

# Representations and information visualization

Human Computer Interaction

Based on slide deck

**Part 4: Designing and building visual interfaces. Representations and information visualization**

Human Computer Interaction I: Principles and Design

by

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*The new slides are marked with a \**

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# **Representations and information visualization**

**Characteristics of good representations  
Information visualization**

guidelines

visual information-seeking mantra

techniques

# Representations

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## Representations

- formal system or mapping by which information can be specified (D. Marr)
- a sign system in that it stands for something other than its self

for example:

decimal: 34

binary: 100010

roman: XXXIV

different representations reveal different aspects of the information

decimal: counting & information about powers of 10

binary: counting & information about powers of 2

roman: counting

## Presentation

how the representation is placed or organized on the screen

34 , 34 , 34

## Representations - Good Representations

~~# Buffalo~~

captures essential elements of the event / world  
deliberately leaves out / mutes the irrelevant  
appropriate for the person and their interpretation  
appropriate for the task, enhancing judgement ability

|||| | |

# Buffalo

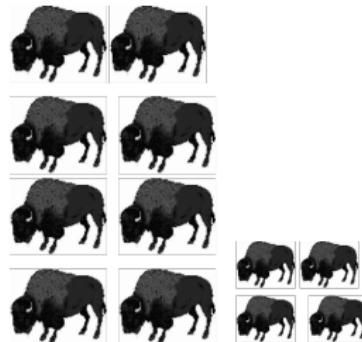
|||||

### **# Adults**

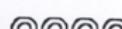
#calfs

8 4

## How many buffalo?



# Representations - Mayan Numerals



Zero

One

Two

Three

Four



Five



Six



Seven



Eight



Nine



Ten



Eleven



Twelve



Thirteen



Fourteen



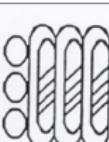
Fifteen



Sixteen



Seventeen

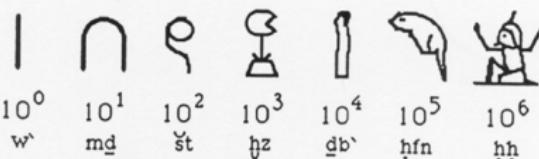


Eighteen



Nineteen

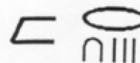
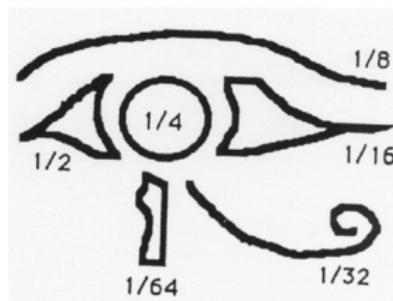
# Representations - Egyptian Numerals



Egyptian cardinal icons.



Sample Egyptian numbers.



$1/2$



$1/14$



$1/16$



$1/244$

< □ > < □ > < □ > < □ > Sample Egyptian fractions

6/59

# Representations

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**Solving a problem simply means representing it so as to make the solution transparent**

(Simon, 1981)

## Good representations

- allow people to find relevant information
  - information may be present but hard to find
- allow people to compute desired conclusions
  - computations may be difficult or "for free" depending on representations

# Which is the best flight?

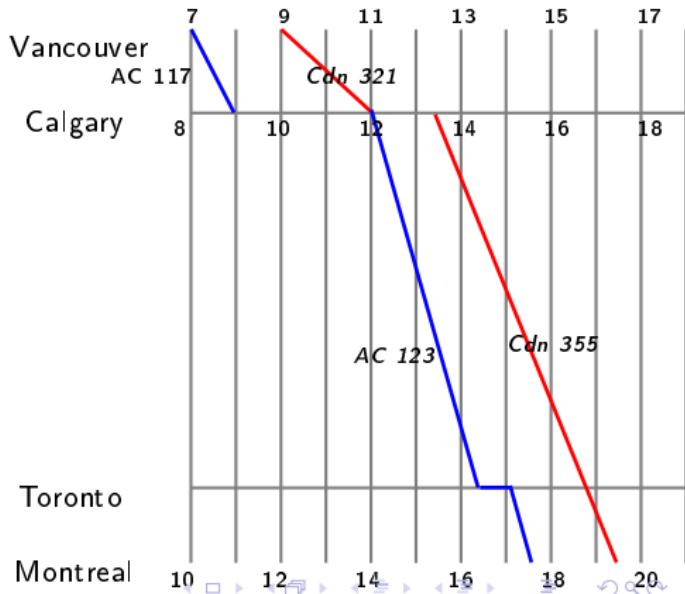
length

stop-overs

switches ...

		depart	arrive
117	Vancouver-Calgary	7:00	9:00
Cdn 321	Vancouver-Calgary	9:00	12:00
Cdn 355	Calgary-Montreal	13:30	19:30
AC 123	Calgary-Toronto	12:30	16:30
Ac 123	Toronto-Montreal	16:45	17:30

\*time zone:  
+1 van-cal,  
+2 cal-tor,  
mtl



# When do I take my drugs?

10 - 30% error rate in taking pills, same for pillbox organizers

Inderal - 1 tablet 3 times a day

Lanoxin - 1 tablet every a.m.

Carafate - 1 tablet before meals and at bedtime

Zantac - 1 tablet every 12 hours (twice a day)

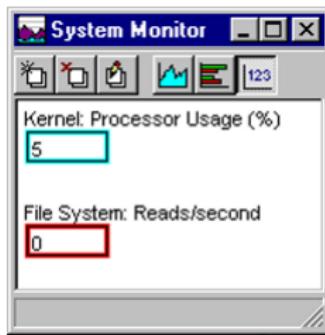
Quinag - 1 tablet 4 times a day

Couma - 1 tablet a day

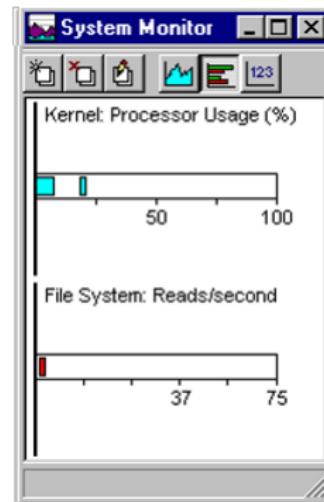
	Breakfast	Lunch	Dinner	Bedtime		Breakfast	Lunch	Dinner	Bedtime
Lanoxin	o				Lanoxin				
Inderal	o	o	o	o	Inderal	Inderal	Inderal	Inderal	
Quinag	o	o	o	o	Quinag	Quinag	Quinag	Quinag	
Carafate	o	o	o	o	Carafate	Carafate	Carafate	Carafate	
Zantac		o		o	Zantac				Zantac
Couma				o	Couma				Couma

# Which representation is best?

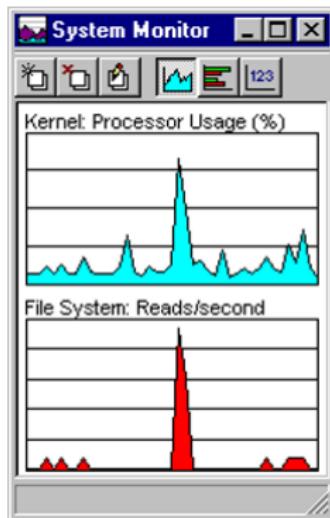
**depends heavily on task**



## What is precise value?

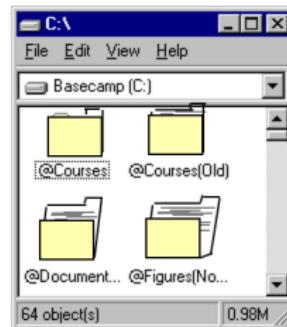
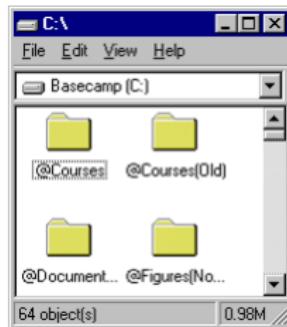


How does the performance now compared to its peak?

