# Design and Perception in Information Visualisation

Matthew Chalmers

Computing Science

University of Glasgow

# Overview

- Origins and basic principles
  – generalisations, taxonomies, rules of thumb
  – ‘perception is stronger than mathematics’
- Techniques for specific data types
  – but... types are interchangeable
- General interaction techniques
  – filtering, categorisation, multiple views...

# Overview

- What is InfoVis about?
  - absolute and relative views
- Shneiderman’s taxonomy
  - dimensional reduction
- Interaction techniques

# What is InfoVis About?

- Information overload
- Three types of navigation
  - spatial, semantic and social
- Metaphor and design
- Good and bad design
- 2D versus 3D visualisation
- Examples of perceptual effects

# A Response to ‘Information Overload’

- Too much information to handle
  - can be large data sets, or complex data
  - too much for simple textual displays
  - can 2D and 3D graphics help?
- Opening up the database ‘black box’
  - data hidden from view, queries reach inside
- The tiresome term ‘data mining’

# InfoVis as ‘Unrestricted I/O’

- Direct Manipulation in the extreme
  - "visual representation of the world of action"
- Just throwing resources at the problem?
  - CPU, disc space, bandwidth, screen resolution, colours, sound, shape, texture...

# Central Themes

- Interaction with (large) data sets
- Abstract, often multiD data
  - cf. scientific visualisation, GIS
- Fit with perceptual skills
  - visual perception, spatial memory
- Understanding relative properties
  - patterns, trends, structure

# A Small Example: the ‘Wolfsberg Demo’

- Dual view display
  – change in one affects the other
- Sliders form dynamic queries
  – lightweight query construction
- 24 dimensional data, 2D display
  – map made using spring model
- Perceptually linear colour scales

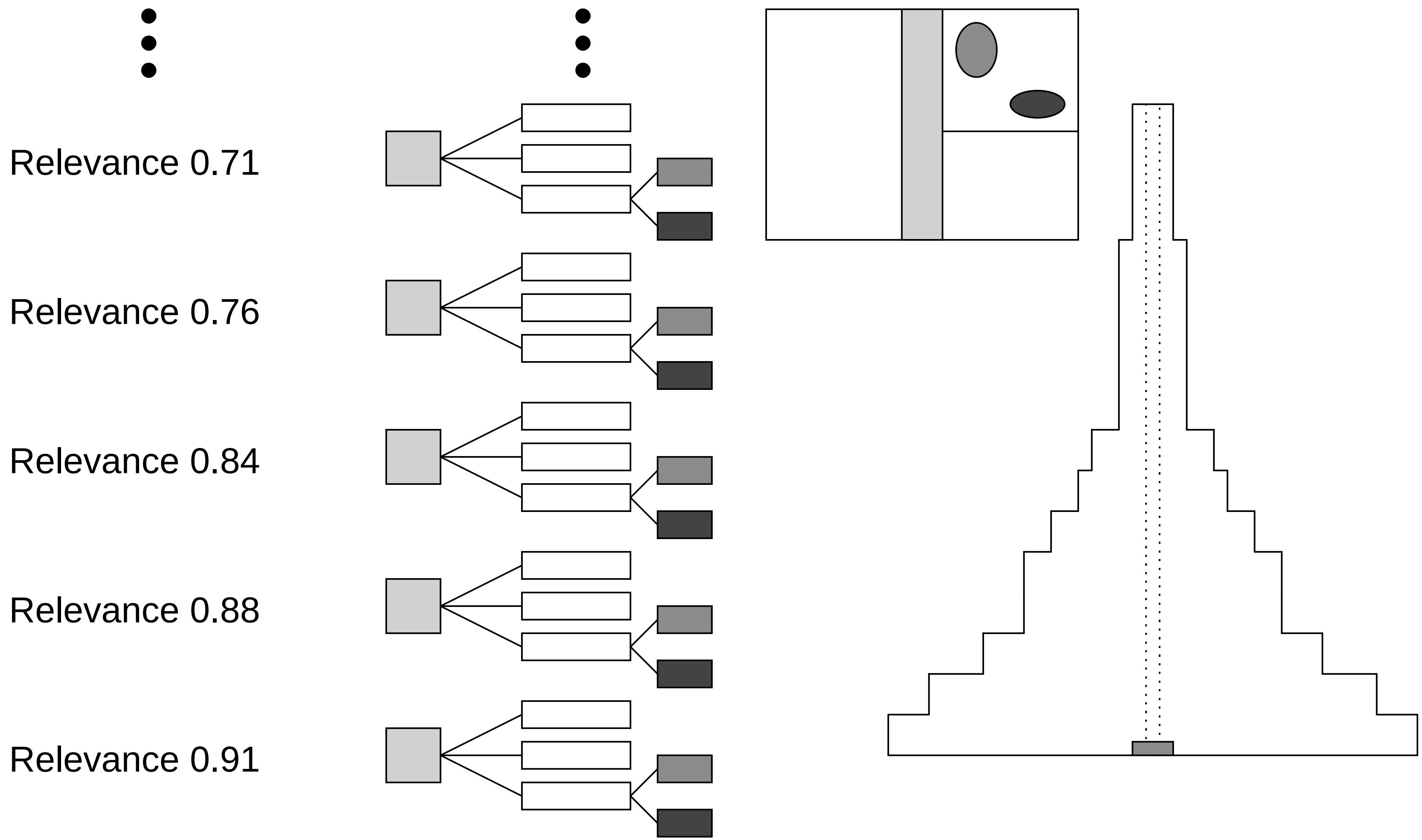
# Three Types of Navigation

- *Spatial:* inherently 2D or 3D data
  - geography, physics
- *Semantic:* metaphorical use of space
  - close ‘is’ similar, high ‘is’ important
- *Social:* using others’ past activity
  - Edit Wear and Read Wear
  - collaborative filtering and paths

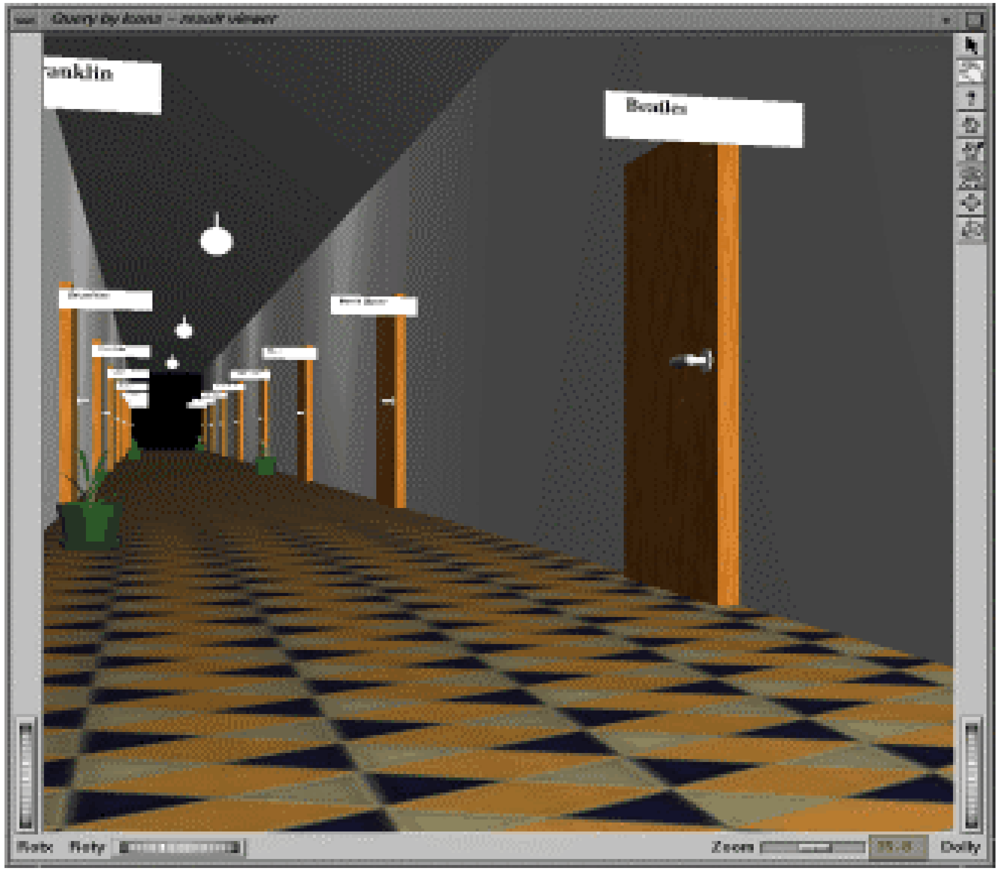
# Metaphor and Design

- More than a mathematical mapping
- Info. design has to make ‘sense’
  - perceptually: skyscraper example
  - culturally: hot=blue, cold=red?
- Interaction has been proven to be non-formalisable (Wegner)
- Information design: not science but craft

# A Skyscraper of Information?



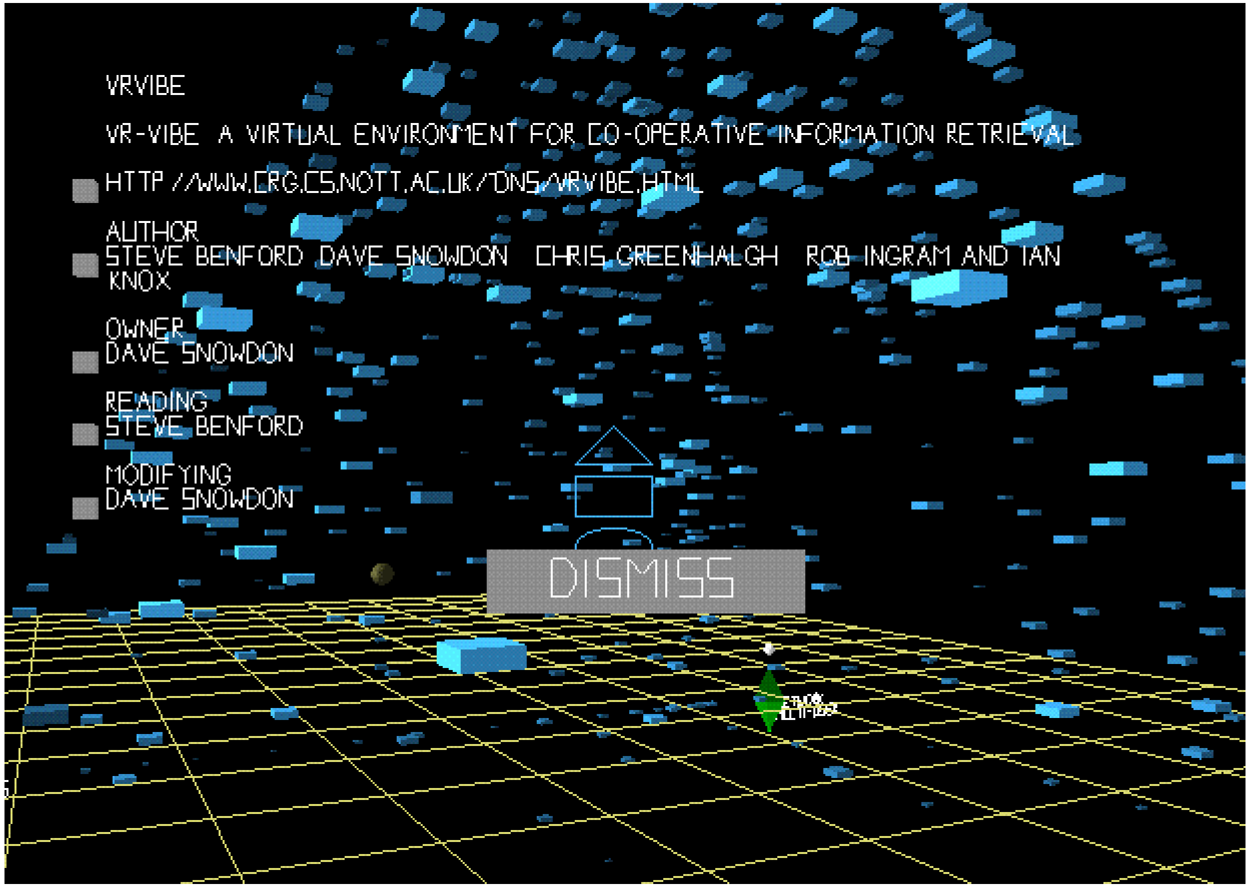
# How much of this picturesque scene is *informative*?



