Information Visualisation (6) Attribute Reduction;

Focus + Context

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Course Outline

- Introduction to Information Visualisation
- Data, Task and Validation
- Marks and Channels; Color Mapping
- Tables, Spatial data, Networks and Trees
- Manipulating View, Facetting
- Reduce Items and Attributes; Focus + Context

Program for Today

- Handling complexity, part two:
  - Filtering
  - Aggregation
  - Embedding / focus + context
- 8 rules of thumbs for infovis

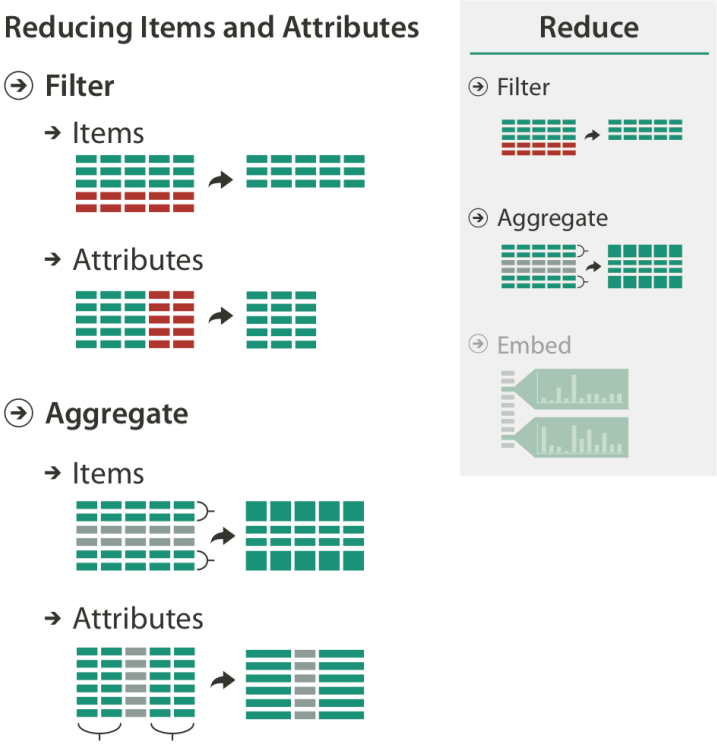
Why Reduce Attributes/Embed Focus & Context?

- Datasets often large and complex
  - Especially in data science…
- Showing everything on the screen leads to visual clutter
- Five possibilities for handling complexity
  - Deriving new data (as seen in chapter 2)
  - Manipulating the view (as seen in chapter 5)
  - Facetting the data (as seen in chapter 5)
  - Reducing/filtering the amount of data
  - Embedding focus + context
- Lets the user decide some design choices (instead of only the designer)

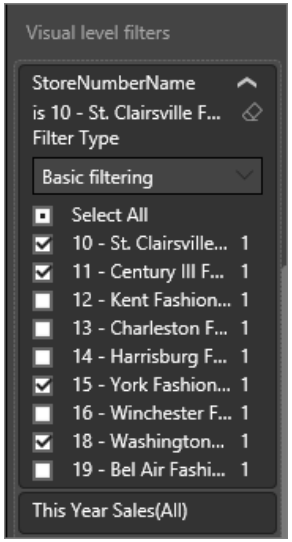
Reducing Items and Attributes

- Filtering
  - Item filtering
  - Attribute filtering
- Aggregation
  - Item aggregation
  - Spatial aggregation
  - Attribute aggregation: dimensionality reduction

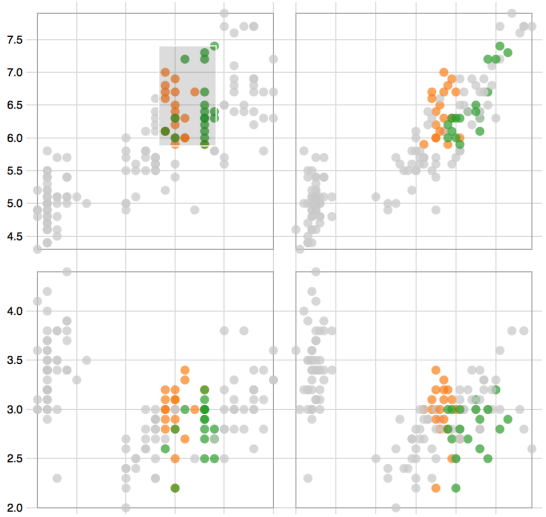
- (Embedding comes later)



Reducing Items and Attributes: Filtering



- Reducing the number of elements shown by removing them (temporarily) from the view
- Two types of filtering
  - By items
  - By attributes
- Good guideline: let the user have a choice of filtering actions
- Challenge: good filtering comes with good interaction
  - Dynamic queries



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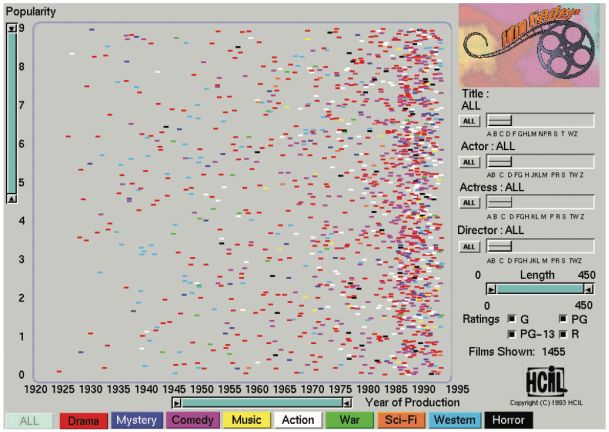
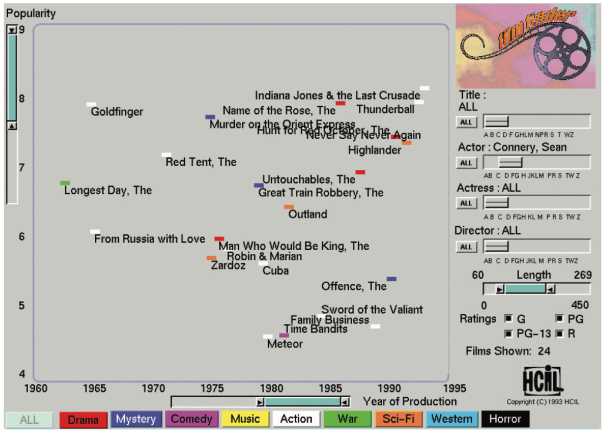
Reducing Items and Attributes: Item Filtering

- Item filtering: filter items based on their values with respect to specific attributes
  - Fewer items shown, but number of attributes does not change
- Alternative approach to simple UI widgets: « scented widgets »
  - Give a « scent » of information for the user



(a)



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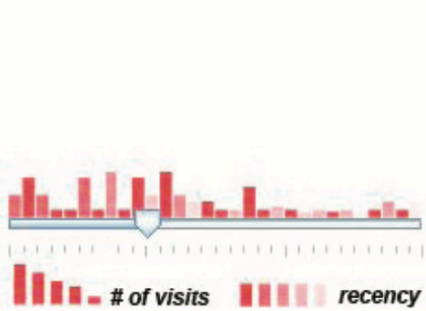
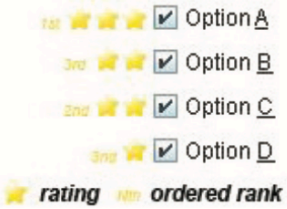
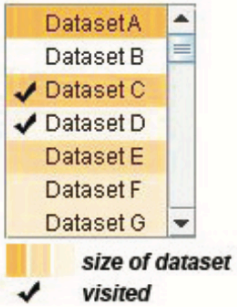
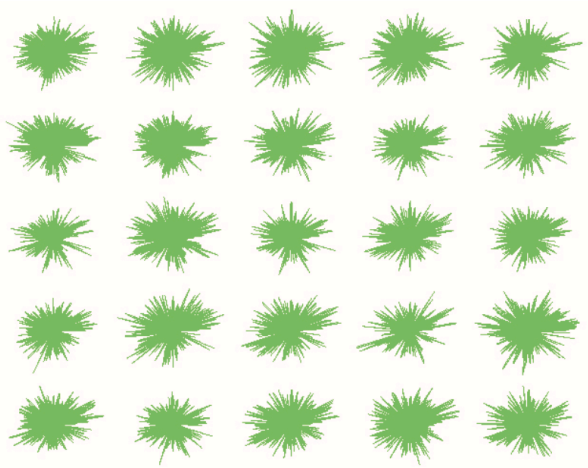