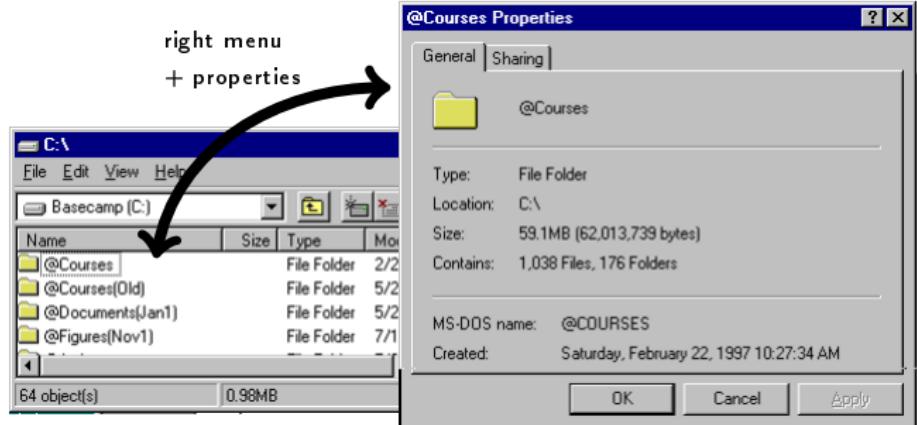


How does the performance change over time?

## Which folder has the most documents?



right menu  
+ properties



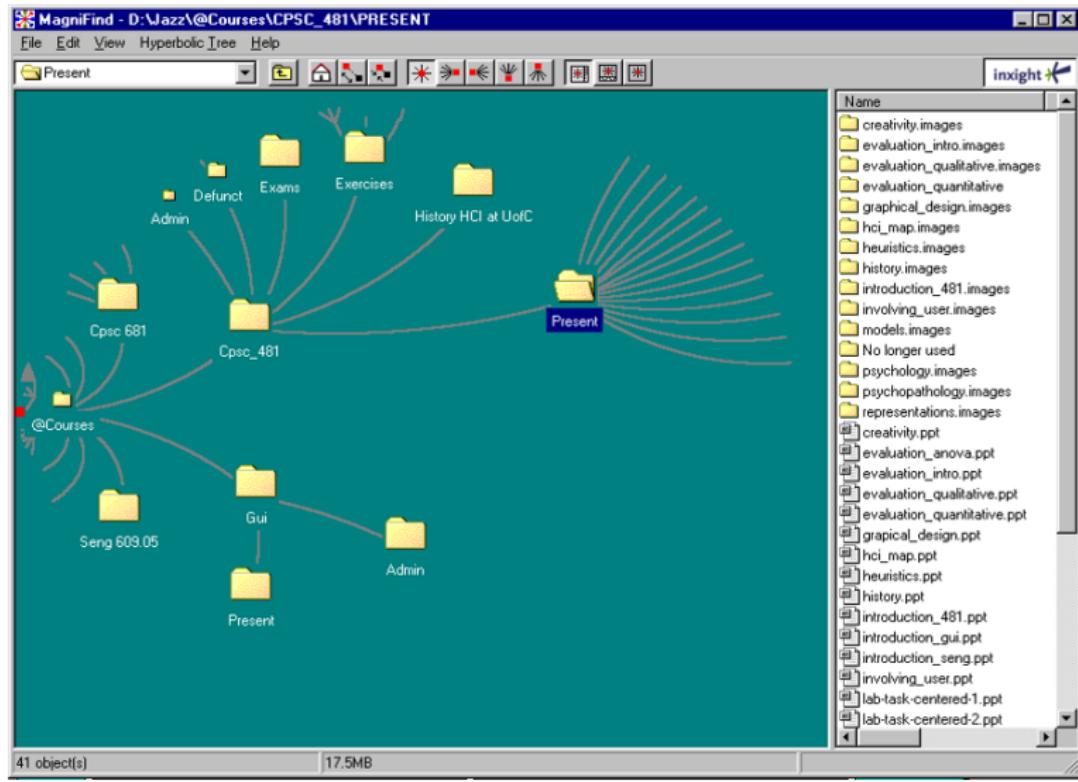
# Where am I?

Detailed navigation  
plus precision

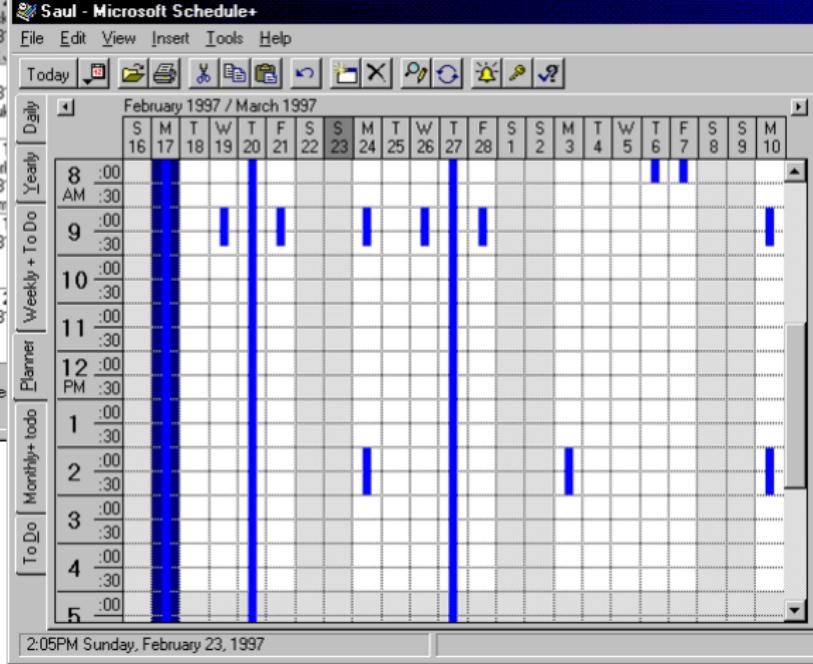
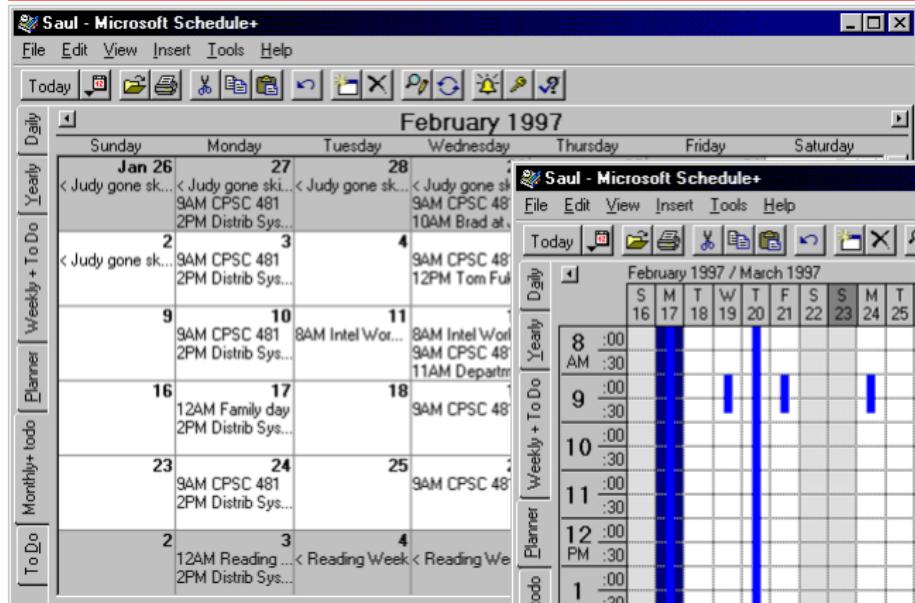