# Detail is set amongst a lot of polished clutter

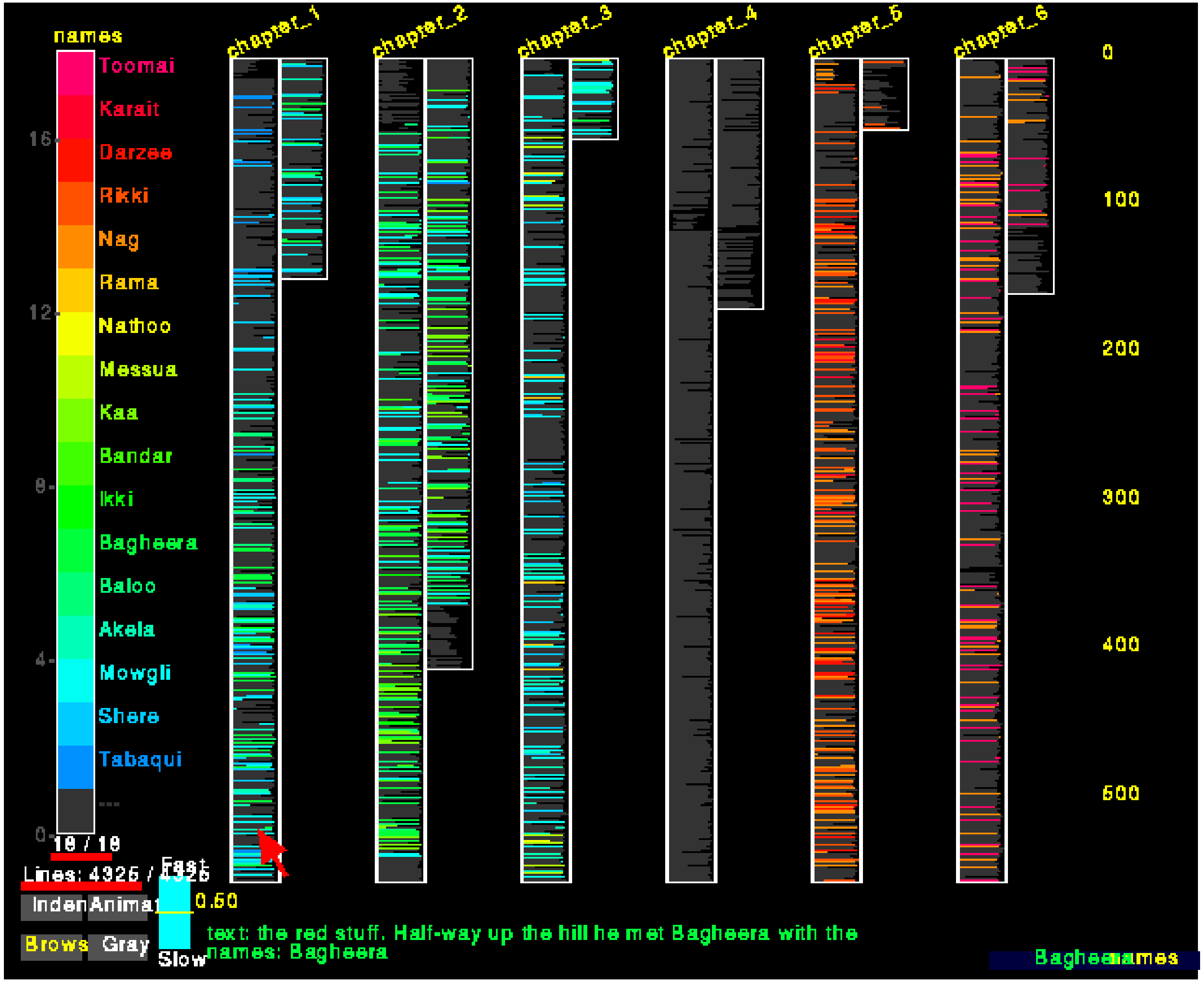
# Bad Visualisation Design

- ‘Clean’ and ‘natural’, but uninformative
  - the skyscraper example
- Cluttered, overloaded, difficult to pick out what is useful
  - ‘point clouds’ e.g. early Bead, VR-VIBE
  - Xerox PARC’s seminal work (ACM CHI91)
    - ConeTrees, Perspective Wall


VRVIBE
VR-VIBE A VIRTUAL ENVIRONMENT FOR CO-OPERATIVE INFORMATION RETRIEVAL
HTTP //WWW.CRG.CS.NOTT.AC.UK/DNS/VRVIBE.HTML
AUTHOR
STEVE BENFORD DAVE SNOWDON CHRIS GREENHALGH ROB INGRAM AND IAN KNOX
OWNER
DAVE SNOWDON
READING
STEVE BENFORD
MODIFYING
DAVE SNOWDON
DISMISS

# Good Visualisation Design

- Technologically efficient and robust
  - science and engineering
- In accord with perception and use
  - psychology, sociology, aesthetics
- Shows useful detail and its context
  - SeeSoft [B1], Spotfire [B4,B5], late Bead?, Wolfsberg demo?


names
Toomai
Karait
Darzee
Rikki
Nag
Rama
Nathoo
Messua
Kaa
Bandar
Ikki
Bagheera
Baloo
Akela
Mowgli
Shere
Tabaqui
16
12
8
4
0
19 / 19
Lines: 4326 / 4326
Fast
Slow
0.50
Inden
Animat
Brows
Gray
chapter_1
chapter_2
chapter_3
chapter_4
chapter_5
chapter_6
0
100
200
300
400
500
text: the red stuff. Half-way up the hill he met Bagheera with the
names: Bagheera
Bagheera
names

# 2D v. 3D display

- 3D has another degree of freedom?
  - Can express more relationships,
  - but can you perceive them?
- "The world is 3D"
  - Not in physics -- relativity, etc.
- Not perceptually either
  - height is a privileged property
  - vision: surfaces not volumes

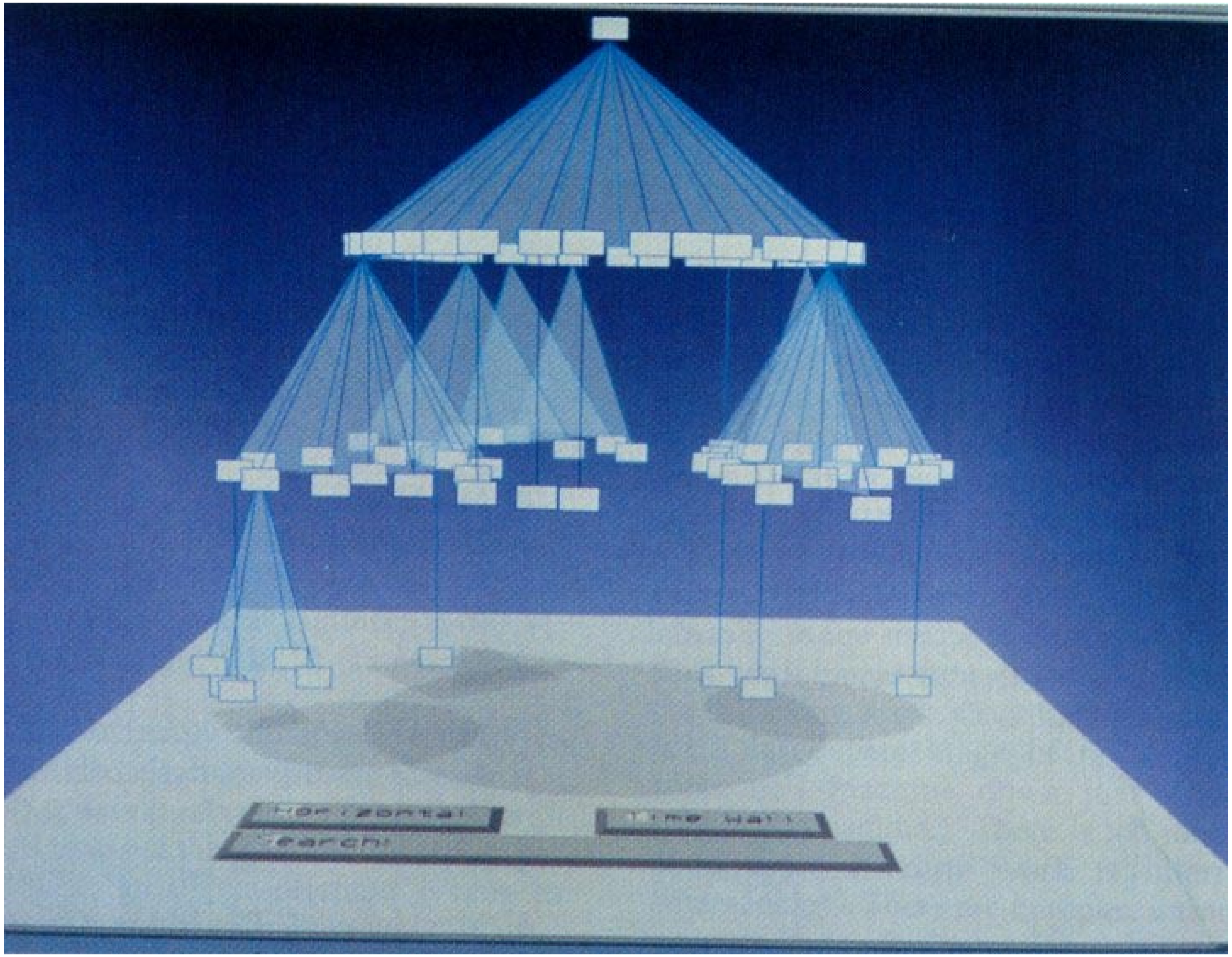
# 2D v. 3D

- A debate that 2D is slowly winning
- 3D better for spatial navigation?
  – perhaps, if the space/model is familiar
- 2D better for semantic & social nav.
  – occlusion, clutter and orientation
  – burn CPU cycles on data, not pixels
  – text is not designed for 3D but is ubiquitous

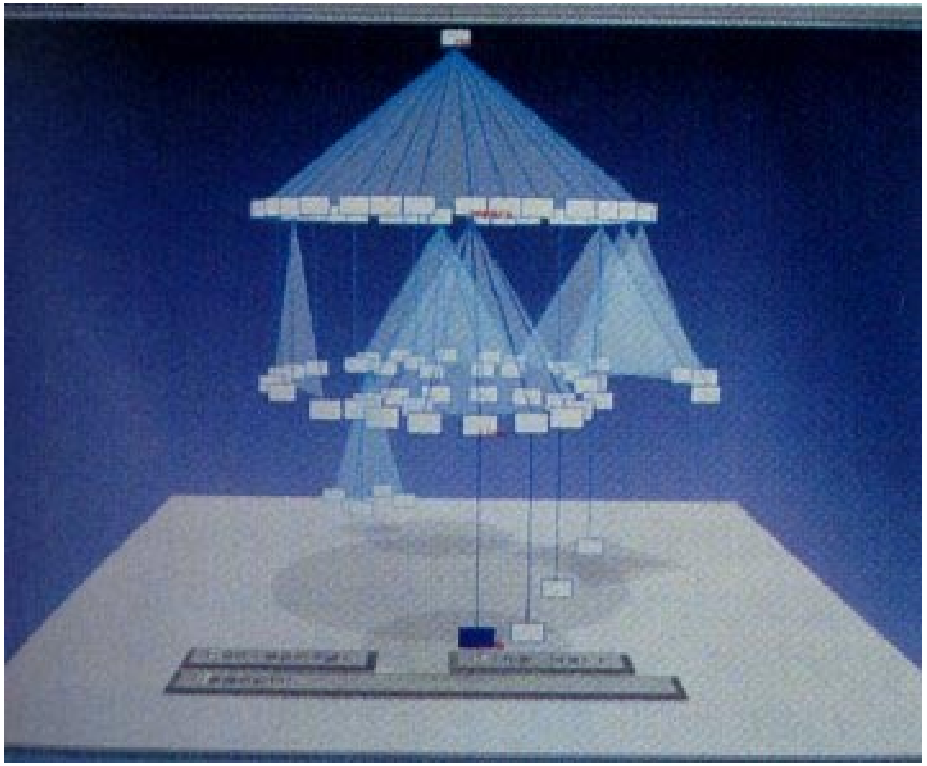
# Example: Trees

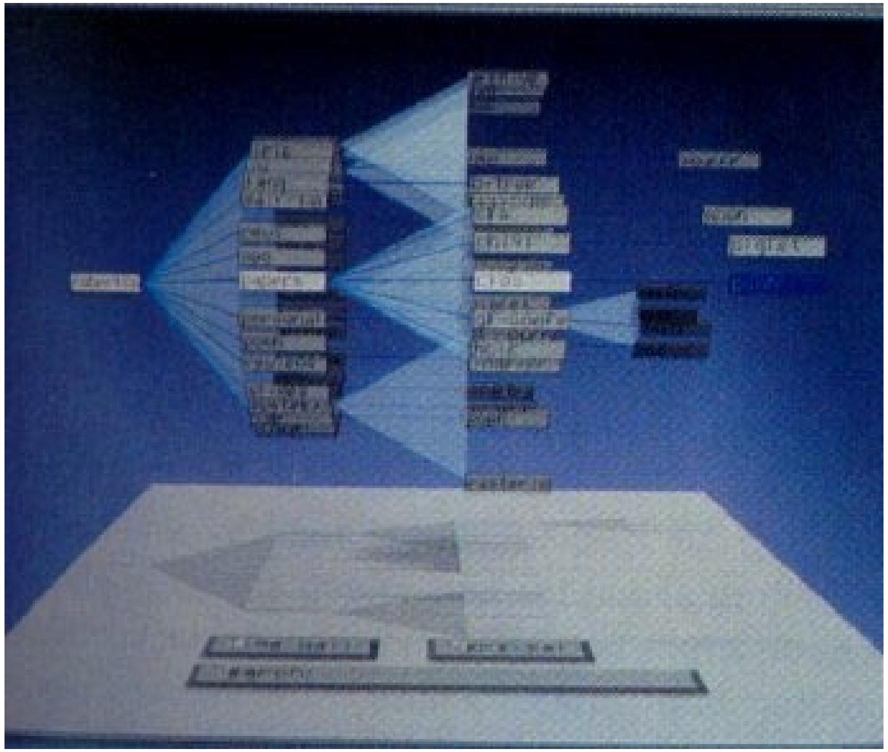
- Two Xerox PARC systems
  - Cone Trees [Plate 15.12]
  - Hyperbolic trees [Plate 15.14]
    - www.inxight.com
- Also many others e.g. Stretch
  - www.elastictech.com

