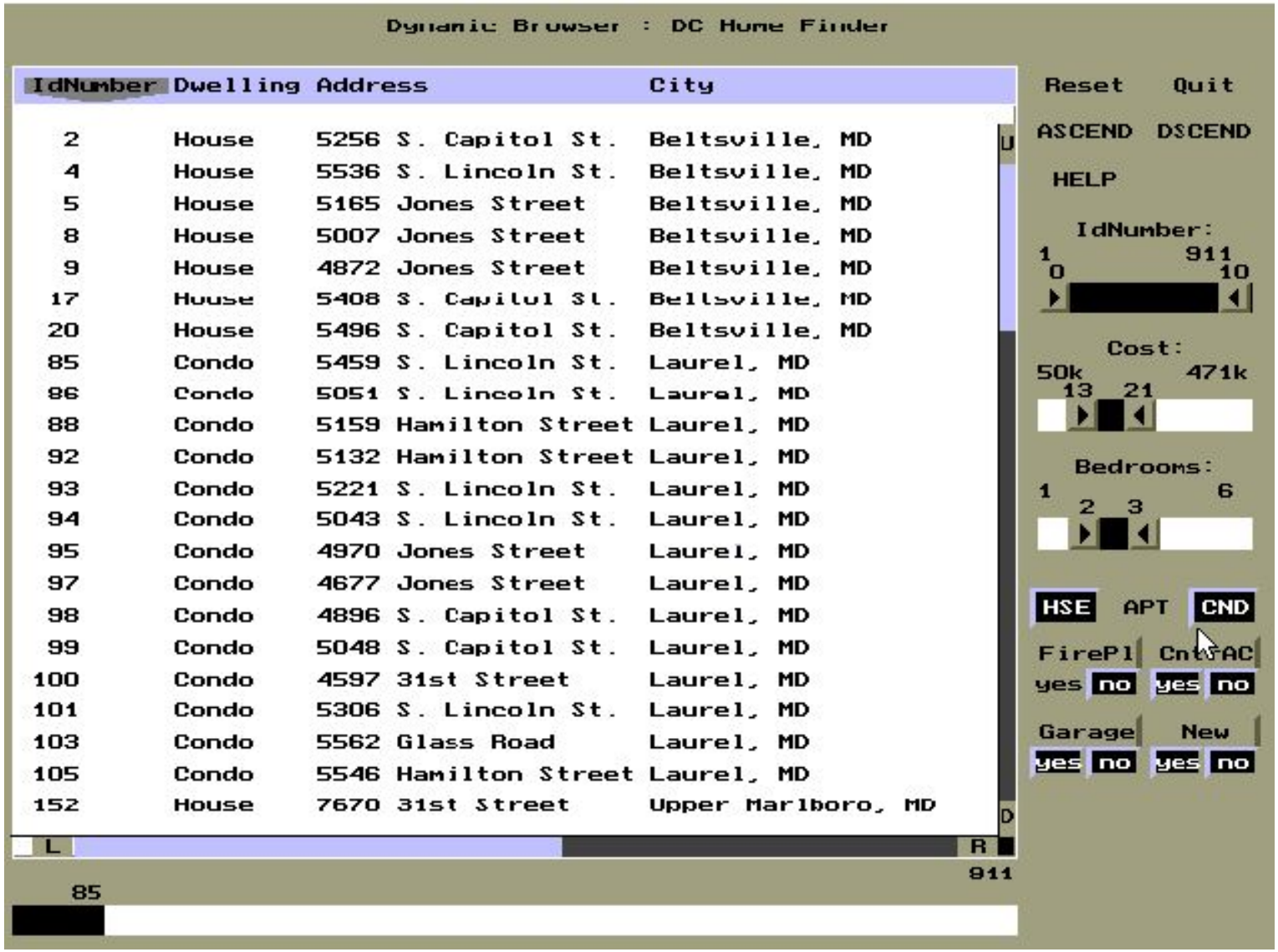
Grg
Fpl
CAC
New
The yellow dots above are homes in the DC area for sale.
You may get more information on a home by selecting it.
You may drag the 'A' and 'B' distance markers to your
office or any other location you want to live near.
Select distances, bedrooms, and cost ranges by
dragging the corresponding slider boxes on the right.
Select specific home types and services by pressing
the labeled buttons on the right.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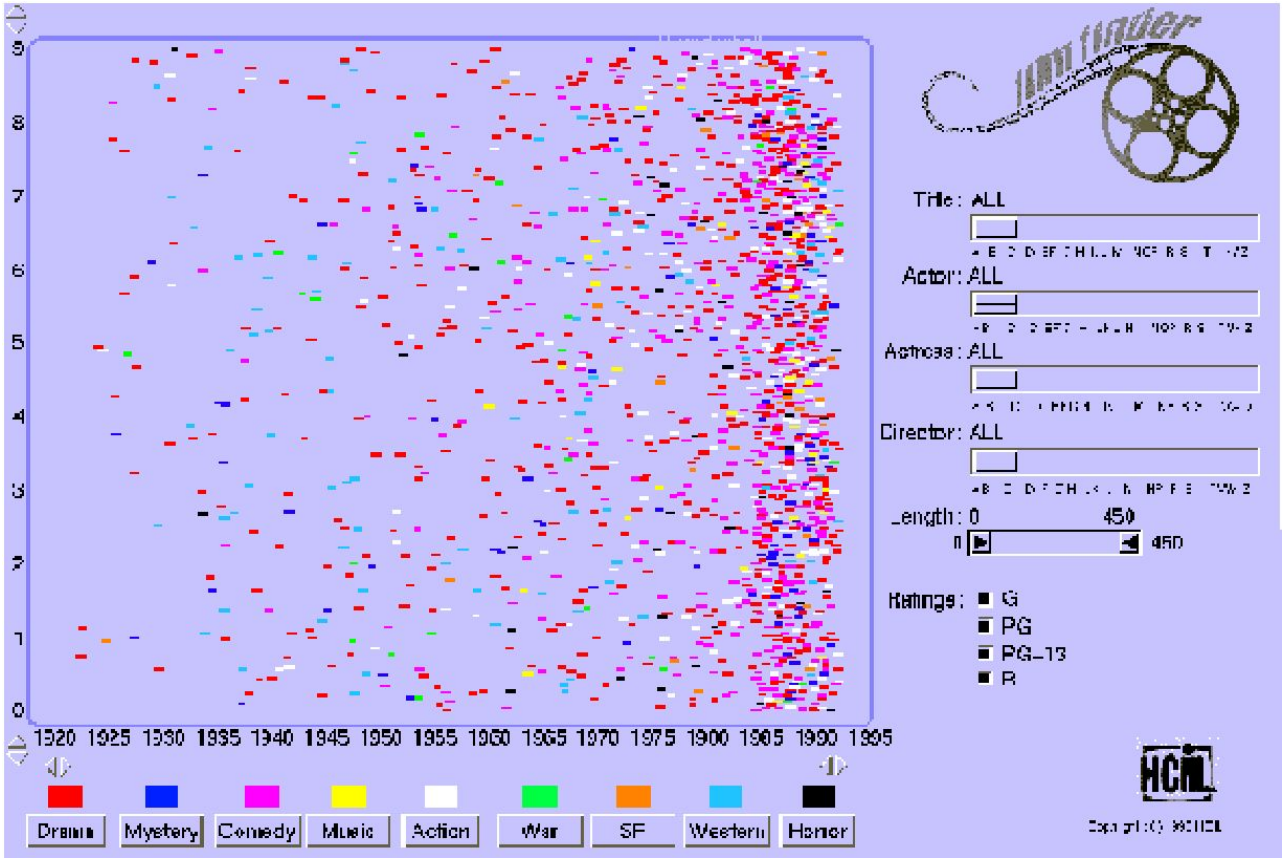
FilmFinder