## General navigation plus orientation

# Where am I?



## What do I have to do?



# Information Visualization

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Graphics should reveal the data

- show the data
- not get in the way of the message
- avoid distortion
- present many numbers in a small space
- make large data sets coherent
- encourage comparison between data
- supply both a broad overview and fine detail
- serve a clear purpose

E. Tufte  
*Visual Display of Quantitative Information*

## \*Anscombe's Quartet

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- ▶ comprises four datasets that have nearly identical simple descriptive statistics
- ▶ yet appear **very different** when graphed
- ▶ constructed in 1973 by the statistician Francis Anscombe to demonstrate the importance of graphing data before analysing it

[https://en.wikipedia.org/wiki/Anscombe%27s\\_quartet](https://en.wikipedia.org/wiki/Anscombe%27s_quartet)

# \*Anscombe's Quartet

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The data:

I		II		III		IV	
x	y	x	y	x	y	x	y
10.0	8.04	10.0	9.14	10.0	7.46	8.0	6.58
8.0	6.95	8.0	8.14	8.0	6.77	8.0	5.76
13.0	7.58	13.0	8.74	13.0	12.74	8.0	7.71
9.0	8.81	9.0	8.77	9.0	7.11	8.0	8.84
11.0	8.33	11.0	9.26	11.0	7.81	8.0	8.47
14.0	9.96	14.0	8.10	14.0	8.84	8.0	7.04
6.0	7.24	6.0	6.13	6.0	6.08	8.0	5.25
4.0	4.26	4.0	3.10	4.0	5.39	19.0	12.50
12.0	10.84	12.0	9.13	12.0	8.15	8.0	5.56
7.0	4.82	7.0	7.26	7.0	6.42	8.0	7.91
5.0	5.68	5.0	4.74	5.0	5.73	8.0	6.89

# \*Anscombe's Quartet

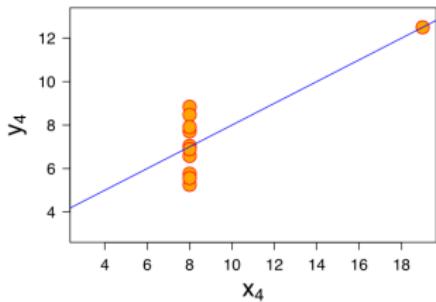
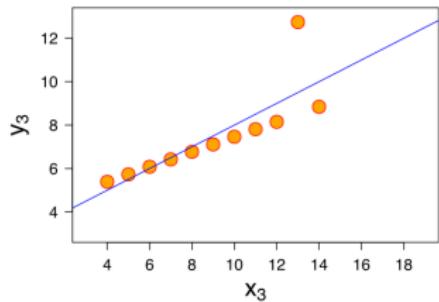
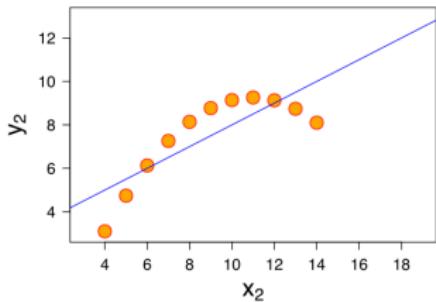
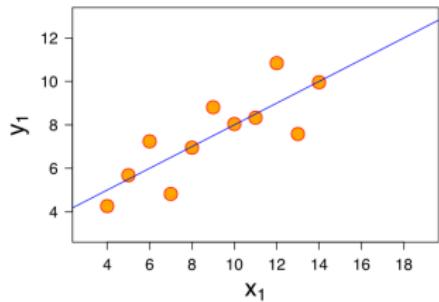
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For all four datasets the basic statistic properties are the same:

Property	Value	Accuracy
Mean of $x$	9	exact
Sample variance of $x$	11	exact
Mean of $y$	7.50	to 2 decimal places
Sample variance of $y$	4.125	$\pm 0.003$
Correlation between $x$ and $y$	0.816	to 3 decimal places
Linear regression line	$y = 3.00 + 0.500x$	to 2 and 3 decimal places, respectively
Coefficient of determination of the linear regression	0.67	to 2 decimal places

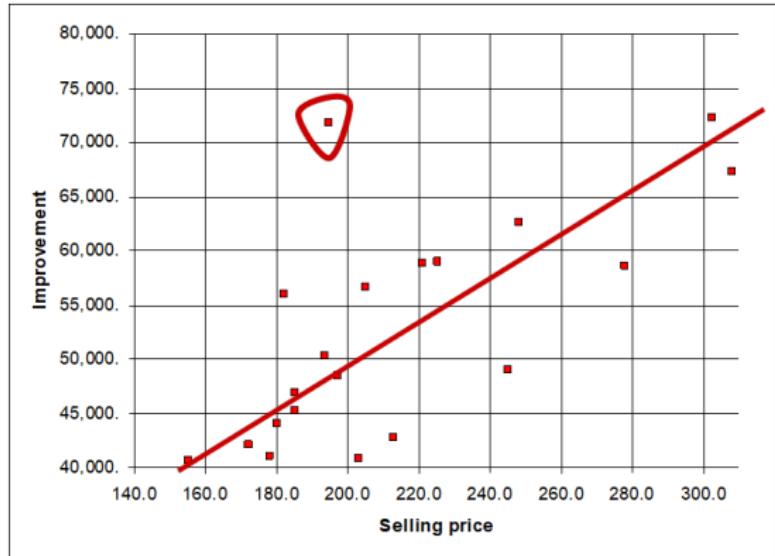
# Anscombe's Quartet

But the **graphics reveal the data**:

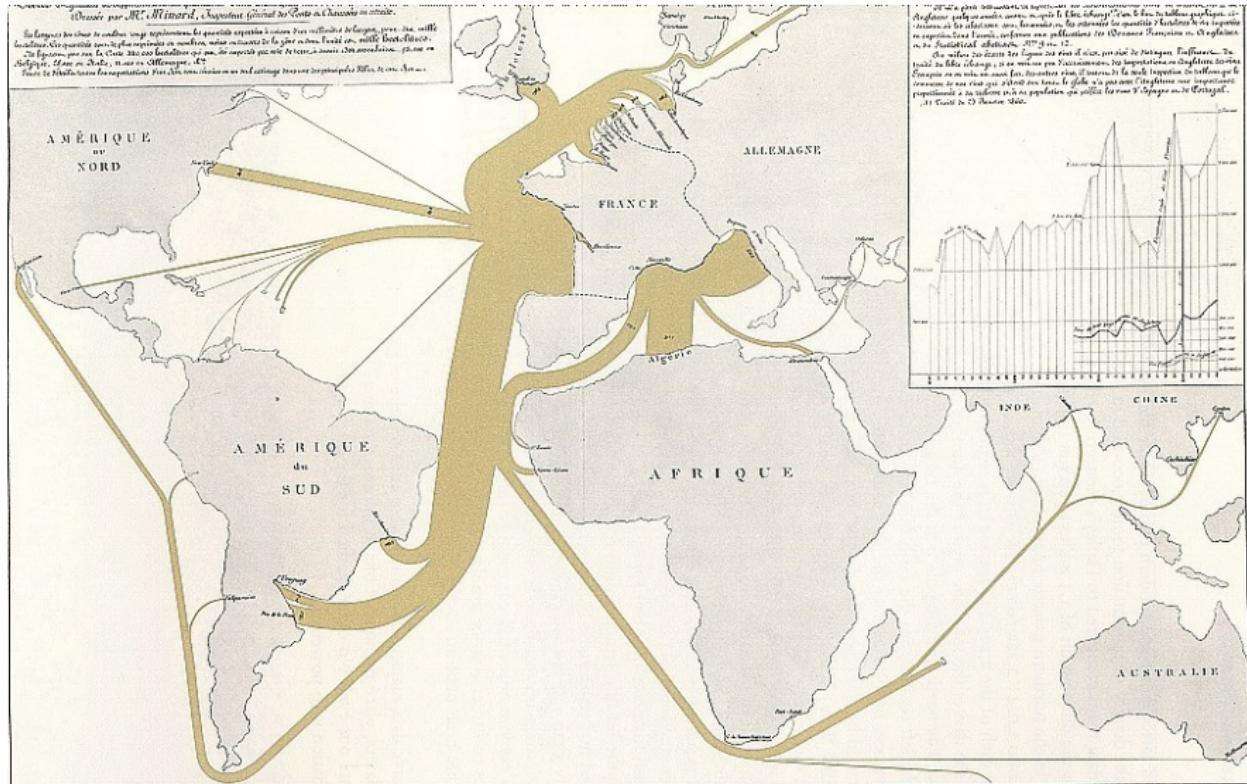


## Do I deserve a tax break?

	A	C
1	Market value (*\$1000)	Improvement
2	140.0	31,120.
3	147.0	29,980.
4	151.0	38,120.
5	152.0	34,360.
6	155.0	40,710.
7	170.0	21,620.
8	172.0	42,100.
9	178.0	41,070.
10	180.0	34,210.
11	180.0	44,090.
12	182.0	55,960.
13	185.0	45,170.
14	185.0	46,820.
15	193.4	50,200.
17	194.5	71,860.
18	197.0	48,460.
19	203.0	40,720.
20	205.0	56,600.
21	213.0	42,780.
22	221.0	58,770.
23	225.0	58,960.
24	245.0	48,910.
25	248.0	62,620.
26	278.0	58,580.
27	302.5	72,200.
28	308.0	67,320.



## Exports of French Wine, 1864



## \*Deaths by Cholera, Dr. John Snow, 1854

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British doctor **John Snow** couldn't convince other doctors and scientists that cholera, a deadly disease, was spread when people drank contaminated water until a mother washed her baby's diaper in a town well in 1854 and touched off an epidemic that killed 616 people.

<https://www.ph.ucla.edu/epi/snow/snowcricketarticle.html>

# Deaths by Cholera, Dr. John Snow, 1854



## \*Deaths by Cholera, Dr. John Snow, 1854

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- ▶ in red his column of bars - each representing a cholera death
- ▶ in blue the local water pumps, including the Broad Street pump - servicing the well that was the source of cholera

[https://www.circleofblue.org/2013/world/](https://www.circleofblue.org/2013/world/peter-gleick-200-years-of-dr-john-snow-a-significant-figure/)

[peter-gleick-200-years-of-dr-john-snow-a-significant-figure/](https://www.circleofblue.org/2013/world/peter-gleick-200-years-of-dr-john-snow-a-significant-figure/)

## \*Napoleons march to Moscow, Charles Joseph Minard

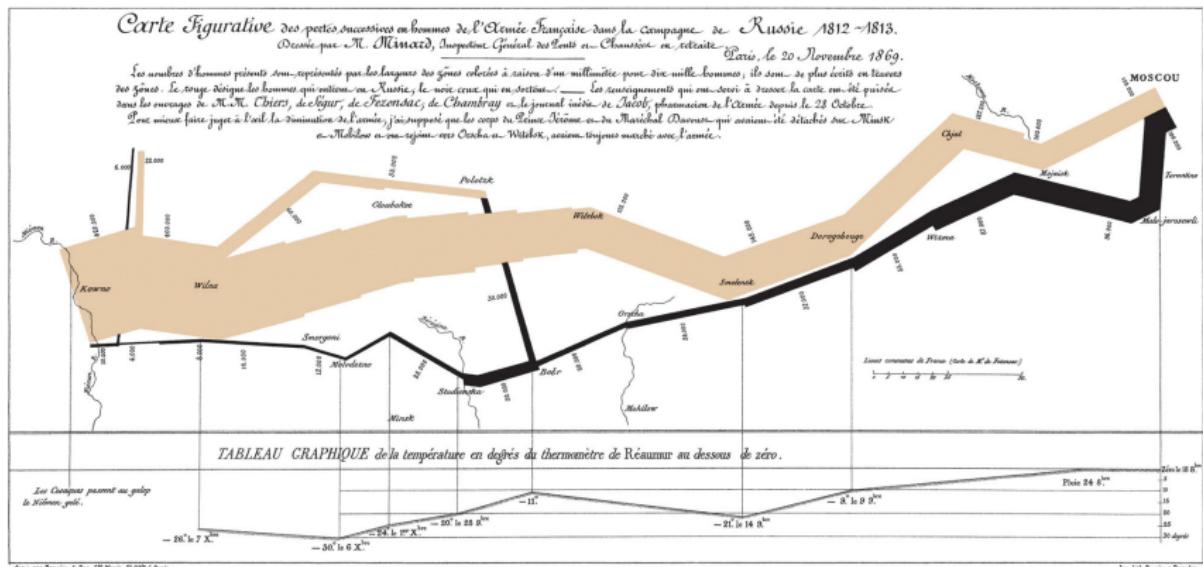
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The graphic is notable for its representation in two dimensions of six types of data:

- ▶ the number of Napoleon's troops
- ▶ distance
- ▶ temperature
- ▶ the latitude and longitude
- ▶ direction of travel
- ▶ location relative to specific dates

