

Beyond Simple Screen Design

Characteristics of good representations

Information visualization

Tufte's guidelines

Visual variables

Visual information-seeking mantra

Metaphors

Direct manipulation

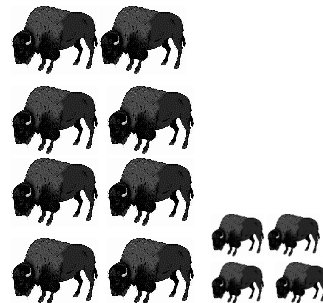
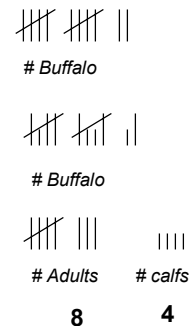
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Representations

Good representations

- 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 judgment ability

How many buffalo?



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Representation

A representation is

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

for example: the number thirty-four *or* the buffalo example

decimal: 34,
binary: 100010,
roman: XXXIV

different representations reveal different aspects of the information

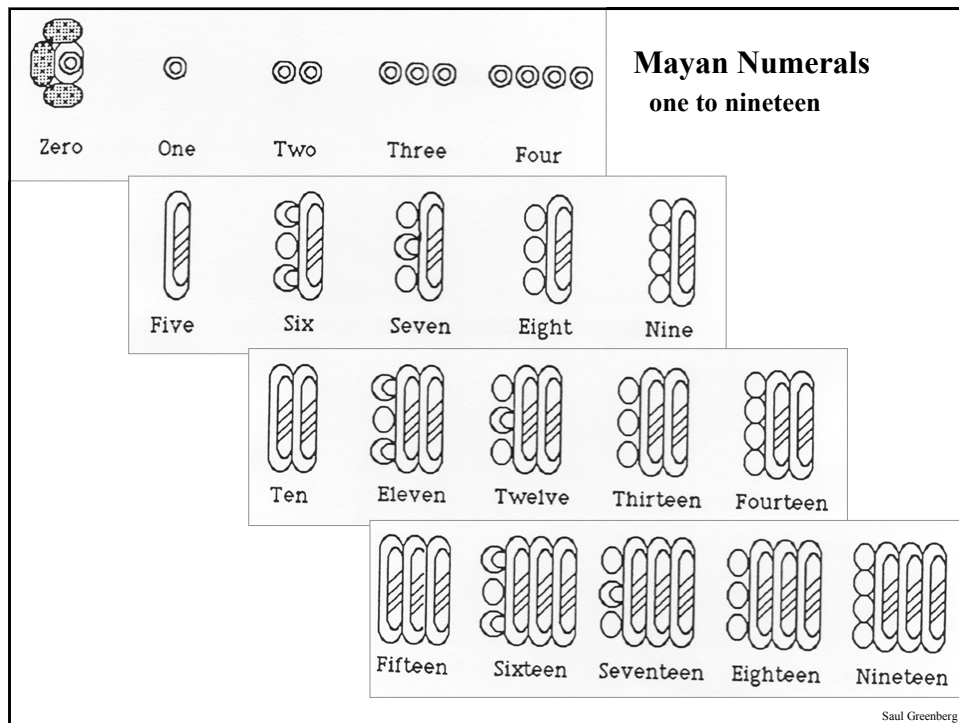
decimal: counting & information about powers of 10,
binary: counting & information about powers of 2,
roman: counting

presentation

how the representation is placed or organized on the screen

34, 34, 34

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Egyptian Numerals

The image displays various Egyptian numerals. At the top, seven cardinal icons are shown with their powers of 10 and hieroglyphic symbols: 10^0 (w), 10^1 (mg), 10^2 (zt), 10^3 (hz), 10^4 (db), 10^5 (hfn), and 10^6 (hh). Below these, two sample numbers are shown: 24 (three tens and four ones) and 142,149 (one hundred, four tens, two ones, and four fifties). At the bottom, sample fractions are shown: $1/2$ (a lotus flower), $1/4$ (a circle), $1/8$ (a triangle), $1/16$ (a triangle with a dot), $1/64$ (a triangle with a dot and a line), $1/32$ (a triangle with a dot and a line), $4/7$ (a lotus flower and four circles), $13/16$ (a lotus flower and thirteen circles), and $1/244$ (a lotus flower and two hundred and forty-four circles).

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Representations

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

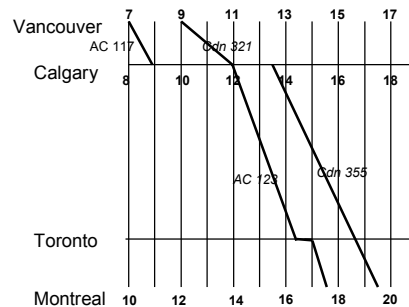
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Which is the best flight?

length, stop-overs, switches...

		depart	arrive
AC 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



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When do I take my drugs?

Note: 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

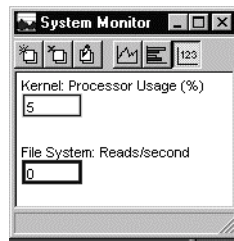
	Breakfast	Lunch	Dinner	Bedtime		Breakfast	Lunch	Dinner	Bedtime
Lanoxin	O				Lanoxin				
Inderal	O	O	O	O	Inderal	Inderal	Inderal	Inderal	Inderal
Quinag	O	O	O	O	Quinag	Quinag	Quinag	Quinag	Quinag
Carafate	O	O	O	O	Carafate	Carafate	Carafate	Carafate	Carafate
Zantac		O		O	Zantac			Zantac	Zantac
Couma			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

Organized by both time of day and by drug

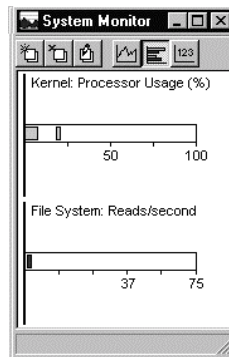
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Which representation is best?

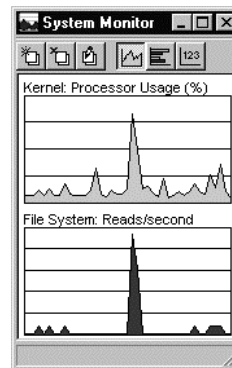
depends heavily on task



What is precise value?



How does the performance now compared to its peak?



How does performance change over time?

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Where am I?

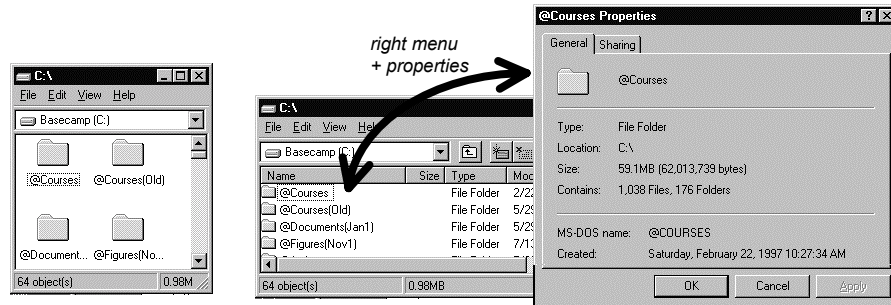
Detailed navigation plus precision



General navigation plus orientation

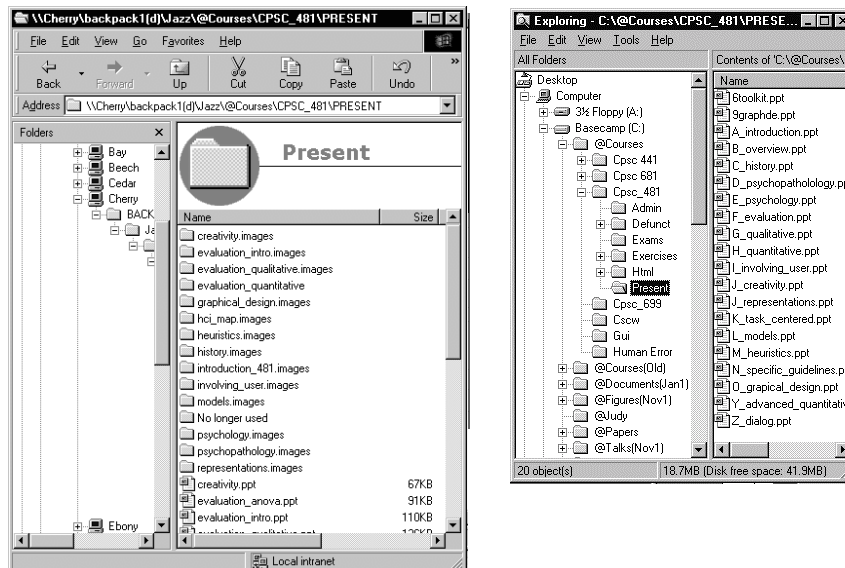
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Which folder has the most documents?



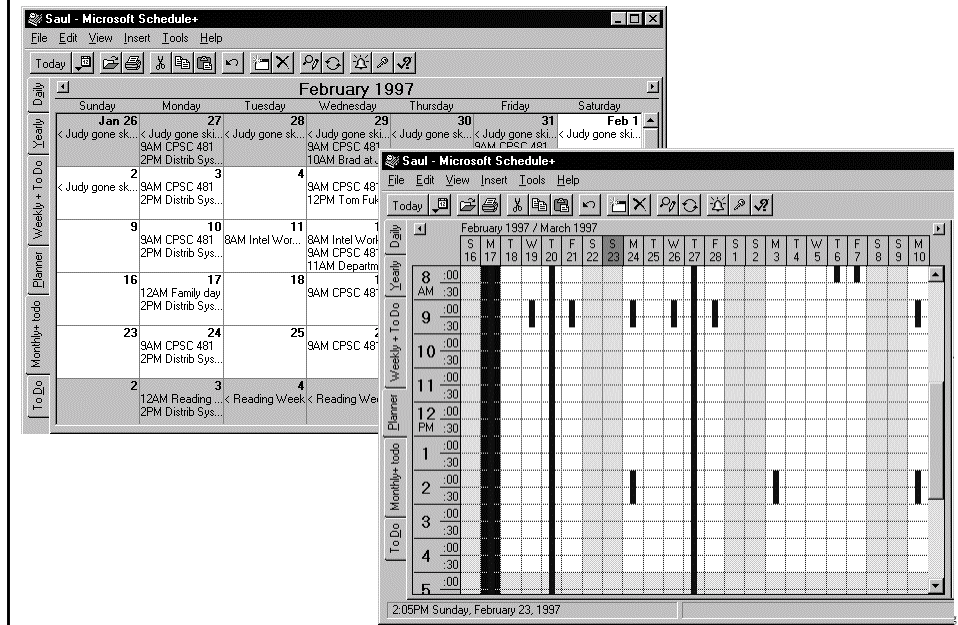
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Where am I?



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What do I have to do?