# Cone Tree (Robertson et al.)

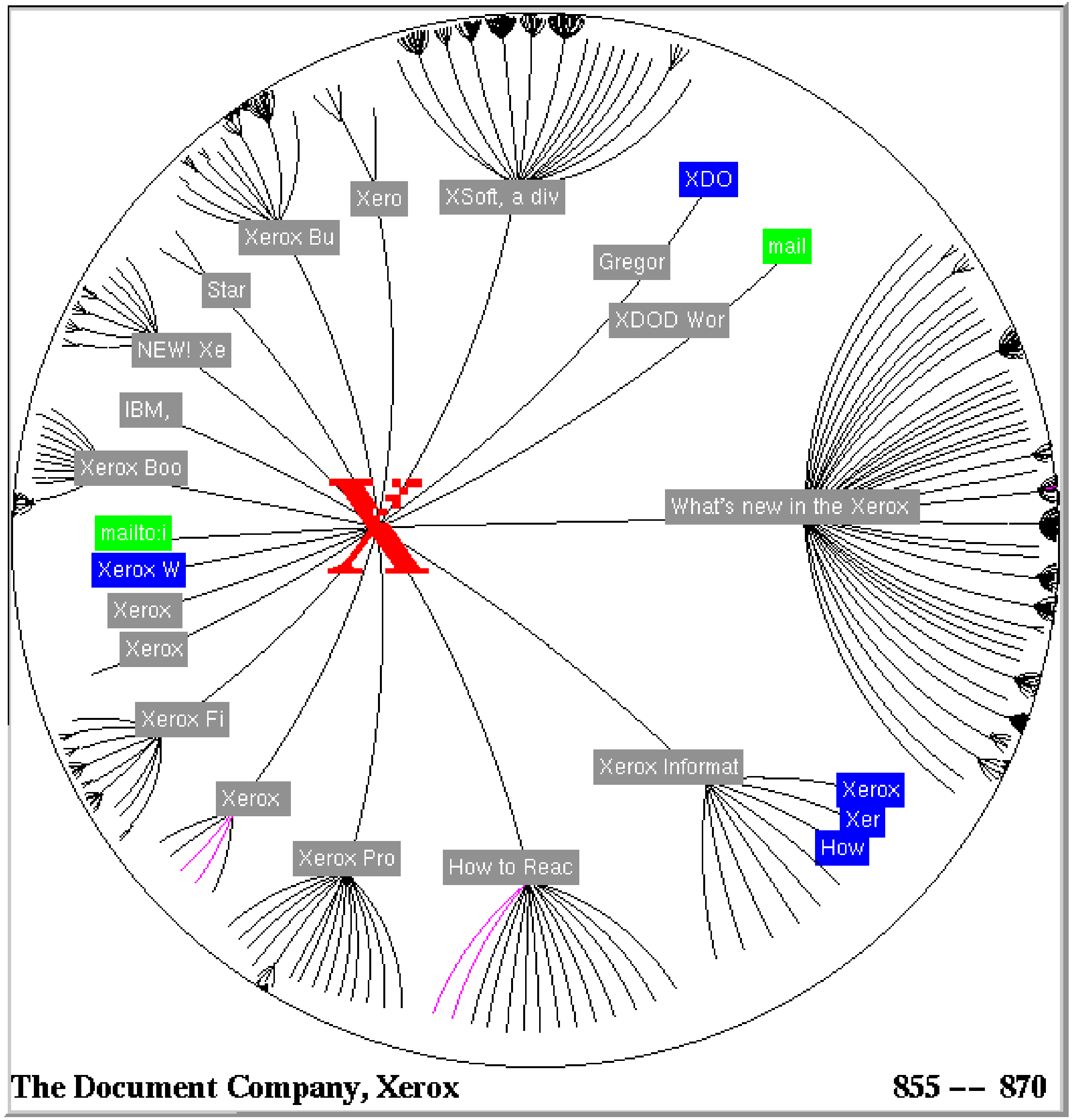


# Cone Tree





# Hyperbolic Tree

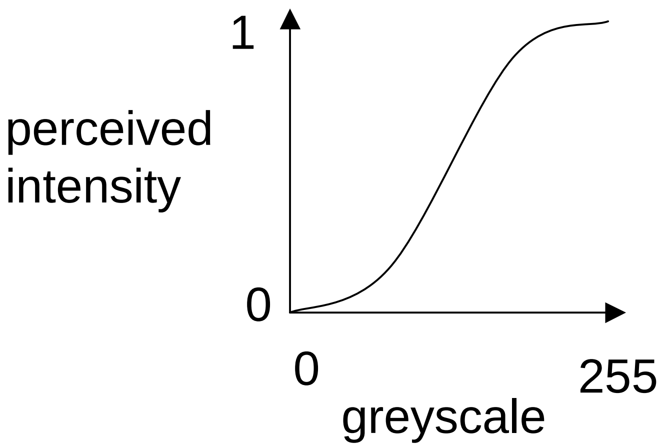


# Mathematics v. Perception

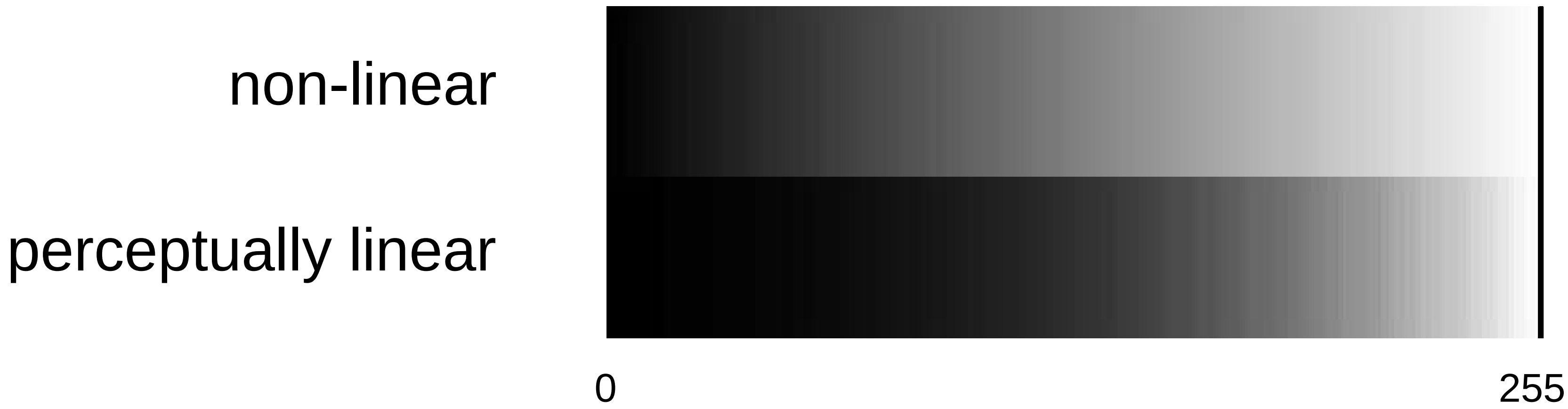
- What is recorded? Orthogonal? Linear?
  - context and history of use
  - people who made it, use it, want it...
  - position, colour, shape, lightness…
- All perceptually non-orthogonal and non-linear
  - even Cartesian coordinates
  - and even similarity: it’s asymmetric

# Linearised Colour Scales

- RGB is perceptually non-linear
  - e.g. (25,50,75) + (25,50,75) ≠ (50,100,150)
- Even grey scales are non-linear



# Linearised Colour Scales



# Linearised Colour Scales

- Applets and Java sources
  - From U. Massachusetts at Lowell
  - examples from book by Haim Levkowitz
  - http://web.cs.uml.edu/~haim/ColorCenter

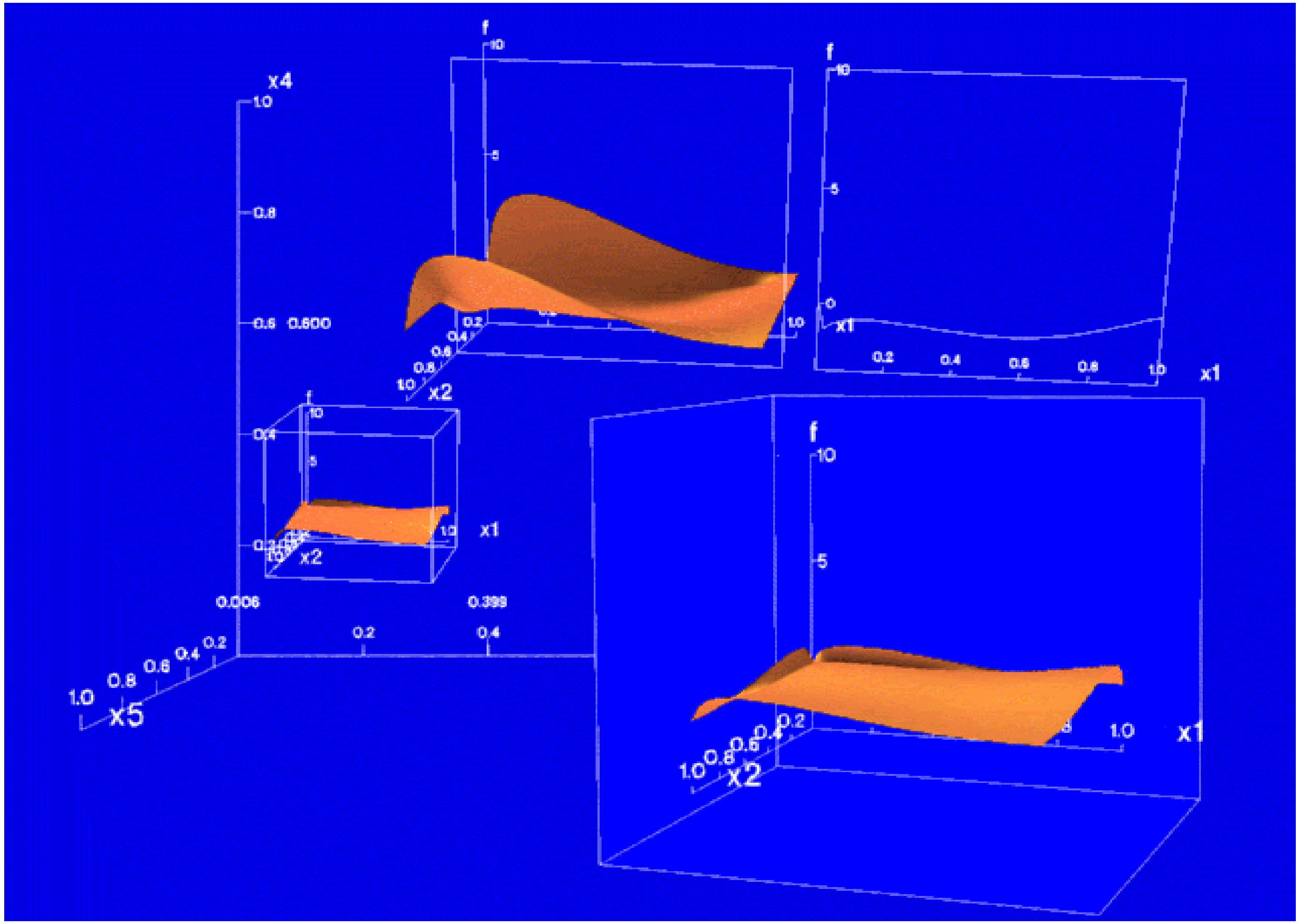
# Absolute and Relative

- Roots in scientific visualisation
- Absolute and relative questions
  – IR/DB for absolute, InfoVis for relative?
- Searching and browsing
- Visualisations as workspaces
  – as places people spend time working

# Roots in Scientific Visualisation

- n-Vision: Feiner and Beshers
- Financial Options pricing
- 6D displayed: ‘worlds within worlds’
  - 3D graph at cursor, within 3D graph
- Comparing points?
- Making relative assessments?
- Getting an overview?

# Worlds Within Worlds



# Relative and Absolute

- "You don’t have to be good to be the best.”

- Absolute properties
  – maximum, average, exact query match
  – need can often can be formalised
  – suited for a command language

# Relative and Absolute

- Relative properties
  - overview, trends, patterns
  - distributions and outliers, ‘sense’
  - often difficult to formalise need
  - suited for direct manipulation [p.71]

# The Importance of Relative Properties

- Items of data do not supply the information necessary for decision making. What must be seen are the relationships which emerge from consideration of the entire set of data. In decision making the useful information is drawn from the overall relationships of the entire set. *(Jacques Bertin)*

# DB and IR

- I’m lumping the two together here
- Obviously a powerful approach, but:
  - what if a query returns too many results?
  - what if it is hard to express what you need?
  - how to use it to make sense of a db?
- Too often, IR and DB systems:
  - focus on the query in isolation
  - lump together everything else: ‘browsing’

# Searching v. Browsing

- Search: query sent into the black box
  - automatic but ‘distant’
  - work done for you, but you can’t guide it
  - query has to represent your need
  - involves the database design or information representation
  - as well as a formal query language

# Searching v. Browsing

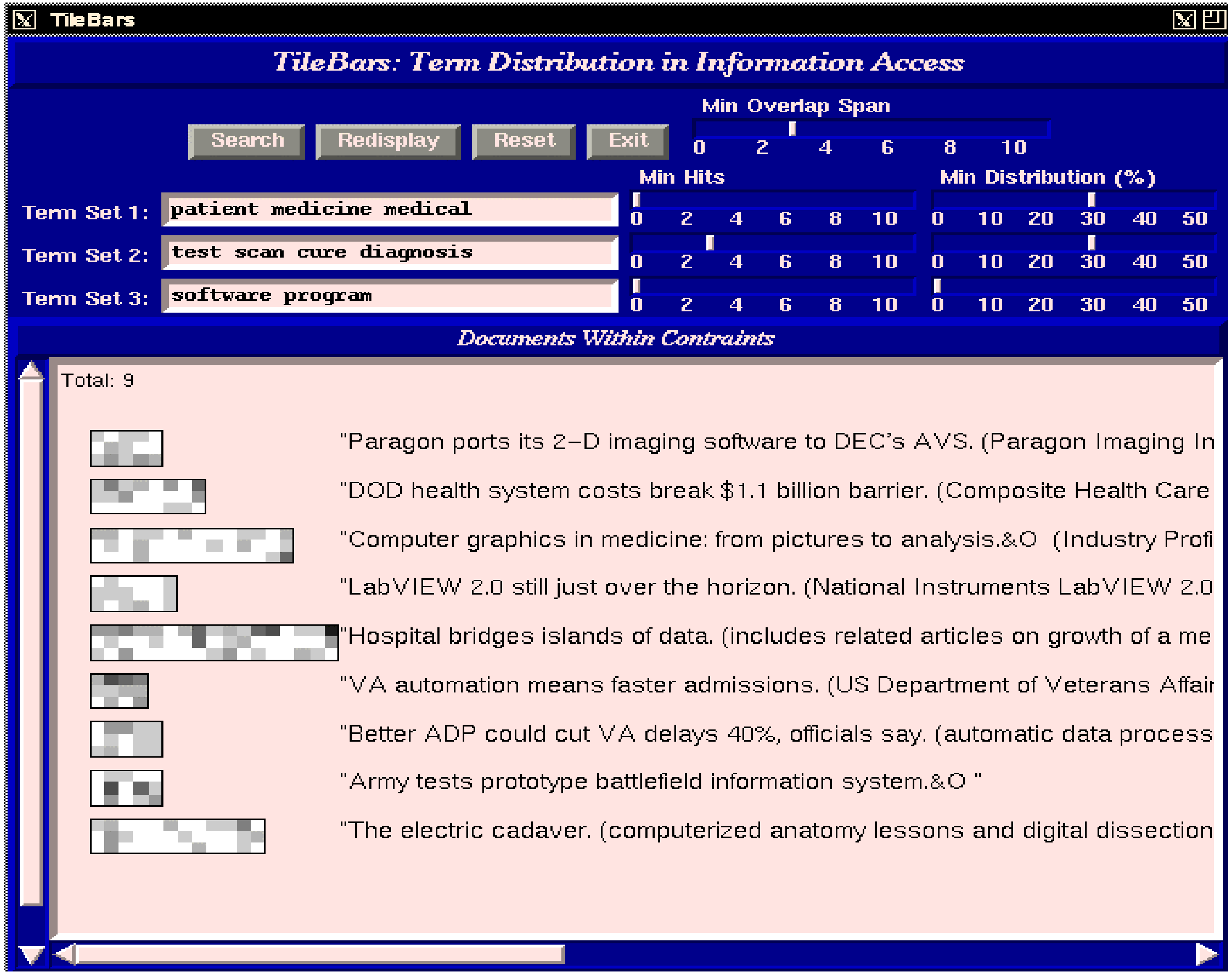
- Browsing: the box is opened up
  - manual but ‘close’
  - *you* do the work (or whatever you’d call it)
  - you don’t have to formally express what you need,
  - but you still rely on the data’s representation