[https://en.wikipedia.org/wiki/Charles\\_Joseph\\_Minard](https://en.wikipedia.org/wiki/Charles_Joseph_Minard)

# Napoleonic's march to Moscow, Charles Joseph Minard



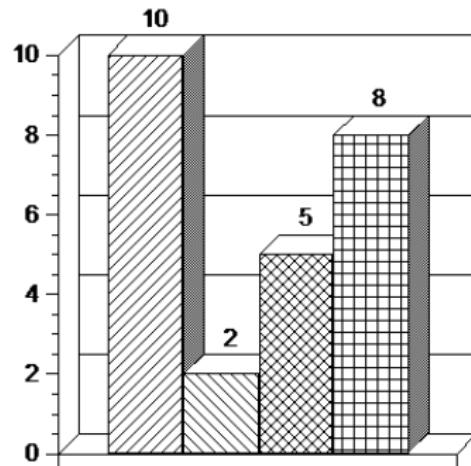
# Chart Junk: A common error

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Information display is not just pretty graphics

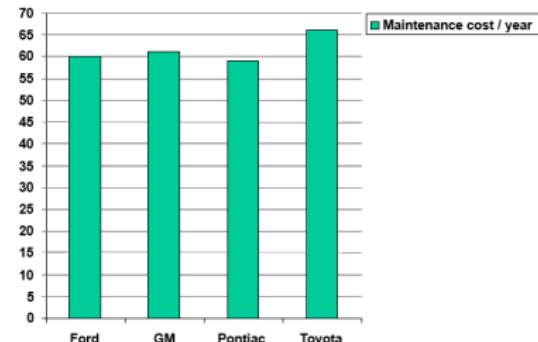
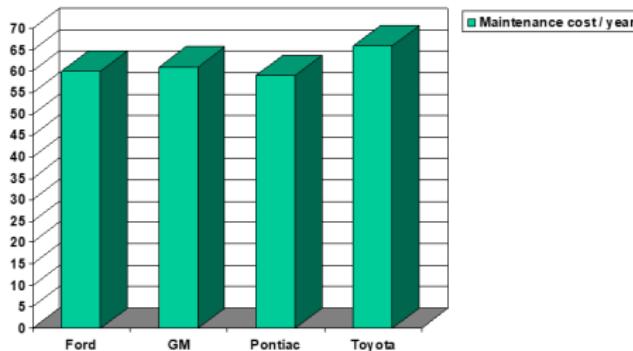
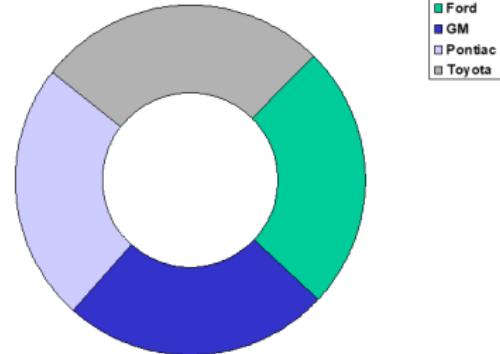
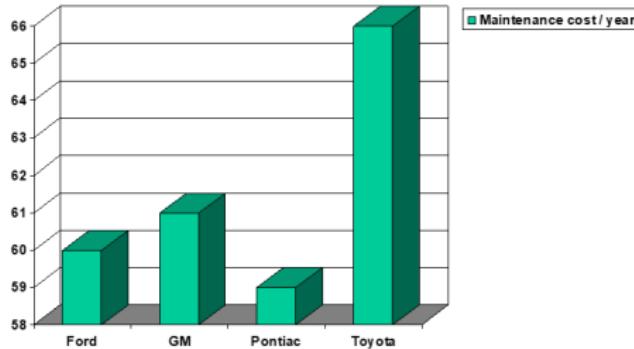
- graphical re-design by amateurs on computers leads to "chart-junk", etc.

Dear Sir,  
This is a *really* exciting opportunity! Take  
advantage of it!



# Chart Junk: Removing deception and simplification

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## \*Small multiples

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- ▶ data visualization that consists of multiple charts arranged in a grid
- ▶ it makes easy to compare the entirety of the data
- ▶ a.k.a. trellis, lattice, grid, and panel charts

<https://www.displayr.com/what-are-small-multiples/>

## \*Small multiples

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The required data for a small multiple is typically a **table**, where the rows or columns contain the data for each of the separate series to be plotted

Column %	Vote for Clinton	Vote for Trump	Vote for another candidate	Not vote	Don't know	I refuse to answer this question	NET
Midwest	21%	21%	17%	21%	0%	20%	21%
Northeast	11%	17%	13%	21%	0%	13%	15%
South	24%	37%	17%	18%	100%	20%	27%
West	43%	25%	52%	39%	0%	47%	38%
Outside of the USA	0%	0%	0%	0%	0%	0%	0%
NET	100%	100%	100%	100%	100%	100%	100%

# \*Small multiples

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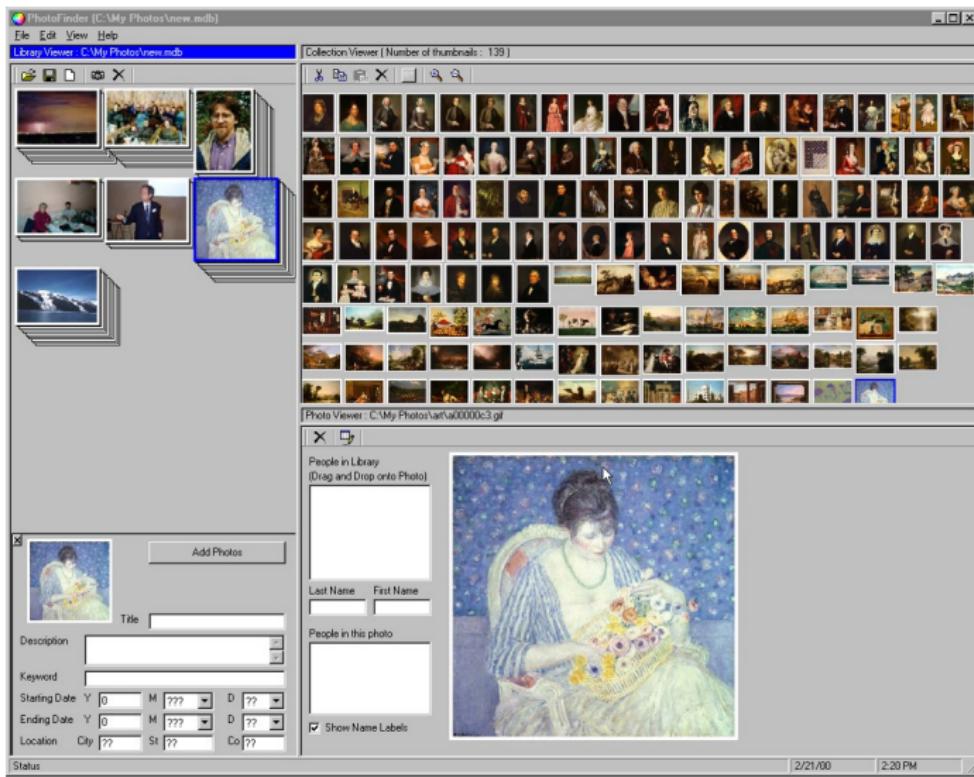
# Visual information-seeking mantra

