Information Visualization

USAGE AGREEMENT

Definition

Visualization is:

- Use of
- computer-supported
- interactive
- visual representation of data
- to amplify cognition

Shneiderman, 2004

Definition

Information visualization is:

- Use of
- computer-supported
- interactive
- visual representation of abstract data
- to amplify cognition

Shneiderman, 2004

Information Visualization

- Use of computer-supported interactive visual representation of abstract data to amplify cognition
- Compact graphical presentation
  - manipulating large numbers of items
  - possibly extracted from far large datasets
- Enables users to make discoveries, decisions, or explanations
- About patterns, groups of items, individual items

Tufte about graphical excellence

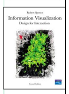
- Excellence consists of complex ideas communicated with clairity, precision, efficiency. Graphical display should:
  - Show the data
  - Induce the viewer to think about the substance rather than about methodology, graphic design, the technology of graphic production, …
  - Avoid distorting what the data have to say
  - Present many numbers in a small space
  - Make large data sets coherent
  - Encourage the eye to compare different pieces of data
  - Reveal the data at several levels of detail
  - Serve a reasonably clear purpose: description, exploration, tabulation, decoration
  - Be closely integrated with the statistical and verbal descriptions of a data set

E. R. Tufte, the Visual Display of Quantitative Information, Graphics Press, Cheshire, Connecticut, 1983

More definitions

- "a process of transforming data and information that are not inherently spatial into a visual form, allowing the user to observe and understand the information…"
  Gershon & Eick, 1995
- "the communication of abstract data through the use of interactive visual interfaces"
  Keim et al., 2006

- "a process of forming a mental model of data, thereby gaining insight into and understanding of that data"
  Spence, 2007



- "produces (interactive) visual representations of abstract data to reinforce human cognition; thus enabling the viewer to gain knowledge about the internal structure of the data and causal relationships in it"
  InfoVis Wiki (http://www.infovis-wiki.net)

What is Information Visualization

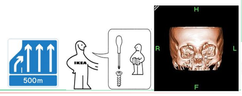
- Visualization is more than method of computing. It is a process of transforming information into a visual form enabling the user to observe the information
- We need to take into account human perceptual and cognitive capabilities, human variations, and task characteristics
- Visualization is more than pretty pictures. Successful visualizations can reduce the time it takes to get information, make sense out of it, and enhance creative thinking
- Information is usually non-spatial data or abstract
- Finding a good spatial representation of the information at hand is one of the most difficult tasks

Information Visualization vs Scientific Visualization

- Scientific visualization is: "The graphical representation of complex physical phenomena in order to assist scientific investigation and to make inferences that aren't apparent in numerical form. Typical examples include processing of satellite photographs and 3D representations of molecules and fluids to examine their dynamics"
  Usability first, 2003
- Scientific Visualization (SV) is focused on visually representing phisical objects and phenomena
- Information Visualization (IV) focuses on more abstract data
- IV tackles applications that deal with data (e.g., Web site accesses) which are outside the scope of SV

Visualization in everyday life

- Table in a newspaper
- Train/subway map with arrival/departure times
- Map of a region
- Weather chart
- Stock market graph
- Your product vs leading brand comparison plot
- 3D reconstruction of a body part generated from a CT scan
- Instruction manual
- Highway signs



Domains

- Finance
- Engineering
- Medicine
- Physics
- Statistics
- Data analysis
- Simulation
- Marketing / advertisement
- …

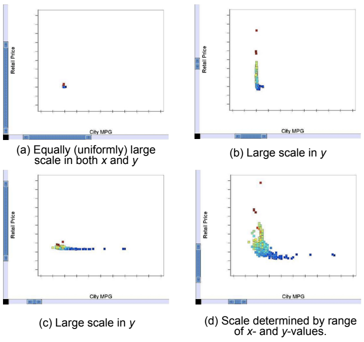
Importance of Visualization

- Billions of potential users
- Huge amounts of existing information
  - Information overload
  - Difficult to make sense
- New visual computing, display technologies, and visualization methods make it possible to represent information effectively

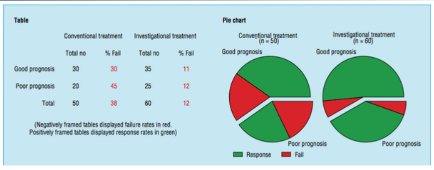
Importance of good Visualization

Same data

Different scale

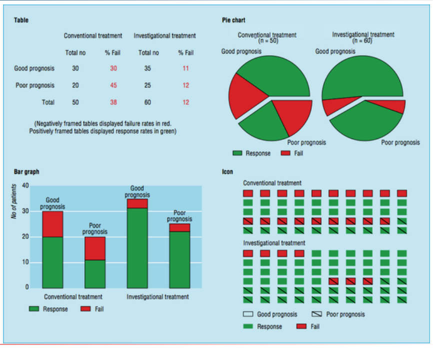


Visualization choice influence (important) decisions

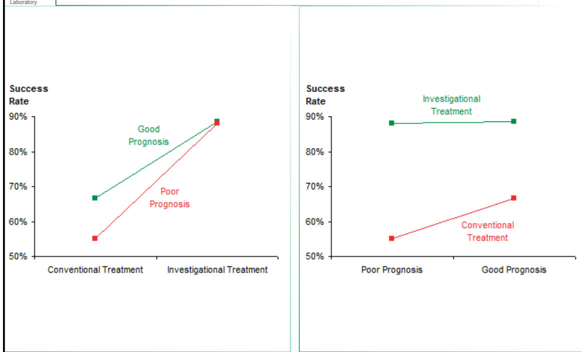


- Continue or abort the trial?

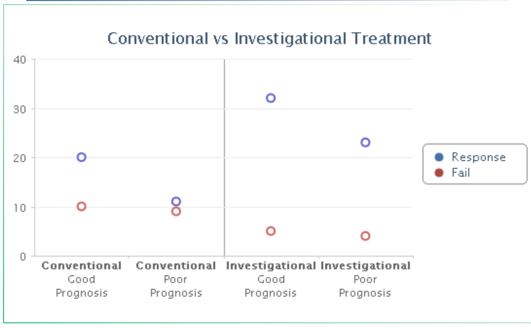
Visualization choice influence (important) decisions



Peltier's alternative proposal



Jamie's alternative proposal



http://eagereyes.org/blog/2011/visualization-choice-influences-decisions

Early Visualizations

One of the Lascaux cave paintings on the notrhern slopes of the French Pyrenees on the banks of the Vézère river

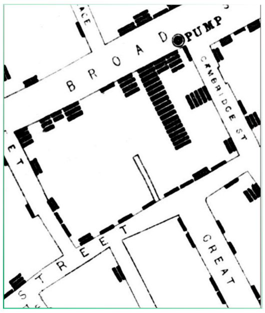
Early Visualizations

One of the 12 pages of the Peutinger Map set, showing the roads of the Roman Empire

Early Visualizations

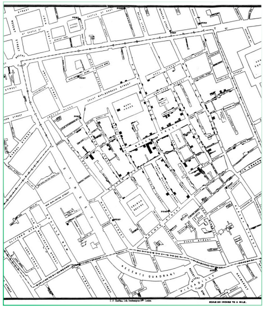
- The famous Hereford map, the largest surviving map of the Middle Ages (1280s)

Early Visualizations



- A section of John Snow's map of the deaths from cholera in London in 1663
- Each bar within the houses represents one deceased individual