# Query Languages

- Example: Marchionini's 1989 study
  - encyclopaedia in print v. electronic form
  - only half the subjects used AND
  - none used OR or NOT
  - 'electronic' group took twice as long
- Formal query languages are hard
  - SQL requires 2 to 20 hours of training,
  - even then users make frequent errors

# Complementarity with IR/DB

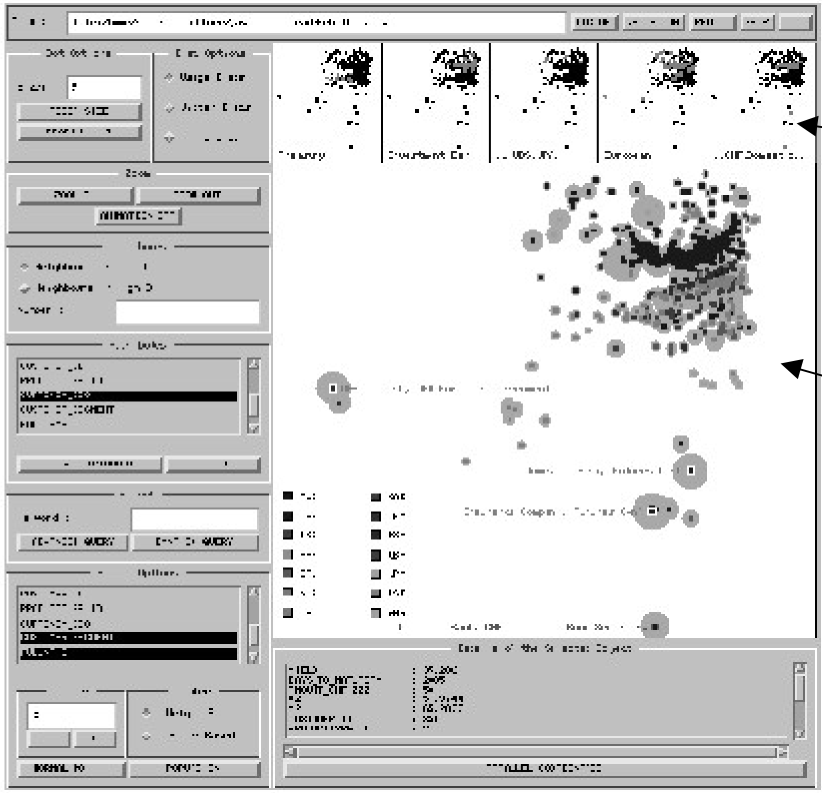
- We need searching *and* browsing, IR *and* InfoVis
- Visualisation inside retrieval
  - vis of search results e.g. Hearst's TileBars
- Retrieval inside visualisation
  - highlight all map elements matching a query [Plate B4]


TileBars
TileBars: Term Distribution in Information Access
Min Overlap Span
Search
Redisplay
Reset
Exit
0 2 4 6 8 10
Min Hits
Min Distribution (%)
Term Set 1: patient medicine medical
Term Set 2: test scan cure diagnosis
Term Set 3: software program
0 2 4 6 8 10
0 10 20 30 40 50
Documents Within Contraints
Total: 9
"Paragon ports its 2-D imaging software to DEC's AVS. (Paragon Imaging In
"DOD health system costs break $1.1 billion barrier. (Composite Health Care
"Computer graphics in medicine: from pictures to analysis.&O (Industry Profi
"LabVIEW 2.0 still just over the horizon. (National Instruments LabVIEW 2.0
"Hospital bridges islands of data. (includes related articles on growth of a me
"VA automation means faster admissions. (US Department of Veterans Affair
"Better ADP could cut VA delays 40%, officials say. (automatic data process
"Army tests prototype battlefield information system.&O "
"The electric cadaver. (computerized anatomy lessons and digital dissection

# Visualisation as Workspace

- Place/setting for fine-grained activities
  - seeing how search results fit
    - Bell Labs' SeeSoft [Plate B1]
    - Bead 'worlds in miniature'
  - spreadsheet-like sorts, classifications...
    - Xerox/InXight's TableLens
  - seeing where others have been or are now
    - e.g. VRs, 'wear' [15.2, 15.3]

# WIMs: Small Multiples



Miniatures of main image, showing most recent searches

Main image

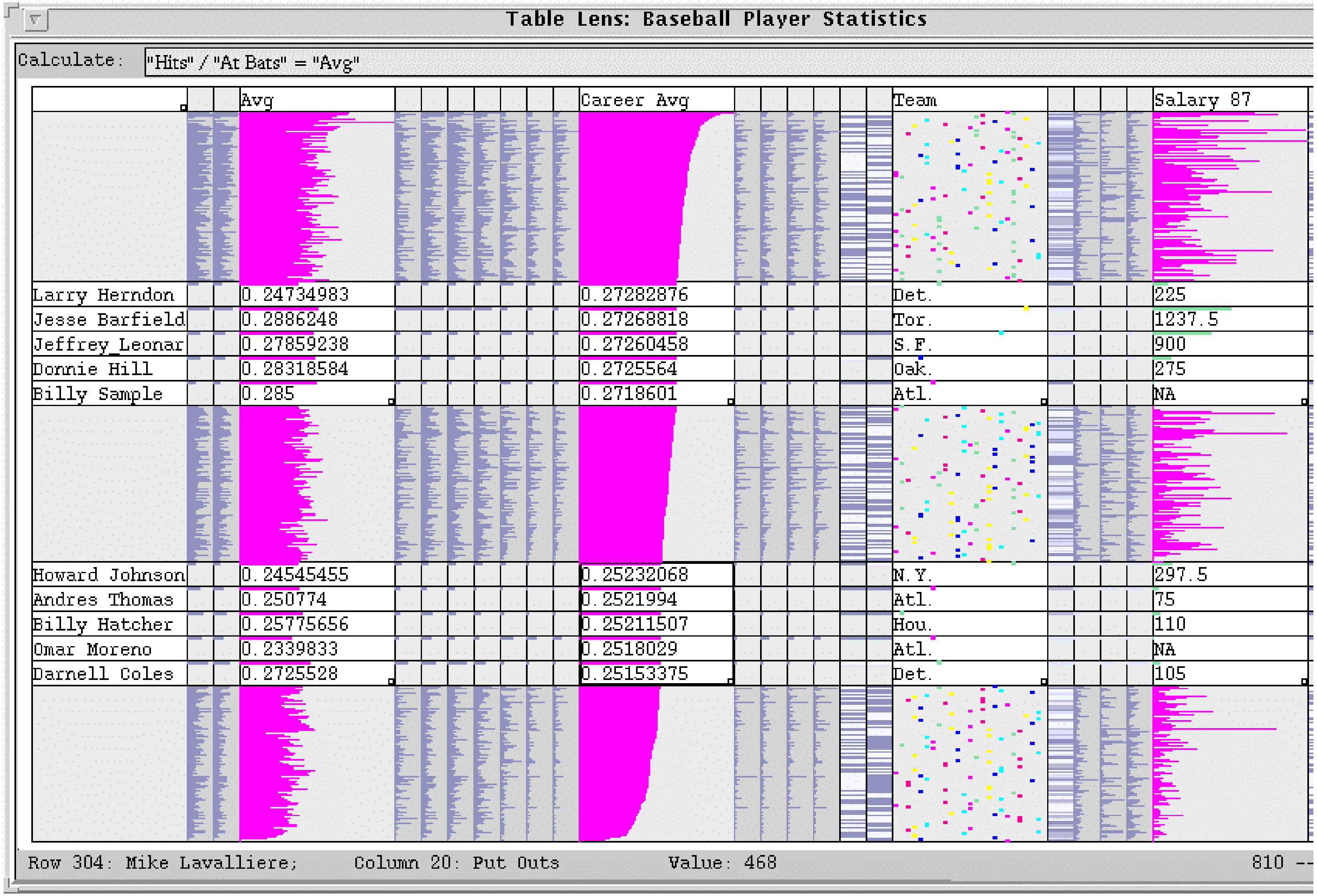
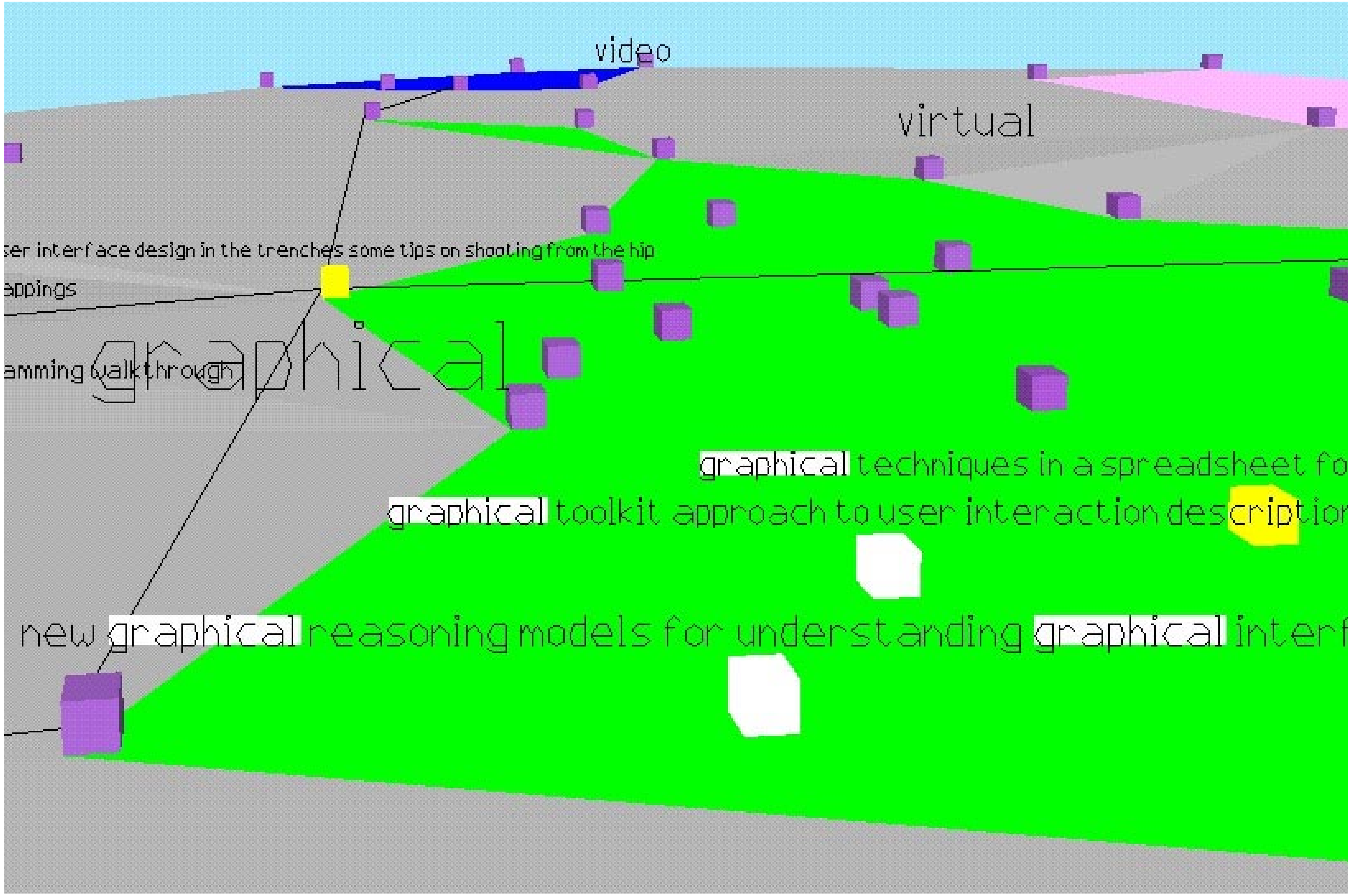


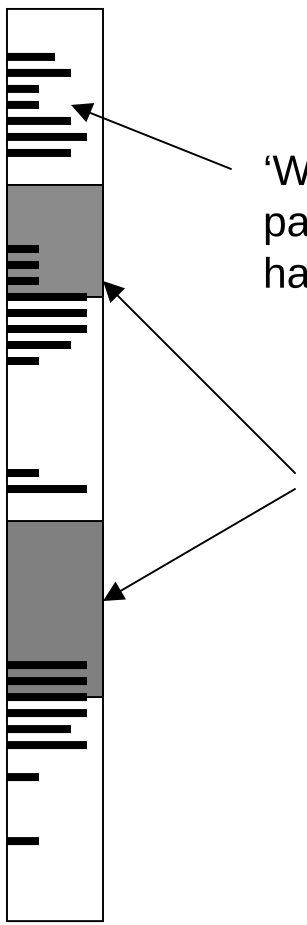
Table Lens: Baseball Player Statistics
Calculate: "Hits" / "At Bats" = "Avg"
Avg
Career Avg
Team
Salary 87
Larry Herndon 0.24734983 0.27282876 Det. 225
Jesse Barfield 0.2886248 0.27268818 Tor. 1237.5
Jeffrey_Leonar 0.27859238 0.27260458 S.F. 900
Donnie Hill 0.28318584 0.2725564 Oak. 275
Billy Sample 0.285 0.2718601 Atl. NA
Howard Johnson 0.24545455 0.25232068 N.Y. 297.5
Andres Thomas 0.250774 0.2521994 Atl. 75
Billy Hatcher 0.25775656 0.25211507 Hou. 110
Omar Moreno 0.2339833 0.2518029 Atl. NA
Darnell Coles 0.2725528 0.25153375 Det. 105
Row 304: Mike Lavalliere; Column 20: Put Outs Value: 468


video
virtual
ser interface design in the trenches some tips on shooting from the hip
appings
amming walkthrough
graphical
graphical techniques in a spreadsheet fo
graphical toolkit approach to user interaction descriptior
new graphical reasoning models for understanding graphical interf

# Edit Wear and Read Wear

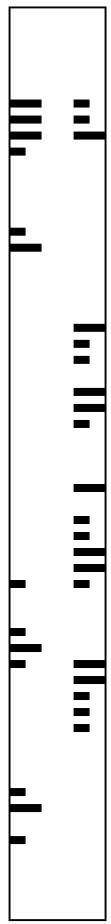
- Metaphor, involving familiar idea
  - wear on well-thumbed books
  - shows accumulated history
- Can extend well-known rep$^{ns}$
  - or be part of newer ones
- No big conceptual jump here
  - but very effective technique

# Edit Wear and Read Wear



‘Wear marks’ show pattern of where file has been most used.

