CSE 564
Visualization & Visual Analytics

Interaction & Information Navigation

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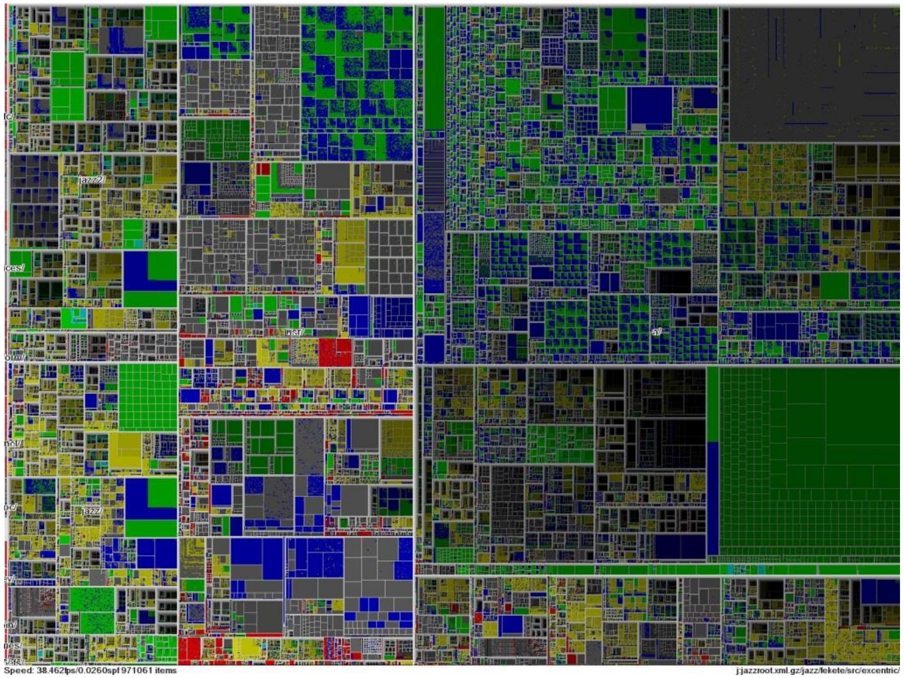
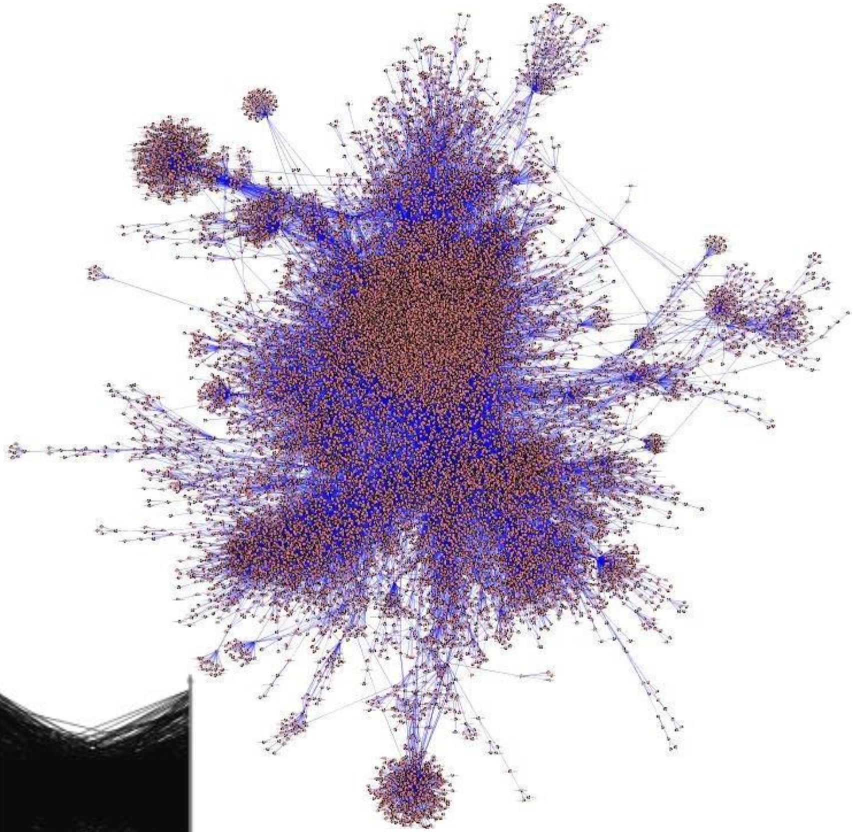
Lecture	Topic	Projects
1	Intro, schedule, and logistics	
2	Applications of visual analytics	
3	Basic tasks, data types	Project #1 out
4	Data assimilation and preparation	
5	Introduction to D3	
6	Bias in visualization	
7	Data reduction and dimension reduction	
8	Data reduction and dimension reduction	Project #2(a) out
9	Visual perception and cognition	
10	Visual design and aesthetics	
11	High-dimensional data visualization: linear methods	
12	High-dimensional data visualization: non-linear methods	Project #2(b) out
13	Cluster analysis: numerical data	
14	Cluster analysis: categorical data	
15	Principles of interaction	
16	Midterm #1	
17	Visual analytics	Final project proposal call out
18	The visual sense making process	
19	Maps	
20	Visualization of hierarchies	Final project proposal due
21	Visualization of time-varying and time-series data	
22	Foundations of scientific and medical visualization	
23	Volume rendering	Project 3 out
24	Scientific and medical visualization	Final Project preliminary report due
25	Visual analytics system design and evaluation	
26	Memorable visualization and embellishments	
27	Infographics design	
28	Midterm #2	

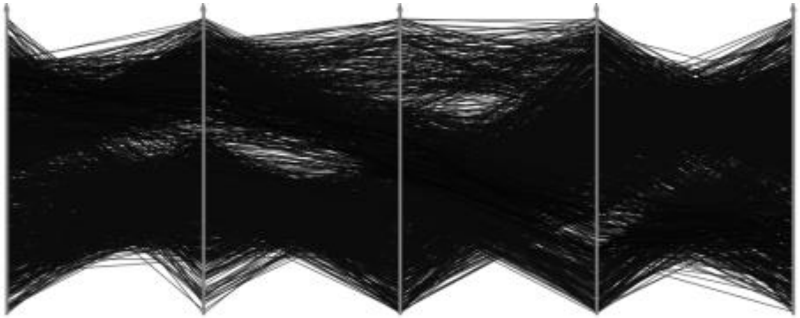
Too Much Data?

How can we deal with data overload

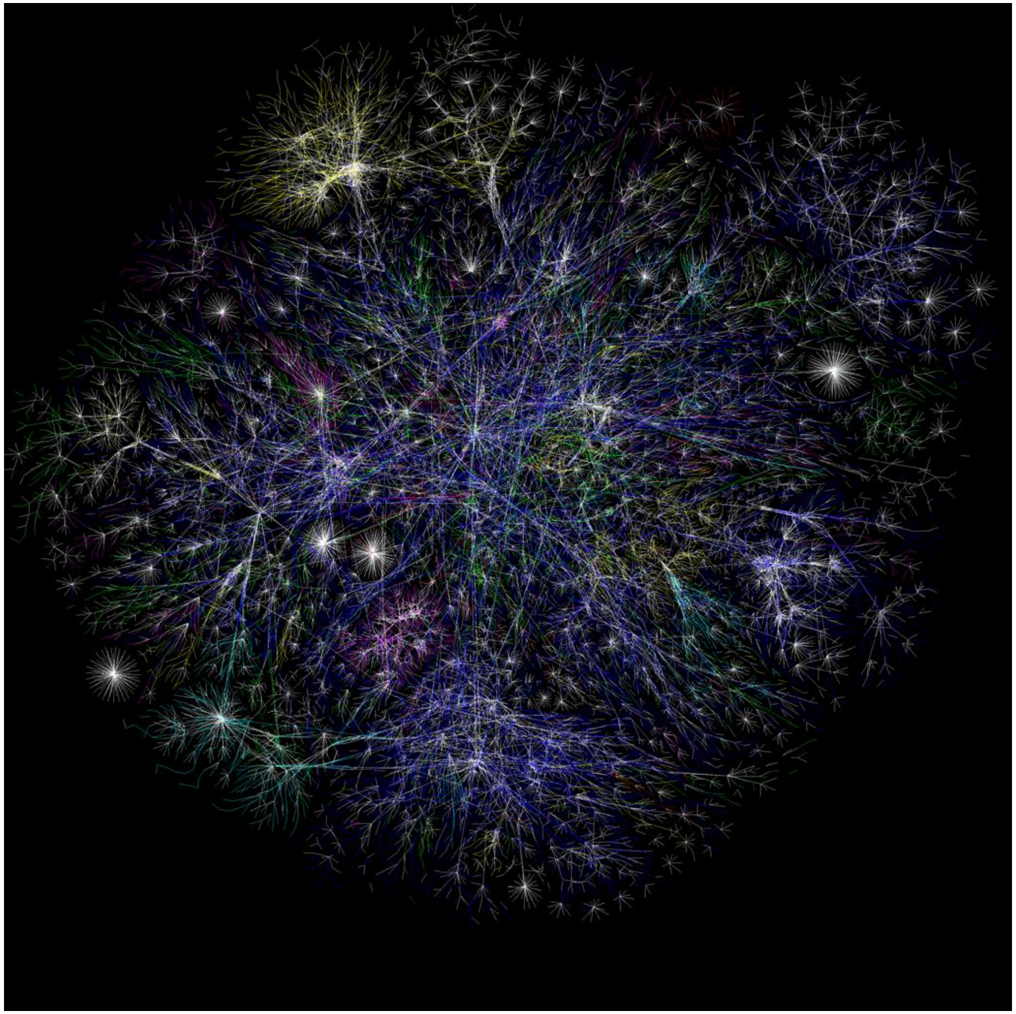
- see the forest for the trees (or the other way around)







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 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

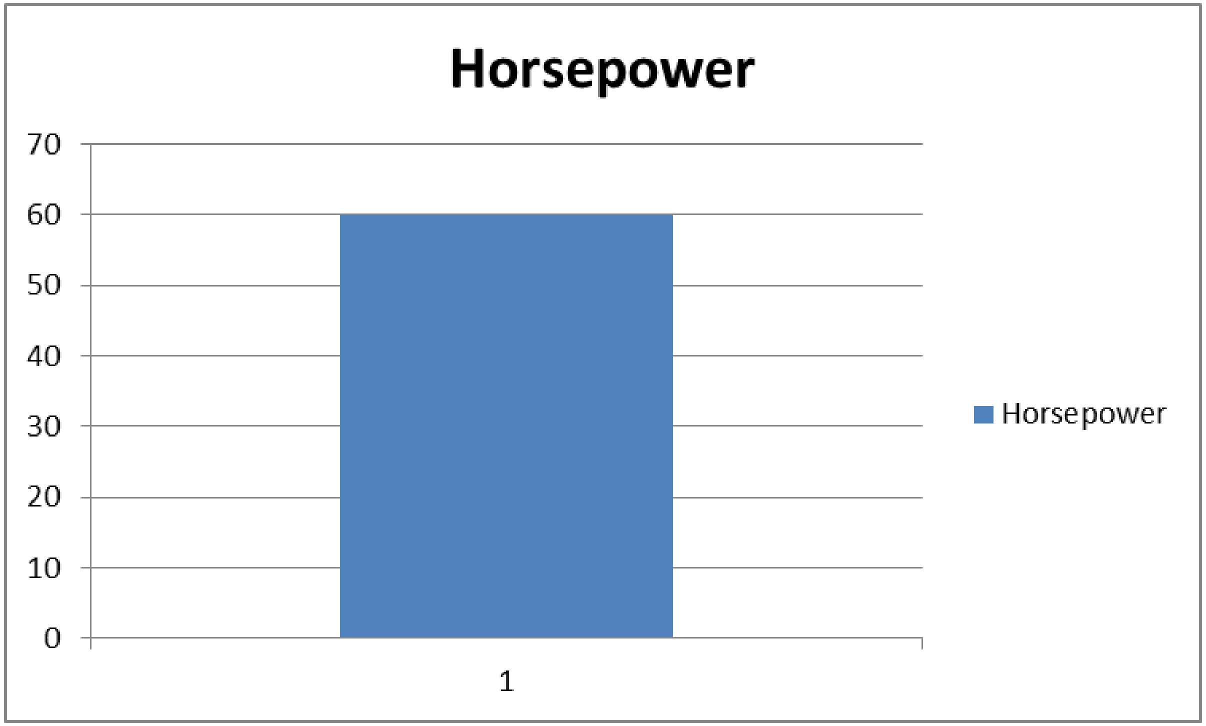
Stephen Few (chapter 4):

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

Example

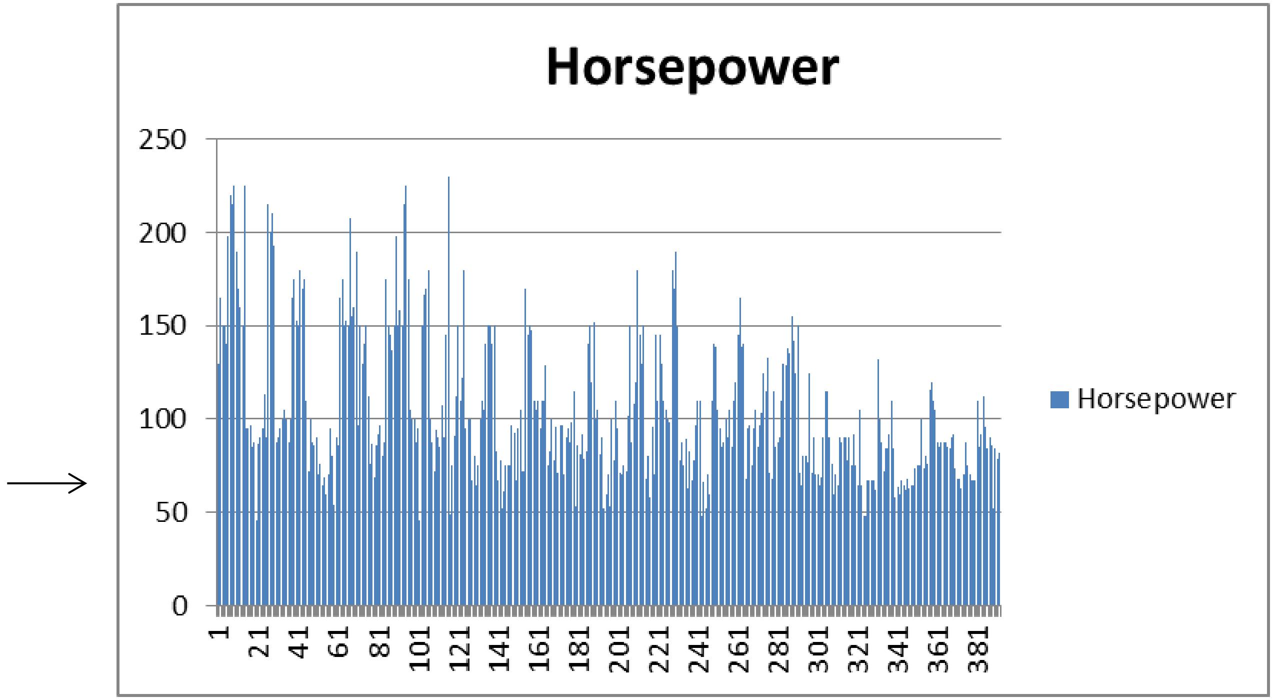
Assume you have been offered a car to buy

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



Compare

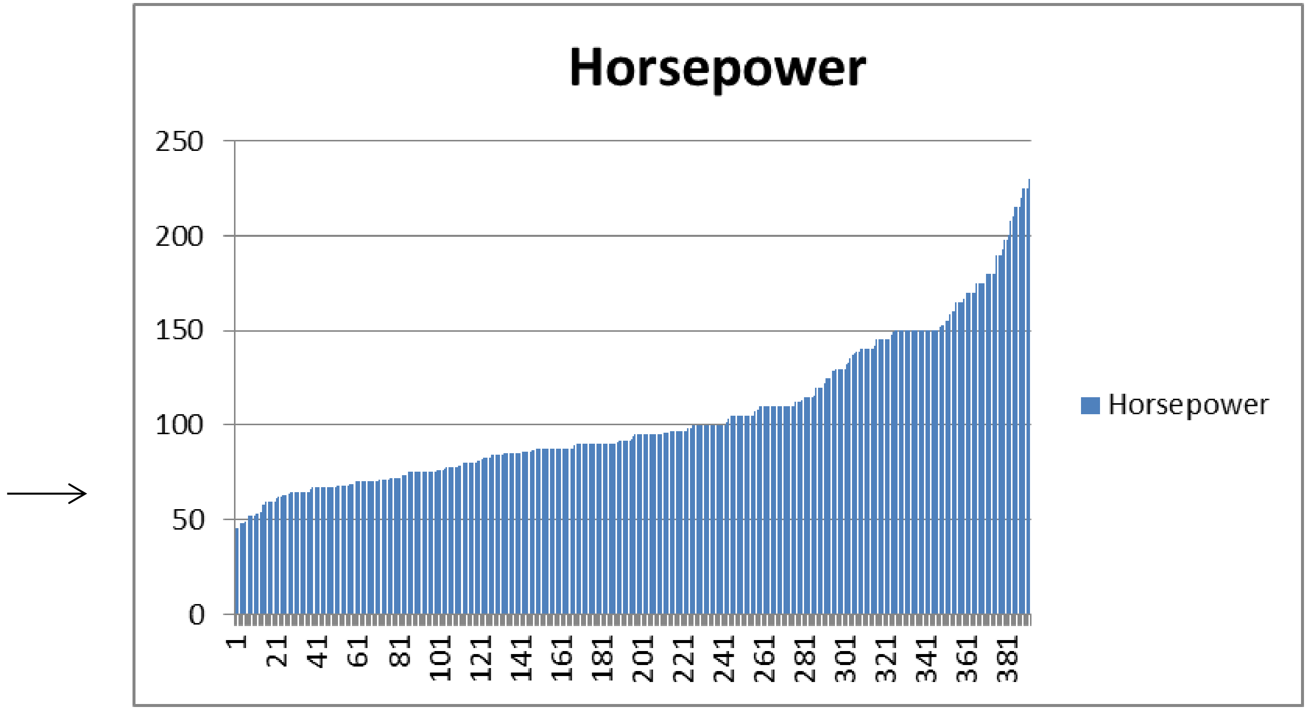
See the car with other available cars



hard to see how it really ranks

Sort

See the car in the context of other available cars

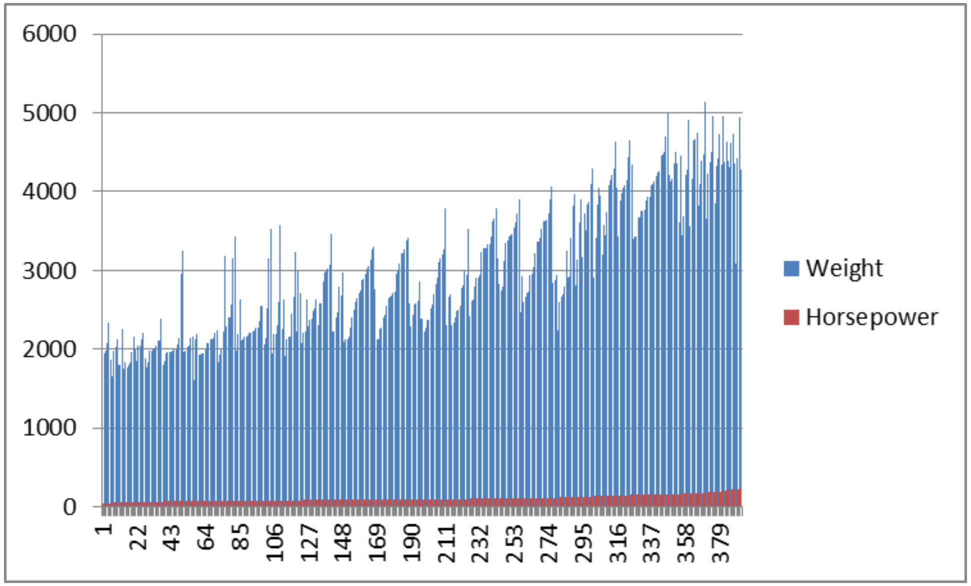


it is a low-horsepower car

Additional Variables

Is horsepower correlated to weight?

- are there trade-offs?