Title: ALL
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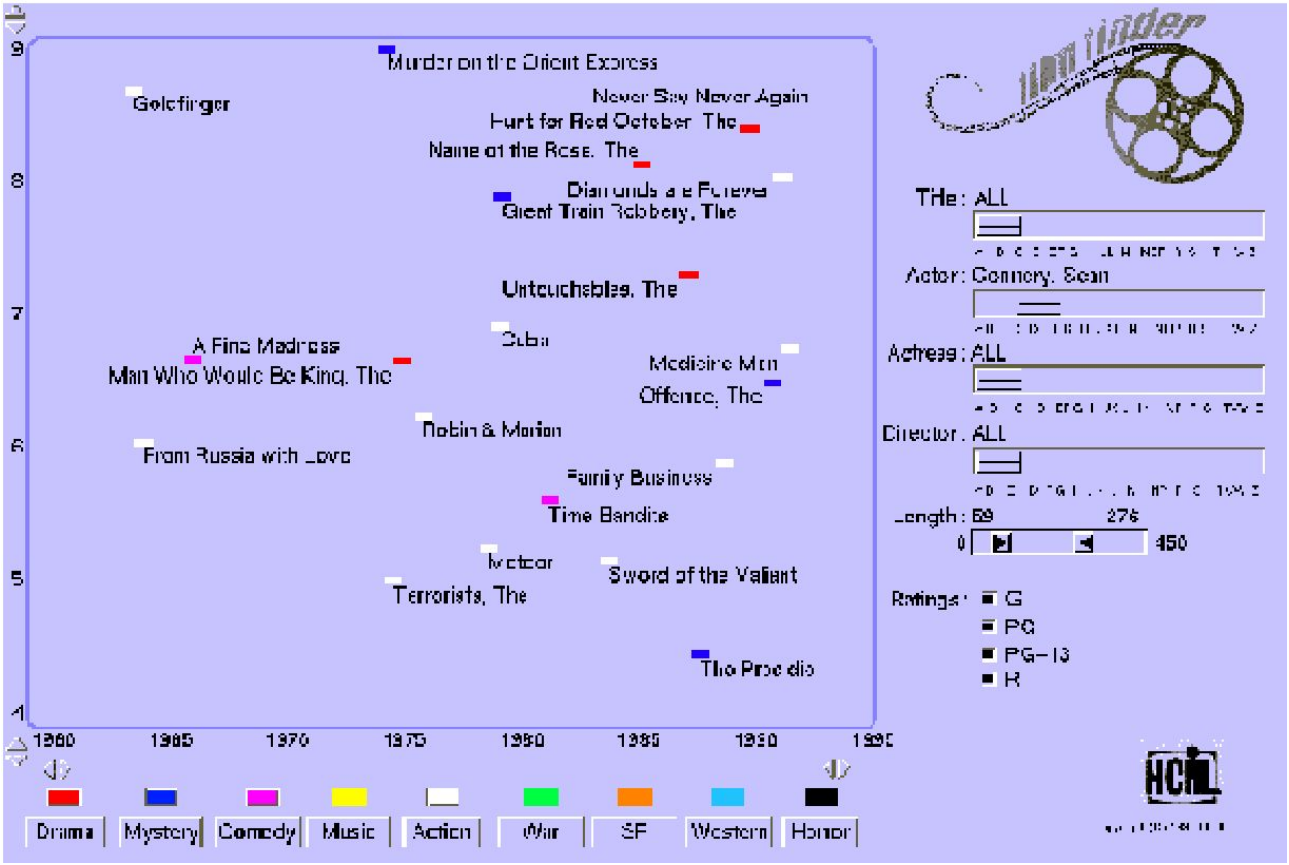
Comedy
Music
Action
War
SF
Western
Horror

FilmFinder


Murder on the Orient Express
Goldfinger
Never Say Never Again
Hunt for Red October, The
Name of the Rose, The
Diamonds are Forever
Great Train Robbery, The
Untouchables, The
Cuba
A Fine Madness
Man Who Would Be King, The
Medicine Man
Offence, The
Robin & Marion
From Russia with Love
Family Business
Time Bandits
Meteor
Sword of the Valiant
Terrorists, The
The Predator
1960
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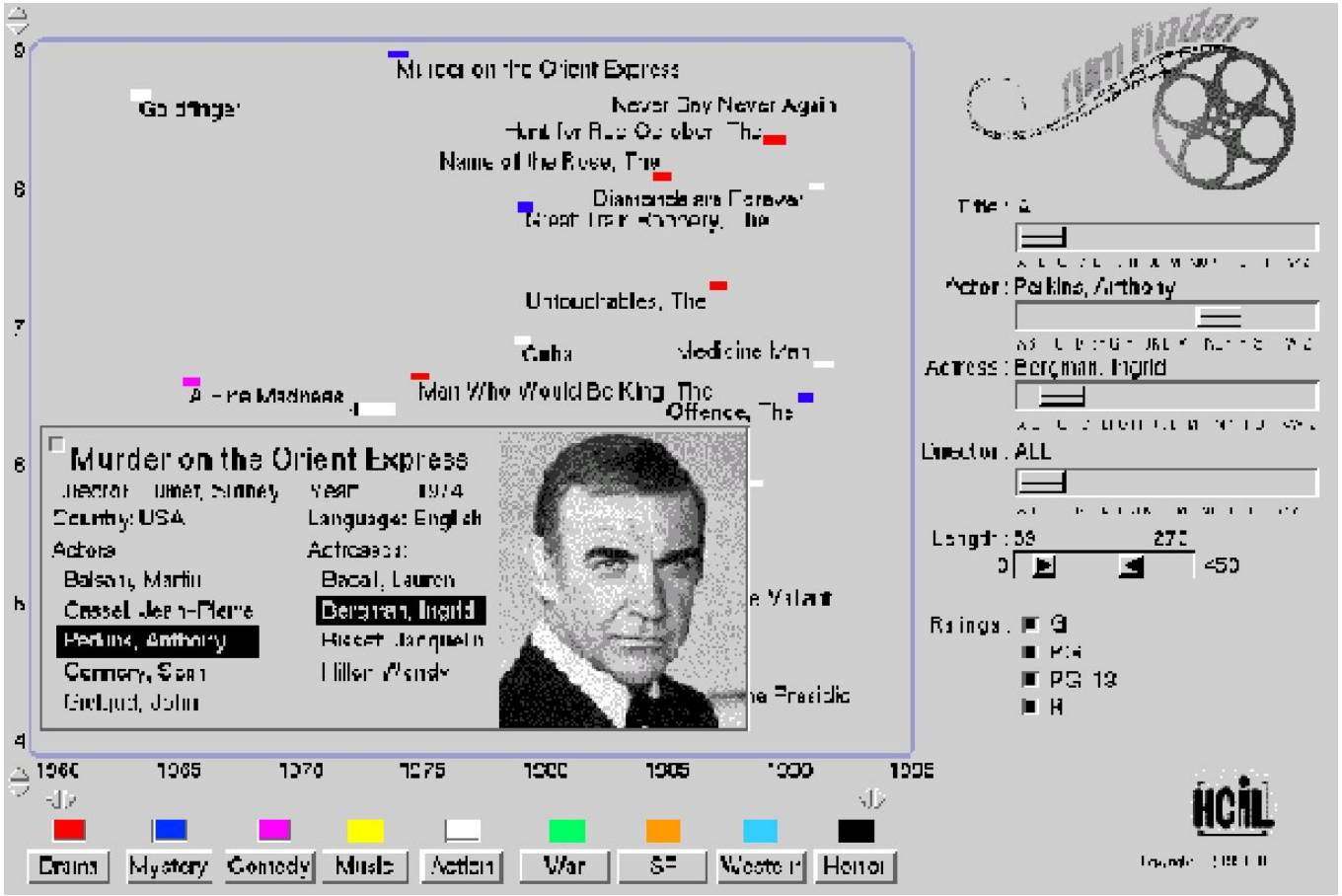
FilmFinder (Contd.)