Information Visualization

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

note:

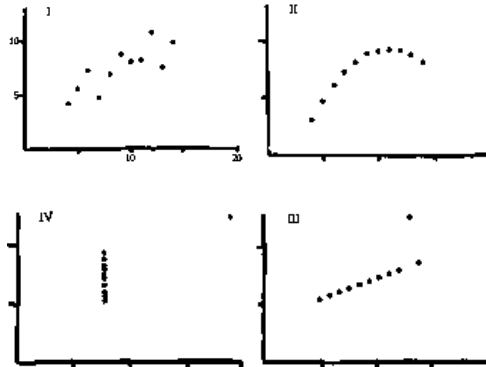
many visual examples on the following slides are taken from Tufte's books

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Anscombe's Quartet

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

N: 11.0
 mean X's : 9.0
 mean Y's : 7.5
 standard error of slope estimate: 0.1
 sum of squares: 110.0
 regression sum of squares: 27.5
 residual sum of squares of Y: 13.8
 correlation coefficient: 0.8
 r squared: 0.7
 regression line: $Y=3+0.5X$

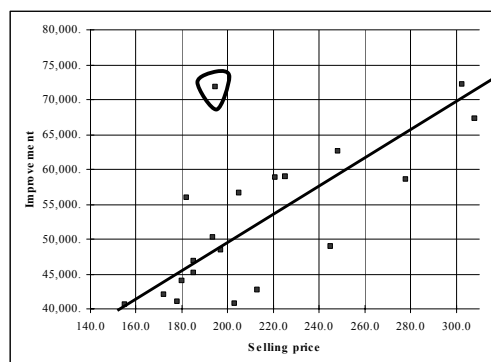


Graphics Reveal the Data

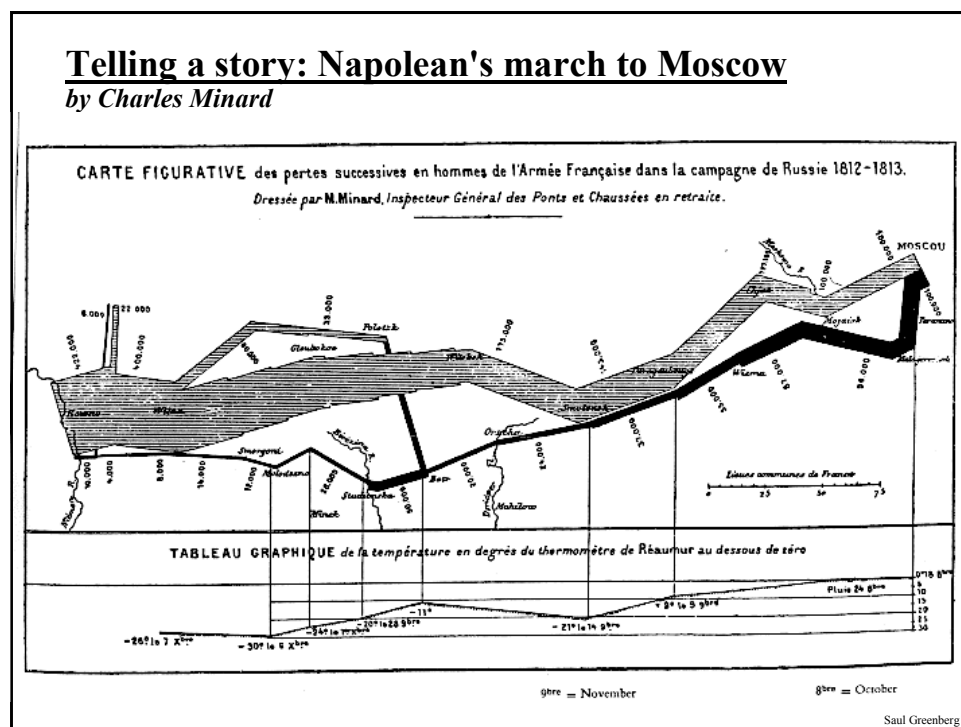
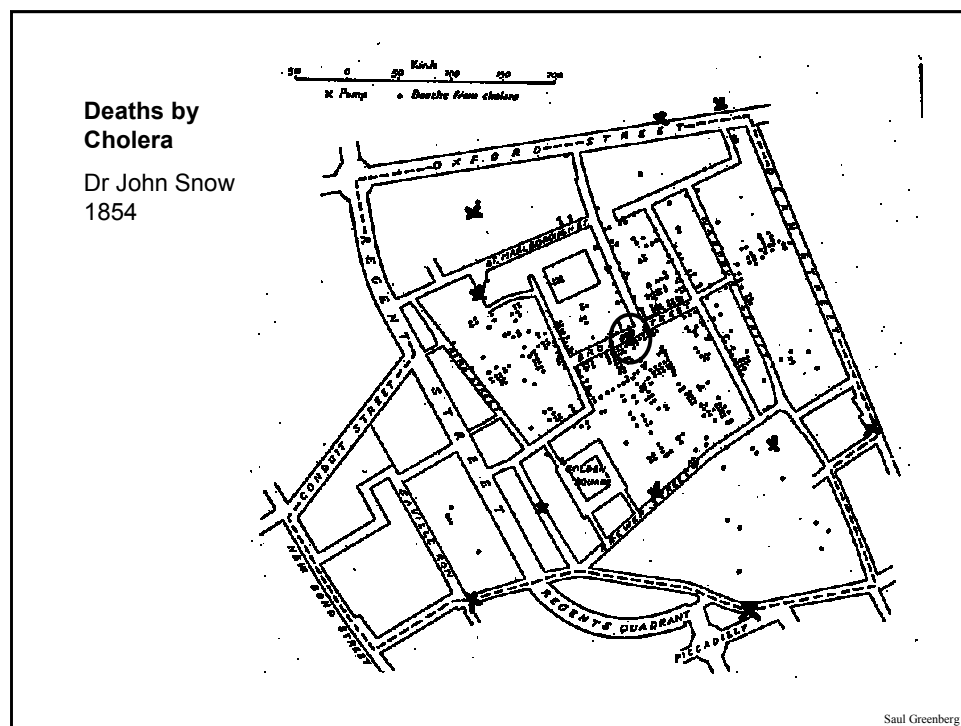
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Do I deserve a tax break?

Taxcomp.xls		
	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.
16	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.



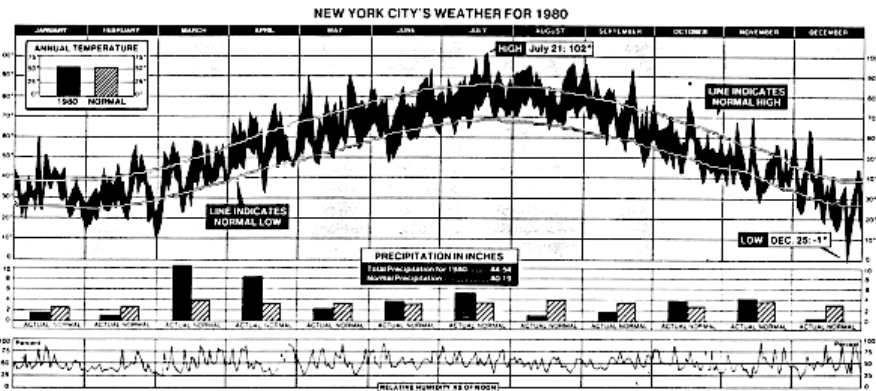
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Data Density

New York Weather History

- 181 numbers/sq inch

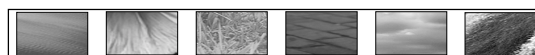
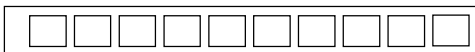
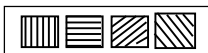
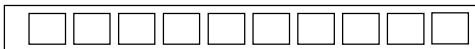
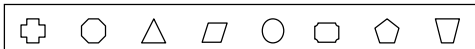
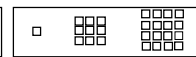
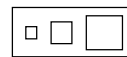
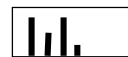
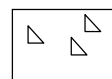


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Visual Variables

Attributes

- **position**
 - changes in the x, y (z) location
- **size**
 - change in length, area or repetition
- **shape**
 - infinite number of shapes
- **value**
 - changes from light to dark
- **orientation**
 - changes in alignment
- **colour**
 - changes in hue at a given value
- **texture**
 - variation in pattern
- **motion**



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Visual Variables

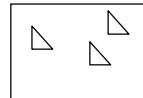
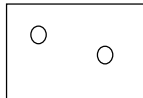
Characteristics of visual variables can be

- **selective**
is a change in this variable enough to allow us to select it from a group?
- **associative**
is a change in this variable enough to allow us to perceive them as a group?
- **quantitative**
is there a numerical reading obtainable from changes in this variable?
- **order**
are changes in this variable perceived as ordered?
- **length**
across how many changes in this variable are distinctions perceptible?

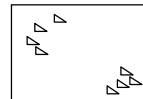
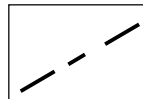
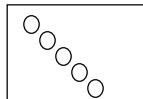
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Visual Variable: Position

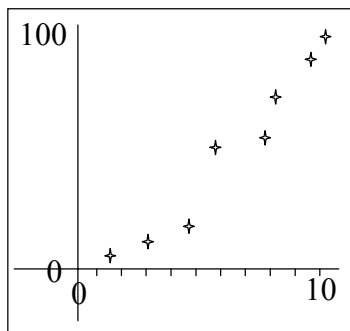
✓ **selective**



✓ **associative**



✓ **quantitative**



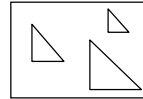
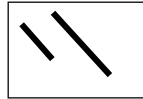
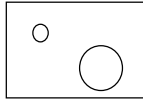
✓ **order**

✓ **length**

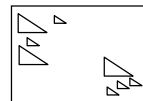
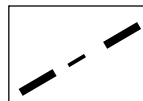
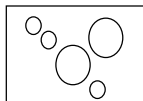
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Visual Variable: Size

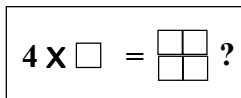
✓ selective



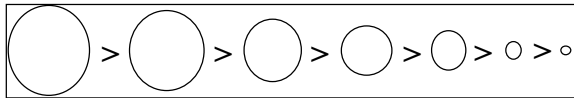
✓ associative



≈ quantitative



✓ order



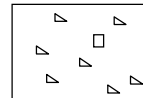
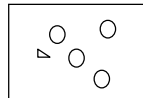
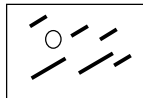
✓ length

- theoretically infinite but practically limited
- association and selection ~ 5 and distinction ~ 20

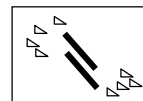
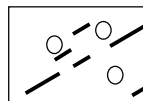
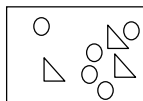
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Visual Variable: Shape

≈ Selective

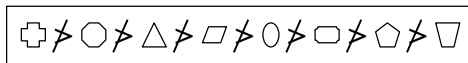


≈ associative

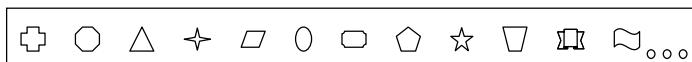


≠ quantitative

≠ order

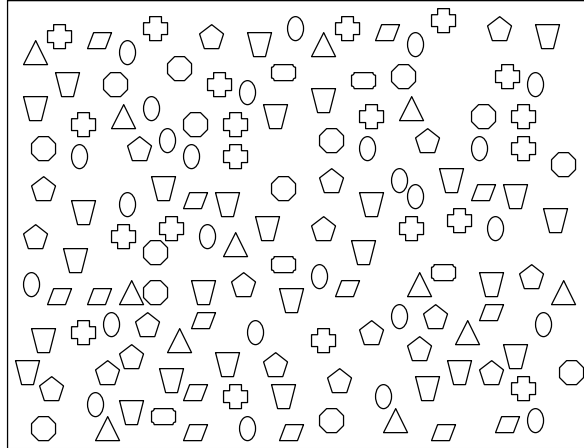


✓ length - infinite variation



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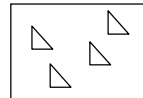
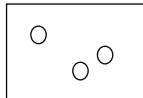
Shape



