VRIJE UNIVERSITEIT BRUSSEL

Information Visualisation

Design Guidelines and Principles

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Guidelines

- No Unjustified 3D
  - Power of the Plane
  - Disparity of Depth
  - Occlusion Hides Information
  - Perspective Distortion Dangers
  - Tilted Text is Not Legible
- No Unjustified 2D
- Eyes Beat Memory
- Resolution Over Immersion
- Overview First, Zoom and Filter, Details on Demand
- Responsiveness is Required

Guidelines …

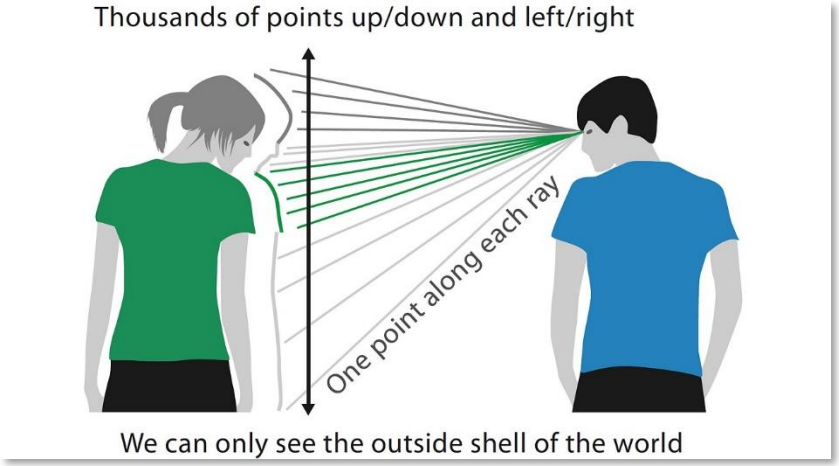
- Get it Right in Black and White
- Function First, Form Next

No Unjustified 3D

- 3D visualisation easily justified for tasks involving shape understanding of *inherently three-dimensional structures*
  - frequently for inherently spatial data
  - in this case benefits of 3D visualisation outweigh the costs
- *Depth cues* (e.g. occlusion, perspective distortion or shadows and lighting) come with some *costs*
  - e.g. legibility of text might be affected
  - justify whether benefits of depth information outweigh the costs
- *Power of the Plane*
  - perceived importance of items ordered on a plane probably dominated by reading conventions (e.g. left to right and top to bottom)

No Unjustified 3D …

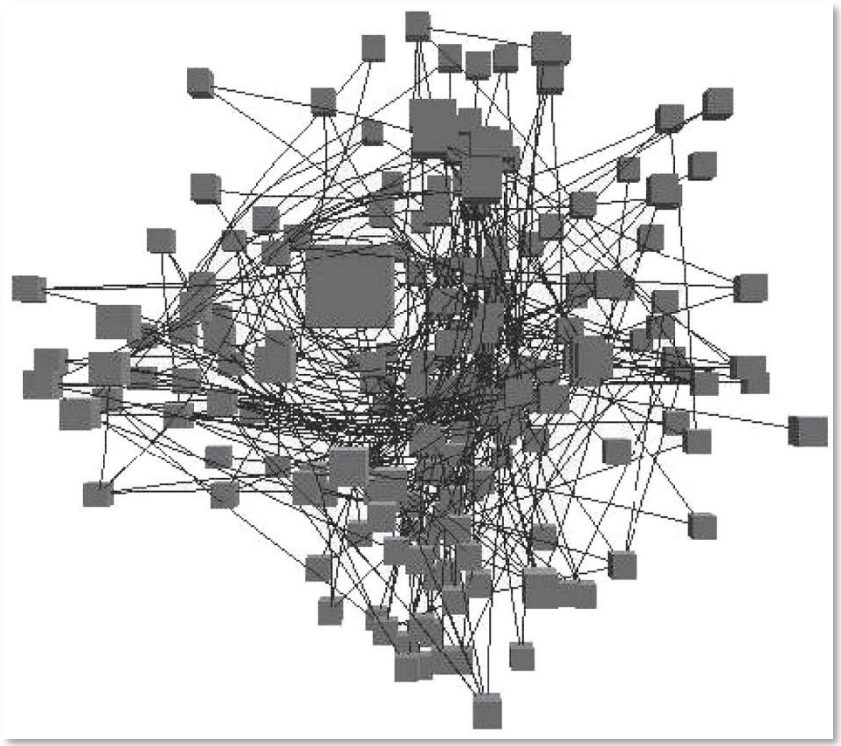
- *Disparity of Depth*
  - we do not really live in 3D but only see slightly more than 2D
  - we see millions of rays along planar axes (*image plane*) but only one point along the depth axis → *line-of-sight ambiguity*