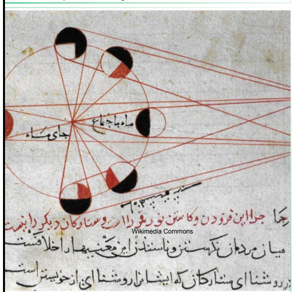
Early Visualizations



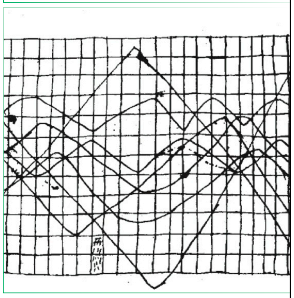
- Overview map of the deaths from Cholera in London in 1663
- Note the concentration around the Broad Street Water Pump
- Note as well the outliers

Early Visualizations (Biruni circa 1030)

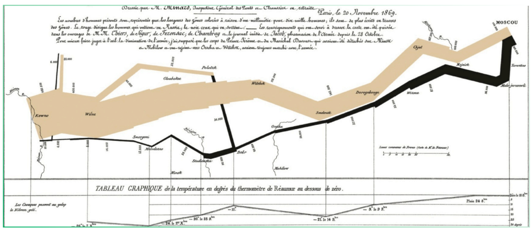
Shows planetary motion



Phases of the moon in orbit



Early Visualizations: Minard's map

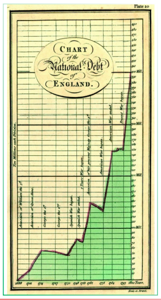


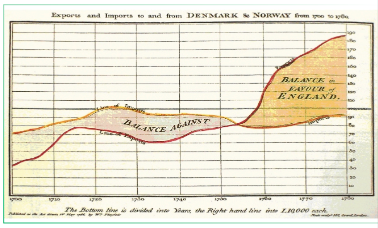
Width: size of the army at that location
Color: direction of movement
Temperature: along the retreat at the bottom

Early Visualizations

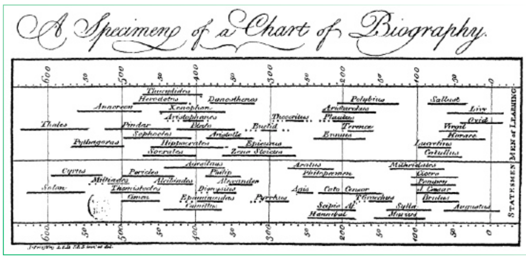
William Playfair

National debt over time



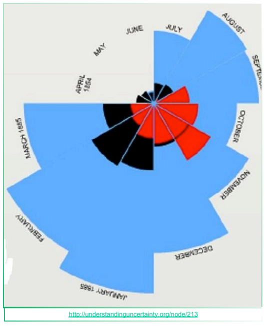


Early Visualizations



Joseph Priestley: the longevity of famous people (1765)

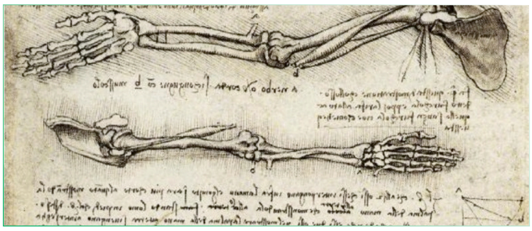
Early Visualizations



http://understandinguncertainty.org/node/213

- Florence Nightingale's coxcomb chart showing monthly deaths from battle and other causes
- Blue: deaths from disease
- Red: deaths from wounds
- Black: all other deaths

Early Visualizations

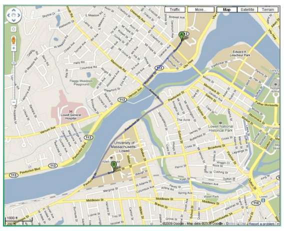


Leonardo Da Vinci's study of the motion of the human arm (1510)

Visualization Today

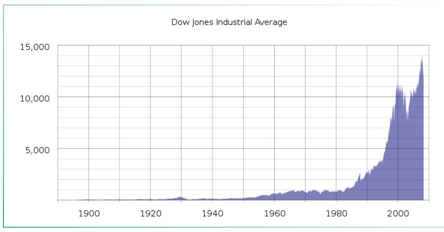
Bari underground map

Visualization Today



The google.com map directions from 198 Riverside St., Lowell, MA (UMass Lowell, North Campus) to 883 Broadway St., Lowell, MA (UMass Lowell, South Campus) Google.com maps provide graphical cues drawn on top of road maps to indicate driving directions from point A to point B

Visualization Today



Dow Jones Industrial Average (DJIA) from 1900 to 2000. The Dow Jones Industrial Average is a U.S. stock index based on the weighted average of the stock prices of 30 large and actively traded U.S. companies. The divisor changes over time as stock splits, so as not to alter that average in those cases.

Visualization Today

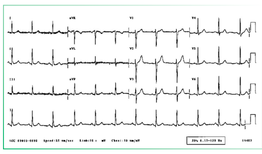
$11,956,584,748,608.58

The outstanding United States public debt as of January 22, 2006

Visualization Today

Two examples of 12-lead ECGs:

A normal adult:

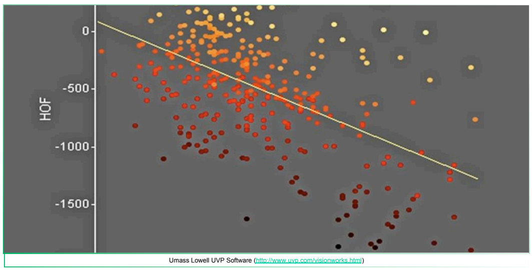


http://www.ecglibrary.com/ecghome.html

An 83-year-old adult with heart problems:

http://www.ecglibrary.com/ecghome.html

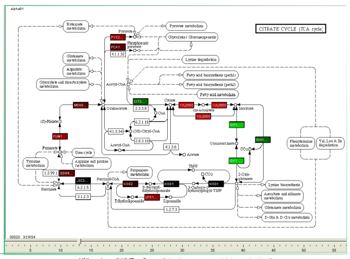
Visualization Today



Umass Lowell UVP Software (http://www.uvp.com/visionworks.html)

Yeast mechanism of action data with regression line

Visualization Today



UMass Lowell UVP software (http://www.uvp.com/visionworks.html)

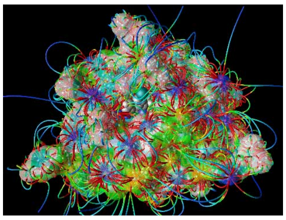
A pathway represented by a network with nodes representing genes and color the level of expression

Visualization vs Computer Graphics

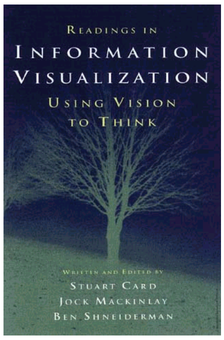
- Originally considered a subfield of CG
- Visualization are always connected to data, do not emphasize visual realism
- CG focuses on graphical objects and organization of graphical primitives. A secondary application of CG is in art and entertainement

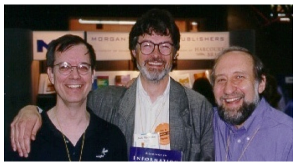
Scientific Data Visualization vs Information Visualization

- Still in early 2000 SciVis and InfoVis were differenciated
- Both provide representations of data
- Dataset are often different