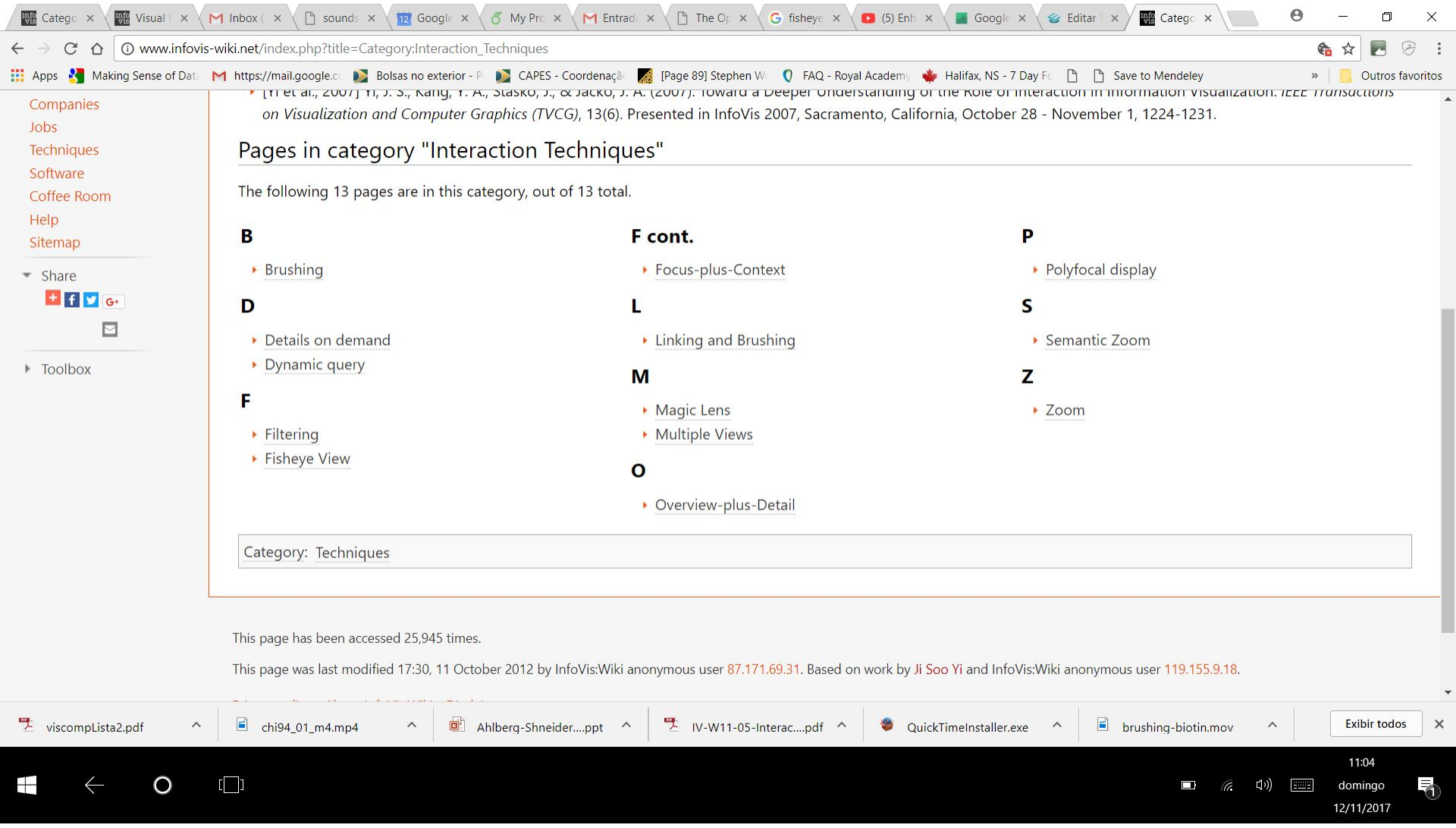
Dynamic query

- **Dynamic Queries Filter:** query parameters rapidly adjusted with slider, buttons etc.
- **Starfield Display:** result sets are continuously available and support viewing of hundreds or thousands of items
- **Tight Coupling:** query components are interrelated in ways that preserve display invariants and support progressive refinement.

Underlying concepts...

- Filtering
- Details-on-demand
- Overview plus detail
- Multiple views/Coordinated views

InfoVis Wiki



Fisheye views

- Fish-eye lenses magnify the center of the field of view, with a continuous fall-off in magnification toward the edges. Degree-of-interest values determine the level of detail to be displayed for each item and are assigned through user interaction.

- Often employed in association with graph visualization

Fisheye views

- http://www.infovis-wiki.net/index.php?title=Fisheye_View
- https://bost.ocks.org/mike/fisheye/
- https://www.youtube.com/watch?v=P_XBL5hYiqQ

Magic lenses

- *"... A Magic Lens is a transparent or semi-transparent user interface element which can be placed over objects to change their appearance and/or their interactive behaviour"*
- https://www.youtube.com/watch?v=e8QqaY1tWpo
- https://www.youtube.com/watch?v=QISfy9Es3VU
- Eric A. Bier, Maureen C. Stone, Ken Pier, William Buxton, Tony D. DeRose. Toolglass and Magic Lenses: The See-Through Interface. *Proceedings of SIGGRAPH '93*, 1993.

Polyfocal displays

- "The **Polyfocal Display** function defines an area for a focal point as a location of high radial magnification accentuated by a surrounding area of decreased magnification. Two parameters define the level of distortion found in the resulting transformation. The first parameter controls the level of magnification at the focal point, whereas the second one controls the rate of change of magnification with distance from the point of focus. Multifocal polyfocal displays also exist, in which more than one focal point is specified."

- Y. K. Leung and M. D. Apperley. A review and taxonomy of distortion-oriented presentation techniques. *ACM Transactions Computer-Human Interaction*, 1(2):126-160, June 1994.