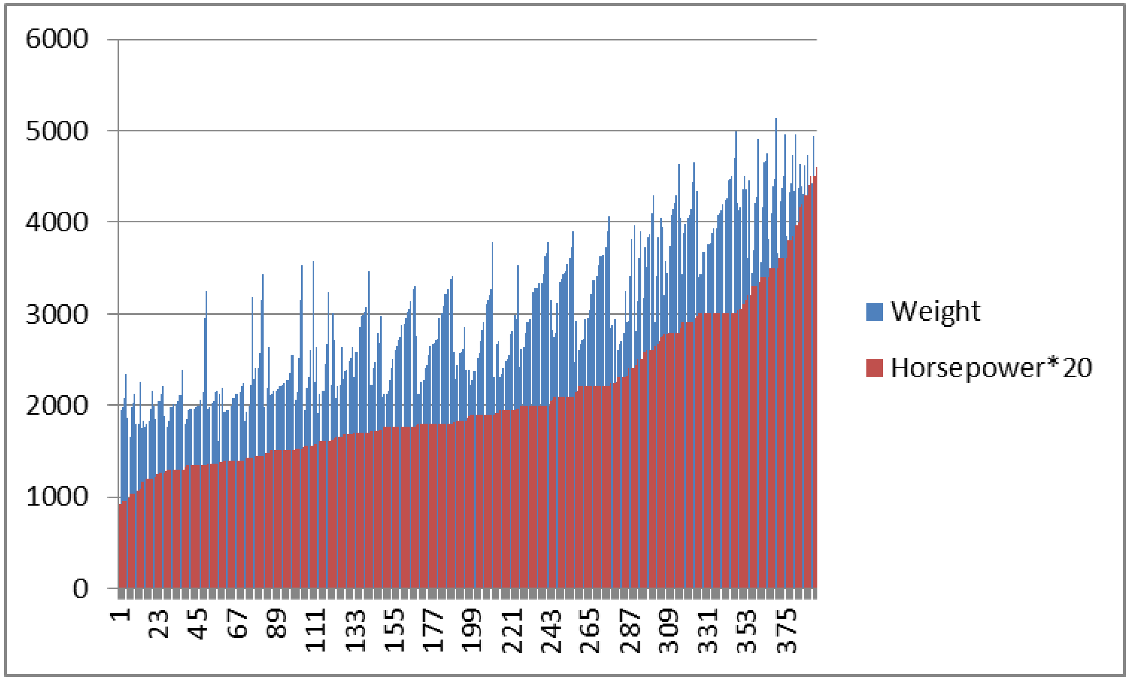


hard to see what is going on

Re-Scale

Scale horsepower into the same range than weight

- could also normalize each to (0.0, 1.0)

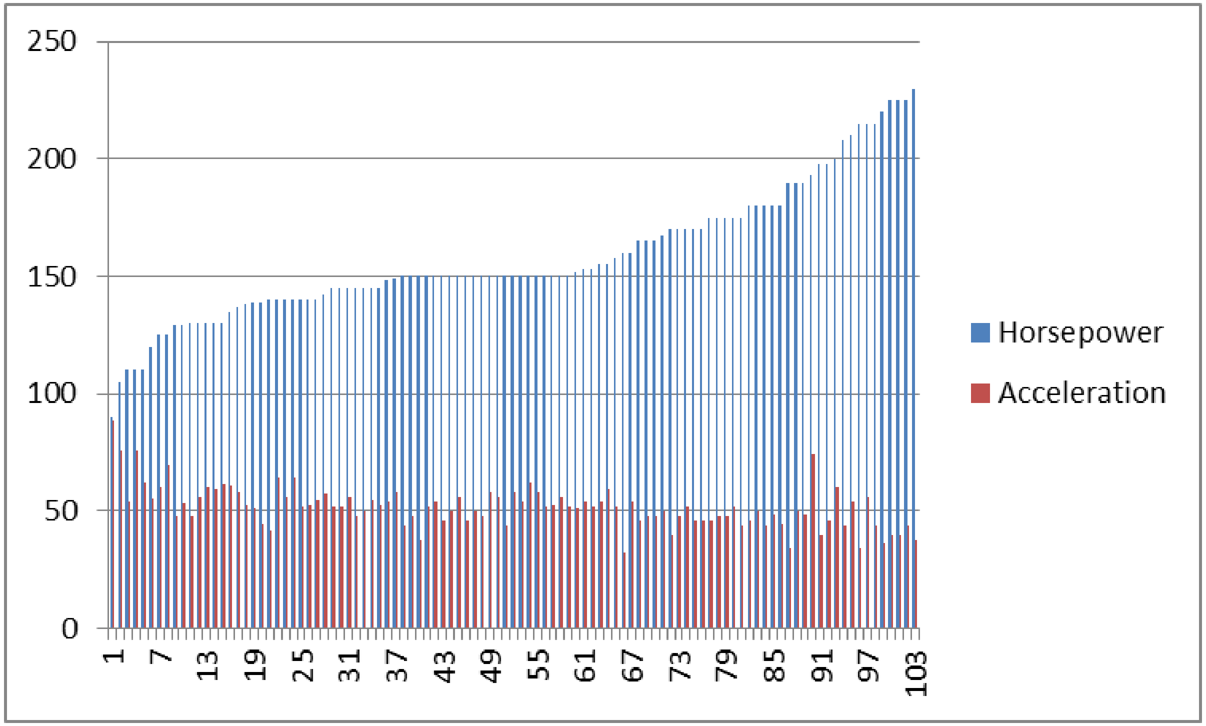


There seems to be a positive correlation

- cars with higher horsepower are also heavier

Another Variable

How does it relate to acceleration?

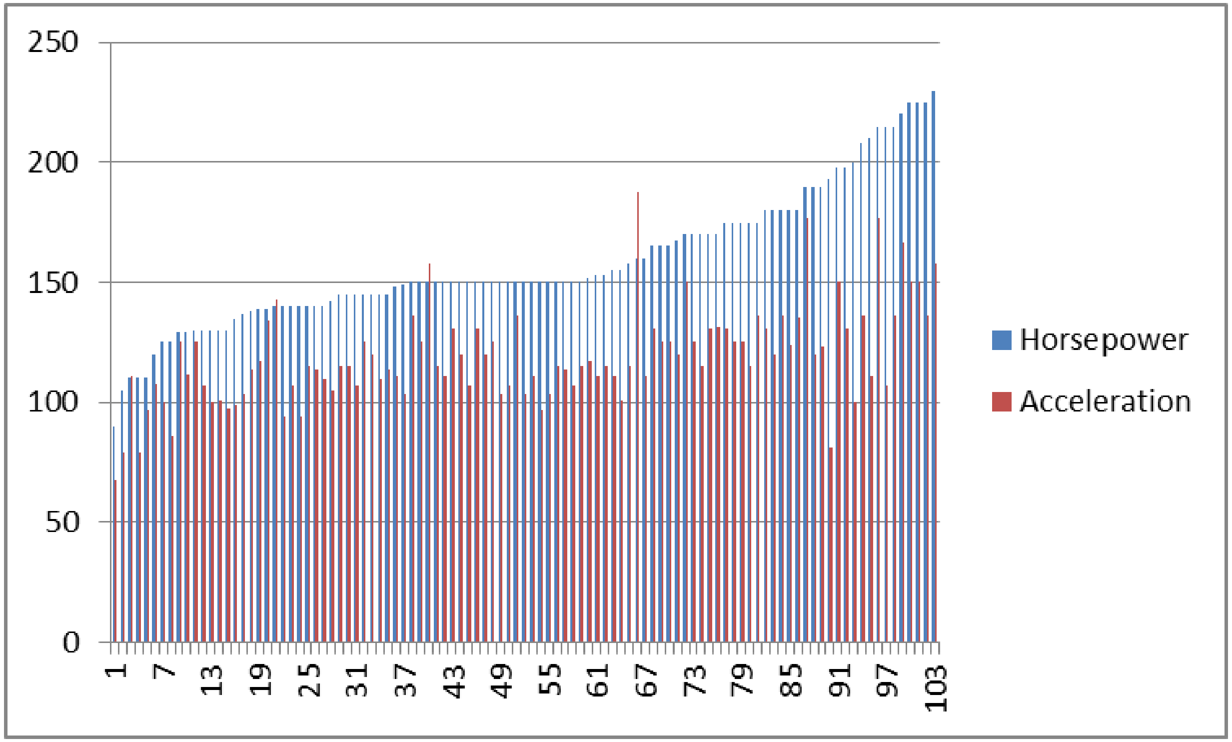


non-intuitive that acceleration is less for high horsepower cars

Re-Express

Acceleration should really be 1/acceleration

- should be measured in 1/sec (and not sec)

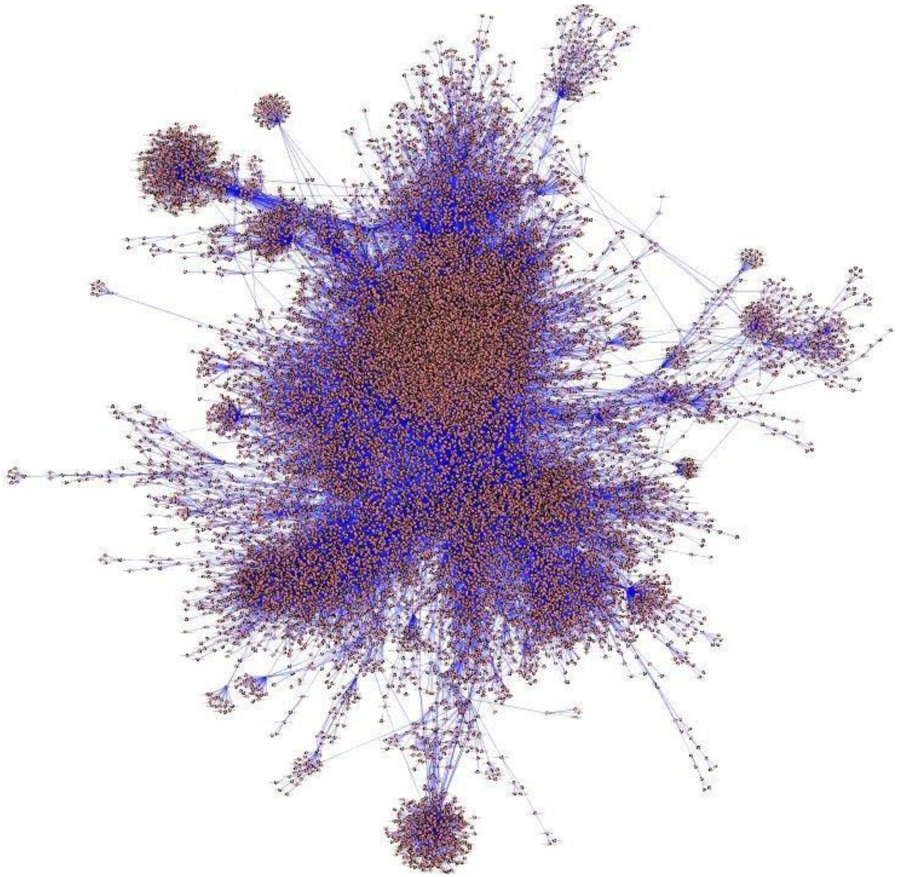


- now higher horsepower cars also seem to have higher acceleration (but the influence is quite minor) → is there a higher-D relationship?