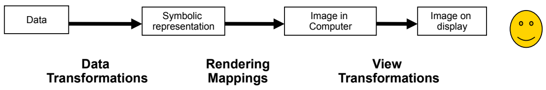


Information Visualization: Using Vision to Think

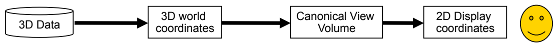




Visualization process

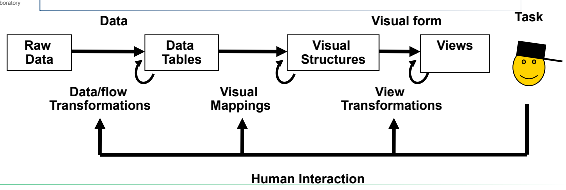


Graphics pipeline



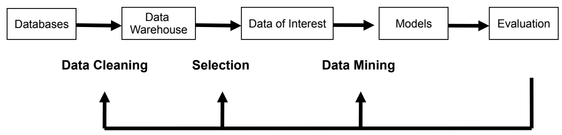
- Modeling (poligons)
- Viewing (cameras)
- Clipping (bounds)
- Hiddens surface removal
- Projections (onto the two-dimensional plane)
- Rendering

Visualization pipeline



- Data modeling
- Data selection
- Data to visual mappings
- Scene parameter settings (view transformations)

Knowledge Discovery Pipeline

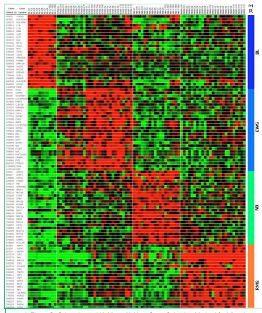


The role of the User

Can be involved in most stages of visualization pipeline

- Exploration
- Confirmation
- Presentation (primary)

Exploratory visualization



J. Zhou, G. Grinstein, and K. Marx. "A New Gene Selection Method for Visual Analysis." Scientific Report No. 015, University of Massachusetts Lowell, 2007

- microarray gene expression experiment analysis

Interaction Visualization Usability & UX laboratory

UNIVERSITÀ DEGLI STUDI DI BARI ALDO MORO

Find what you need
Understand what you Find

Simple visualization: Scatterplot

The scatterplot

```
Scatterplot(xDim,yDim,cDim,rDim,rMin,rMax)
  for each record i 'for each record
    do x <- Normalize(i,xDim) 'derive location
      y <- Normalize(i,yDim)
      r <- Normalize(i,rDim,rMin,rMax) 'radius
      MapColor(i,cDim) 'and color then
      Circle(x,y,r) 'draw the record as circle
```


The Scatterplot

Vehicle Name	Sedan	Sports	SUV	Wagon	Minivan	Pickup	AWD	RWD	Price
Acura 3.5 RL 4dr	1	0	0	0	0	0	0	0	43755
Acura MDX	0	0	1	0	0	0	1	0	36945
Suzuki XL-7 EX	0	0	1	0	0	0	0	0	23699

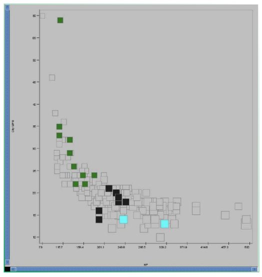
A simple partial table of the car and truck data. Note that you can think of this as a row-based table (cars and trucks) or a column-based table (car attributes)

The Scatterplot

Vehicle Name	Small/Sporty/ Compact/Large Sedan	Sports Car	SUV	Wagon	Minivan	Pickup	AWD	RWD	Retail Price	Dealer Cost	Engine Size (l)	Cyl	HP	City MPG	Hwy MPG	Weight	Wheel Base	Len	Width
Toyota 4Runner SR5 V6	0	0	1	0	0	0	0	0	27710	24801	4	6	245	18	21	4035	110	189	74
Toyota Avalon XL 4dr	1	0	0	0	0	0	0	0	26560	23693	3	6	210	21	29	3417	107	192	72
Toyota Avalon XLS 4dr	1	0	0	0	0	0	0	0	30920	27271	3	6	210	21	29	3439	107	192	72
Toyota Camry LE 4dr	1	0	0	0	0	0	0	0	19560	17558	2.4	4	157	24	33	3086	107	189	71
Toyota Camry LE V6 4dr	1	0	0	0	0	0	0	0	22775	20325	3	6	210	21	29	3296	107	189	71
Toyota Camry Solara SE 2dr	1	0	0	0	0	0	0	0	19635	17722	2.4	4	157	24	33	3175	107	193	72
Toyota Camry Solara SE V6 2dr	1	0	0	0	0	0	0	0	21965	19819	3.3	6	225	20	29	3417	107	193	72
Toyota Camry Solara SLE V6 2dr	1	0	0	0	0	0	0	0	26510	23908	3.3	6	225	20	29	3439	107	193	72
Toyota Camry XLE V6 4dr	1	0	0	0	0	0	0	0	25920	23125	3	6	210	21	29	3362	107	189	71
Toyota Celica GT-S 2dr	0	1	0	0	0	0	0	0	22570	20363	1.8	4	180	24	33	2500	102	171	68
Toyota Corolla CE 4dr	1	0	0	0	0	0	0	0	14085	13065	1.8	4	130	32	40	2502	102	178	67
Toyota Corolla LE 4dr	1	0	0	0	0	0	0	0	15295	13889	1.8	4	130	32	40	2524	102	178	67
Toyota Corolla S 4dr	1	0	0	0	0	0	0	0	15030	13650	1.8	4	130	32	40	2524	102	178	67
Toyota Echo 2dr auto	1	0	0	0	0	0	0	0	11560	10896	1.5	4	108	33	39	2085	93	163	65
Toyota Echo 2dr manual	1	0	0	0	0	0	0	0	10760	10144	1.5	4	108	35	43	2035	93	163	65
Toyota Echo 4dr	1	0	0	0	0	0	0	0	11290	10642	1.5	4	108	35	43	2055	93	163	65
Toyota Highlander V6	0	0	1	0	0	0	1	0	27930	24915	3.3	6	230	18	24	3935	107	185	72
Toyota Land Cruiser	0	0	1	0	0	0	1	0	54765	47986	4.7	8	325	13	17	5390	112	193	76
Toyota Matrix XR	0	0	0	1	0	0	0	0	16695	15156	1.8	4	130	29	36	2679	102	171	70
Toyota MR2 Spyder convertible 2dr	0	1	0	0	0	0	0	1	25130	22787	1.8	4	138	26	32	2195	97	153	67
Toyota Prius 4dr (gas/electric)	1	0	0	0	0	0	0	0	20510	18926	1.5	4	110	59	51	2890	106	175	68
Toyota RAV4	0	0	1	0	0	0	1	0	20290	18553	2.4	4	161	22	27	3119	98	167	68
Toyota Sequoia SR5	0	0	1	0	0	0	1	0	35695	31827	4.7	8	240	14	17	5270	118	204	78
Toyota Sienna CE	0	0	0	0	1	0	0	0	23495	21198	3.3	6	230	19	27	4120	119	200	77
Toyota Sienna XLE Limited	0	0	0	0	1	0	0	0	28800	25690	3.3	6	230	19	27	4165	119	200	77
Toyota Tacoma	0	0	0	0	0	1	0	1	12800	11879	2.4	4	142	22	27	2750	103	*	*
Toyota Tundra Access Cab V6 SR5	0	0	0	0	0	1	1	0	25935	23520	3.4	6	190	14	17	4435	128	*	*
Toyota Tundra Regular Cab V6	0	0	0	0	0	1	0	1	16495	14978	3.4	6	190	16	20	3925	128	*	*

Toyota vehicle table. All variables are shown.
Notice that there are a few missing values