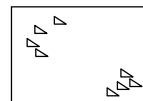
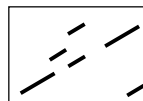
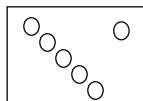
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Visual Variable: Value

✓ selective

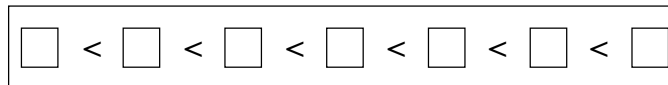


✓ associative



≠ quantitative

✓ order



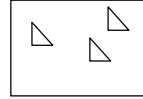
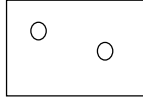
✓ length

- theoretically infinite but practically limited
- association and selection ~ < 7 and distinction ~ 10

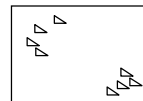
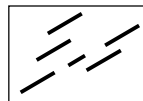
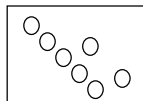
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Visual Variable: Colour

✓ Selective

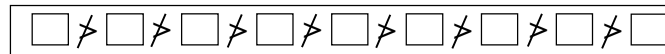


✓ associative



≠ quantitative

≠ order

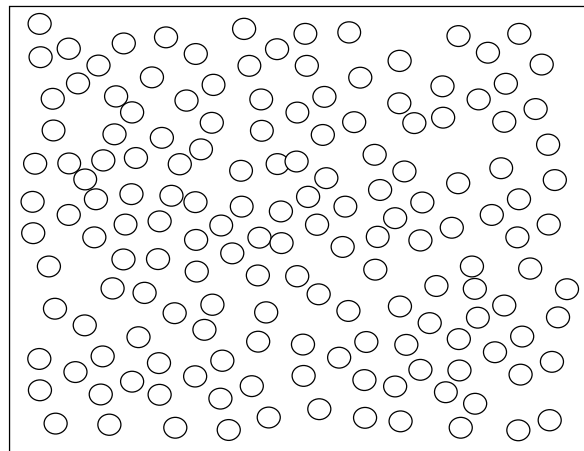


✓ length

- theoretically infinite but practically limited
- association and selection ~ < 7 and distinction ~ 20

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Colour



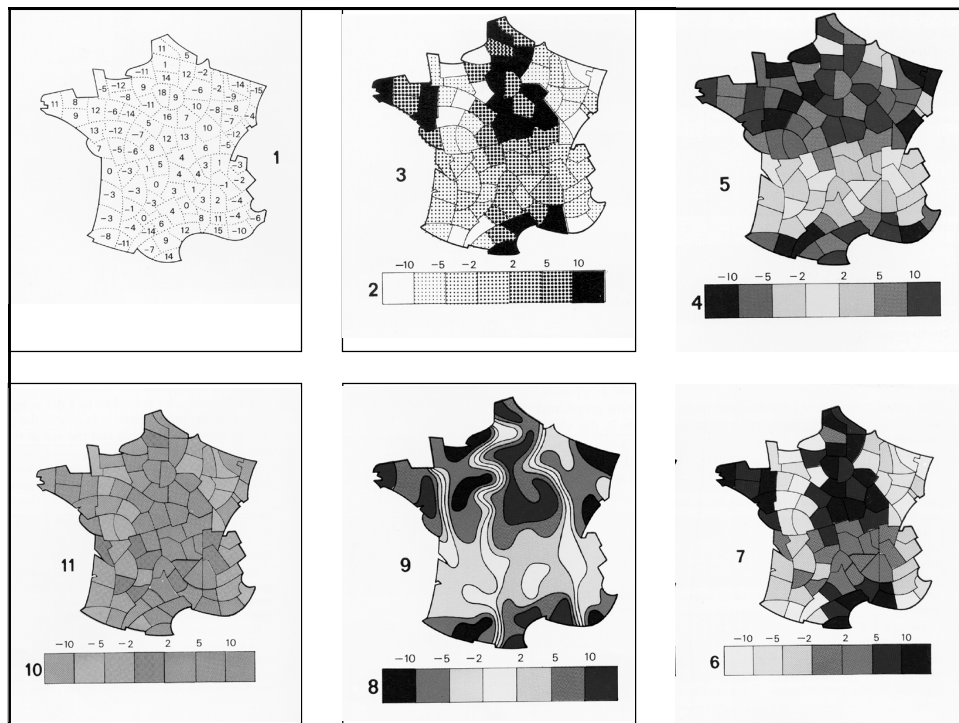
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Encoding

Common advice says use a rainbow scale

- Marcus, Murch, Healey
- problems with rainbows

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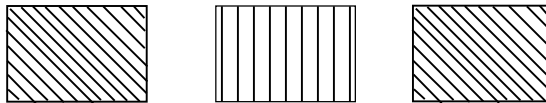


Visual Variable: Orientation

✓ selective

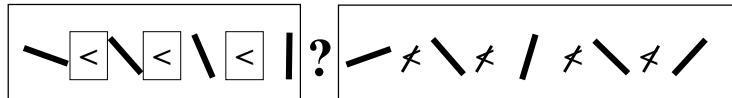


✓ associative



≠ quantitative

≠ order



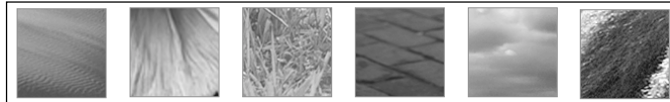
✓ length

- ~5 in 2D; ? in 3D

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Visual Variable: Texture

✓ Selective



✓ associative



≠ quantitative

≠ order

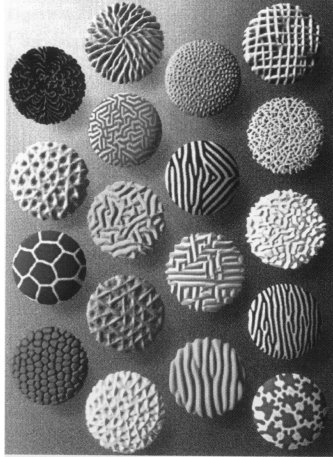


✓ length

- theoretically infinite

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Textures



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Visual Variable: Motion

✓ **selective** - motion is one of our most powerful attention grabbers

✓ **associative** - moving in unison groups objects effectively

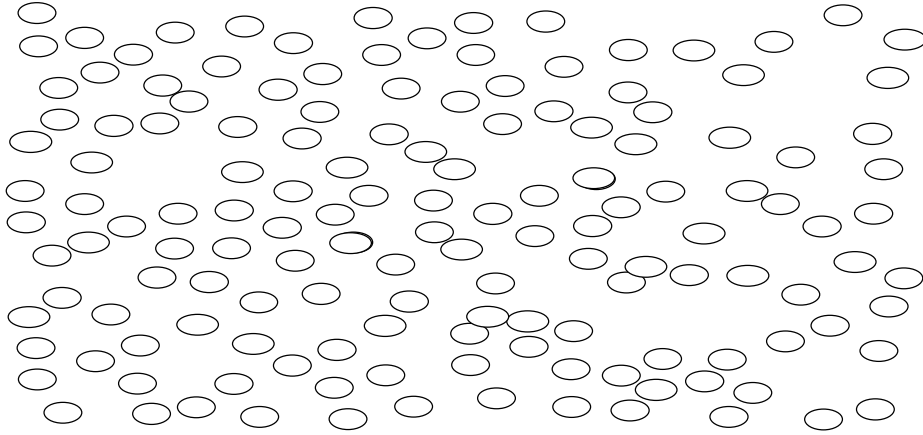
≠ **quantitative** - subjective perception

≠ **order** -

? **length** - distinguishable types of motion?

Saul Greenberg

Motion



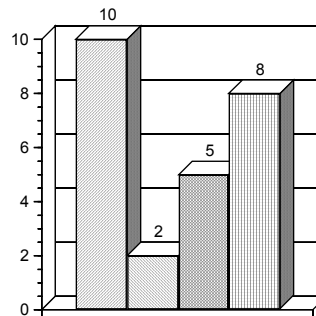
Saul Greenberg

Chart Junk: A common error

Information display is not just pretty graphics

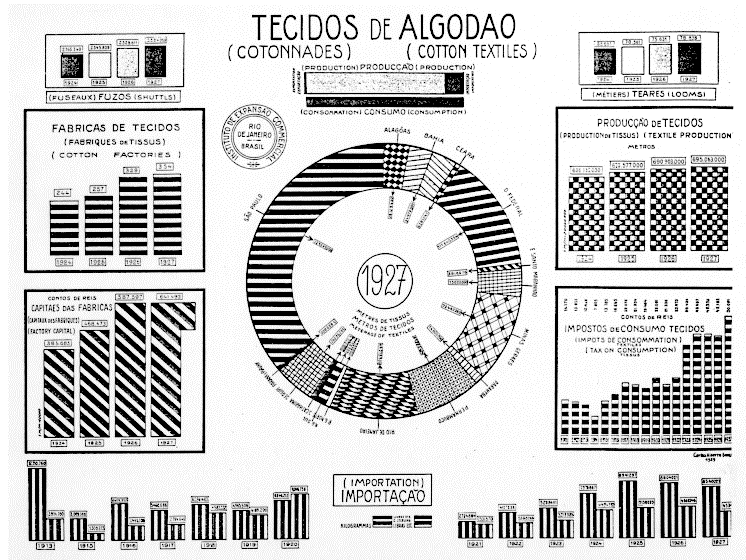
- graphical re-design by amateurs on computers gives us
 - “fontitis,” “chart-junk,” etc.

