

CSE 564: Visualization

Interaction and Information Navigation

Klaus Mueller

(Presented by Darius Coelho)

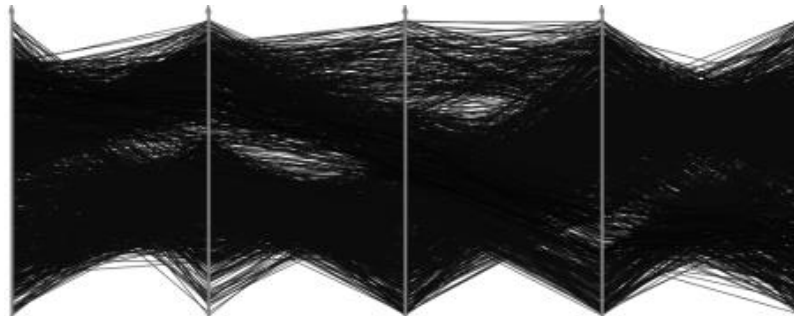
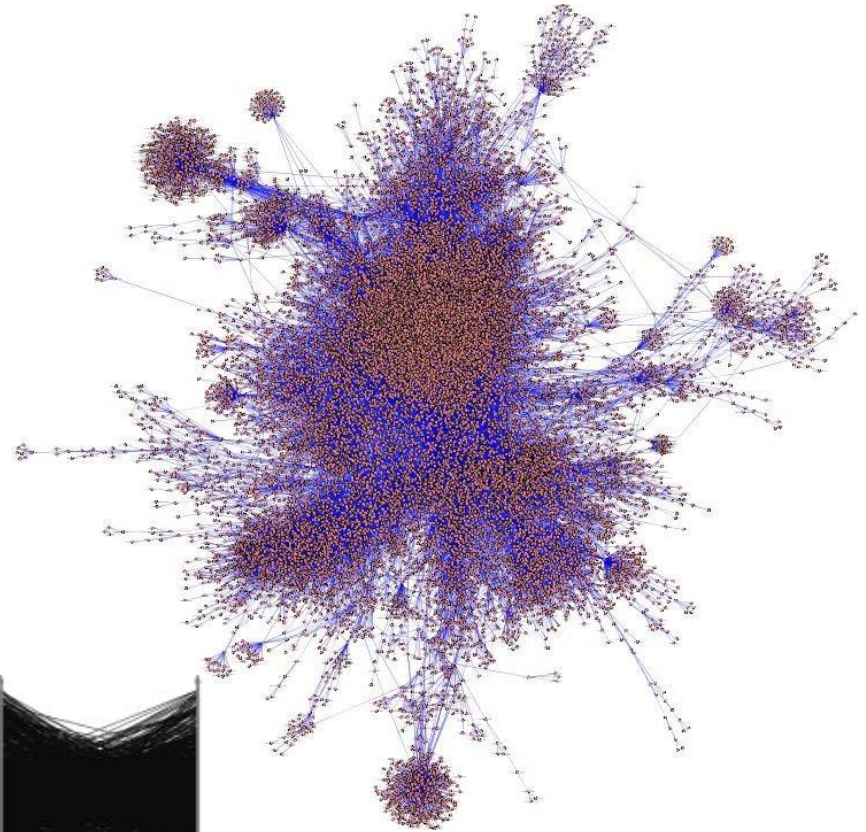
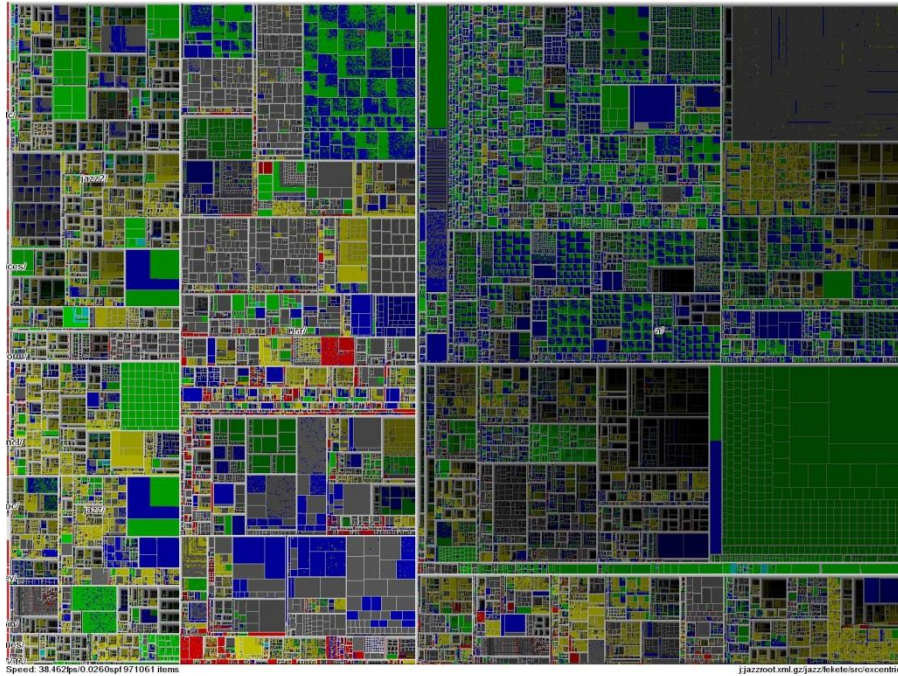
Computer Science Department

Stony Brook University

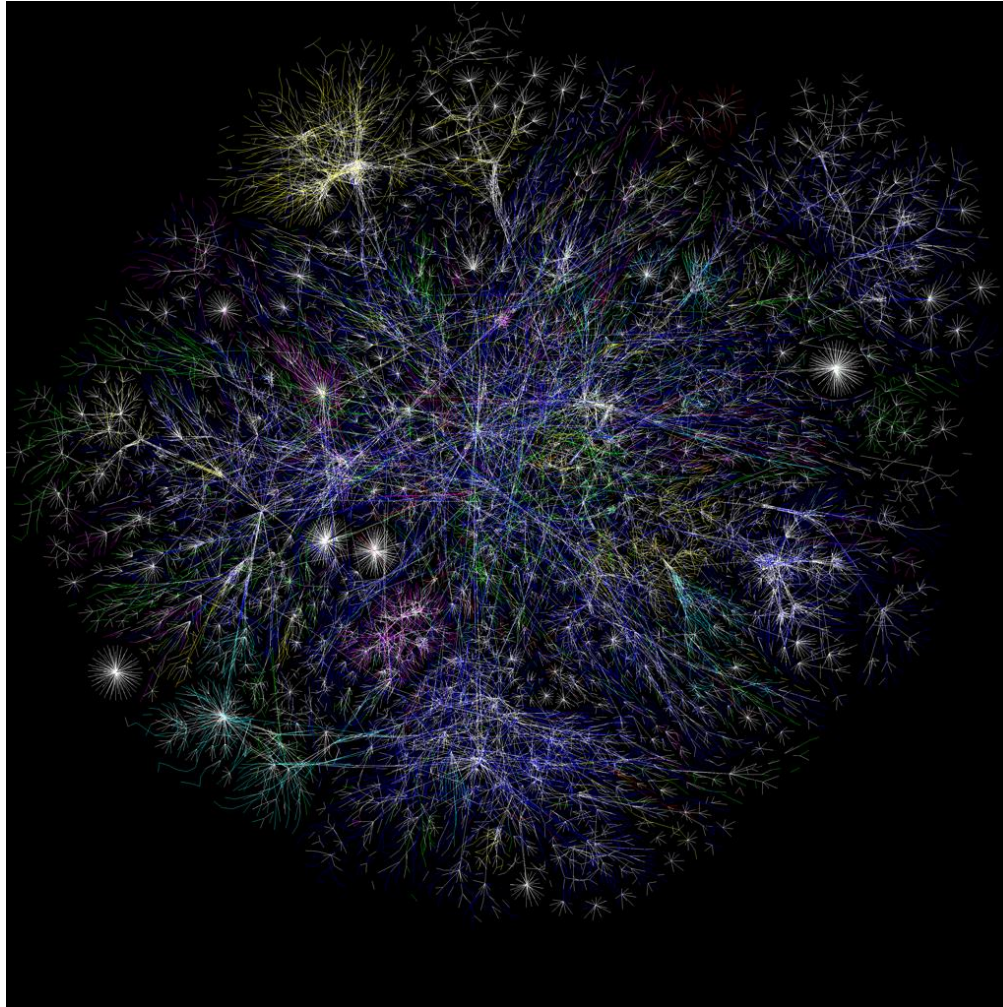
Too Much Data?

How can we deal with data overload

- see the forest for the trees (or the other way around)



Too Much Data?



Internet routes (1/15/2005)

(NY Museum of Modern Art)

The Key to Overcome the Data Deluge: Interaction

Allow users to control what is currently shown:

- level of detail
- extent of the data (spatial, values)
- aspects of the data (attributes)

But do not leave the user lost in the forest

- provide navigation hints

Two powerful paradigms:

- overview, and detail on demand (forest and trees)
- focus and context (trees and forest)

Interaction needs to be interactive (as in responsive)

- user needs to get quick visual feedback on actions

Interaction: Key to Visual Analytics

Puts the human in the loop

- appeals to human's expertise and intuition

Requires a suitable human-computer interface

- recall the lectures on color and perception

Interaction can help with:

- making sense of it all
- putting things in proper context
- data overload (scalability)
- telling stories with data (explain findings to others)

Evaluate effectiveness

- do human users actually benefit?
- user studies!

A Taxonomy of Fundamental Interaction Types

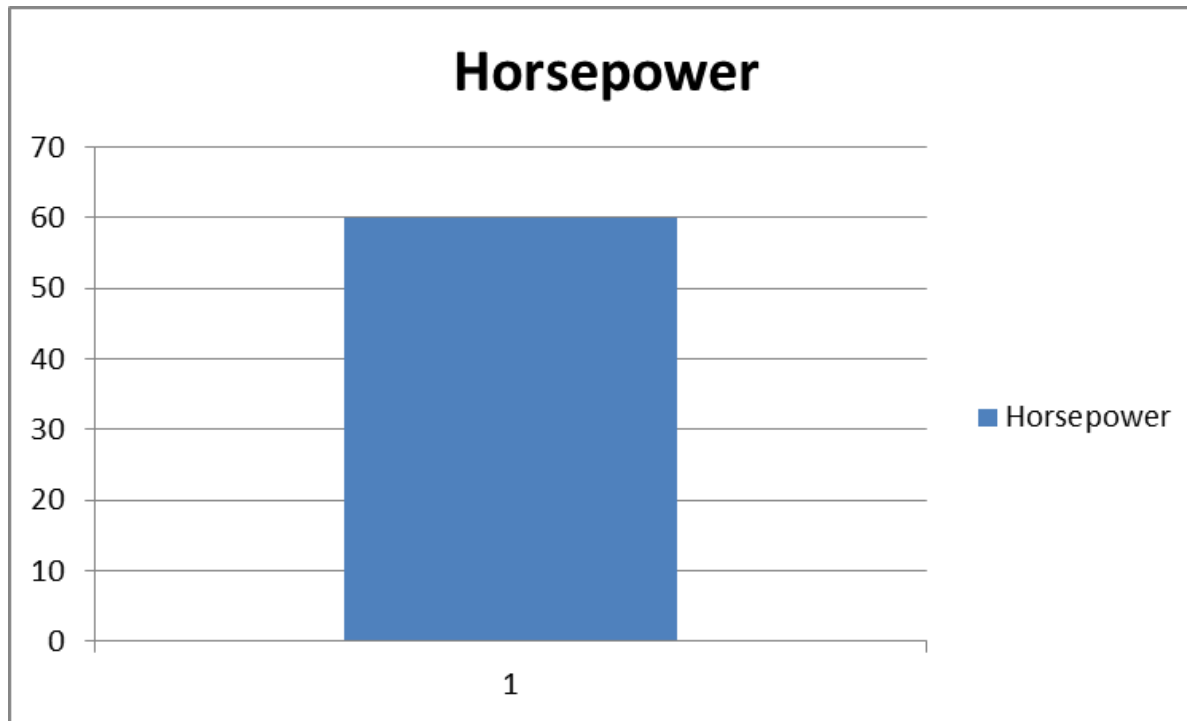
Stephen Few (chapter 4):

- compare
- sort
- add variables
- re-scale
- re-express
- filter
- highlight
- annotate
- bookmark
- aggregate
- re-visualize
- zoom and pan
- details on demand

Example

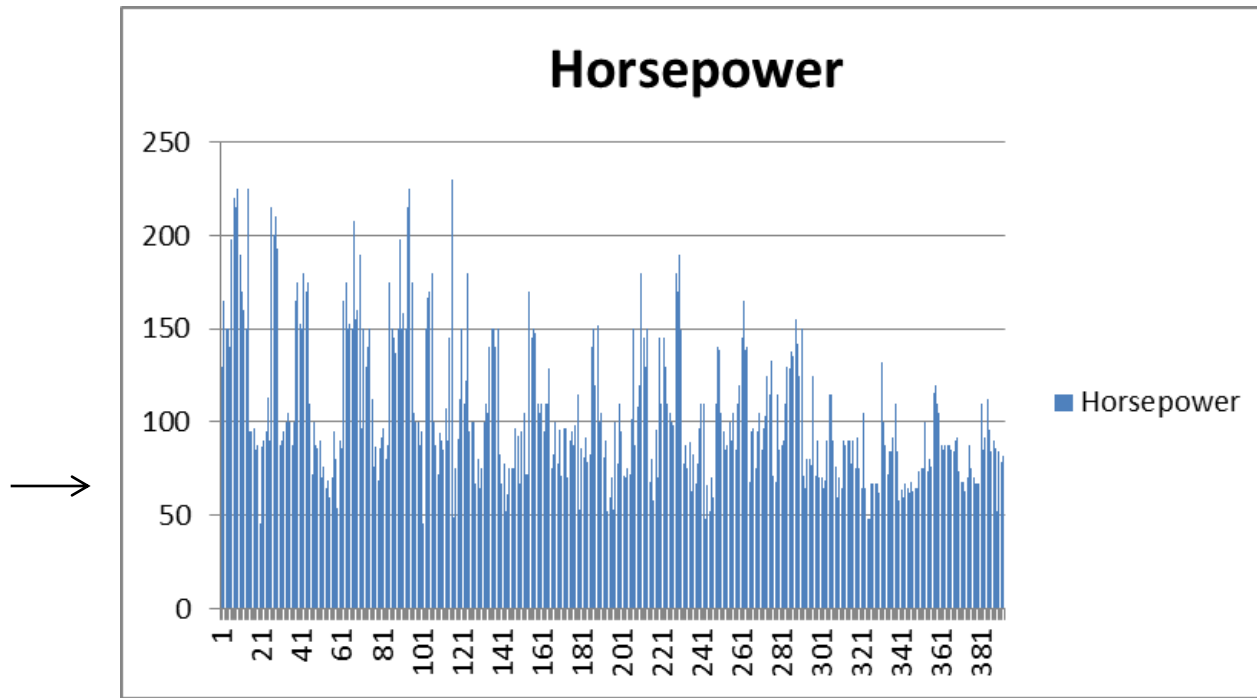
Assume you have been offered a car to buy