The Scatterplot



- A scatterplot of horsepower versus city MPG for Toyota vehicles
- The vehicle class is mapped to color

The Scatterplot

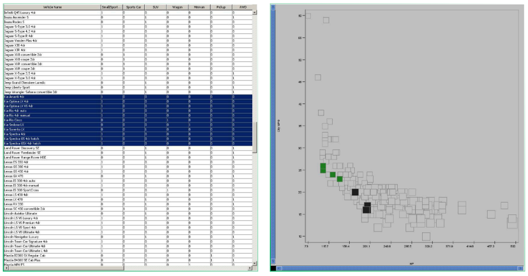


Table and scatterplot of the Kia vehicles.
Note that here, too, a linear relationship holds

The Scatterplot

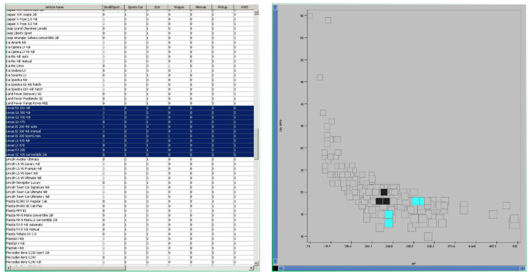
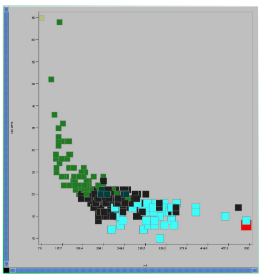


Table and scatterplot of the Lexus vehicles.
Note that the hypothesis is not validated

The Scatterplot



- Scatterplot of all vehicles
- There is lots to explore here

Information Visualization: Data Types taxonomy *(Shneiderman)*

- 1-D Linear
- 2-D (Map)
- 3-D (World)
- Multi-Dimensional
- Temporal
- Tree
- Network

Information Visualization: Tasks taxonomy *(Shneiderman)*

- Overview
- Zoom
- Filter
- Details-on-demand
- Relate
- History
- Extract
- …?
- Search

End of part 1

Part 2

Information Visualization: Data Types taxonomy *(Keim)*

- Ordinal
  - Binary
  - Discrete
  - Continuous
- Nominal
  - Categorical
  - Ranked (young, adult, elderly)
  - Arbitrary
- Scale
  - Ordering relation
  - Distance metric
  - Exhistence of absolute zero (

Structures within and between records

- Scalar, vector, tensors
  - Scalar: tensor of rank 0 - vector: tensor of rank 1
- Geometry and grids
  - Especially for 3D objects
  - Coordinates in different systems (cartesian, spherical, hyperbolic, …)
  - Irregular geometry is common (wind flow simulation)
- Other forms
  - Timestamp (dealing with time, which has one of the widest range of possible value, ranging from picoseconds to millenia, and can also be relative or absolute, uniformly spaced or uneven spaced)
  - Topology (connection beween data), important for resampling and interpolation

Examples of various structured data

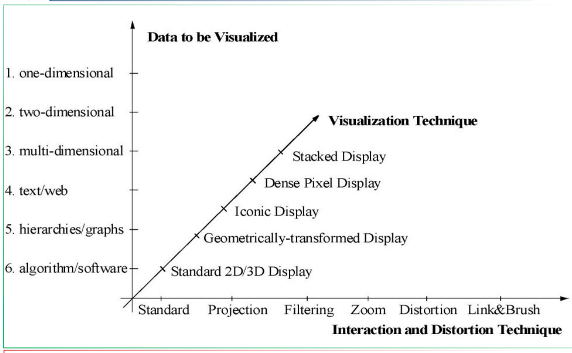
- **MRI** (scalar, 3 spatial attribute, 3D connectivity)
- **CFD** (3-dim for displacement, one temporal, 3 spatial attibutes, 3D connectivity)
- **Financial** (non geometric, n possibly independent components, nominal and ordinal, temporal attributes)
- **CAD** (3 spatial attributes, edge and poligon connections, surface properties)
- **Remote sensing** (multiple channels, 2/3 spatial attributes, 1 temporal attribute, grid connectivity)
- **Census** (multiple fields of all types, spatial attributes, temporal attribute, connectivity implied by similarities in fields)
- **Social Network** (nodes consisting of multiple fields of all types, various connectivity: spatial, temporal, other)

Keller & Keller taxonomy

(Peter R. Keller and Mary M. Keller, Visual Cues: Practical Data Visualization, IEEE Computer Society Press, 1994)

- Data types
  - Scalar
  - Nominal
  - Direction
  - Shape
  - Position
  - Spatially extended region / object
- Tasks
  - Identify (recognize)
  - Locate (abs/rel)
  - Distinguish (≠identify)
  - Categorize
  - Cluster
  - Rank
  - Compare (sims & diffs)
  - Associate (link)
  - Correlate (connection)

Keim taxonomy



Information Visualization: Design Guidelines *(Shneiderman)*

- Direct manipulation strategies
  - Visual presentation of query components
  - Visual presentation of results
  - Rapid, incremental and reversible actions
  - Selection by pointing (not typing)
  - Immediate and continuous feedback
  - Reduces errors
  - Encourages exploration

Information Visualization: Mantra

- Overview, zoom & filter, details-on-demand
- Overview, zoom & filter, details-on-demand
- Overview, zoom & filter, details-on-demand
- Overview, zoom & filter, details-on-demand
- Overview, zoom & filter, details-on-demand
- Overview, zoom & filter, details-on-demand
- Overview, zoom & filter, details-on-demand
- Overview, zoom & filter, details-on-demand
- Overview, zoom & filter, details-on-demand
- Overview, zoom & filter, details-on-demand
- …

Shneiderman

Strategies for Visual Information Reduction

- Difficulties to represent all information in the limited space of a display, and to navigate within the representation at different levels of detail
- Fisheye views (Furnas, 1981 & 1986)
  - "… an example of a more basic strategy for the display of large structures. This basic strategy uses a Degree of Interest (DOI) function which assigns to each point in the structure a number telling how interested the user is in seeing that point, given the current task. A display of any desired size, n, can then be made by simply showing the n most interesting points, as indicated by the DOI function."
- DOI of an object is computed with respect to a particular focus fp
- DOI (x | fp=y) = API (x) – D (x,y)
- API (x) is the a priori interest of point x
- D (x,y) is the current distance between x and fp
- Applicazioni: hierachies, structured text, calendars, …

- Focus + context (Card et al., CHI '91)
- Information Visualization Seeking Mantra (Shneiderman, 1996)
- Want to know more? Stasko may help…

User Interface Design Goals

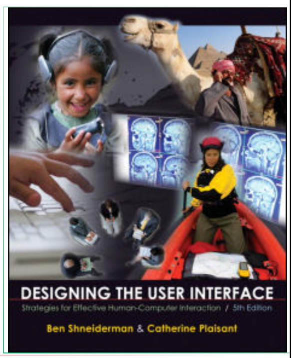
- Cognitively comprehensible:
  Consistent, predictable & controllable
- Affectively acceptable:
  Mastery, satisfaction & responsibility
- NOT: Adaptive, autonomous & anthropomorphic

Scientific Approach (beyond user friendly)

- Specify users and tasks
- Predict and measure
  - time to learn
  - speed of performance
  - rate of human errors
  - human retention over time
- Assess subjective satisfaction
  (Questionnaire for User Interface Satisfaction)
- Accommodate individual differences
- Consider social, organizational & cultural context

Design Issues

- Input devices & strategies
  - Keyboards, pointing devices, voice, gestures
  - Direct manipulation
  - Menus, forms, commands
- Output devices & formats
  - Screens, windows, color, sound
  - Text, tables, graphics
  - Instructions, messages, help
- Collaboration & communities
- Manuals, tutorials, training



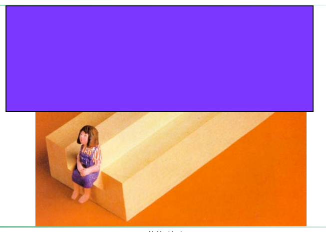
Perceptual issues

Human Perception and Information Processing

Perception?