Rectangles can show where each person is currently reading.



Can represent more than one feature by using multiple bands, such as reading, edits, Y2K ‘sensitivity’ etc.

# Looking Back

- A first (naïve?) characterisation
  - absolute ↔ DB/IR ↔ searching
  - relative ↔ InfoVis ↔ browsing
- Perceptual issues vitally important
  - 2D as superior to 3D
  - over time, link fine-grained activities
  - show history to help guide future activity

# After Tea

- Shneiderman’s taxonomy of data types
  - dimensional reduction
  - ‘heterogeneous’ data
- Interaction techniques
  - linking, distorting, lenses...

# Shneiderman’s Taxonomy of Data Types

- 1D and temporal data
- 2D: maps, scatterplots
- 3D e.g. the world
- hierarchical e.g. trees
- graph data e.g. web pages and links
- multidimensional data: everything else?

# 1D Data

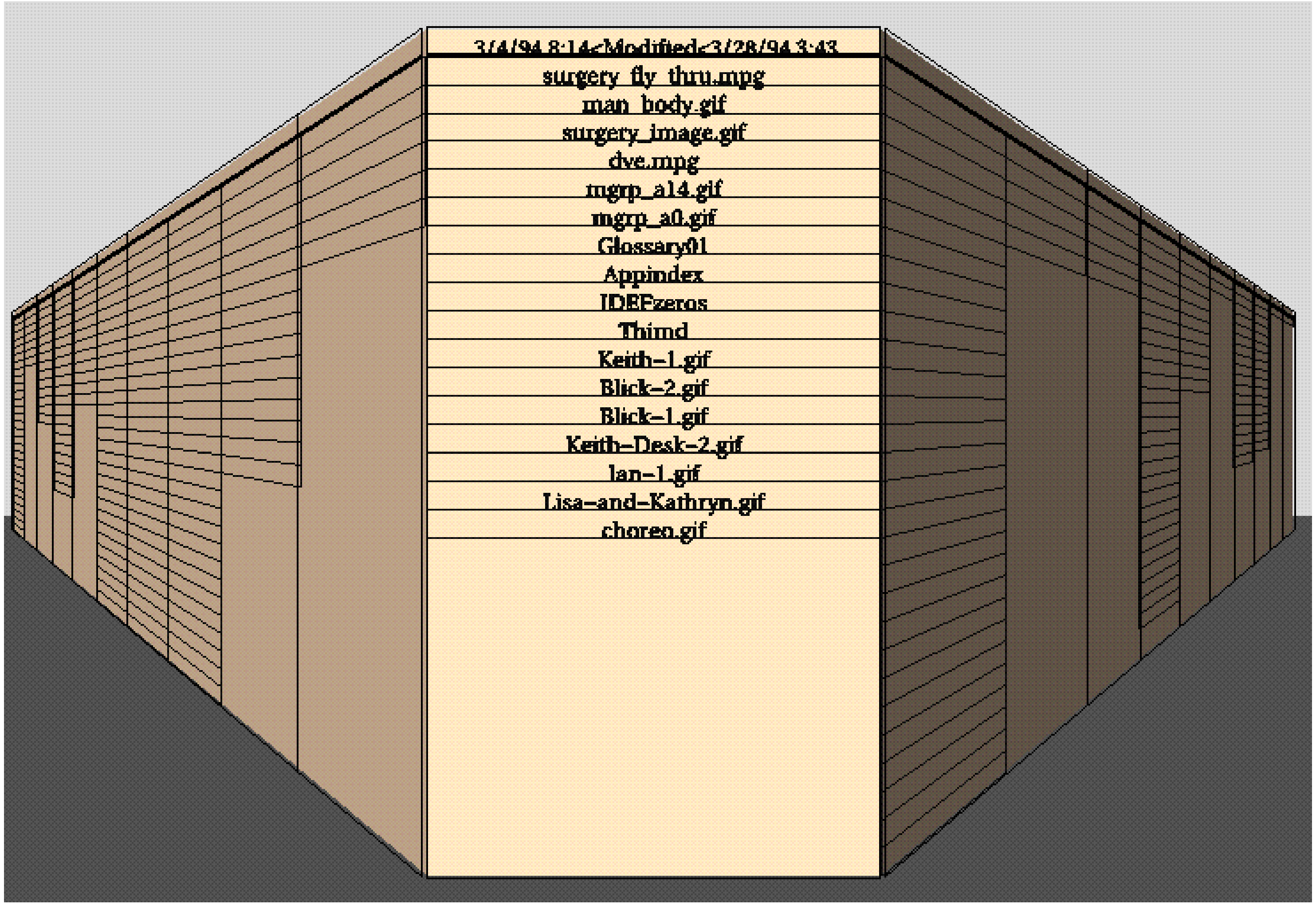
- Could just use a scrolling list
- Different scale views e.g. scrollbars [15.3]
  - edit wear and read wear
- Dual, shared view
  - allows *focus* on detail as usual
  - adds extra *context* unobtrusively

# Focus+Context

- A powerful interaction approach
  - magnify the centre or *focus*
  - compress the periphery or *context*
- Assumption: focus is more important
  - so *distort* or split to give it more pixels
- Best known approaches
  - scrollbar: edit wear and read wear
  - Perspective Wall, 2D: ‘fisheye’ lens [13.15]

# Temporal Data

- Shneiderman distinguishes this from 1D
  - very common: records, logs...
- ‘Parallel’ features, sharing time axis
- Can use 1D techniques
- Can set 1D in 3D e.g. Perspective Wall
  - early InfoVis exemplar from Xerox PARC
  - jazzy use of 3D, but is it really useful?

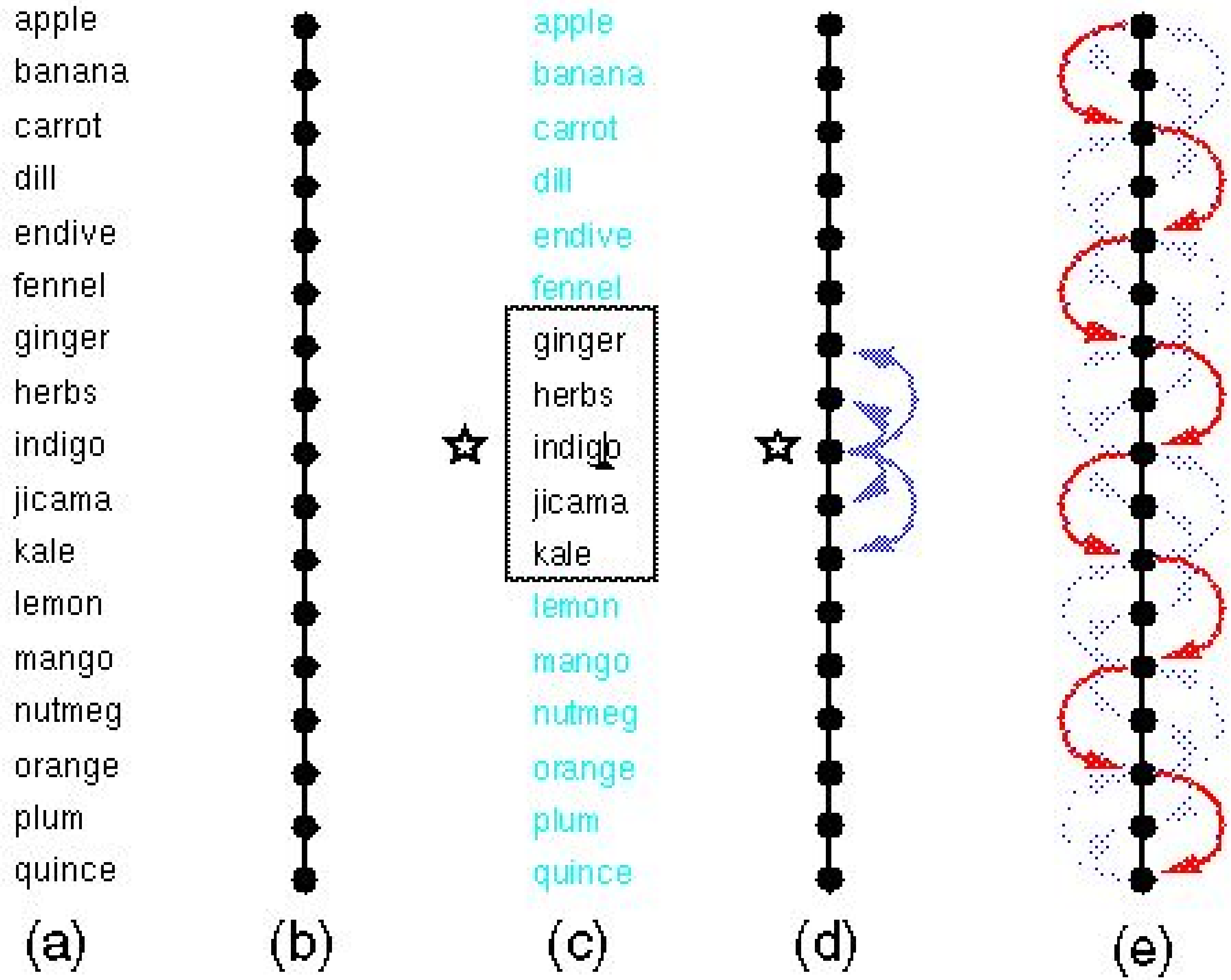



Not the best picture, but anyway...

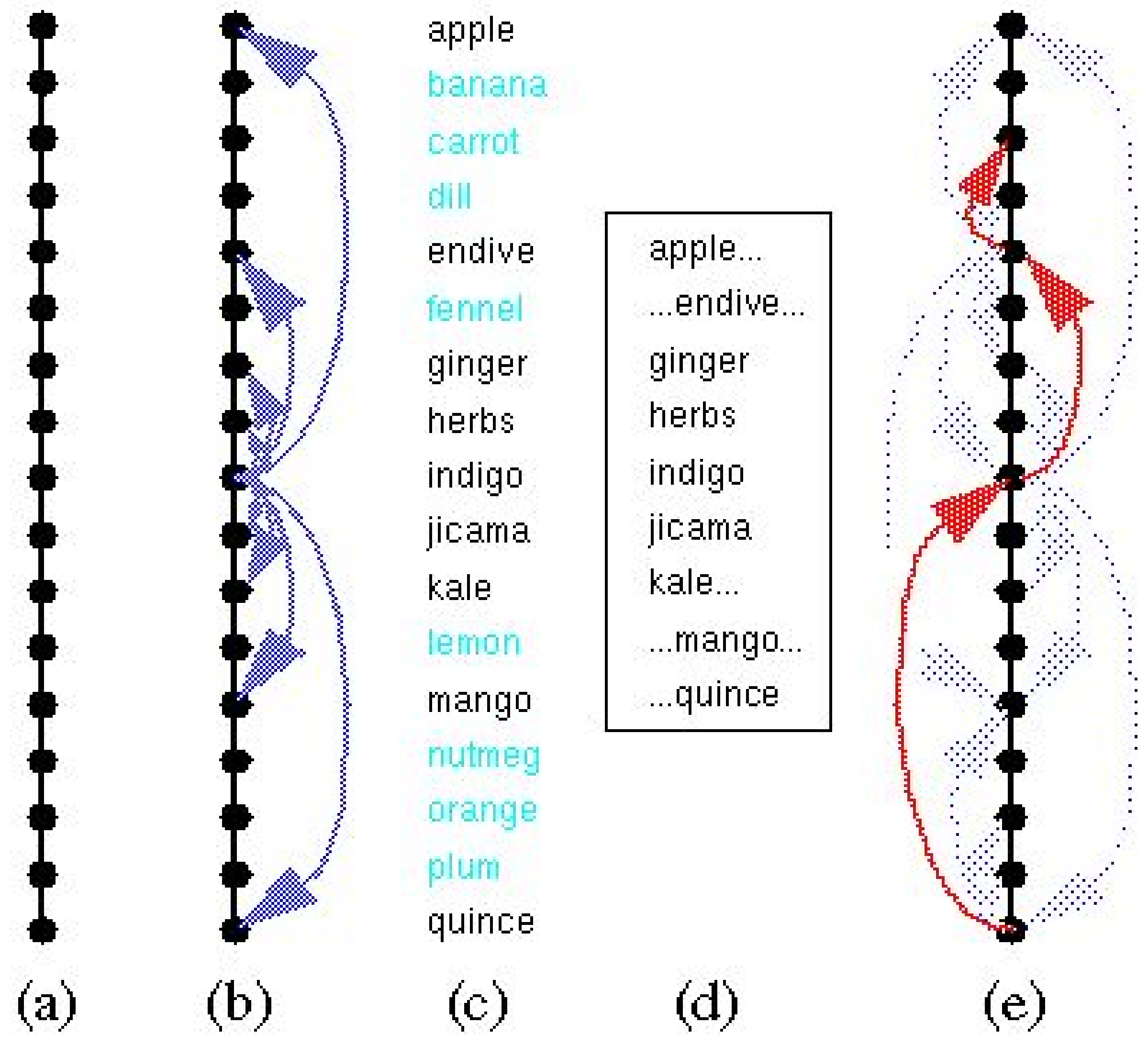
# Perspective Wall

- Effectively a distortion technique
  - better image: [15.8]
  - central *focus* region has detail
  - gradually compressed *context*
- Appeal to natural perspective view
  - closer things take up more of field of view
  - further things take up progressively less
  - as distance $\rightarrow \infty$, resolution $\rightarrow$ zero

