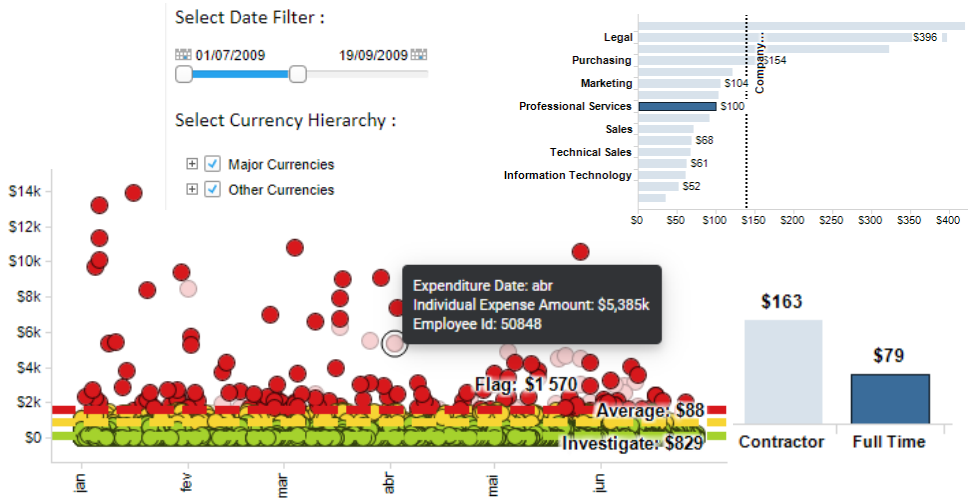
Universidade de Aveiro
Departamento de Electrónica,
Telecomunicações e Informática

Presentation and Interaction

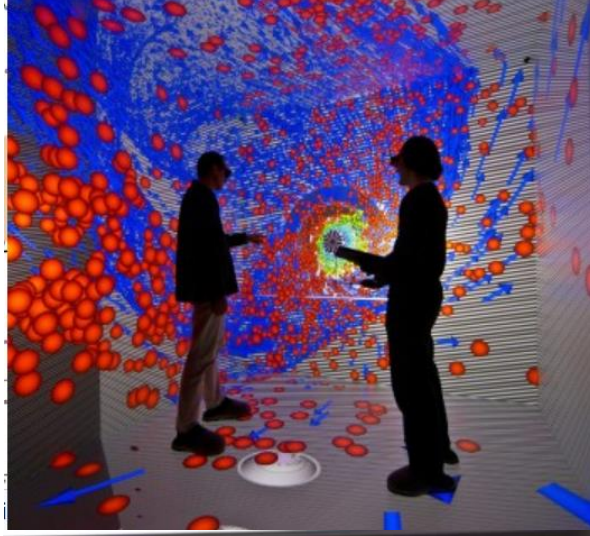


[Spotfire interactive demos]

Visualizations may be presented in different ways (ever more so)

Impacting their design

Different platforms have specific issues



Designing for large screens may be different due:

Size

Viewing angle

Viewing distance

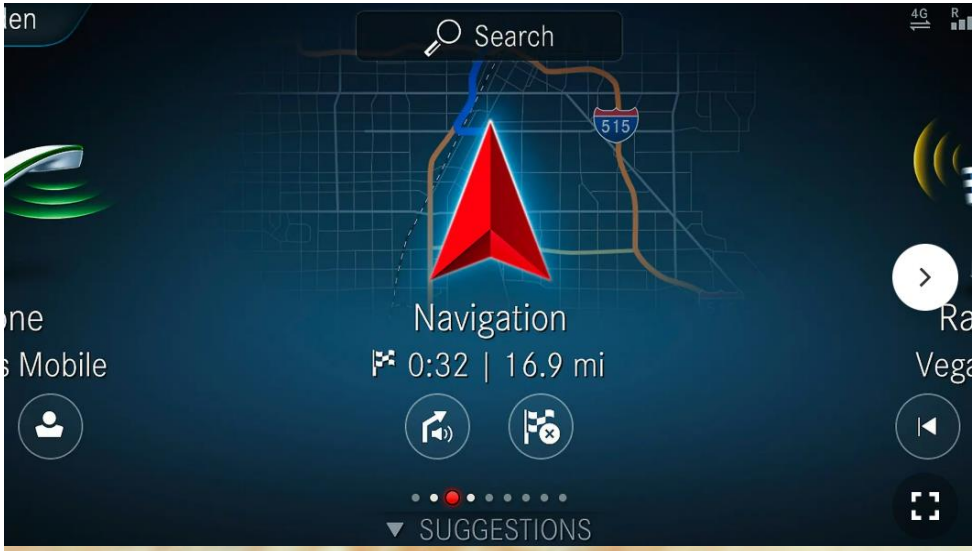
…

Even for large displays attention limitations still hold…

5 Important Factors of Control Room Display Wall Design

Visual ergonomics: large format screens or multidisplay | GESAB

Revolution in the Cockpit: Mercedes-Benz UX



What about other platforms?

cars onboard systems

wearable devices

The Role of Wearable Devices in Monitoring Health

Specific issues for different platforms: mobile

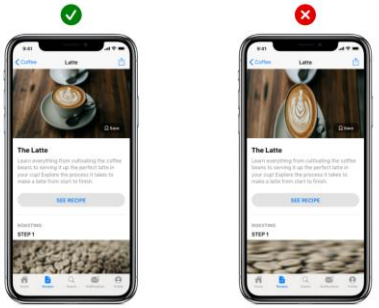
- Many guidelines are similar for mobile and desktop design, but their mobile interpretation is **much more unforgiving**
  - Context of use
  - Size of screen
  - Platform limitations

- There are guidelines for different platforms

Design & Plan | Android Developers

UI Design Dos and Don’ts - Apple Developer

Mobile UX Sharpens Usability Guidelines



Specific issues for different platforms: wearable

Designing for wearables: some rules:

Glanceability

Keep it simple

Minimalistic interface

…

Remember also:

Privacy and Wireless connectivity

Designing for wearables: 7 rules and best practicesl

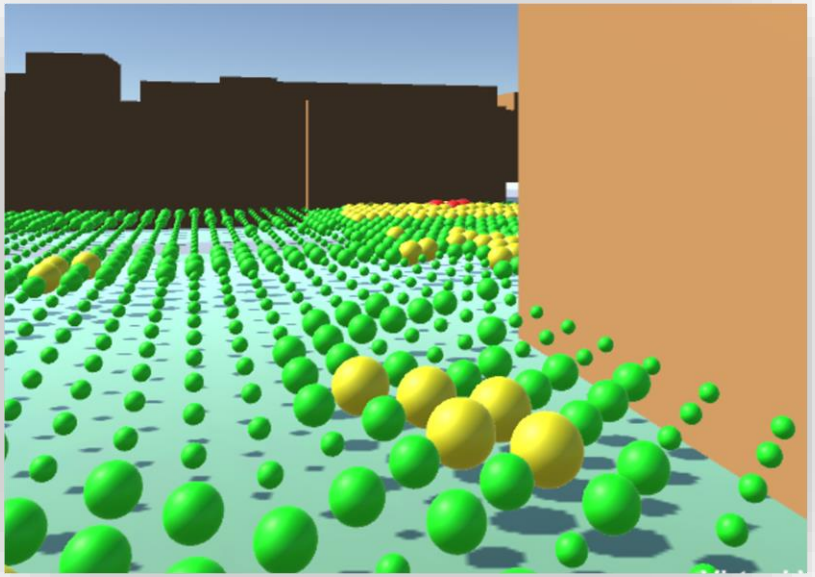
What about Immersive Visual Analytics?

(Skarbez et al., 2019)
Frontiers | Immersive Analytics: Theory and Research Agendal Visualization Meets Immersive Computing

Situated Visualization

Examples in industry and pollution awareness combining Visualization & Augmented Reality

[Pervasive Augmented Reality to support real-time data monitoring in industrial scenarios: Shop floor visualization evaluation and user study - ScienceDirect]



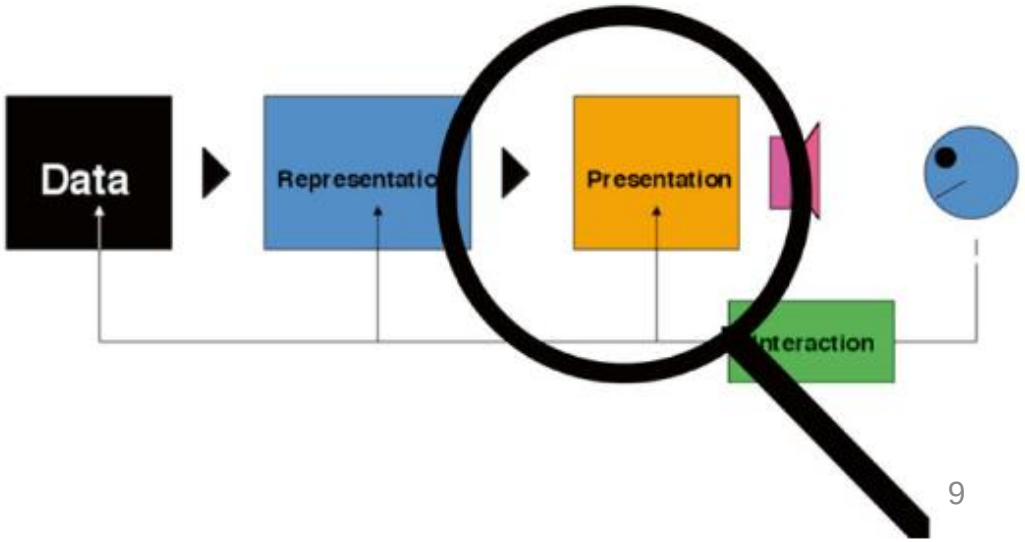
The general presentation issue

- Whatever the platform the issue of **layout** is important not only due to the limited screen real estate, as well as users' cognitive limitations

- Irrespective of how data may be represented decisions have to be made:
  - **how the visual representation is to be displayed**
  - **when and where it is to be displayed**

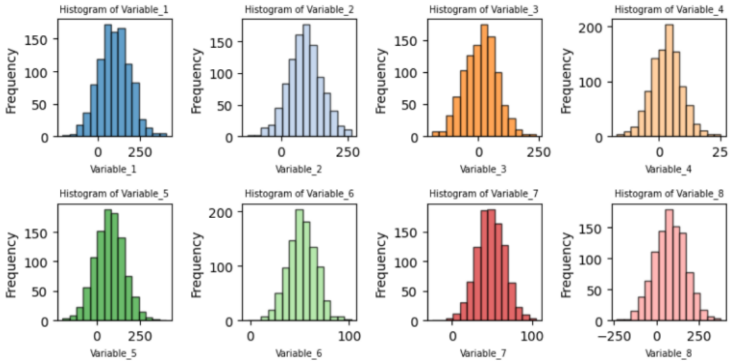
(Spence, 2014)

- Links to representation and **interaction** are important



Techniques for presenting several visualizations

- Small multiples



[Histogram with small multiples]

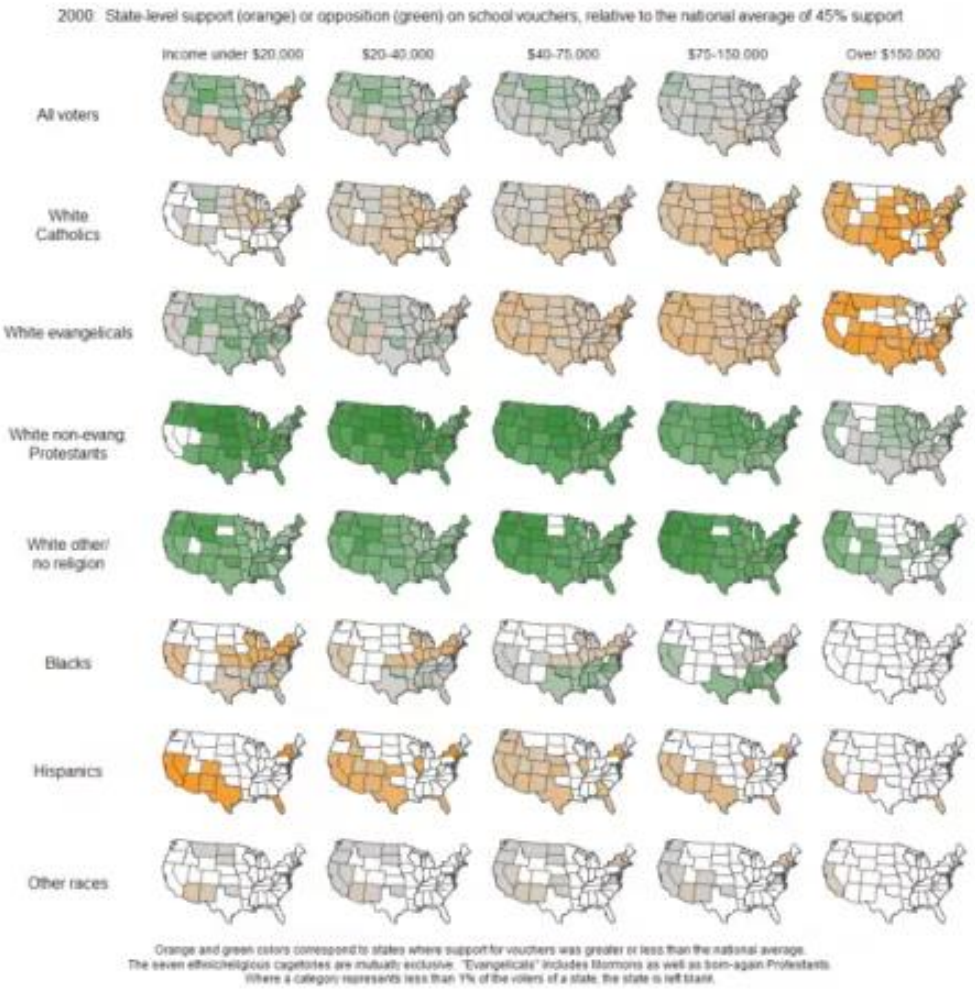
- Dashboards

[What Do We Talk About When We Talk About Dashboards? | IEEE Xplore]

Small multiples

"**arrangement** approach that facilitates efficient and **effective comparisons**"

(Kirk, 2012)



[Small multiple - Wikipedia]

Dashboards

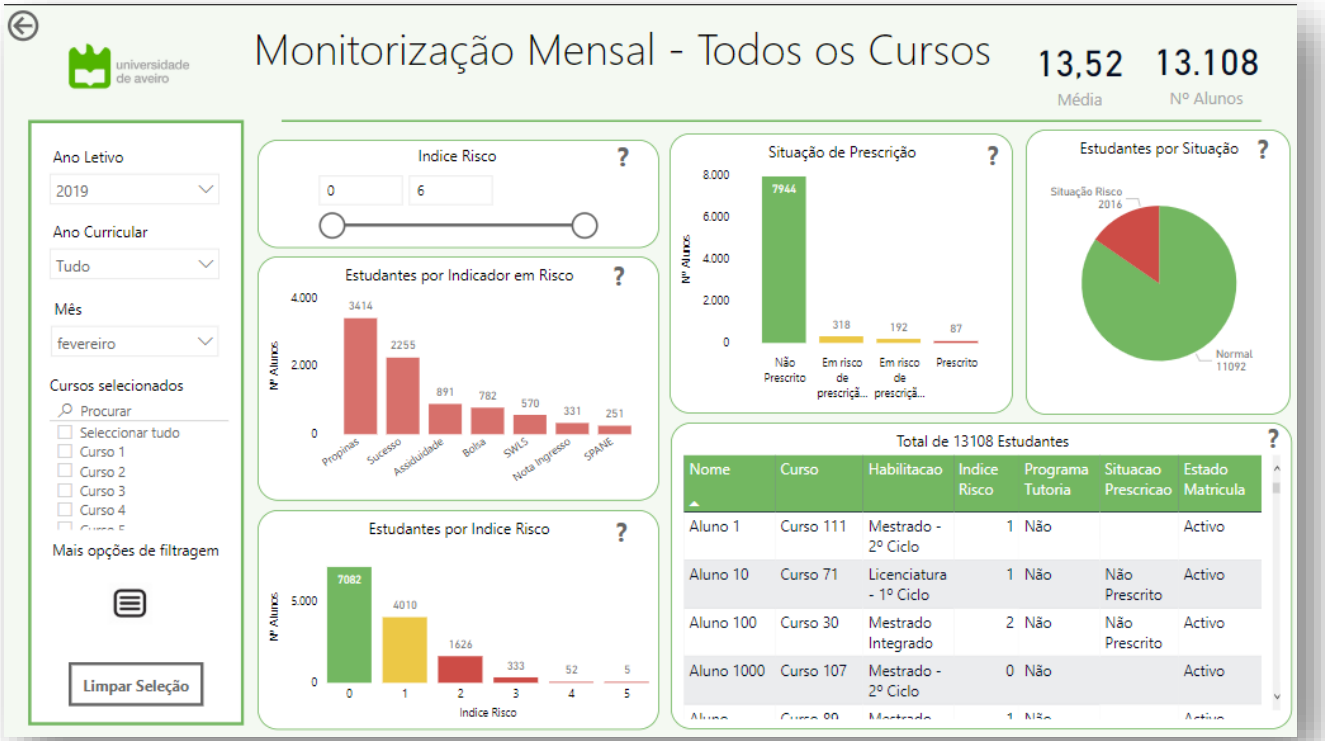
Visual display summarizing a dataset providing information **at-a-glance** (e.g. KPIs)