- The process by which we interpret the world around us, forming a mental representation of the environment
- Non-isomorfic representation since the brain have to overcome inherent ambiguity in all sensory data
- Visual representation can be misinterpreted

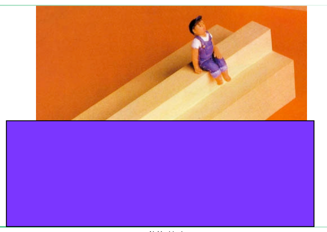
Two seated figures



N. Yoshigahara

Two seated figures, making sense at a higher, more abstract level, but still disturbing
On closer inspection, these seats are not realizable

Two seated figures



N. Yoshigahara

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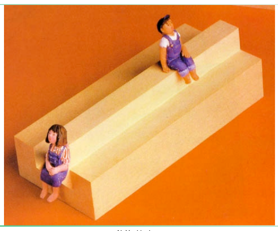
Two seated figures

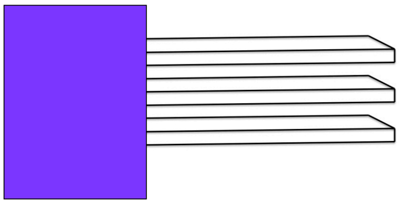


N. Yoshigahara

Two seated figures, making sense at a higher, more abstract level, but still disturbing

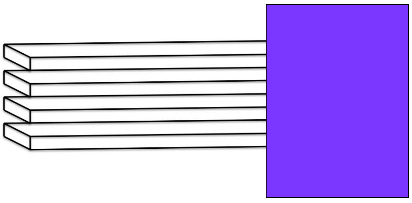
On closer inspection, these seats are not realizable

Four ≠ three



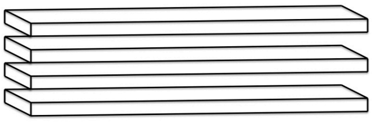
This object would have a problem being built (there are four boards on the left and three on the right)

Four ≠ three



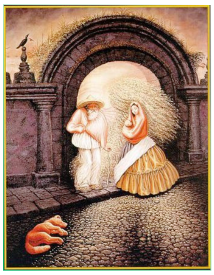
This object would have a problem being built (there are four boards on the left and three on the right)

Four ≠ three



This object would have a problem being built (there are four boards on the left and three on the right)

Two people making a face



A more complex illusion:

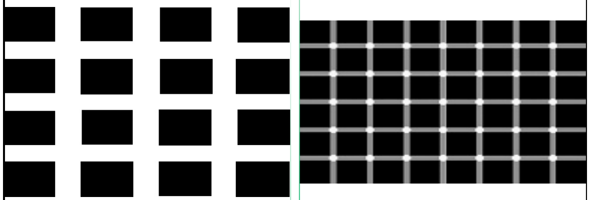
There are two people drawn as part of the face

Two people making a face

A more complex illusion:

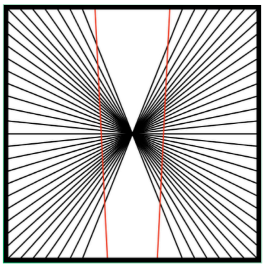
There are two people drawn as part of the face

Grid illusion



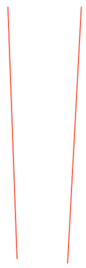
The Hermann grid illusion: (left) illusionary black squares appear over the complete image as you gaze at it; (right) similar to (left) but even more dynamic and engaging

Classic straight lines example



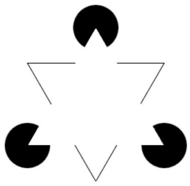
The Hering illusion:
red lines are straight

No trick, lines are straight



The Hering illusion:
red lines are straight

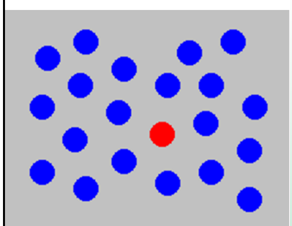
The Kanizsa illusion



A triangle seems to pop out of the image even though no such triangle is drawn

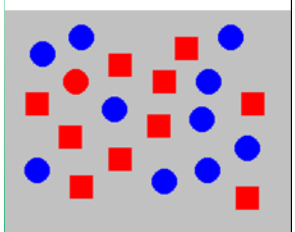
Preattention

Works



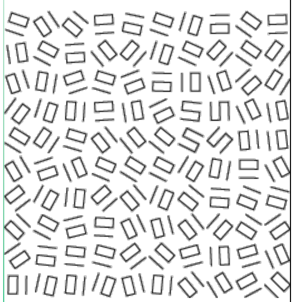
Preattention

Do not works

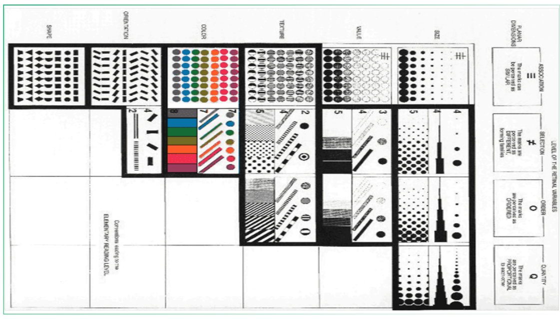


Attention processing

- Preattentive
- Attentive
- Postattentive

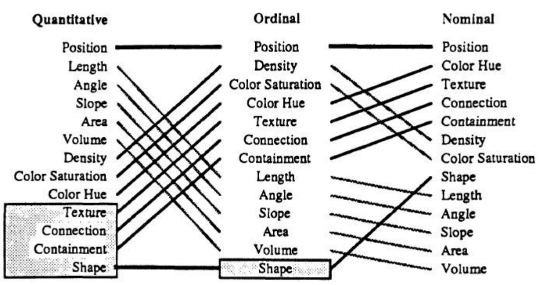


Different encoding and performance



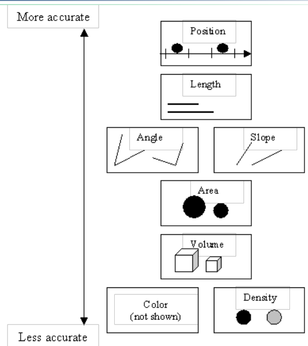
J. Bertin

Ordering by task



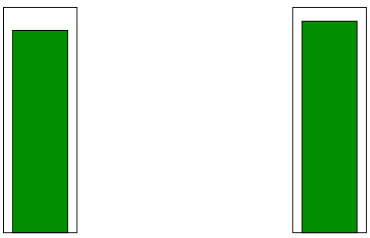
J. Mackinlay

Accuracy



J. Mackinlay

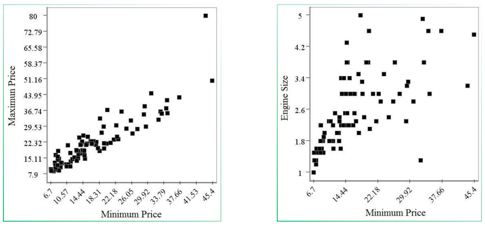
Relative judgment



The eight visual variables

- Position
- Mark
- Size
- Brightness
- Color
- Orientation
- Texture
- Motion

Position

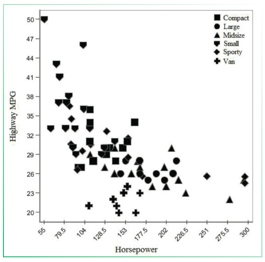


Example visualizations: (left) using position to convey information. Displayed here is the minimum price versus the maximum price for cars with a 1993 model year. The spread of points appears to indicate a linear relationship between minimum and maximum price; (right) another visualization using a different set of variables. This figure compares minimum price with engine size for the 1993 cars data set. Unlike (left), there does not appear to be a strong relationship between these two variables.