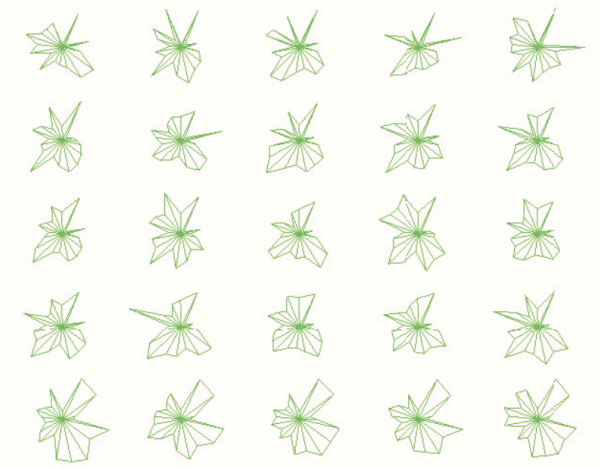


Reducing Items and Attributes: Attribute Filtering

- Attribute filtering: show the same number of items, but with fewer attributes per item
- Often used together with attribute ordering
  - Or dimensional ordering
  - Similarity measure used to order attributes



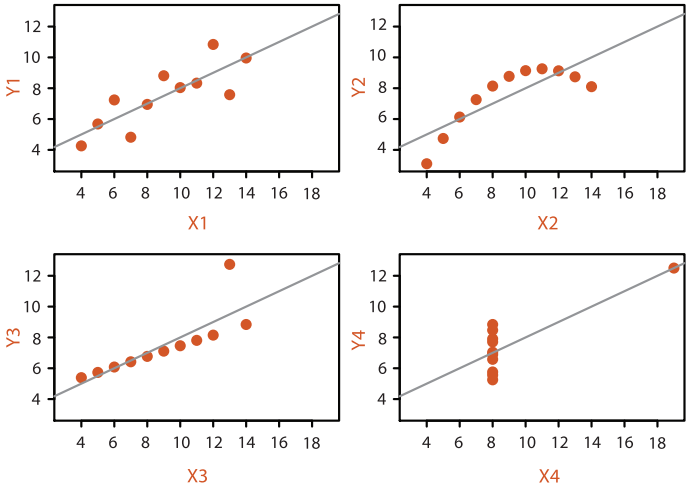
(a)



(b)

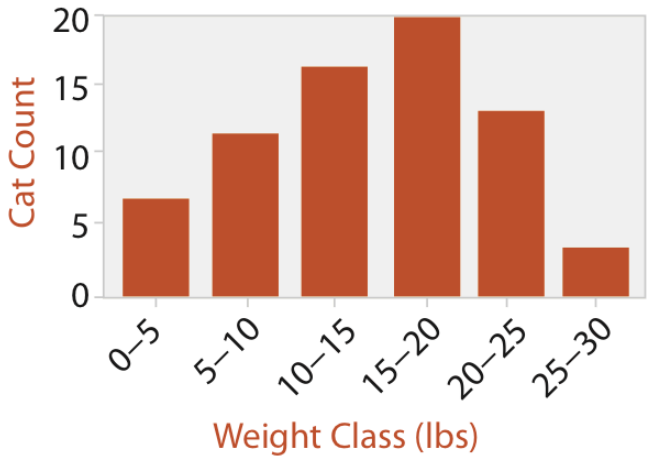
Reducing Items and Attributes: Aggregation

- Aggregation: a group of element will be represented by one new derived element
- Elements are merged together
- Two types of aggregation (again):
  - Item aggregation
  - Attribute aggregation
- Main challenge: avoid eliminating the interesting signals in the dataset when merging elements together



Aggregation: Item Aggregation

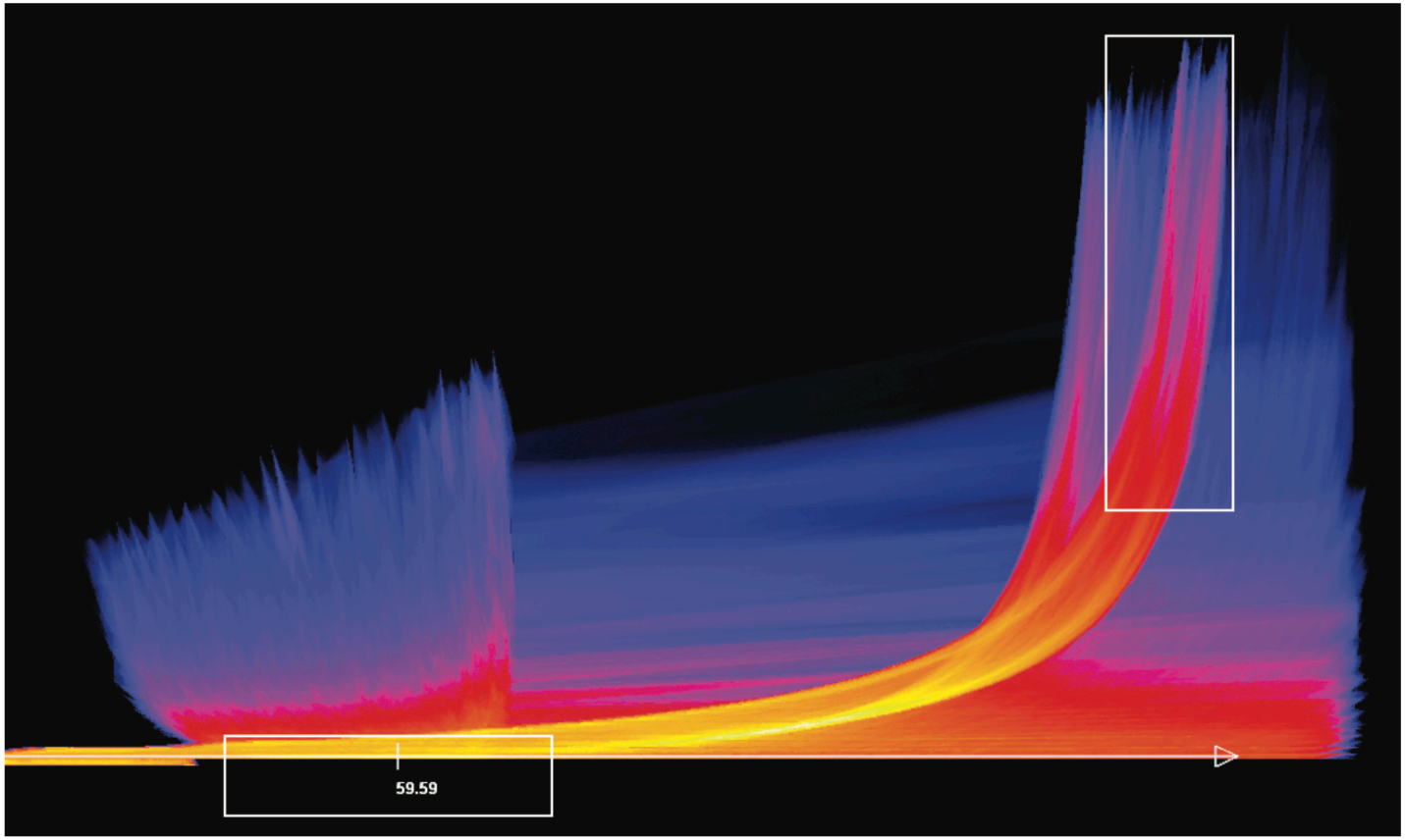
- Aggregate multiple items into one
- Improves readability, prevents (or circumvents) occlusions…
- Simple example (barchart grouping):