Filtering

Example: Graph of concepts

- related concepts group closer

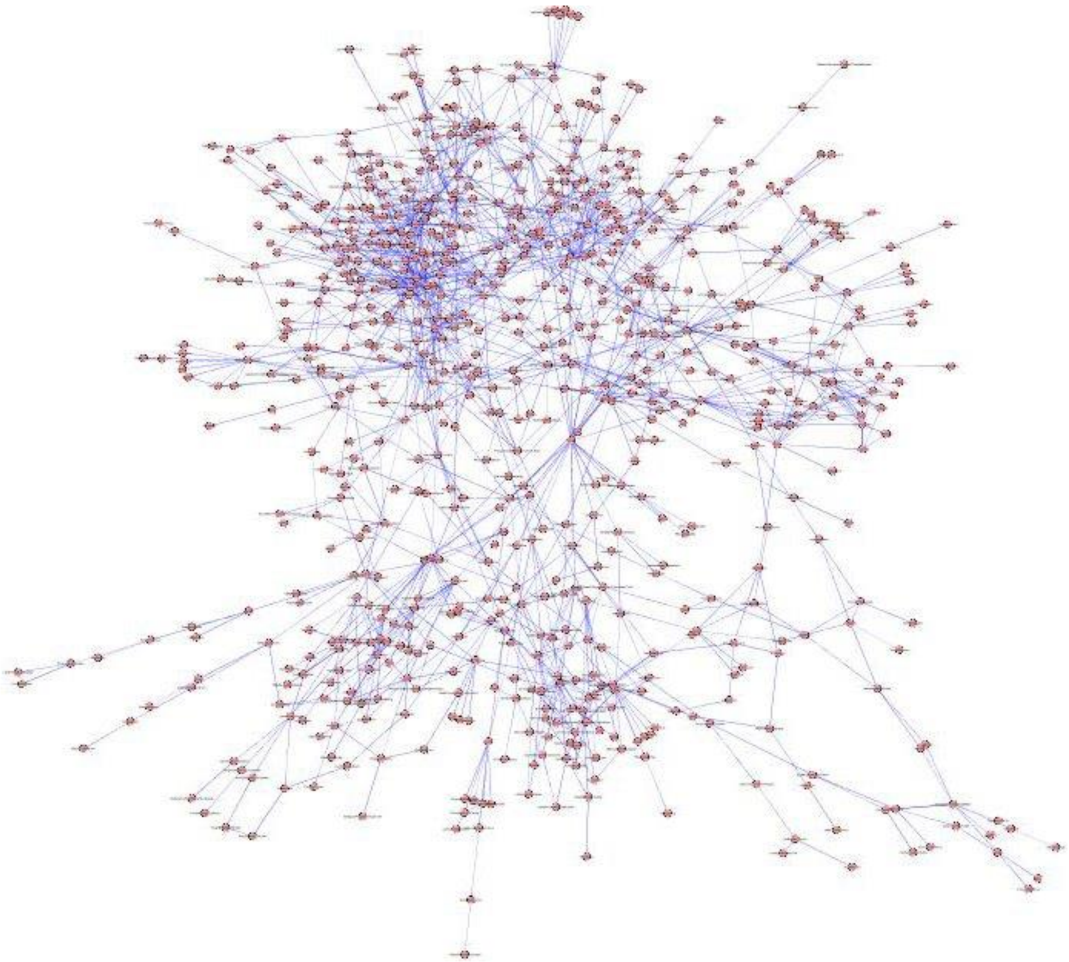


from: http://www.mkbergman.com/date/2008/02/

Filtering

Example: Graph of concepts

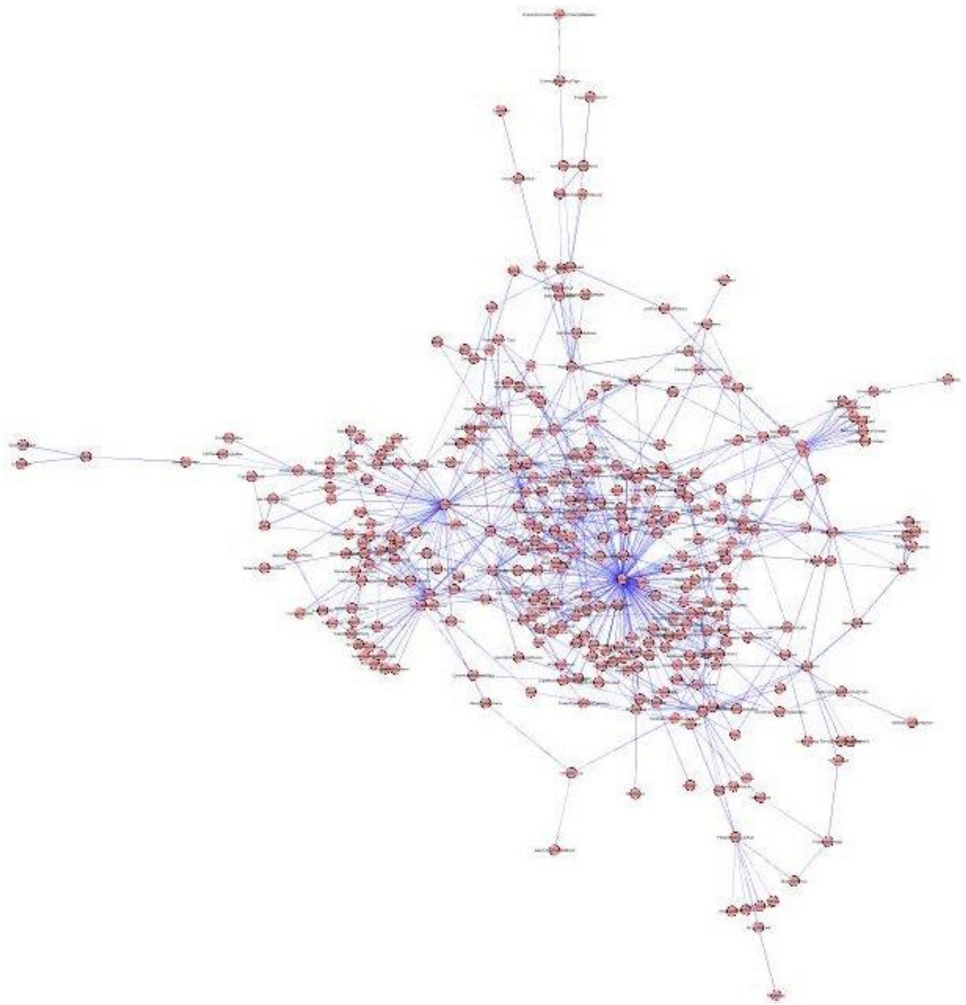
- only keep top 750 connected nodes



Filtering

Example: Graph of concepts

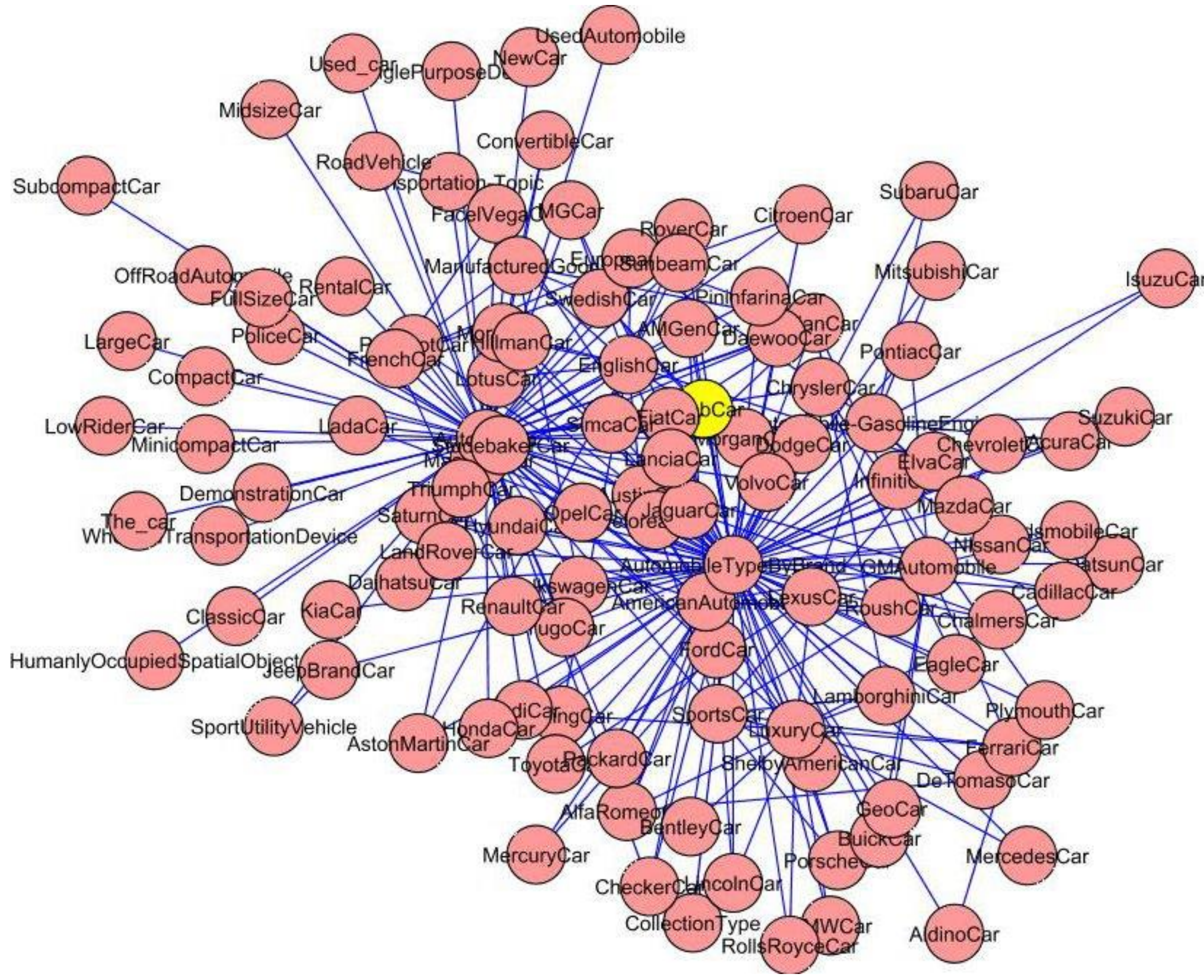
- only keep top 350 connected nodes



Zooming

Example: Graph of concepts

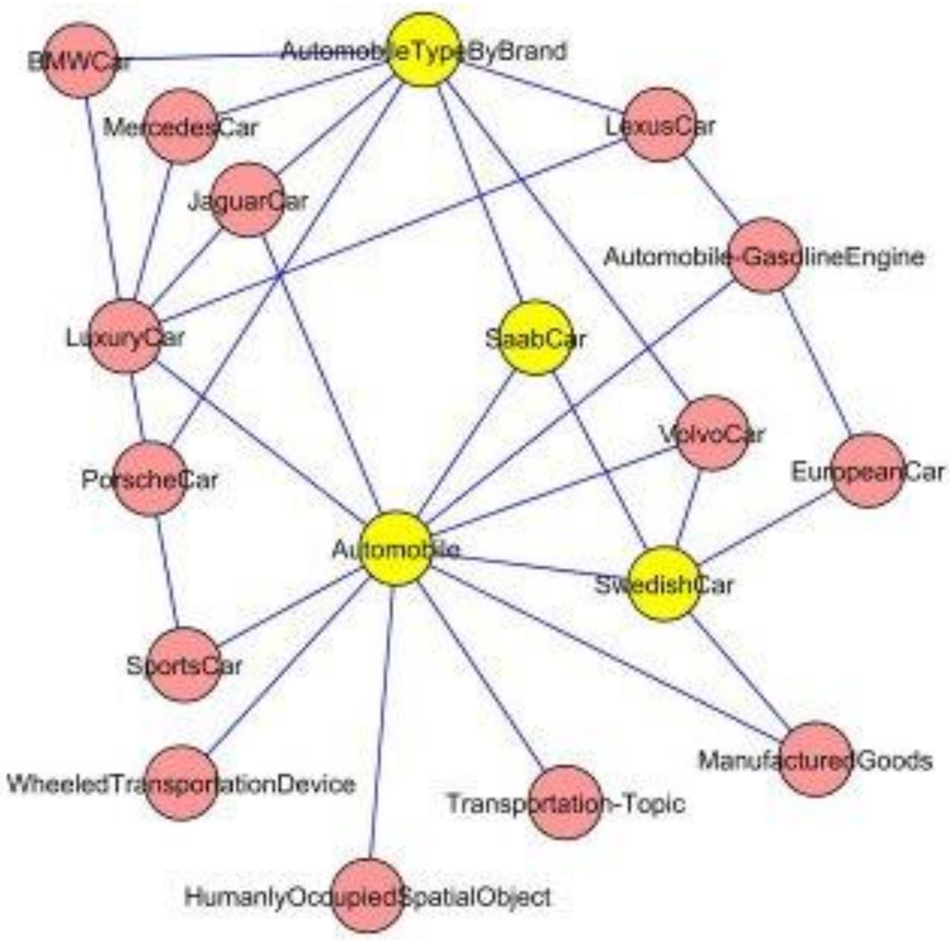
- only keep Saab neighborhood



Zooming

Example: Graph of concepts

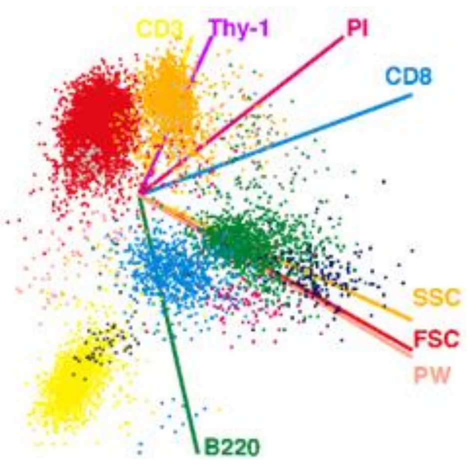
- only keep Saab neighborhood, zoom in more



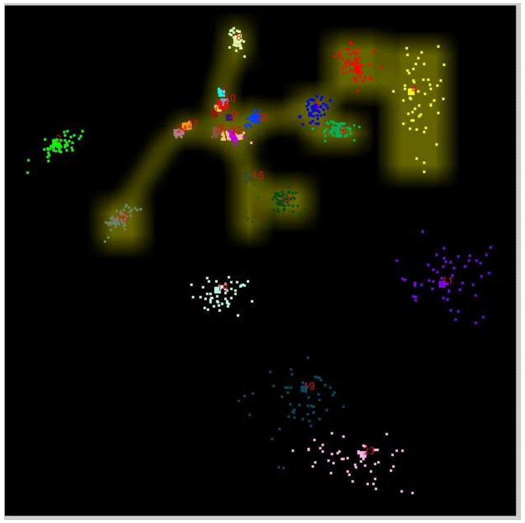
Aggregate

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

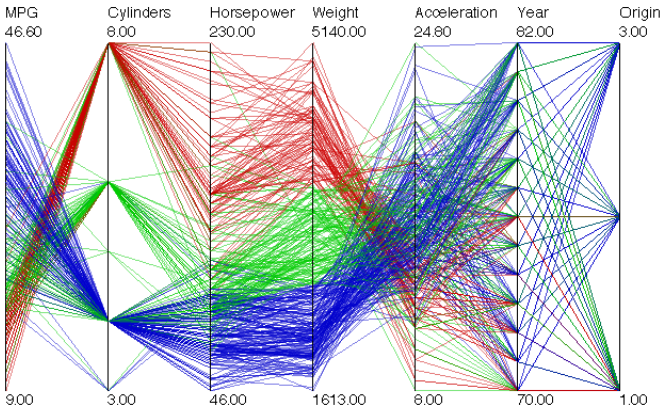
- biplots (project all data into a PCA vector basis)
- multidimensional Scaling (MDS)
- parallel coordinates



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

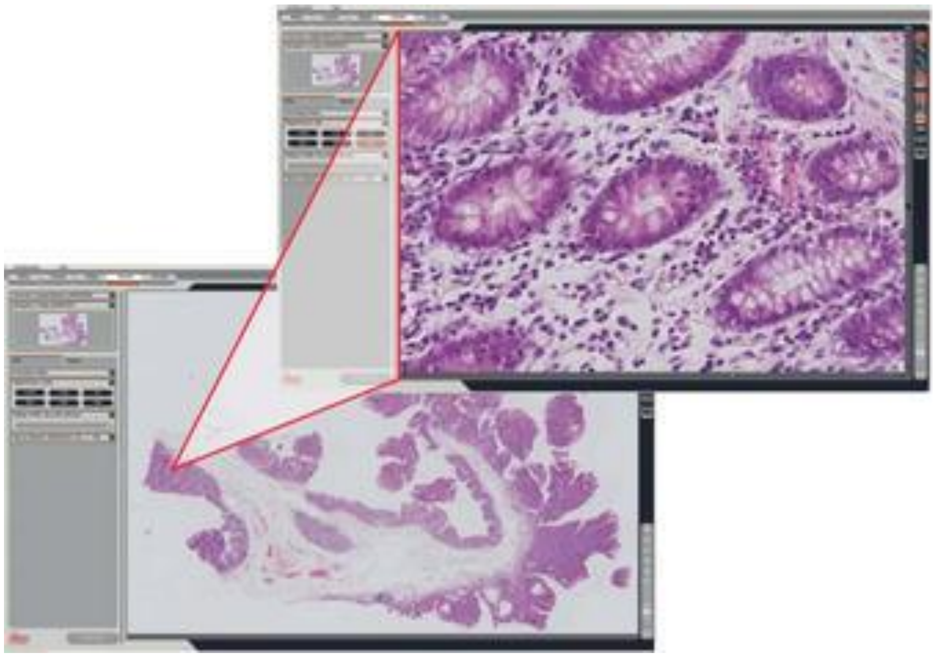
Overview, zoom and filter, then details-on-demand

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

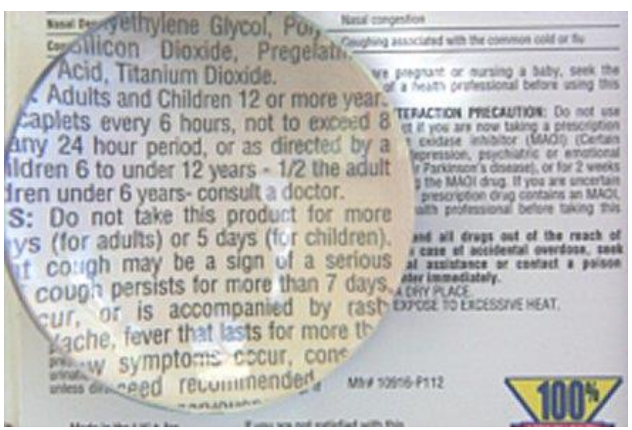
Focus + Context

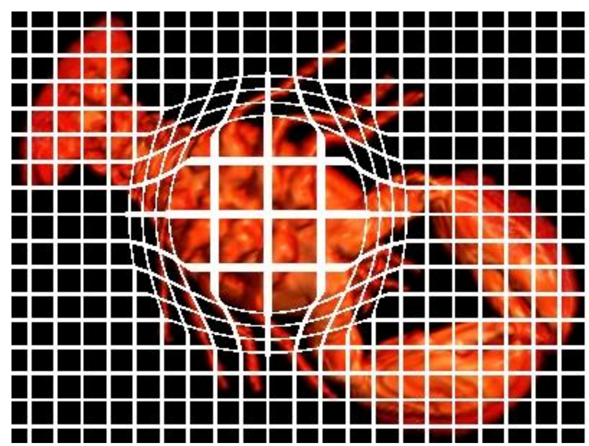
Overview and detail

- 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

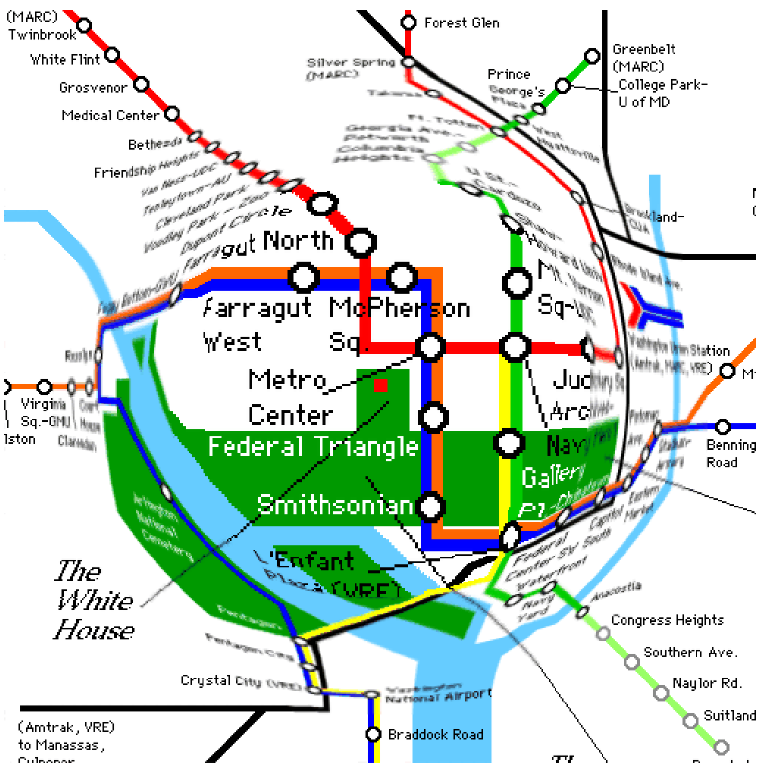
- one single view which shows information in direct context
- maintains continuity across the display
- do not require viewer to shift back and forth
- a good F+C paradigm is the *lens*
- but: there will be distortion