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



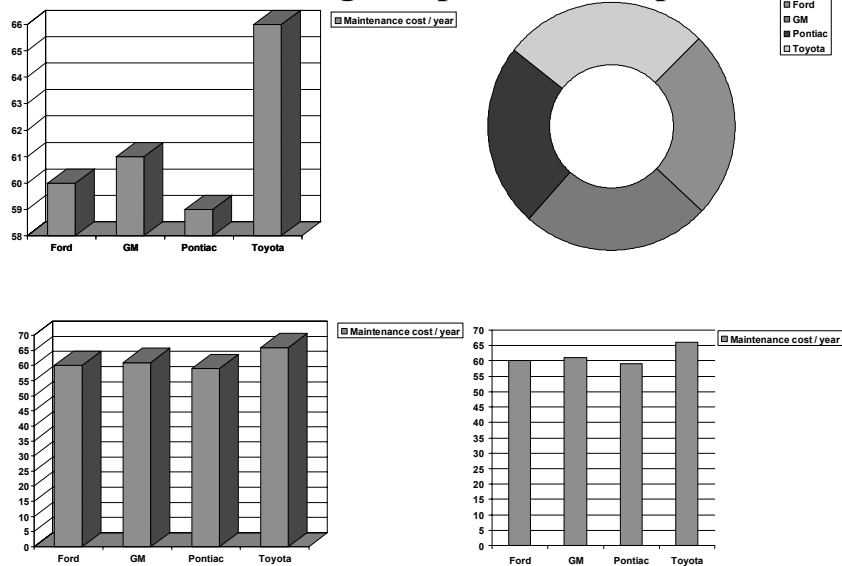
Saul Greenberg

Chart Junk: Cotton production in Brazil, 1927



Saul Greenberg

Chart Junk: Removing deception and simplification

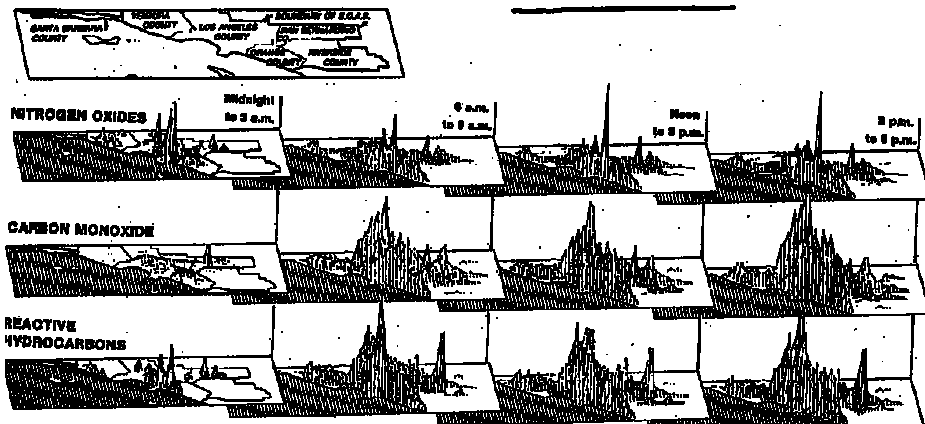


Saul Greenberg

Small Multiples

Learn once

Invite comparisons



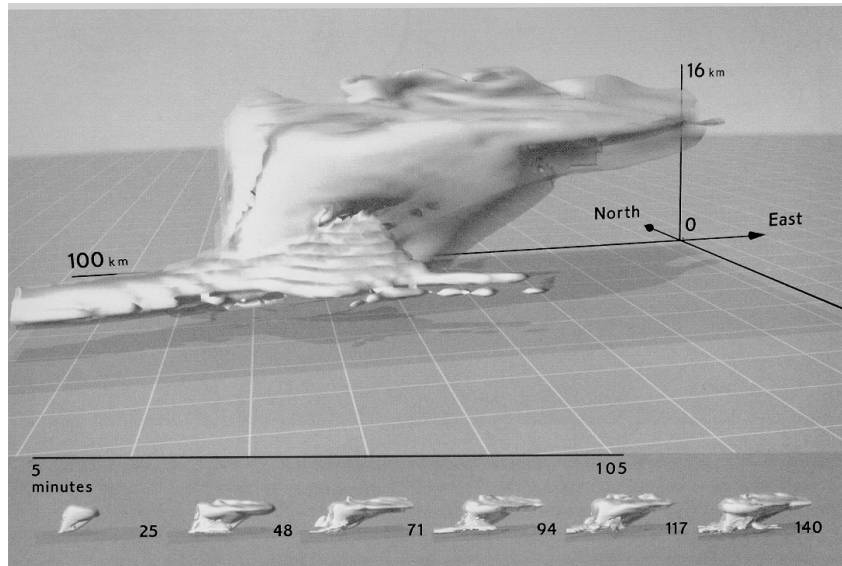
Saul Greenberg

Small Multiples: Showing Time and Change



Saul Greenberg

Small Multiples: Showing Time and Change



Saul Greenberg

Visual Information-Seeking Mantra

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

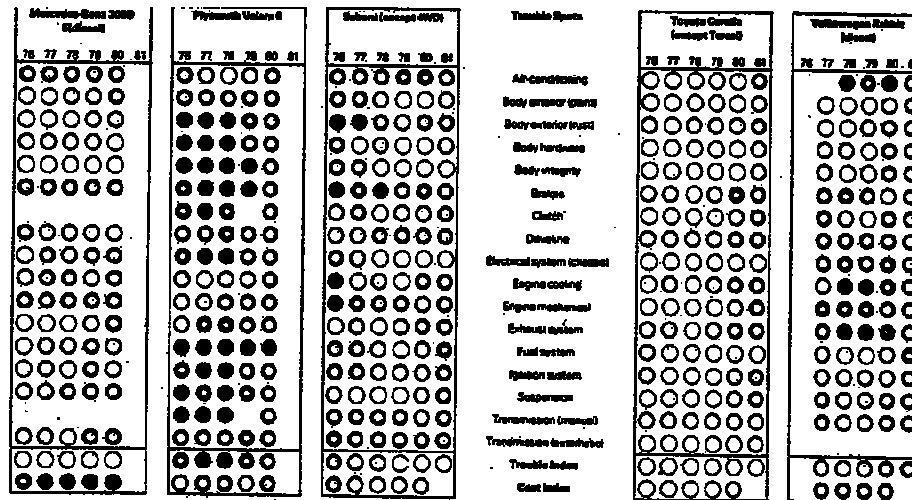
Overview first, zoom and filter, then details on demand

Overview first, zoom and filter, then details on demand

Shneiderman, Designing the User Interface 3rd Ed. 1997 p523

Saul Greenberg

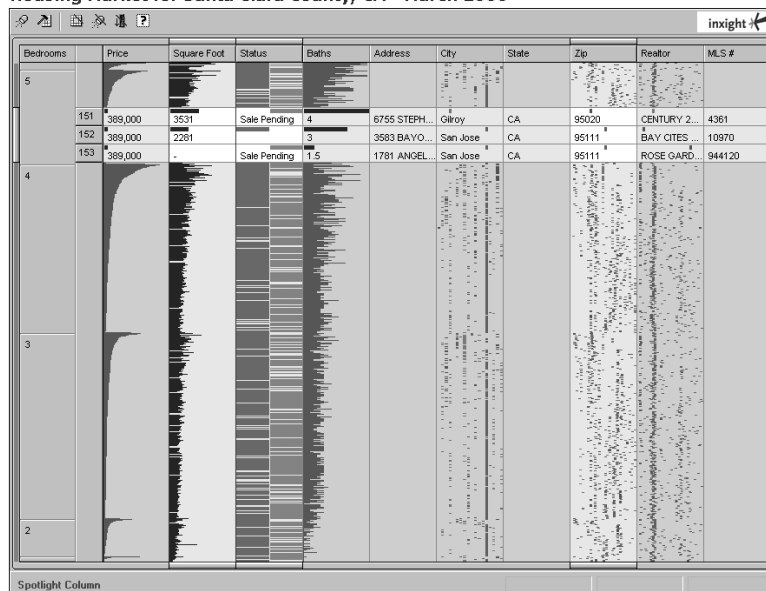
Overview & detail for comparisons using small multiples and data density



Saul Greenberg

Table Lens

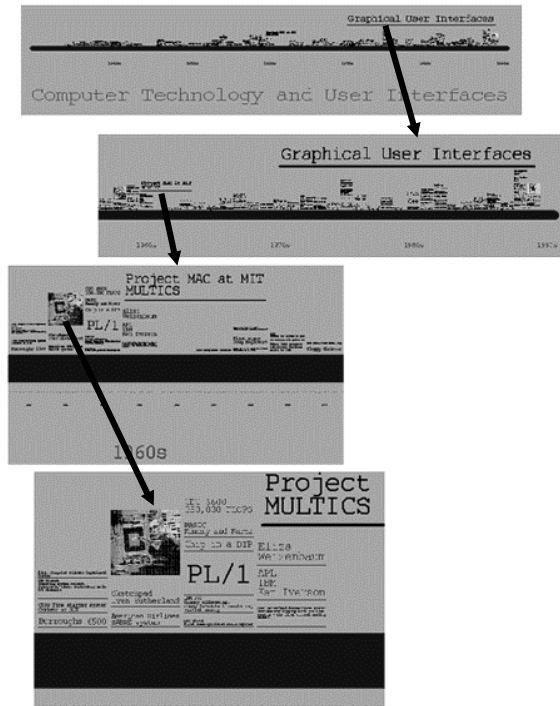
Housing Market for Santa Clara County, CA - March 2000



Inxight: www.inxight.com

Saul Greenberg

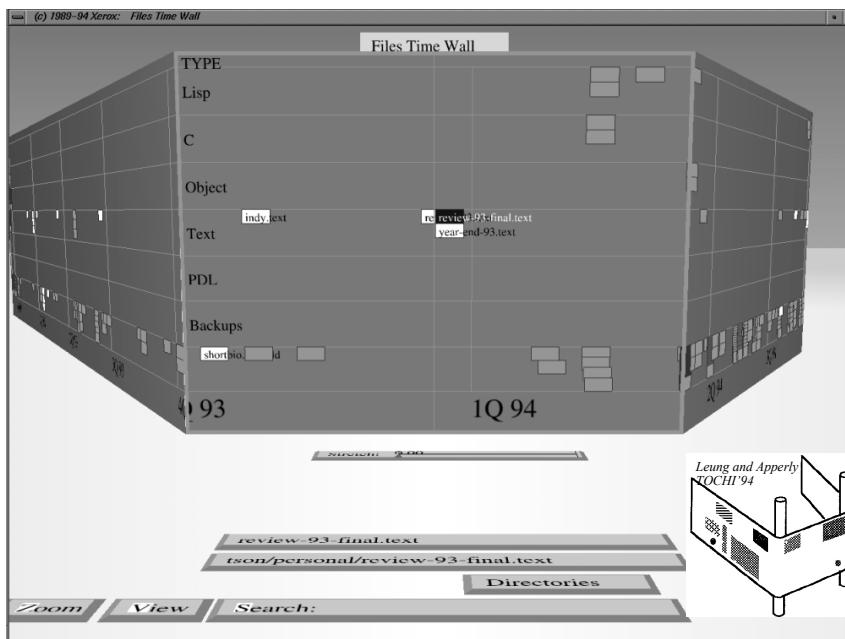
Infinite Zoom



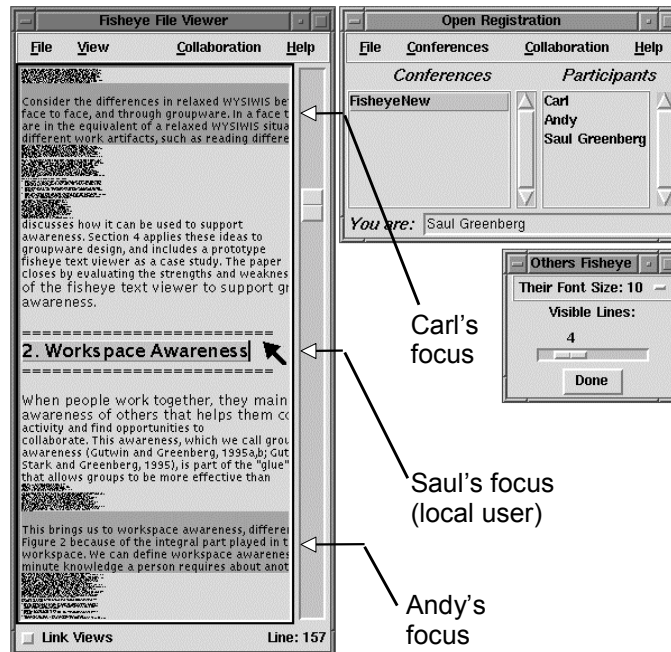
Pad++: A Zoomable Graphical Sketchpad for Exploring Alternate Interface Physics
Bederson et al
Journal of Visual Languages and Computing 7, 1996