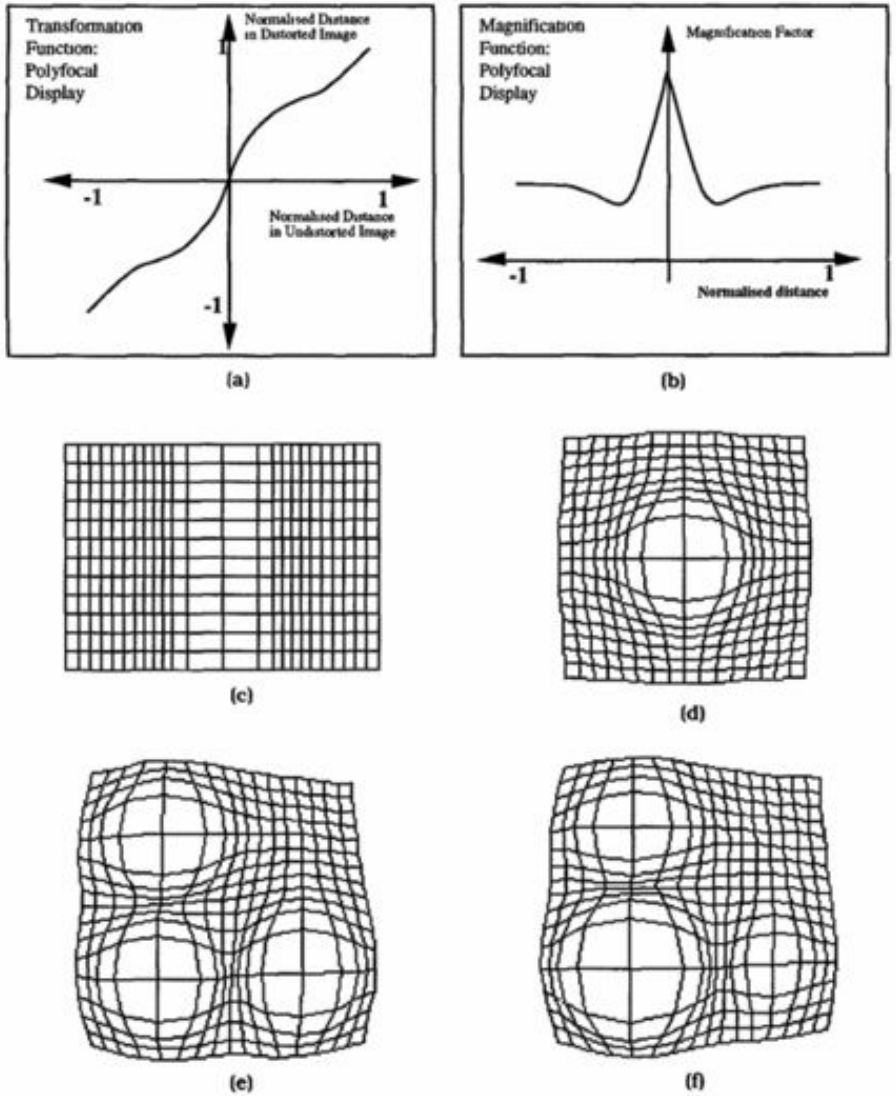
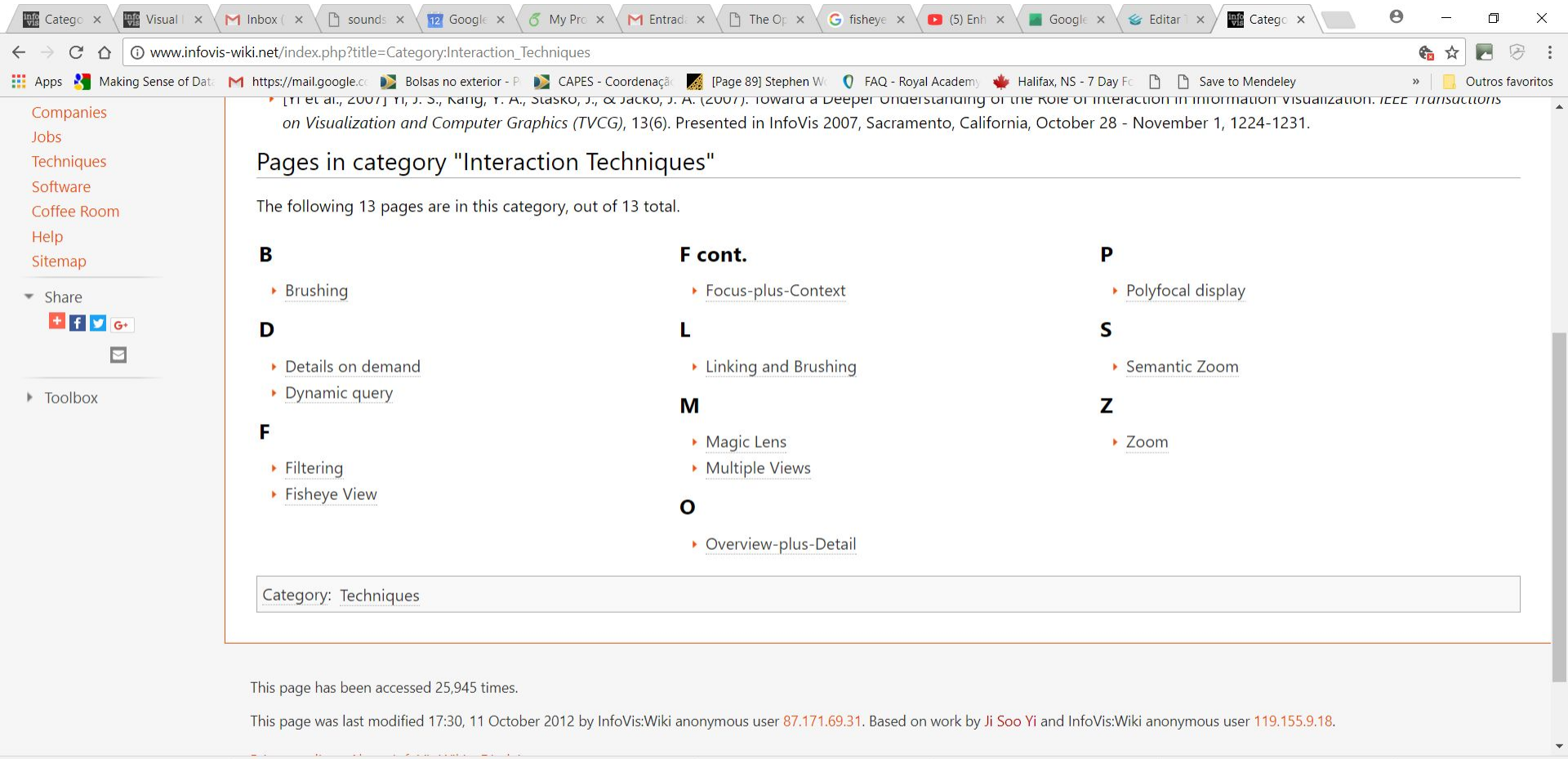


Fig. 5. The polyfocal projection: (a) a typical transformation function of a polyfocal projection; (b) the corresponding magnification function; (c) the application of the projection in one dimension; (d) the application of the projection in two dimensions; (e) a multiple-foci view of the projection using the same parameters for each focus point; (f) a multiple-foci view using different parameters.