- More complex examples follow

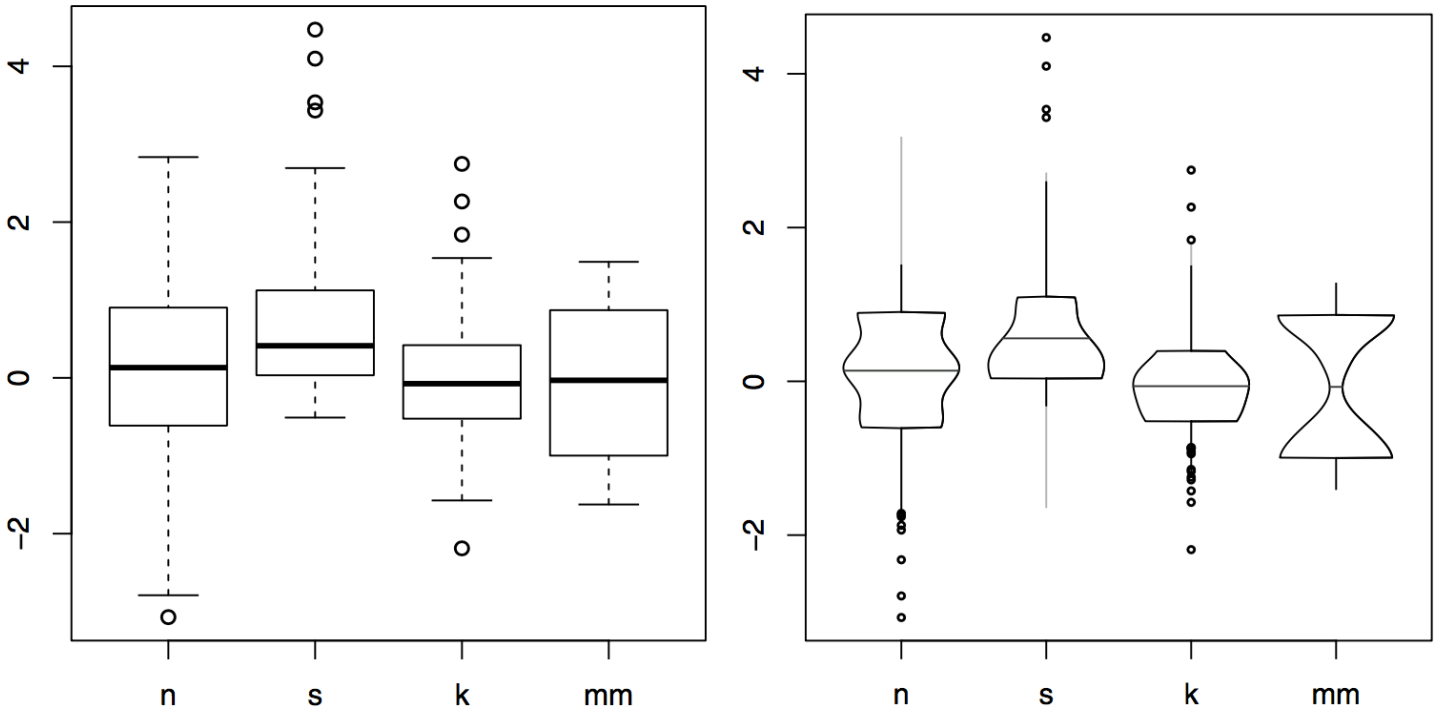
Item Aggregation: Scatterplot

- Scatterplot density mapped to colour



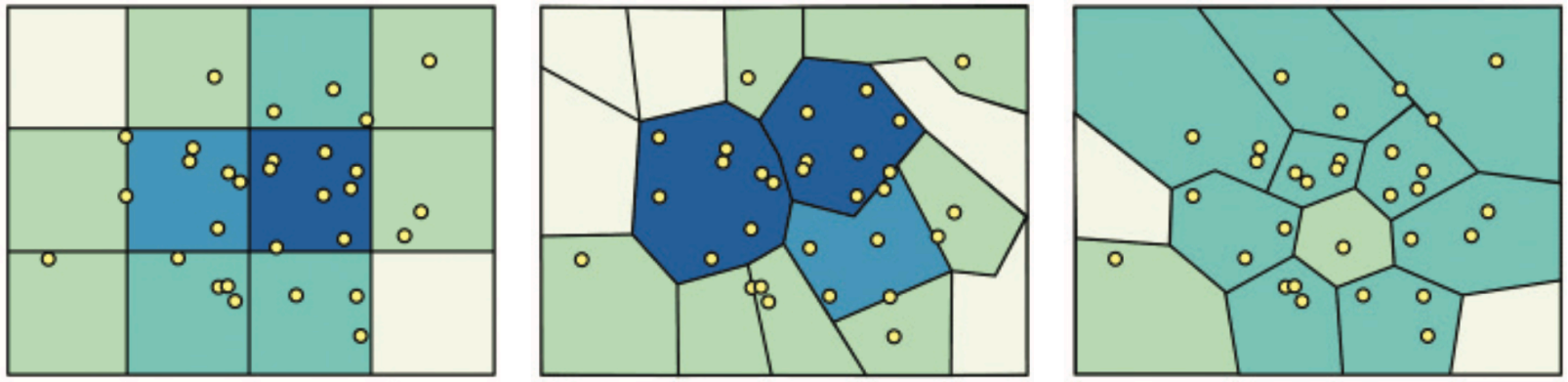
Item Aggregation: Boxplots

- Goal of a boxplot: show an aggregate statistical summary of all values of a single quantitative attribute
  - Median, lower/upper quartiles, lower upper fences, outliers...



Aggregation: Spatial Aggregation

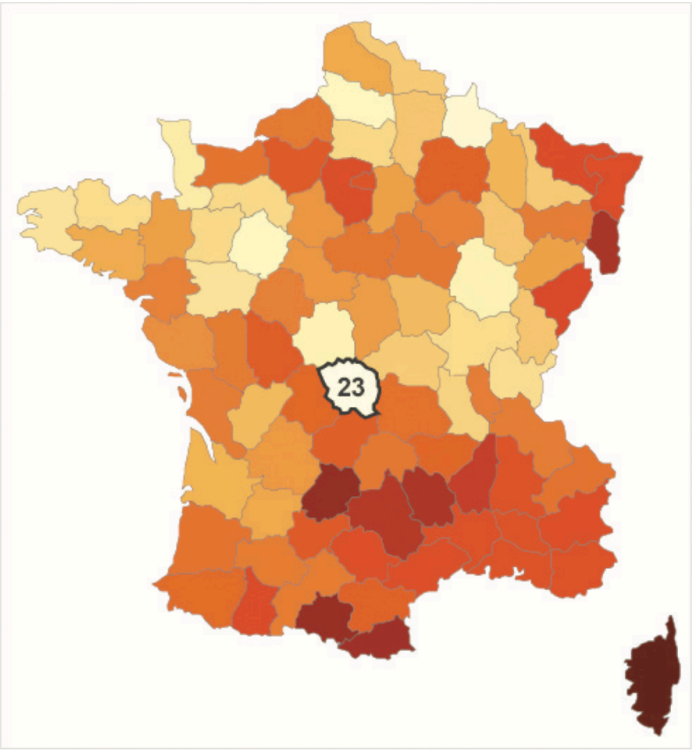
- Challenge: taking the spatial nature of data into account correctly when aggregating it
- Importance of selecting « correct » boundaries when aggregating spatial data
  - Dubbed « modifiable area unit problem » in cartography
  - For the same data, different boundaries will produce radically different visualisations

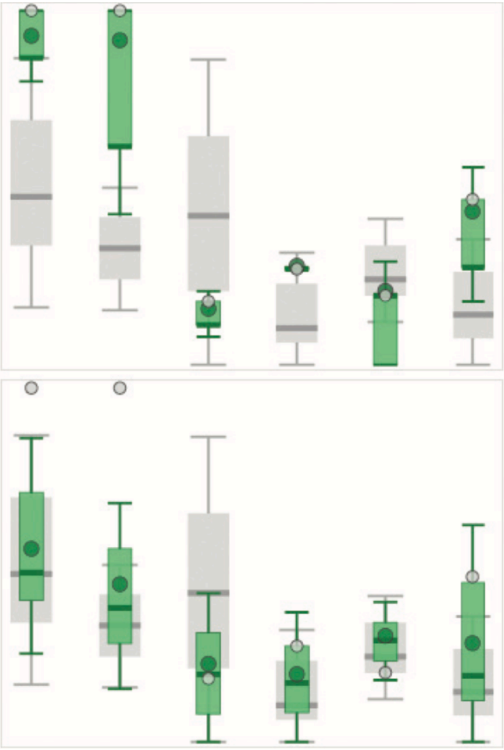


(a) (b) (c)

Aggregation: Spatial Aggregation

- Example with a standard choropleth linked with global/local boxplots





Aggregation: Attribute Aggregation

- Attribute aggregation: synthesizing new attributes to take the place of multiple original attributes
  - Simple possibility: group attributes by a similarity measure
  - More complex possibility: dimensionality reduction
- Dimensionality reduction goal: preserve the meaningful structure of a dataset while using fewer attributes to represent items
  - Many approaches, some rather straightforward (e.g. combining together attributes), some others less so (e.g. multidimensional scaling)