Perspective Wall

Mackinlay / Robertson / Card: *Proc ACM CHI'91*

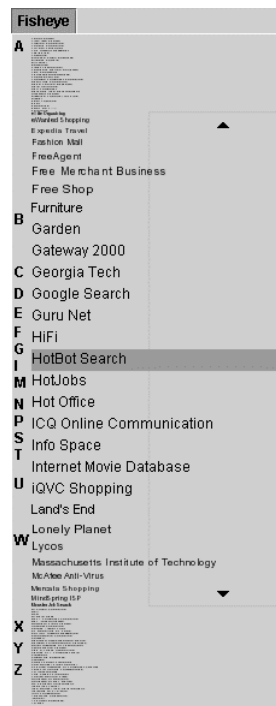


Fisheye Text groupware



Saul Greenberg

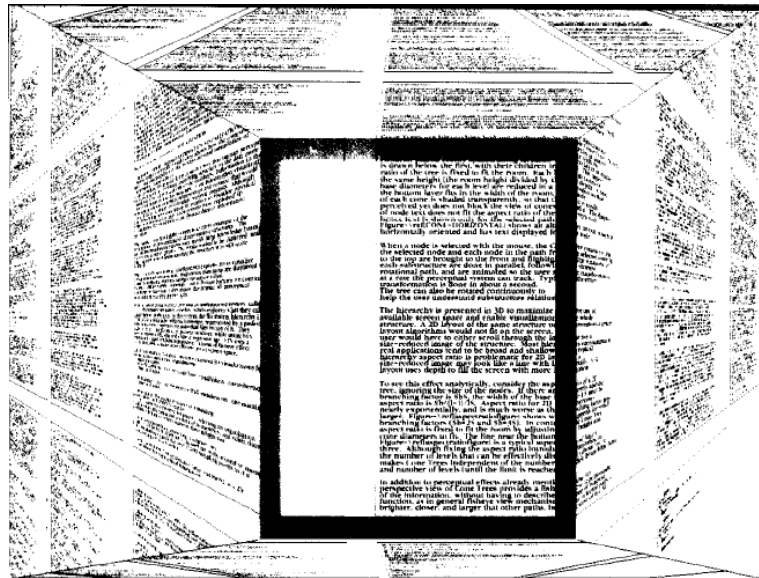
Fisheye Menus



Bederson, B.B. (May 2000)
University of Maryland
www.cs.umd.edu/hcil/fisheyemenu/

Saul Greenberg

Document Lens

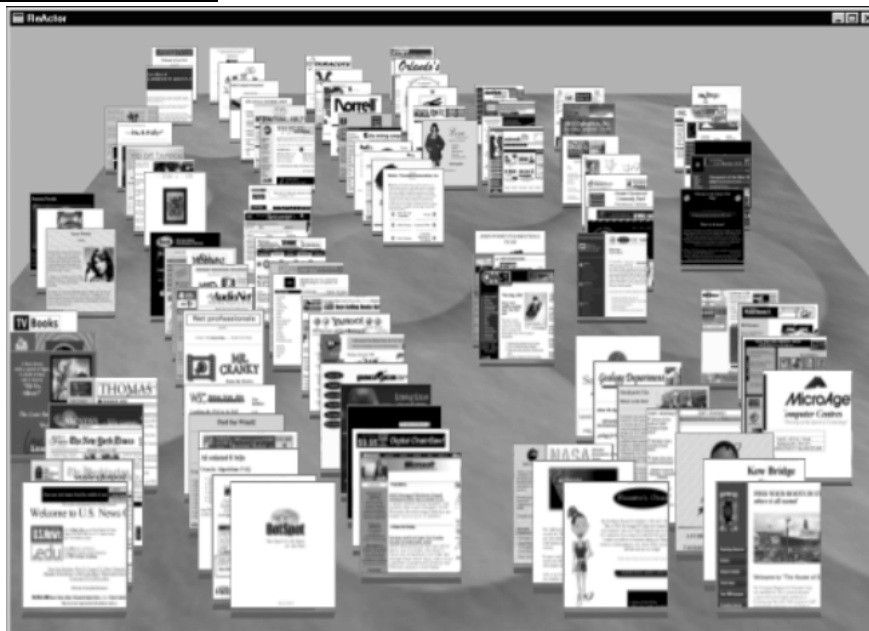


Robertson / Mackinlay ACM UIST 1993

Saul Greenberg

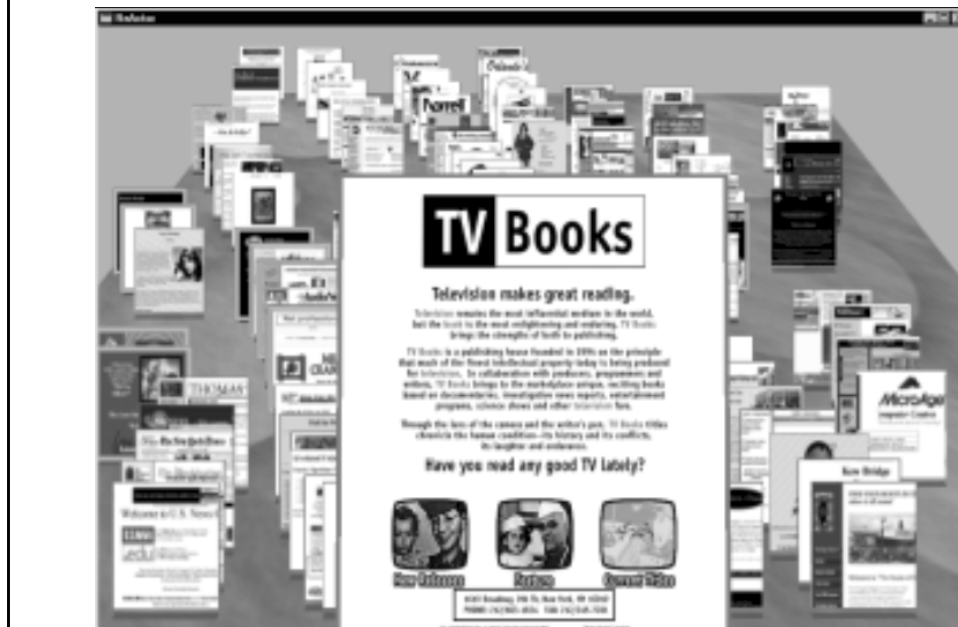
Data Mountain

Robertson / Czerwinski / Larson / Robbins / Thiel / van Dantzich
Data Mountain: Using Spatial Memory for Document Management
Proc ACM UIST '98



Data Mountain

Robertson / Czerwinski / Larson / Robbins / Thiel / van Dantzich
Data Mountain: Using Spatial Memory for Document Management
Proc ACM UIST'98

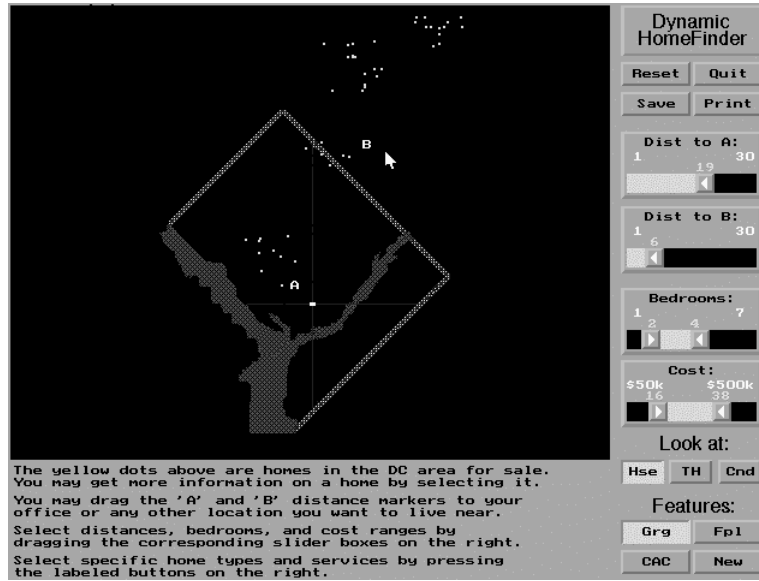


Task Gallery

www.research.microsoft.com/ui/TaskGallery/



Dynamic Queries (Home Finder)



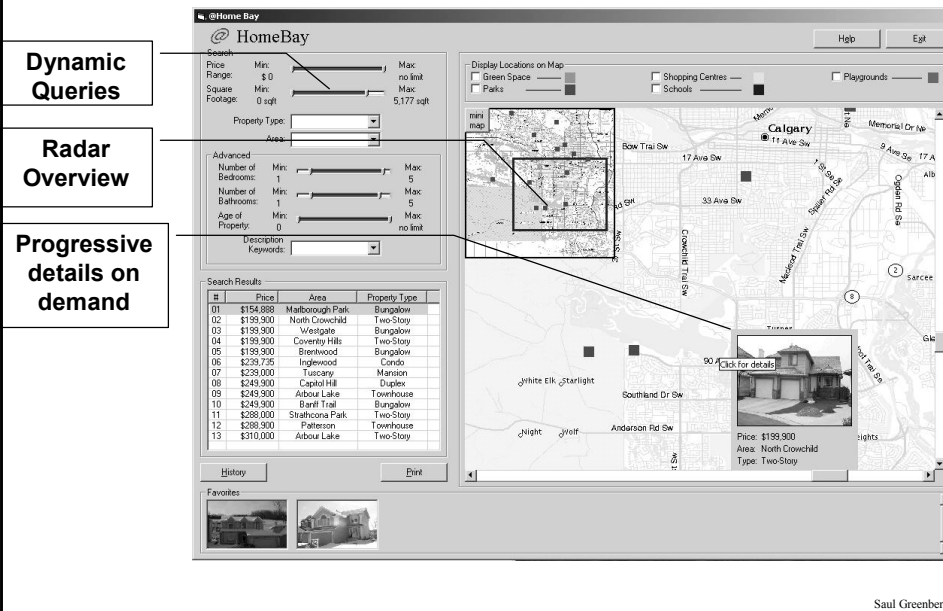
The yellow dots above are homes in the DC area for sale. You may get more information on a home by selecting it. You may drag the 'A' and 'B' distance markers to your office or any other location you want to live near. Select distances, bedrooms, and cost ranges by dragging the corresponding slider boxes on the right. Select specific home types and services by pressing the labeled buttons on the right.