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

Shneiderman, Designing the User Interface 3rd Ed., 1997, p. 523

# PhotoFinder



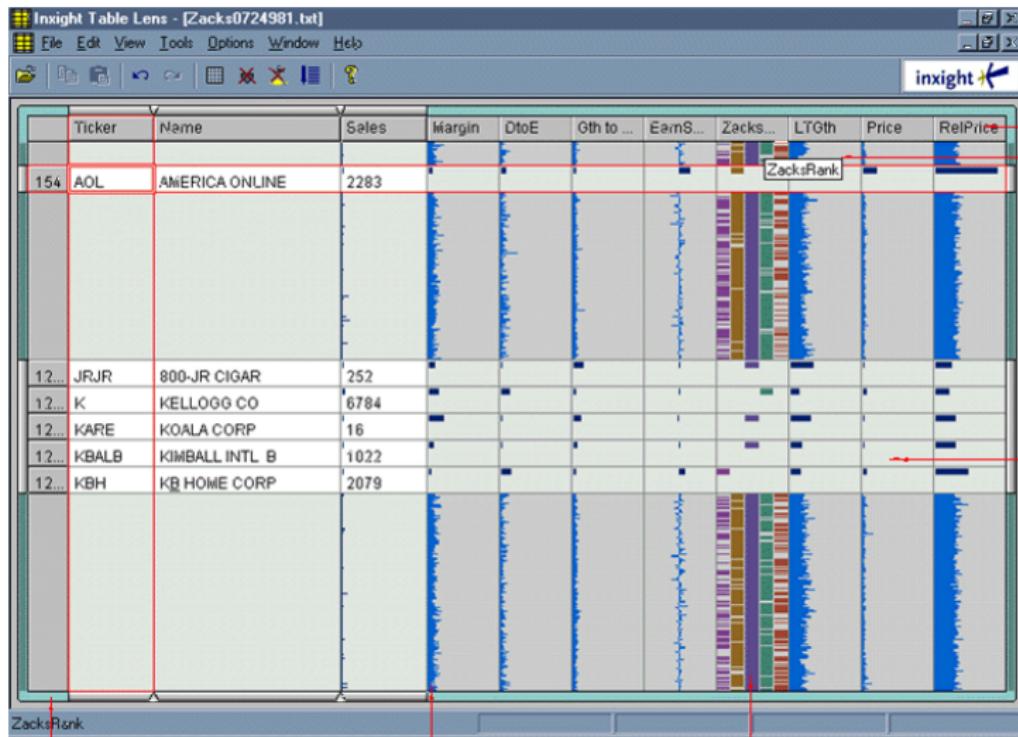
# \*PhotoFinder

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University of Maryland, Human Computer Interaction Laboratory

<http://www.cs.umd.edu/hcil/photolib/>

# Table Lens



Inxight Table Lens

# Table Lens

Housing Market for Santa Clara County, CA - March 2000

Bedrooms	Price	Square Foot	Status	Baths	Address	City	State	Zip	Realtor	MLS #
5	151	389,000	3531	Sale Pending	4	6755 STEPH...	Gilroy	CA	95020	CENTURY 2... 4361
	152	389,000	2281		3	3583 BAYO...	San Jose	CA	95111	BAY CITES ... 10970
	153	389,000	-	Sale Pending	1.5	1781 ANGEL...	San Jose	CA	95111	ROSE GARD... 944120
4										
3										
2										

Spotlight Column

## \*Table Lens

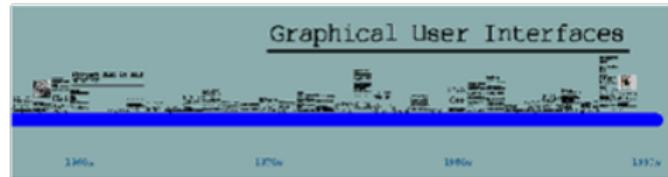
---

Ramana Rao and Stuart K. Card, **The Table Lens: Merging Graphical and Symbolic Representations in an Interactive Focus+ Context Visualization for Tabular Information**, Proceedings of the SIGCHI conference on Human factors in computing systems, pp. 318-322, ACM, 1994

<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.115.8862&rep=rep1&type=pdf>

# Infinite Zoom

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## \*Infinite Zoom

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B. B. Bederson et al, **Pad++: A Zoomable Graphical Sketchpad for Exploring Alternate Interface Physics**, Journal of Visual Languages and Computing vol. 7, issue 1, March 1996

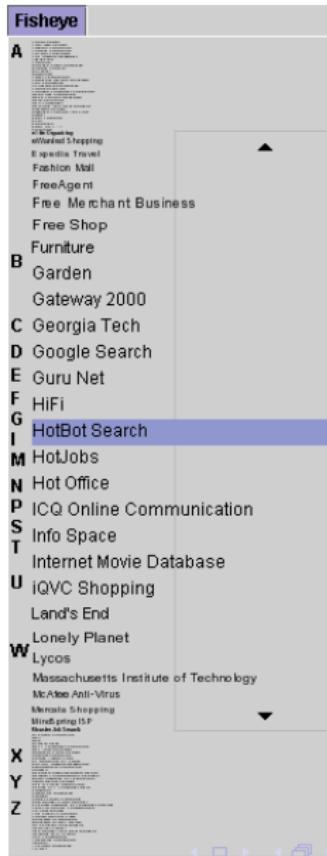
<https://www.cs.umd.edu/hcil/pad++/papers/chi-94-pad/index.html>

Article presentation:

<https://slideplayer.com/slide/8806742/>

# Fisheye Menus

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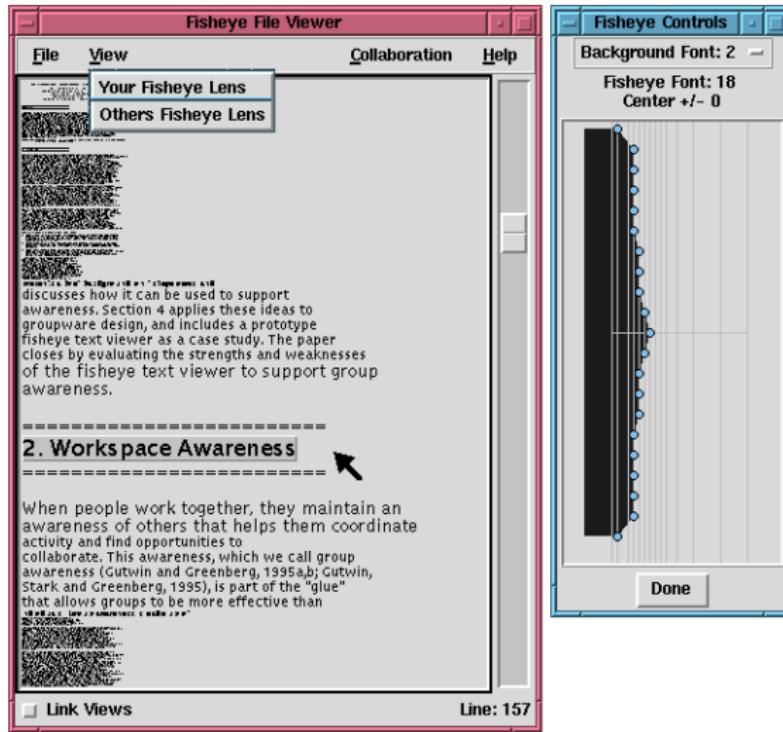
## \*Fisheye Menus