R. Spence on the bifocal display

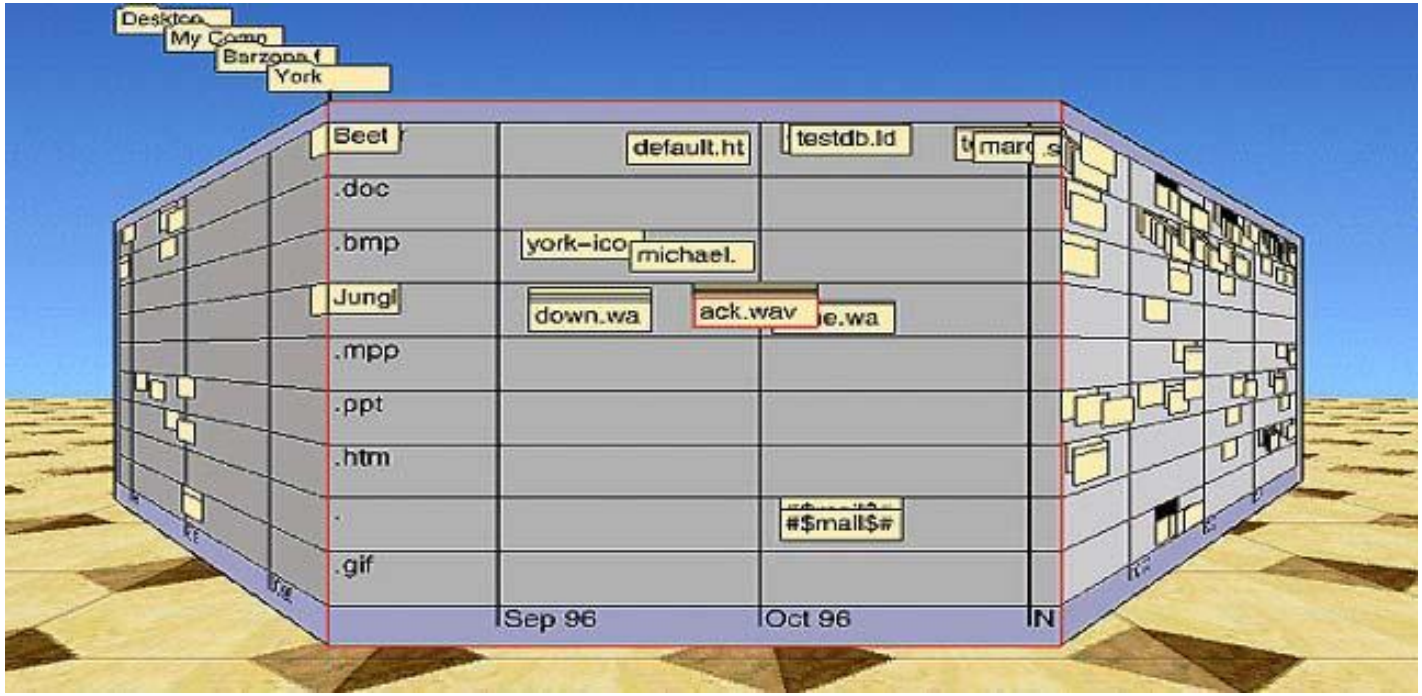
- https://www.youtube.com/watch?v=DaF5brrdpJw
- https://www.youtube.com/watch?v=RN3Z4XojDP4

InfoVis Wiki

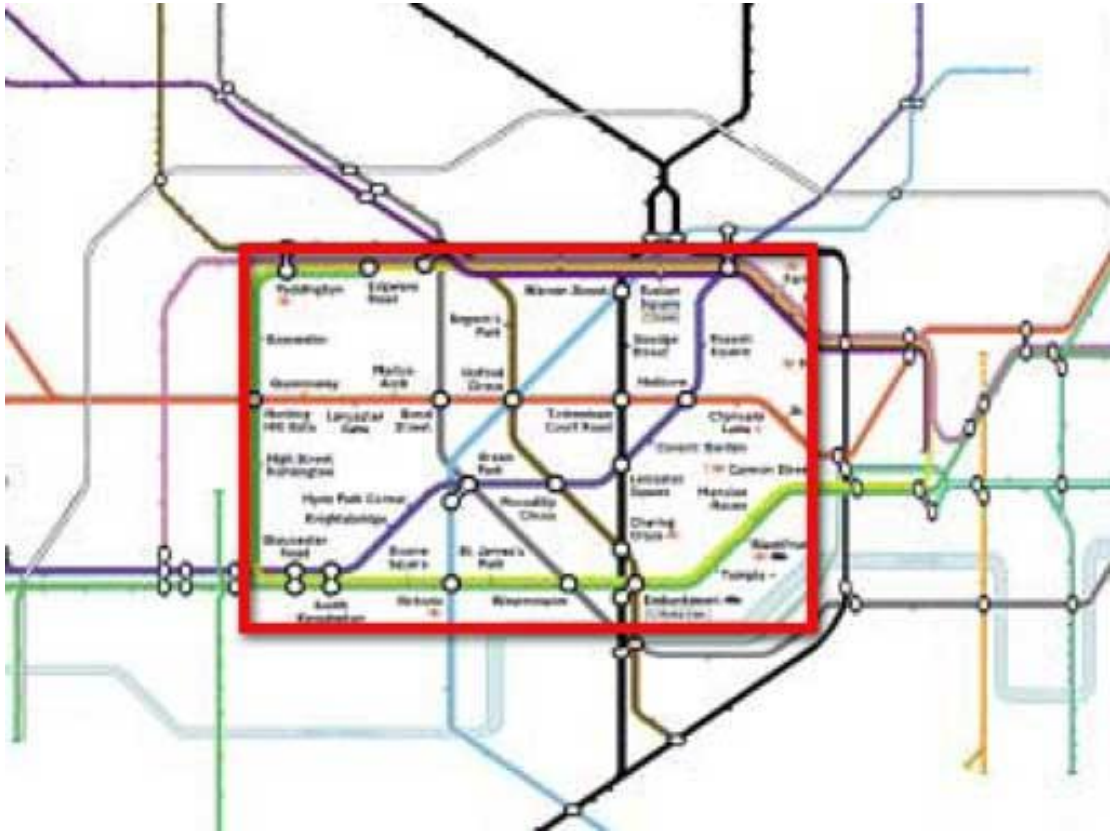


Related...

The perspective wall, Mackinlay et al. 1991



https://www.youtube.com/watch?v=hYUZbrWtCZg



Bifocal display representation of the London Underground map, showing the central area in full detail, while retaining the context of the entire network. It is important to note the continuity of the lines between the focus and context regions, in spite of the differing magnification factors.

https://www.interaction-design.org/literature/book/the-encyclopedia-of-human-computer-interaction-2nd-ed/bifocal-display

Hyperbolic tree

- A **hyperbolic tree** (**hypertree**) is an information visualization and graph drawing method inspired by hyperbolic geometry.

https://en.wikipedia.org/wiki/Hyperbolic_tree

- *Lamping, J; Rao, R; Pirolli, P (1995). A focus+context technique based on hyperbolic geometry for visualizing large hierarchies.*

Hyperbolic tree

- https://www.youtube.com/watch?v=8bhq08BQLDs&t=4s
- http://ocsigen.org/js_of_ocaml/files/hyperbolic/index.html
- https://philogb.github.io/jit/static/v20/Jit/Examples/Hypertree/example1.html

Underlying concepts

- Distortion lenses
- Distorted views
- Focus + context
- Overview plus detail
- Changing viewpoint (navigation)

Dust & Magnet

- "*Dust & Magnet (DnM) is an information visualization technique to help people understand relatively large, multivariate data sets. DnM is especially designed for use by people who struggle with interpreting complex data of everyday problems and who are not experts in information*" Ji Soo Yi

- Yi, J. S., Melton, R., Stasko, J., & Jacko, J. (2005) Dust & Magnet: Multivariate Information Visualization using a Magnet Metaphor. Information Visualization, 4(4), 239-256.