" A dashboard is a visual display of the most important information needed to achieve one or more objectives; consolidated and arranged on a single screen so the information can be monitored at a glance. "(Few, 2004)

[Dashboards: Making Charts and Graphs Easier to Understand - NN/G]
[Intro to dashboards for Power BI designers - Power BI | Microsoft Learn]

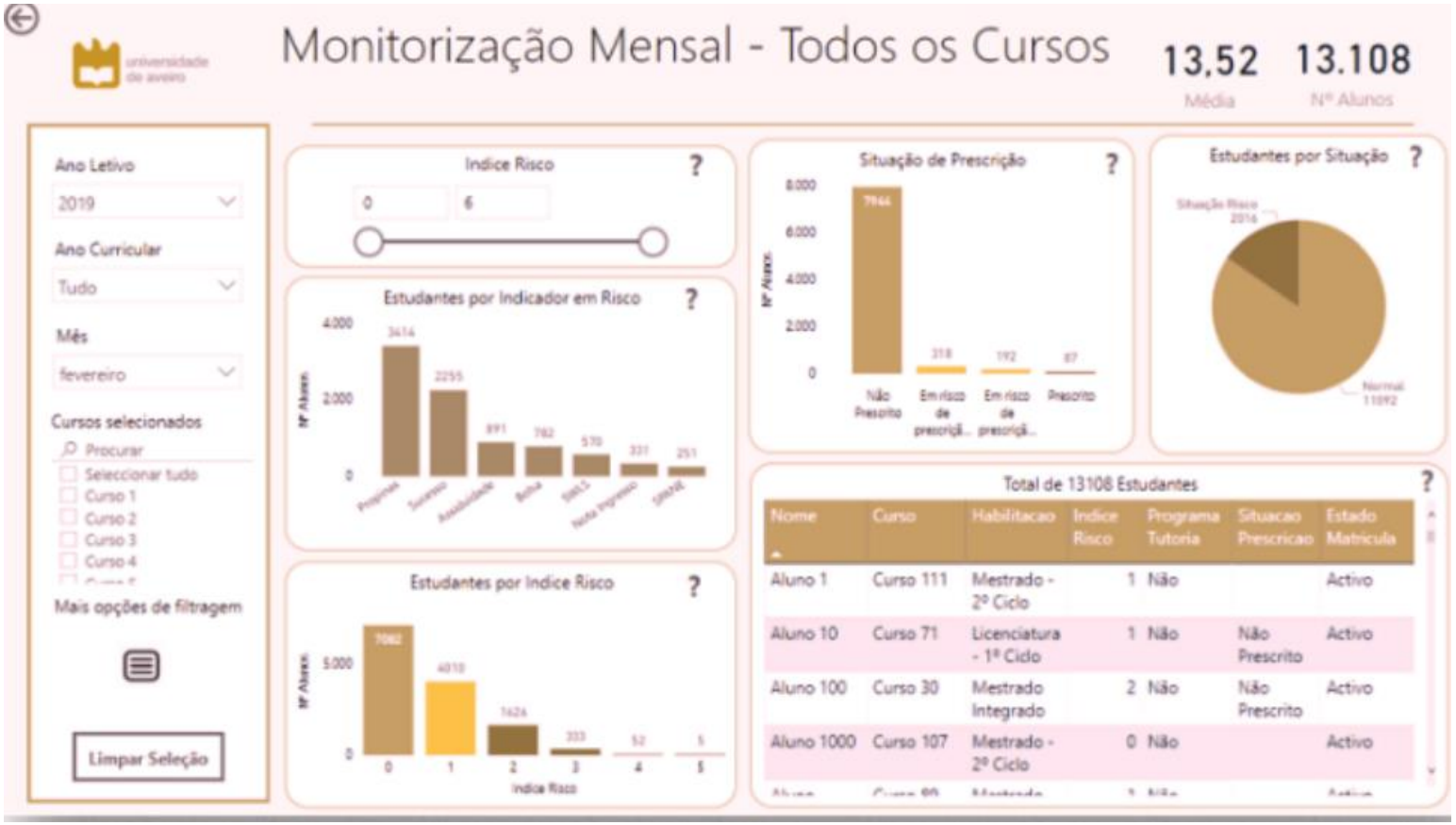
Prototype: "Portal dos indicadores, UA"

Any issues about the color?

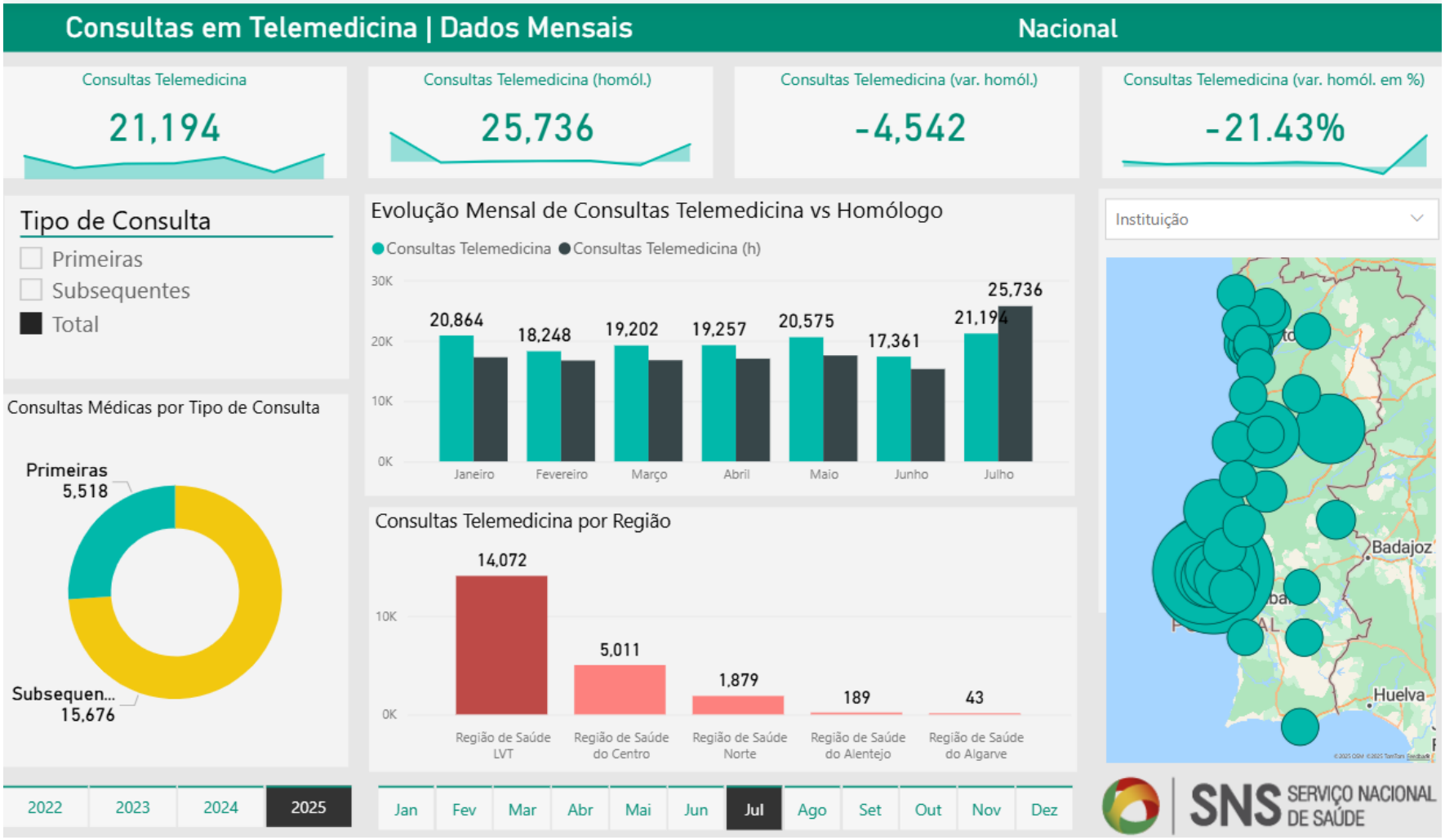


Testing readability to color-blind users:

As seen by someone with deuteranopia (red-green blindness)
[Coblis — Color Blindness Simulator – Colblindor]



Another example



[Consultas em Telemedicina – SNS]

Techniques to help overcome space limitations

- Scrolling
- Overview + detail
- Distortion
- Suppression
- Zoom and pan

- Scrolling consists in moving displayed text or graphics on a screen in order to view different parts of them

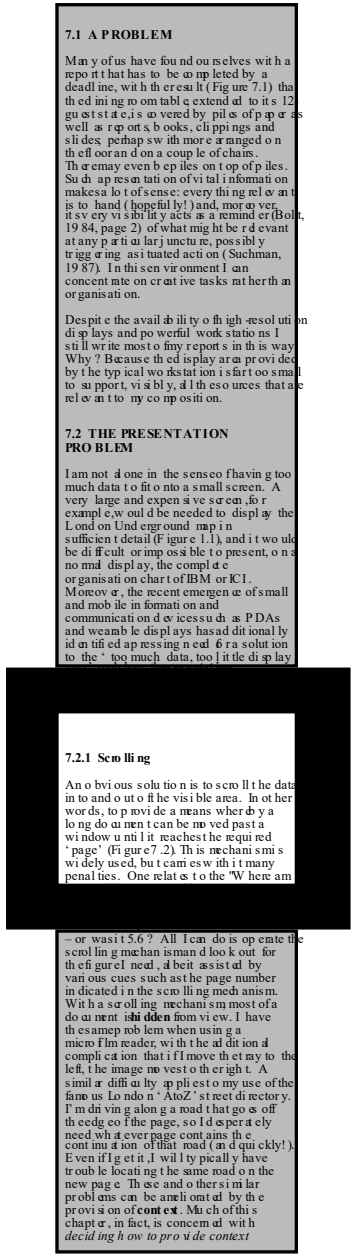
- an obvious solution when a document is larger than the display area

- A long document can be moved past a “window”

- Often it is not a satisfactory solution

- Scrolling hides most of a document:

  there is not a view of context as well as detail



7.1 A PROBLEM

Many of us have found ourselves with a report that has to be completed by a deadline, with the result (Figure 7.1) that the dining room table, extended to its 12 guest state, is covered by piles of paper as well as reports, books, clippings and slides, perhaps with more arranged on the floor and on a couple of chairs. There may even be piles on top of piles. Such a presentation of vital information makes a lot of sense: everything relevant is to hand (hopefully!) and, moreover, it's very visibility acts as a reminder (Bolt, 1984, page 2) of what might be relevant at any particular juncture, possibly triggering a situated action (Suchman, 1987). In this environment I can concentrate on creative tasks rather than organisation.

Despite the availability of high-resolution displays and powerful workstations I still write most of my reports in this way. Why? Because the display area provided by the typical workstation is far too small to support, visibly, all the resources that are relevant to my composition.

7.2 THE PRESENTATION PROBLEM

I am not alone in the sense of having too much data to fit onto a small screen. A very large and expensive screen, for example, would be needed to display the London Underground map in sufficient detail (Figure 1.1), and it would be difficult or impossible to present, on a normal display, the complete organisation chart of IBM or ICI. Moreover, the recent emergence of small and mobile information and communication devices such as PDAs and wearable displays has additionally identified a pressing need for a solution to the ‘too much data, too little display

7.2.1 Scrolling

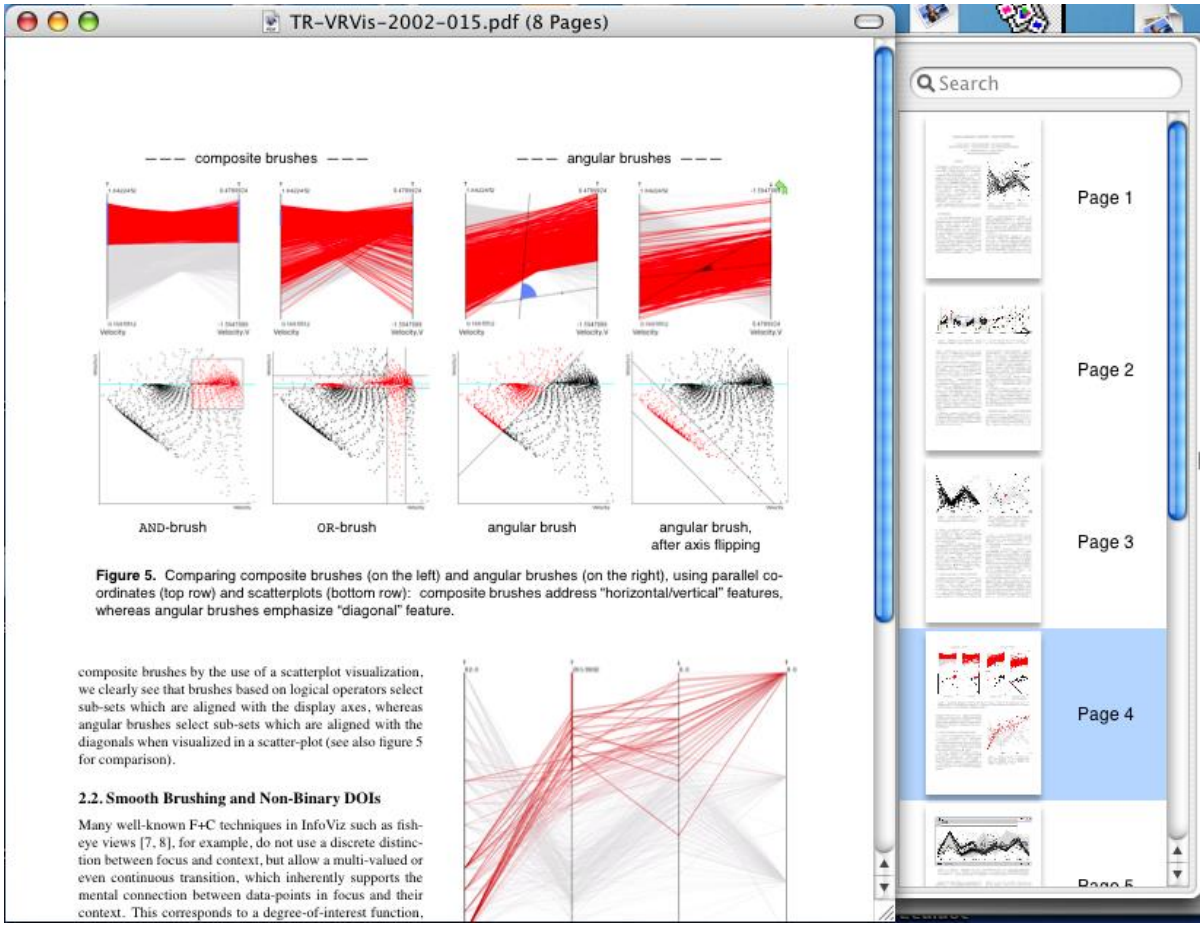
An obvious solution is to scroll the data into and out of the visible area. In other words, to provide a means whereby a long document can be moved past a window until it reaches the required ‘page’ (Figure 7.2). This mechanism is widely used, but carries with it many penalties. One relates to the "Where am

– or was it 5.6? All I can do is operate the scrolling mechanism and look out for the figure I need, albeit assisted by various cues such as the page number indicated in the scrolling mechanism. With a scrolling mechanism, most of a document is **hidden** from view. I have the same problem when using a microfilm reader, with the additional complication that if I move the tray to the left, the image moves to the right. A similar difficulty applies to my use of the famous London ‘AtoZ’ street directory. I'm driving along a road that goes off the edge of the page, so I desperately need what ever page contains the continuation of that road (and quickly!). Even if I get it, I will typically have trouble locating the same road on the new page. These and other similar problems can be ameliorated by the provision of **context**. Much of this chapter, in fact, is concerned with *deciding how to provide context*

- Two separate views of detail and of context can be combined in a overview + detail view helps with the **focus + context** problem

"You are here"

Another example

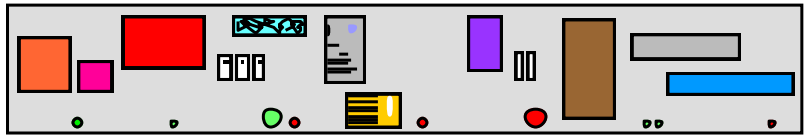


Detail plus Overview. Miniatures of pages of a pdf document provide useful context while attention is paid to detail of one page (Spence, 2007)

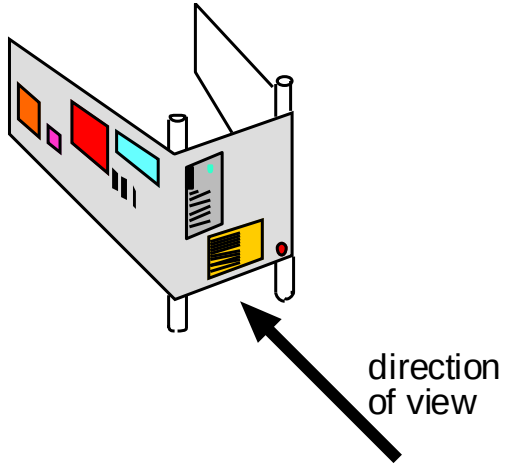
- Distortion offers a way of solving the **focus + context** problem

- The bifocal display (Spence and Apperley, 1982) uses distortion and is based on a simple metaphor

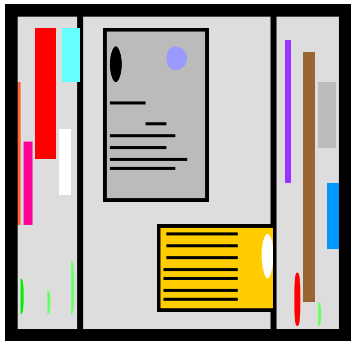
- Part of an information space can be viewed in detail; a bird's eye view is provided of the remainder



(a) An information space containing documents, emails, etc.