- assume you are mostly interested in horsepower, weight, acceleration
- the car you have been offered has 60 hp, 1834 kg, 8 s



Compare

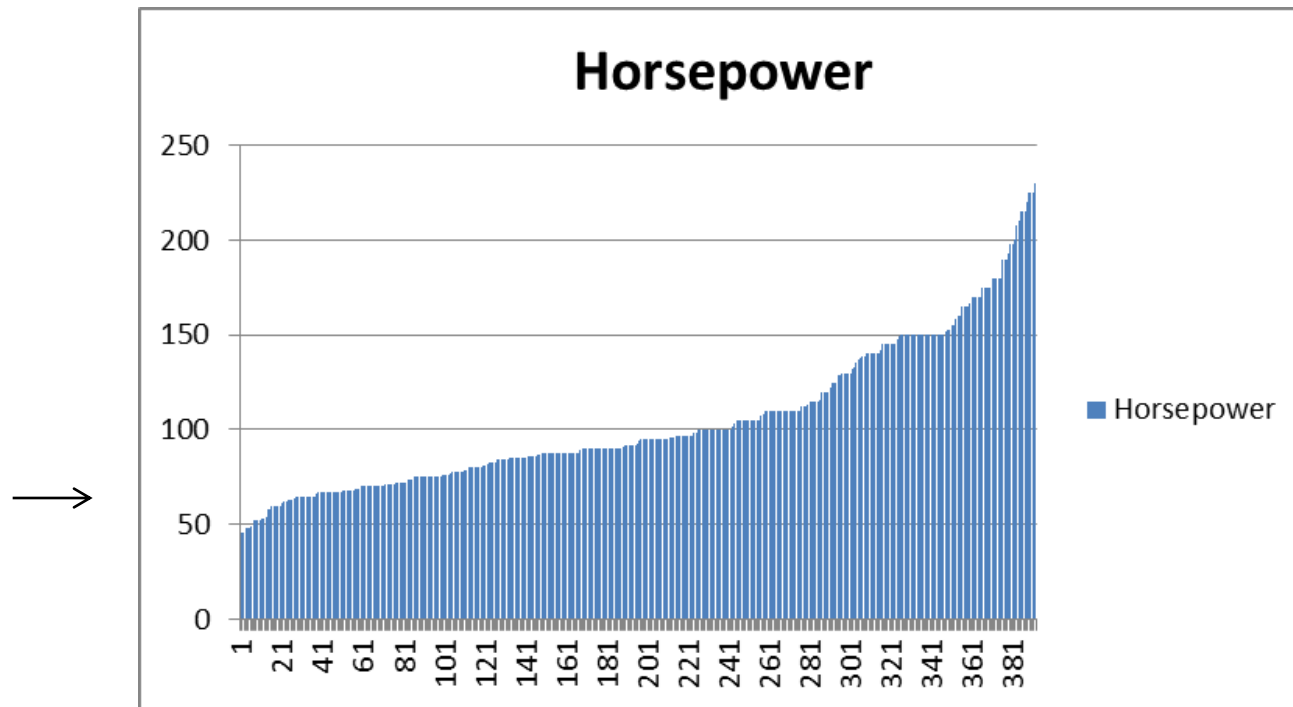
See the car with other available cars



hard to see how it really ranks

Sort

See the car in the context of other available cars

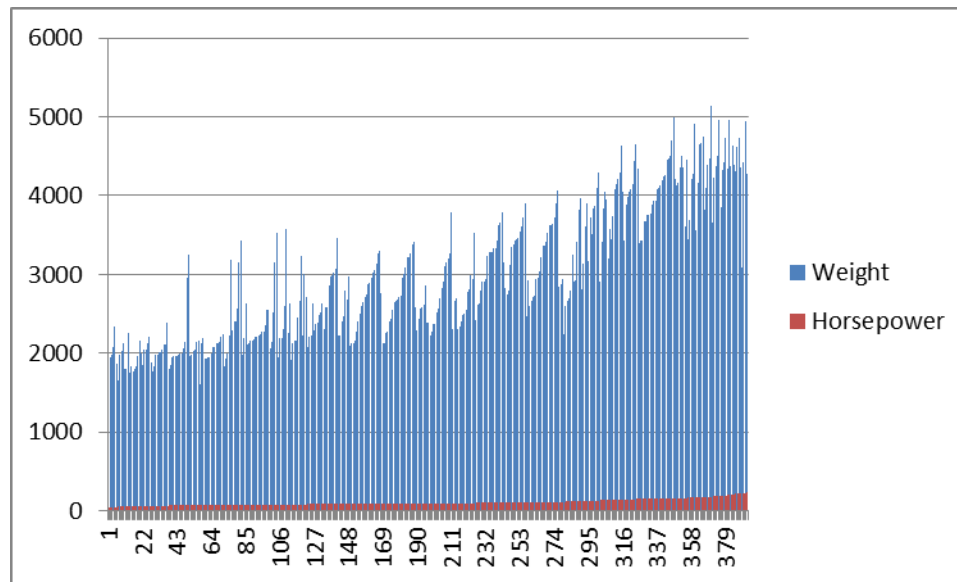


it is a low-horsepower car

Additional Variables

Is horsepower correlated to weight?

- are there trade-offs?

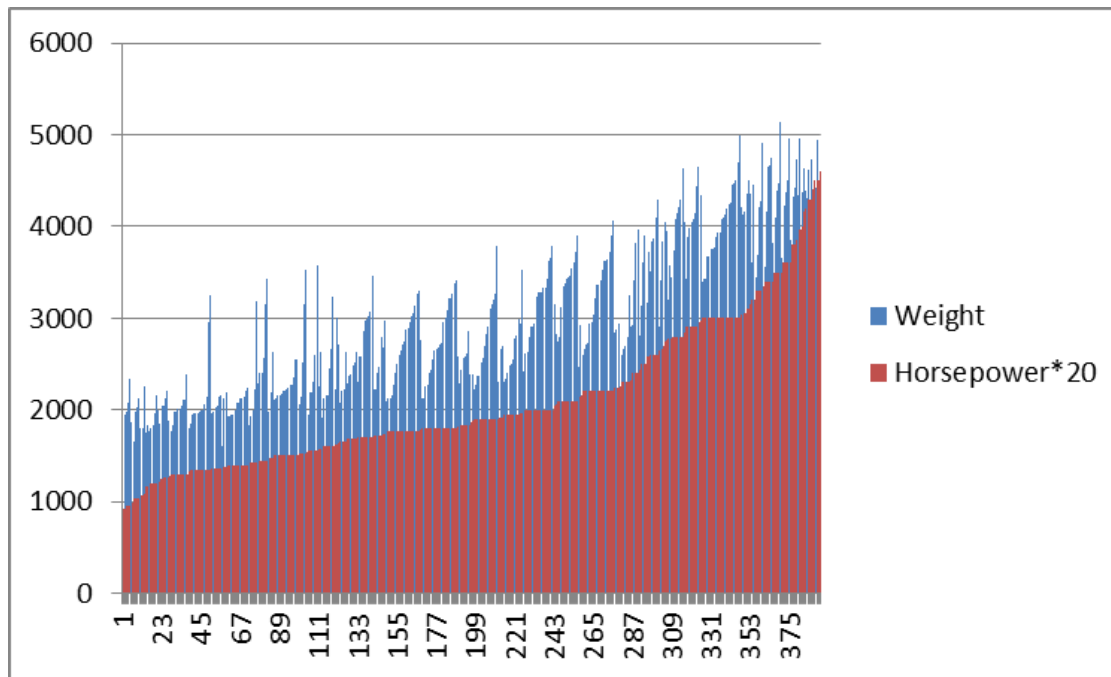


hard to see what is going on

Re-Scale

Scale horsepower into the same range than weight

- could also normalize each to (0.0, 1.0)

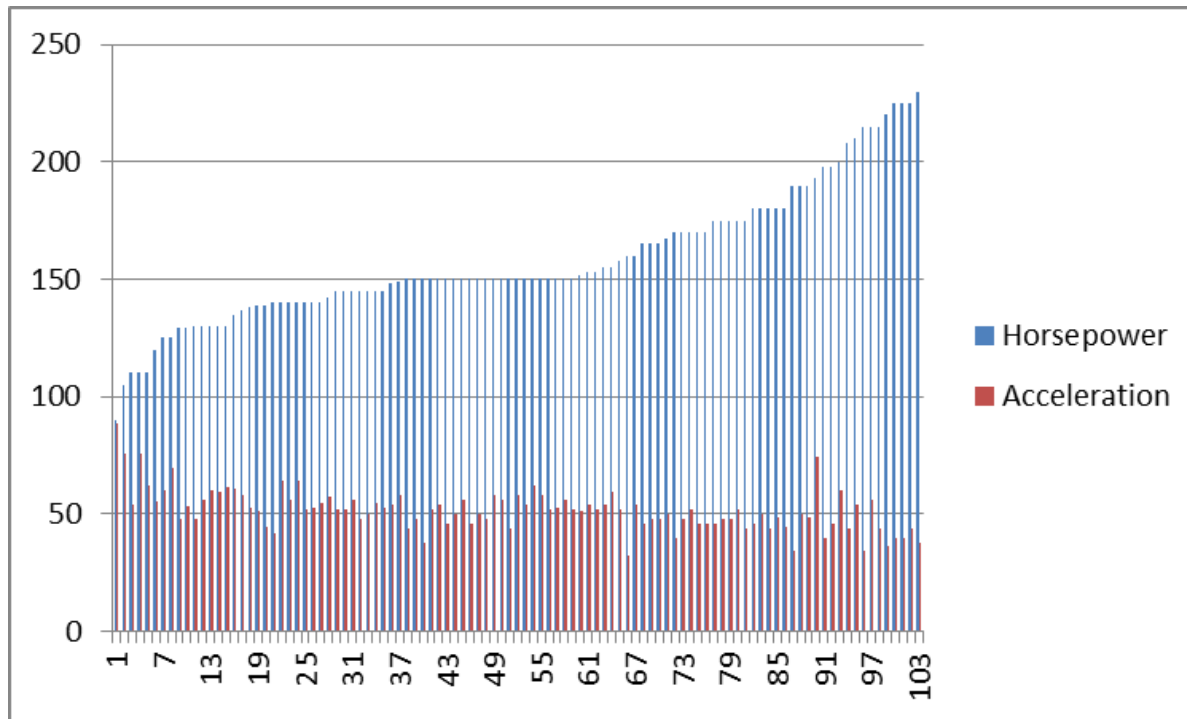


There seems to be a positive correlation

- cars with higher horsepower are also heavier

Another Variable

How does it relate to acceleration?

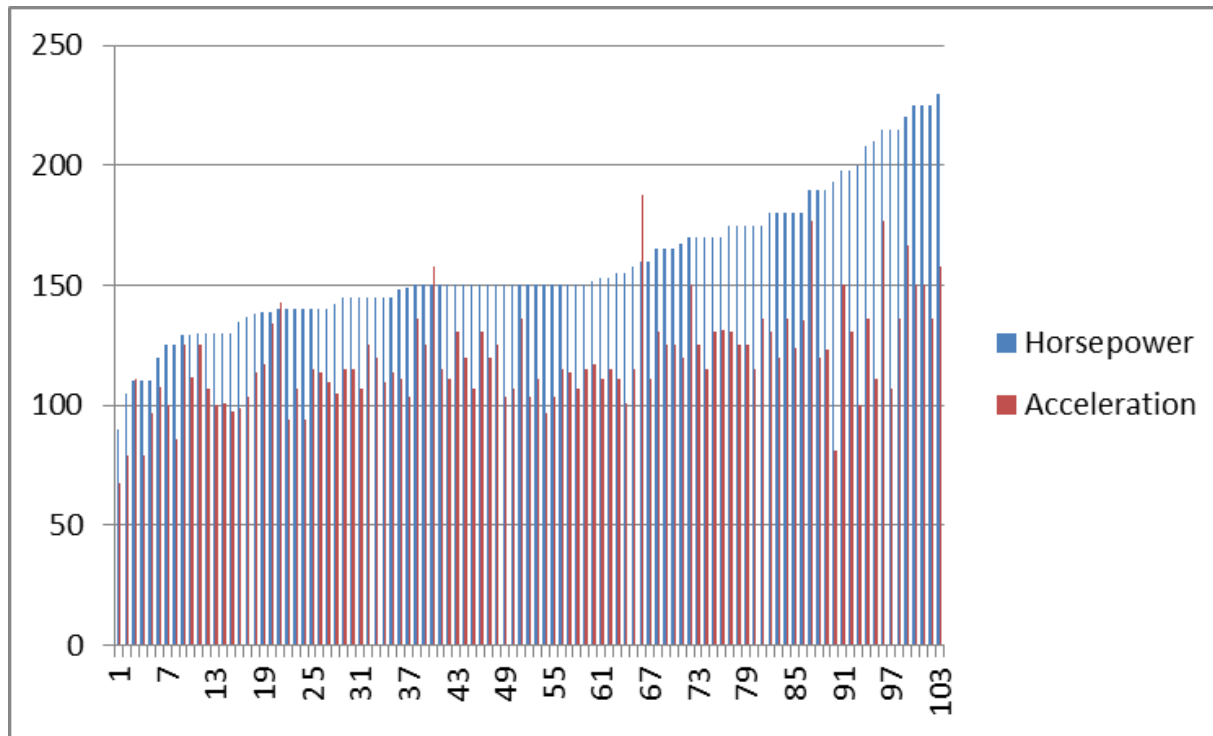


non-intuitive that acceleration is less for high horsepower cars

Re-Express

Acceleration should really be $1/\text{acceleration}$

- should be measured in $1/\text{sec}$ (and not sec)

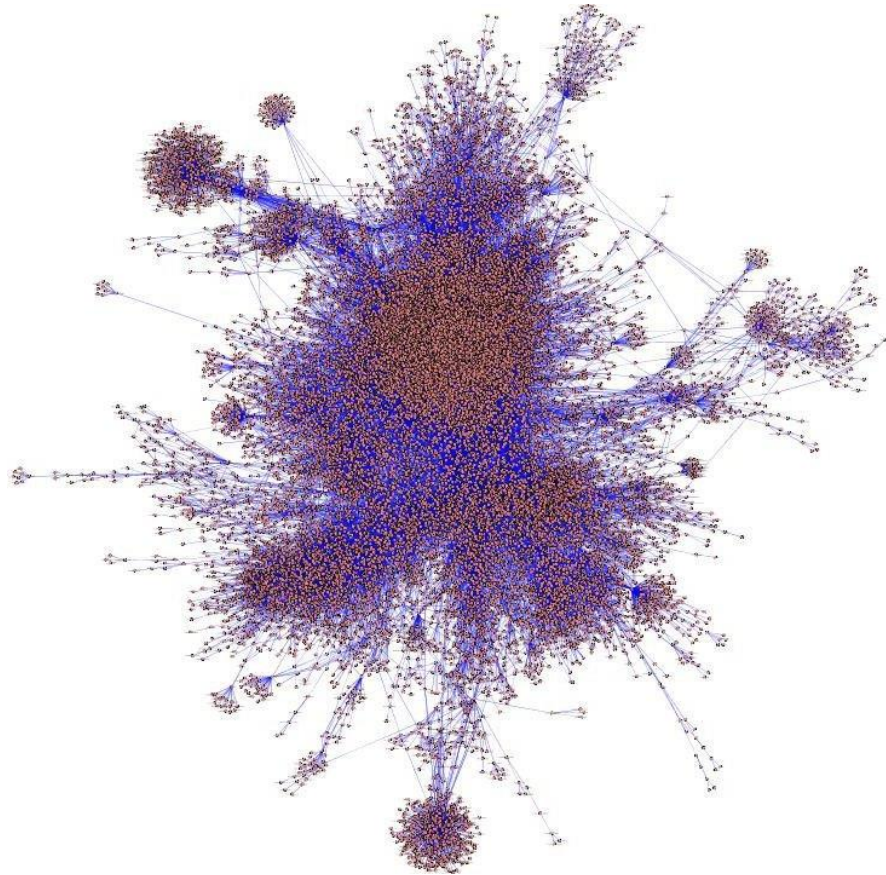


- now higher horsepower cars also seem to have higher acceleration (but the influence is quite minor) → is there a higher-D relationship?