Mark

Several examples of different marks or glyphs that can be used

Mark

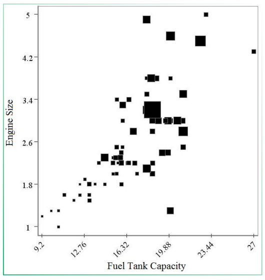


This visualization uses shapes to distinguish between different car types in a plot comparing highway MPG and horsepower. Clusters are clearly visible, as well as some outliers

Size (Length, Area and Volume)

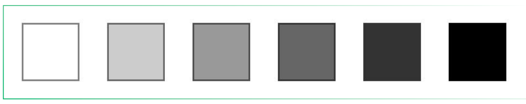
Example sizes to encode data.

Size (Length, Area and Volume)



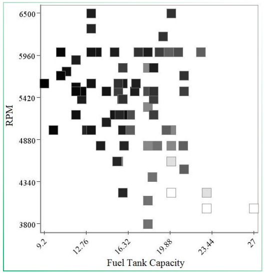
This is a visualization of the 1993 car models data set, showing engine size versus fuel tank capacity. Size is mapped to maximum price charged

Brightness



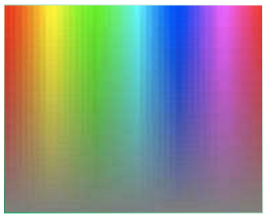
Brightness scale for mapping values to the display.

Brightness



Another visualization of the 1993 car models data set, this time illustrating the use of brightness to convey car width (the darker the points, the wider the vehicle).

Color

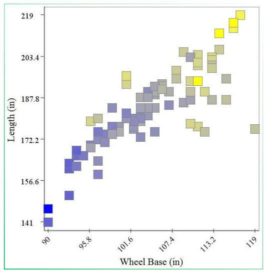


Microsoft hue/saturation color selector

Color

Example colormap that can be used to encode a data variable

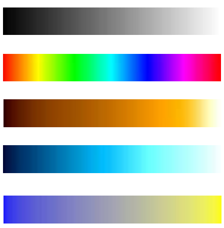
Color



A visualization of the 1993 car models, showing the use of color to display the car's length. Here length is also associated with the *y*-axis and is plotted against wheelbase. In this figure, blue indicates a shorter length, while yellow indicates a longer length

Color

Some common colormaps:



standard linear gray scale

rainbow

heated

blue to cyan

blue to yellow

Interaction Visualization Usability & UX laboratory

UNIVERSITÀ DEGLI STUDI DI BARI ALDO MORO

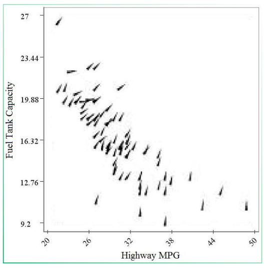
Cynthia Brewer

http://www.dataspora.com/2009/03/how-to-color-multivariate-data/

Orientation

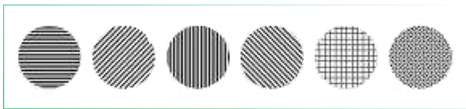
Example orientations of a representation graphic, where the lowest value maps to the mark pointing upward and increasing values rotate the mark in a clockwise rotation

Orientation



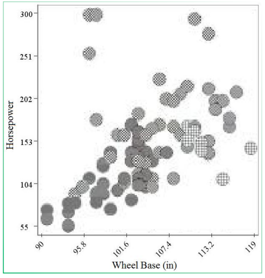
Sample visualization of the 1993 car models data set depicting using highway milesper-gallon versus fuel tank capacity (position) with the additional data variable, midrange price, used to adjust mark orientation

Texture



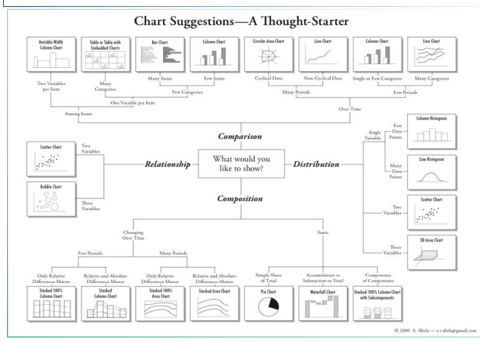
Six possible example textures that could be used to identify different data values

Texture



Example visualization using texture to provide additional information about the 1993 car models data set, showing the relationship between wheelbase versus horsepower (position) as related to car types, depicted by different textures

Chart suggestions



http://extremepresentation.typepad.com/blog/2006/09/choosing_a_good.html

Comunicazione…

Links

- 7 classic Vis Papers: http://fellinlovewithdata.com/guides/7-classic-foundational-vis-papers
- 6 niches visualization blogs: http://eagereyes.org/blog/2011/six-niche-visualization-blogs

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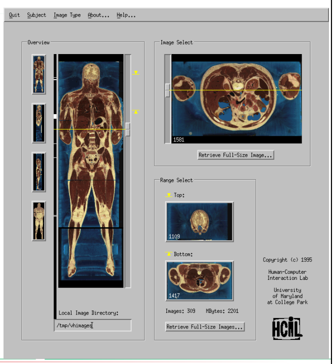
Tools

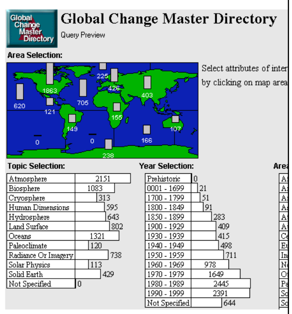
Visible Human Explorer (NLM)

- Doctors
- Surgeons
- Researchers
- Students

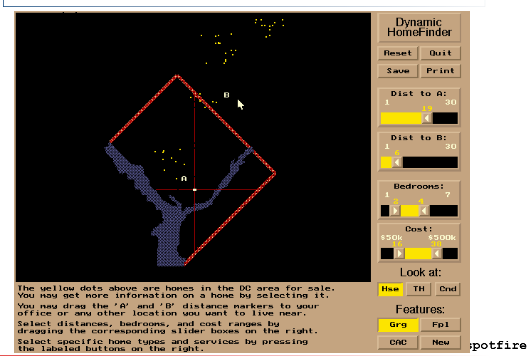


NASA Environmental Data

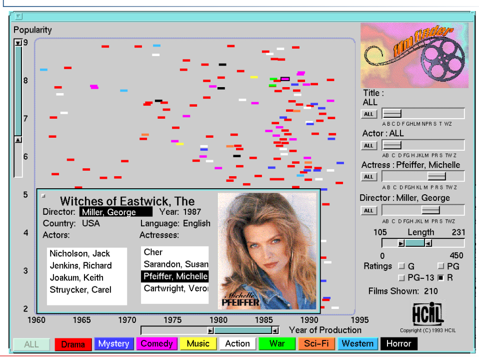
- Scientists
- Farmers
- Land planners
- Students