(b) The same space wrapped around two uprights.

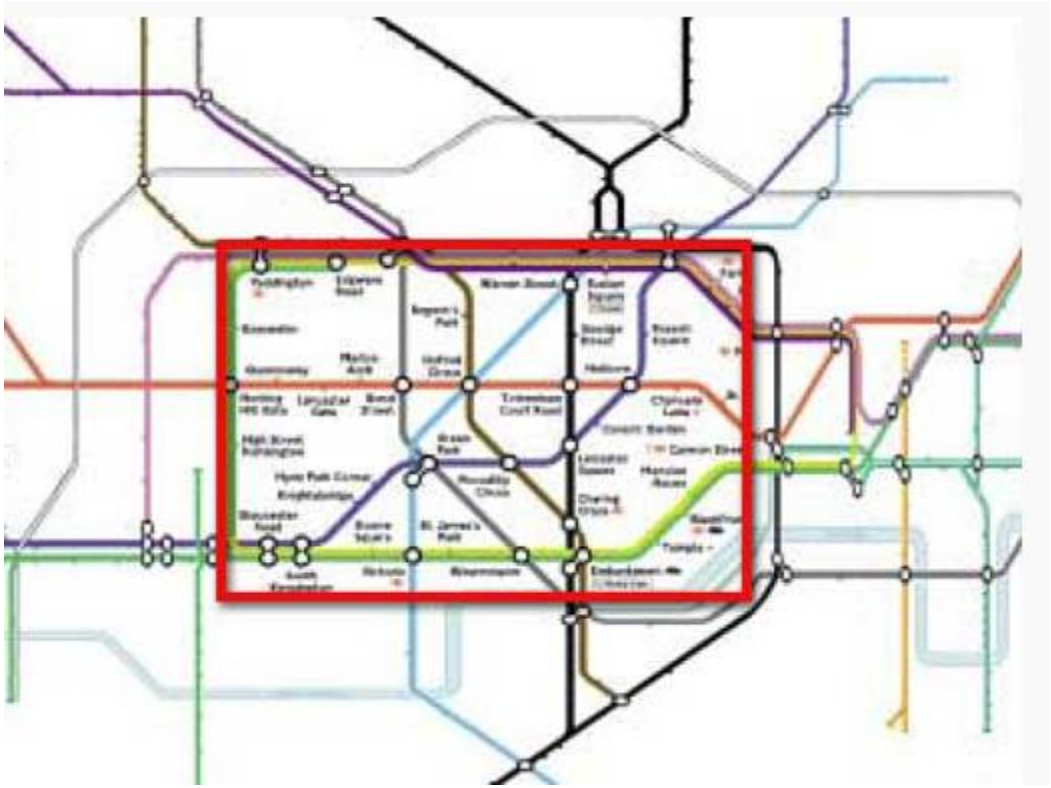


(c) Appearance of the information space when viewed from an appropriate direction

Original videos:

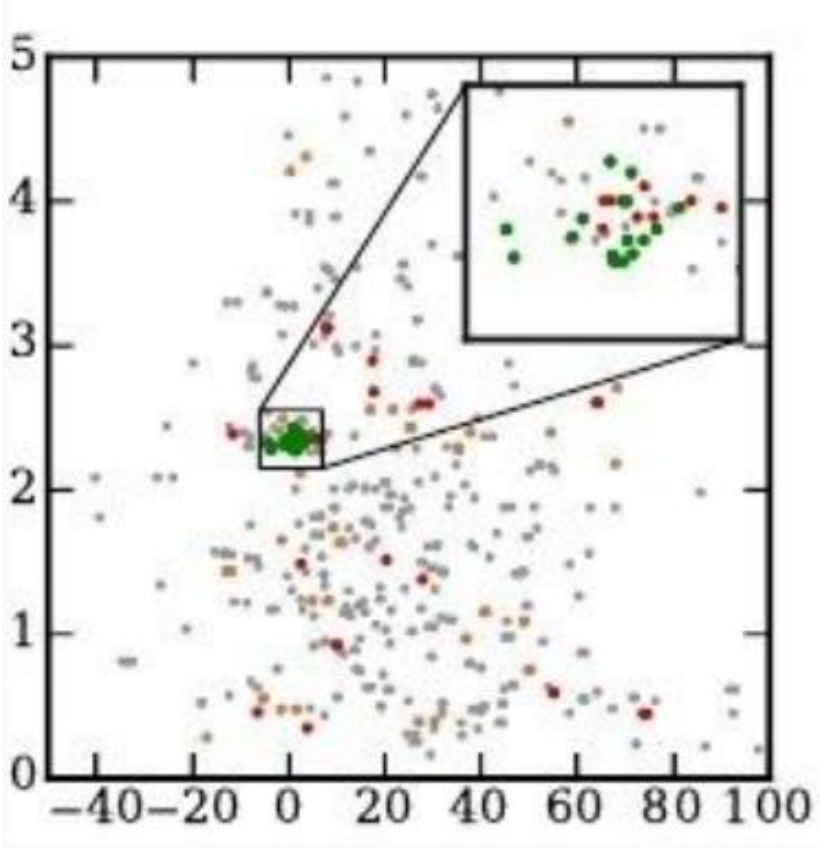
[Bifocal Display Concept Video from 1982]
[How the Bifocal Display was invented and launched - Video 3]

The Bifocal Display allows a large data space to be viewed as a whole, while simultaneously a portion is seen in detail.
The detail is seen in the context of the overview, with continuity across the boundaries, rather than existing in a disjoint window



The Bifocal Display - Example 2
Bifocal Display | The Encyclopedia of Human-Computer Interaction, 2nd Ed.

Another example



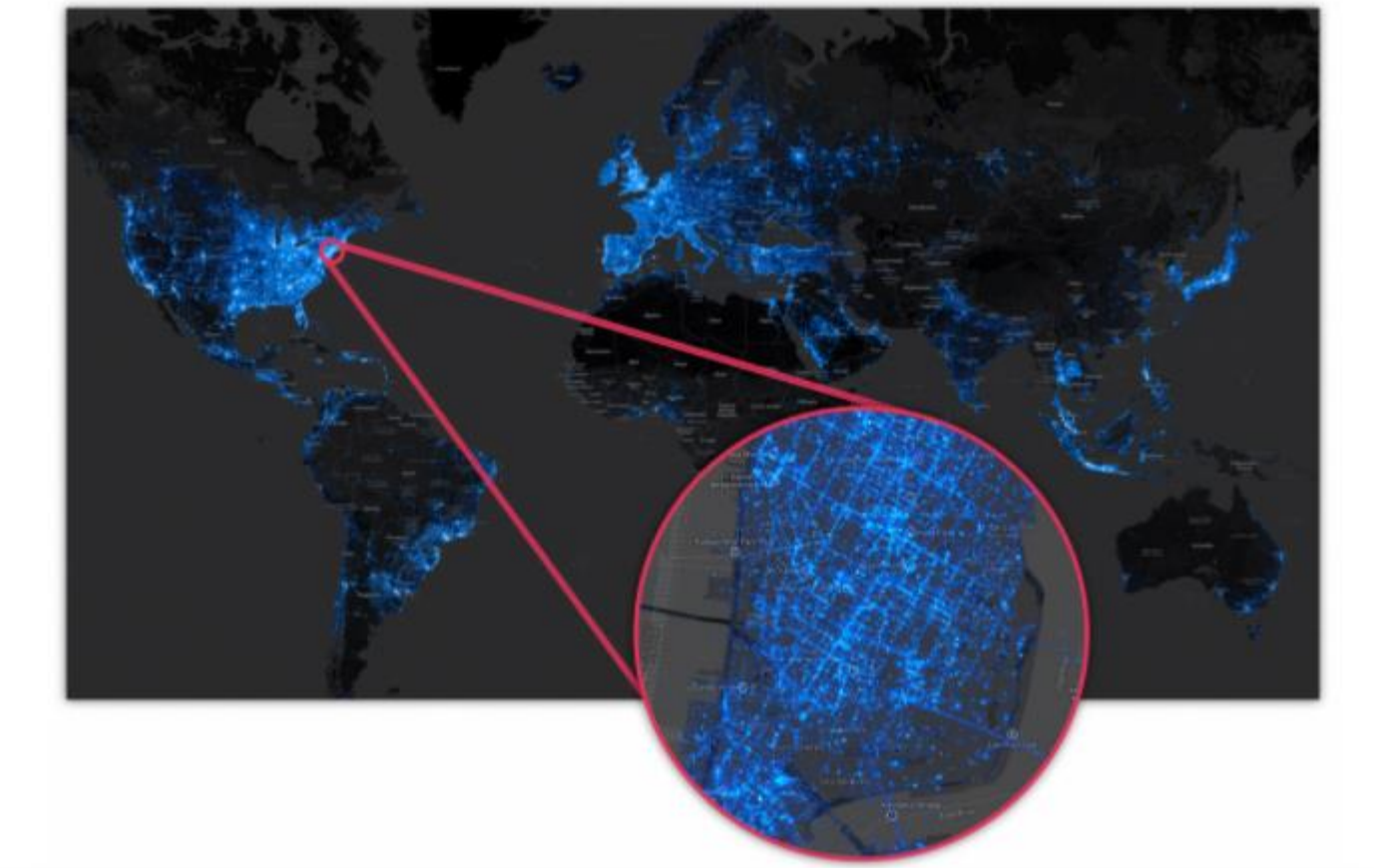
(Tao et al., 2021)

- The use of a "magnifying glass" helps minimize the **focus + context** problem

- a small region of interest is shown amplified and the context is maintained

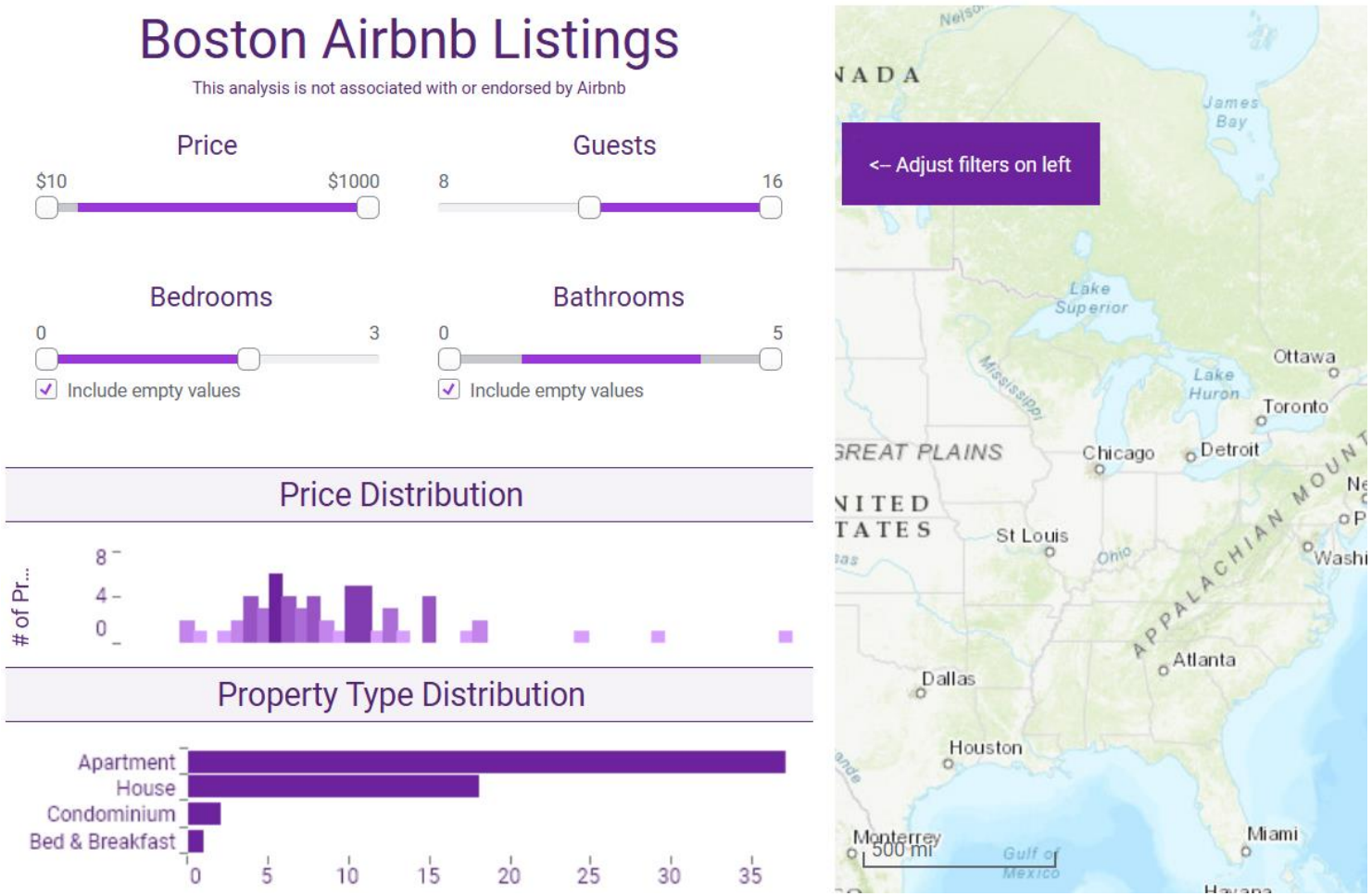
Kyrix-S: Authoring Scalable Scatterplot Visualizations of Big Data | IEEE TVCG

Example: a small region of interest in a context map can be flexibly positioned to provide a magnified view



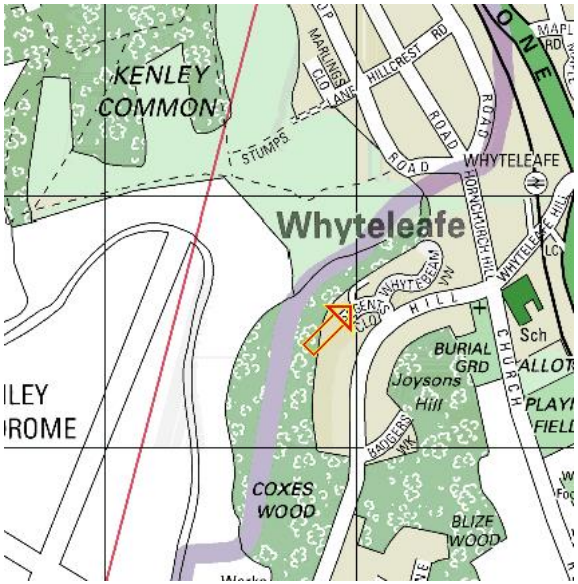
PanTera Big Data Visualization Leverages the Power of Databricks