Attribute Aggregation Example: Multidimensional scaling with Glimmer

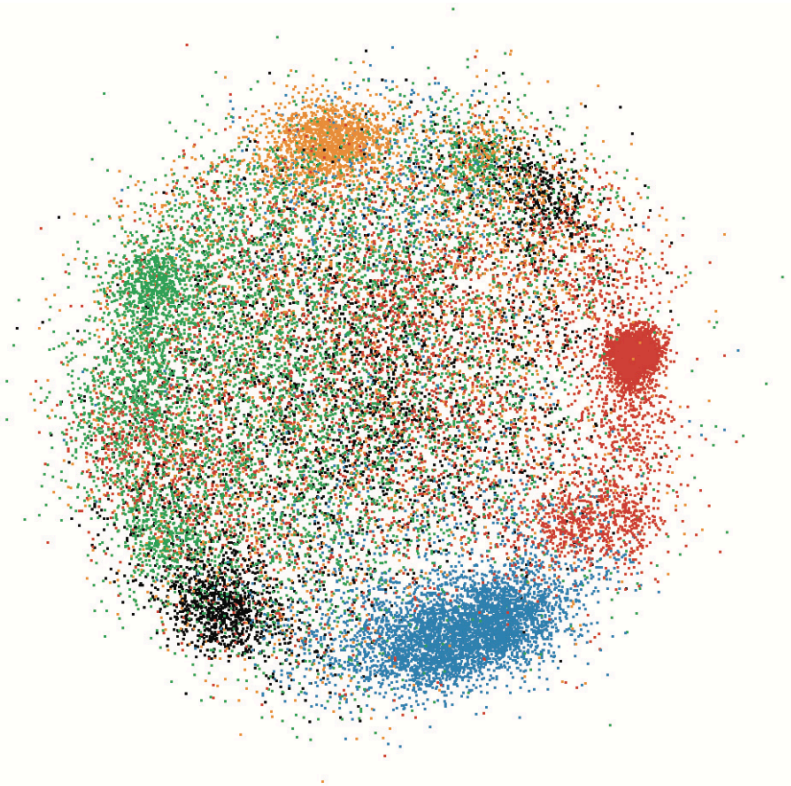
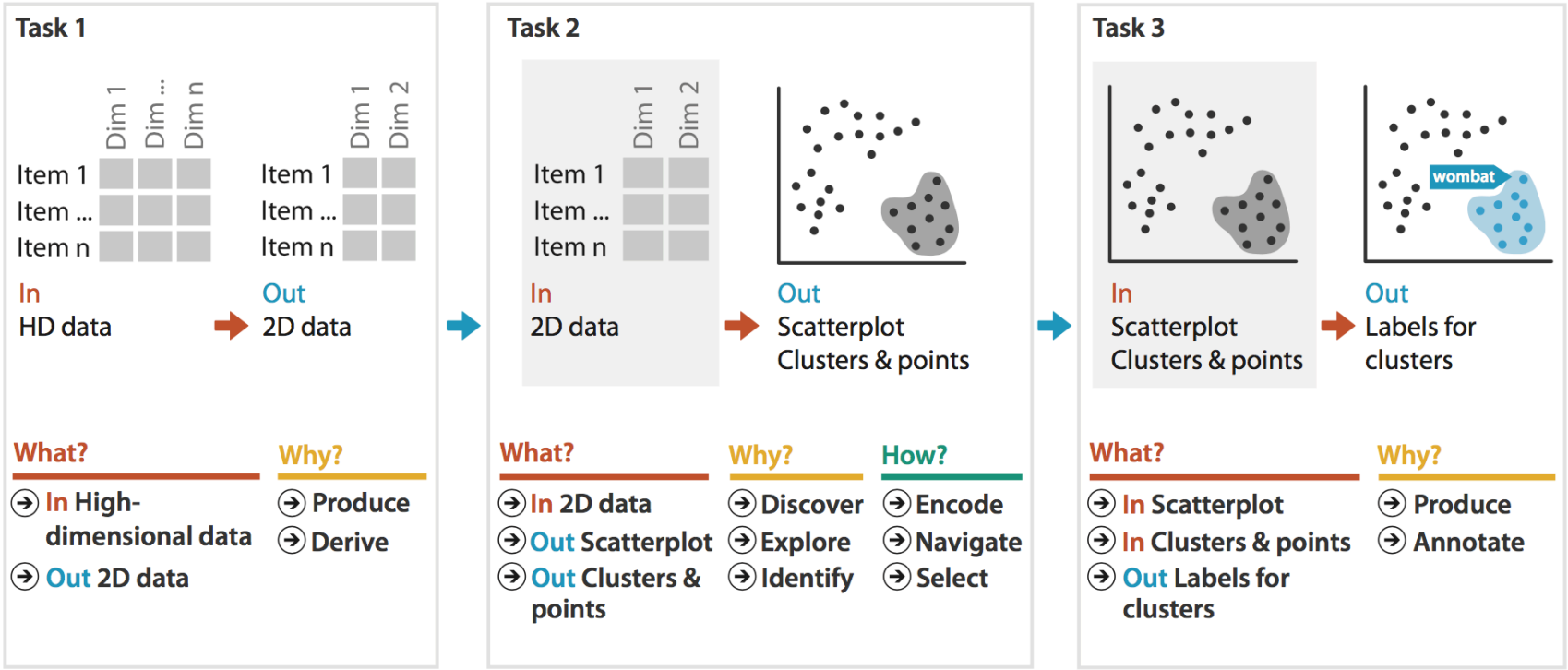


Figure 13.12. Dimensionality reduction of a large document collection using Glimmer for multidimensional scaling. The results are laid out in a single 2D scatterplot, allowing the user to verify that the conjectured clustering shown with color coding is partially supported by the spatial layout. From [Ingram et al. 09, Figure 8].

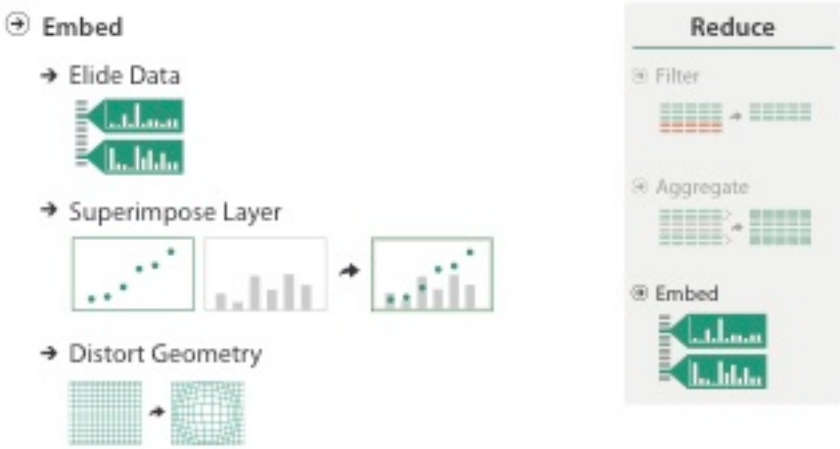
Attribute Aggregation Example: Multidimensional scaling with Glimmer