Filtering

Example: Graph of concepts

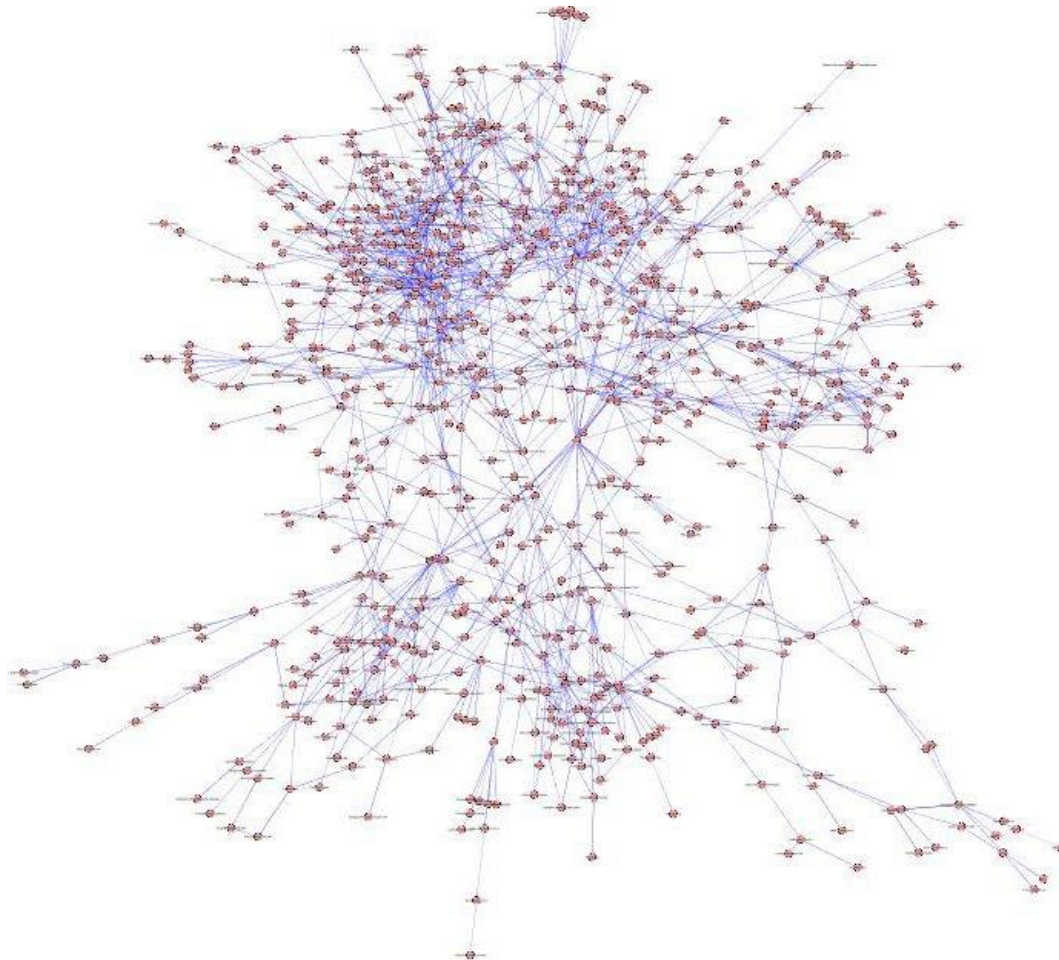
- related concepts group closer



Filtering

Example: Graph of concepts

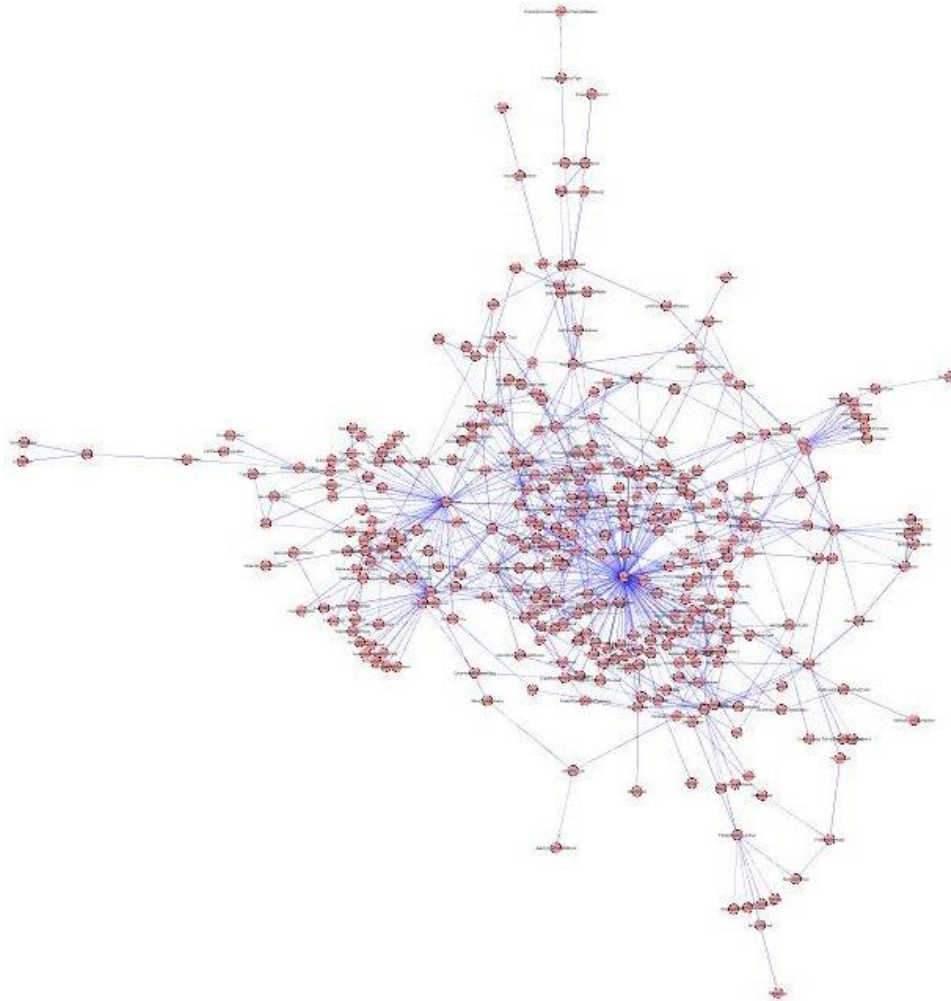
- only keep top 750 connected nodes



Filtering

Example: Graph of concepts

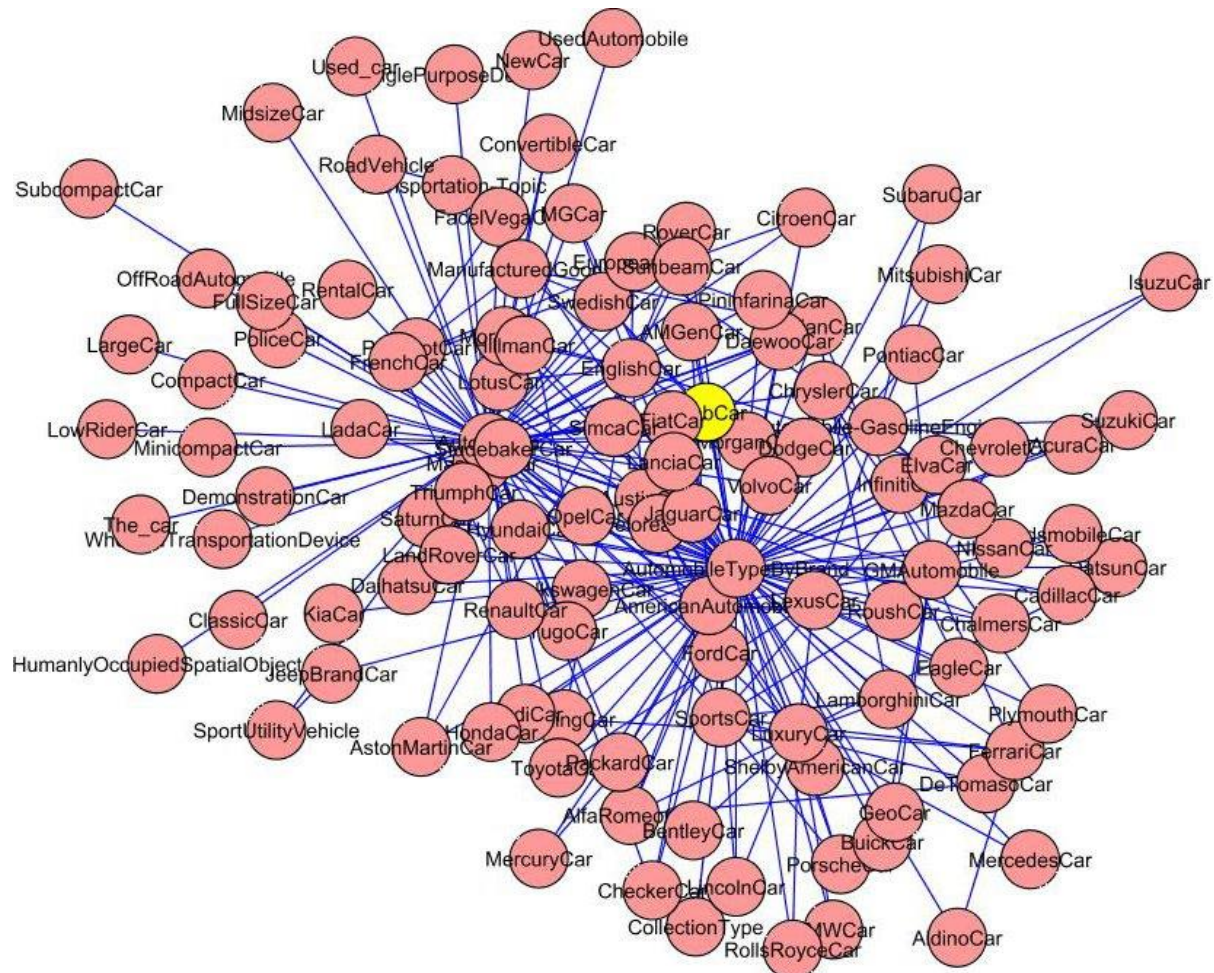
- only keep top 350 connected nodes



Zooming

Example: Graph of concepts

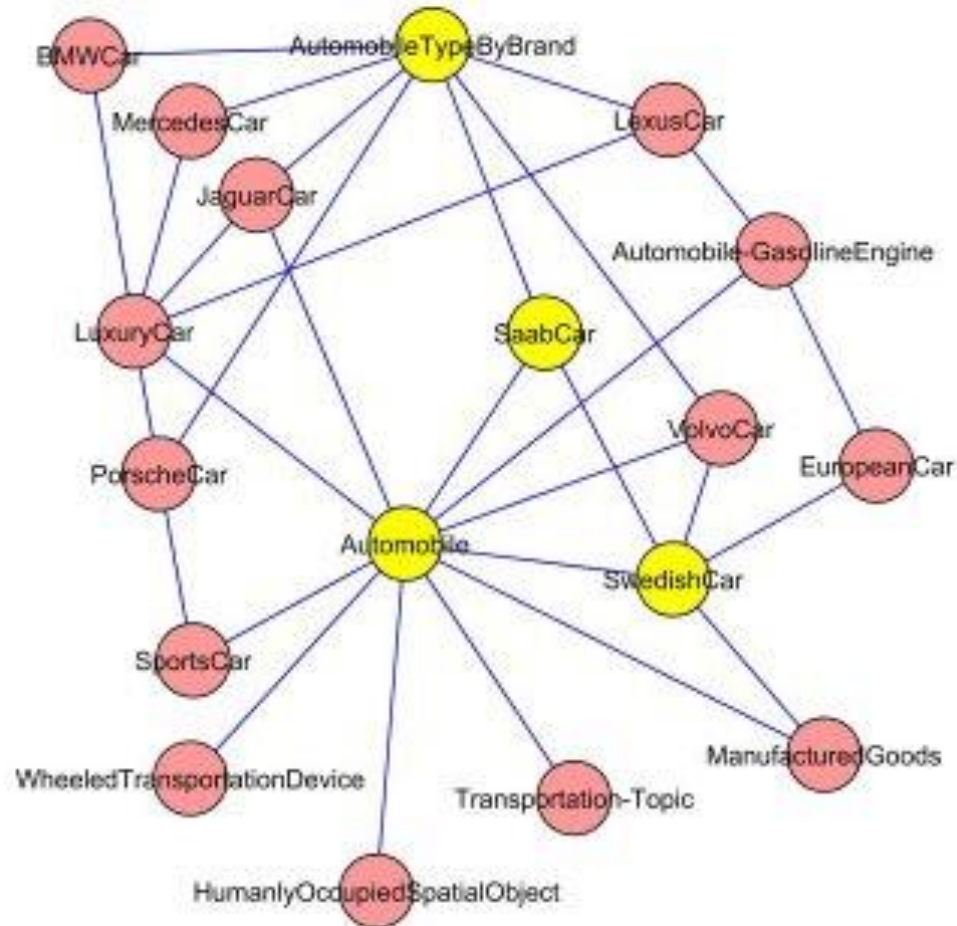
- only keep Saab neighborhood



Zooming

Example: Graph of concepts

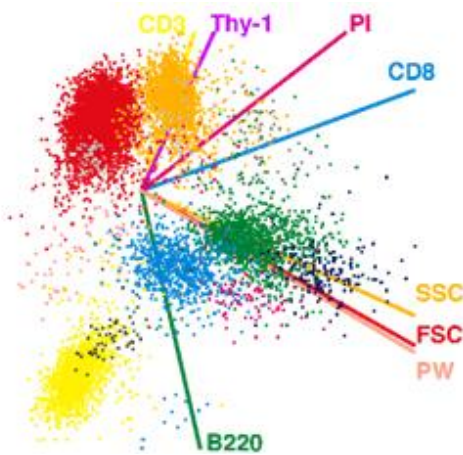
- only keep Saab neighborhood, zoom in more