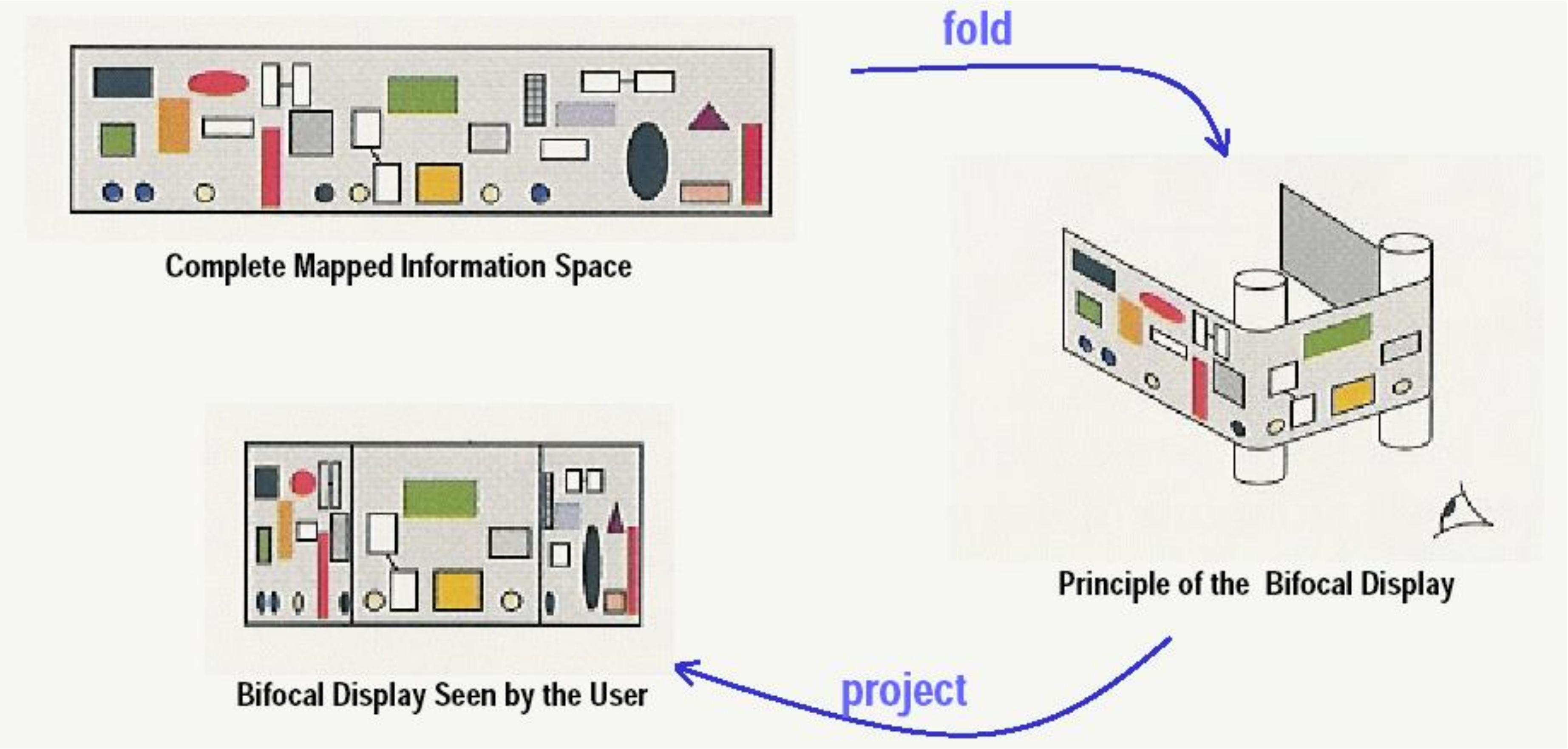


Fisheye lenses

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

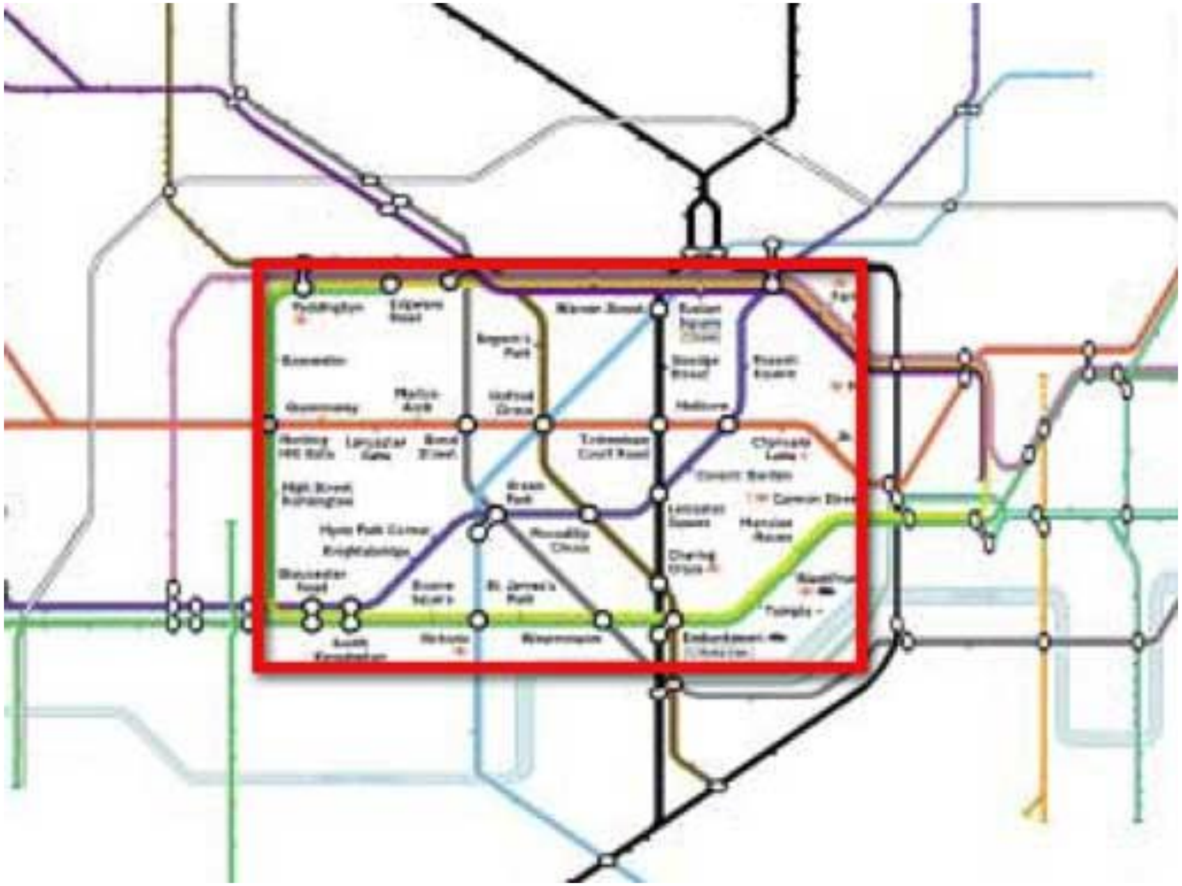


Bifocal Lens

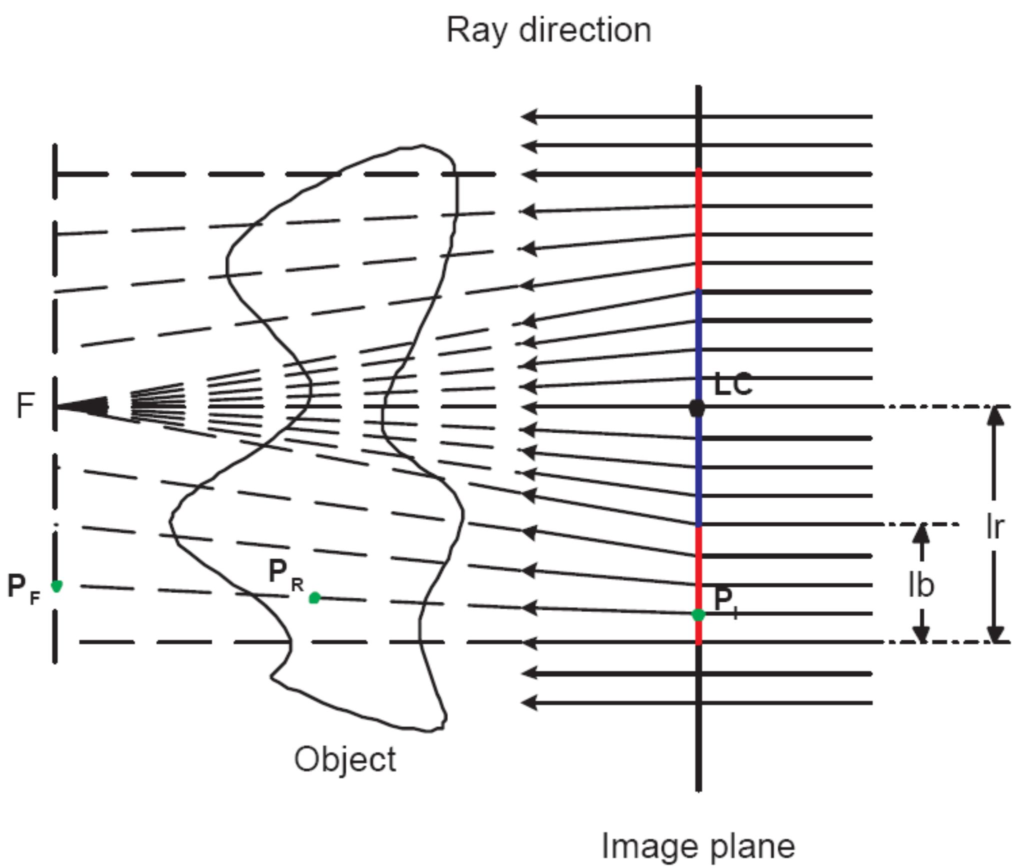


Bifocal Lens

London subway map



(Volumetric) Magnification Lenses



normal region

transition region

magnification region

transition region

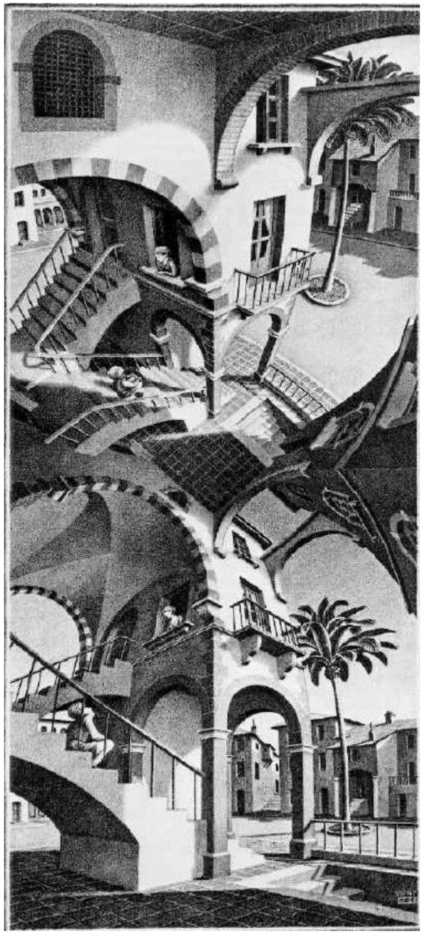
normal region

Avoid aliasing in transition regions by low-pass filtering

Generalized Lenses

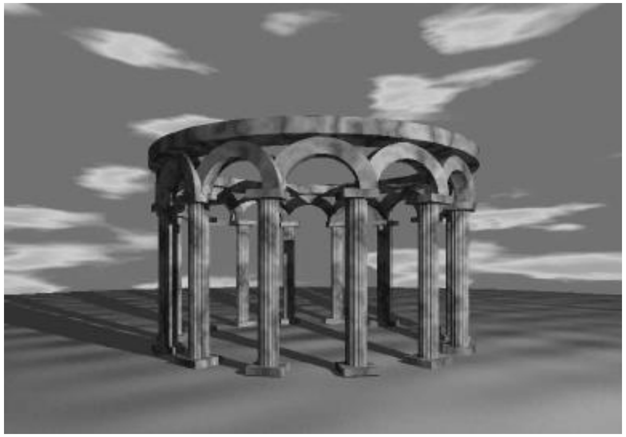
Computers can go beyond (stretch) the laws of physics

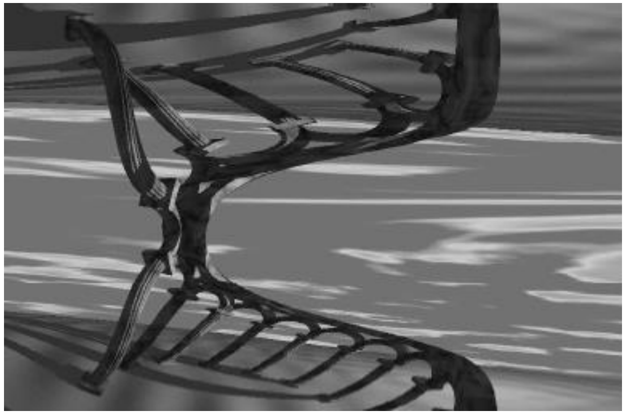
- example: multi-perspective lens rendering, gaze-directed, …



MC Escher

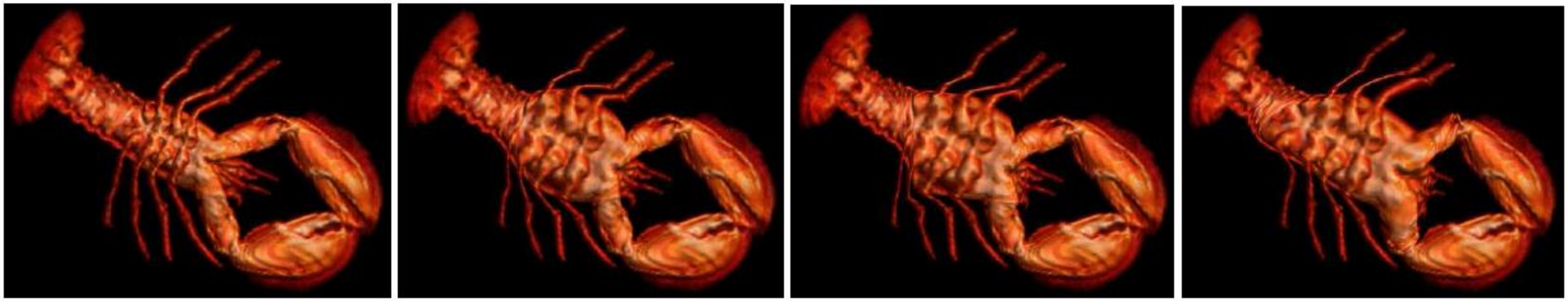
Rademacher/Bishop



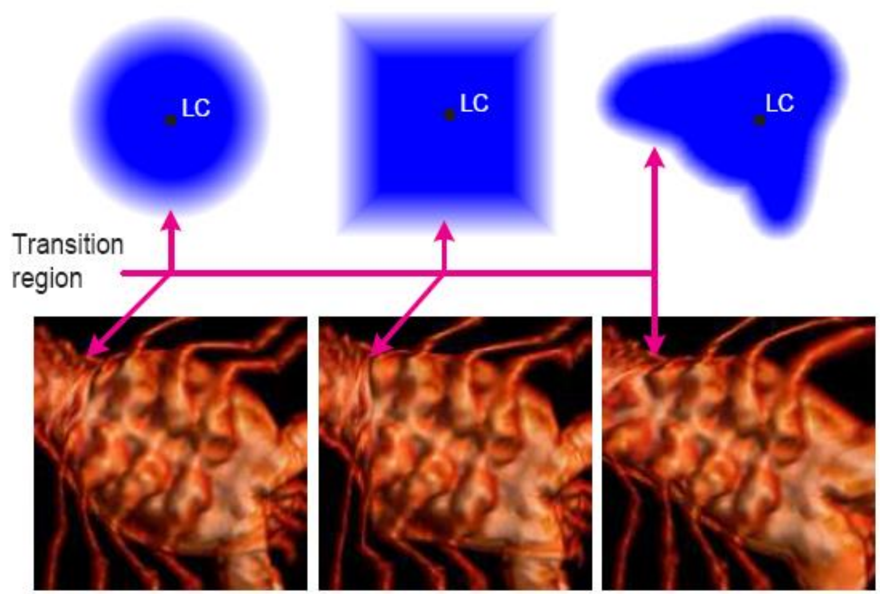


Loeffelmann/Groeller

Generalized Lenses



no lens

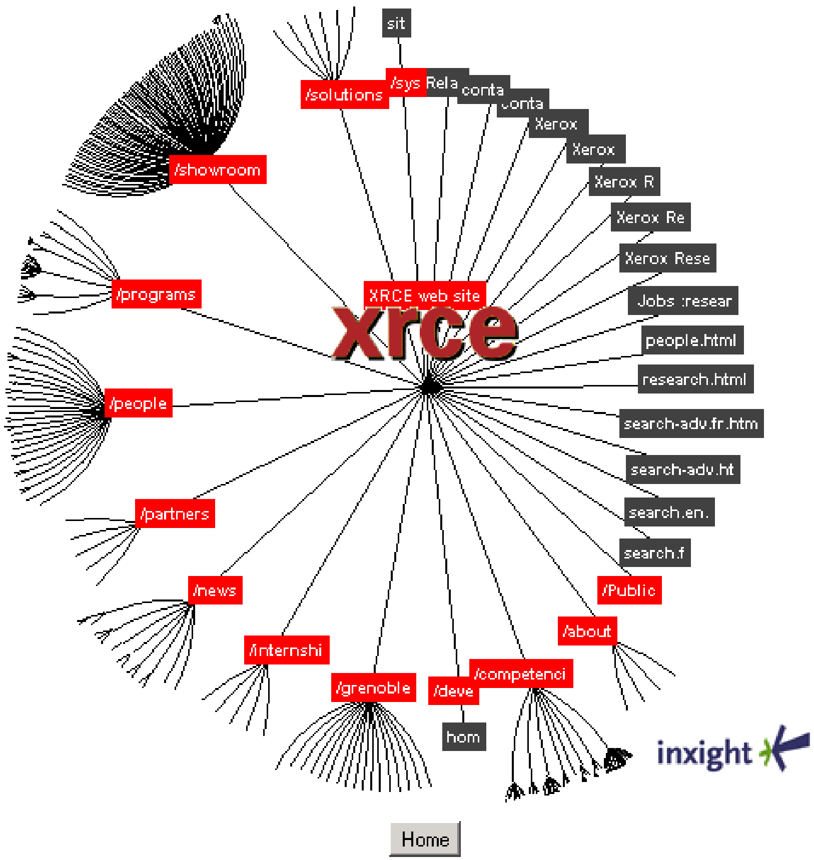


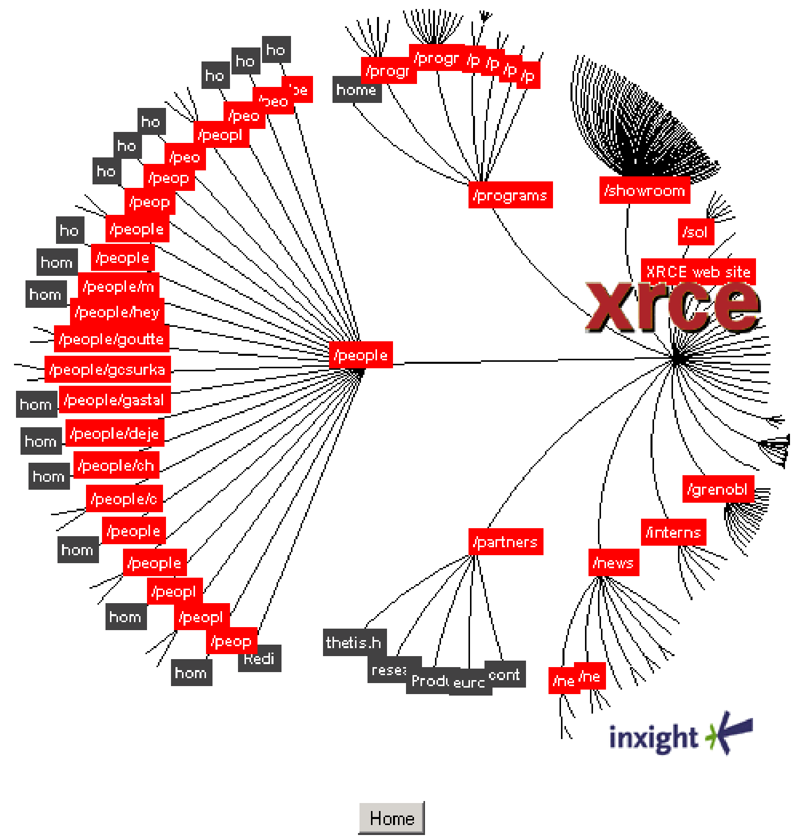
Wang et al., 2005

Lenses in Information Visualization

Hyperbolic Tree fisheye lens

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

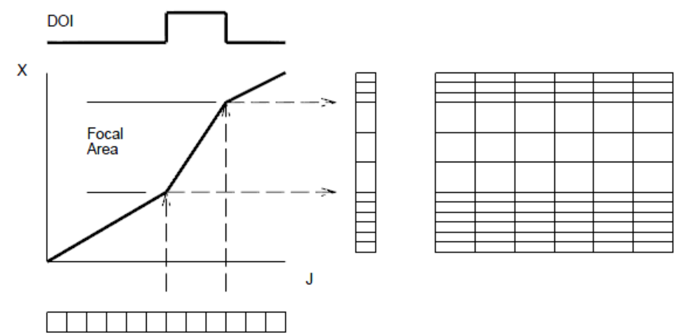


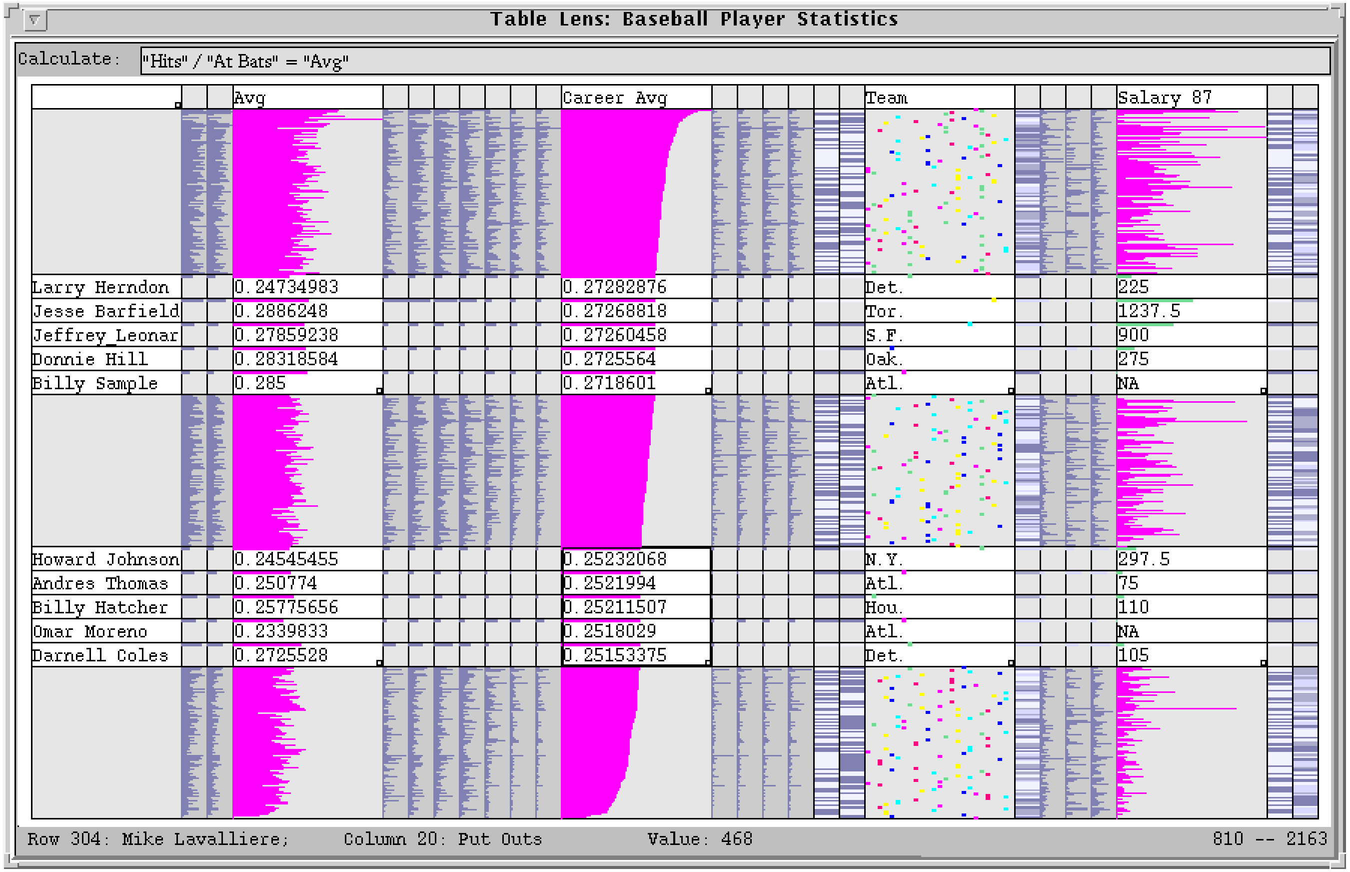


Lenses in Information Visualization

Table Lens (Rao and Card, 1994)