Dust & Magnet

- https://www.youtube.com/watch?v=wLXwL38xek0
- https://www.youtube.com/watch?v=laGJ4v7DEU0

Underlying concepts

- Filtering
- User-driven manipulation

Geometric vs Semantic Zooming

- Geometric zooming: affects the size of the objects displayed
- Semantic zooming: the representation of the object adapts to the space (# of pixels) available to the image-space region occupied by the object (Munzner´s book chap. 11)

- https://bl.ocks.org/mbostock/3680957

Semantic Zooming

- In Windows: https://docs.microsoft.com/en-us/windows/uwp/design/controls-and-patterns/semantic-zoom

- LiveRAC system demo: https://www.youtube.com/watch?v=ld0c3H0VSkw

Semantic Zooming

- In Windows:

  https://docs.microsoft.com/en-us/windows/uwp/design/controls-and-patterns/semantic-zoom

- LiveRAC system demo: https://www.youtube.com/watch?v=ld0c3H0VSkw

Panning & Zooming

- https://observablehq.com/@d3/focus-context

- Panning & zooming for focus + context

Underlying concepts

- Focus + context
- Changing viewpoint (navigation)

Demos – NYT interactive charts

- https://www.nytimes.com/interactive/2014/06/05/upshot/how-the-recession-reshaped-the-economy-in-255-charts.html
- http://www.nytimes.com/interactive/2014/09/19/nyregion/stop-and-frisk-map.html
- https://www.nytimes.com/interactive/2014/upshot/buy-rent-calculator.html

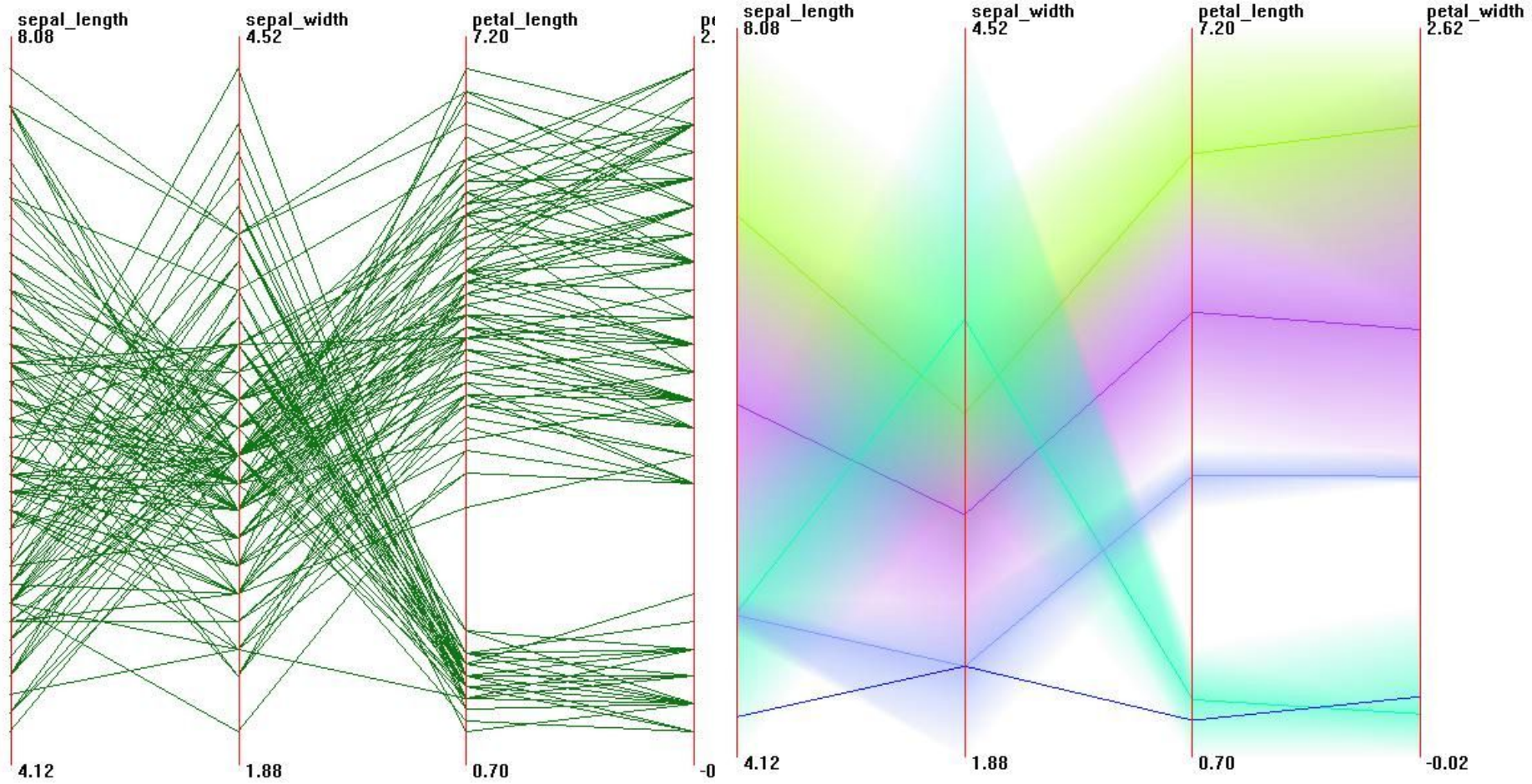
Underlying concepts so far

- Filtering: linking and brushing, dynamic queries
- Details-on-demand
- Focus + context
- Overview + detail
- Navigation: panning, zooming
- Distortion lenses
- Multiple views/Coordinated views
- Distorted views