Shneiderman et al
University of Maryland
<http://www.cs.umd.edu/hcil/spotfire/>

Saul Greenberg

HomeBay

481 Student Project (April, 2000)
Rob Pearson, Kashama Wilms and James Chisan



Dynamic Queries

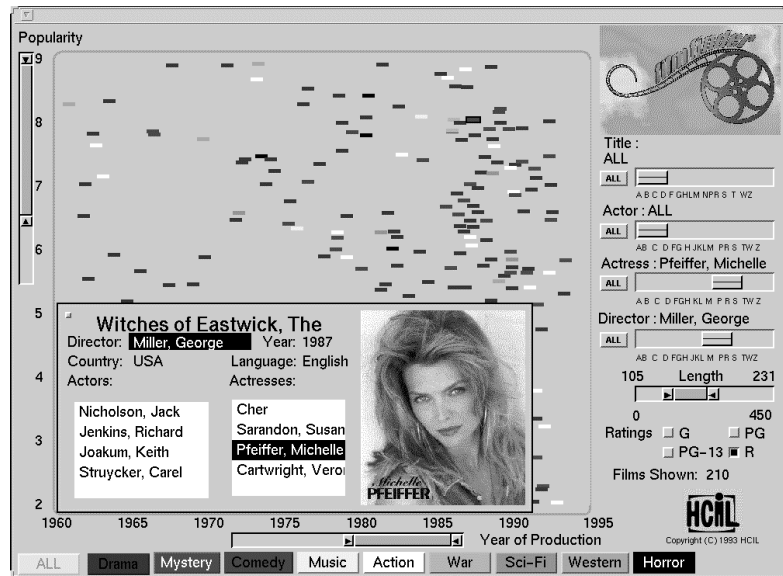
Radar Overview

Progressive details on demand

#	Price	Area	Property Type
01	\$154,888	Marlborough Park	Bungalow
02	\$159,900	North Crowchild	Two-Story
03	\$159,900	Westgate	Bungalow
04	\$159,900	Coventry Hills	Two-Story
05	\$159,900	Brentwood	Bungalow
06	\$229,725	Inglewood	Condo
07	\$235,000	Tuscany	Manor
08	\$243,900	Capitol Hill	Duplex
09	\$243,900	Arbour Lake	Townhouse
10	\$243,900	Barrie Trail	Bungalow
11	\$288,000	Strathcona Park	Two-Story
12	\$288,000	Parkson	Townhouse
13	\$310,000	Arbour Lake	Two-Story

Saul Greenberg

Starfield Display

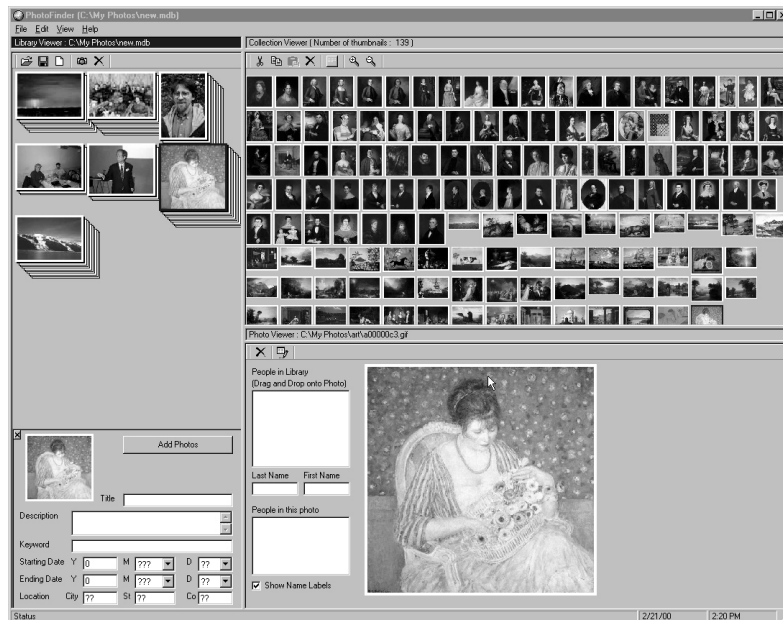


Ahlberg, University of Maryland
<http://www.cs.umd.edu/hcil/spotfire/>

Saul Greenberg

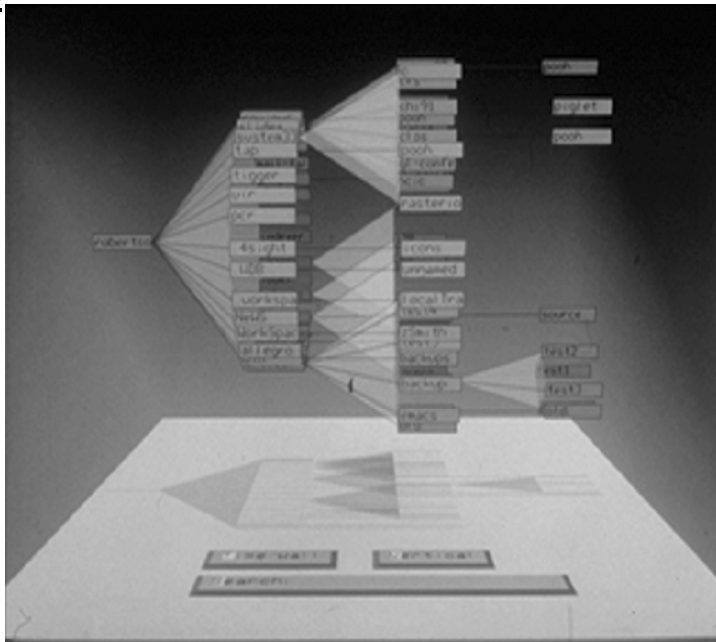
PhotoFinder

University of Maryland
 Human Computer Interaction Laboratory
<http://www.cs.umd.edu/hcil/>

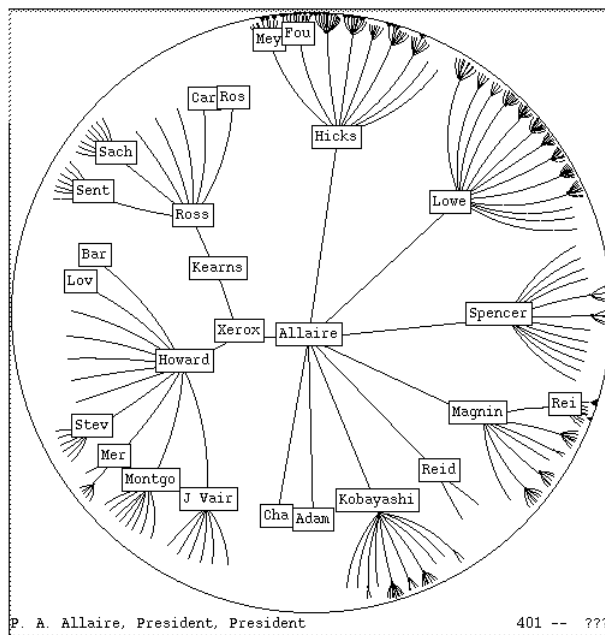


Cone Trees

Robertson / Mackinlay / Card
Cone Trees: Animated 3D Visualizations of
Hierarchical Information. *Proc ACM CHI'91*



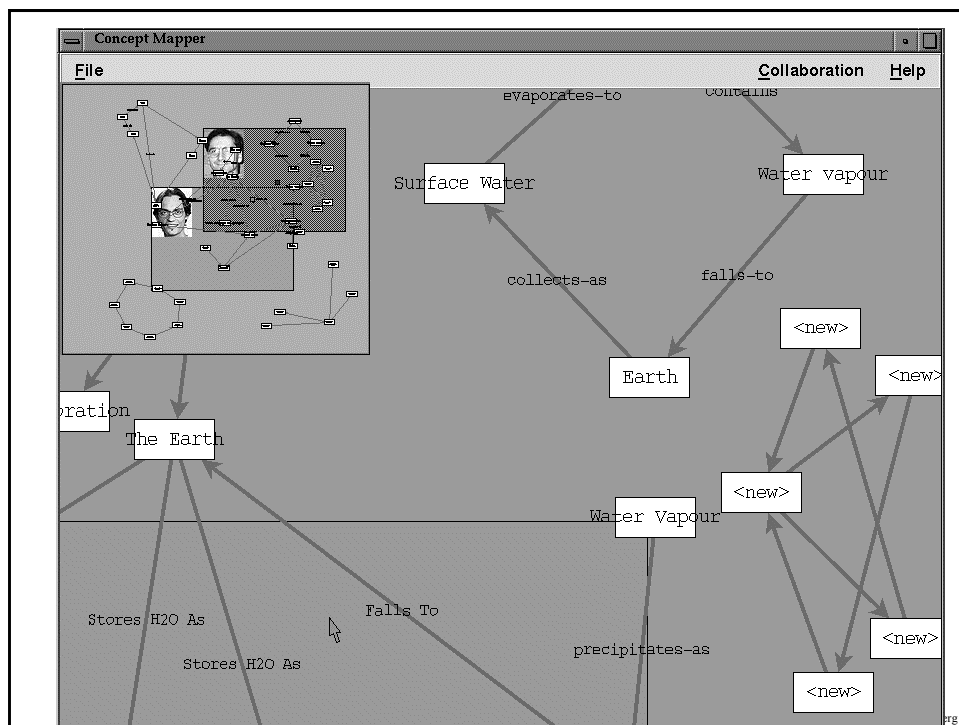
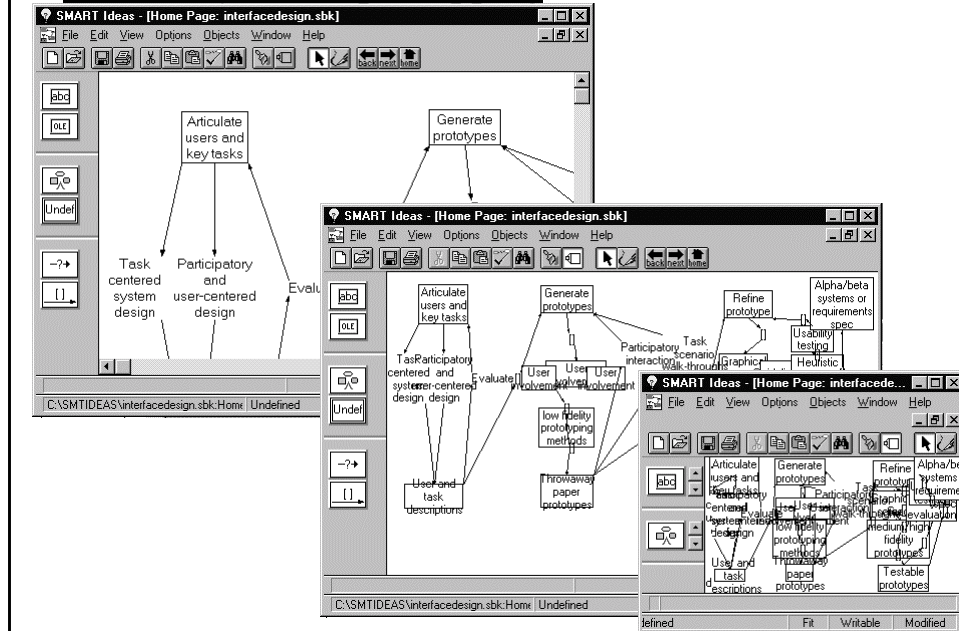
Hyperbolic Lens