From 10’000 attributes (word count) to 2 attributes

Embedding: Focus + Context

- Embedding:
  - Elision
  - Superimposing
  - Distorting

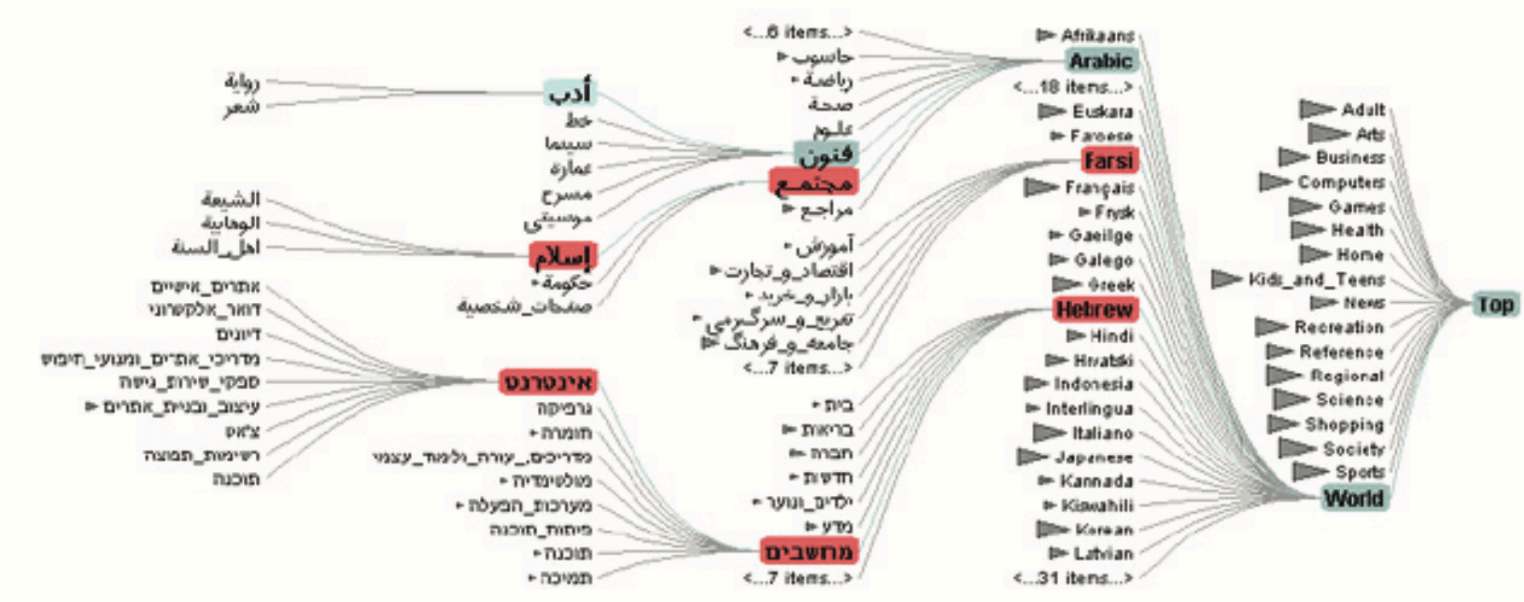


Embedding: Focus + Context

- Goal of embedding (aka focus and context): mitigate the potential for disorientation that comes with standard navigation techniques (like geometric zooming)
- Subset of the dataset items are interactively chosen by the user to be focussed on; rest of the dataset also shown for context
  - Examples of nonliteral navigation
  - Semantic zooming is another example of nonliteral navigation
  - Frequently, some kind of distortion is used with focus + context
  - Synthesis/fusion of both visual + interaction points of view!

Focus + Context Design Choice 1: Elision

- Principle of elision:
  - Some items are omitted from the view completely, in a form of dynamic filtering
  - Other items are (dynamically) summarized



Focus + Context Design Choice 2: Superimposing

- Principle of superimposing: a local, « focus » layer is superimposed over a global, « context » layer

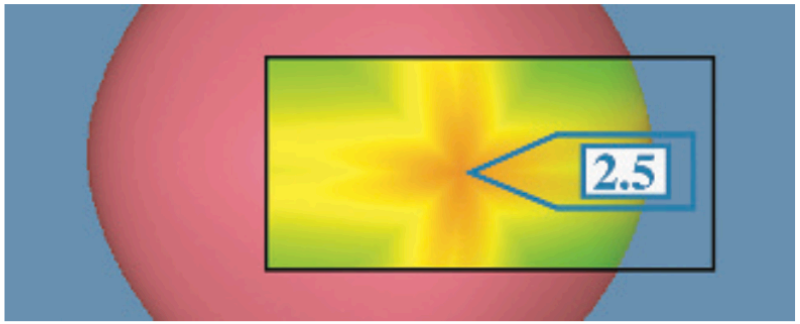


Figure 14.3. The Toolglass and Magic Lenses idiom provides focus and context through a superimposed local layer: the see-through lens color codes the patchwork sphere with Gaussian curvature information and provides a numeric value for the point at the center. From [Bier et al. 93, Figure 12].

Focus + Context Design Choice 3: Distorting

- Distorting the contextual regions used to make room for details on the focus regions
- Five examples of distortion-based focus+ context in the next slides:
  - 3D perspective
  - Fisheye lens
  - Hyperbolic geometry
  - Stretch and squish navigation
  - Magnification field

Focus + Context Distortion: 3D Perspective

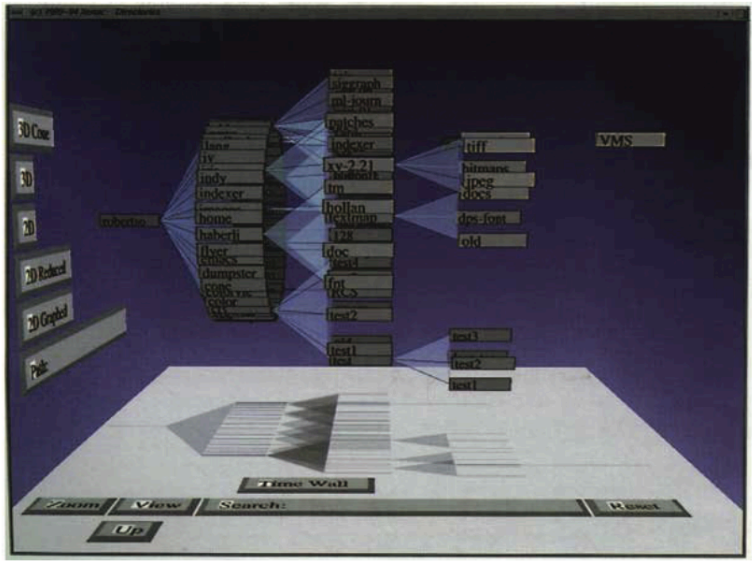
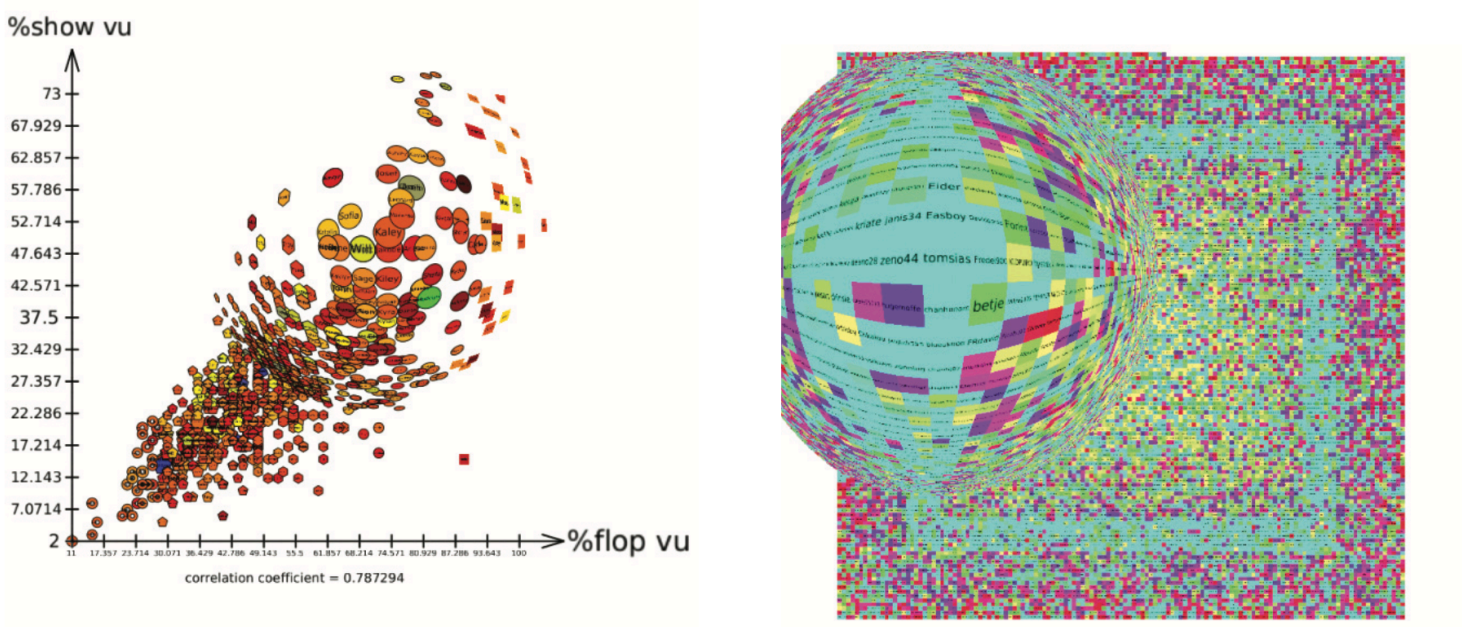


Figure 14.4. The Cone Tree system used 3D perspective for focus+context, providing a global distortion region with a single focus point, and using standard geometric navigation for interaction. From [Card and Mackinlay 99, Figure 10].