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

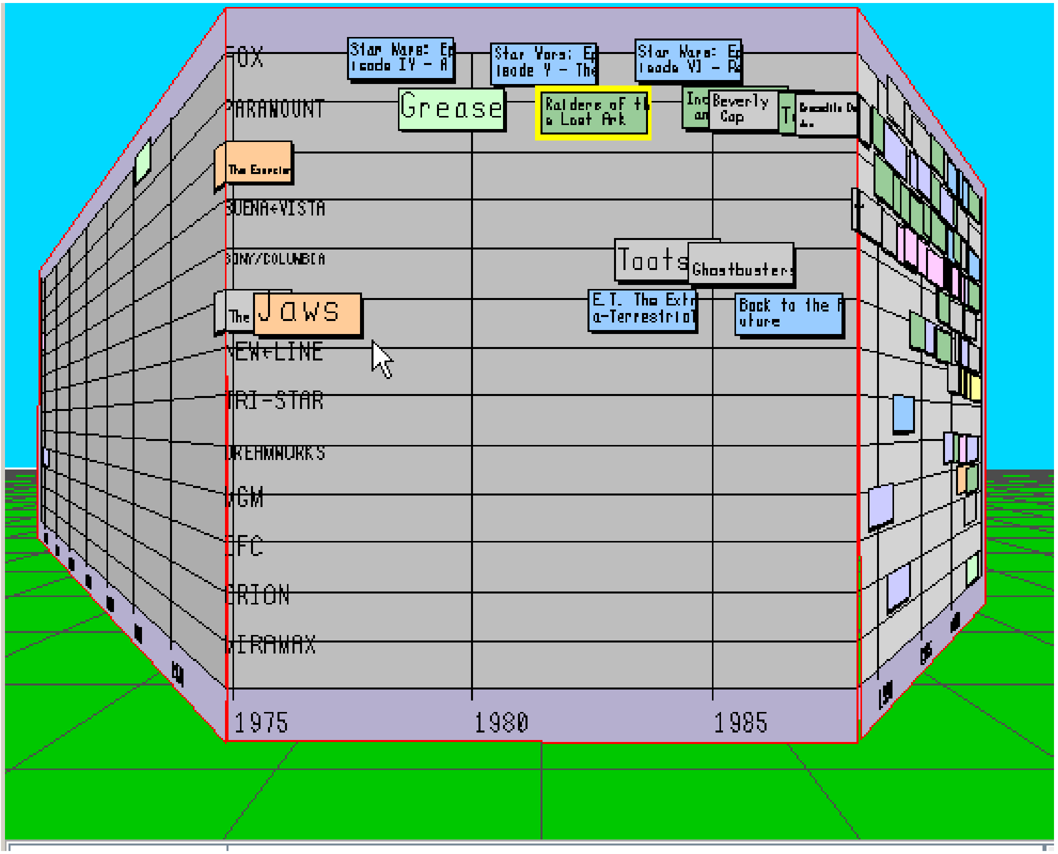




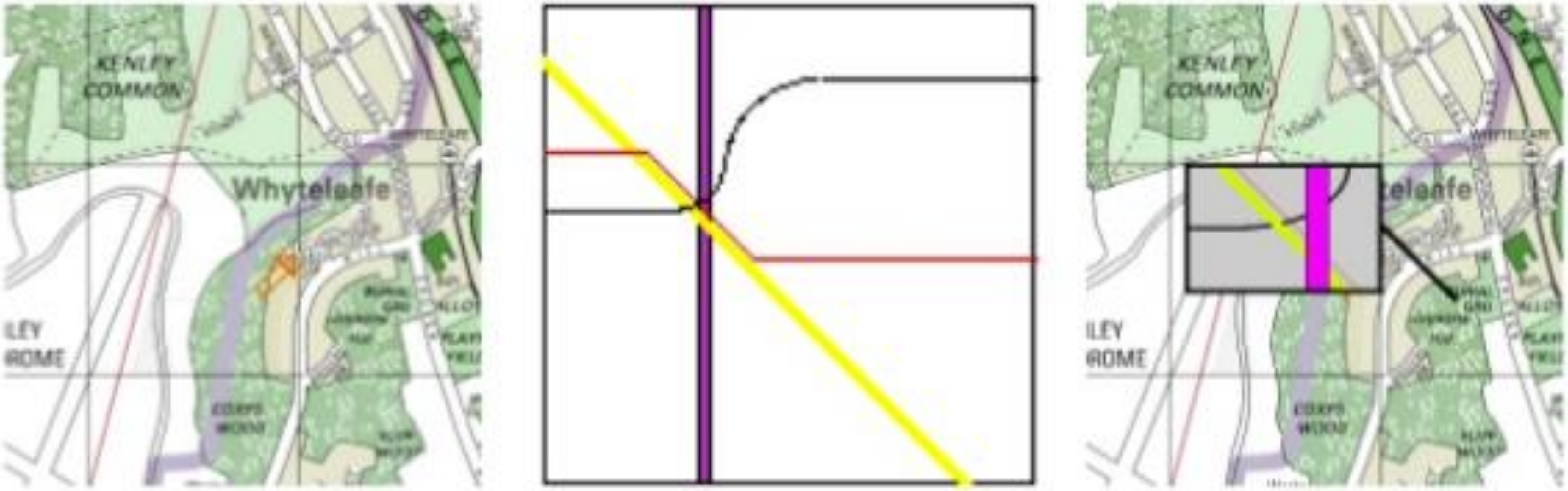
Lenses in Information Visualization

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



Magic Lens



Illustrating the concept of a magic lens. (a) shows a conventional map of an area, (b) shows the location of services (gas, water and electricity pipes) in the same area, and (c) a (movable) magic lens shows services in an area of interest, in context

[Video]

Zoom and Pan

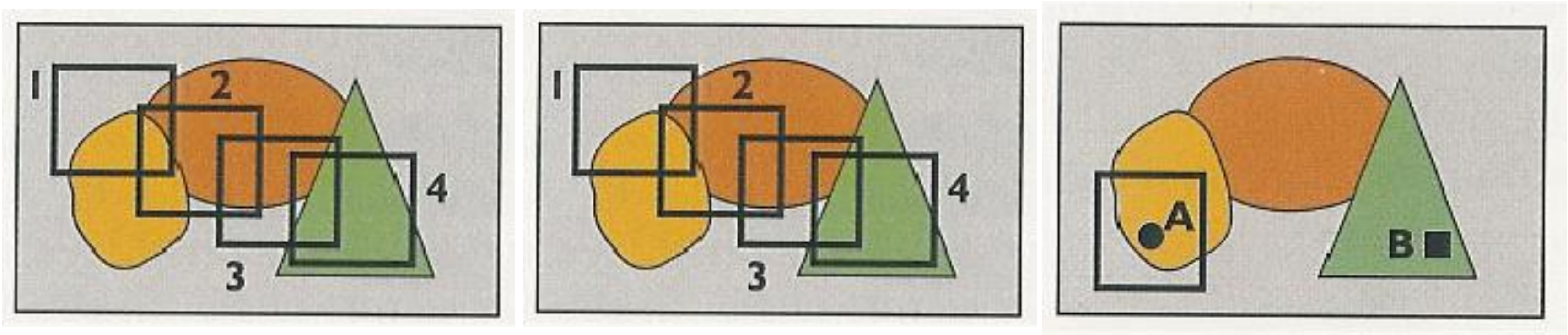
Panning

- 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:

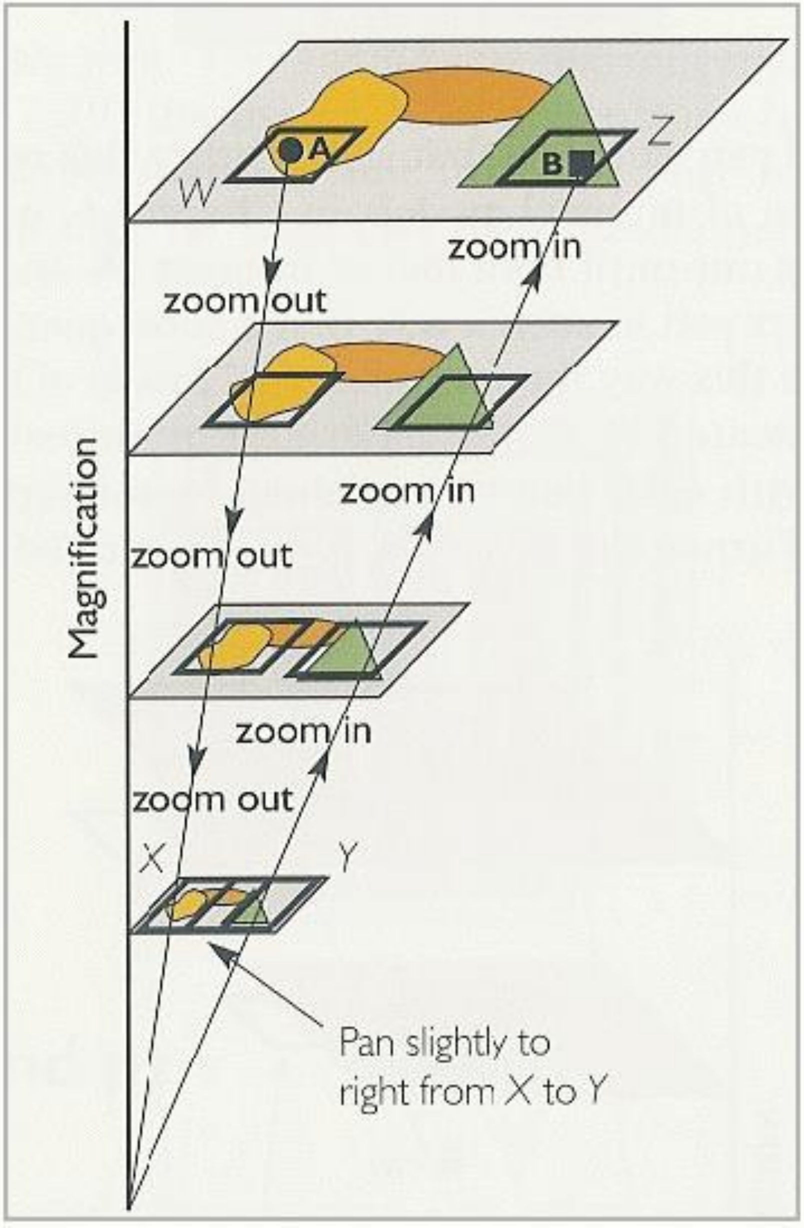
- zoom out → pan → zoom in



Scale-Space Diagrams

Efficient transfer of the focus of attention:

- zoom out → pan → zoom in



Furnas, Bederson, 1995

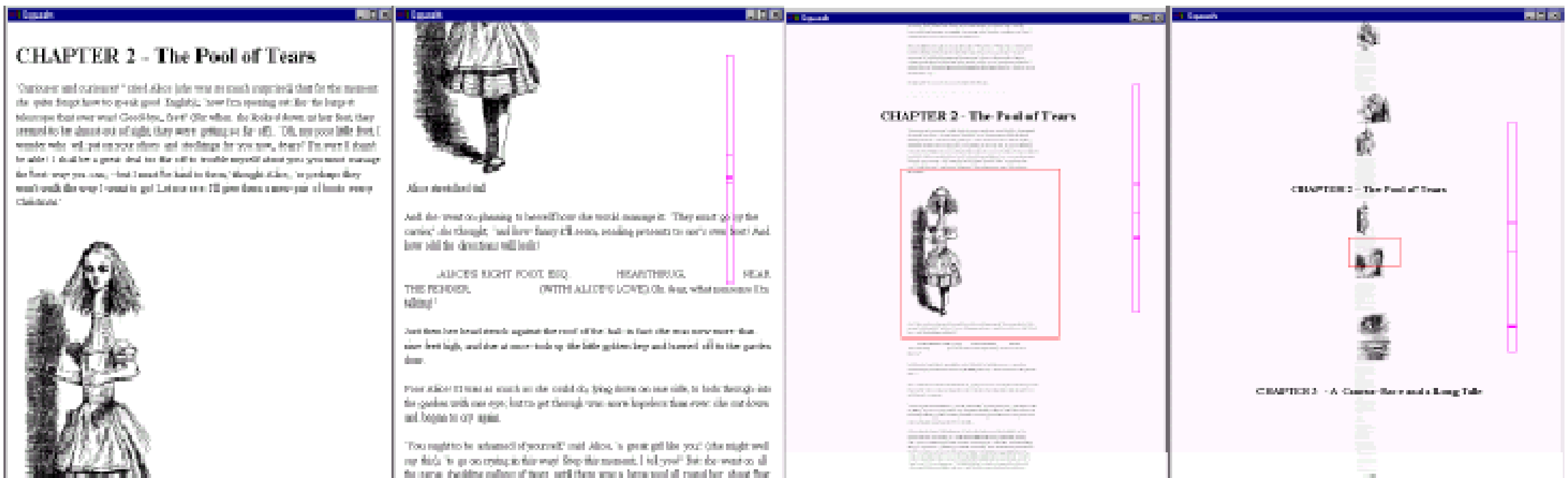
Scale-Space Diagrams Application

video on youtube

Intelligent Zooming

Depending on scrolling speed, zoom more or less

- allows efficient navigation of large documents
- employs semantic zooming



a) Static view b) Scrolling slowly c) Scrolling fast d) Scrolling very fast

Igarashi, Hinckley, 2000

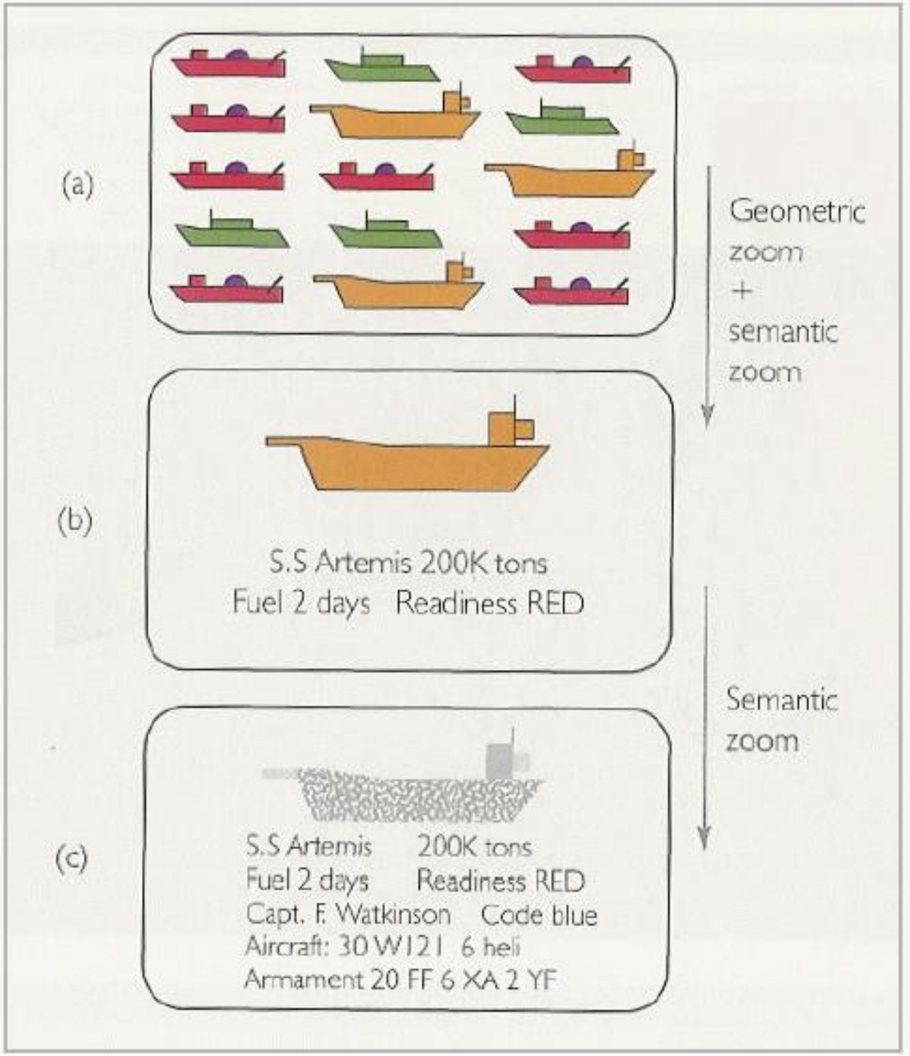
Semantic Zoom

Standard zoom:

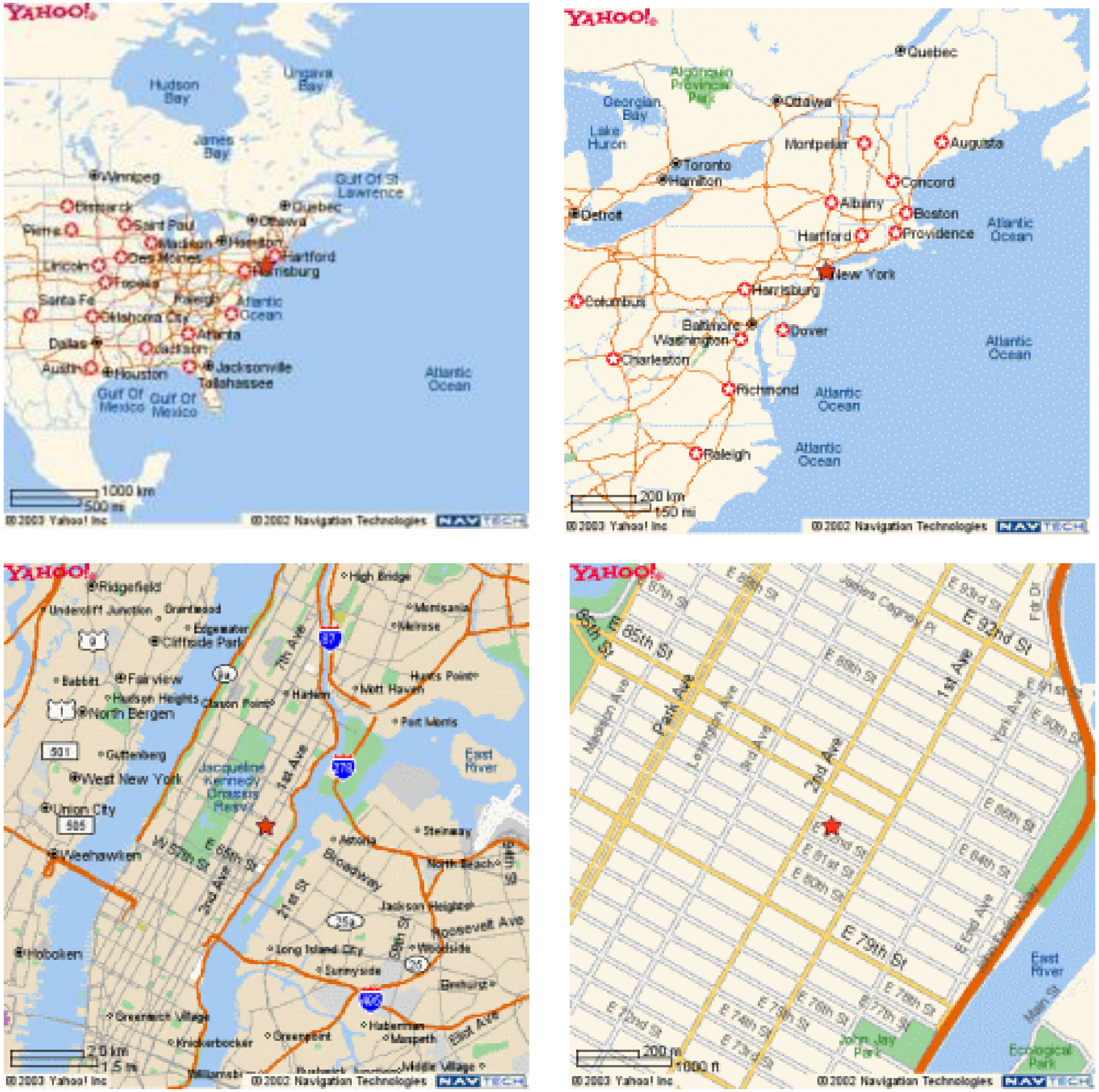
shows a down/up scaled version of the object/image

Semantic zoom:

- shows a different representation determined by the space available



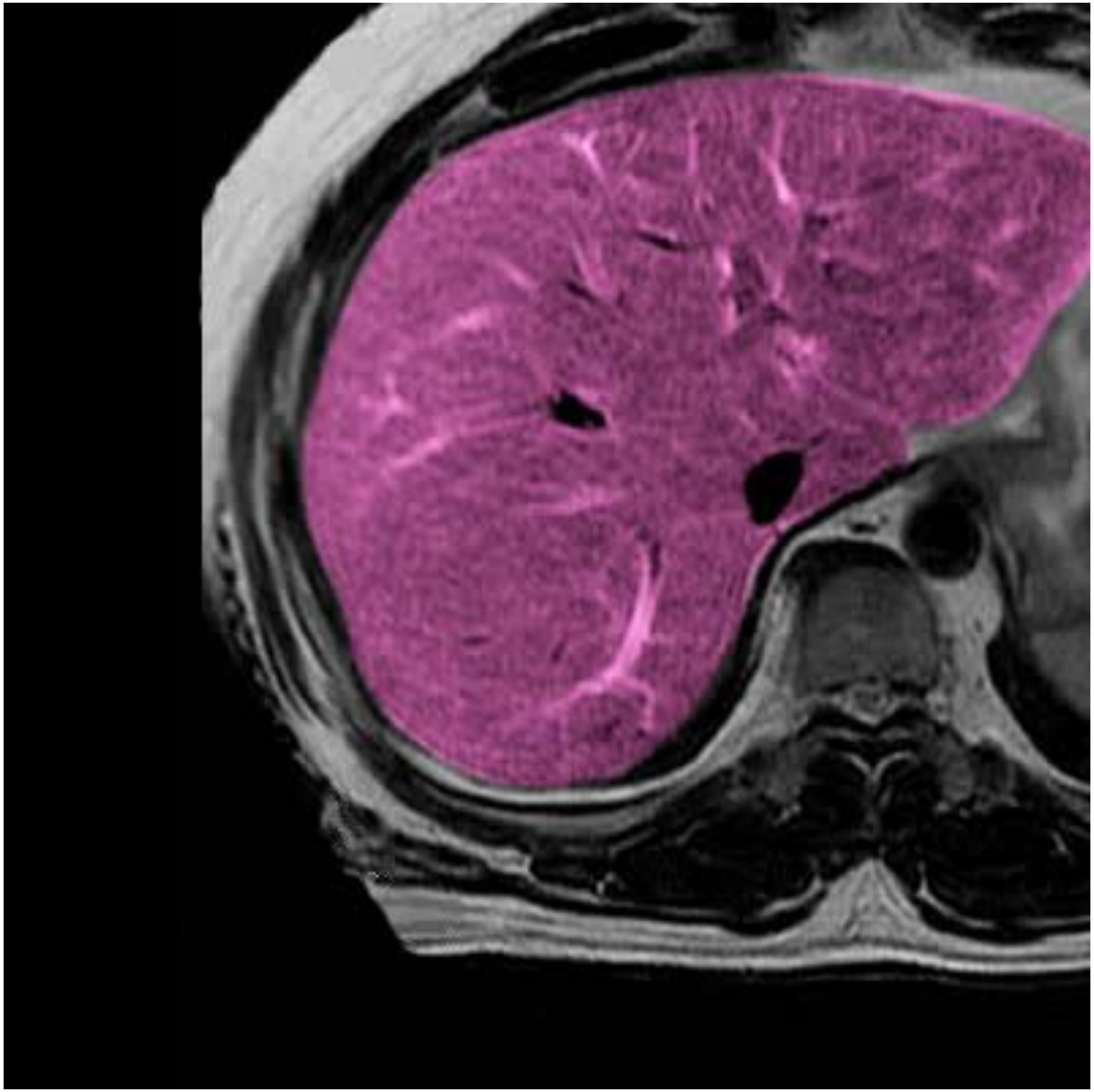
Semantic Zooms: Maps



Semantic Zoom: The Infinite Microscope

L. Wang, K. Mueller, "Enhancing volumetric datasets with sub-resolution detail using texture synthesis," IEEE Visualization Conference, 2004