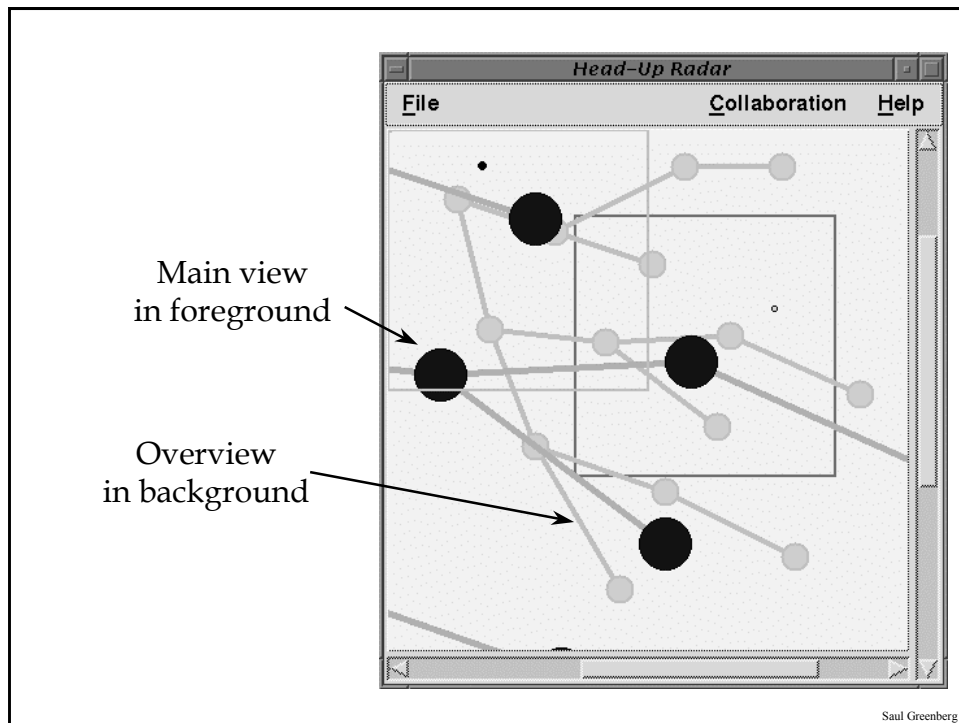
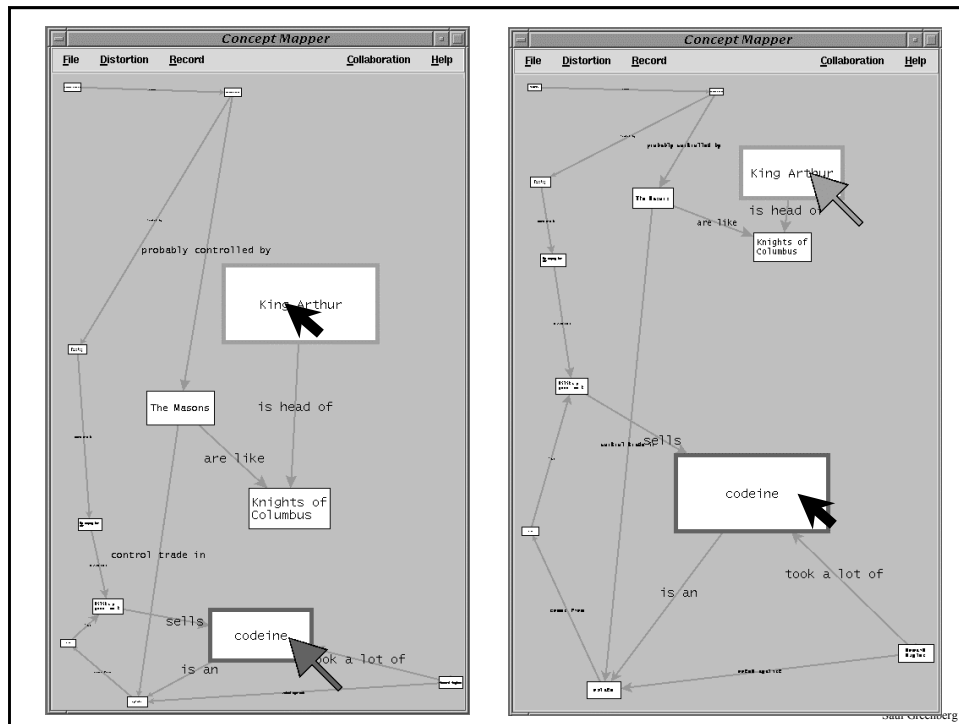


Xerox Parc/Inxight

Saul Greenberg

Case study: Concept mapping



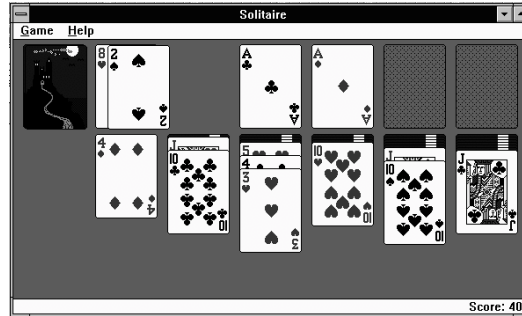


Metaphors

Pervade excellent interfaces

	A	B	C	D
1	Market value	Land	Improvement	Total assess
2	140.0	65,850.	73,120.	138,970.
3	147.0	77,780.	72,070.	149,850.
4	151.0	74,850.	88,740.	163,590.
5	152.0	80,110.	99,410.	179,520.
6	155.0	79,050.	109,130.	188,180.
7	170.0	94,750.	50,960.	145,710.
8	172.0	82,150.	106,250.	188,400.
9	178.0	78,560.	132,660.	211,220.
10	180.0	92,840.	105,670.	198,510.
11	180.0	80,090.	103,130.	183,220.
12	182.0	76,650.	115,210.	191,860.
13	185.0	75,590.	152,710.	228,300.
14	185.0	85,870.	105,330.	191,200.
15	185.0	80,060.	113,600.	193,660.
16	193.4	80,140.	131,340.	211,480.
17	194.5	73,400.	176,210.	249,610.
18	197.0	84,960.	129,800.	214,760.
19	203.0	91,600.	119,170.	210,770.
20	205.0	79,460.	137,250.	216,710.
21	213.0	87,060.	124,350.	211,410.
22	221.0	97,330.	167,500.	264,830.
23	225.0	87,160.	157,290.	244,450.
24	245.0	79,520.	144,840.	224,360.
25	248.0	89,470.	183,500.	272,970.
26	278.0	82,150.	168,720.	250,870.
27	302.5	118,500.	109,800.	228,300.
28	308.0	83,100.	141,730.	224,830.

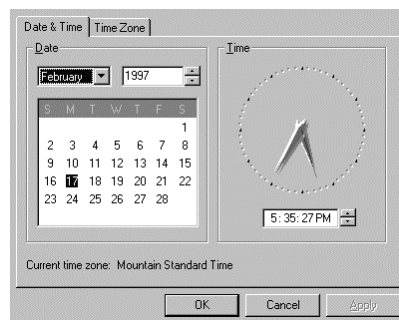
spreadsheet (actuary sheet)



games (literal world)

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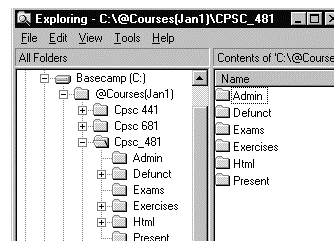
Examples continued



Control Panels with familiar controls

Name: _____
 Address: _____
 City: _____
 Province: _____
 Postal Code: _____

Forms



Hierarchical Folders

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Interface Metaphors

Definition of Metaphor

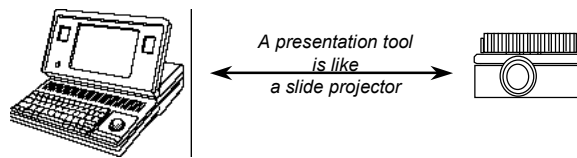
- application of name or descriptive term to an object to which it is not literally applicable

Purpose

- function as natural models
- leverages our knowledge of familiar, concrete objects/experiences to understand abstract computer and task concepts

Problem

- metaphor may portray inaccurate or naive conceptual model of the system



Saul Greenberg

Creating Interface Metaphors (continued)

Generating metaphors

- Use metaphors that matches user's conceptual task
 - desktop metaphor for office workers
 - paintbrush metaphor for artists...
- Given a choice, choose the metaphor close to the way the system works
- Ensure emotional tone is appropriate to users
 - eg file deletion metaphors
 - trashcan
 - black hole
 - paper shredder
 - pit bull terrier
 - nuclear disposal unit...

Saul Greenberg

Metaphors continued

Evaluating metaphors

- consider probable consequences
 - will metaphor restrict what people could actually do?
eg strict file/folder hierarchy vs system allows links between directories
 - will metaphor believe that people can do more than what is possible?
eg agent-based systems, Eliza...

Evolve metaphors

- is metaphor extensible to new features?
- when is the metaphor no longer useful?

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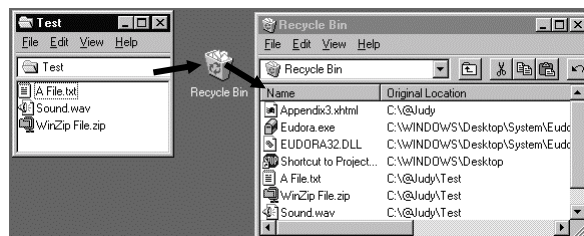
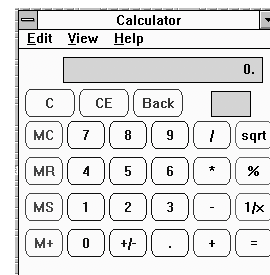
Metaphors continued

Caveat

- metaphors can be overdone!