# 1D Distortion (Furnas, CHI97)

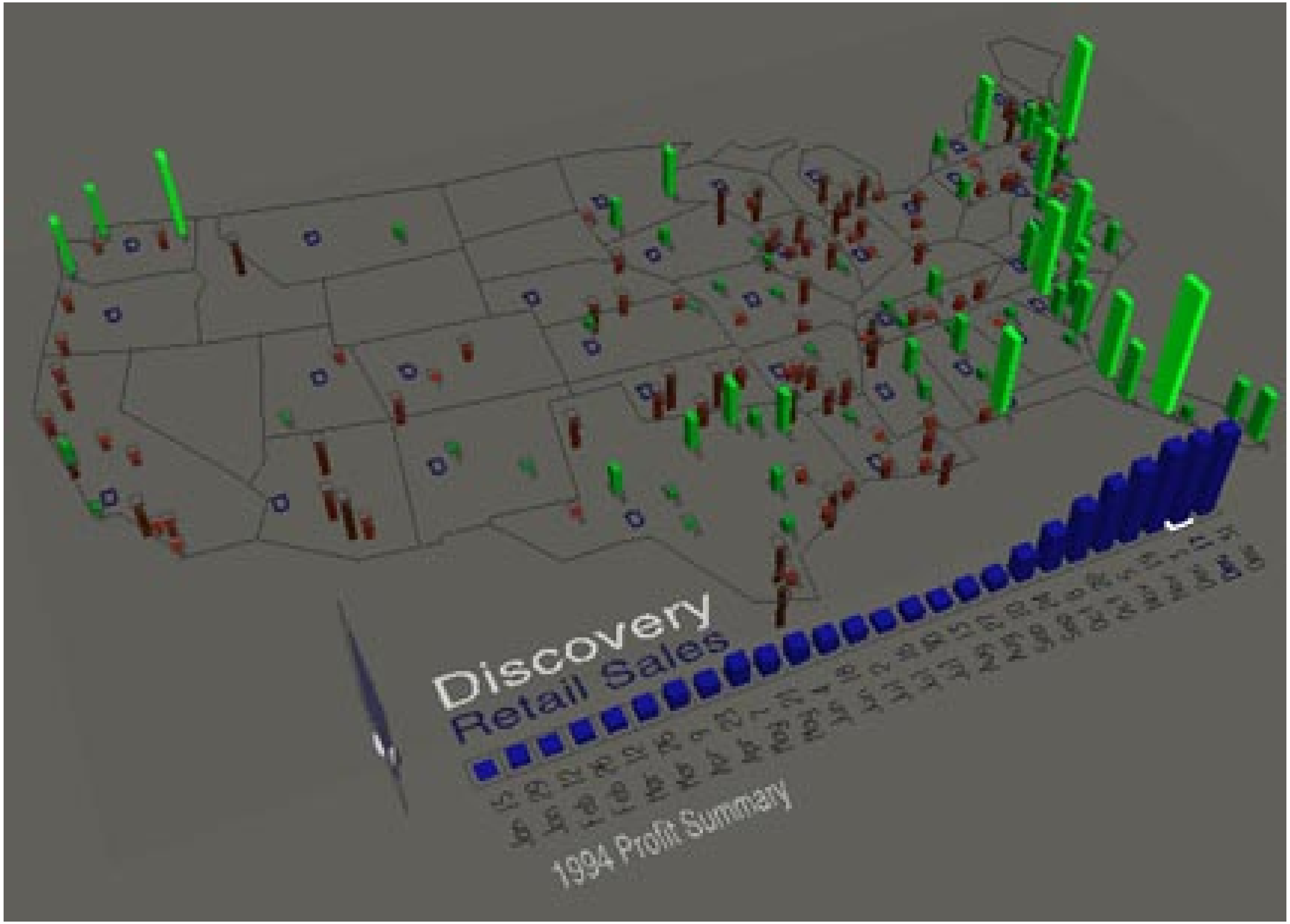


# 1D Distortion



# 2D Data

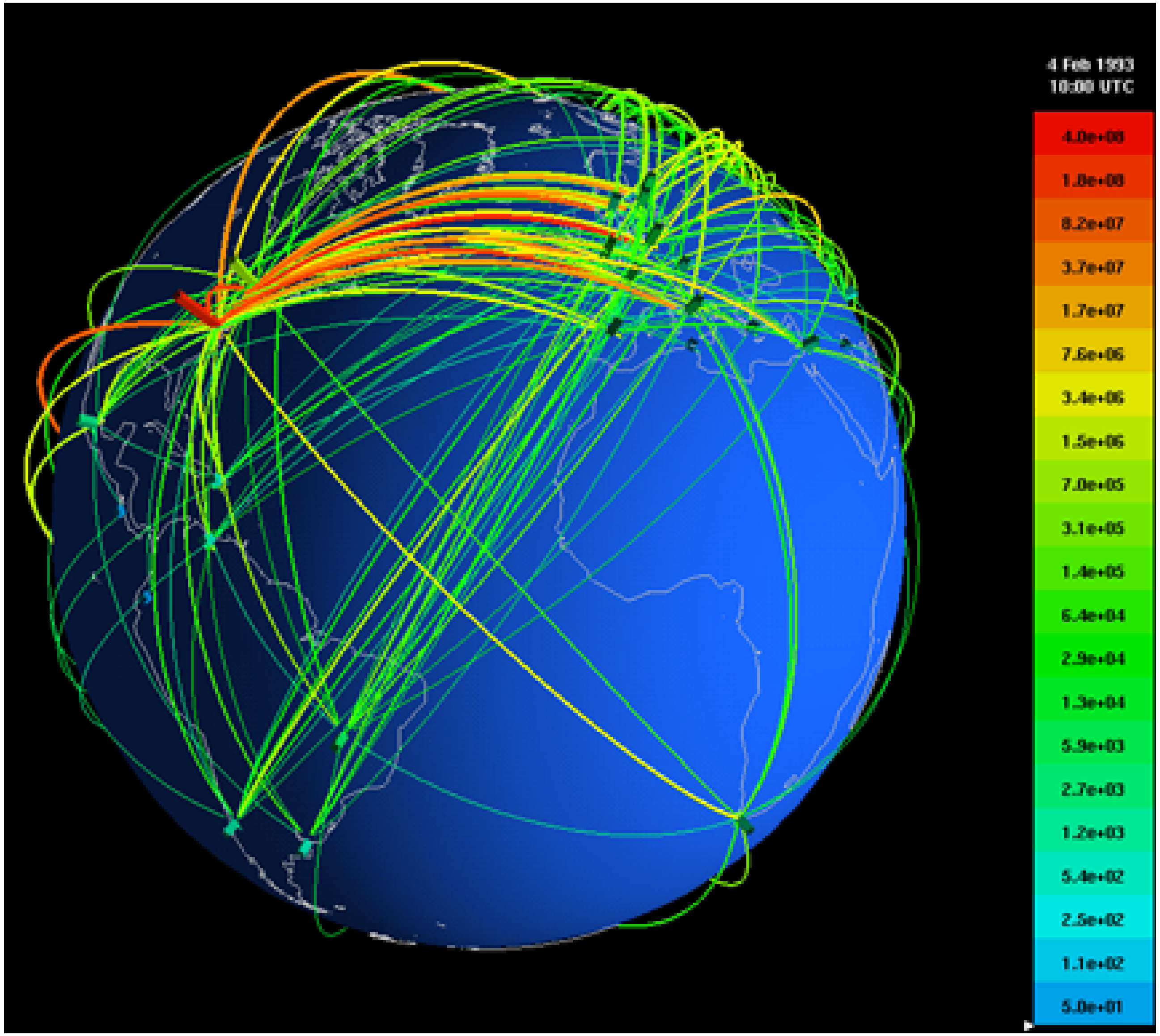
- 2D structure in 2D view
  - scatterplots and maps: Spotfire
- 2D structure in 3D view
  - landscapes, increasingly common in VRs
  - 3D features placed on ground plane
  - but: high values block low ones
  - can fail due to occlusion

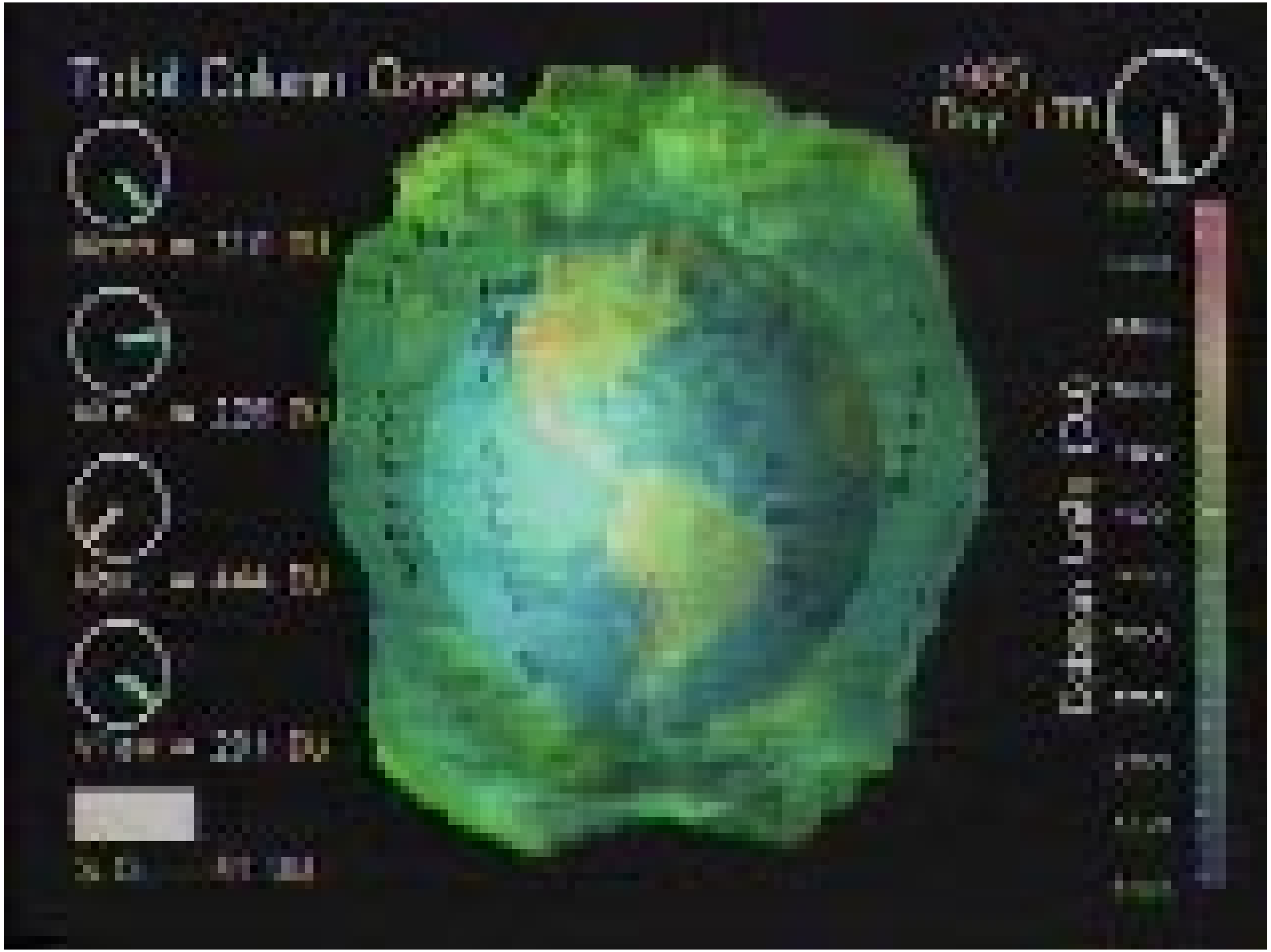

Discovery
Retail Sales
1994 Profit Summary

# 3D Data

- Appeal to the ‘natural’ world
  - we often think of the world as a 3D shape
  - but we don’t treat it that way
  - e.g. how wide is a city? How high?
  - e.g. can only see surfaces of most objects
- Often invites occlusion problems
  - nearby objects block view of distant ones
  - e.g. can only see half of a sphere

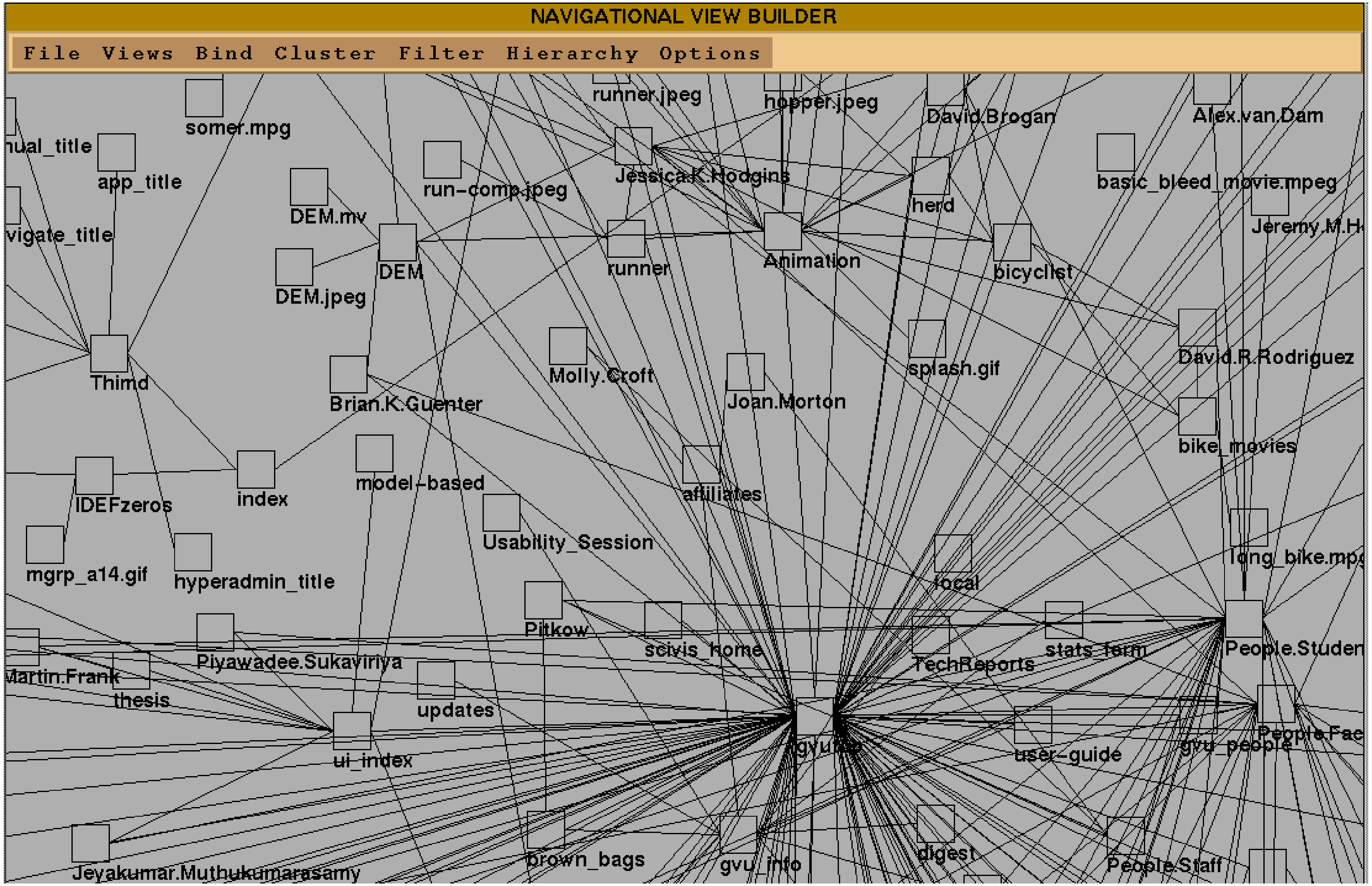
# Global Network Traffic




Total Column Ozone
Dobson Units (DU)