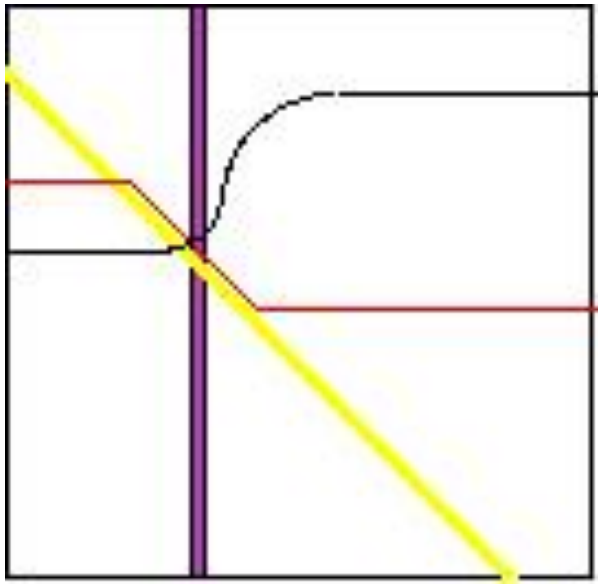
Suppression is used in Filtering

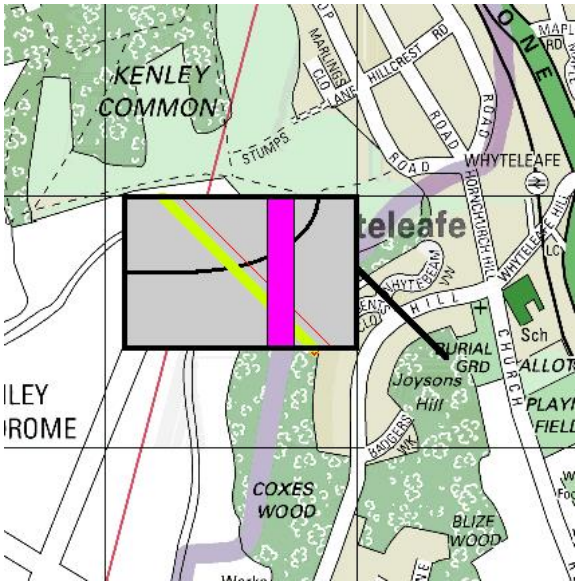


Filtering may be done in different ways through the User Interface (sliders, check boxes, …)

Suppression finds valuable application in the Magic Lens (Stone et al., 1994)

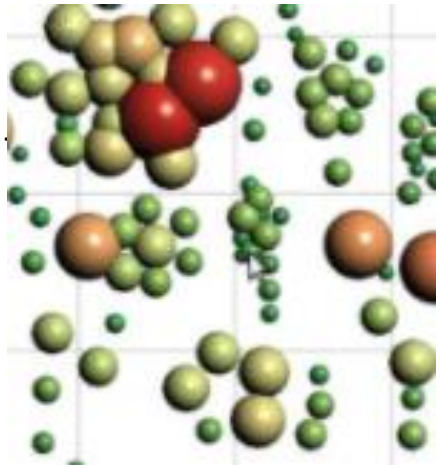




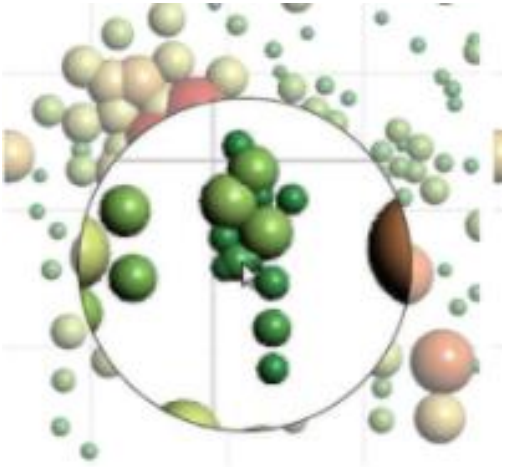


Magic Lens:
(a) shows a conventional map of an area,
(b) shows the location of services (gas, water and electricity pipes)
(c) a (movable) Magic Lens shows services in an area of interest, in context
(Spence, 2007)
Magic Lens - InfoVis:Wiki

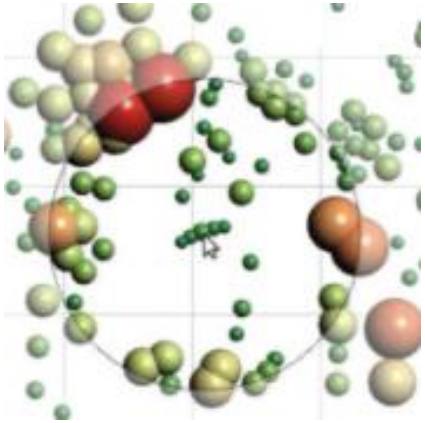
- The magic lens offers another way of solving the focus + context problem



Original view



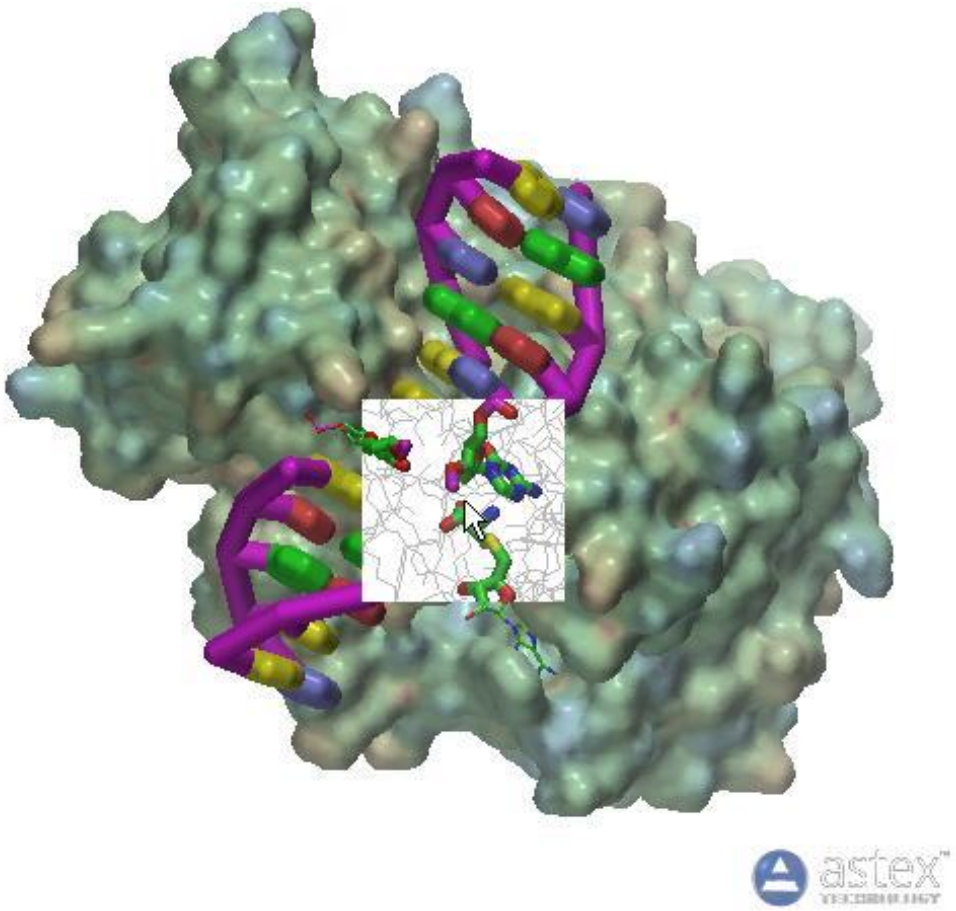
Simple magnification



Fish-eye distortion

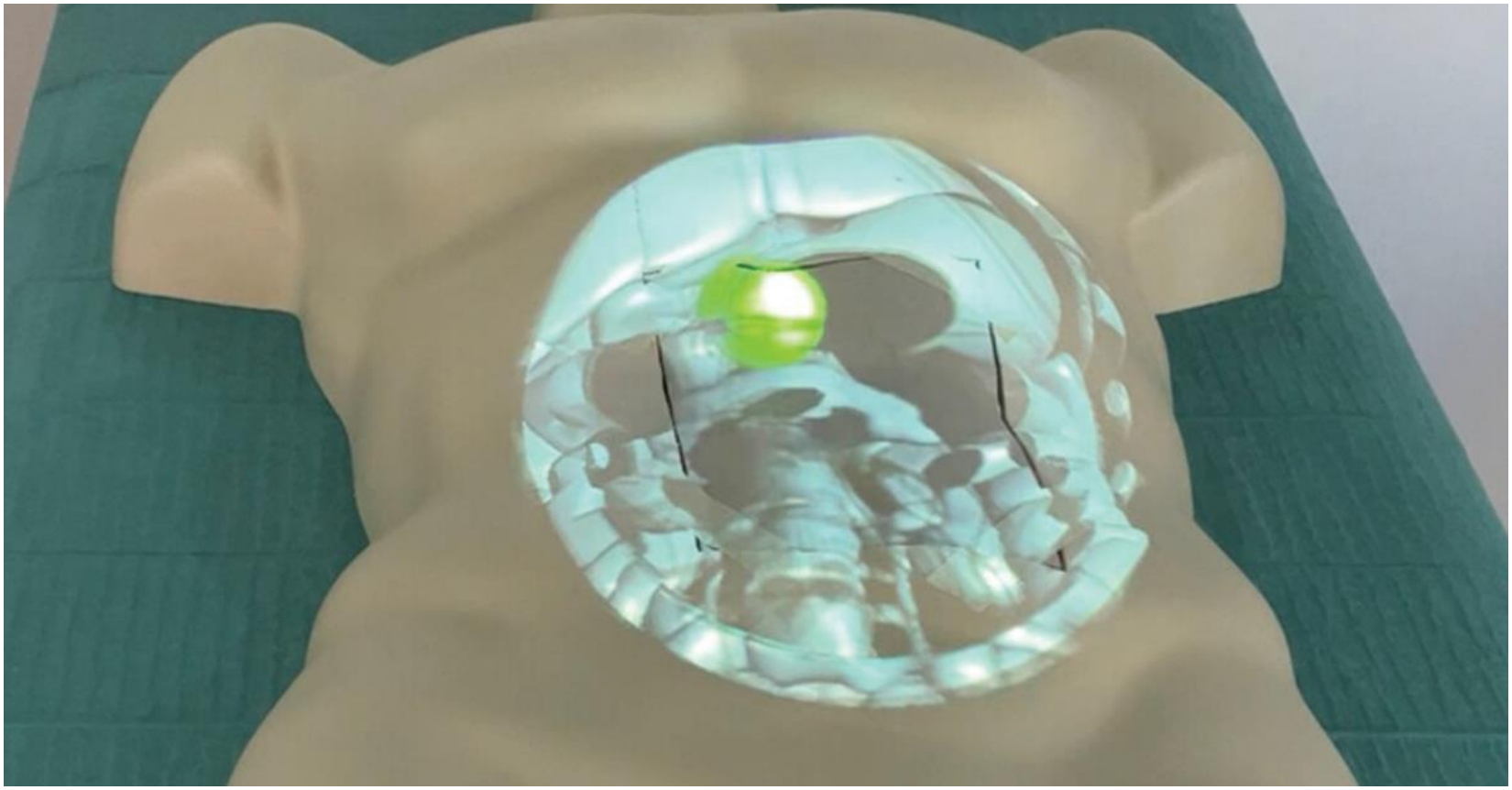
(Tominski et al., 2016)

Interactive Lenses for Visualization: An Extended Survey - Tominski - 2017 - Computer Graphics Forum



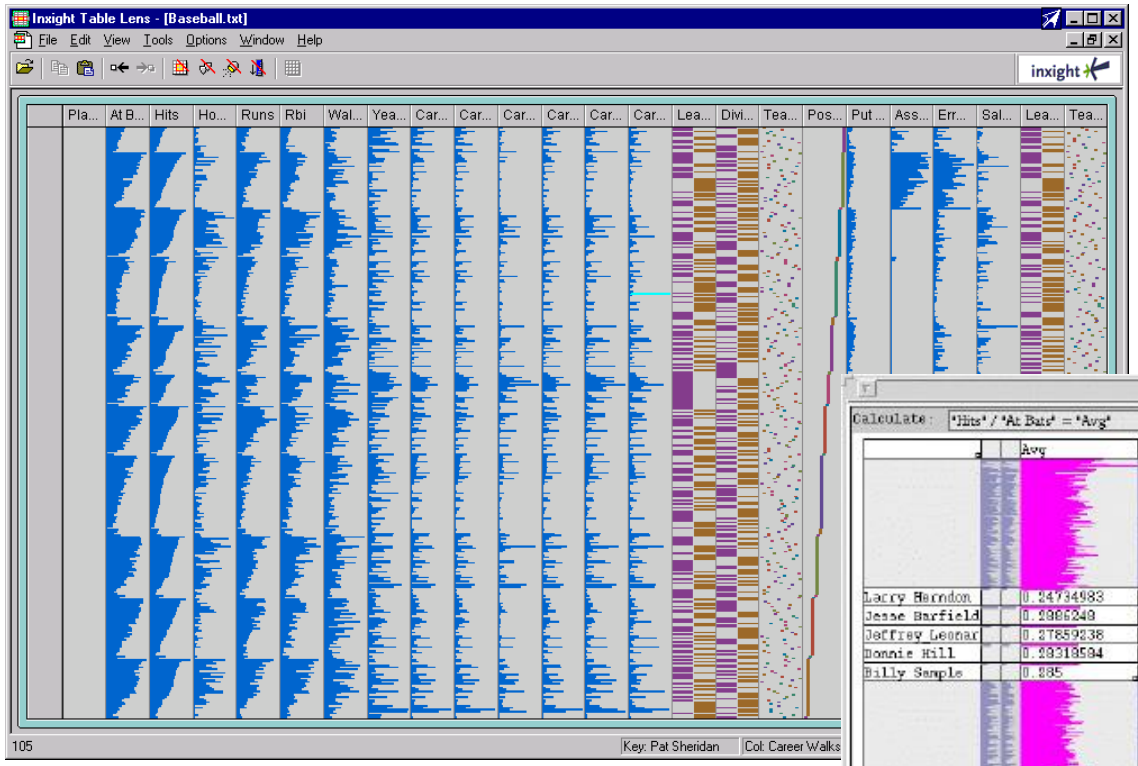
A molecular surface of the protein transferase colored by electrostatic potential bound to DNA shown as a schematic. The magic lens window allows a view of the atomic structure bonding to be shown, with the bound ligand structure highlighted as cylinders, thereby providing a view inside the protein (Spence, 2007)

The Magic Lens using Augmented Reality for Data Visualization



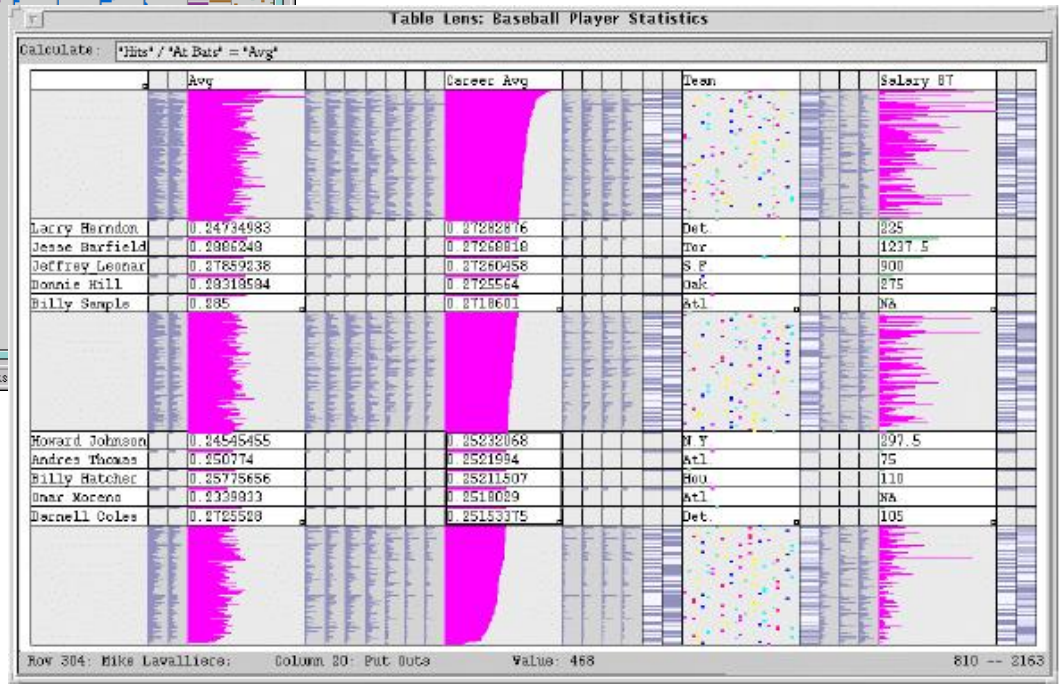
L Schwenderling, et al., “Activation modes for gesture-based interaction with a magic lens in AR anatomy visualisation,” *Computer Methods in Biomechanics and Biomedical Engineering: Imaging & Visualization*, vol. 11, n. 4, pp. 1243-1250, 2023
https://www.tandfonline.com/doi/full/10.1080/21681163.2022.2157749