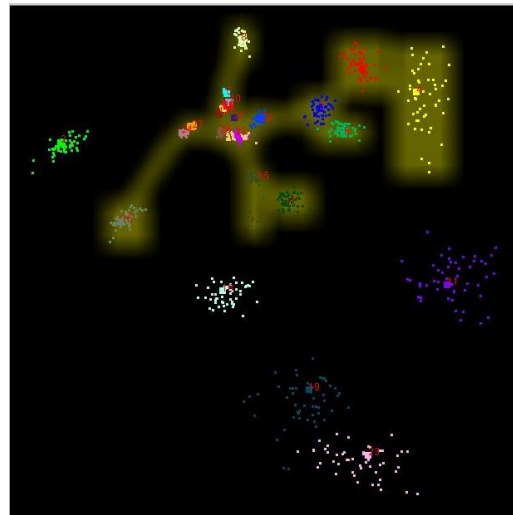
Aggregate

As discussed, good ways to aggregate all data into a single display are:

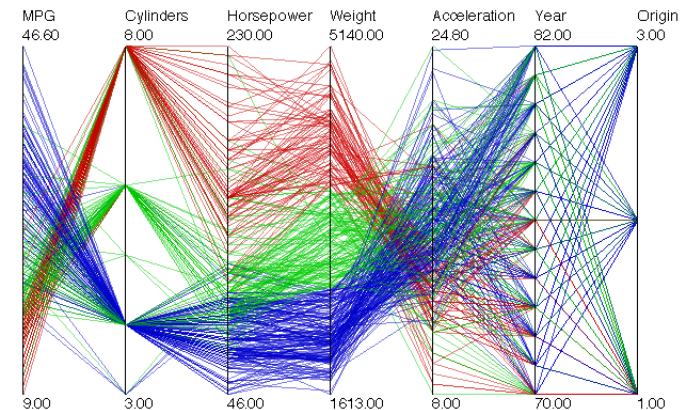
- biplots (project all data into a PCA vector basis)
- multidimensional Scaling (MDS)
- parallel coordinates



biplot



MDS



parallel coordinates

Overview and Detail

The Visual Information-Seeking Mantra

- devised 1996 by Ben Shneiderman (U Maryland, College Park)
- summarizes many visual design guidelines
- in some ways inspired by human vision/behavior
- provides an excellent framework for designing Information visualization applications.



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

....

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

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

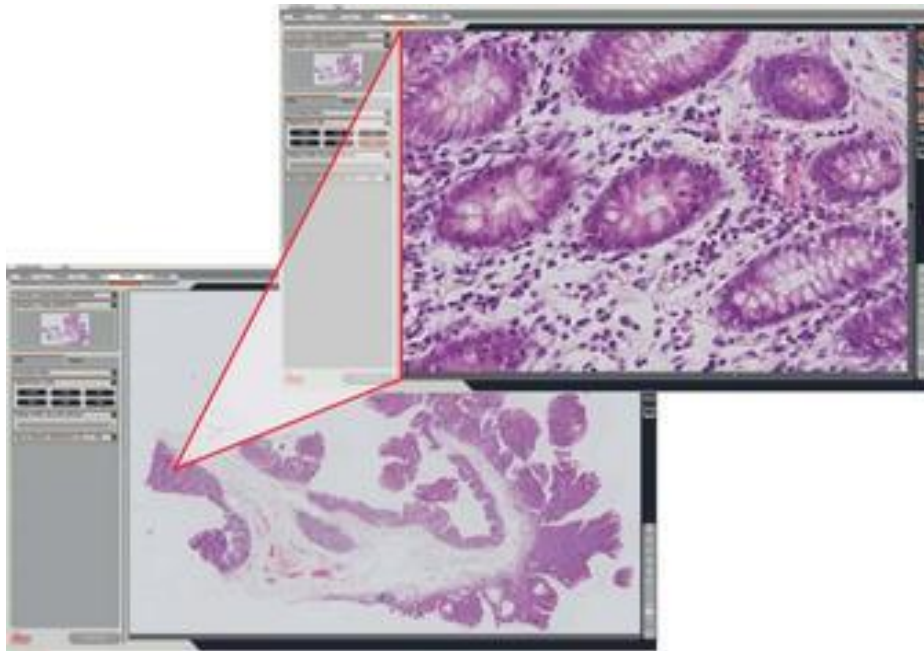
Overview, zoom and filter, then details-on-demand

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

Overview and Detail

Information space overview plus some detail

- maintains (some) context with the detail currently focused on



Leica Microsystems



WikiViz

Overview and detail

- disjoint views, maybe connected by a fan
- but: they simultaneously shows both overview and details
- require the viewer to consciously shift his/her focus of attention

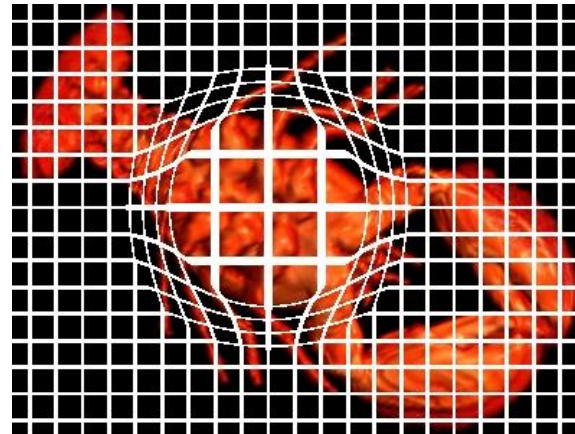
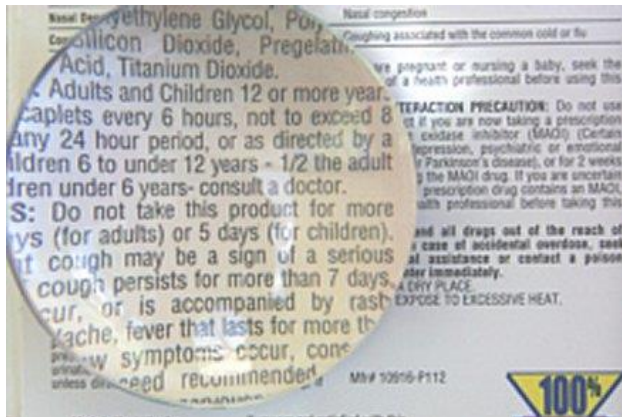
Focus + Context

Overview and detail

- disjoint views, maybe connected by a fan
- but: they simultaneously shows both overview and details
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Focus + context

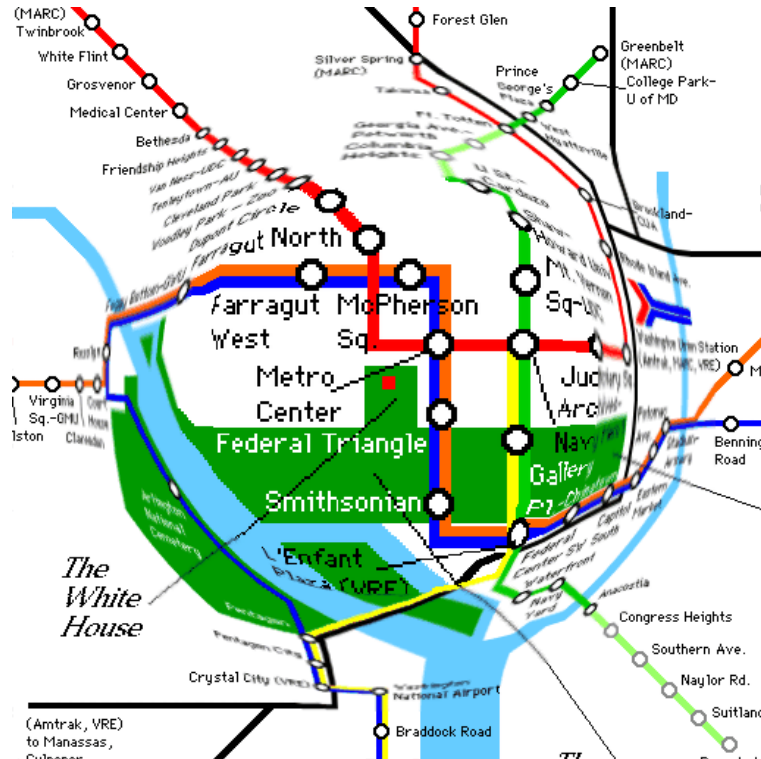
- one single view which shows information in direct context
- maintains continuity across the display
- do not require viewer to shift back and forth
- a good F+C paradigm is the *lens*
- but: there will be distortion



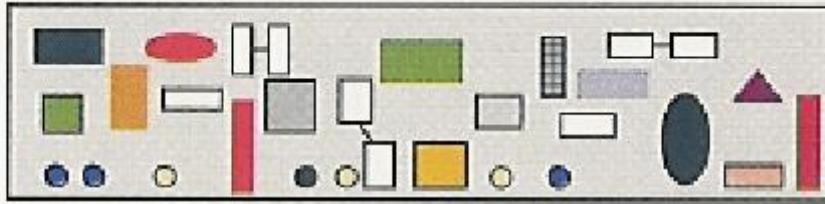
Fisheye Lenses

Fisheye lenses

- physically correct and therefore familiar
- keep target item in focus
- less relevant peripheral items are dropped or reduces in size
- distortion