# Hierarchical Data

- Trees:
  - Cone trees, cam trees, ... (3D)
  - Hyperbolic trees, Stretch... (2D)
- Still difficult to handle
  - some people use *focus+context*
  - show detail on central focus area
  - use distortion to retain rough context


NAVIGATIONAL VIEW BUILDER
File Views Bind Cluster Filter Hierarchy Options
somer.mpg
app_title
Thimd
DEM.mv
DEM
DEM.jpeg
run-comp.jpeg
runner.jpeg
Jessica.K.Hodgins
runner
hopper.jpeg
Animation
David.Brogan
herd
bicyclist
Alex.van.Dam
basic_bleed_movie.mpeg
David.R.Rodriguez
bike_movies
IDEFzeros
index
Brian.K.Guenter
Molly.Croft
Joan.Morton
splash.gif
model-based
affiliates
mgrp_a14.gif
hyperadmin_title
Usability_Session
local
Pitkow
scivis_home
TechReports
stats_form
People.Studen
Piyawadee.Sukaviriya
thesis
updates
ui_index
user-guide
gvu_people
Jeyakumar.Muthukumarasamy
brown_bags
gvu_info
digest
People.Staff

# Graph Data

- Important e.g. Web, but difficult
- Sometimes reduce to simpler type
  - e.g. convert to a tree: choose a root, lift up, cut off excess links
- Sometimes use optimisation algorithms
  - attempt to minimise edge crossings
  - connectivity $\rightarrow$ ideal proximity $\rightarrow$ error
- Or let the user(s) handle the problem

# WebBook (Xerox PARC)

# Multidimensional Data

- Dimensional reduction
  - transform to one of the other types
  - e.g. force-based layouts to make a 2D map
- Sometimes data inherently too complex
  - even apparently simple cases e.g.
  - 4 objects, all 1m from each other $\rightarrow$ 2D?
- More on this later...

# Limits of the Taxonomy?

- Heterogenous data?
- He treats the web *only* as a graph
  - assumes use is driven only by local links
  - counterexample: search engines
- He focuses on the authored content…
  - …but not on how we read and use it
- He focuses on visual perception…
  - …but not on how use affects perception

# Let the Users do the Work

- Xerox PARC WebBook
  - people place web objects in 3D
  - similar: Pad++ web viewer
- Problems
  - manual, scaling to large numbers
- Still, it's good to see multiple pages

# Heterogeneous Data

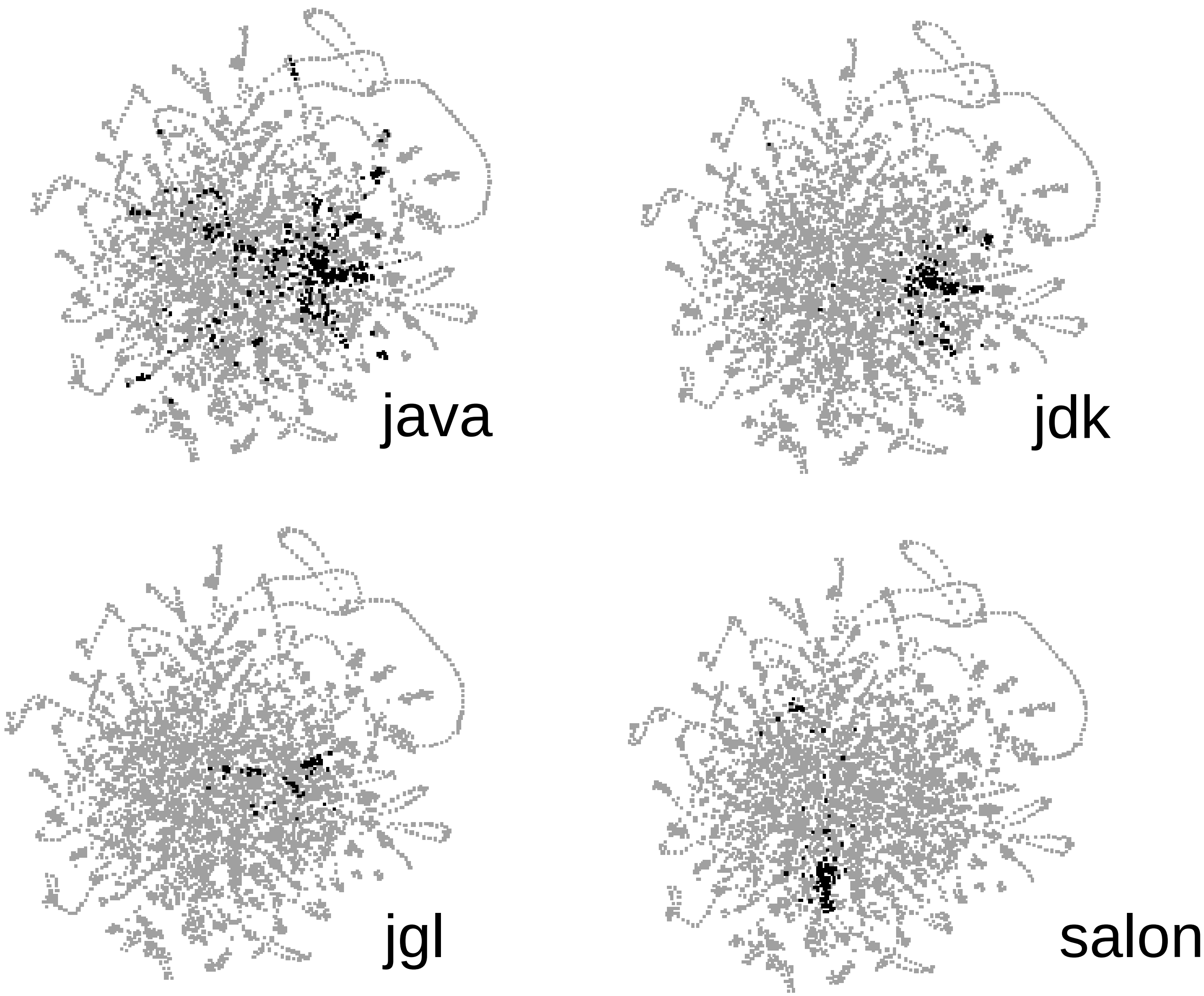
- Handling a mix of types e.g. on the Web
  - text, images, sound, programs
- Often very complex data
  - music, films, novels… web pages
- Content analysis doesn’t work (yet?)
  - how to define ‘similarity’?
  - attempts to work via abstract metadata fail

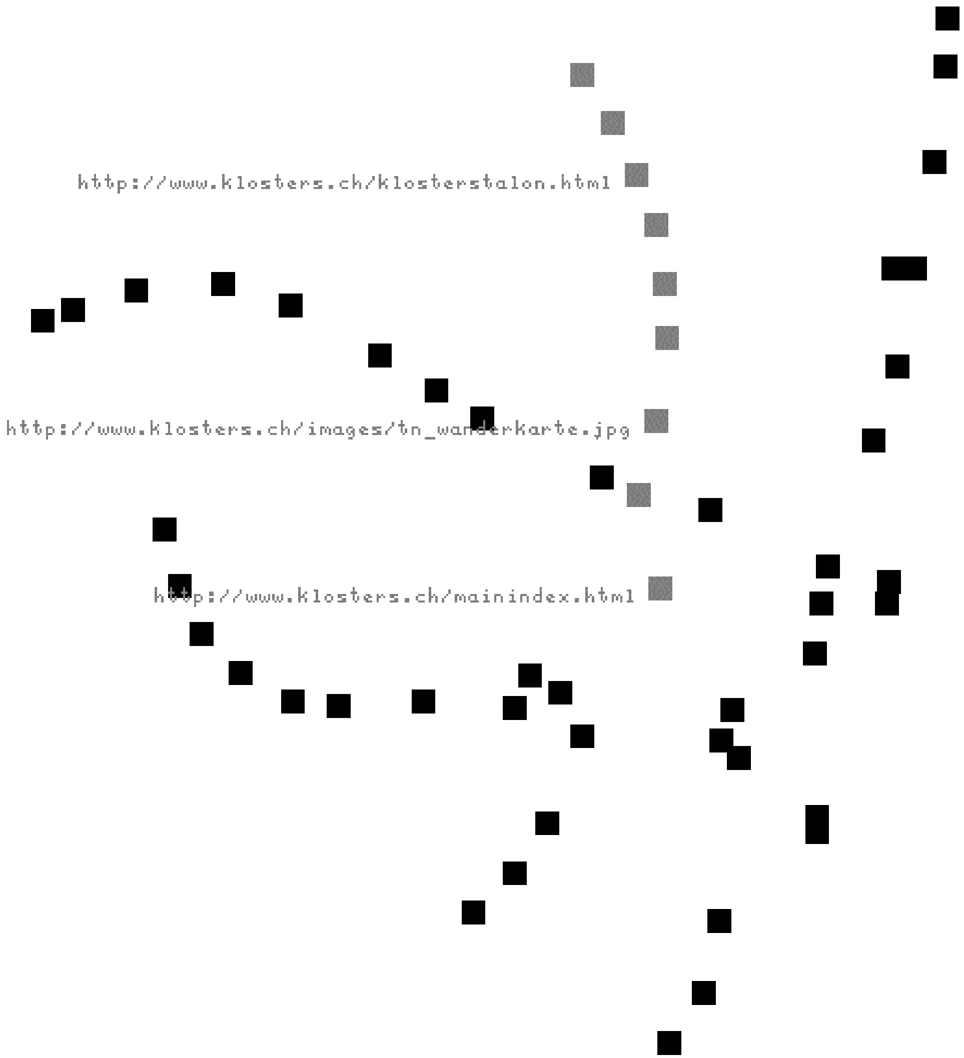
# The Path Model

- Extension of collaborative filtering (CF)
  - Resnick/Varian CACM special issue
- *Path*: a user's history of choices
  - order over time is represented
- Can use co-occurrence statistics
  - co-occurrence treated as similarity
  - use dimensional reduction to make maps

# Similarity Metric

- A matrix, $f(URL_i, URL_j) \rightarrow$ real
- Use statistics of co-occurrence
  - for each window of length k URLs
    - get each pair of URLs *i* and *j* in the window
    - add 1 to $f(URL_i, URL_j)$ for each *i,j*
  - step window on along path by one
  - when end reached, normalise


java
jdk
jgl
salon


http://www.klosters.ch/klosterstalon.html
http://www.klosters.ch/images/tn_wanderkarte.jpg
http://www.klosters.ch/mainindex.html

# CF and Paths

- Complement traditional IR/DB work
  - focus on individuals’ choices/activity
  - IR focuses on data independent of activity
  - CF and paths need IR to feed them
- Adaptive, subjective, minimise metadata
- Handle heterogeneous data
  - which IR can not do

# Shneiderman's Taxonomy

- OK for a first cut, but too simple
- Data is transformable between types
  - graphs to trees, multiD to 2D, tree to 1D
  - …and what about heterogeneous data?
- No 'perfect' way to handle data
  - subjective, depends on situation
  - tasks are interwoven and interdependent
  - ...so use multiple views and transforms

# Dimensional Reduction

- What is it?
- Similarity metrics
  - functions to say how alike two things are
- Two non-linear approaches
  - (Kohonen maps (or ‘SOMs’))
  - Force-based layouts
- Traditional approaches too constrained?
  - PCA, SVD...

# What is it?

- n-dimensional data reduced to 2D
  - preserve relationships of n-D
  - metaphor: close $\cong$ similar, far $\cong$ dissimilar
- What does ‘close’ mean?
  - Euclidean distance on 2D map?
- What does ‘similar’ mean?
  - Euclidean distance in n-D space?
  - used in similar ways by similar people?