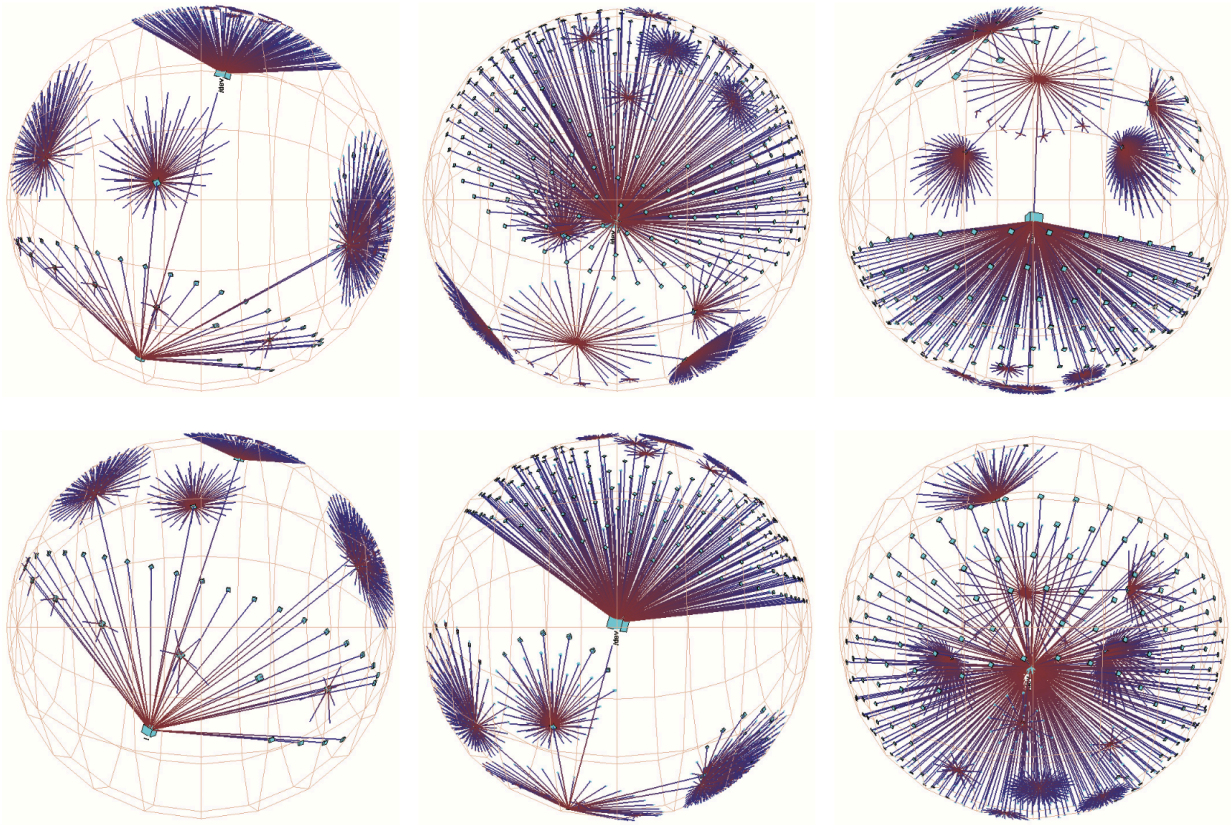
Focus + Context Distortion: Fisheye Lens



(a) (b)

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

Focus + Context Distortion: Hyperbolic Geometry



Focus + Context Distortion: Stretch and Squish Navigation

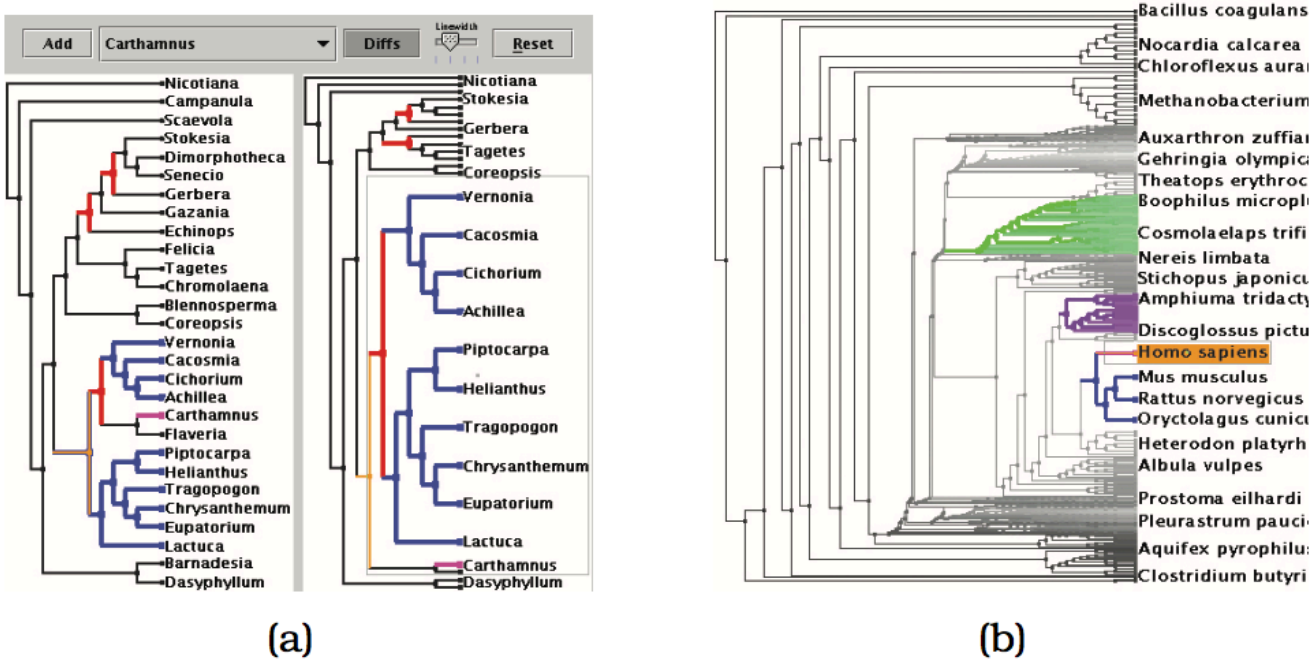


Figure 14.7. TreeJuxtaposer uses stretch and squish navigation with multiple rectangular foci for exploring phylogenetic trees. (a) Stretching a single region when comparing two small trees. (b) Stretching multiple regions within a large tree. From [Munzner et al. 03, Figures 5 and 1].