Another concept: aggregation

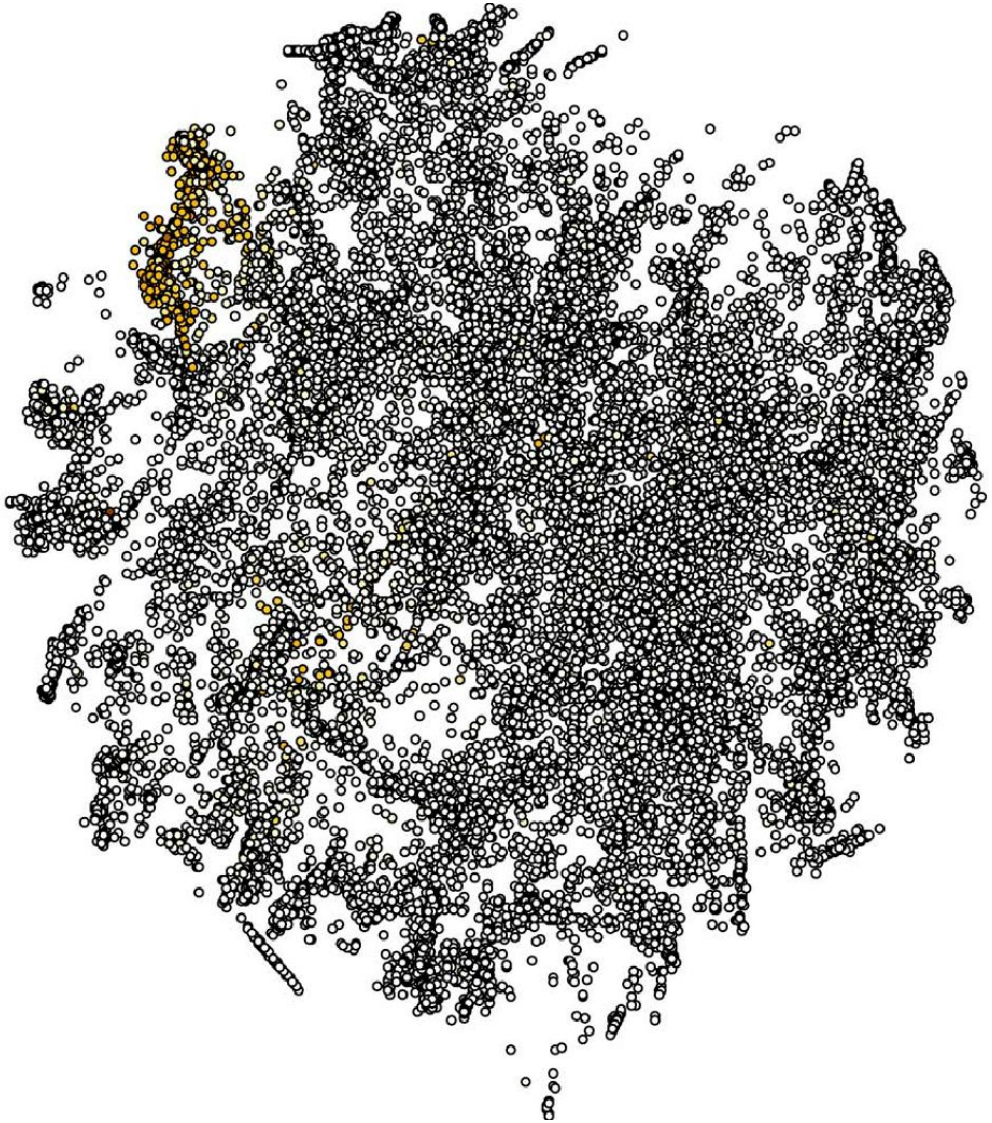
- If there is too much data (too many data points) show aggregations, rather than individual data points
  - overplotting problem
- Represent subsets, rather than individual items
  - Aggregation may be a strategy of the visual mapping technique, e.g., as hierarchical parallel coordinates, hierarchical LSP (HiPP), or...
  - it may be handled association with the interaction technique

Ex. aggregation in mapping



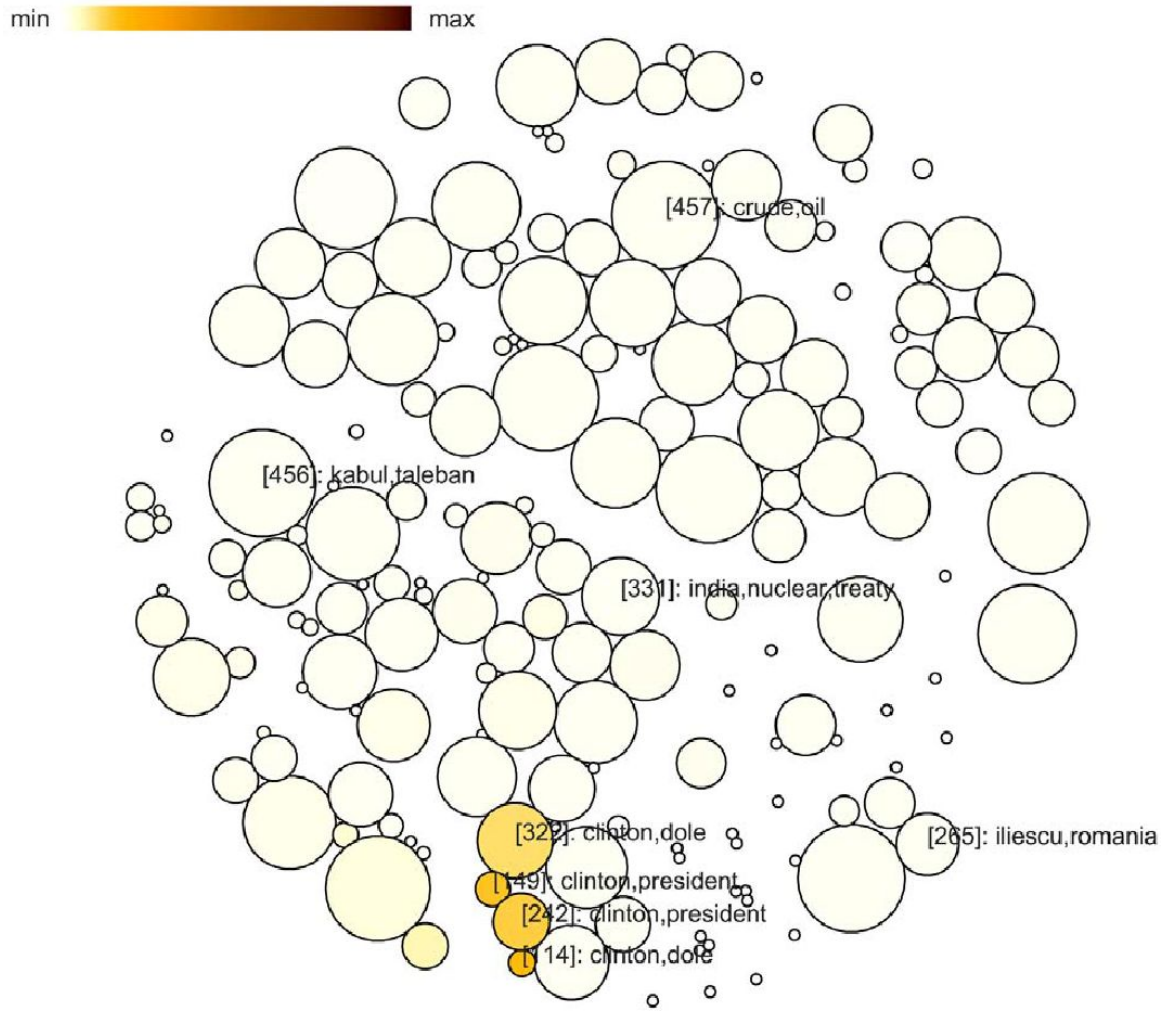
Standard and aggregated (5 clusters shown) Parallel Coordinates (Ward, Ch. 2)