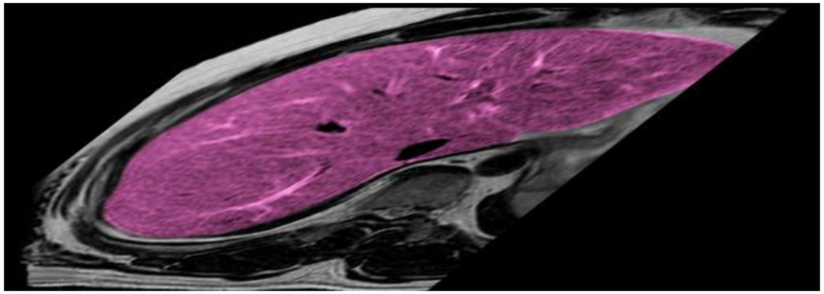
Semantic Zoom: The Finite Microscope



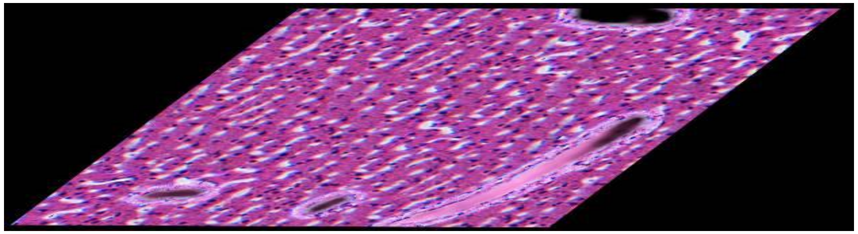
Semantic Zoom: The Multi-Sample Microscope

What to do normally, in this case:

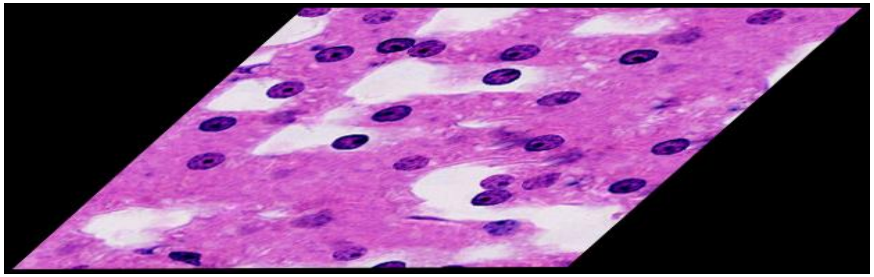
- switch to the dataset acquired with suitable modality (higher resolution)



level 1



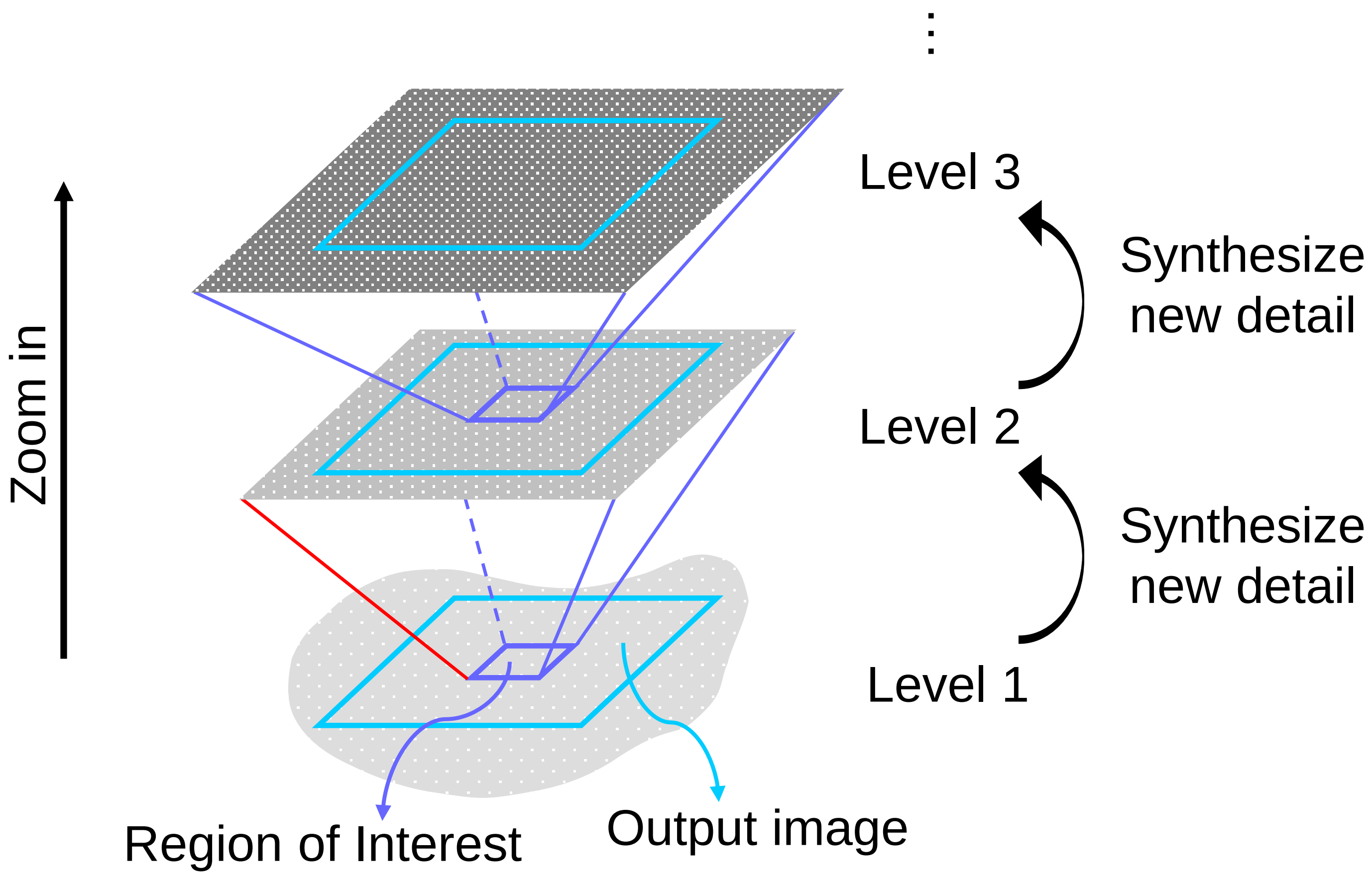
level 2



level 3

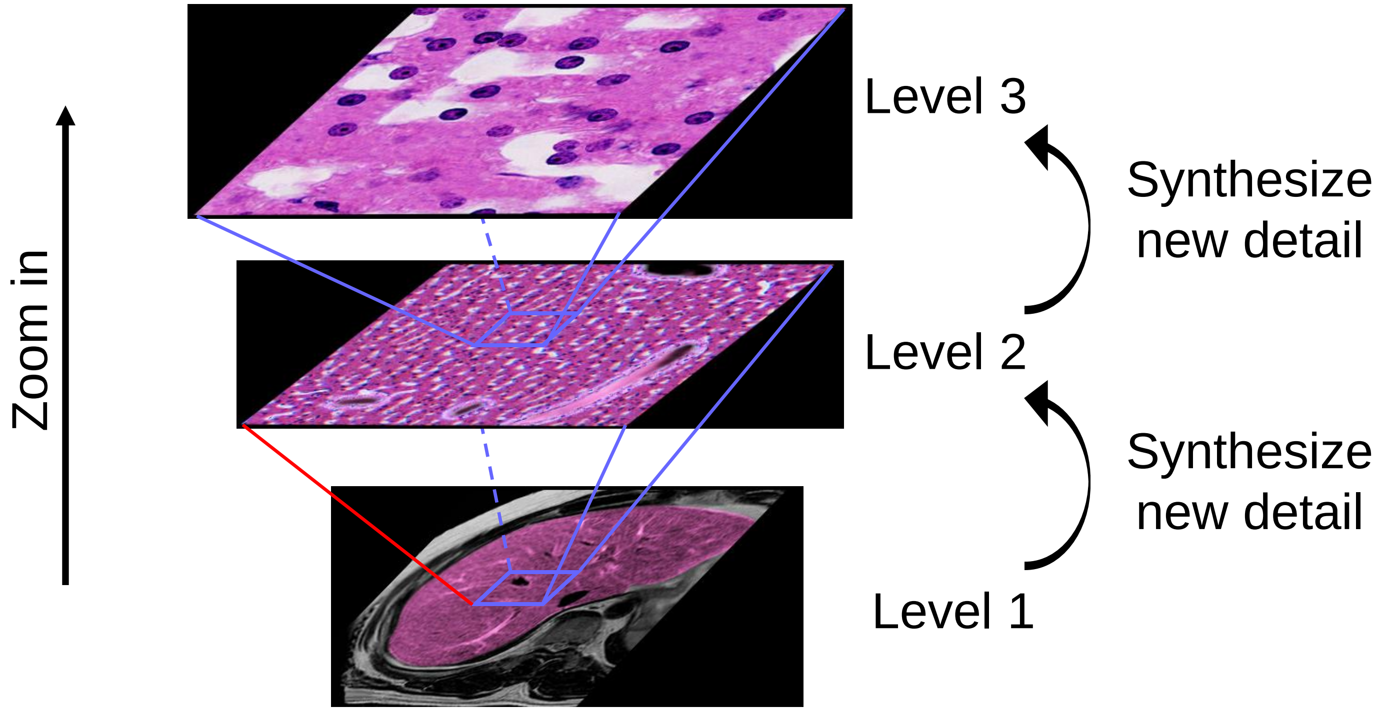
Semantic Zoom: The Infinite Microscope

Apply constrained multi-scale texture synthesis to facilitate semantic zooms



Semantic Zoom: The Infinite Microscope

Apply constrained multi-scale texture synthesis to facilitate semantic zooms

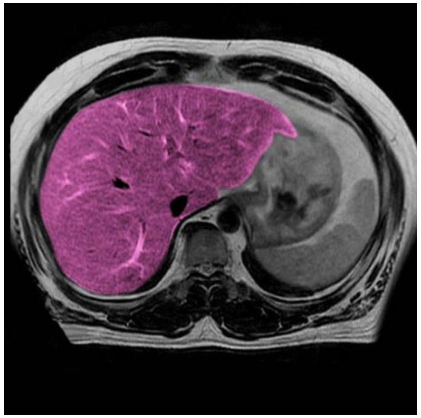


Semantic Zoom: The Infinite Microscope

Data collection (sample images)

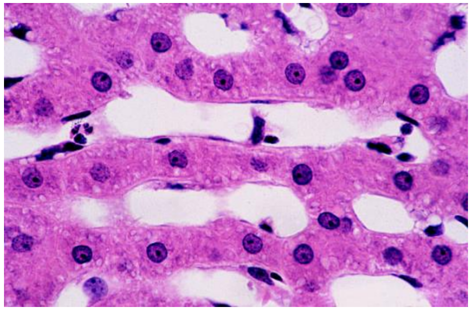
Colorization

- reduce the distinct discontinuities during zoom



MRI level

histology level



cell level

Sample Images

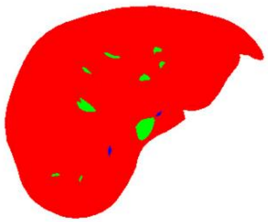
Semantic Zoom: The Infinite Microscope

Data collection (sample images)

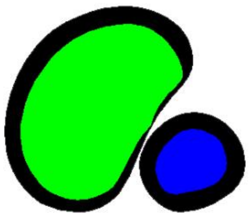
Colorization

- reduce the distinct discontinuities during zoom

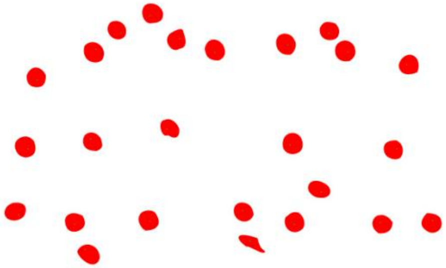
Segmentation (to enable constrained synthesis)



MRI level



histology level



cell level

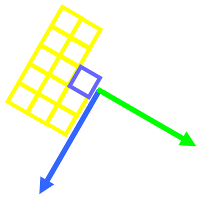
Tag Images

Constrained Synthesis

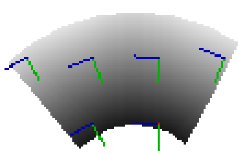
Standard L-neighborhood will not work

- distance and shape dependencies exist

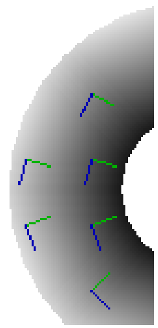
Rotated L-neighborhood



Sample texture



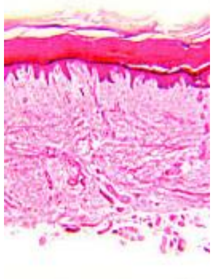
Distance and gradient fields



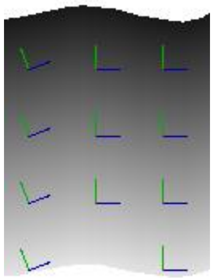
Reference distance and gradient fields

Synthesized texture

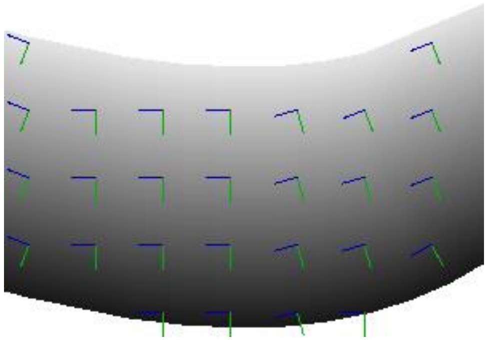
Example: Skin Histology



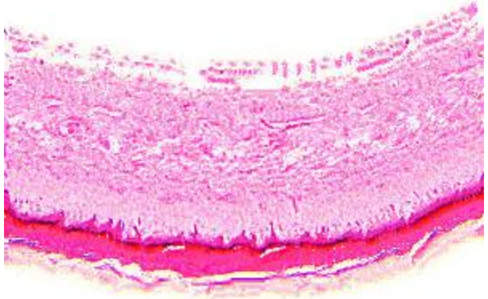
Sample image



Distance and gradient fields



Reference distance and gradient fields



Synthesized skin histology image

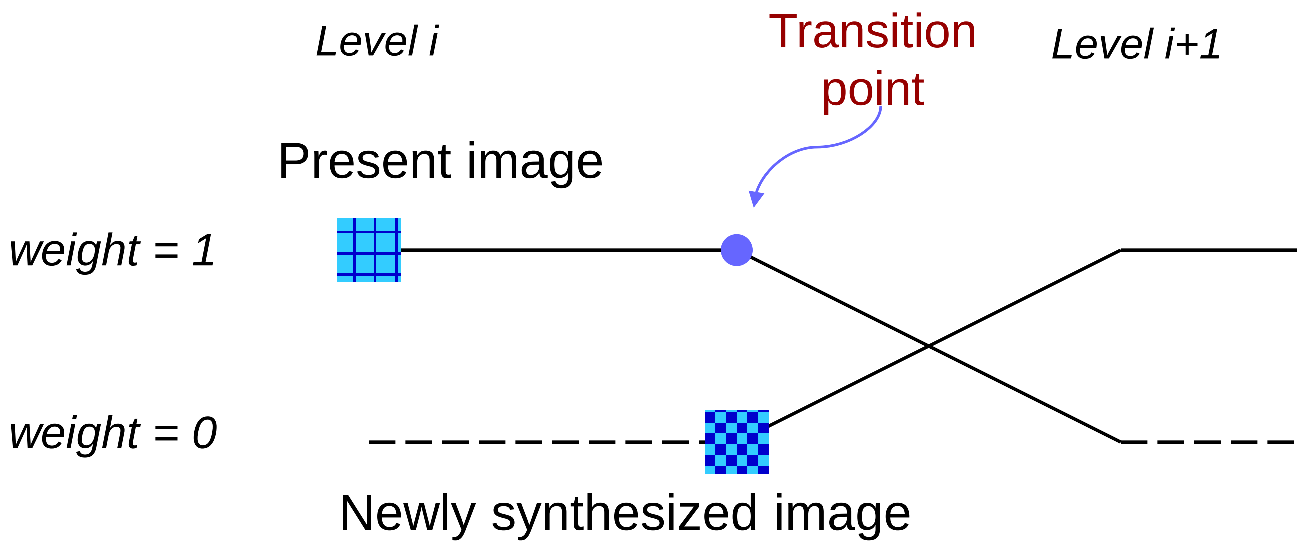
Smooth Semantic Zooms

Magnify low resolution level image

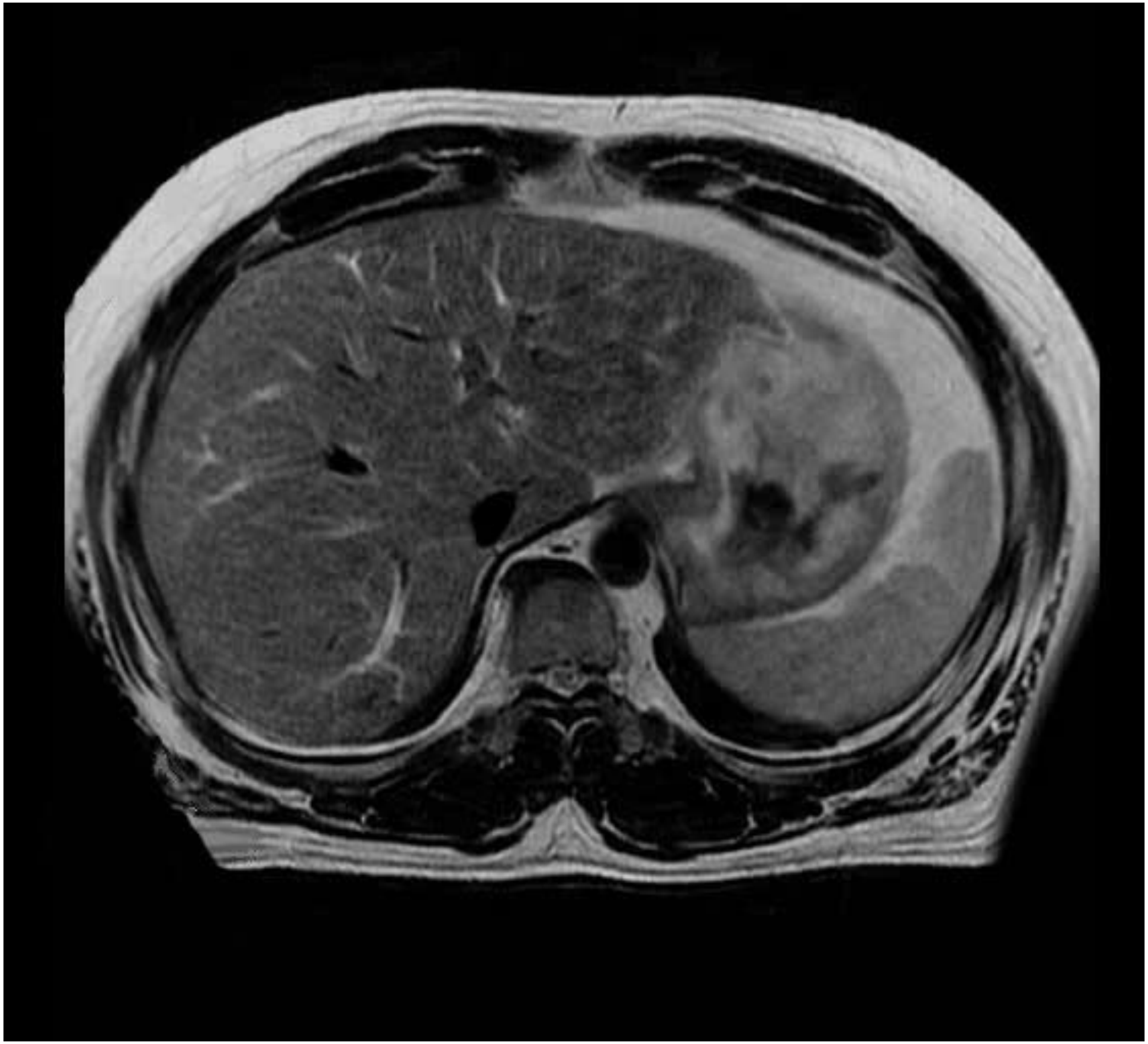
Synthesize new detail at transition point