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B. B. Bederson, **Fisheye Menus**, Proceedings of ACM Conference on User Interface Software and Technology (UIST 2000), pp. 217-226, ACM Press, November 2000

<http://www.cs.umd.edu/hcil/fisheyemenu/>

# Fisheye Text Editors



# Fisheye Text Editors

The image displays three windows from the Fisheye Text Editors application:

- Fisheye File Viewer**: A window showing a document with a QR code. The text discusses the differences between relaxed WYSIWIS face-to-face and through groupware, mentioning the equivalent of WYSIWIS situations like reading different work artifacts. It also mentions a prototype fisheye text viewer and its strengths and weaknesses.
- Open Registration**: A window titled "Conferences" showing "FisheyeNew" listed. The "Participants" section shows "Carl", "Andy", and "Saul Greenberg". Below it, a message says "You are: Saul Greenberg".
- Others Fisheye**: A settings window with "Their Font Size: 10" and "Visible Lines: 4" selected. There is a "Done" button at the bottom.

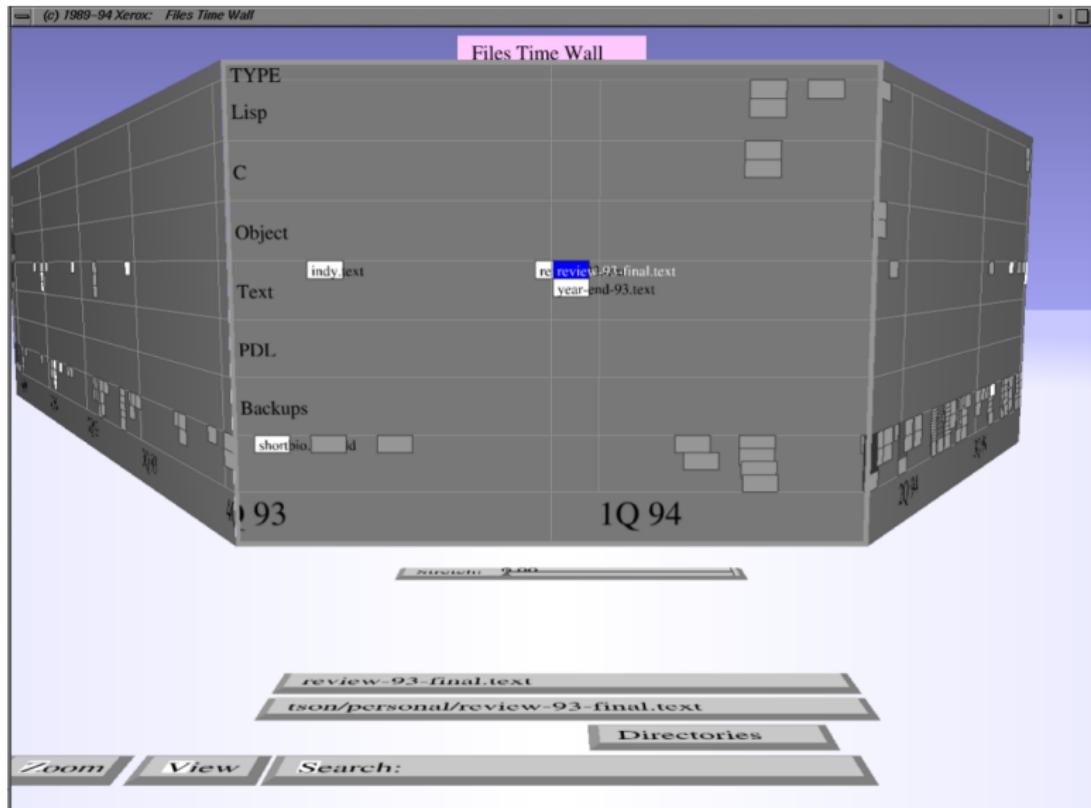
## \*Fisheye Text Editors

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Saul Greenberg, **A Fisheye Text Editor for Relaxed-WYSIWIS Groupware**, Conference on Human Factors in Computing Systems: Conference companion on Human factors in computing systems: common ground, vol. 13, no. 18, 1996

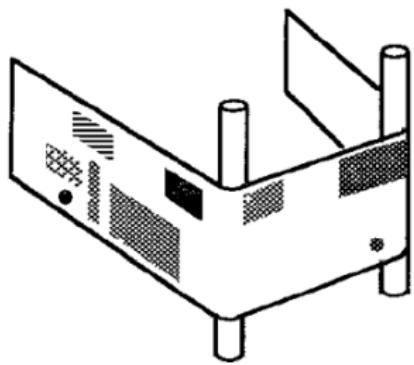
<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.41.4101&rep=rep1&type=pdf>

# Perspective Wall



# Perspective Wall

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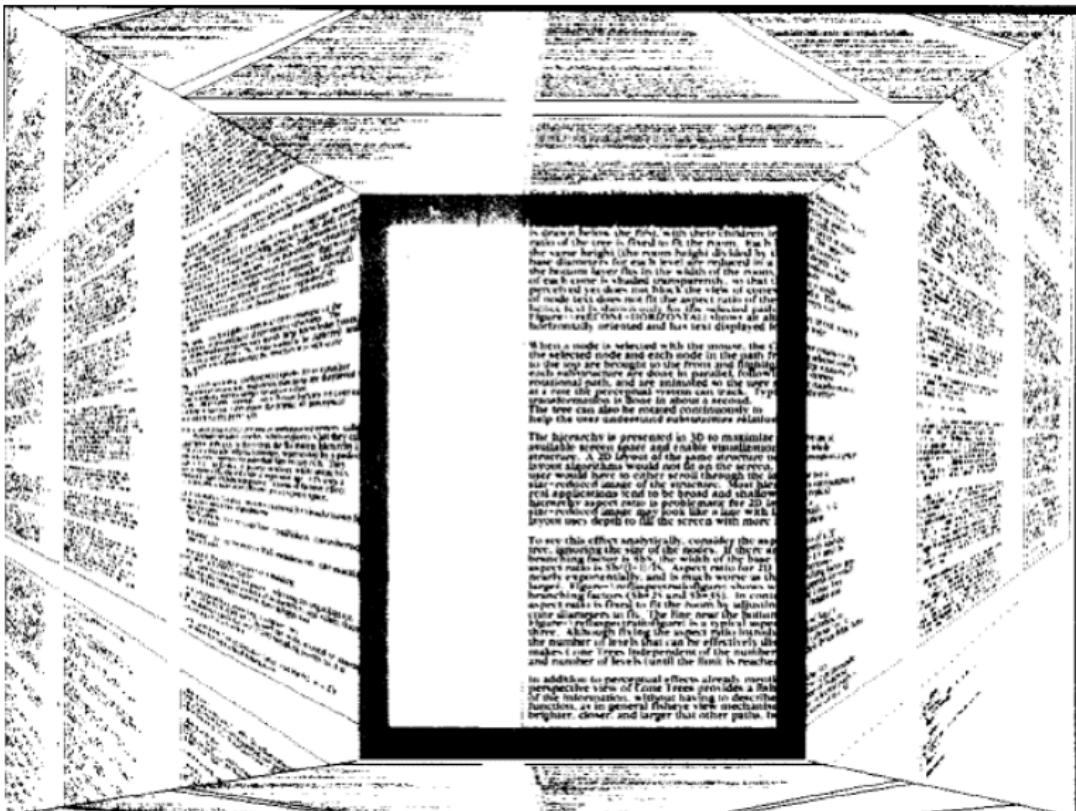
## \*Perspective Wall