The Table Lens is method to dynamically explore large amounts of tabular data



The Table Lens
(Rao and Card, 1995)

- without distortion;
- with distortion (expansion) to show names

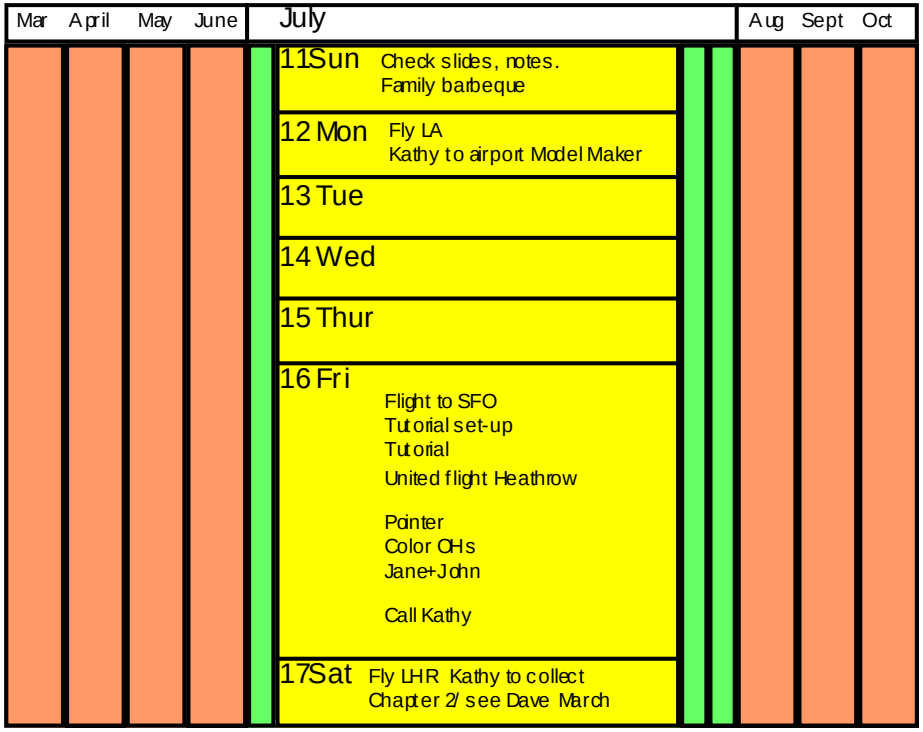


Original video:
[Exploring Large Tables with the Table Lens]

P. Pirolli and R. Rao, “Table lens as a tool for making sense of data”, Proc. of the workshop on Advanced visual interfaces (AVI96) https://doi.org/10.1145/948449.948460

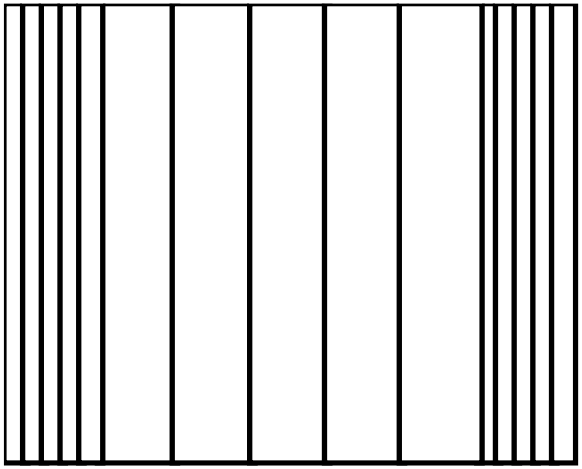
- This simple but powerful concept can be generalized

- It is possible to use X and Y distortion

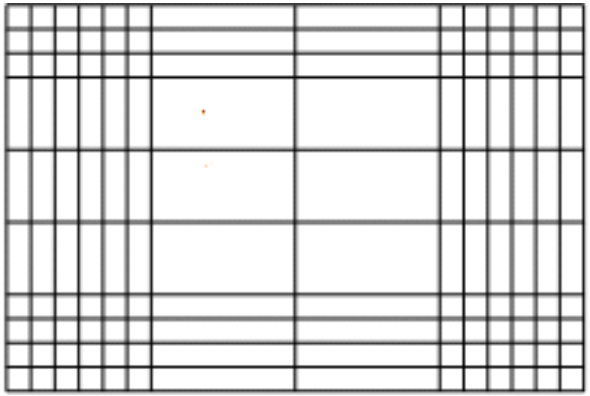


Calendar interface using X and Y distortion
(Bederson et al., 2003, 2004)

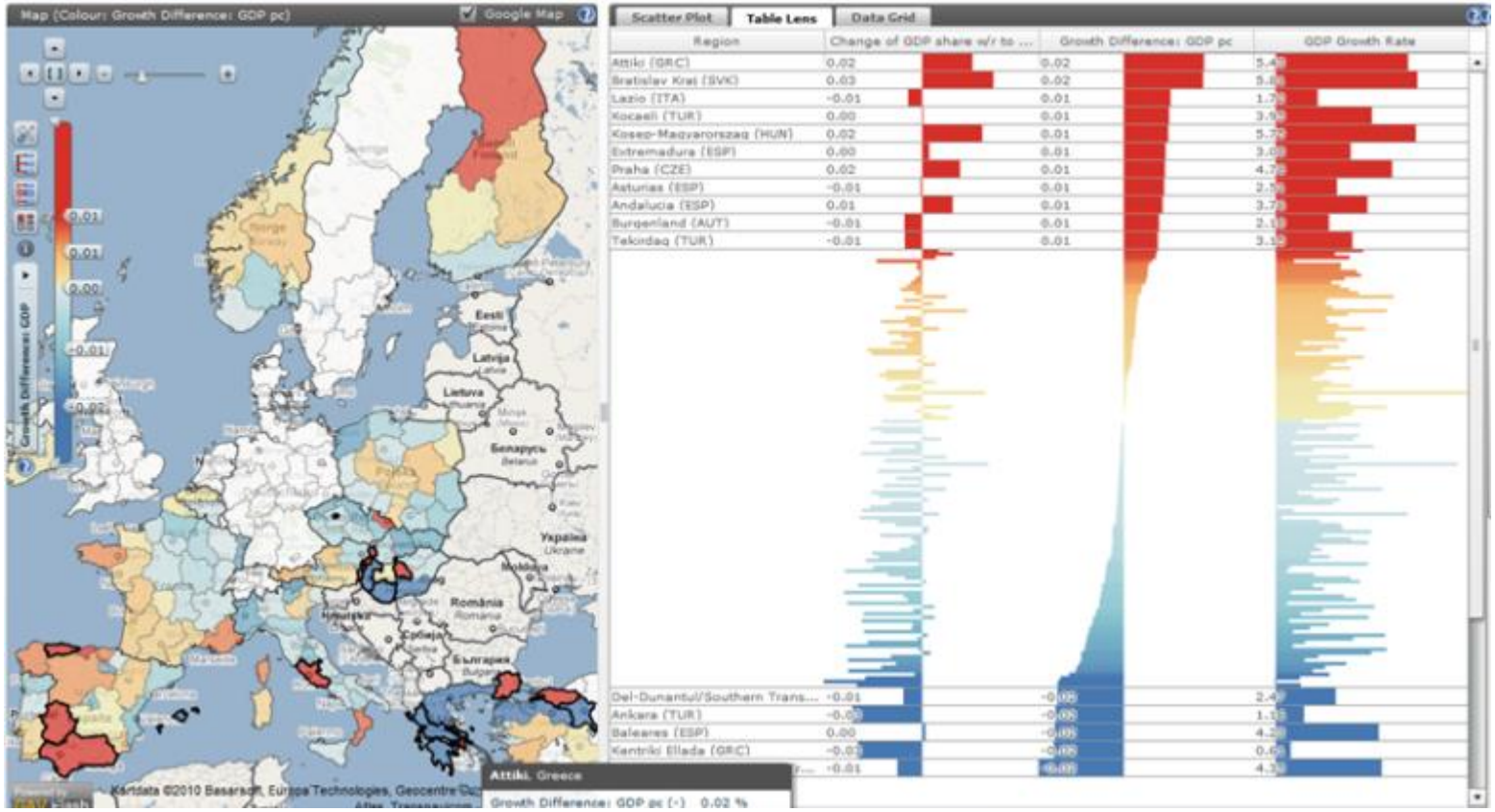
X-distortion



X and Y -distortion



The Table Lens a is method to dynamically explore large amounts of tabular data



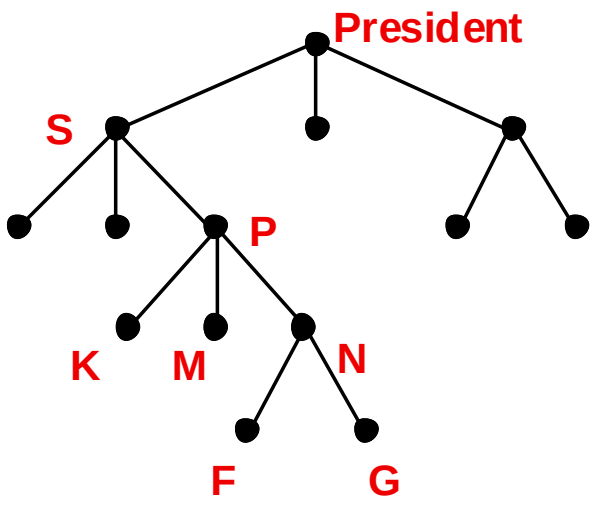
It allows to sort records, focus “zoom” in on interesting areas in the data (to reveal exact numerical information) using “focus + context“

- Furnas proposed a Degree of Interest (DoI) to determine which data should be represented and presented and which should be suppressed

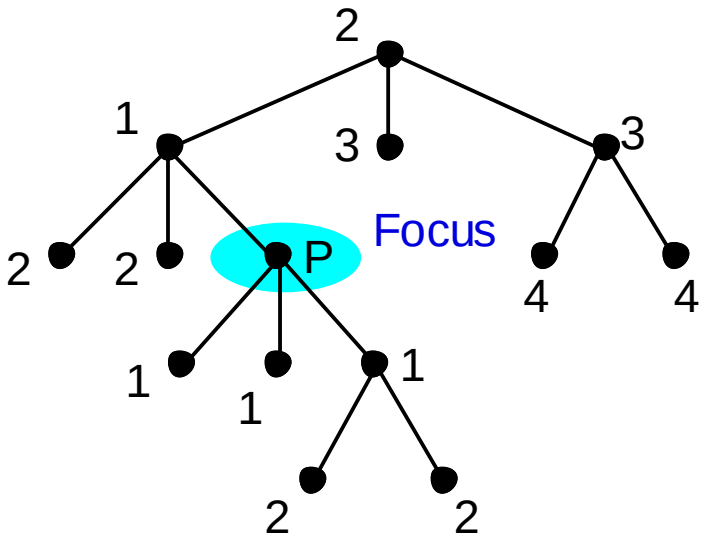
- The Degree of Interest of any item is expressed as a function of:
  - *A priori* importance (API)
  - Distance (D) between that item and the item which is currently the user's focus of interest

Example (Spence, 2007)
Considering only Distance:

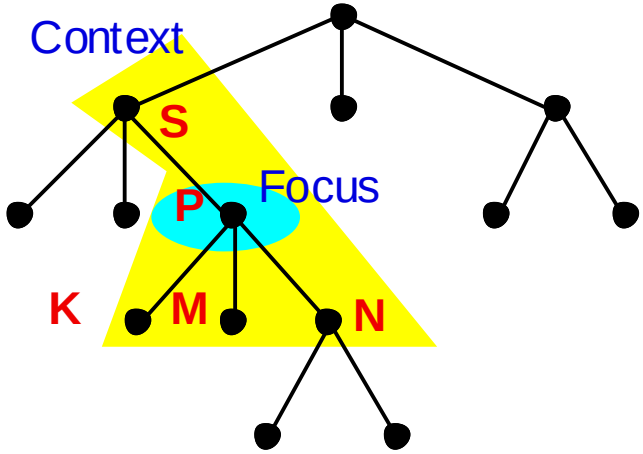
1-The organization tree of a company



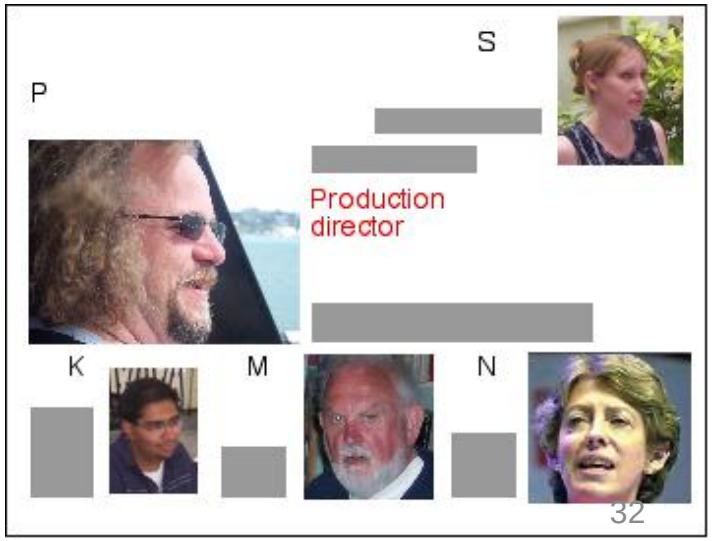
2- Distance 'D' of each node from the focus of attention



3- The context defined by setting an upper threshold of unity for distance from a focus



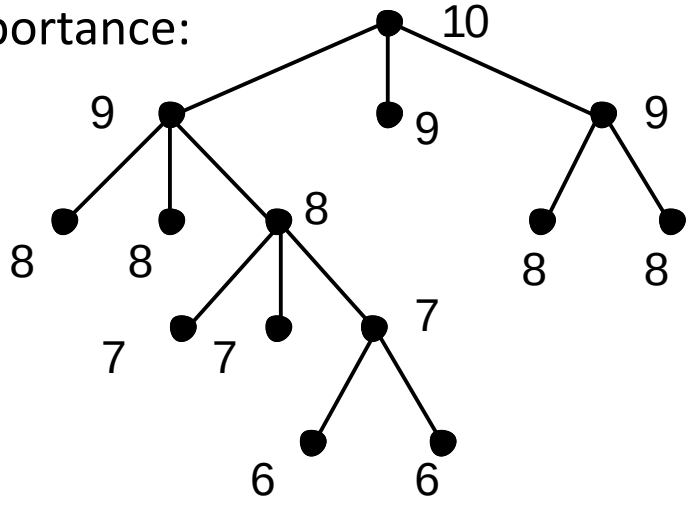
4- Display that might be associated with the focus and context defined



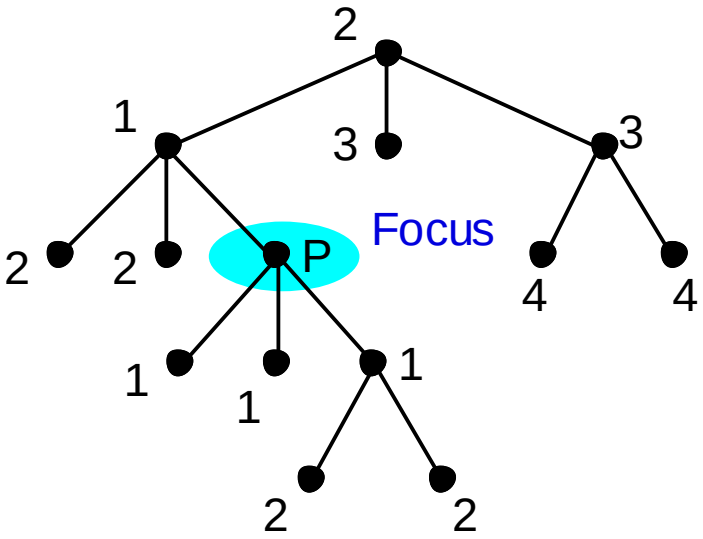
Example (Spence, 2007)

Considering a priori importance:

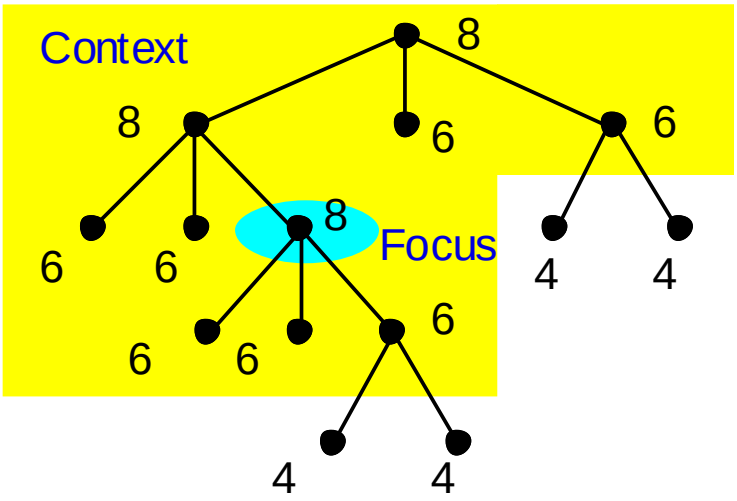
A priori importance:



Distance to the focus:



What is shown/suppressed:

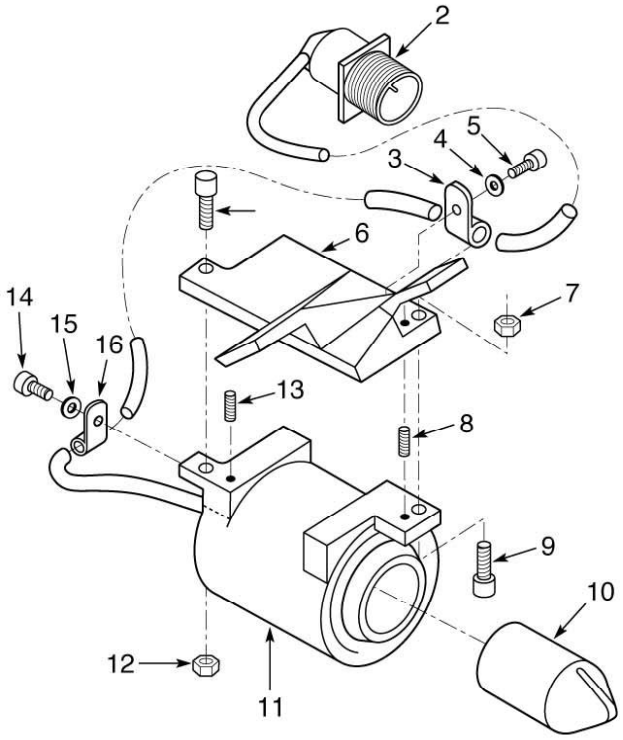


⇐ Nodal values of Degree of Interest:

DoI =API – D

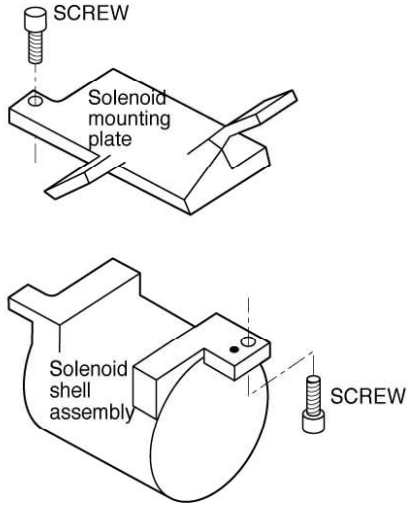
Setting a lower limit of 6 for DoI identifies the nodes within the shaded region

Example:
Part of an engineering drawing



The engineering drawing simplified in the context of a suspected fault

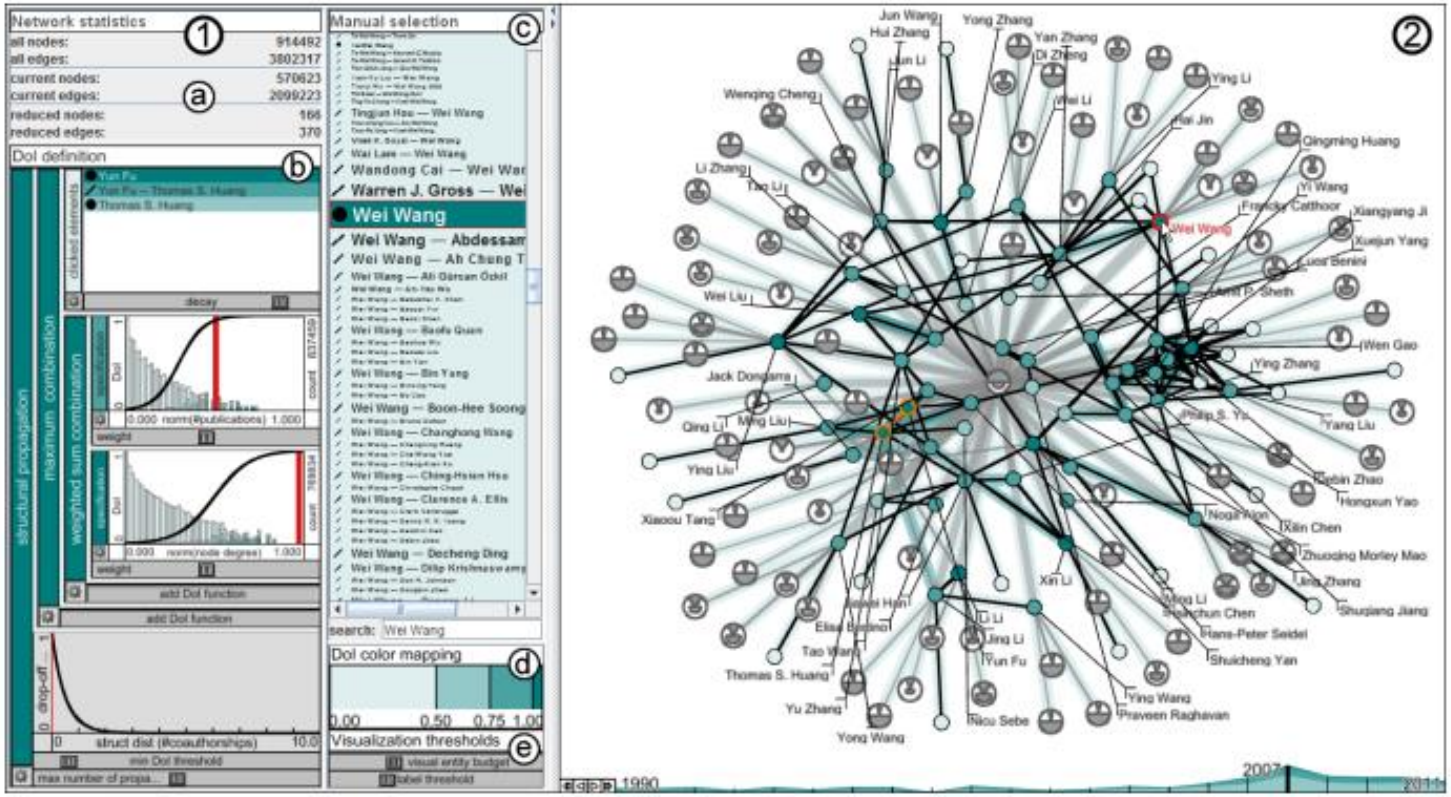
(Spence, 2007)



Another example :

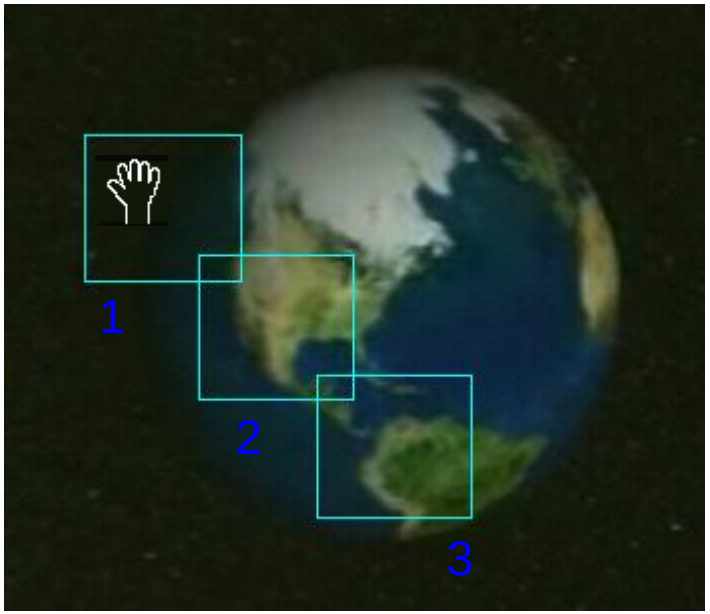
• providing both overview and detail on a dynamic citation network is a challenge, and small changes can be drowned out by larger ones

• a degree-of-interest specification by which the user can identify salient changes at the desired scale and importance may help

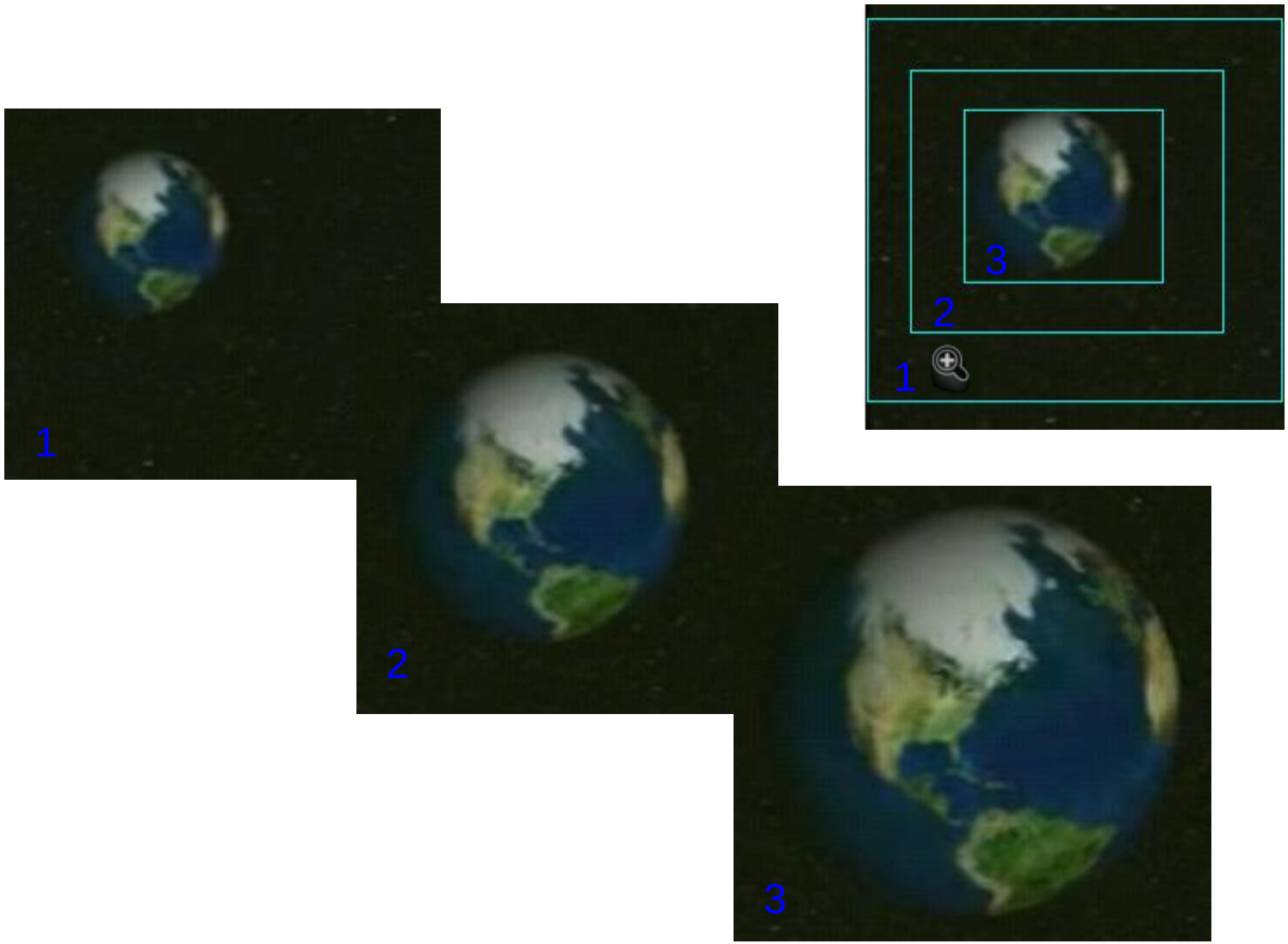


Two main views: (1) the DoI view and (2) the Network view (a snapshot of the DBLP dataset for the year 2007 reduced according to the defined DoI function).

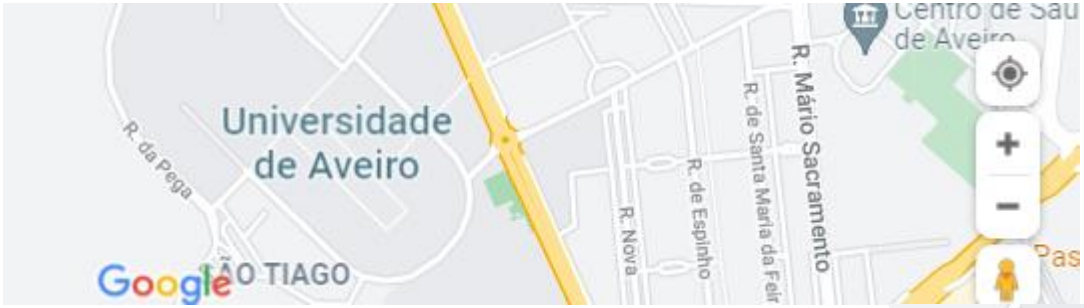
(Abello et al., 2014)



Panning is the smooth movement of a viewing frame over a 2D image



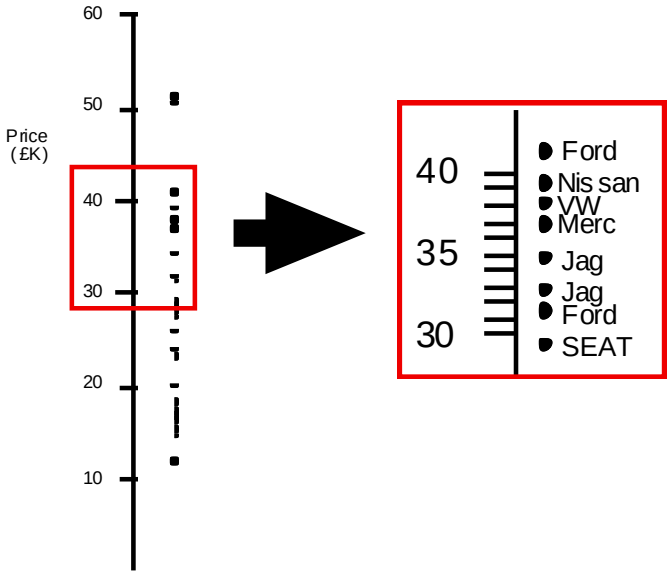
Zooming is the increasing magnification of a fraction of an image (or *vice versa*)



1

2

Zooming is the increasing magnification of a fraction of an image (or *vice versa*)
Semantic zoom- more information is shown (not only the previous one magnified)
Semantic Zoom - InfoVis:Wiki

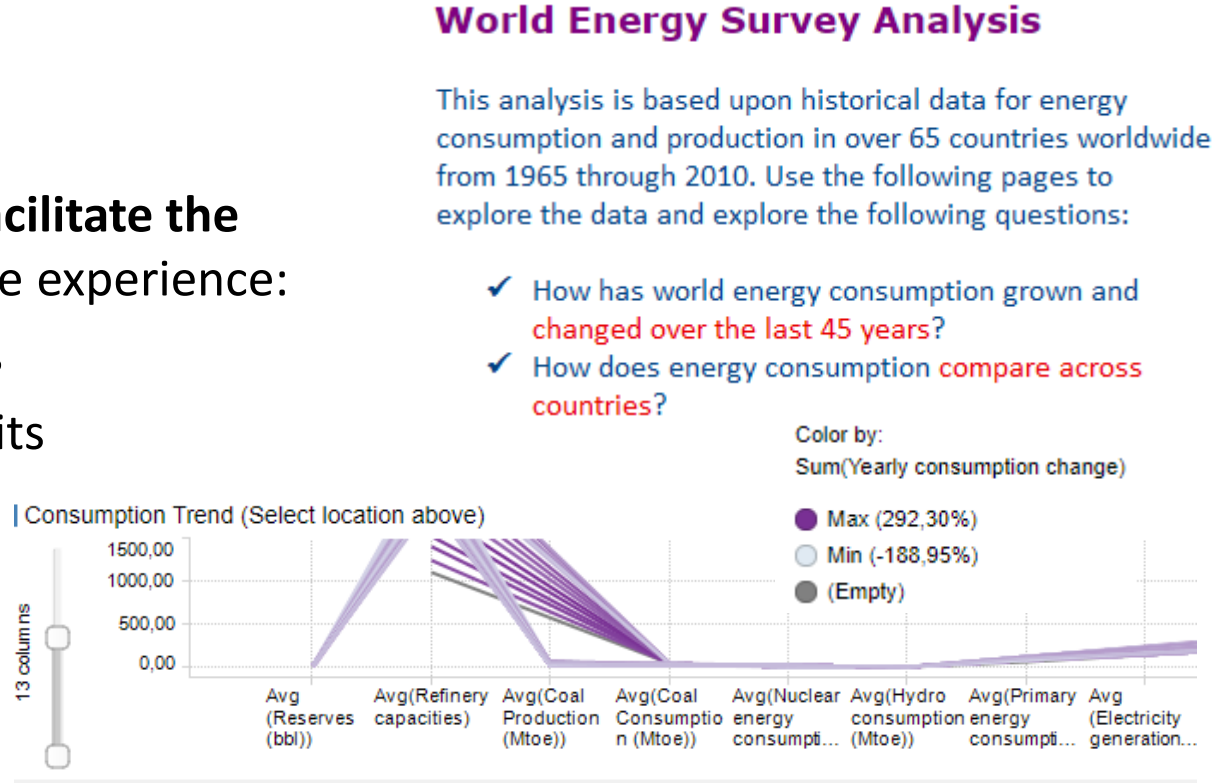


In semantic zoom the meaning conveyed by the new view differs from the conveyed by the previous one