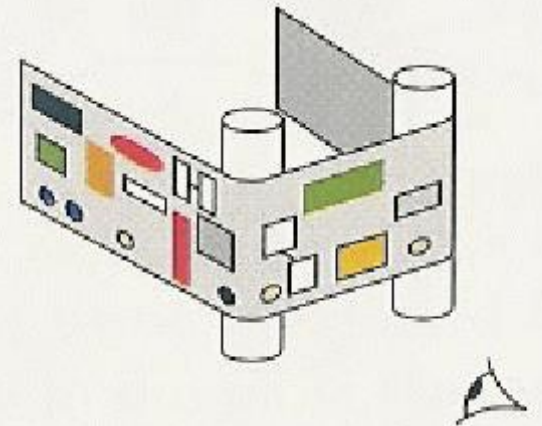


Bifocal Lens



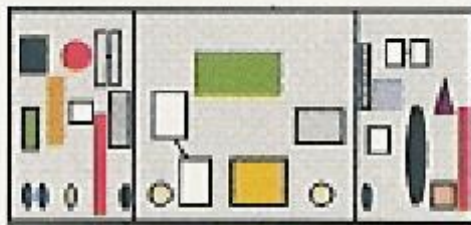
Complete Mapped Information Space

fold



Principle of the Bifocal Display

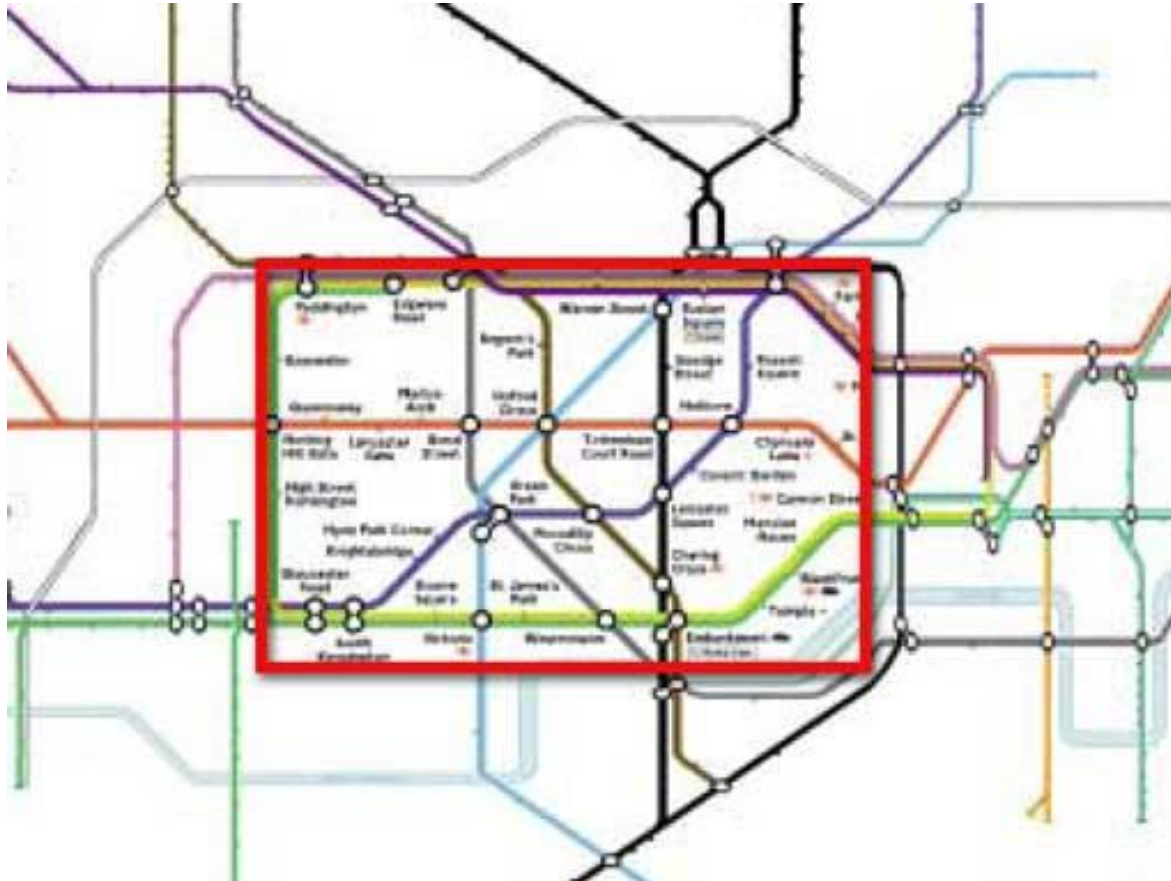
project



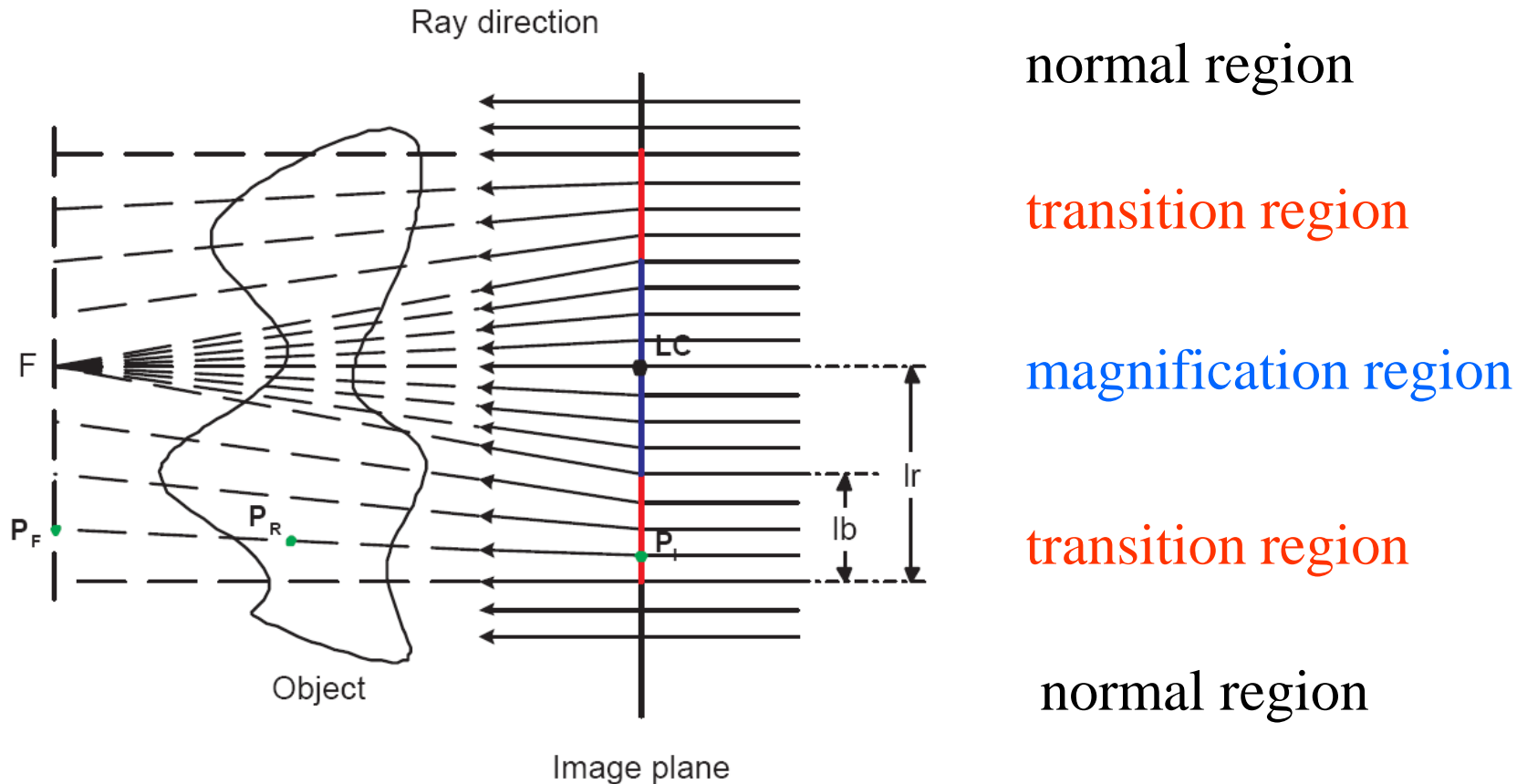
Bifocal Display Seen by the User

Bifocal Lens

London subway map



(Volumetric) Magnification Lenses

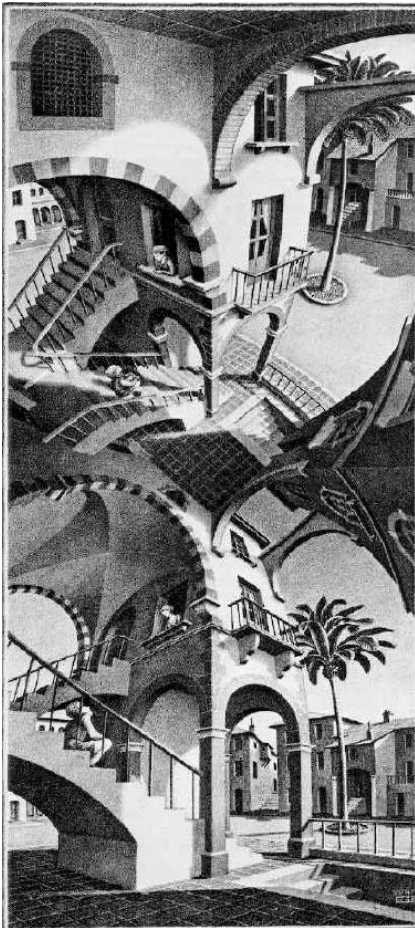


Avoid aliasing in transition regions by low-pass filtering

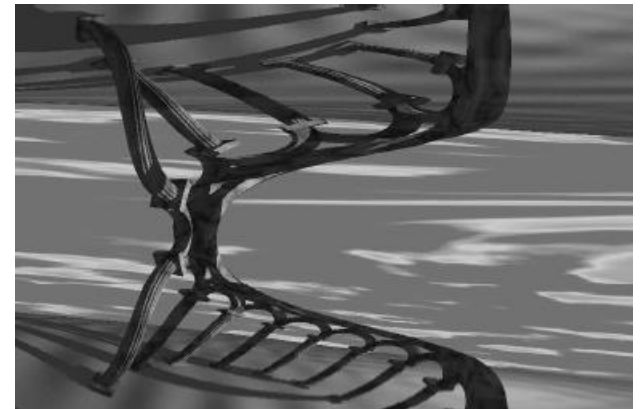
Generalized Lenses

Computers can go beyond (stretch) the laws of physics

- example: multi-perspective lens rendering, gaze-directed, ...



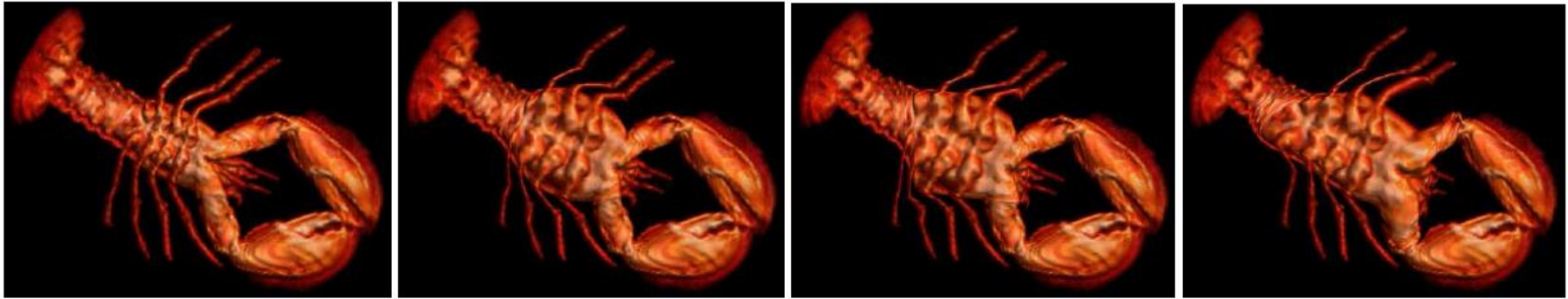
Rademacher/Bishop



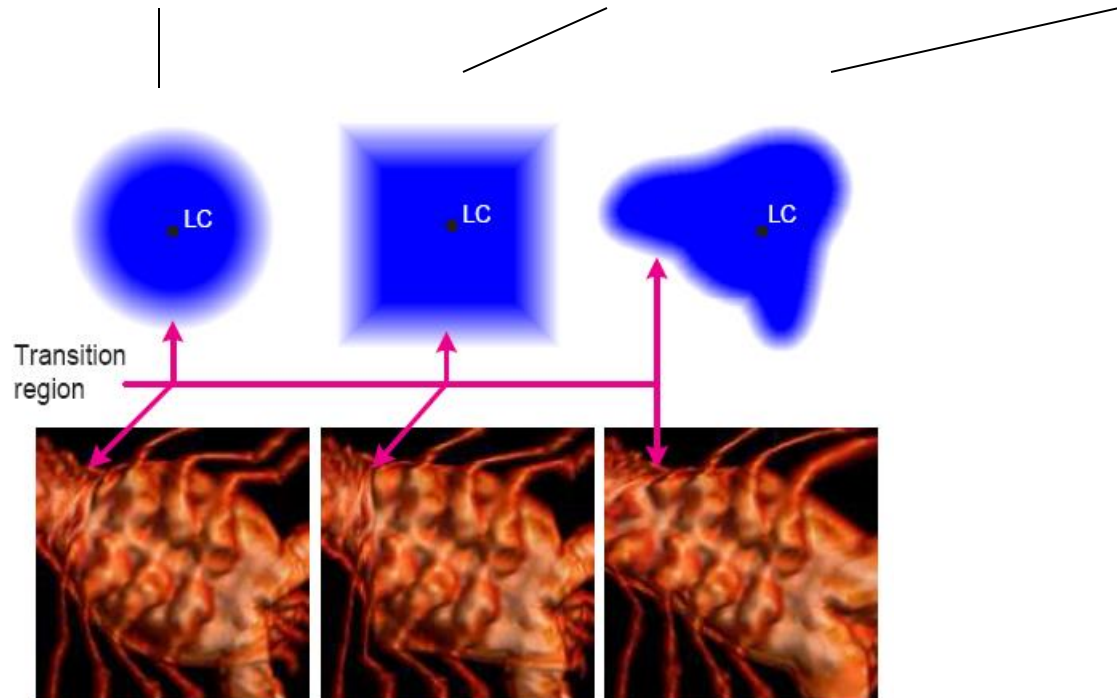
MC Escher

Loeffelmann/Groeller

Generalized Lenses



no lens

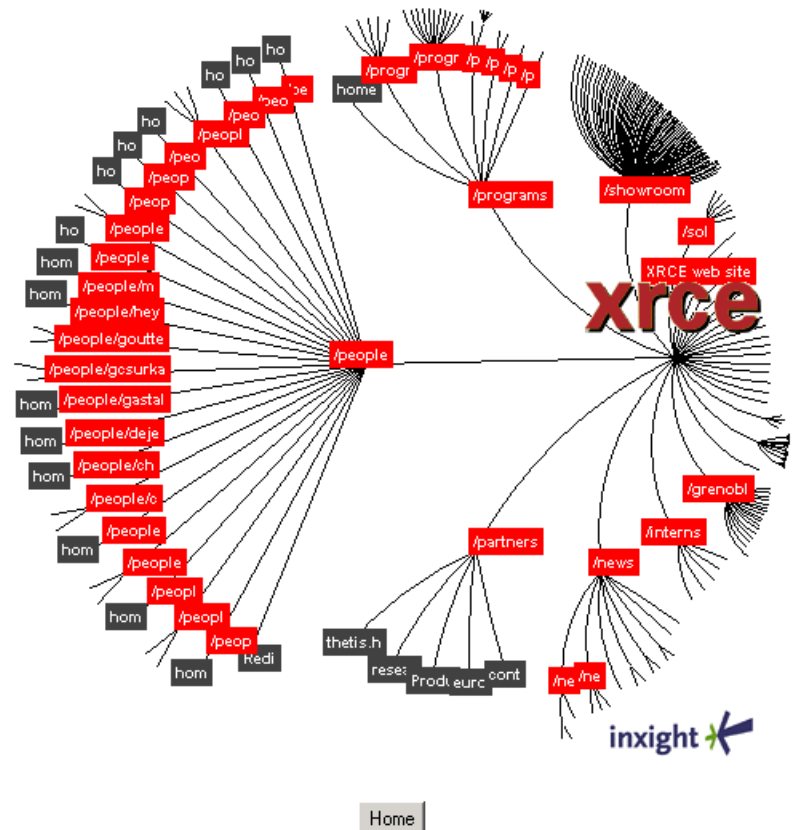
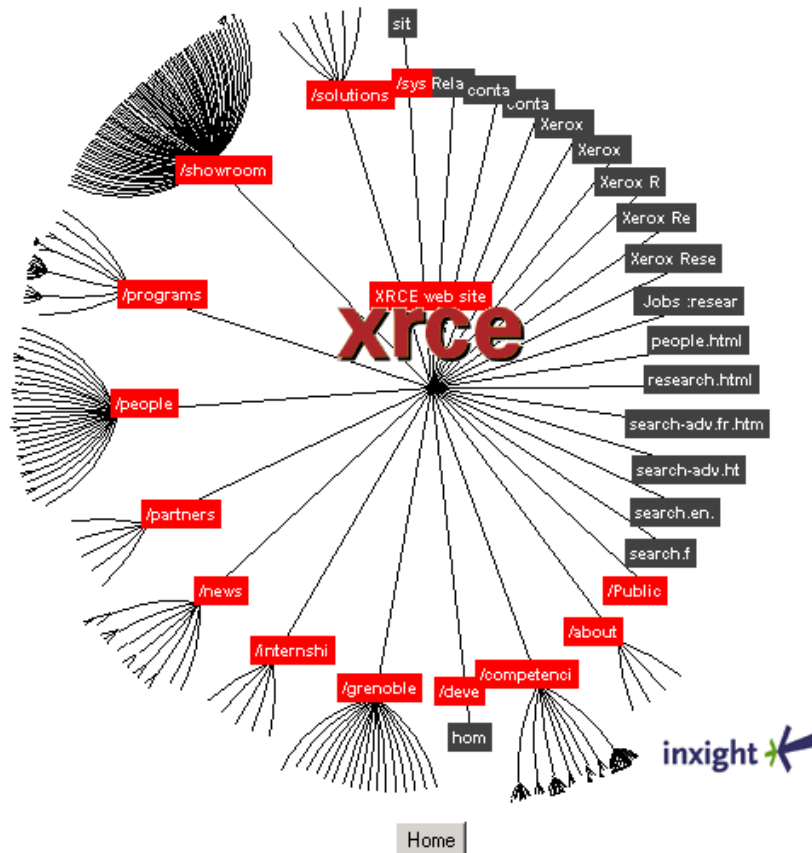