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Jock D. Mackinlay, George G. Robertson, Stuart K. Card, **The perspective wall: detail and context smoothly integrated**, CHI '91 Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, pp. 173-176, New Orleans, Louisiana, USA, April 27 - May 02, 1991

[https://www.researchgate.net/profile/Stuart\\_Card/publication/221514203\\_The\\_perspective\\_wall\\_Detail\\_and\\_context\\_smoothly\\_integrated/links/09e4150e317b65a315000000.pdf](https://www.researchgate.net/profile/Stuart_Card/publication/221514203_The_perspective_wall_Detail_and_context_smoothly_integrated/links/09e4150e317b65a315000000.pdf)

# Document Lens



is drawn below the tree, with their children's ratios of the tree is fixed to fit the screen. So is the screen height (the screen height divided by a factor of two) and the width of the screen. The beams layer fits in the width of the screen, so each beam's width is shaded transparently, so that the user can see the text behind it. The ratio of node texts does not fit the aspect ratio of the beams to its children in width, so the selected path is highlighted in black. The user can scroll through the tree to see more nodes.

If a node is selected with the mouse, the children of the selected node and each node in the path from the top are brought to the front and displayed in perspective. They are rotated around their rotational path, and are estimated on the size of a tree the percentage screen can track. Typically, the tree is much larger than the screen. The tree can also be rotated continuously to help the user understand substructure relations.

The hierarchy is presented in 3D to maximize available screen space and enable visualization of large amounts of data. A 2D representation of these algorithms would not do the screen justice. The user would have to either scroll through the screen to see all the data or zoom in to see the details. Most graphical applications tend to have broad and shallow hierarchy aspect ratios is problematic for 2D visualization. Document Lens uses a perspective view to draw users deep to the screen with more.

To see this effect spatially, consider the image tree, ignoring the size of the nodes. If there are branching factor of six, the width of the tree is six times the size of a single node. And each node is the same size, exponentially, and much worse as the larger. Figure 1 illustrates a figure showing a tree with a branching factor of six, where the aspect ratio is fixed to fit the screen by utilizing the differences in fig. The line near the bottom of the image is the root node, and the line is reached after 10 levels. Interestingly, the line is much longer than the others, and the line is reached after 10 levels.

In addition to perspective effects already, many perspective view of Cone Trees provides both the depth of the information, without having to describe the entire tree. The tree is much more compact, and the higher, closer and larger that other parts. In

## \*Document Lens

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George G. Robertson, Jock D. Mackinlay, **The document lens**,  
UIST '93 Proceedings of the 6th annual ACM symposium on User  
interface software and technology, pp. 101-108, Atlanta, Georgia,  
USA

[https://www.researchgate.net/profile/Jock\\_Mackinlay/  
publication/220877428\\_The\\_Document\\_Lens/links/  
0deec52598e6e183e000000/The-Document-Lens.pdf](https://www.researchgate.net/profile/Jock_Mackinlay/publication/220877428_The_Document_Lens/links/0deec52598e6e183e000000/The-Document-Lens.pdf)

# Data Mountain

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# Data Mountain



## \*Data Mountain

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Robertson, Czerwinski, Larson, Robbins, Thiel, van Dantzich, **Data Mountain: Using Spatial Memory for Document Management**, Proceedings of the 11th annual ACM symposium on User interface software and technology, ACM, 1998

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# Task Gallery

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## \*Task Gallery

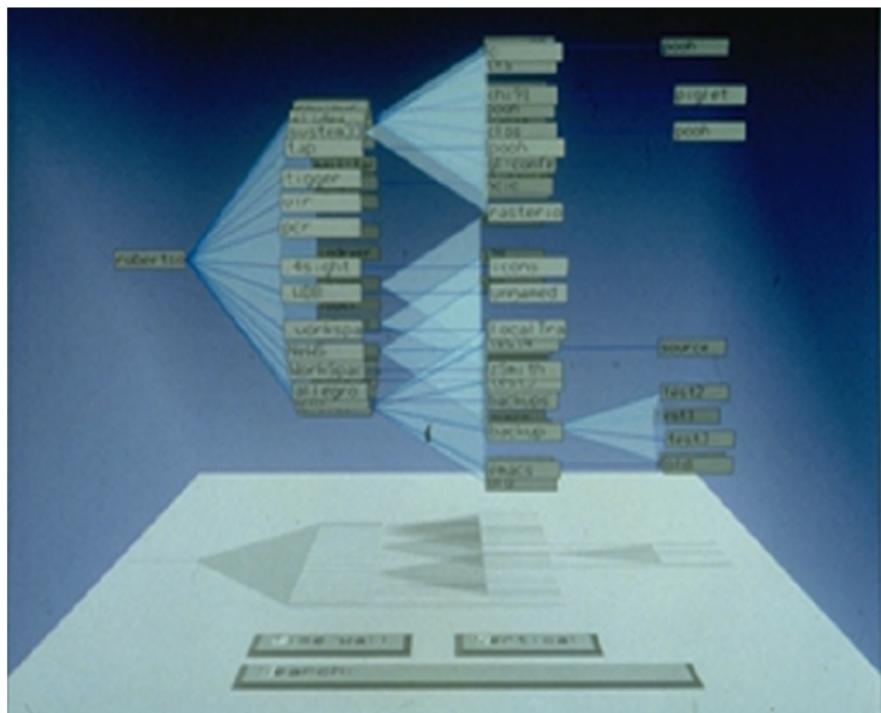
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George Robertson, Maarten van Dantzich, Daniel Robbins, Mary Czerwinski, Ken Hinckley, Kirsten Risden, David Thiel, Vadim Gorokhovsky, **The Task Gallery: A 3D Window Manager**, CHI '00 Proceedings of the SIGCHI conference on Human Factors in Computing Systems, April 2000

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# Cone Trees

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## \*Cone Trees

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# What you now know

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## Good representations

- appropriate for the person, their task, and their interpretation
- captures essential elements of the event / world & mutes the irrelevant

## Information visualization

- Tufte's principles
- overview first, zoom and filter, then details on demand
- many techniques now available

# Interface Design and Usability Engineering

## Goals:

Articulate:  
• who users are  
• their key tasks

Brainstorm designs

Refined designs

Completed designs

Task centered system design  
Participatory design  
User-centered design

Evaluate tasks

Psychology of everyday things  
User involvement  
**Representation & metaphors**

Participatory interaction

Task scenario walk-through

Graphical screen design  
Interface guidelines  
Style guides

Usability testing  
Heuristic evaluation

Field testing

## Methods:

User and task descriptions

low fidelity prototyping methods

Throw-away paper prototypes

high fidelity prototyping methods

Testable prototypes

Alpha/beta systems or complete specification

## Products:

# \*Bibliography

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