  - Steven's Psychophysical Power Law shows that accuracy for lengths on a 2D plane (N=1.0) is better than for depth (N=0.67)
    - stereo displays can help to slightly improve depth perception but accuracy for planar positions is still better

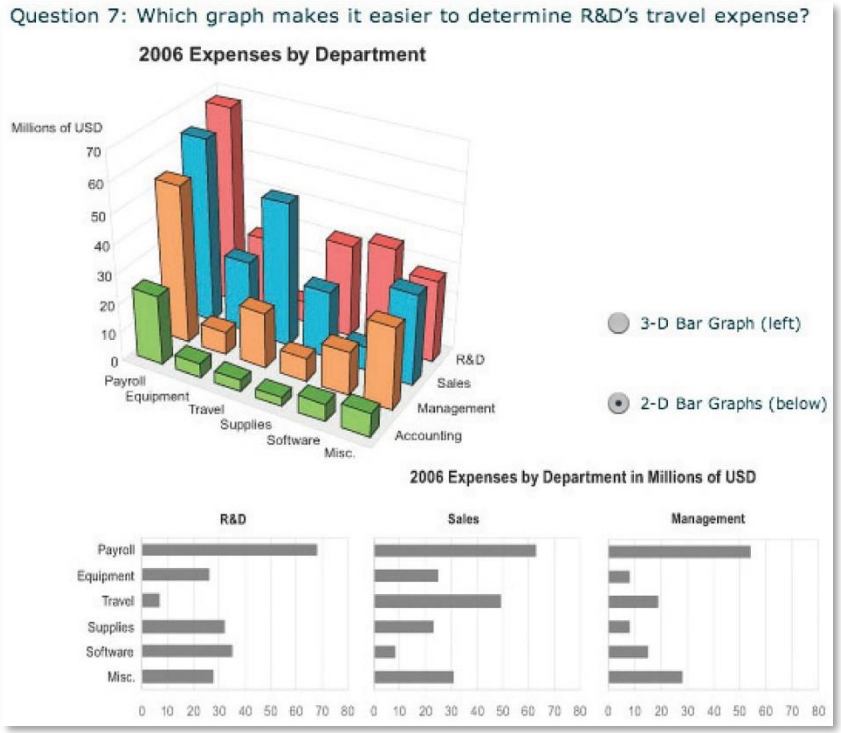
No Unjustified 3D …

- *Occlusion Hides Information*
  - occlusion is the most powerful depth clue
  - occlusion between objects changes with viewpoint (*motion parallax*)
  - different viewpoints needed to understand 3D structure
    - costs of interactive navigation
    - additional cognitive load to remember information from different viewpoints



No Unjustified 3D …

- *Perspective Distortion Dangers*
  - *perspective distortion* (fore-shortening) affects objects
    - objects appear smaller and change their position on the image plane
  - bad thing for the visual encoding of abstract data
    - *power of the plane is lost*
    - e.g. more difficult to judge bar heights in 3D bar chart