Dynamic Queries: HomeFinder

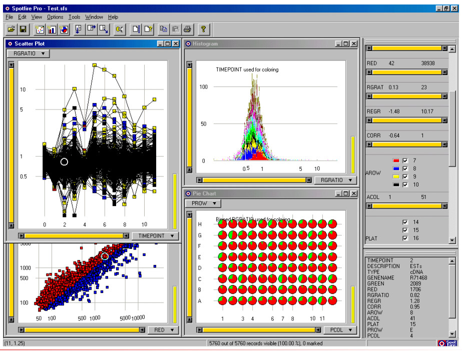


Starfield display: FilmFinder

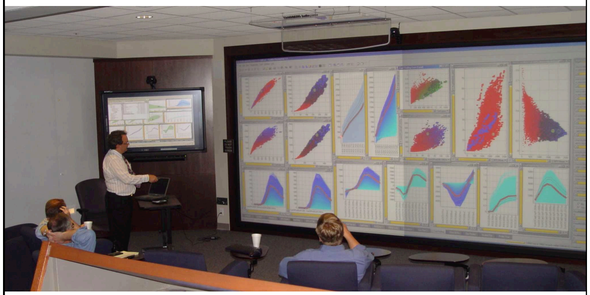


Spotfire

www.spotfire.com



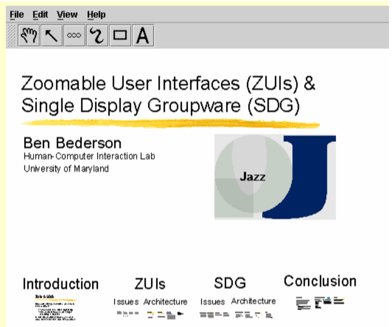
Spotfire

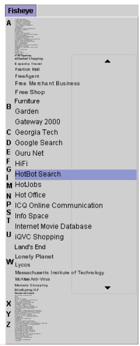


Fisheye Views & Zooming User Interfaces

- Distortion to magnify areas of interest
  - User-control, zoom factors of 3-5
- Multi-scale spaces
  - Zoom in/out & Pan left/right
- Smooth zooming
- Semantic zooming
- Overviews + details-on-demand

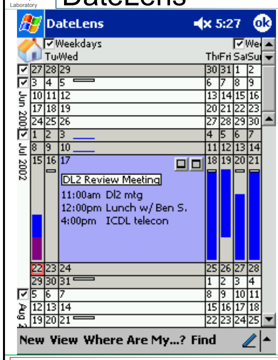
Zooming Presentations & Fisheye Menus

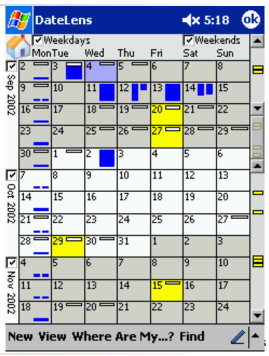




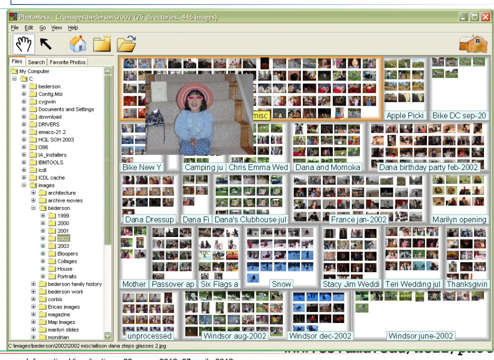
www.cs.umd.edu/jazz

Zooming User Interfaces, e.g. DateLens





PhotoMesa

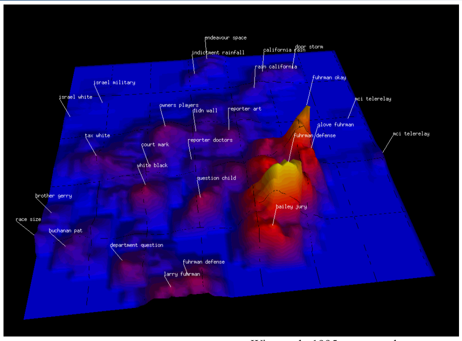


Feature Detection in High-Dimensional Spaces

- Correlations - Trends - Patterns
- Clusters
- Outliers
- Gaps

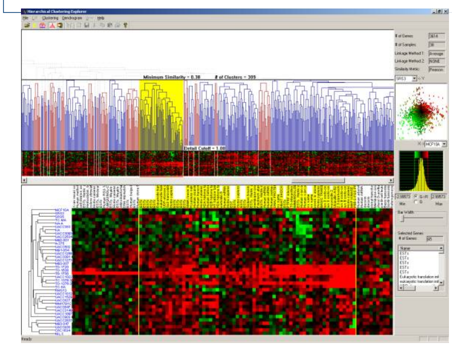
- Multiple View Coordination
- Rank-by-Feature
- Knowledge Integration

Themescape



Wise et al., 1995 - see also www.omniviz.com

Hierarchical Clustering Explorer



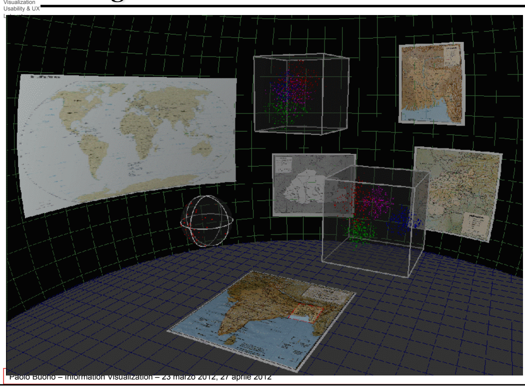
www.cs.umd.edu/hcil/hce

Spectrum of 3-D Visualizations

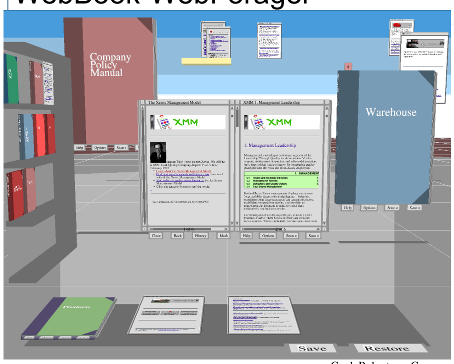
- Immersive Virtual Environment
  with head-mounted stereo display and head tracking
- Desktop 3-D for 3-D worlds
  - medical, architectural, scientific visualizations
- Desktop 3-D for artificial worlds
  - Bookhouse, file-cabinets, shopping malls
- Desktop 3-D for information visualization
  - cone/cam trees, perspective wall, web-book
  - SGI directories, Visible Decisions, Media Lab landscapes
  - XGobi scatterplots, Themescape, Visage
- Chartjunk 3-D: barcharts, piecharts, histograms