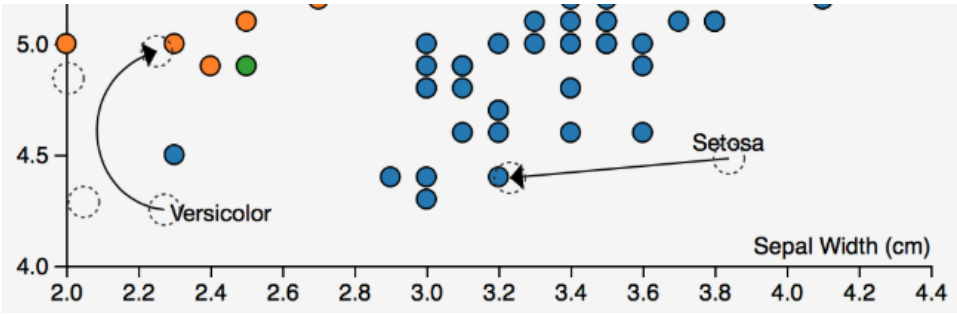
(Spence, 2007)

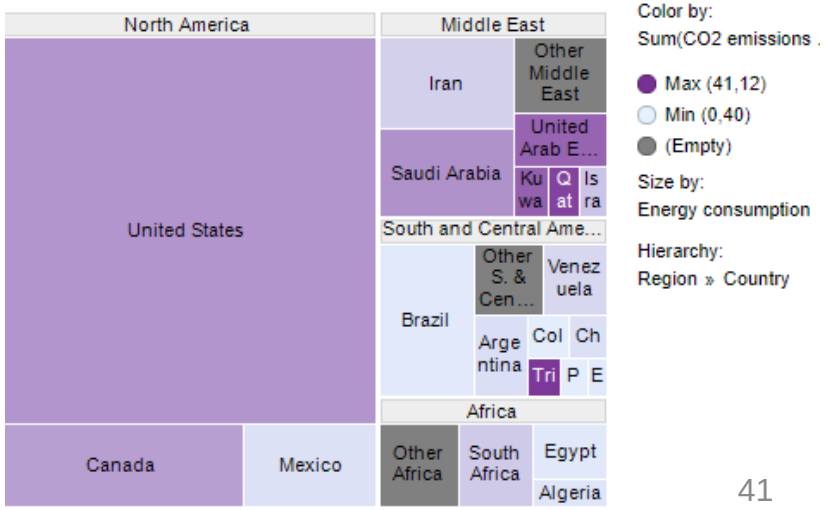
Annotation

- Can **help explain** and **facilitate the viewing** and interpretive experience:
  - Titles and introductions
  - Captions, labels and units
  - User guides
  - Attribution
  - Data sources



[Making Annotations First-Class Citizens in Data Visualization | by Elijah Meeks](#)
[Forecasting Energy Consumption and Generation - Spotfire® Analytics](#)





Creating Interaction

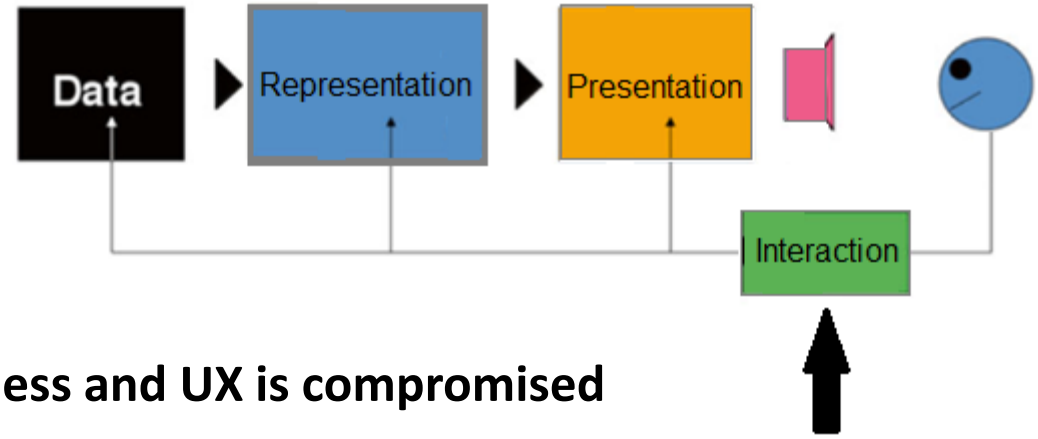
Enhancements in technology over the past decade have created incredible opportunities to construct powerful interactive visualizations

The development of an interactive design **requires technical capabilities**

Technical constraints should be pondered:

- platform compatibility,
- data loading speed,
- server capacity

…



If not correctly tackled the usefulness and UX is compromised

Creating Interaction

- When the complexity of the data is incompatible with a static portrayal, interaction is vital

- Careful consideration of the **motivation** and **intention** is still needed; specifically: what functional experience is the goal of the design?
  - exploratory,
  - explanatory,
  - or maybe a combined design?

- Different features and functions should be considered:
  - Manipulating variables and parameters (e.g. select, filter, modify, sort, …)
  - Adjusting the view
  - Annotating details
  - Animation

Visual Information-Seeking Mantra

(Shneiderman, 1996)

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

Summarizes many visual design guidelines and provides a excellent framework for designing Infovis applications

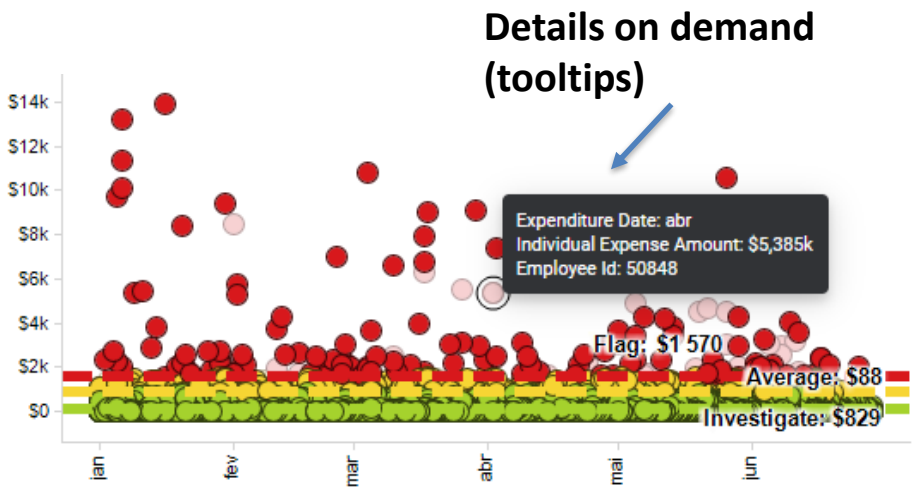
Visual Information-Seeking Mantra - InfoVis:Wiki

Few, S., The Surest Path to Visual Discovery

The Surest Path to Visual Discovery

Yet, **not always…** (some domain experts operate under a Details-first model, not Overview-first)

Details on demand

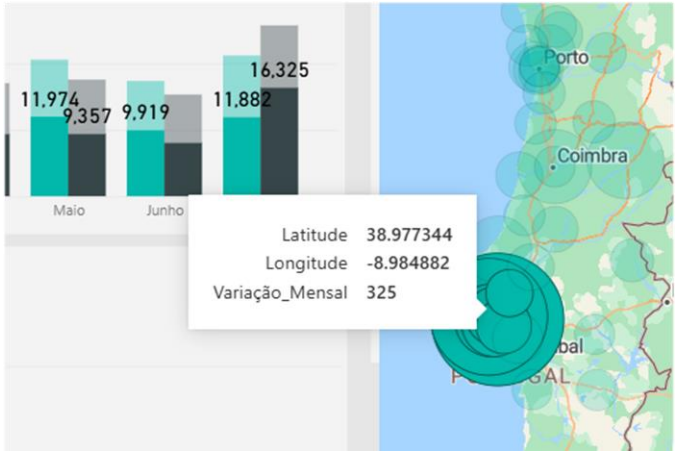


- Is about creating extra layers of data detail through interactive events such as hovering or clicking

- This is particularly useful to reveal **actual data values** or **extra detail** about a given category or event

- By having the backup of absolute data accuracy through the values, allows using a more creative visual representation

- It's almost like having a “perceptual safety net” (Kirk, 2019)



Manipulating variables and parameters

- The ability to select, filter, exclude, or modify certain variables is a valuable way of letting the user interact with different slices of the data
- Grouping and sorting options are common for extracting new insights
- You can also modify a variable using a slider to see changes across numerous values of the variable
- Brushing —highlighting a set of data marks—is a powerful way of focusing in on a subset view the presented data
- Linking - user interactions in one visualization are applied to others; linked and brushing is one of the most powerful interactive techniques for visual data exploration

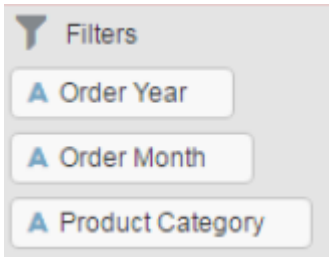
- brushing and linking is the connection of two or more views of the same data, such that a change to the representation in one view affects the representation in the other

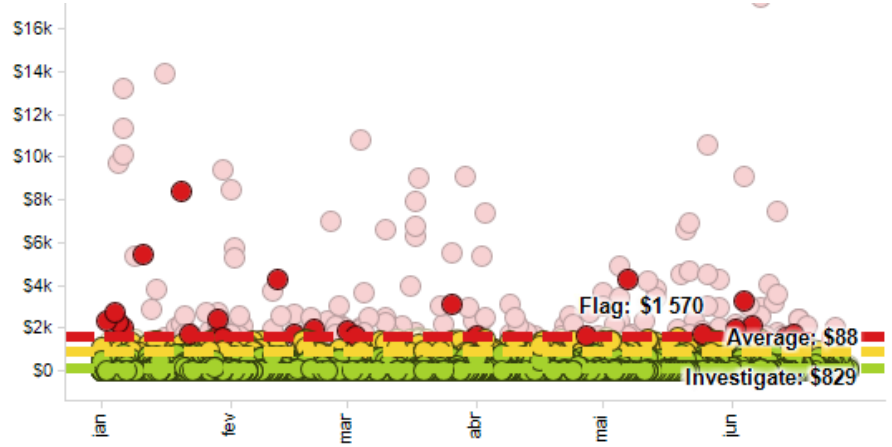
- Selecting a portion of data in one chart can highlight corresponding data points in other visualizations.

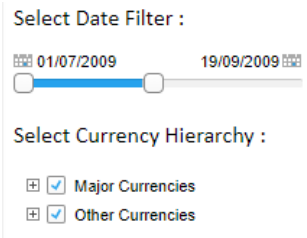
Example:
Selecting a different slice changes the other visualization

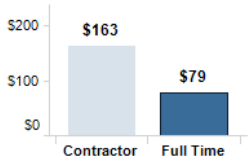
[Strategic HR Insights - Spotfire® Analytics]

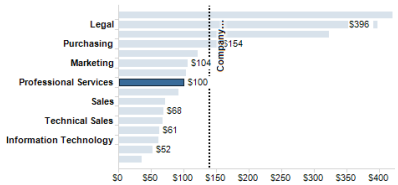
Manipulating variables and parameters (e.g. select, filter, modify, sort, …)





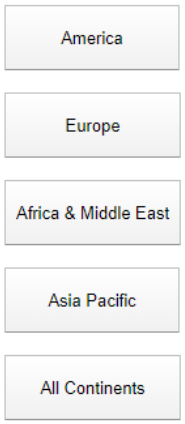


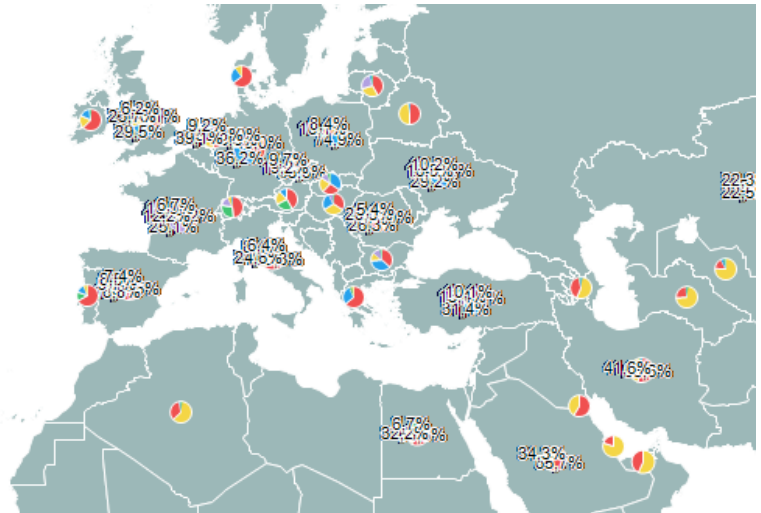




Linking and brushing

select





sort

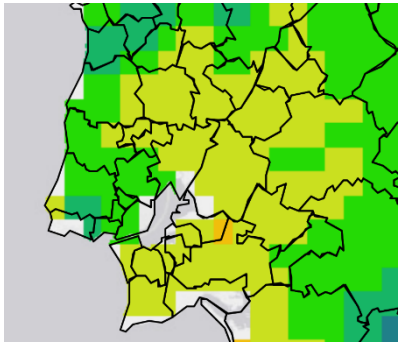
Reducing the complexity

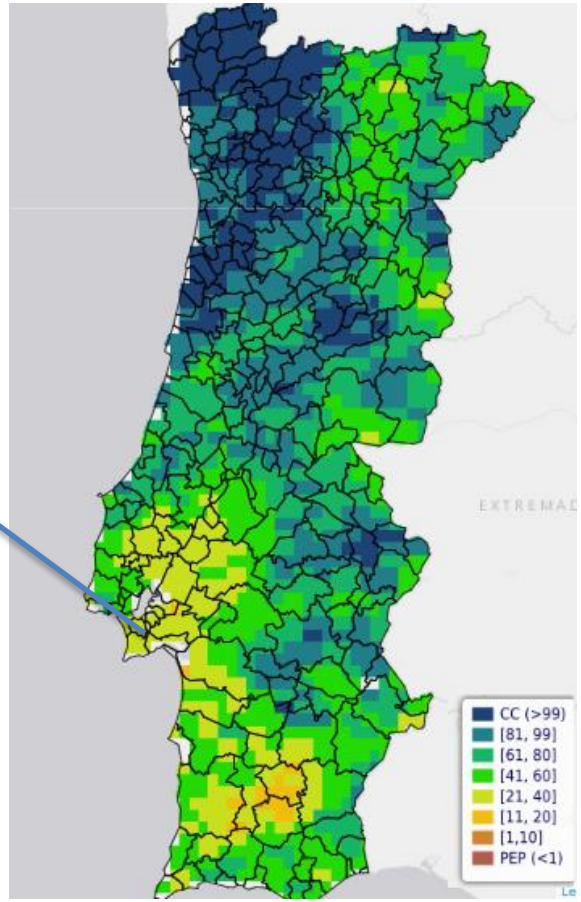
- Is important to help users better understand the data (in static or interactive solutions)

- Different ways to do it, may be organized:
  - Filter
    - Items
    - Attributes
  - Aggregate
    - Items
    - Spatial data
    - Attributes