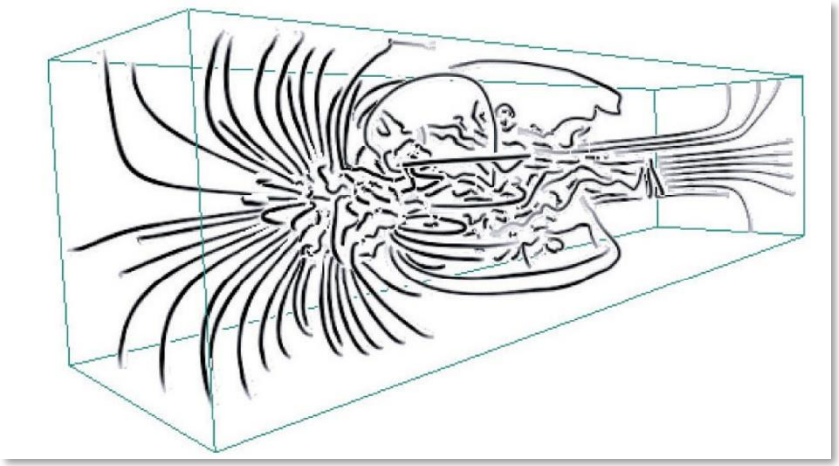


No Unjustified 3D …

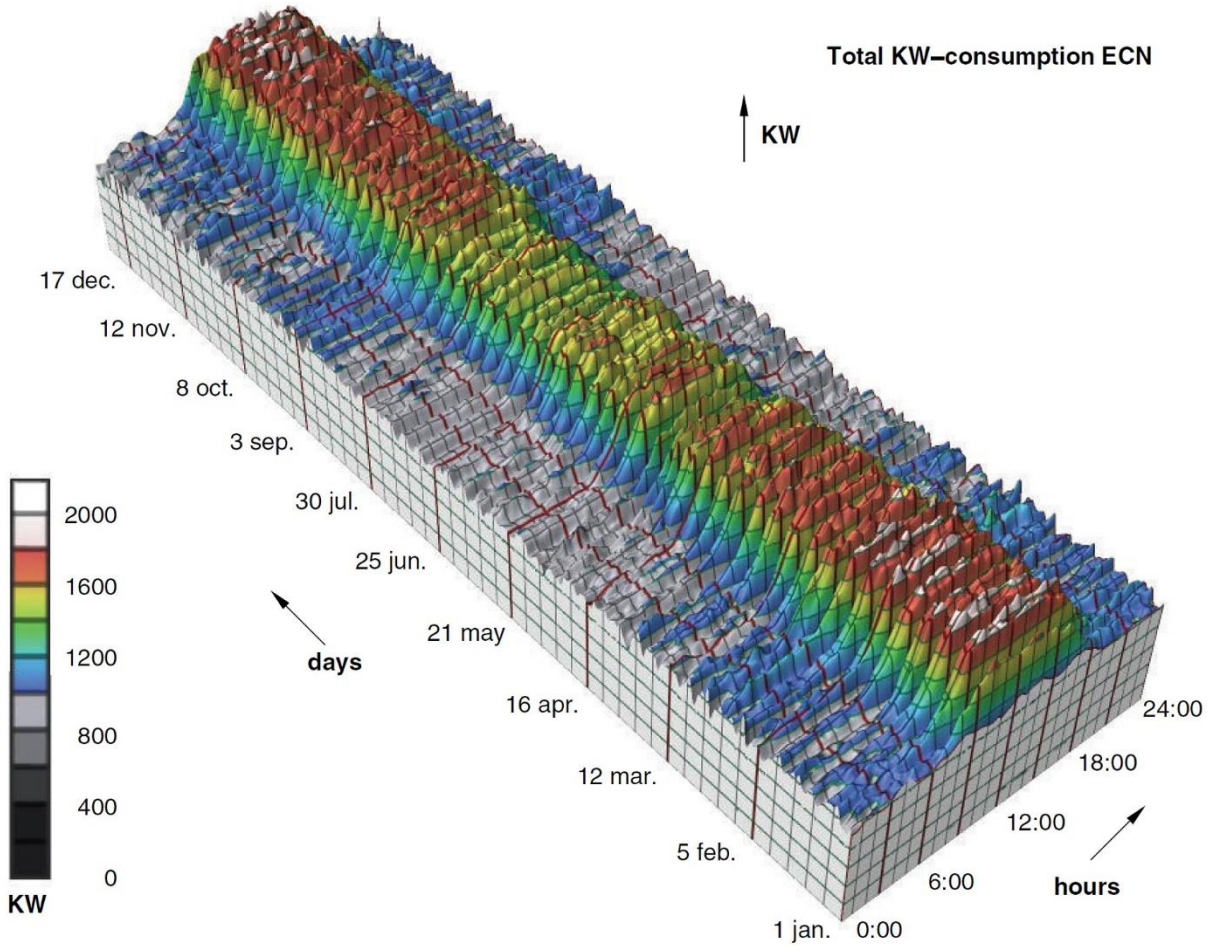
- Depth cues of *shadows* and *surface shading*
  - adds visual clutter when visualising abstract data
  - shading interferes with colour channels
  - shadows might be mistaken for true marks
- *Tilted Text is Not Legible*
  - fonts have been designed for optimal readability on 2D displays
  - tilted text becomes blocky and jaggy (less readable)
  - high-resolution displays and careful rendering might improve the legibility in the future