Wang et al., 2005

Lenses in Information Visualization

Hyperbolic Tree fisheye lens

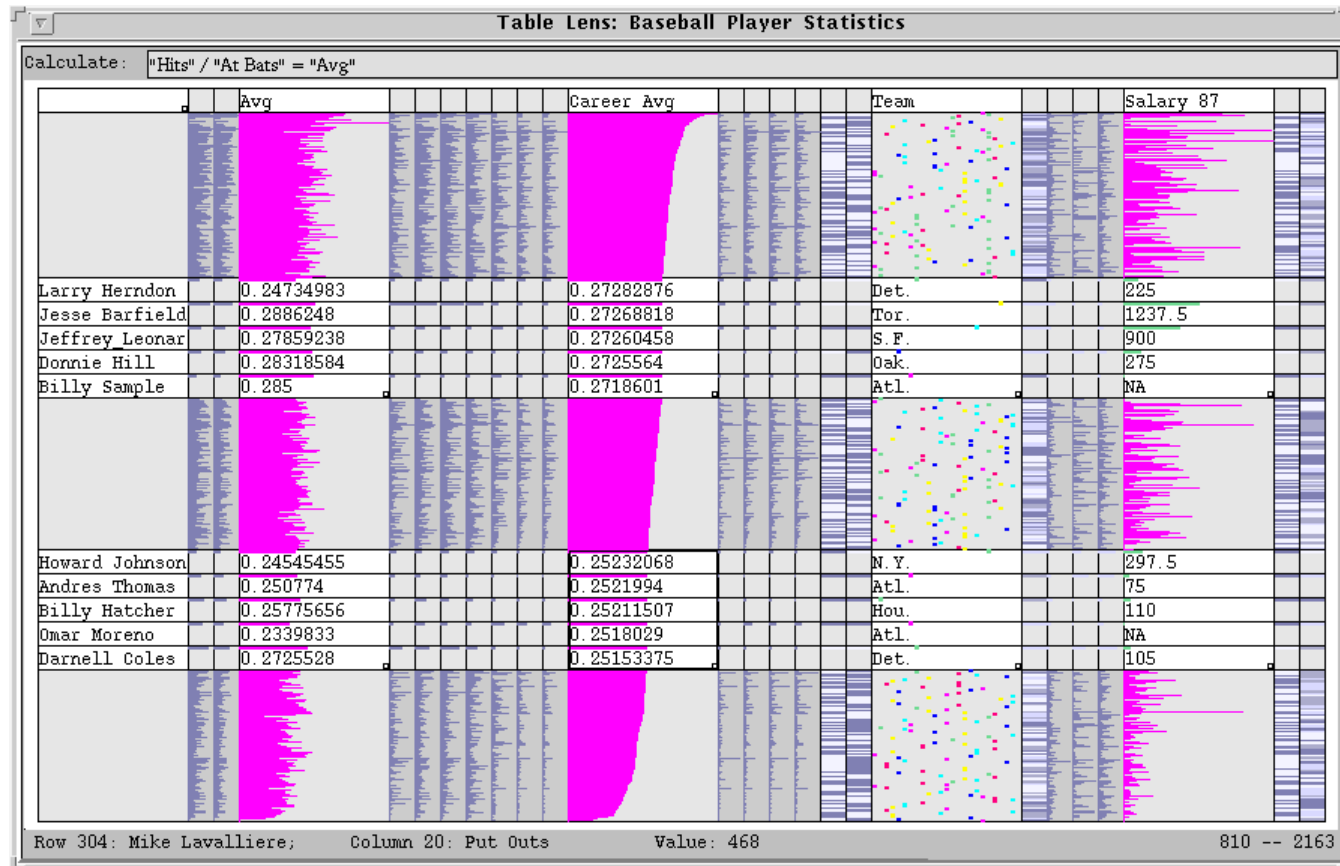
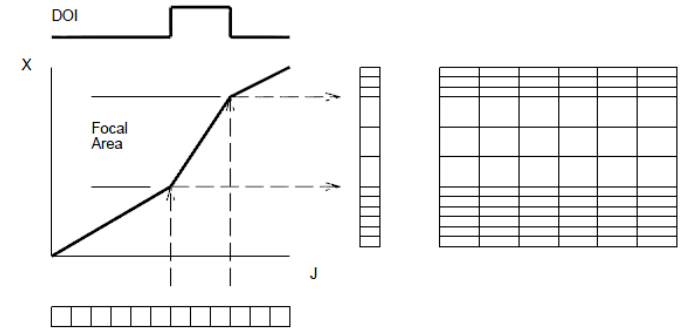
- Xerox PARC/Inxight
- selectively and smoothly reduce complexity as user focus changes



Lenses in Information Visualization

Table Lens (Rao and Card, 1994)

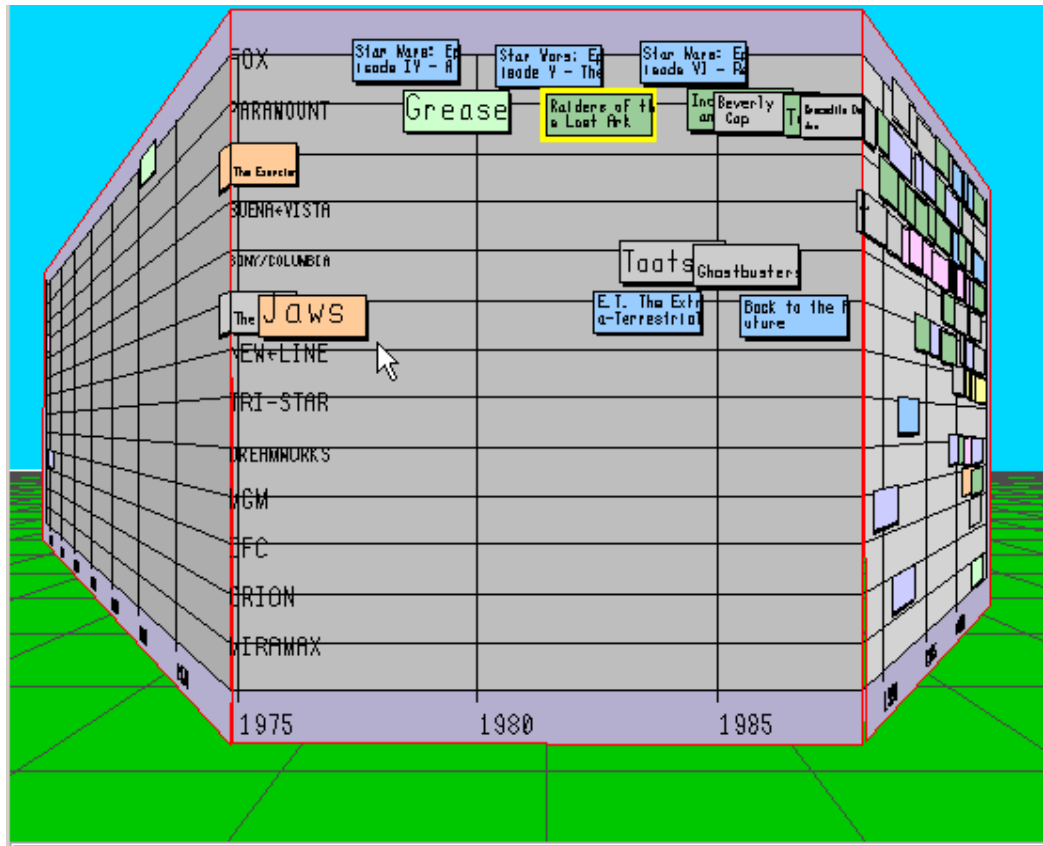
- uses a DOI (degree of interest) lens
- fuses symbolic and graphical detail driven by the DOI lens



Lenses in Information Visualization

Perspective Wall

- Xerox PARC/Inxight
- details on the center panel are at least three times larger than the details on a flat wall that fits the field of view



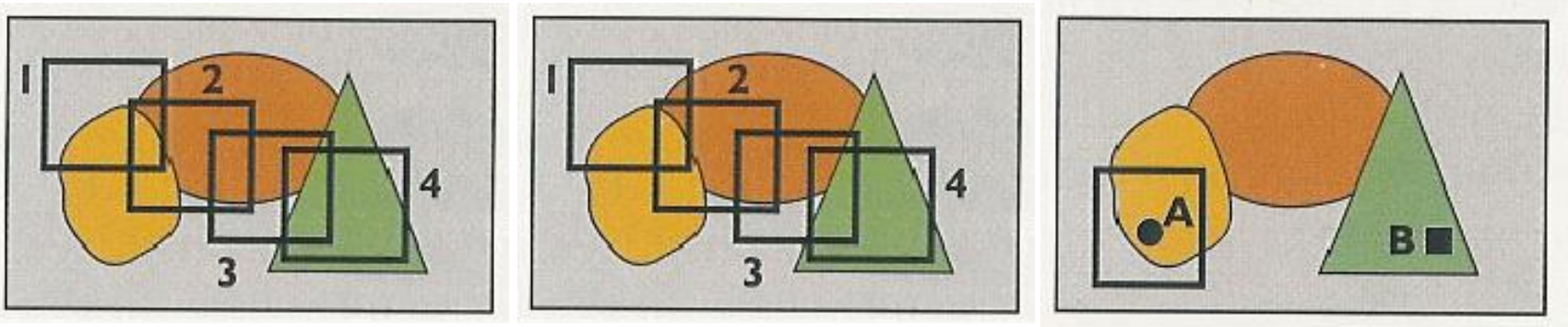
Zoom and Pan

Panning

- smooth movement of a viewing frame over a 2D image of greater size
- Zooming
 - increasing magnification of a decreasing fraction (or vice-versa) of a 2D image under the constraint of a viewing frame of constant size

Transfer of the focus of attention:

- zoom out → pan → zoom in

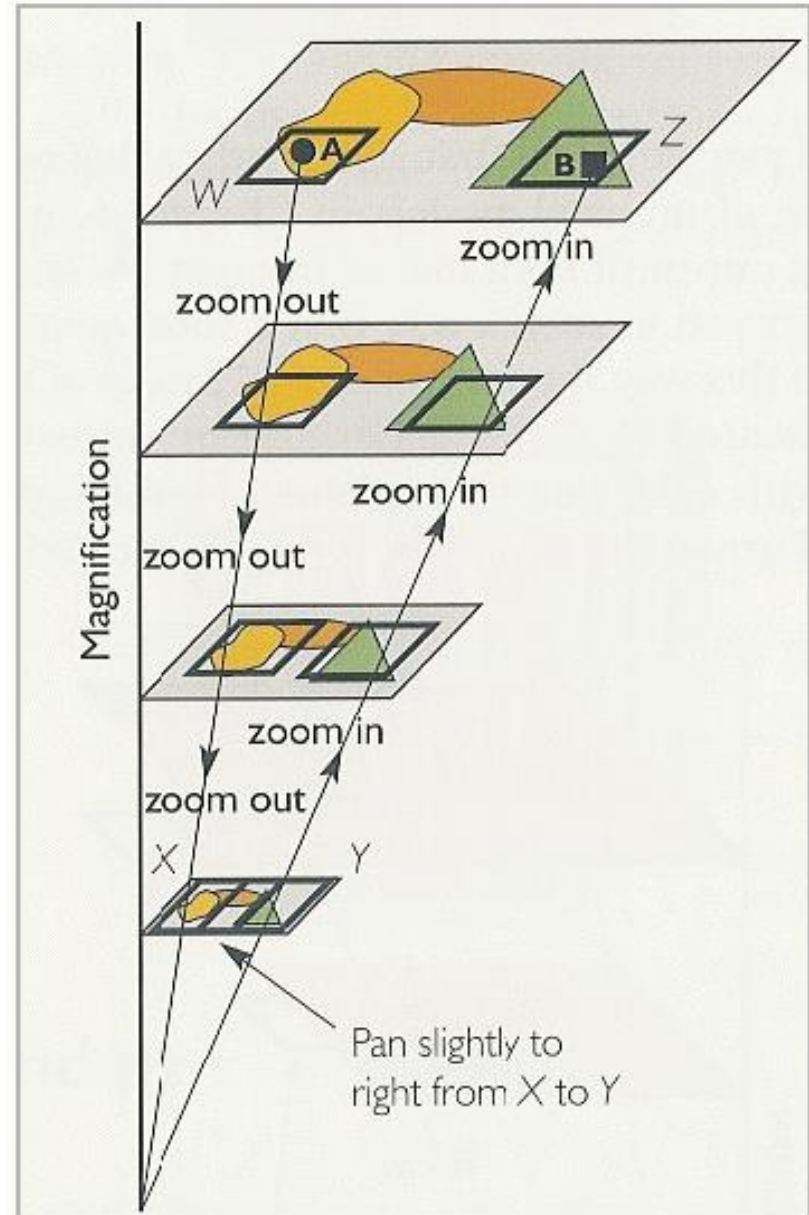


Scale-Space Diagrams

Efficient transfer of the focus of attention:

- zoom out → pan → zoom in

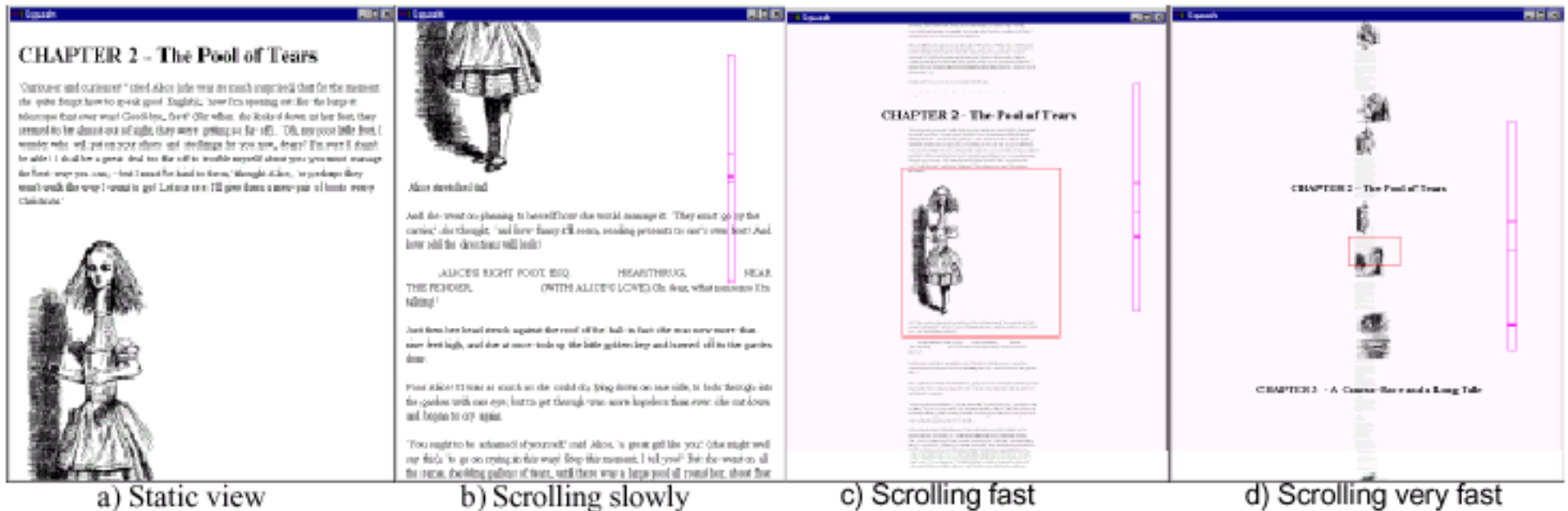
Furnas, Bederson, 1995



Intelligent Zooming

Depending on scrolling speed, zoom more or less

- allows efficient navigation of large documents
- employs semantic zooming



Igarashi, Hinckley, 2000

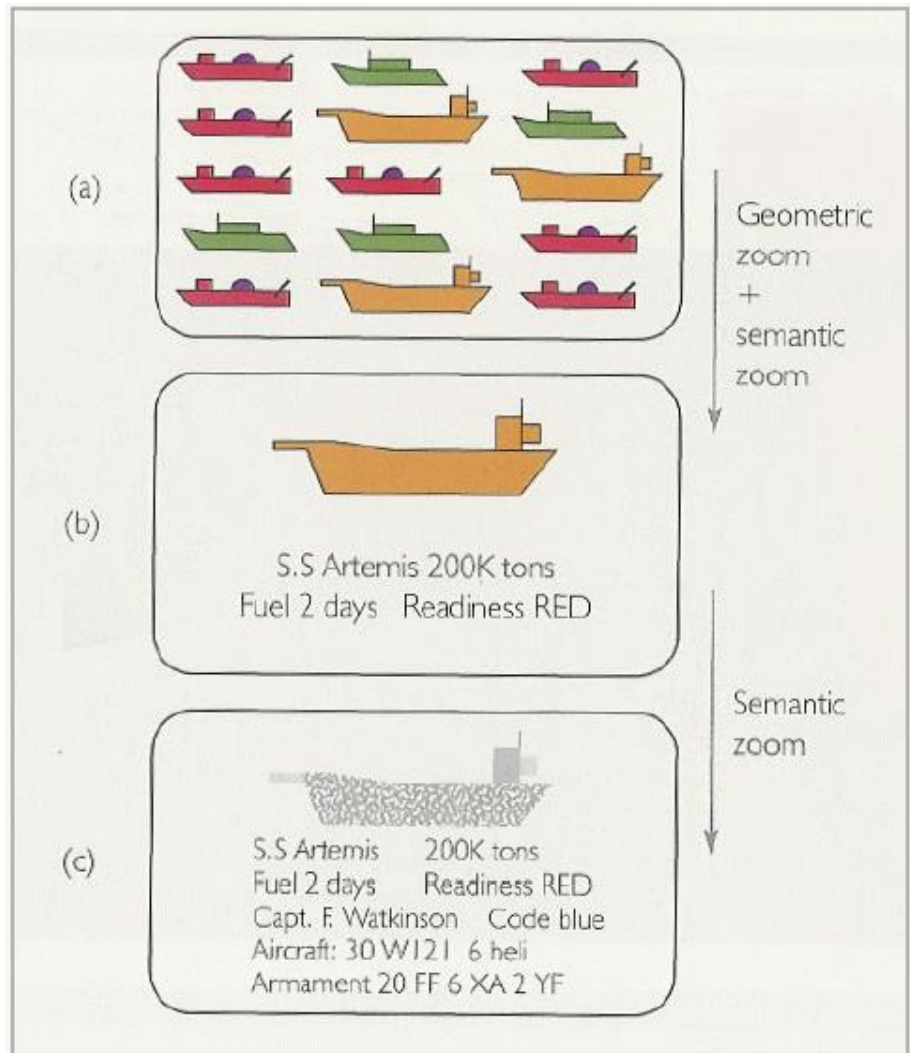
Semantic Zoom

Standard zoom:

shows a down/up scaled version of the object/image

Semantic zoom:

- shows a different representation determined by the space available



Semantic Zooms: Maps



Semantic Zooms: Information Visualization

Could show different levels/aspects of information

- on a map, show either parking lots, bars, or restaurants
- zoom in by price range (cheap first, then more expensive...)
- zoom in by preference (favorite food first, then less favorite...)
- may combine these criteria into a preference function

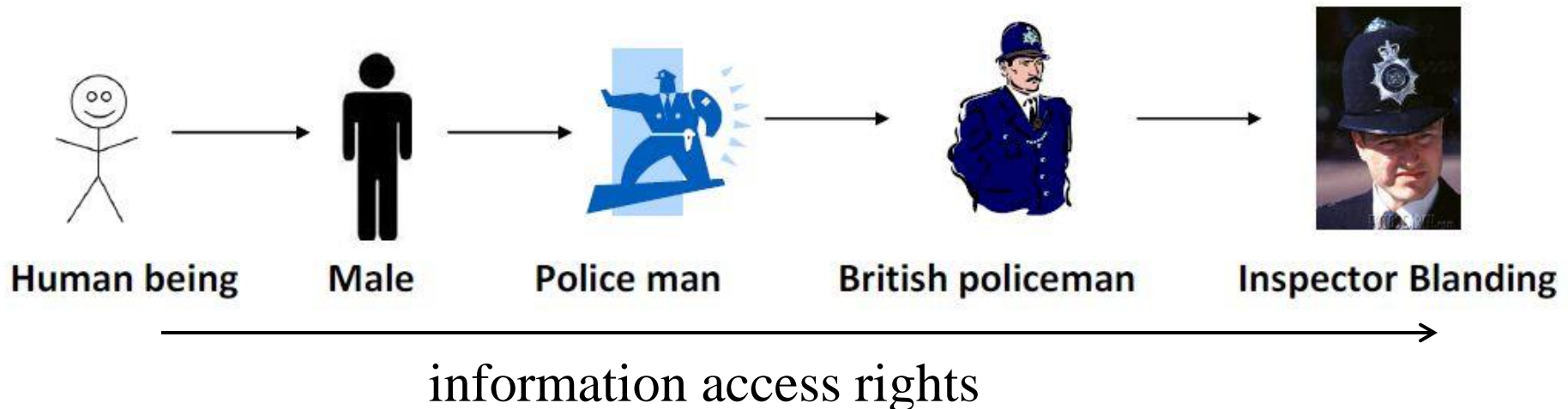
Semantic Zooms: Information Visualization

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Zoom levels may require access rights

- members only
- big wallets only
- classified information



Brushing and Linking

Interactive technique

- Highlighting
- Brushing and Linking

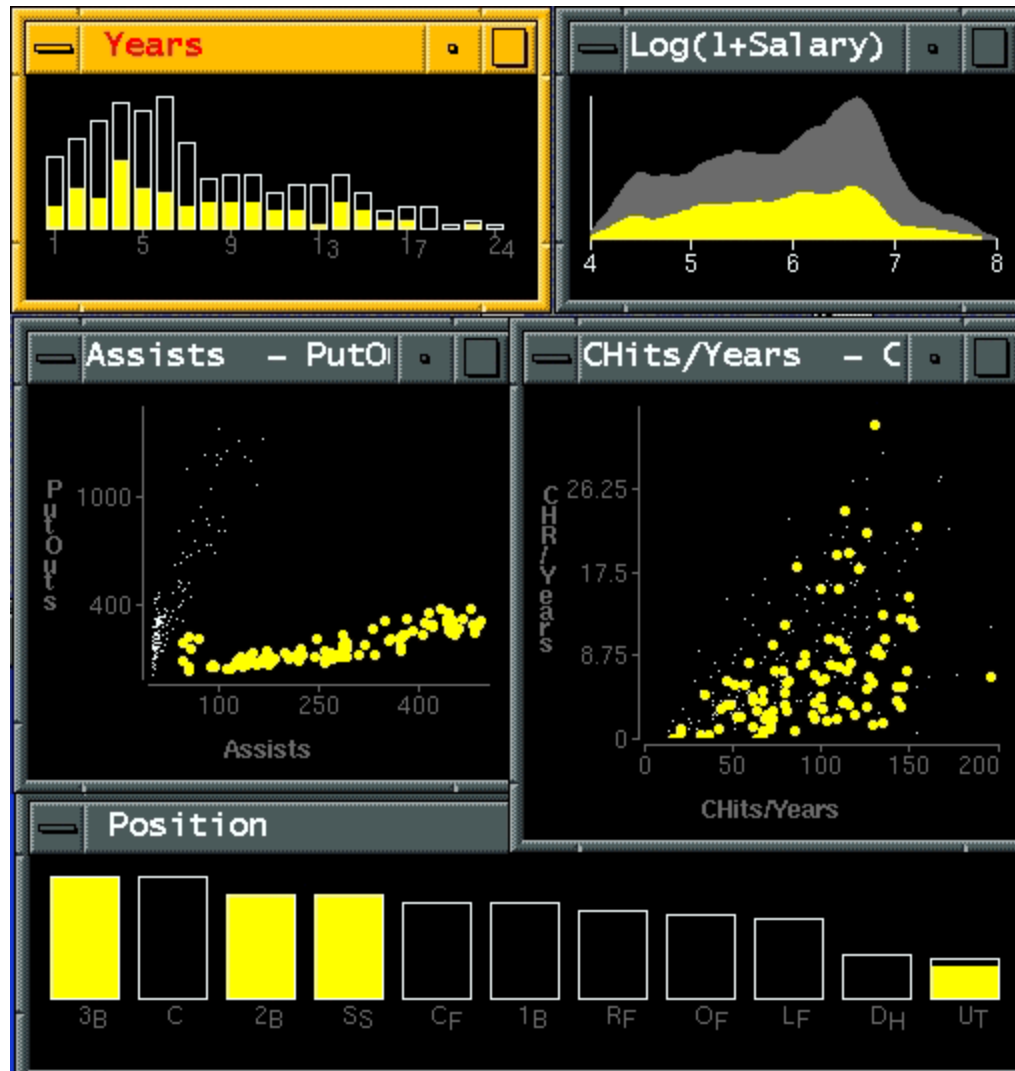
At least two things must be linked together to allow for brushing

- select a subset of points
- see the role played by this subset of points in one or more other views

Example systems

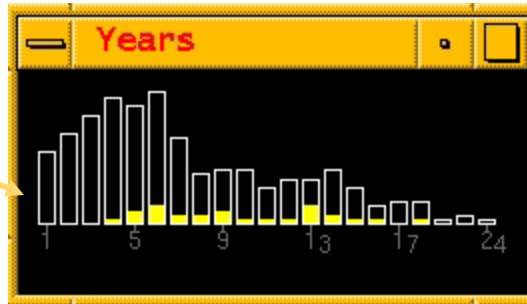
- Graham Will's EDV system
- Ahlberg & Sheiderman's IVEE (Spotfire)

Linking Types of Assist Behavior to Position Played

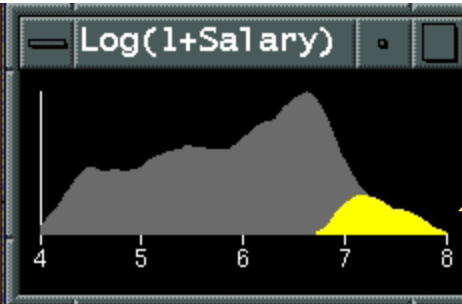


Baseball Data: Scatterplots and Histograms and Bars

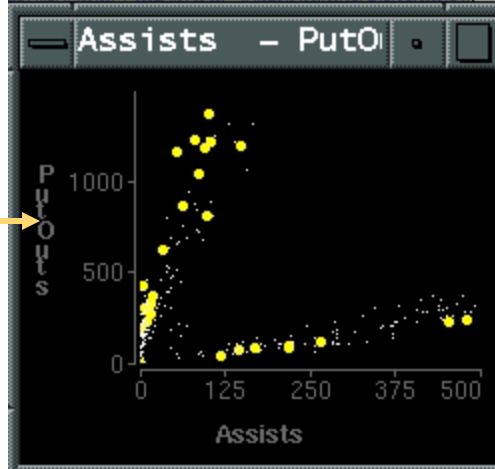
how long
in majors



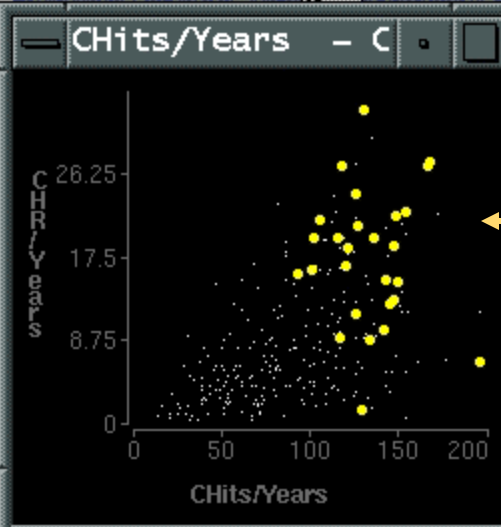
select high
salaries



avg assists vs
avg putouts
(fielding ability)



avg career
HRs vs avg
career hits
(batting ability)



distribution
of positions
played



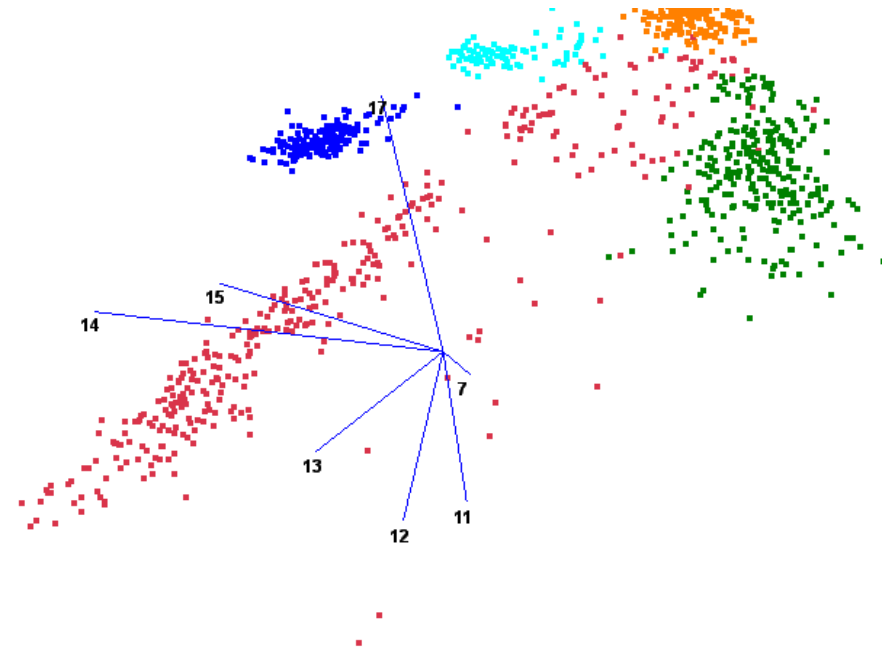
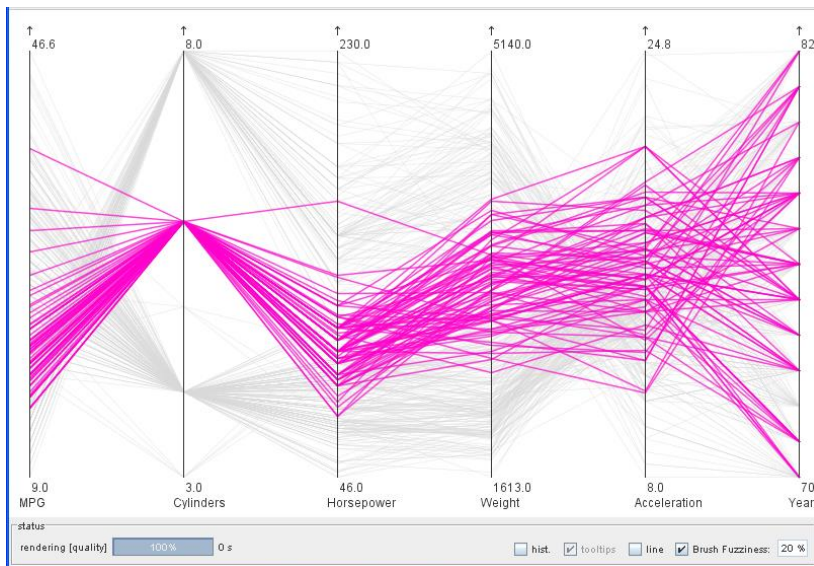
What was Learned from Interaction w/ the Baseball Data?