Minify synthesized next high level image

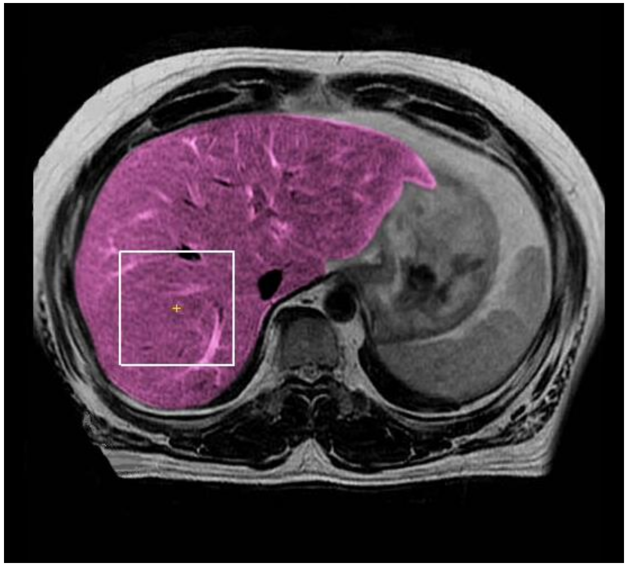
Weighted Blending

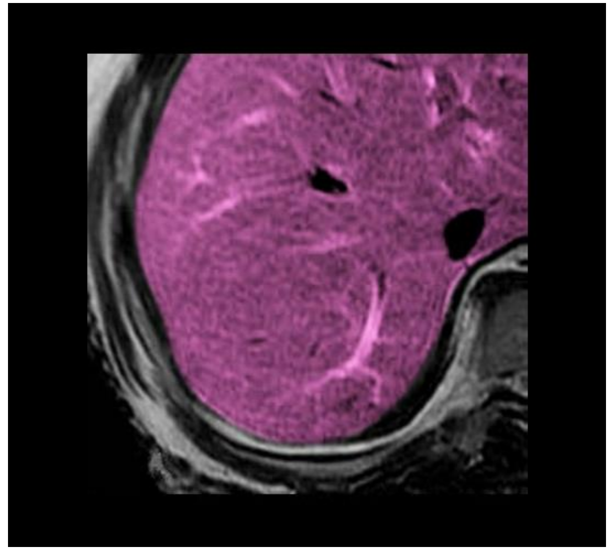


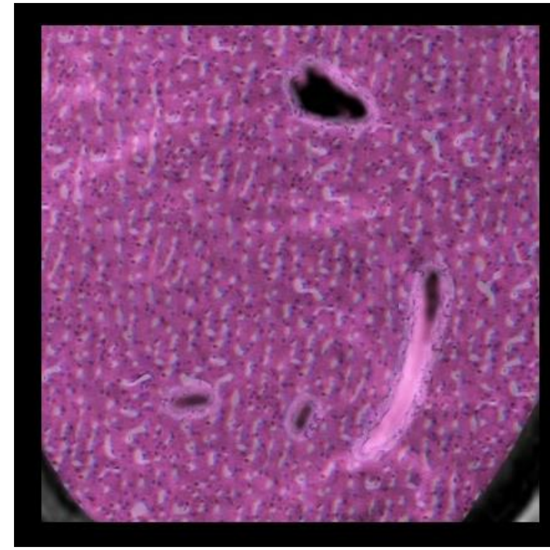
Semantic Zoom: The Infinite Microscope

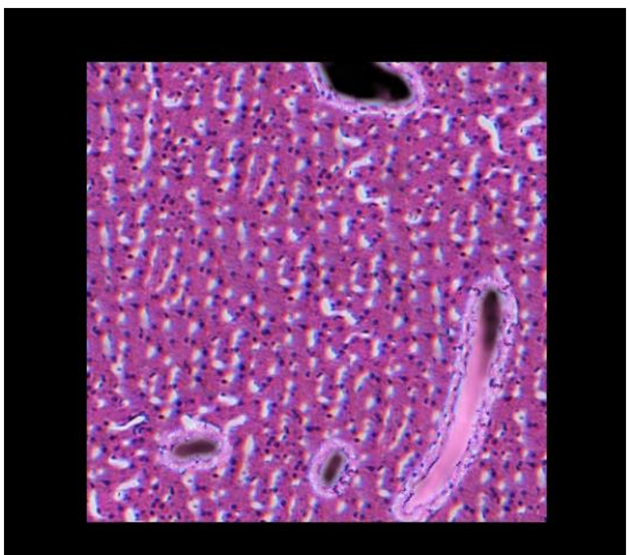


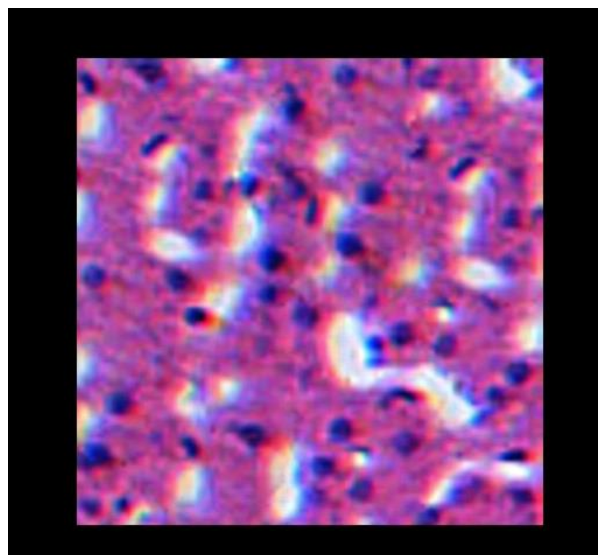
Semantic Zoom: The Infinite Microscope Still Frames

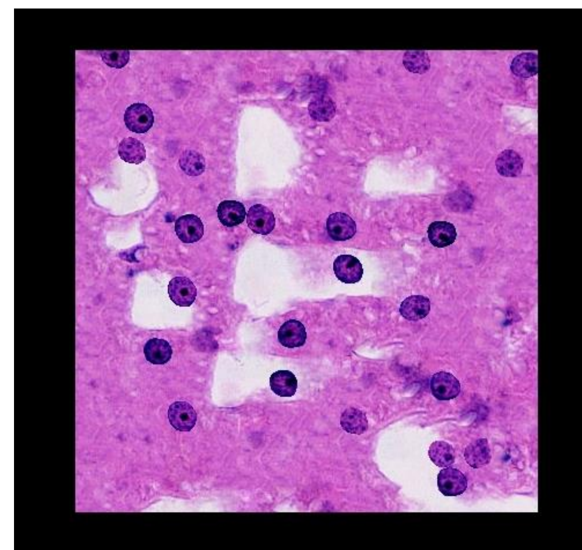




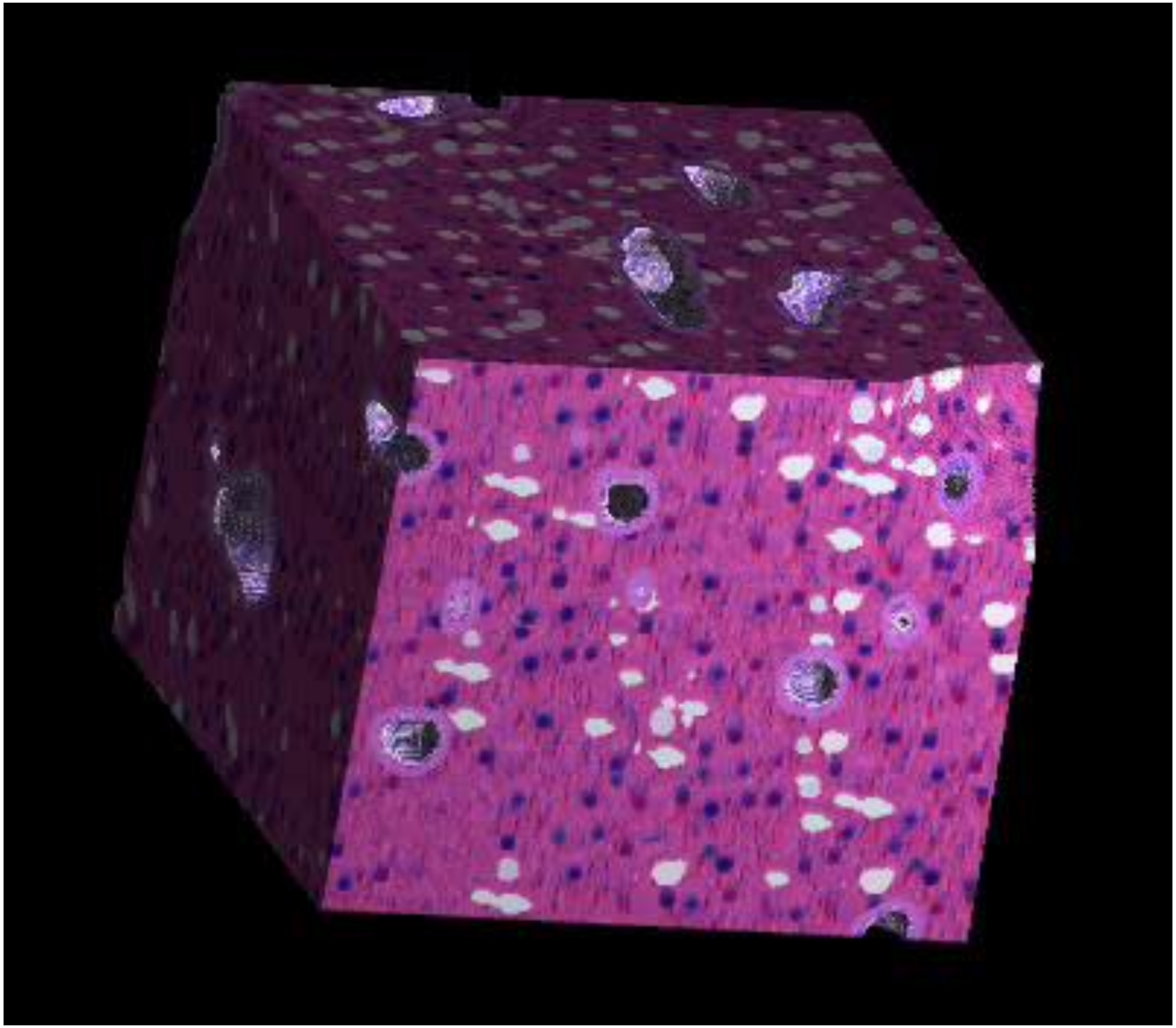








3D Microscope Semantic Zoom



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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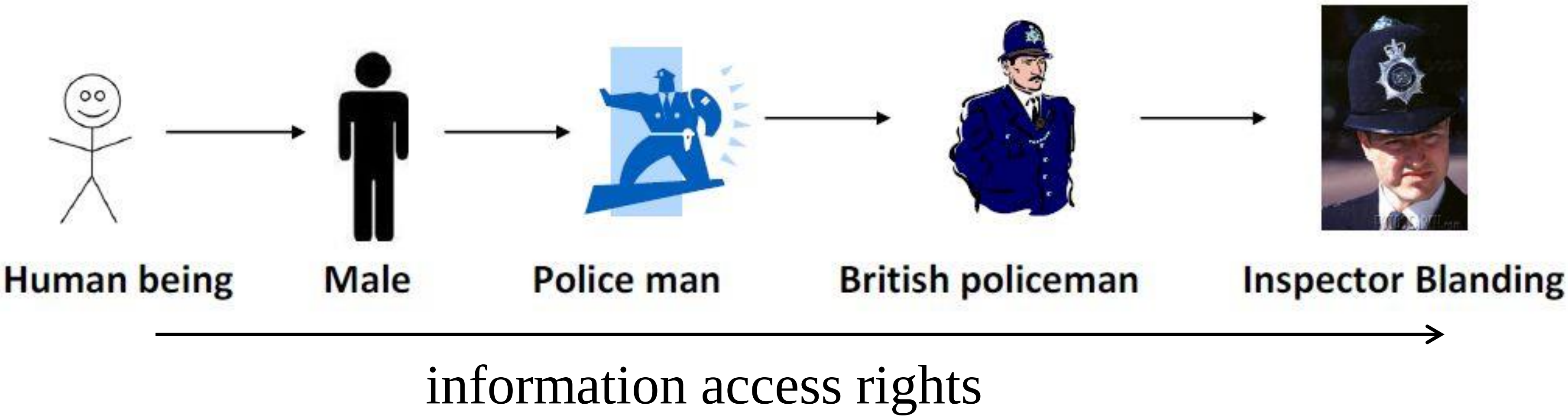
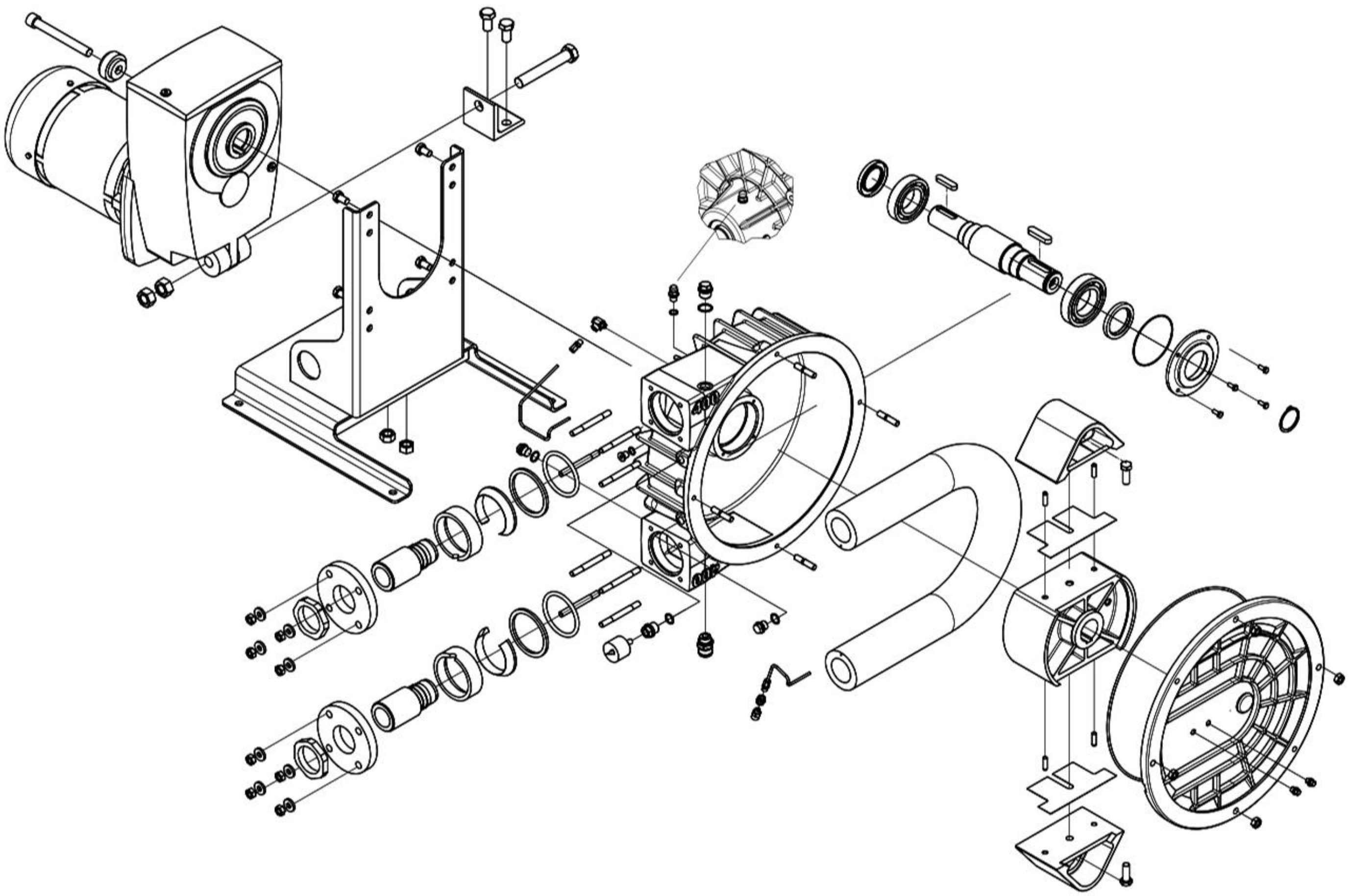
Zoom levels may require access rights

- members only
- big wallets only
- classified information

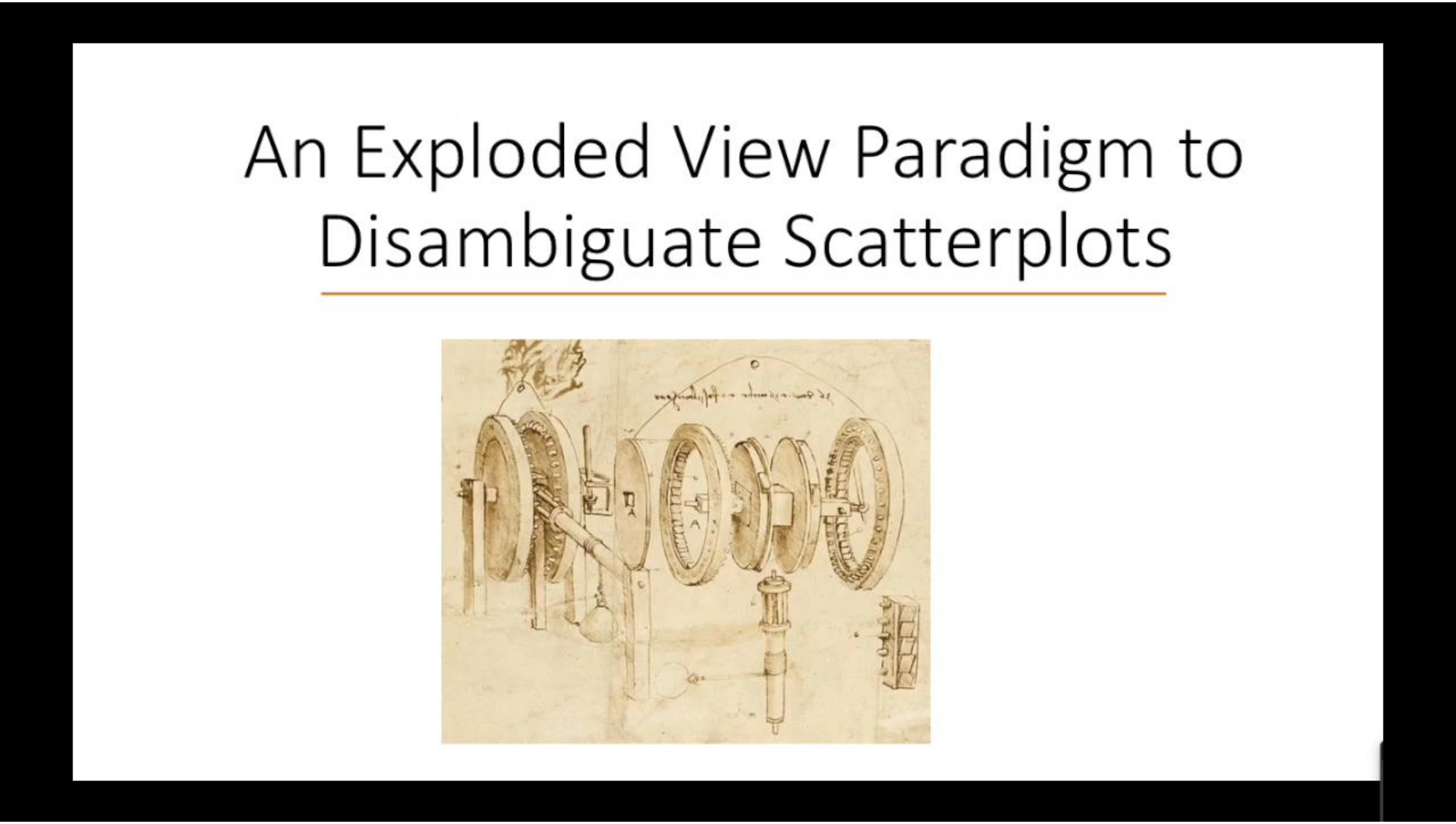


Exploded Views



S, Mahmood, K. Mueller, “An Exploded View Paradigm to Disambiguate Scatterplots,” Computers & Graphics, 2018