Starlight

Battelle – Pacific Northwest National Lab



WebBook-WebForager



Card, Robertson, George and York, CHI 96

Microsoft: Task Gallery

research.microsoft.com/ui/TaskGallery/

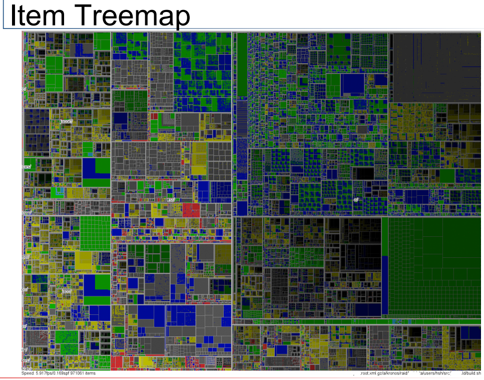
Clockwise3d

www.clockwise3d.co

Challenges

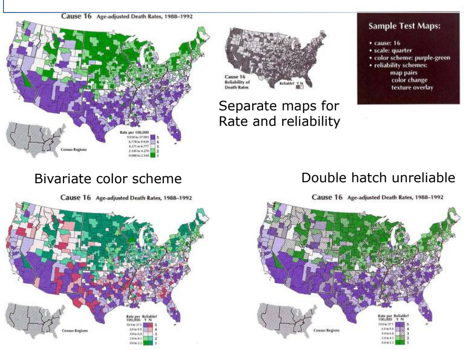
- Dealing with large volume of data
  - Also problem of missing data, uncertainty, data provenance
- Combining visual with textual representations
- Collaborative exploration
  - Environments for publishing results, sharing knowledge
  - Large shared displays
- Integrating with data mining
- Specialized toolkits and development tools
- Addressing Universal Usability
- Evaluation

Large volume of data e.g. Million-Item Treemap

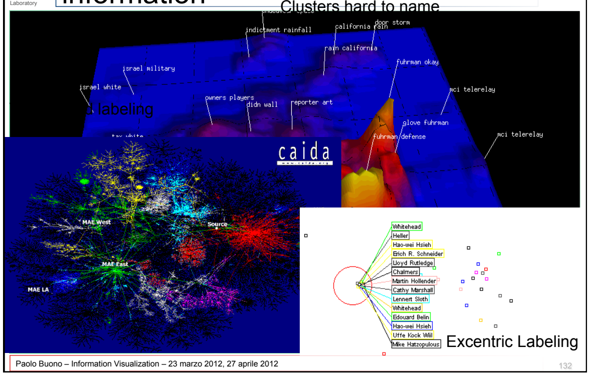


See www.cs.umd.edu/hcil/millionvis

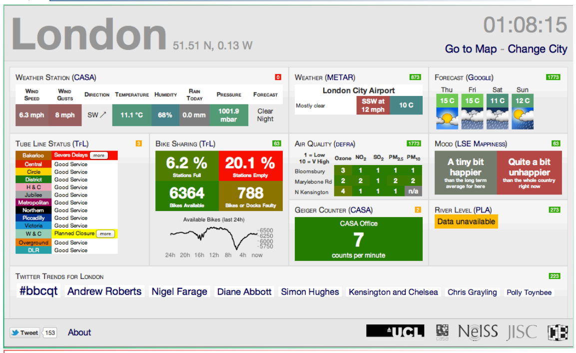
Showing uncertainty, Examples from MacEachren et al., Environment & Planning A, 1998



Combining visual and textual information



http://citydashboard.org



Paolo Buono – Information Visualization – 23 marzo 2012, 27 aprile 2012

Challenges

- Dealing with large volume of data
  - Missing data, uncertainty
- Combining visual with textual representations
- Collaborative exploration
  - Environments for gathering data, publishing results, sharing knowledge
  - Large shared displays
- Integrating with data mining
- Specialized toolkits and development tools
- Addressing Universal Usability
- Evaluation

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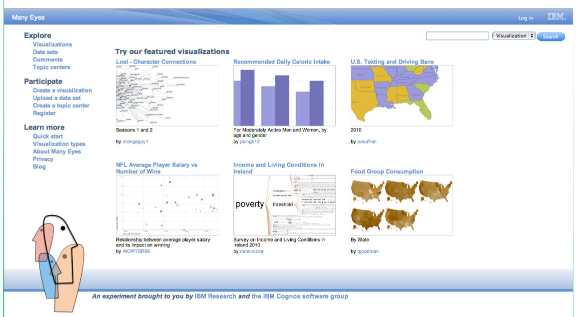
Many eyes: http://www-958.ibm.com



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Collaboration - Wall-Size Displays

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Challenges

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- Effective evaluation

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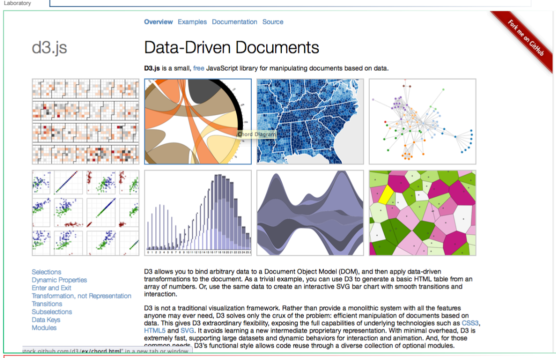
Toolkits – d3.js



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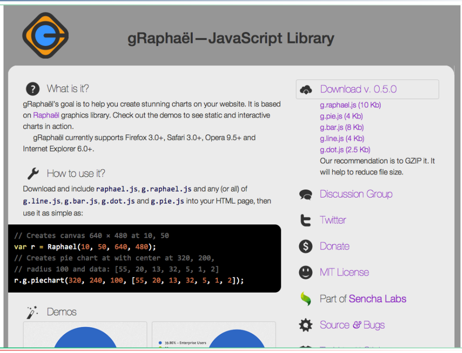
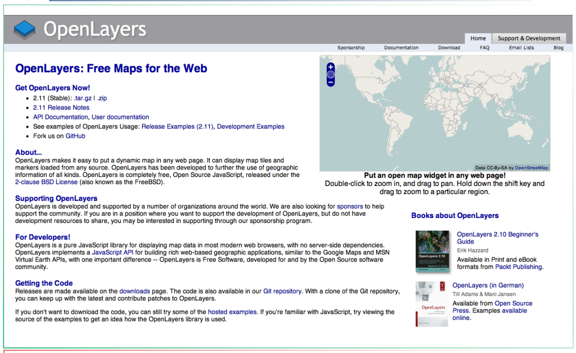
Toolkits – gRaphaël

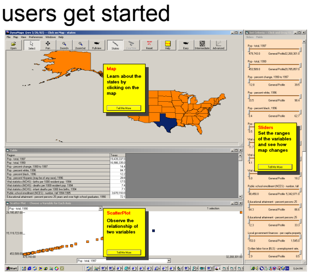


Toolkits – OpenLayers



Addressing Universal Usability

- Section 508 / users with disabilities
- Helping new users get started



- Dealing with variety of devices and network speed

AudioMap: Sonification

- **Motivation**: improve vision-impaired users' access to geo-referenced statistical data
- **Approach**: interactive sonification
  - Tie spatial sound to areas to create a virtual map
  - Data-to-sound mapping: Piano pitch -> value. Can be followed by short string pitch -> vertical position
  - Interactions for auditory information seeking
    - Gist (overview): spatial sweeping
    - Navigation: state-by-state exploration
    - Details-on-demand: name & value spoken on request
- Pilot user study (9 sighted subjects)
  - Users can recognize some geographical patterns
  - Users preferred spatial audio map over table

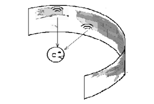


Figure 2 The 3D sounds create the virtual US state map

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Opportunities

- Improve traditional user testing
  - More complex tasks
  - Benchmark datasets AND tasks
  - Longitudinal studies
- Case studies and records of success stories
  - Looking at data from different perspectives, over a long time
  - Answering questions you didn't know you had
  - Discovery and the benefits of awareness