3D Visualisation for Shape Perception

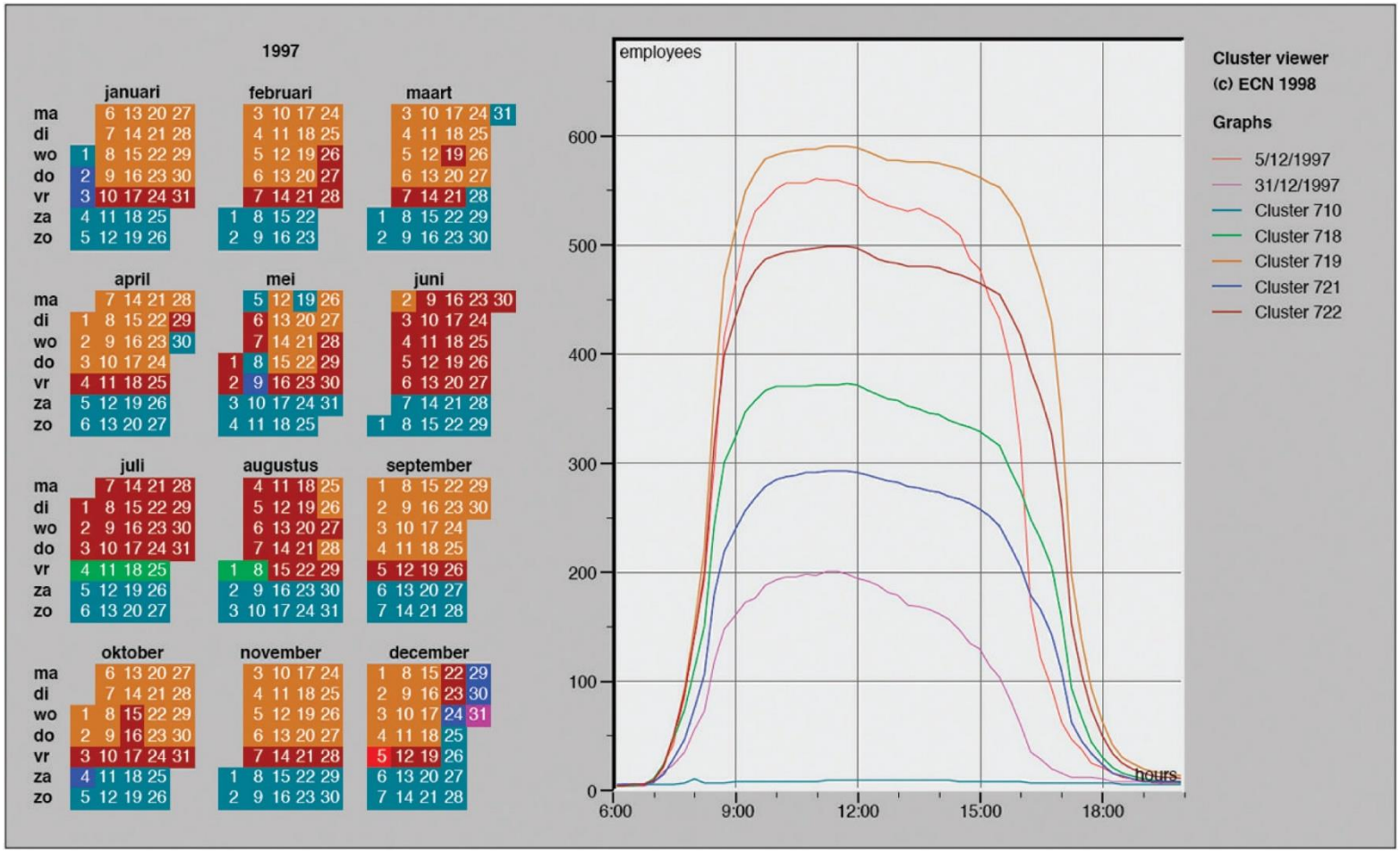
- Benefits for understanding 3D geometric structures
  - supports mental model via interactive navigation controls
  - e.g. object structure easier to understand from 3D visualisation than 2D blueprints
    - but 2D blueprints better to determine the size of elements
  - 3D outperforms 2D for *shape understanding tasks*
    - medical imagining datasets of human body
    - fluids flows
    - molecular cell interactions
    - …