Focus + Context Distortion: Nonlinear Magnification Fields

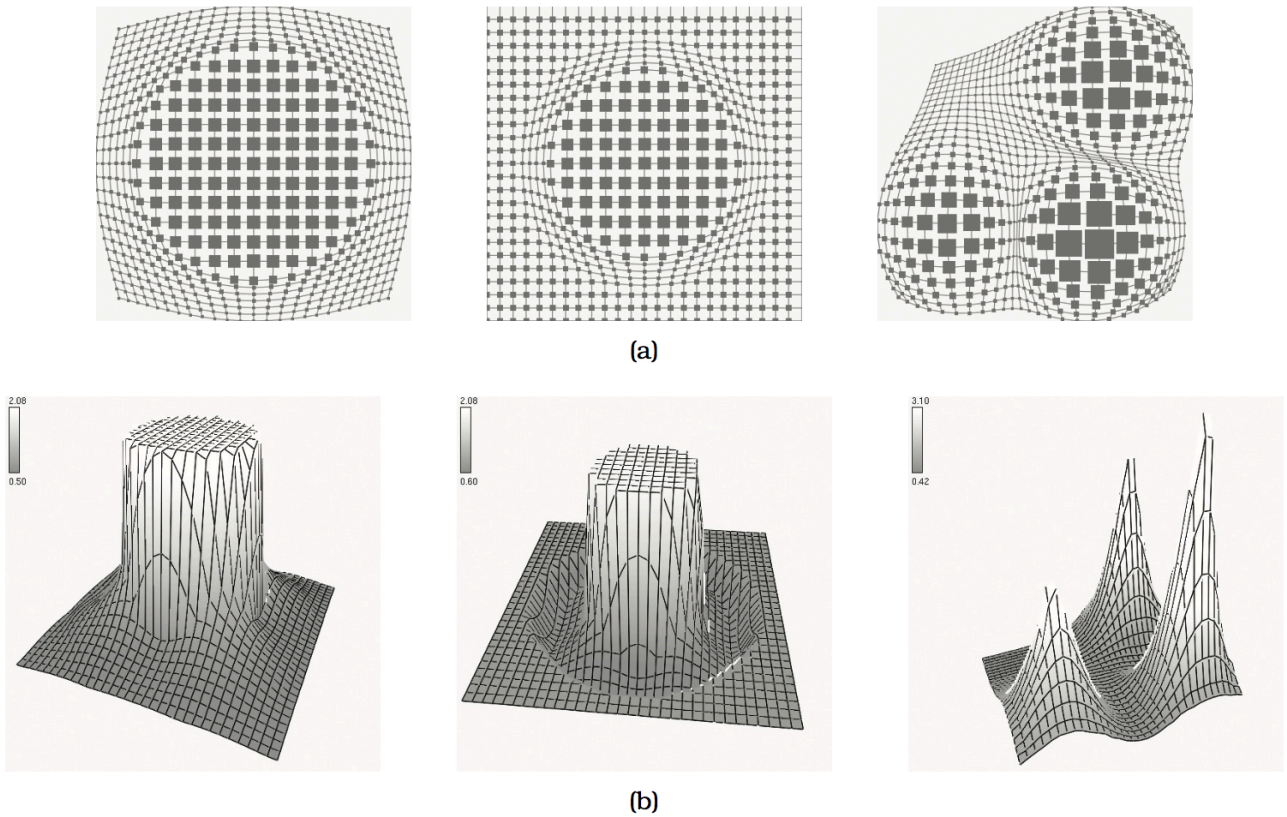


Figure 14.9. General frameworks calculate the magnification and minimization fields needed to achieve desired transformations in the image. (a) Desired transformations. (b) Calculated magnification fields. From [Keahey 98, Figure 3].

Distortion: Costs and Benefits

- Costs:
  - Distance/length judgements are severely impaired
  - Users may not aware of the distortion, thus misunderstanding the object structure
  - Internal overhead of maintaining object consistency (two representations – one focussed, one contextual – of the same object)
- Benefits:
  - Very effective focus + context design choice
  - Fits very well for exploration of node-link layouts, or graphs/trees

Four Alternatives to Graph Exploration: Discussion

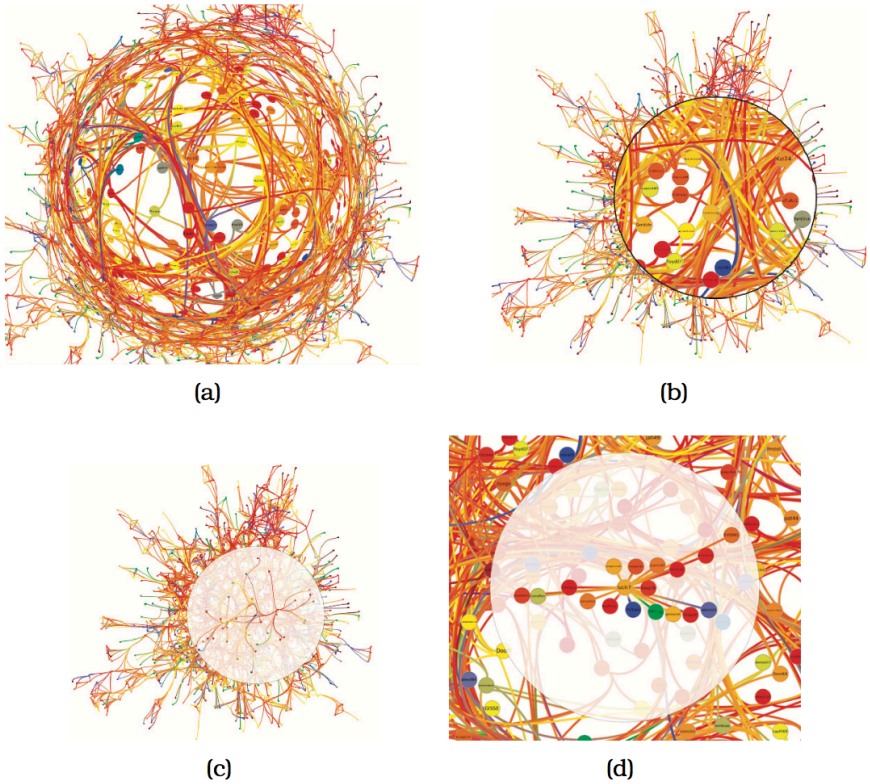


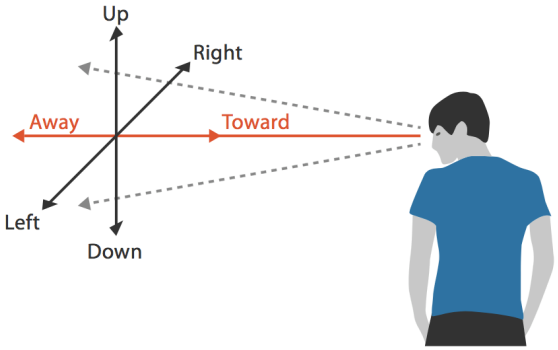
Figure 14.10. Four approaches to graph exploration. (a) Fisheye lens. (b) Magnifying lens. (c) Neighborhood highlighting with layering. (d) Neighborhood highlighting with both layering and Bring and Go interaction. From [Lambert et al. 10, Figures 2a, 2b, 3b, and 4b].

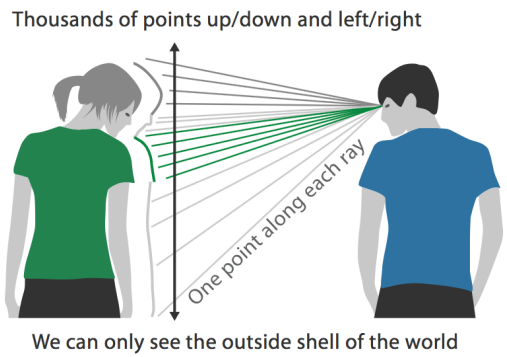
Information Visualisation: 8 Rules of Thumb

- No Unjustified 3D
- No Unjustified 2D
- Eyes Beat Memory
- Resolution over Immersion
- Overview First, Zoom and Filter, Detail on Demand
- Responsiveness is Required
- Get It Right in Black and White
- Function First, Form Next