Exploded View Applied to Infovis



video

Brushing and Linking

Interactive technique

- Highlighting
- Brushing and Linking

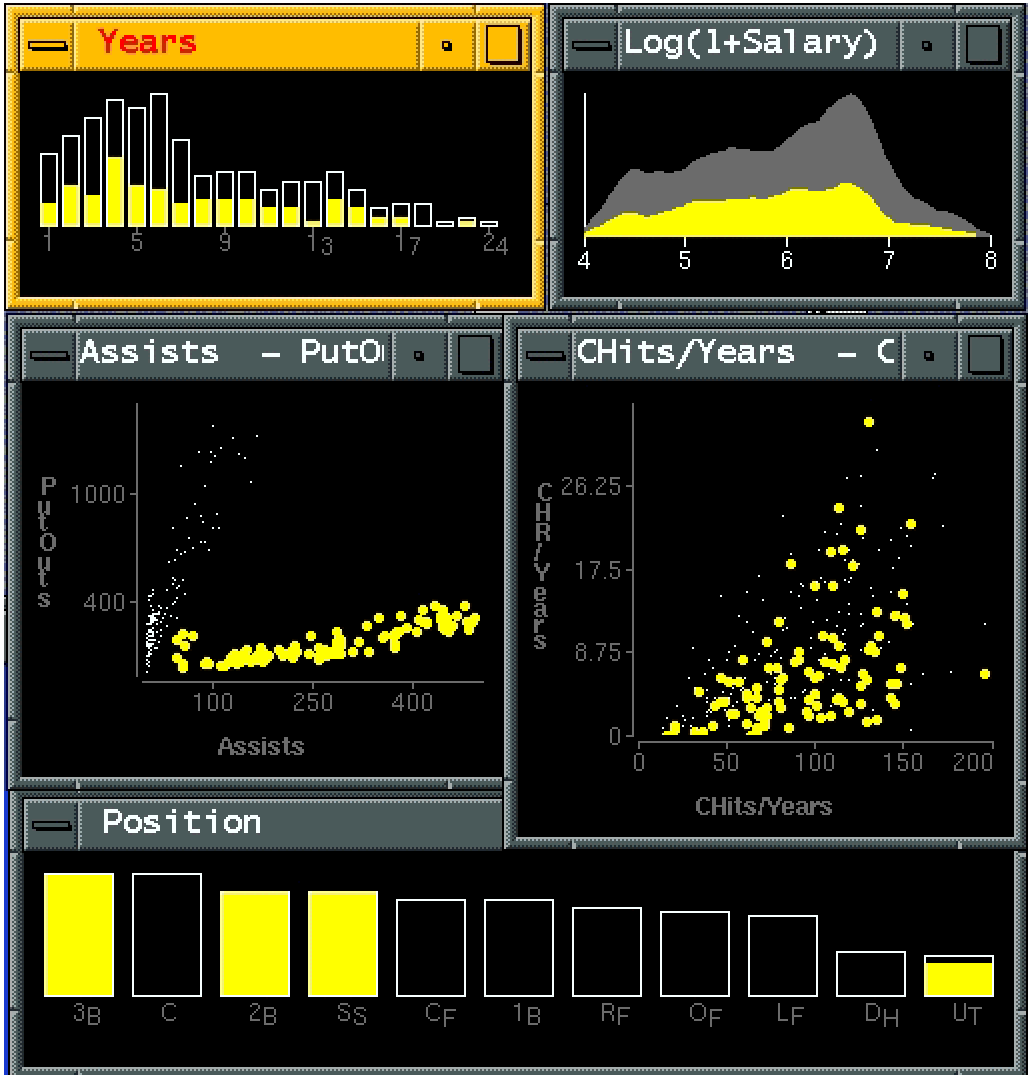
At least two things must be linked together to allow for brushing

- 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

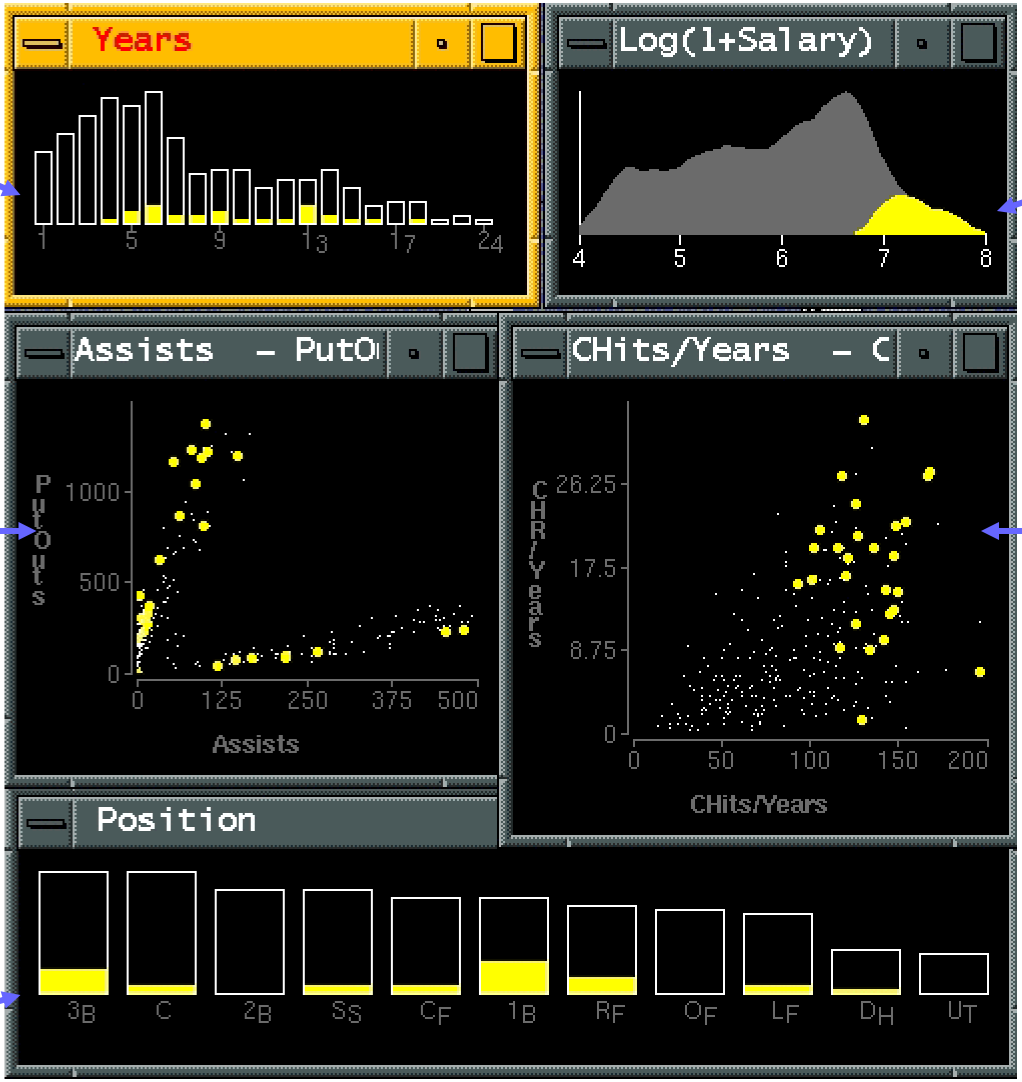


Baseball Data: Scatterplots and Histograms and Bars

how long in majors

avg. assists (x) vs. avg. putouts (y) (fielding ability)

distribution of positions played



select high salaries

avg. career home runs (y) vs. avg. career hits (x) (batting ability)

anything interesting?

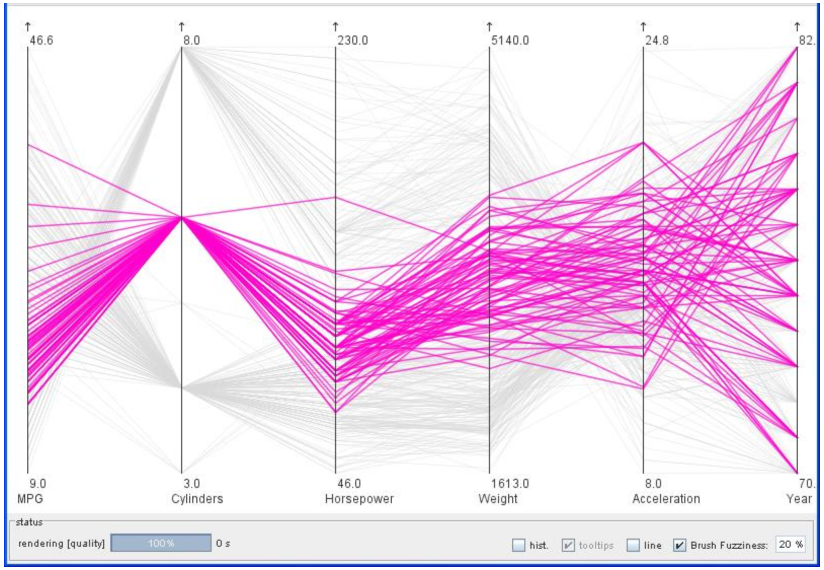
What was Learned from Interaction w/ the Baseball Data?

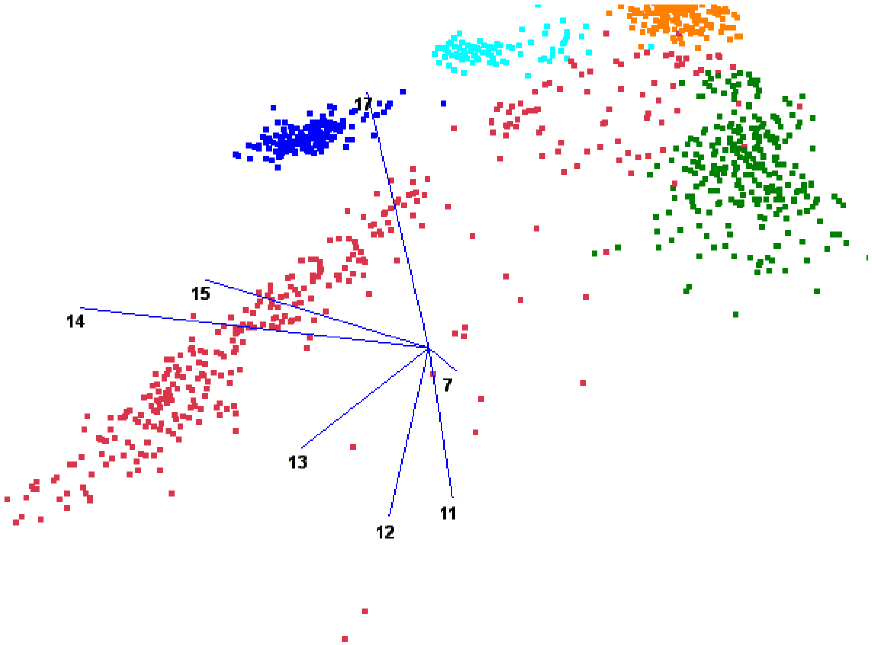
- Seems impossible to earn a high salary in the first three years
- High salaried players have a bimodal distribution (peaking around 7 & 13 yrs)
- Hits/Year a better indicator of salary than HR/Year
- High paid outlier with low HR and medium hits/year. Reason: person is player-coach
- There seem to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

Brushing: Highlighting

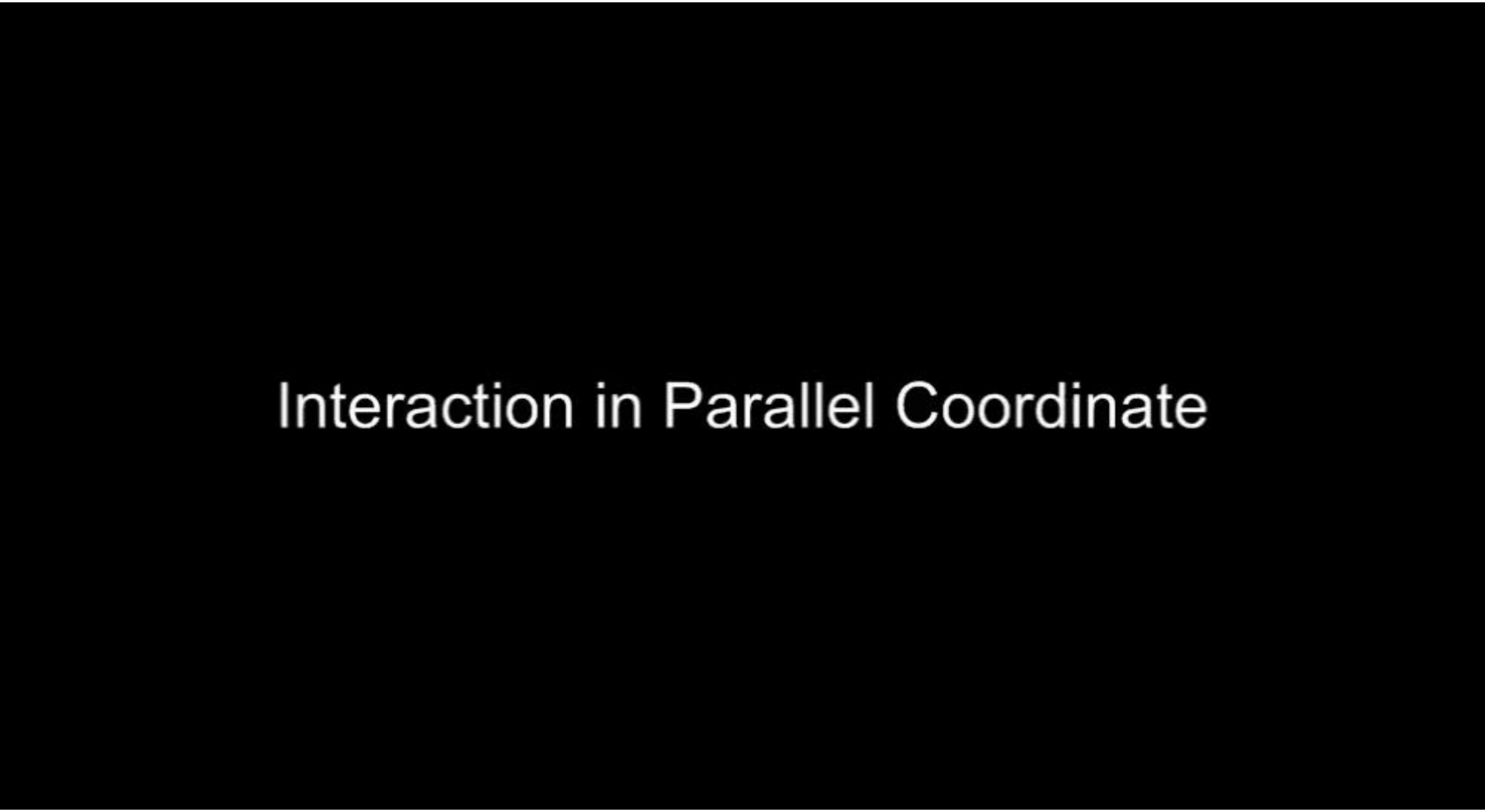
Use mouse interaction to highlight points and lines in

- parallel coordinates
- scatterplots



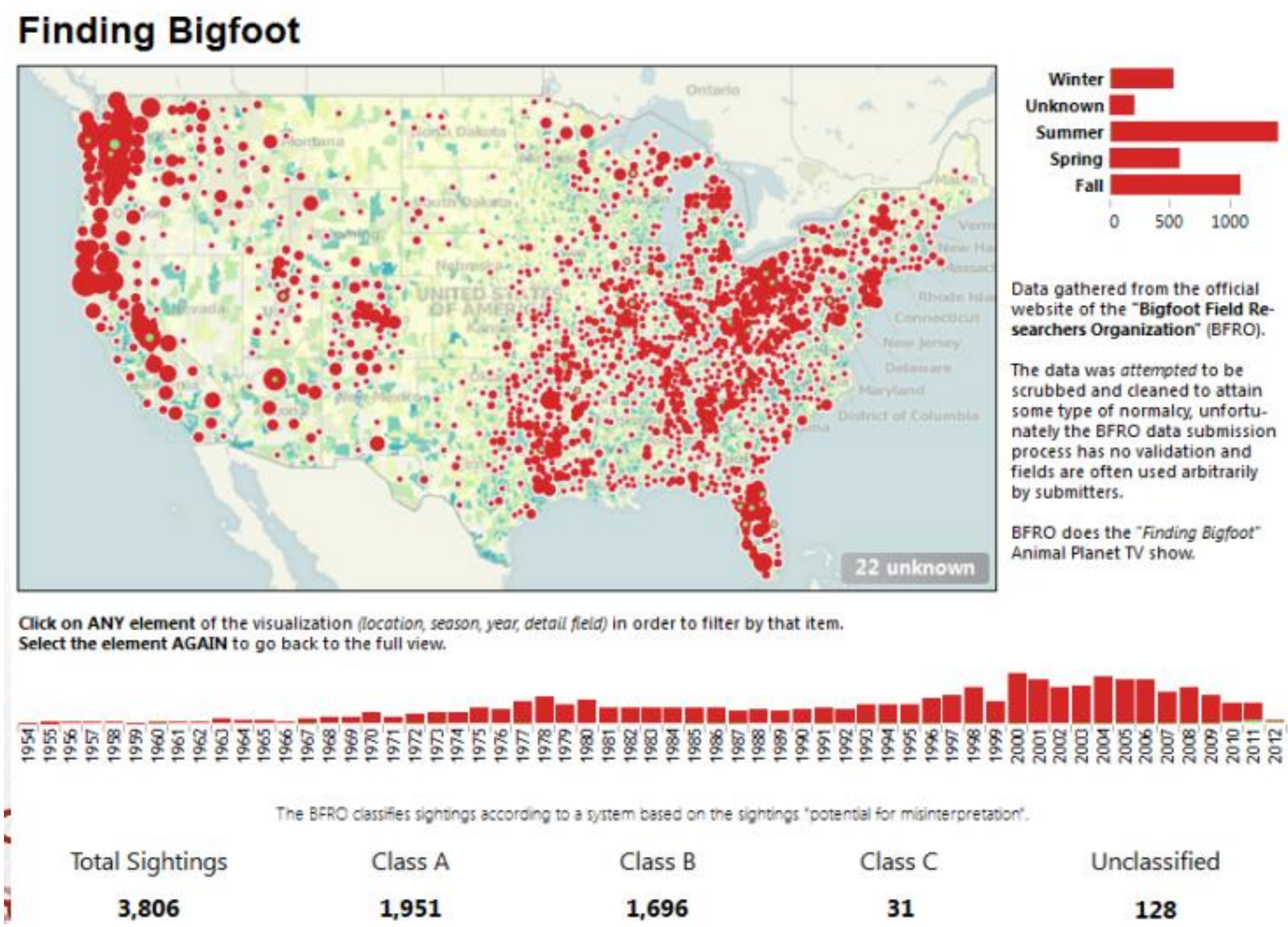


Interaction Video #1



Accelerate Understanding

Dashboards should pass the 5-second test



Accelerate Understanding

Important rules:

- most important view goes on top or top left
- legends go near their views
- avoid using multiple color schemes
- use 5 views or fewer
- provide interactivity