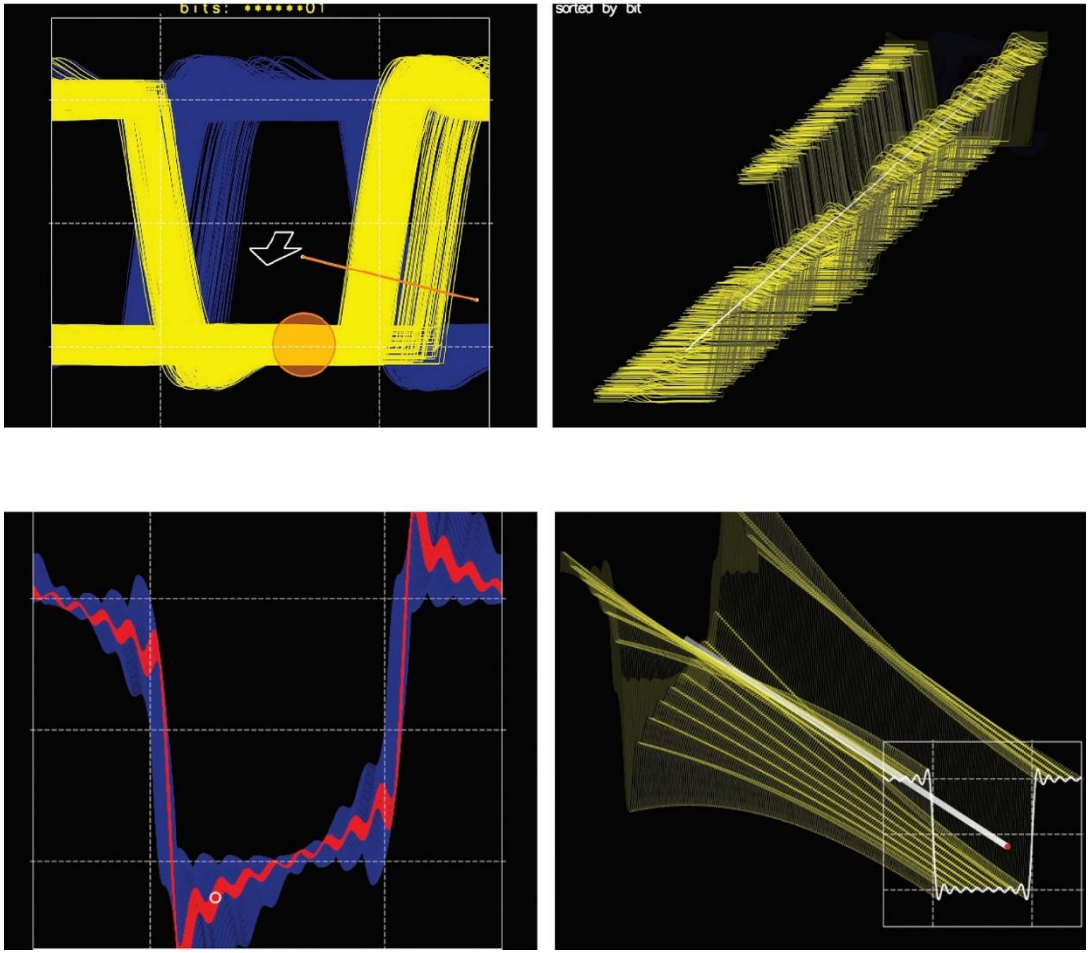
Cluster-Calendar Time-Series Vis



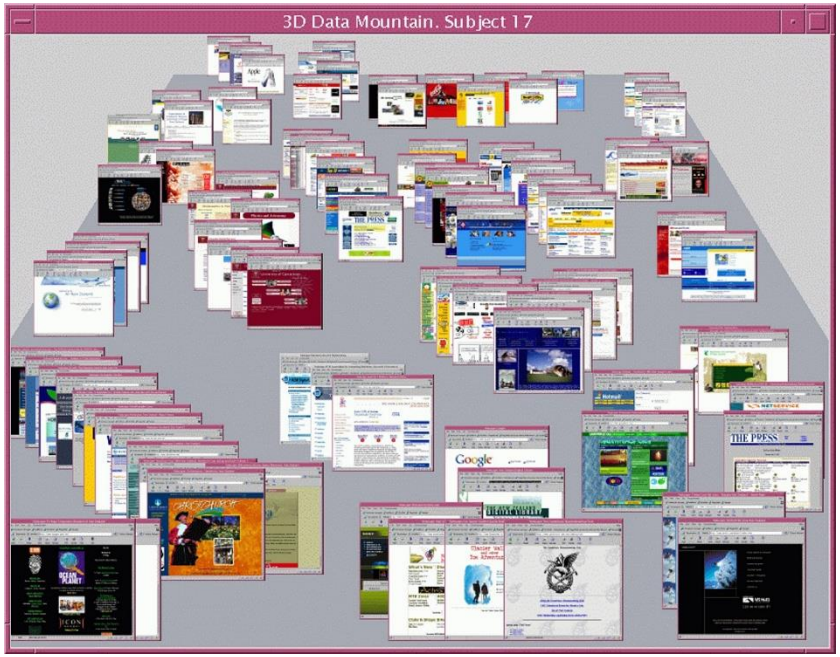
Cluster-Calendar Time-Series Vis …

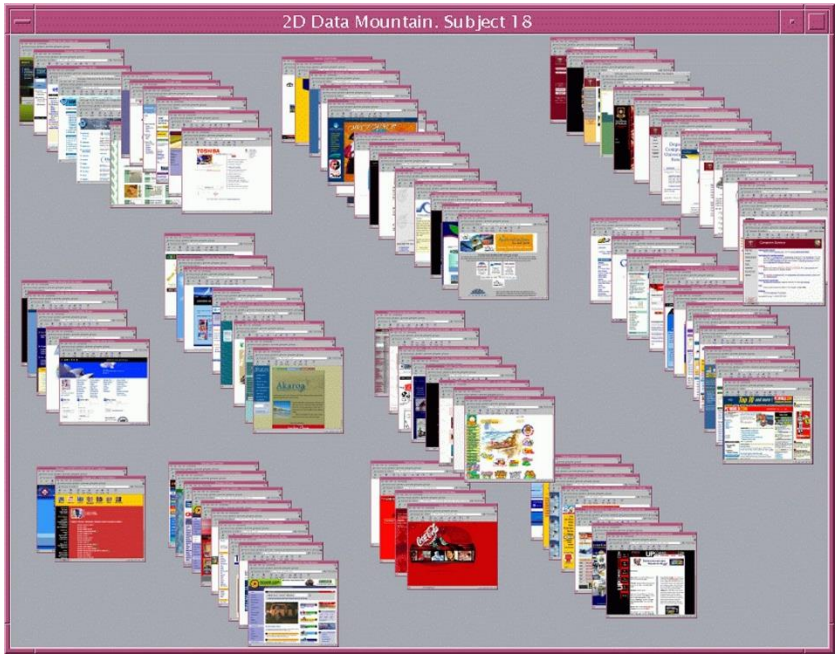


Layer-oriented Time Series Vis



Empirical Evidence of 3D vs. 2D





- Not always easy to prove the effect of using 3D infovis
  - e.g. original claim of 3D benefits in 3D Data Mountain
  - later shown that 2D Data Mountain has similar performance

No Unjustified 2D

- Laying out data in 2D space should also be justified compared to simply showing data with a 1D list
  - *information density* (e.g. number of labels) is higher in lists
  - ordered lists are excellent for lookup tasks
- Benefits of explicitly showing relationships outweigh the costs of required space when a task requires the *understanding of the topological structure of a network*
- Some tasks might be handled well by 1D lists even if the original data has a network structure

Eyes Beat Memory