Ex. aggregation in mapping



LSP projection of
30,000 news feeds

Ex. aggregation in mapping



HiPP projection of 30,000 news feeds

Paulovich & Minghim. HiPP: A Novel Hierarchical Point Placement Strategy and its Application to the Exploration of Document Collections. IEEE InfoVis 2008

Ex. aggregation + interaction

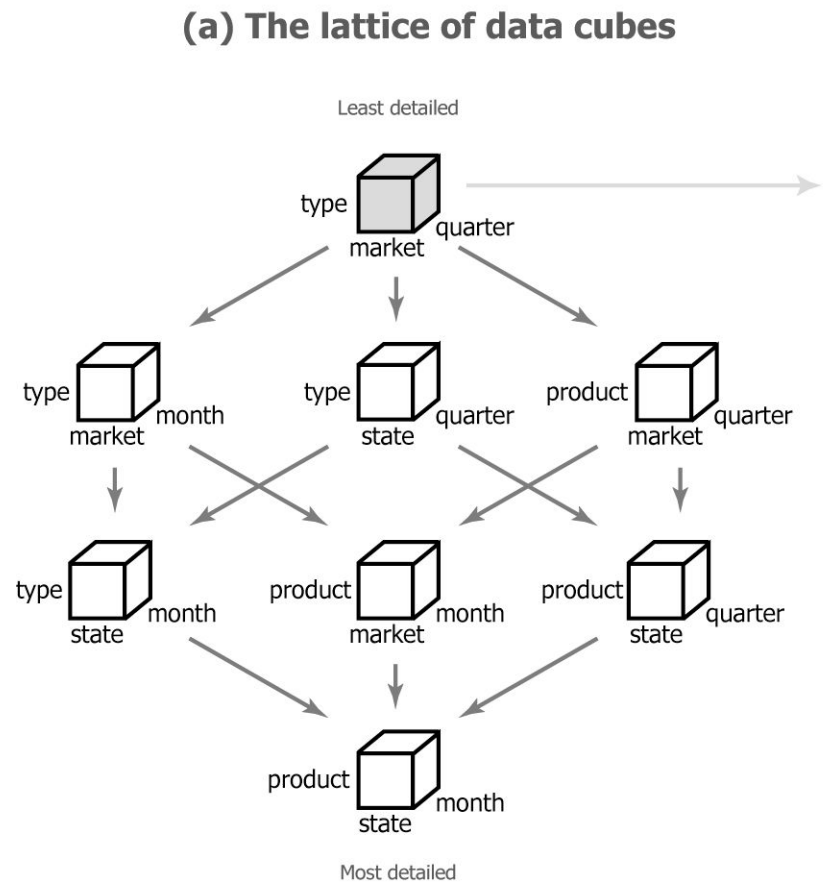
- Bostock et al.'s Crossfilter http://square.github.io/crossfilter/
- Liu et al.'s Immens http://vis.stanford.edu/papers/immens
- Lins et al.'s Nanocubes http://nanocubes.net/

Underlying concepts

- Filtering, dynamic queries, linking + aggregation

- Underlying technology: Data Cubes

Stolte et al. Multiscale Visualization using Data Cubes, Infovis 2002


(a) The lattice of data cubes
Least detailed
type
market
quarter
type
market
month
type
state
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product
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product
market
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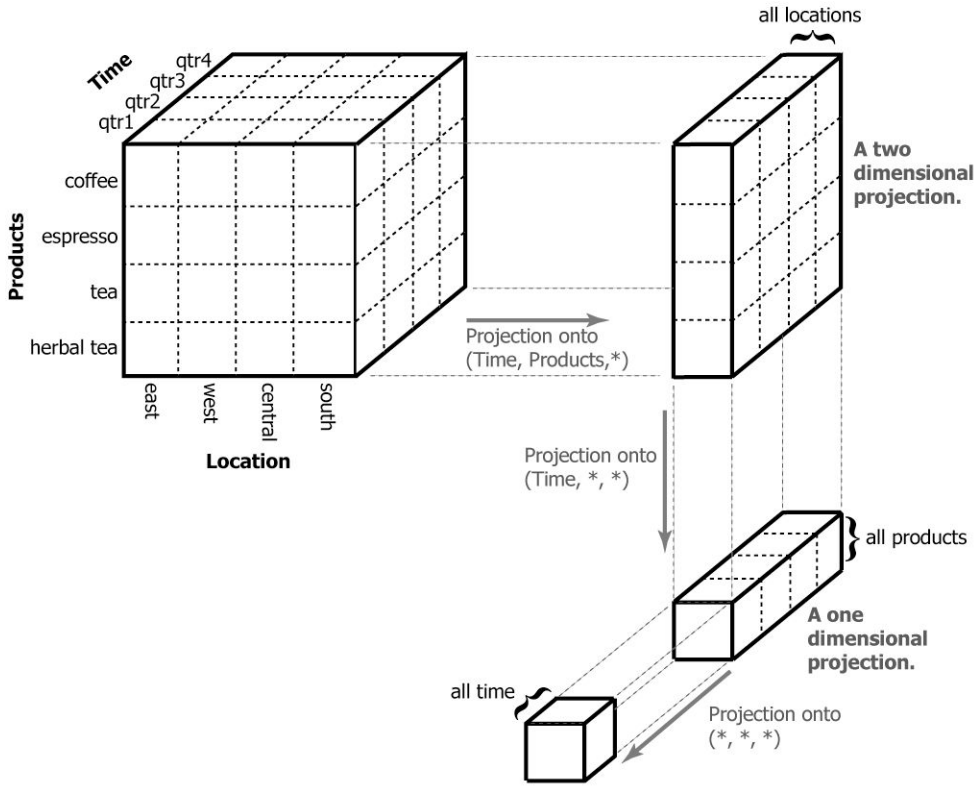
Most detailed


(b) Projecting a three dimensional data cube
all locations
Time
qtr4
qtr3
qtr2
qtr1
Products
coffee
espresso
tea
herbal tea
east
west
central
south
Location
Projection onto
(Time, Products,*)
A two
dimensional
projection.
Projection onto
(Time, *, *)
all products
A one
dimensional
projection.
all time
Projection onto
(*, *, *)

Part 2 – taxonomies of techniques

Visual information seeking

- The Visual Information-Seeking Mantra summarizes many visual design guidelines and provides a framework for designing Information Visualization applications.

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

- Ben Shneiderman, The Eyes Have It: A Task by Data Type Taxonomy for Information Visualizations. *Proc. IEEE Symp. on Visual Languages*, 336-343, 1996.

Task abstraction (high-level)

- **Overview:** Gain an overview of the entire collection.
- **Zoom** : Zoom in on items of interest.
- **Filter:** filter out uninteresting 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

Data types

- one-dimensional
- two-dimensional
- three-dimensional
- temporal
- multidimensional
- tree
- network

- http://www.nytimes.com/interactive/dining/new-york-health-department-restaurant-ratings-map.html

- http://cscheid.net/static/mlb-hall-of-fame-voting/

Categories of interaction

- Yi et al. TVCG 2007 Toward a deeper understanding of the role of interaction in information visualization

- Define categories of interaction techniques widely used in InfoVis...
- ... organized around a user´s intent while interacting

Categories of interaction

- *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

Final– word of caution

- Ronald Coase – Nobel Prize in Economy 1991

  "*torture your data enough, and it will tell you anything*"

- http://tylervigen.com/spurious-correlations