- Seems impossible to earn a high salary in the first three years
- High salaried players have a bimodal distribution (peaking around 7 & 13 yrs)
- Hits/Year a better indicator of salary than HR/Year
- High paid outlier with low HR and medium hits/year. Reason: person is player-coach
- There seem to be two differentiated groups in the put-outs/assists category (but not correlated with salary) Why?

Brushing: Highlighting

Use mouse interaction to highlight points and lines in

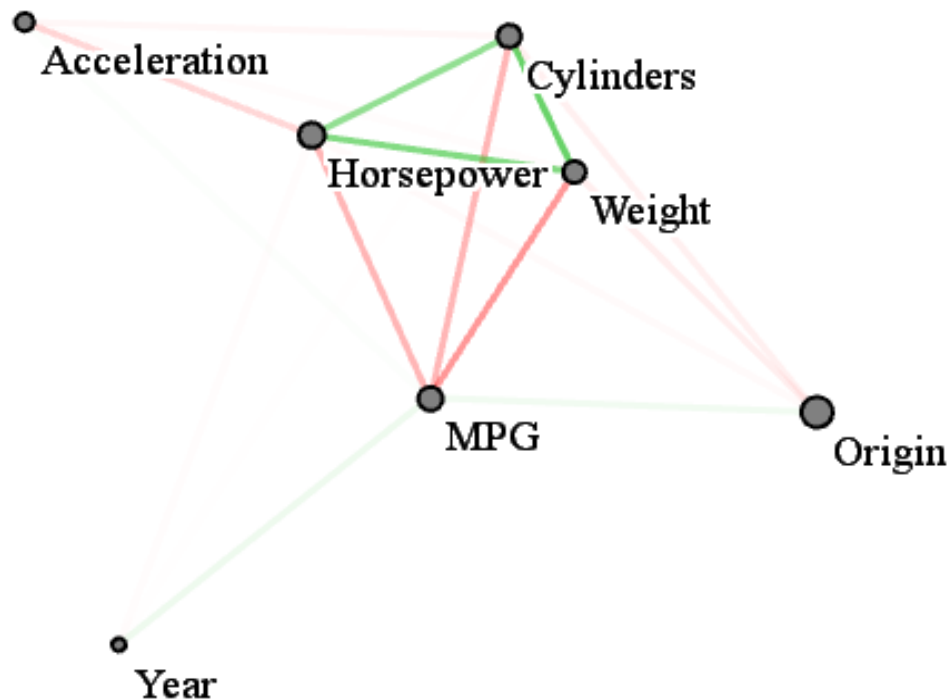
- parallel coordinates
- scatterplots



Show Meta Information: Correlation of Attributes

Based on Pearson's correlation for all attribute pairs

- vertices: attributes
- edges: correlation between attributes



Correlation Graph

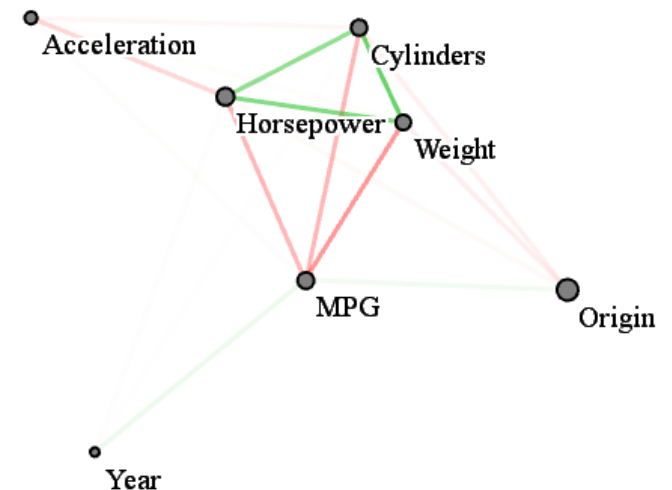
Use Mass-Spring Model for layout

Edge is weighted by the correlation

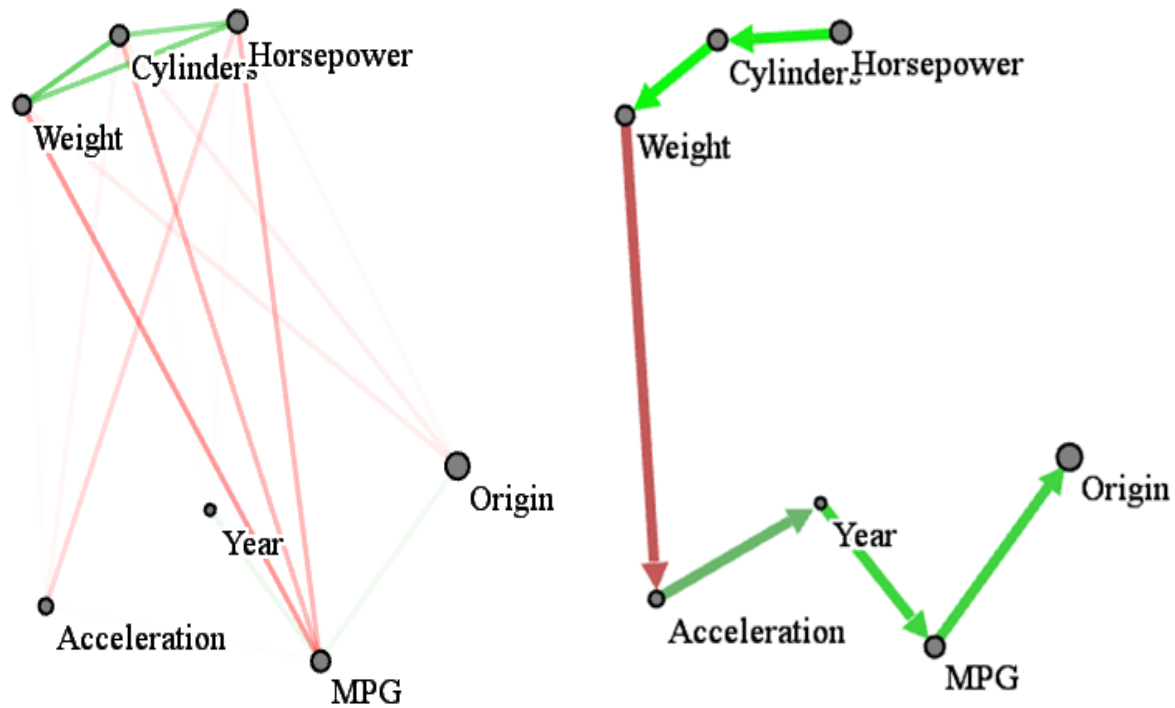
- negative, positive, or absolute

The correlation itself is encoded by color

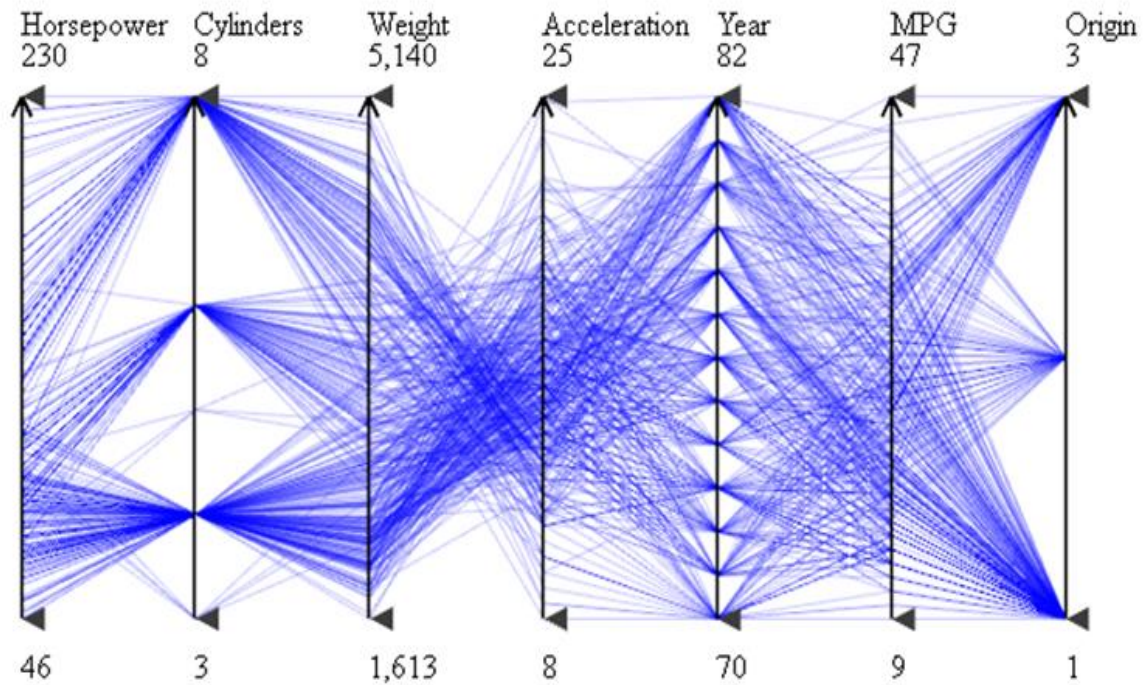
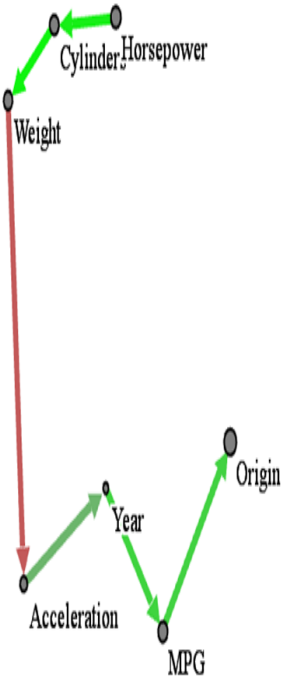
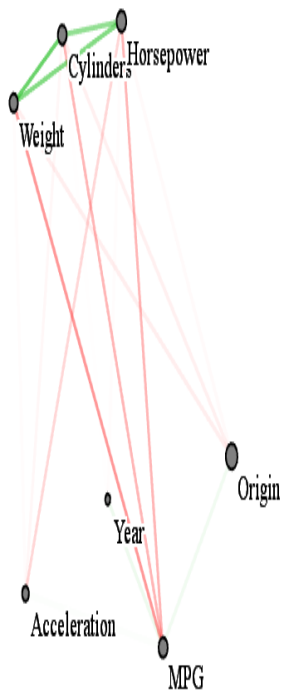
- green : correlation = 1.0
- red : correlation = -1.0
- linear interpolation computes the colors in between.



Compute Optimal Path



Re-Order Parallel Coordinate Display



Responsiveness in Javascript/D3.js

Remember? - Interaction needs to be interactive

- User needs to get quick visual feedback on actions

When does performance decrease in JavaScript?

Responsiveness in Javascript/D3.js

Remember? - Interaction needs to be interactive

- User needs to get quick visual feedback on actions

When does performance decrease in JavaScript?

- Mainly when the size of the dataset increases

Responsiveness in Javascript/D3.js

Remember? - Interaction needs to be interactive

- User needs to get quick visual feedback on actions

When does performance decrease in JavaScript?

- Mainly when the size of the dataset increases

Two areas where performance drops:

- Rendering (Increase in DOM nodes)
- Filtering (More data items to compare)

HTML Canvas: Solution to Rendering Issues

Rendering issues have been addressed by using a Canvas instead of SVG

- One html element instead of multiple elements

How does it work?

- We draw/project a view of the data on to a canvas(Occluded points are not drawn).

Issues with using canvas:

- No sub-elements \therefore interaction becomes non-trivial
- To support advanced interaction we need to maintain data structure in the memory.

Crossfilter.js: Solution to Filtering Issues

Filtering large datasets in the JSON format can be done quickly with Crossfilter.js

- Uses sorted indexes to improve performance of live histograms and top-K lists.

Crossfilter.js functionality:

- Filtering of course.
- Histogram computation.
- Sorting.

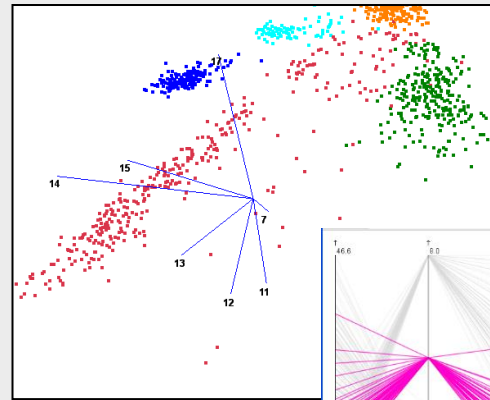
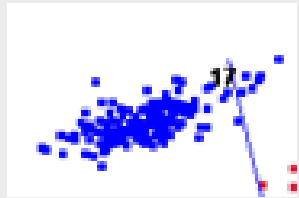
Example: <http://selfiecity.net/selfiexploratory/>

Library & Tutorial: <http://square.github.io/crossfilter/>

Multiple Linked Views (Dashboard)

Overview

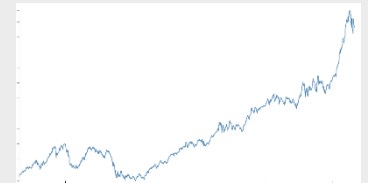
Details/Zoom



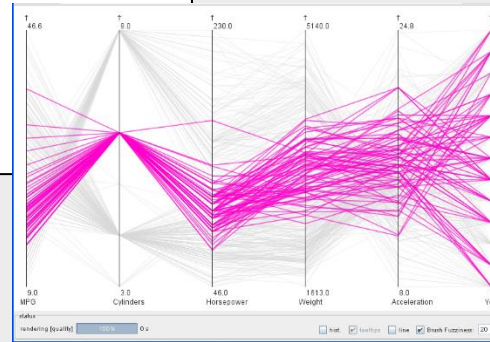
Biplot/MDS



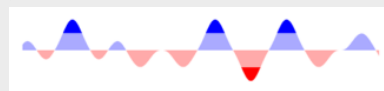
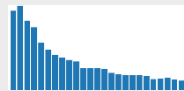
Individual
Dimension



Parallel
Coordinates



Histogram/Timeline



Brushing in D3.js

Support by [d3-brush](#)

Rectangular brush

- [scatterplot matrix brushing](#)
- [scatterplot brushing](#)
- [brush and zoom](#)

Polygonal brush

- [polybrush](#)
- [github](#)