- Cognitive load to switch between different views that are *visible simultaneously* is much lower than comparing to a memorised previous view
- *Memory and Attention*
  - limited capacity of short-term memory (*working memory*)
    - *cognitive load* and failure to absorb all presented information if limit is reached
  - limited human attention
    - e.g. conscious search for items gets more difficult for increasing number of items
- *Animation versus Side-by-Side Views*
  - some animation-based idioms impose significant cognitive load
  - animation powerful for transitions between dataset configurations
    - helps to maintain context

Eyes Beat Memory …

- *Change Blindness*
  - we fail to notice even major changes if our attention is directed elsewhere
  - makes it difficult to track complex changes across multiframe animations

Video: Change Blindness

Resolution Over Immersion

- Trade-off between the number of available pixels (*resolution*) and the level of *immersion* (feeling of presence in virtual reality)
  - available number of pixels is most critical constraint in vis design
    - extremely rare that immersion is worth the cost in resolution
- Another issue of immersive environments (e.g. via head-mounted displays) is its special-purpose setting
  - not integrated with a user's typical computer-based workflow
  - no support for task switching between vis and other applications
- Immersive environments might be helpful for shape understanding tasks as described earlier

Overview First, Zoom and Filter, Details on Demand

- Ben Shneiderman's Visual Information-Seeking Mantra
  - overview and need to see details
  - role of data reduction and navigation
- *Overview* has the goal to summarise
  - shows all items of a dataset simultaneously
  - helps to find regions that should be further investigated
  - often shown at the beginning of an exploration process
- Overview construction
  - geometric zooming might not be sufficient
    - number of marks might become larger than the number of available pixels
  - number of marks might be reduced via *aggregation*
    - similar to semantic zooming