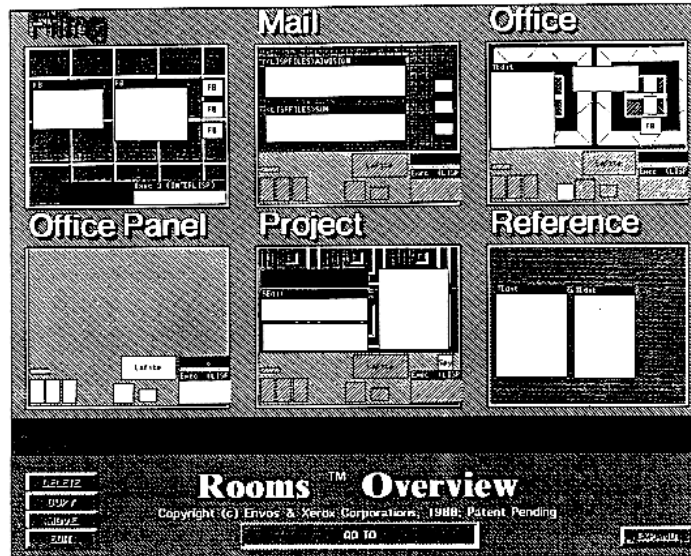
Common pitfalls

- overly literal
 - unnecessary fidelity
 - excessive interactions
- overly cute
 - novelty quickly wears off
- overly restrictive
 - cannot move beyond
- mismatched
 - does not match user's task and/or thinking



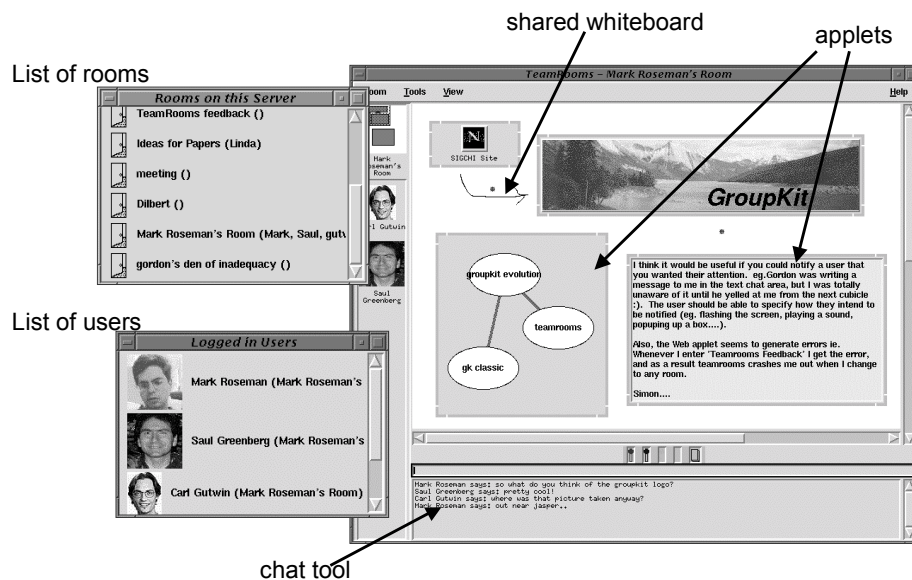
Saul Greenberg

Example: The Rooms Metaphor



Saul Greenberg

Example: TeamRooms



Saul Greenberg

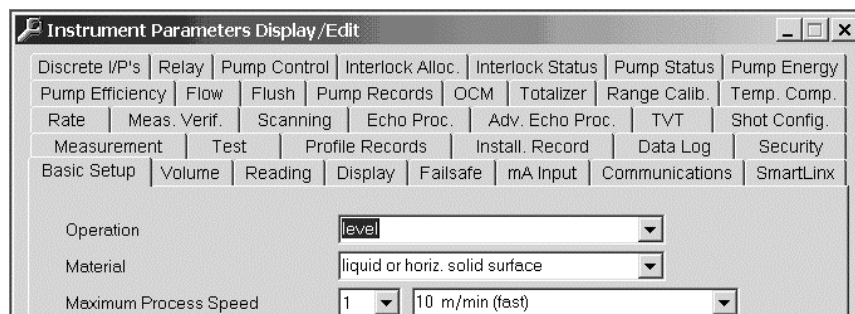
Example: TeamRooms

Metaphor implies:

- persistent room artifacts
- both synchronous and asynchronous activity
- asynchronous communication by sticky notes attached to artifacts
- “for free” standard tools
- ability to bring in custom tools via (applets)
- same place/different place activity
- knowing who is around
- trivial groupware connectivity
- ...

Saul Greenberg

Misuses of Metaphors



Milltronics' *Dolphin Plus*

a configuration package for industrial level and flow sensors

Saul Greenberg

Direct Engagement & Direct Manipulation

Direct Engagement

- the feeling of working *directly* on the task

Direct Manipulation

- An interface that behaves as though the interaction was with a real-world object rather than with an abstract system

Central ideas

- visibility of the objects of interest
- rapid, reversible, incremental actions
- manipulation by pointing and moving
- immediate and continuous display of results

Almost always based on a metaphor

- mapped onto some facet of the real world task semantics)

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Direct Engagement

Xerox Star: pioneered in early '80s, copied by almost everyone

- simulates desktop with icons
 - in and out baskets
 - file folders and documents
 - calculators
 - printers
 - blank forms for letters and memos
- small number of generic actions applicable system wide
 - move, copy, delete, show properties, again, undo, help
 - eg same way to move text, documents, etc
 - property sheets
 - pop-up form, alterable by user
- What you see is what you get (WYSIWYG)

Saul Greenberg

Xerox Star continued

Star's observers:

- objects understood in terms of their visual characteristics
 - affordances, constraints
- actions understood in terms of their effects on the screen
 - causality
- intuitively reasonable actions can be performed at any time
 - conceptual model

*A subtle thing happens when everything is visible:
the display becomes reality*

Saul Greenberg

Example: A telephone database

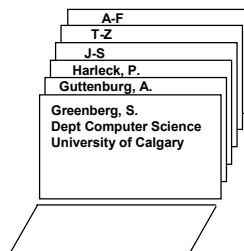
Find "Green"
>S. Greenberg
>Dept Computer Science
>University of Calgary

Command system
no direct manipulation

Search for: Green

Result: S. Greenberg
Dept Computer Science
University of Calgary

Form metaphor:
syntactic direct
manipulation

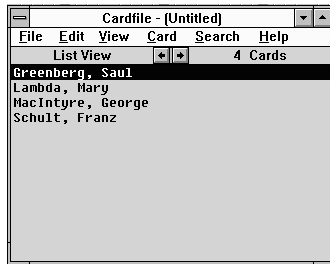


Rolodex metaphor:
full direct manipulation

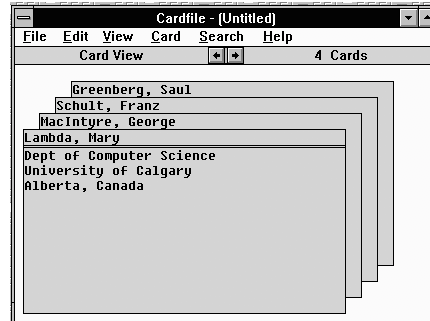
Saul Greenberg

Phone list

List metaphor

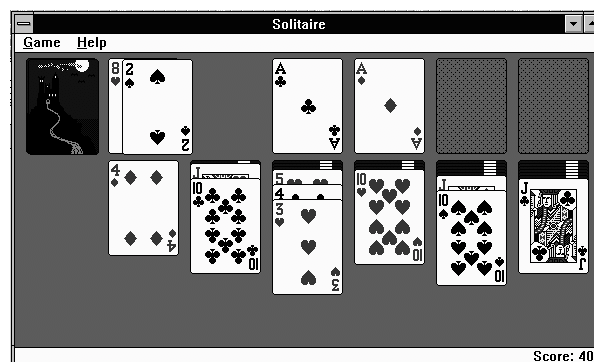


Rolodex metaphor



Saul Greenberg

Games

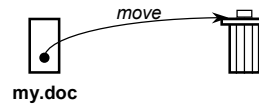


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Object-Action vs Action-Object

Select object, *then* do action

- interface emphasizes 'nouns' (visible objects) rather than 'verbs' (actions)



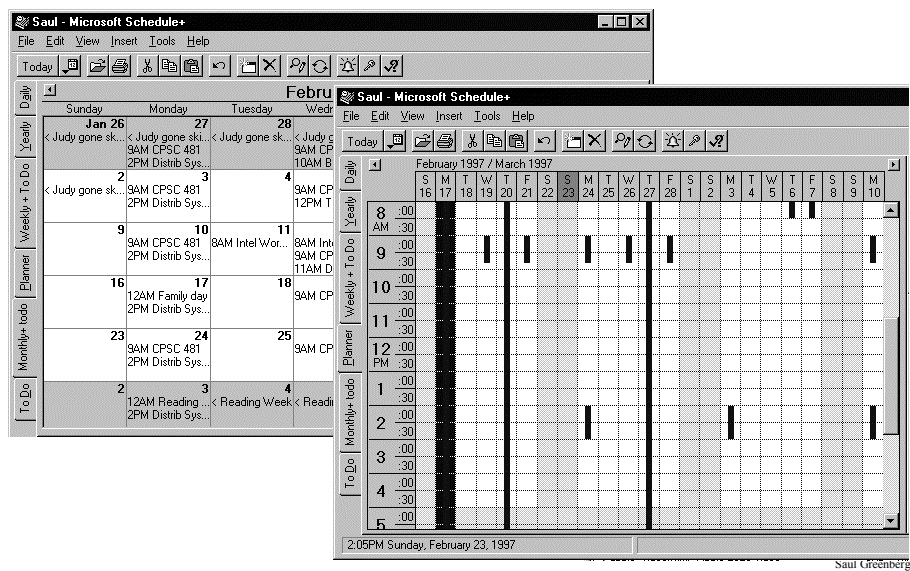
Advantages

- closer to real world
- modeless interaction
- *actions* always within context of object
 - inappropriate ones can be hidden
- *generic commands*
 - the same type of action can be performed on the object
 - eg drag 'n drop:
 - folders
 - files
 - paragraphs
 - text
 - numbers...

Saul Greenberg

Direct manipulation

Representation directly affects what can be directly manipulated



Is direct manipulation the way to go?

Some Disadvantages

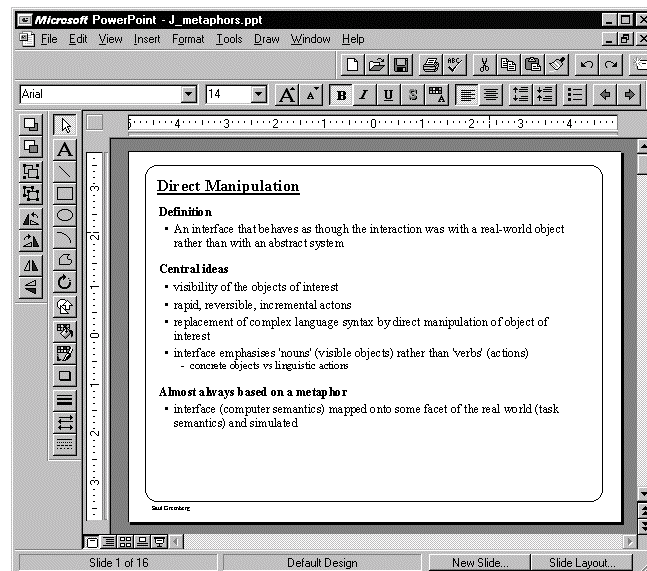
- Ill-suited for abstract operations
 - spell-checker?
- Tedium
 - manually search large database vs query
- Task domain may not have adequate physical/visual metaphor
- Metaphor may be overly-restrictive

Solution

- Most systems combine direct manipulation and abstractions
 - word processor:
 - WYSIWYG document (direct manipulation)
 - buttons, menus, dialog boxes (abstractions, but direct manipulation “in the small”)

Saul Greenberg

Conventional Applications: A Mix



Saul Greenberg

What you now know

Good Representations

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

Information Visualization

- Tufte's principles
- exploits our knowledge of visual variables
- Mantra: Overview first, zoom and filter, then details on demand
- many techniques now available

Metaphors

- uses our knowledge of the familiar and concrete to represent abstract concepts
- need not be literal
- has limitations that must be understood

Direct manipulation

- visibility of the objects of interest
- rapid, reversible, incremental actions
- manipulation by pointing and moving
- immediate and continuous display of results

These four components are the foundation of a true Visual Interface

Saul Greenberg