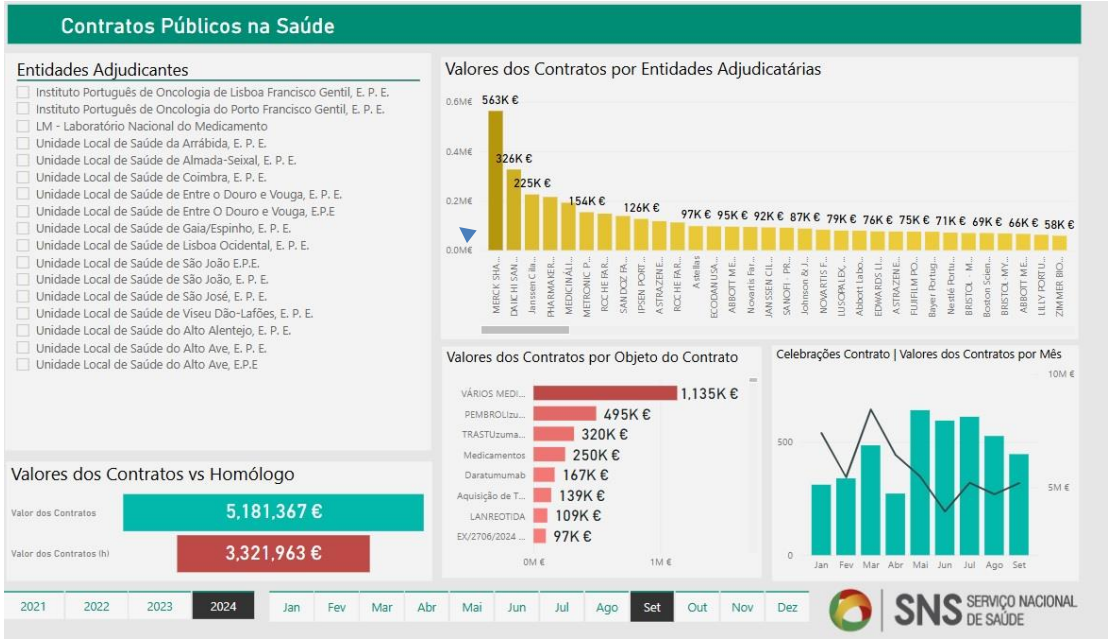
- Filtering items

(just ignoring part of the items)





[IPMA - Ground percentage of water]



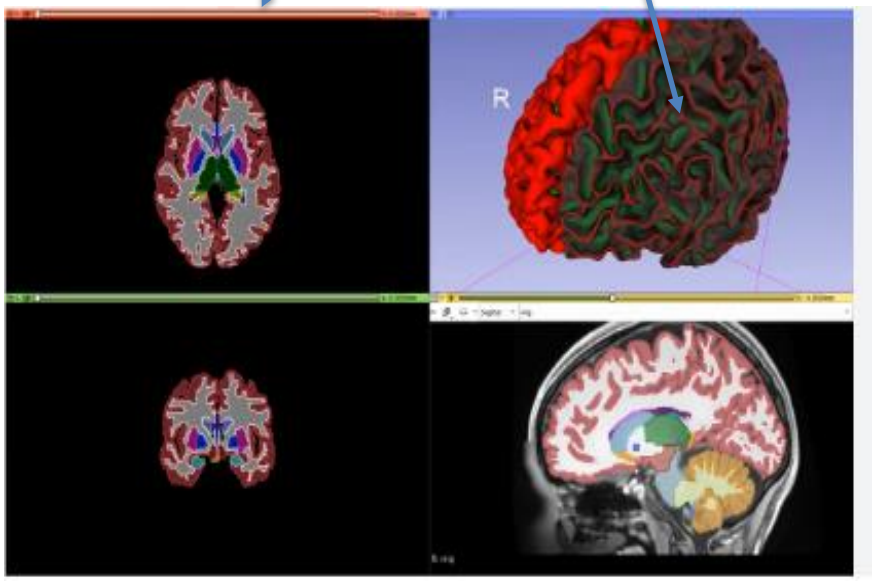
[Monitoring SNS – SNS]

- Filtering attributes

ignoring part of the attributes/dimensions:

Slice

Cut

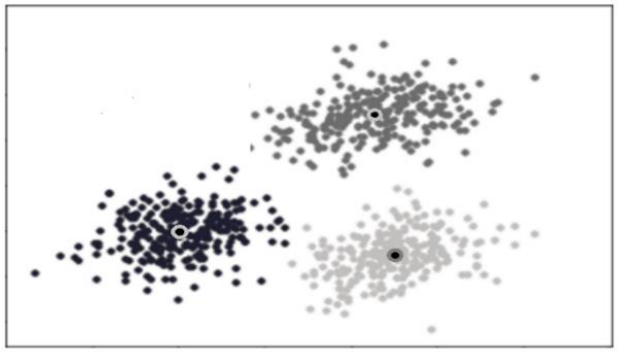


Easier to understand in spatial data

But also interesting for abstract data

[3D Slicer image computing platform | 3D Slicer]

- Aggregating items and spatial data

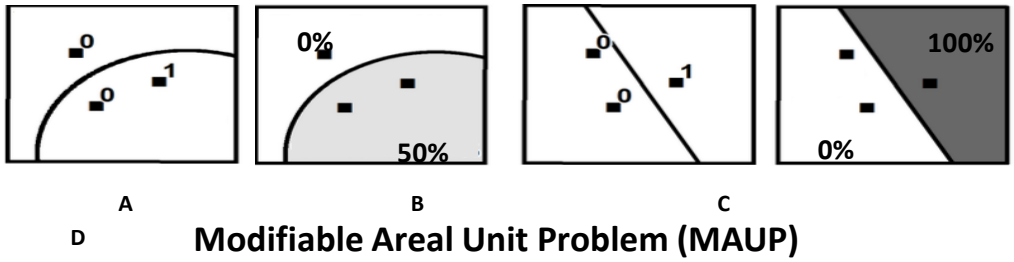


Several items are replaced by just one :

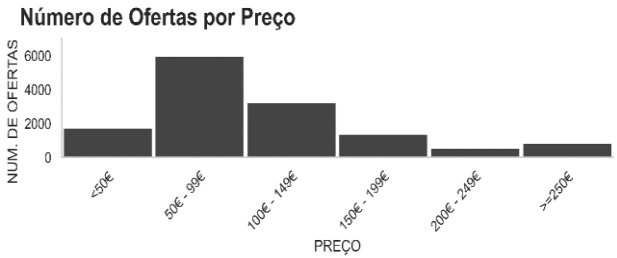
Histograms

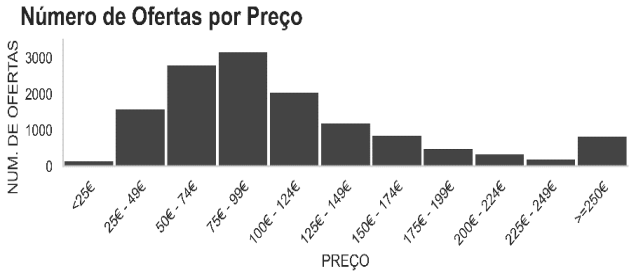
Boxplots

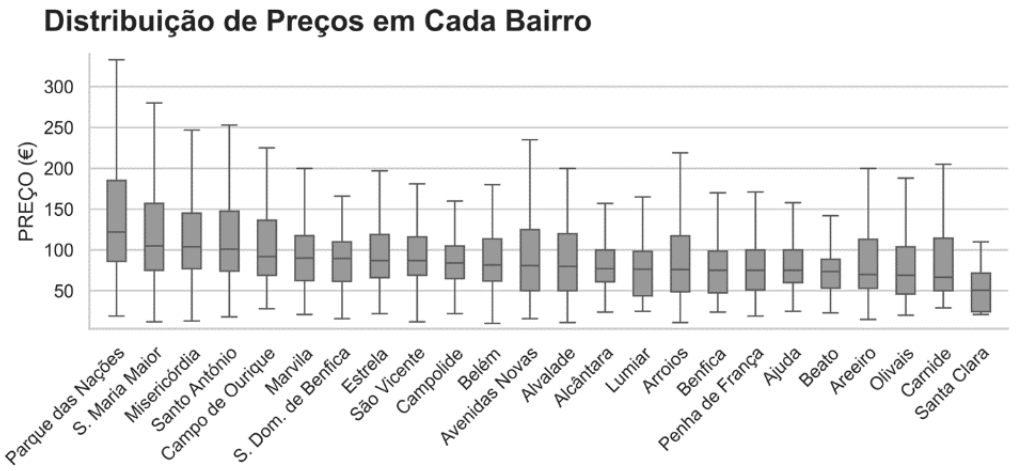
Clustering …



Modifiable Areal Unit Problem (MAUP)







- Aggregating attribute

Dimensionality reduction techniques:

Try represent a n dimensional dataset using k<n attributes/dimensions

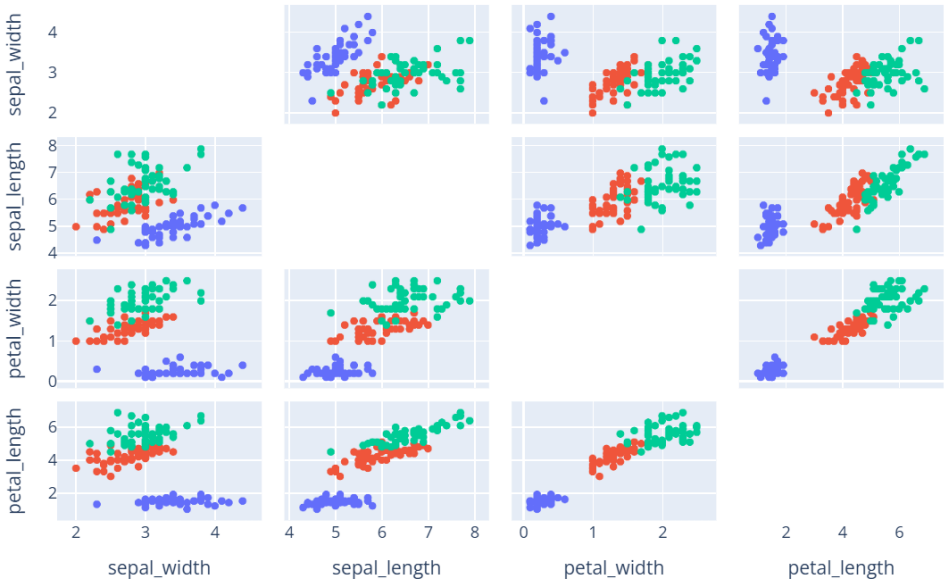
Principal Component Analysis (PCA)

Linear Discriminant Analysis (LDA)

Multi Dimensional Scaling (MDS)

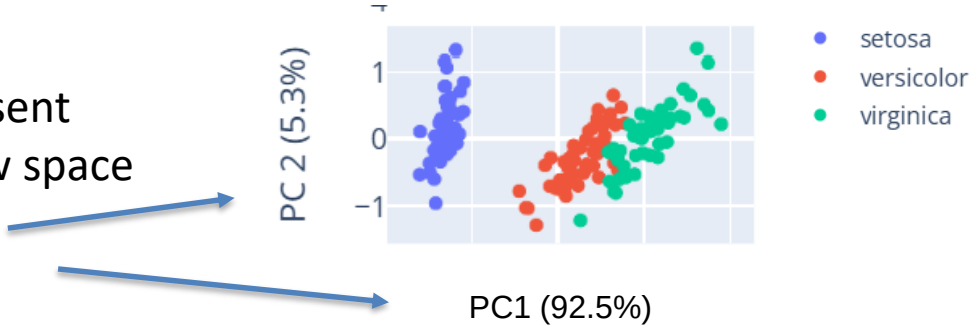
t- Distributed Stochastic Neighbor Embedding (t-SNE)

Etc.

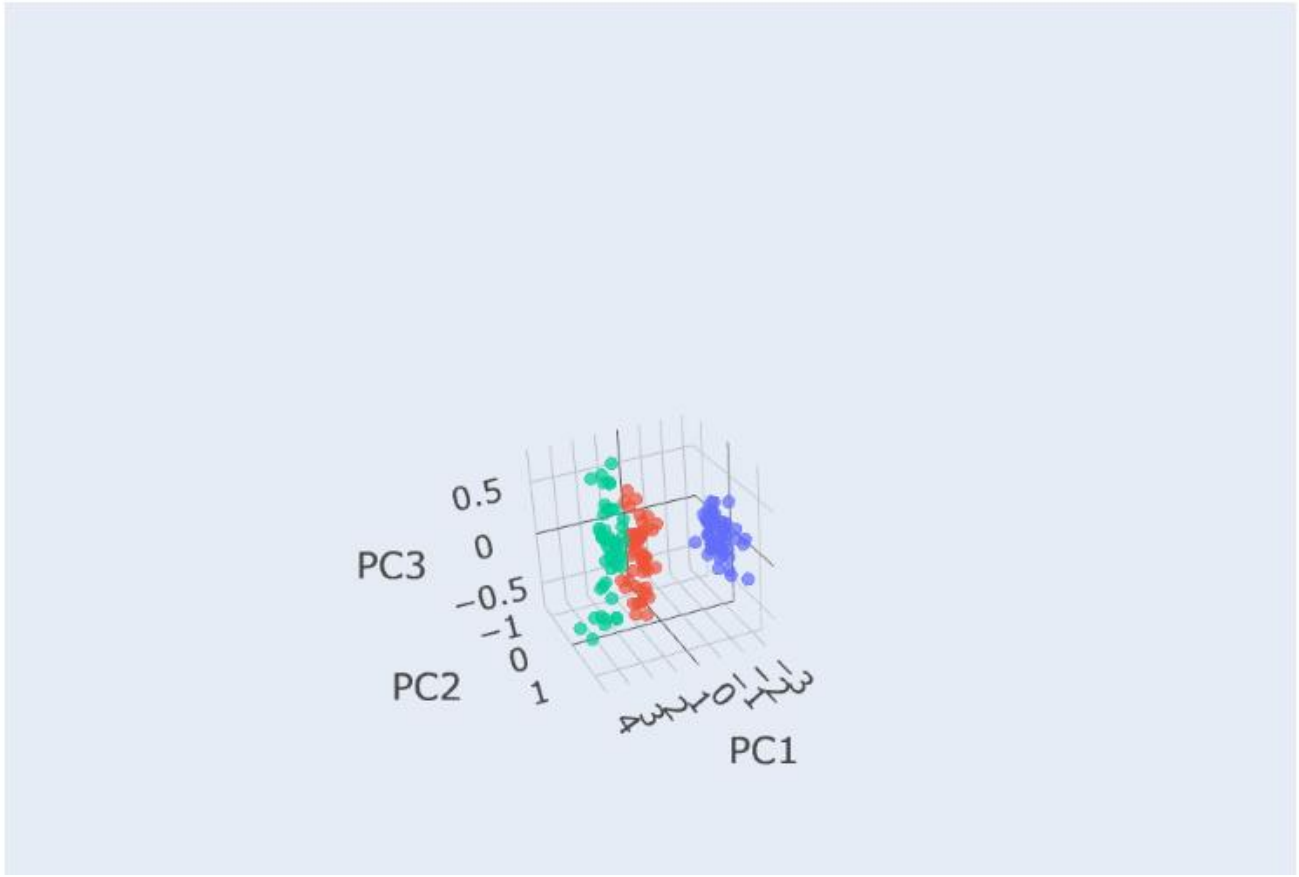


Example:
Only two attributes (CP1 and CP2) represent 97.5% of the original iris dataset in a new space

https://plotly.com/r/pca-visualization



Total Explained Variance = 99.48



Method	Main characteristics	Main usage in Visualization
PCA	Non-supervised (does not need a predifined k)	Exploring the dataset, particularly when struture particularly is important
	Linear (new attributes/dimensions (PC) are linear combinations of the originals)	
	PCs are ordered by importance	
	Tries to preserve dataset global structure	
LDA	Supervised (needs predefined k)	Representing well separeted classes, mainly in annotated datasets
	Linear	
	Tries to maximize separation among classes	
MDS	Non-supervised	Visualizing pairs of items when only relative distances are known
	Não Linear	
	Tries to preserve distances (or their order)	
t-SNE	Non-supervised	Representing clusters, particularly for very high n datasets
	Non-linear (probabilistic approach)	
	Tries to preserve local dataset structure	

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Explore books with * and other Visualization books available at the playlist:

https://learning.oreilly.com/playlists/74bfec5e-4346-48ff-82b4-657fda6922b6

Acknowledgement: The author of these slides is grateful to Professor Robert Spence as he provided the electronic version of his book figures, as well as to colleagues and students who have provided examples

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- Visualization Wiki, http://www.wikiviz.org/wiki/Main_Page

Examples: https://www.spotfire.com/demos