Overview First, Zoom and Filter, Details on Demand …

- Detail view might pop up in response to a select action but detail view might also be permanently visible side-by-side with an overview

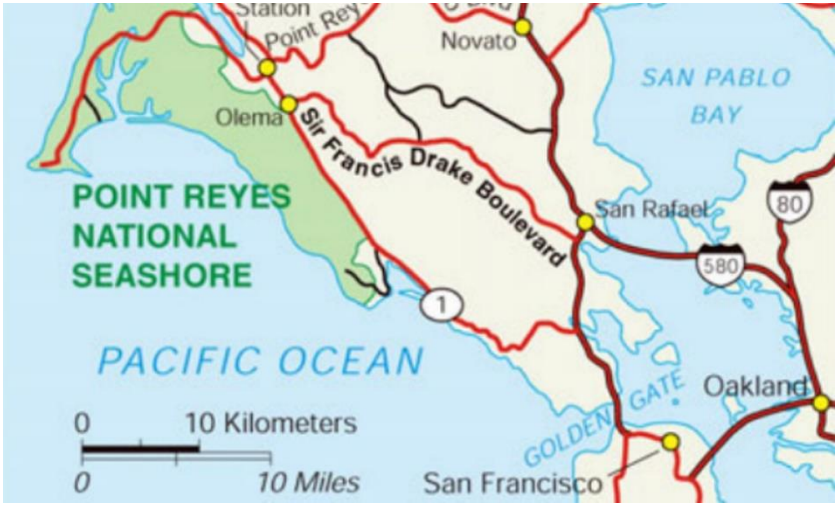
Responsiveness is Required

- *Visual Feedback*
  - user should get feedback that an action has been completed
    - e.g. highlighting of a selected item
  - when navigating, the feedback is normally represented by the new frame that is drawn based on a new viewpoint
  - visual feedback should typically take place within one second (immediate response)
  - if an action takes significantly longer than what the user might expect, some progress indicator should be shown

Responsiveness is Required …

- *Latency and Interaction Design*
  - different implementations of the operation to see more details for an item
    - clicking on the item (slowest)
    - hovering over the item for some short period of dwell time
    - hovering over the item without dwell time (fastest)
  - different mechanisms for visual feedback (details)
    - fixed detail pane at the side of the screen (eyes have to be moved)
    - popup window at the current cursor location (potential occlusion)
    - visual highlight directly in the view (e.g. highlighting neighbours in graph)
- *Interactivity Costs*
  - interaction requires human time and attention
    - trade-off between finding automatable aspects and relying on the human in the loop to detect patterns

Get it Right in Black and White



- Design guideline for effective use of colour by Maureen Stone
  - ensure that the most crucial aspects of the visual representation are even legible in black and white
    - suggests using the luminance channel for the most important attribute

Function First, Form Next

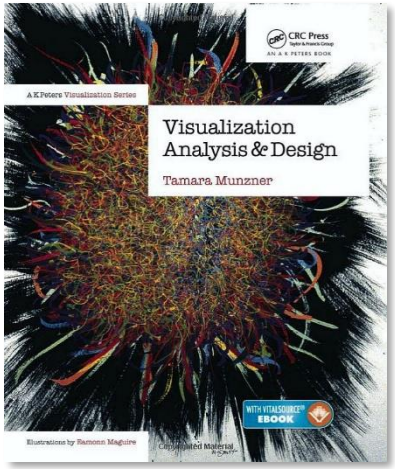
- Focus should be on the function first
  - form can be refined for an effective but originally "ugly" design
  - beautiful but ineffective design cannot be refined
- However, visual beauty does matter!
  - given two equally effective systems, users prefer the more beautiful design

Exercise 6

- Analysis and Validation

Further Reading

- This lecture is mainly based on the book *Visualization Analysis & Design*
  - chapter 6
    - Rules of Thumb



References

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- Video: Change Blindness
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Next Lecture

Visualisation Techniques