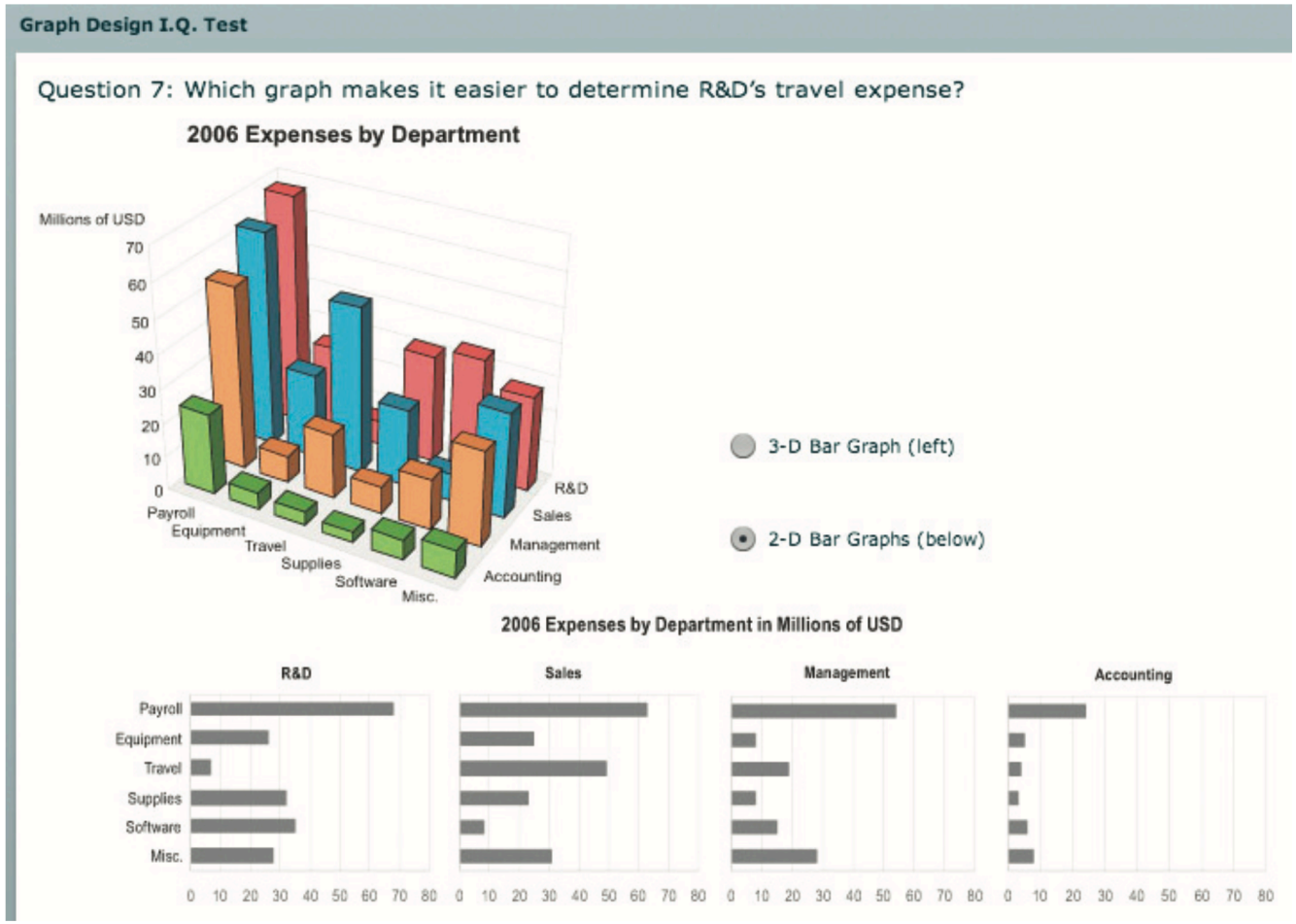
No Unjustified 3D

- 3D is justified when the user's task involves understanding an inherently three-dimensional structure
- … In almost all other cases, 3D is **not** justified:
  - Human efficiency at interpreting spatial position apply only on planes
  - Depth is not that well perceived by human beings
  - Occlusion (frequent with 3D) hides information
  - Issues with perspective distortion



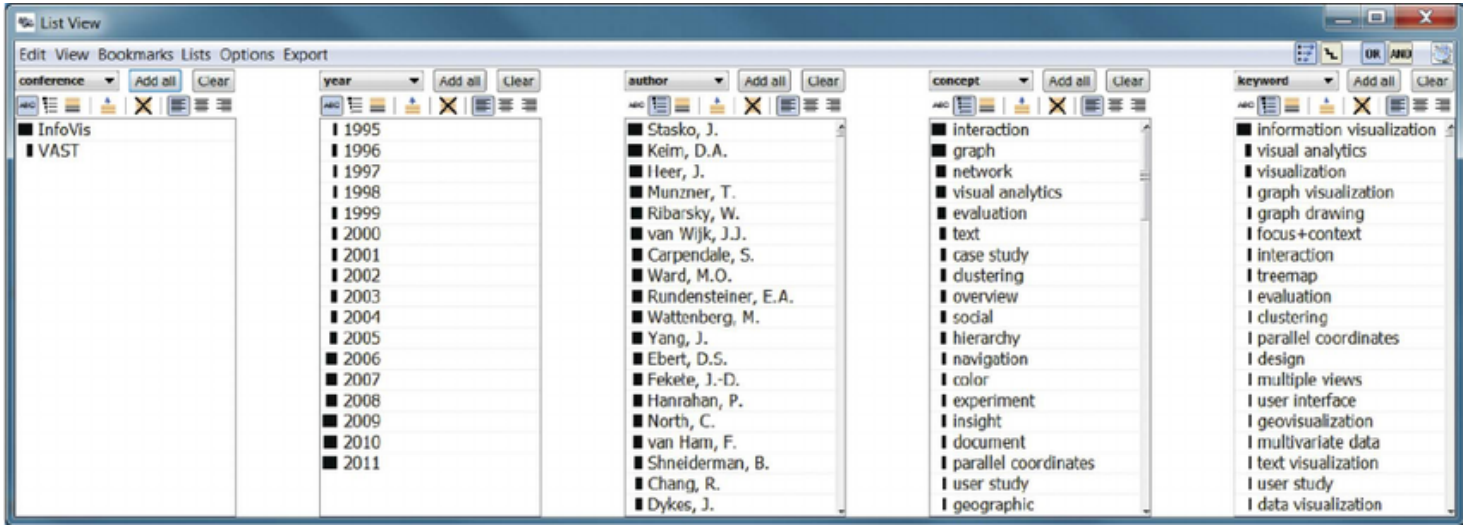


No Unjustified 3D



No Unjustified 2D

- … Sometimes, lists (in 1D) can be quite efficient too
  - Show maximal amount of information
  - Excellent for lookup tasks when they are ordered properly
  - If topological information is not important, linear lists can even replace networks



Eyes Beat Memory

- Human memory is bad
- Displaying more information so that users don't have to consult their memory to compare with a current view
  - Less cognitive load for users
- More generally, users' attention span is short
  - E.g. conscious search of an element becomes quickly tedious
- Guide the eyes of your users for successful storytelling
- Take change blindness into account

Resolution over Immersion

- Pixels are precious!
- Trade-off between resolution and immersion
  - Immersion: feeling of presence in a virtual environment
  - Resolution: Number of available pixels
- Immersion is most important when a sense of presence is important for the task at hand
  - Doesn't happen often in infovis...

Overview First, Zoom and Filter, Detail on Demand

- Mantra defined by Ben Schneiderman in 1996
- Interplay between the need for overview and need for details
- Overview
  - Gives the user a broad awareness of the entire information space
  - Summary (in terms of « Why » tasks)
- Zoom and filter
  - Gives the detailed view from an aggregated/reduced view
- Details on demand
  - Gives the full information on a specific item

Responsiveness is Required

- Latency of interaction: how much time is needed to update a system's view
- Human response to interaction changes dramatically at three time thresholds:
  - Up to 0,1 seconds: perceptual processing (feeling of « fluidity »)
  - Up to 1 second: immediate responds
  - Up to 10 seconds: brief tasks
- Give visual feedback to users
  - Confirmation that operations have completed
  - For long actions, display some kind of progress bar

Get It Right in Black and White

- Ensure that the most crucial aspects of visual representation are legible even if the image is transformed from full colour to black and white
  - Use a tool like photoshop, or print your work on a B&W printer...
  - Underlying importance of the luminance channel

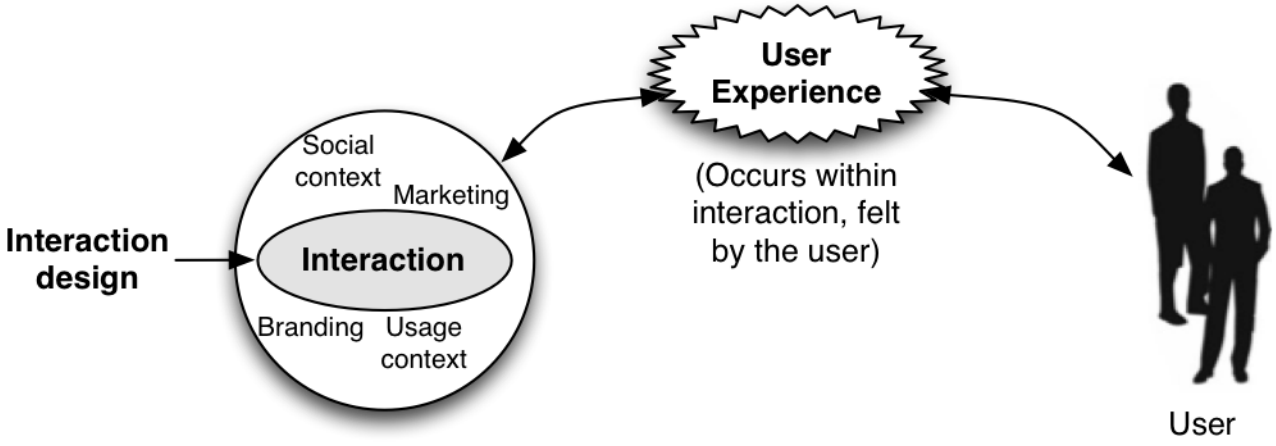
OPINION

Obama's Divided Nation

R.I.
Conn.
Del.
D.C.

Obama Romney

Source: AP

Function First, Form Next

- The best tools shine both in terms of form and function
- … However, if you have to choose, focus on function
  - An effective but ugly design is easier to improve than a beautiful but ineffective one
  - Visual beauty does matter, though
  - Concept of user experience (UX)