# Similarity Metrics

- Textual documents: word frequencies
- Doc represented as vector of pairs

  *($word_i$, $f_i$)*

- similarity: use scalar product
  - Sum over each word of $f_i \,.\, f_j$

# Similarity Metrics

- Spreadsheets: matrix of data $M_{ij}$
- Need metric for similarity of two rows
  - build from metrics for simpler data types
  - numerical types: reals, integers
  - ordinal types: name, currency
- Sum effect of each column in each row
  - usually do some normalisation first

# Similarity Metrics

- Numerical columns: sum over columns

  $s=0$

  $s \mathrel{+}= (M_{ik} - M_{jk})$ for each column $k$

- Ordinal columns: product over columns

  $p=1$

  $\text{if } (M_{ik} = M_{jk}) \text{ then } p \text{ else } 0.75*p$

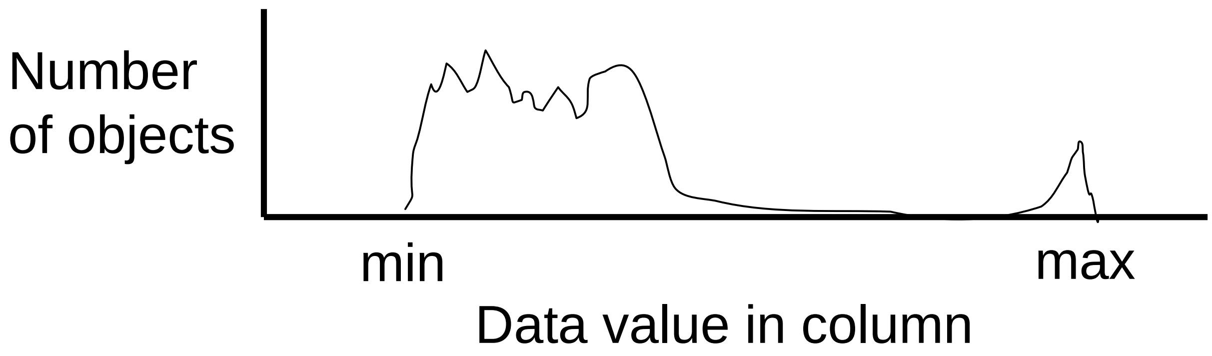
- Similarity = (1 - $s$) * $p$

# A Sweeping Generalisation

- For *any* data type, *some* similarity metric is feasible
  - a function $f(a,b) \rightarrow real$
- Problem is whether it makes any sense
  - normalisation and outliers
  - limits of applicability of mathematics
- So, make some initial rough cut
  - be aware that it is likely to be rough

# Normalisation

- Spreadsheets: summing differences
  - what if one column has large numbers...
  - ...and another has small numbers?
  - Quick normalisation: scale by *max-min*
  - Or: scale by 1 or 2 standard deviations



# Applicability of Mathematics

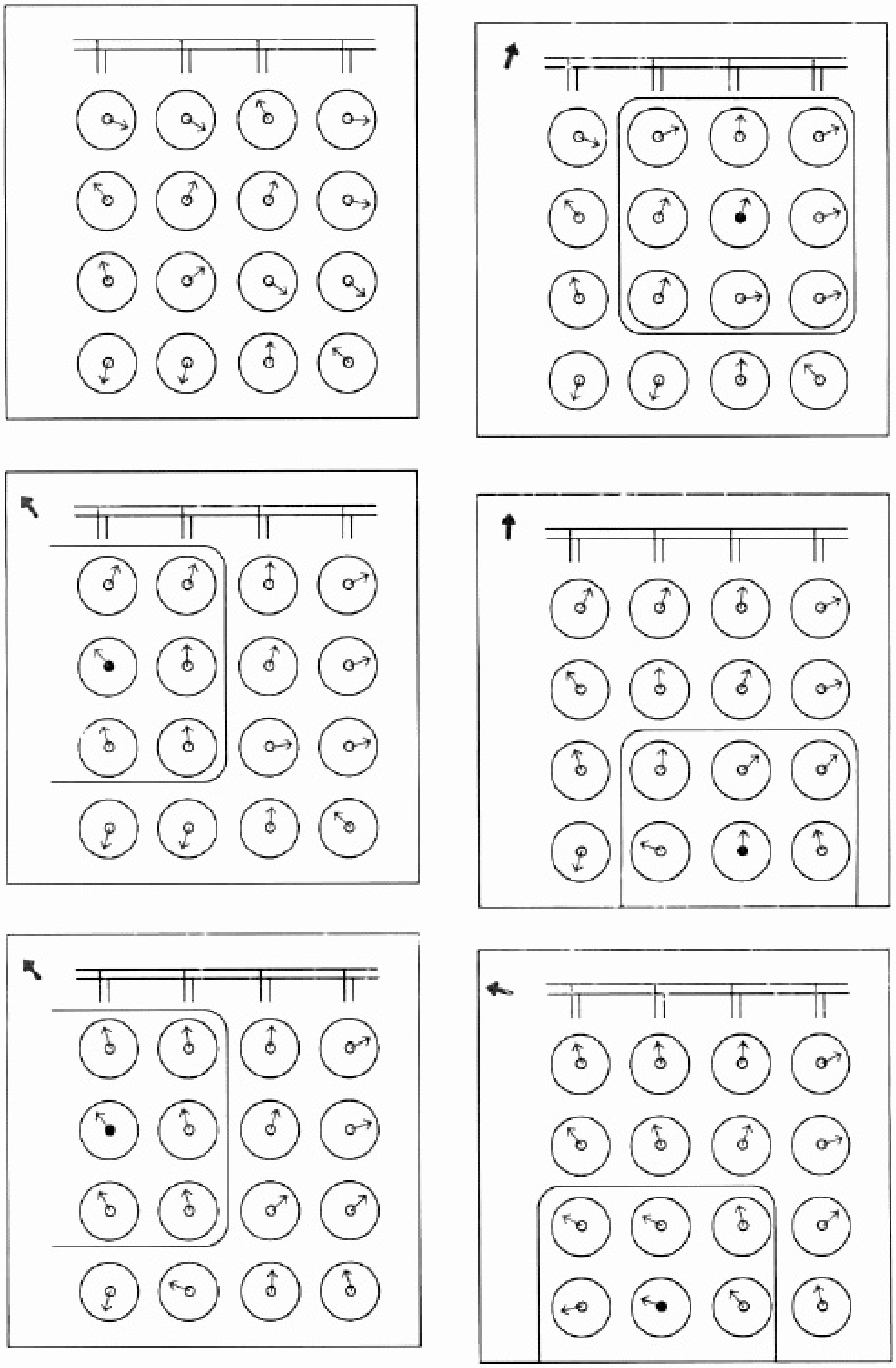
- Word frequency
  - Twice as frequent $\Rightarrow$ twice as important?
  - Zero means word not relevant to doc?
- Spreadsheets
  - why $(M_{ik} - M_{jk})$ and not $(M_{ik} - M_{jk})^2$
  - why $0.75p$ and not $0.751p^{23}$
- Usually people ‘just try stuff’
  - can’t model subjectivity and contextuality

# Self-Organising Maps (SOMs)

- 2D grid of points $p_i$ with vectors $v_i$
- Make grid 'fit' dist$^{\underline{n}}$ of input n-D data
  - not a map of input data, but a map of statistical patterns/distribution of input
- Similar grid points are close together
- Relies on metric:
  - similarity ($v_i$, *input)* $\rightarrow$ real
- http://websom.hut.fi

# Kohonen SOM Algorithm

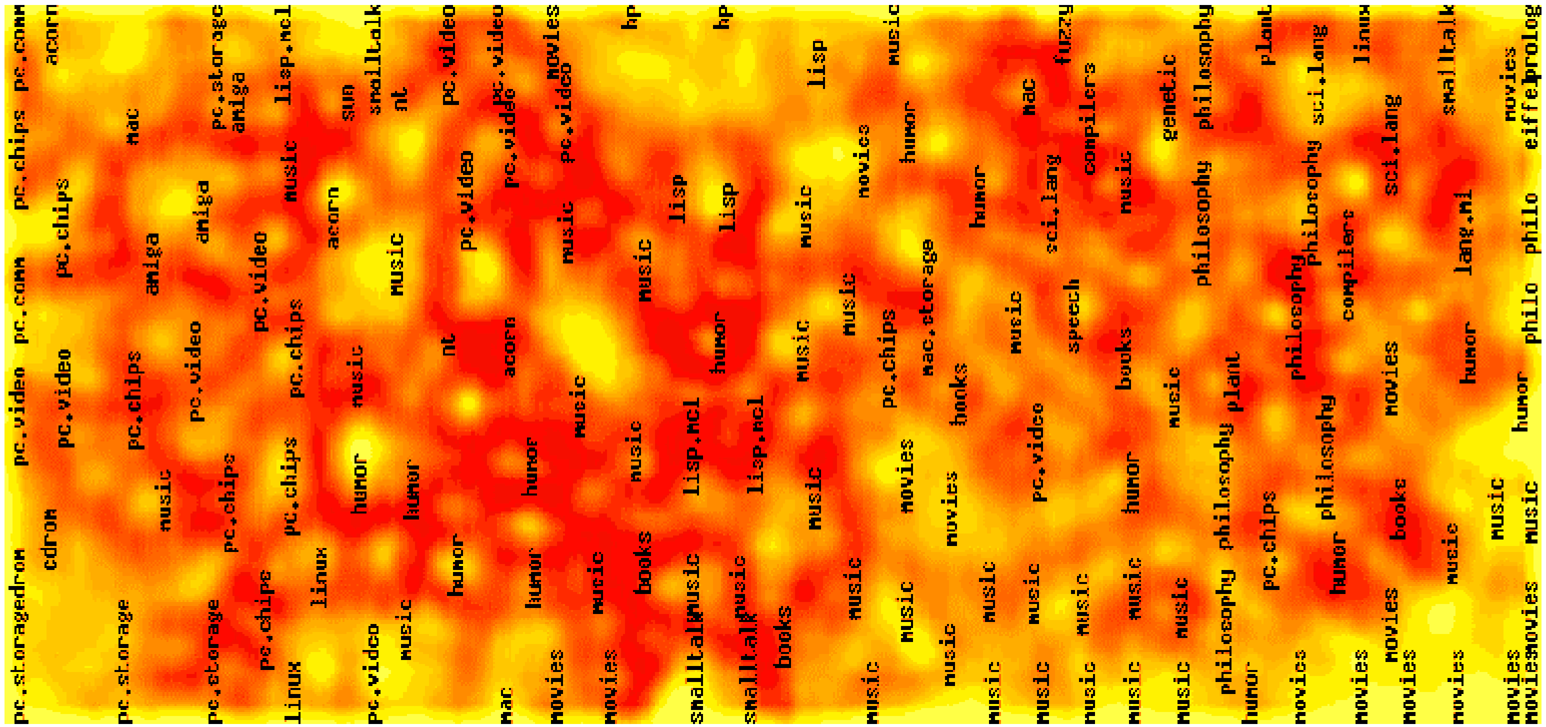
- create grid: $p_i$
- give random n-D vector to each: $v_i$
- for each n-D training input $t$
  - find the node most similar to $t$: $v_{winner}$
  - adjust: $v_{winner} = av_{winner} + (1-a)\ t$
    - *a* determines how quickly the map is adjusted i.e. the ‘learning rate’
  - for each neighbour node of $v_{winner}$
    - use higher *a* (slower learning) and adjust it



# After the Map has been Made

- Create a set for each grid point, to store a number of the inputs. Initially null.
- For each one of the training inputs
  - find most similar node, add input to set
- Then, a mouse click on a node $\rightarrow$
  - pop up its related set of inputs
  - Or use in searches, fisheyes, zooms…
- Show set size as ‘density’ $\rightarrow$ colour

# WebSOM example



# Strengths and Weaknesses

- Cost
  - O(trainingSetSize . #dimensions . gridSize)
- Distance ($p_i$, $p_j$) $\rightarrow$ ???
- Distance between two inputs $\rightarrow$ ???
- All dimensions combined
  - not for exploring individual dimensions

# Force-Based Models

- Spring model, force-directed placement
- A simulated physical system
  - Positions, velocities and forces
  - Far, similar objects pull each other close
  - Close, dissimilar objects push apart
- Relies on metric:
  - similarity (obj, obj) $\rightarrow$ real
- Force (obj, obj) $\propto$ similarity - closeness

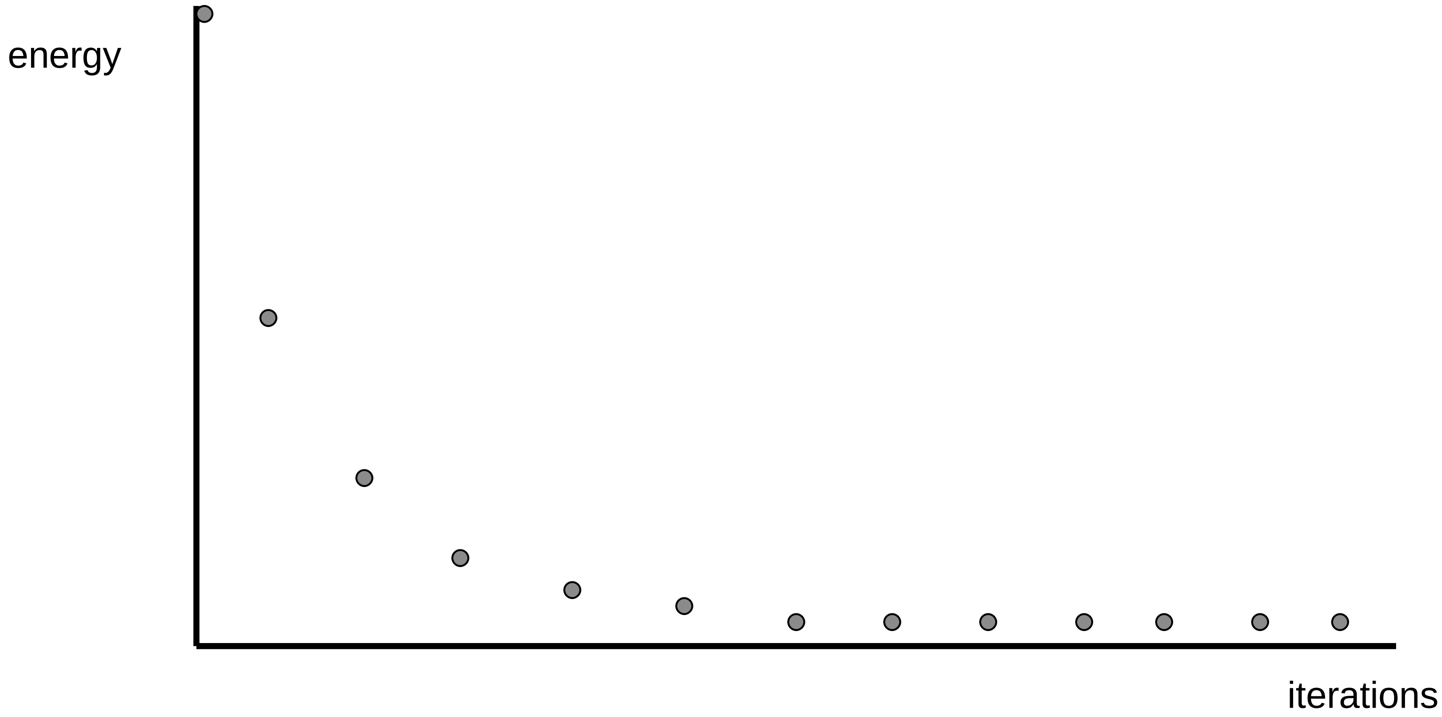
# Simplified Algorithm

- for each iteration
- for each object i
- for each other object j

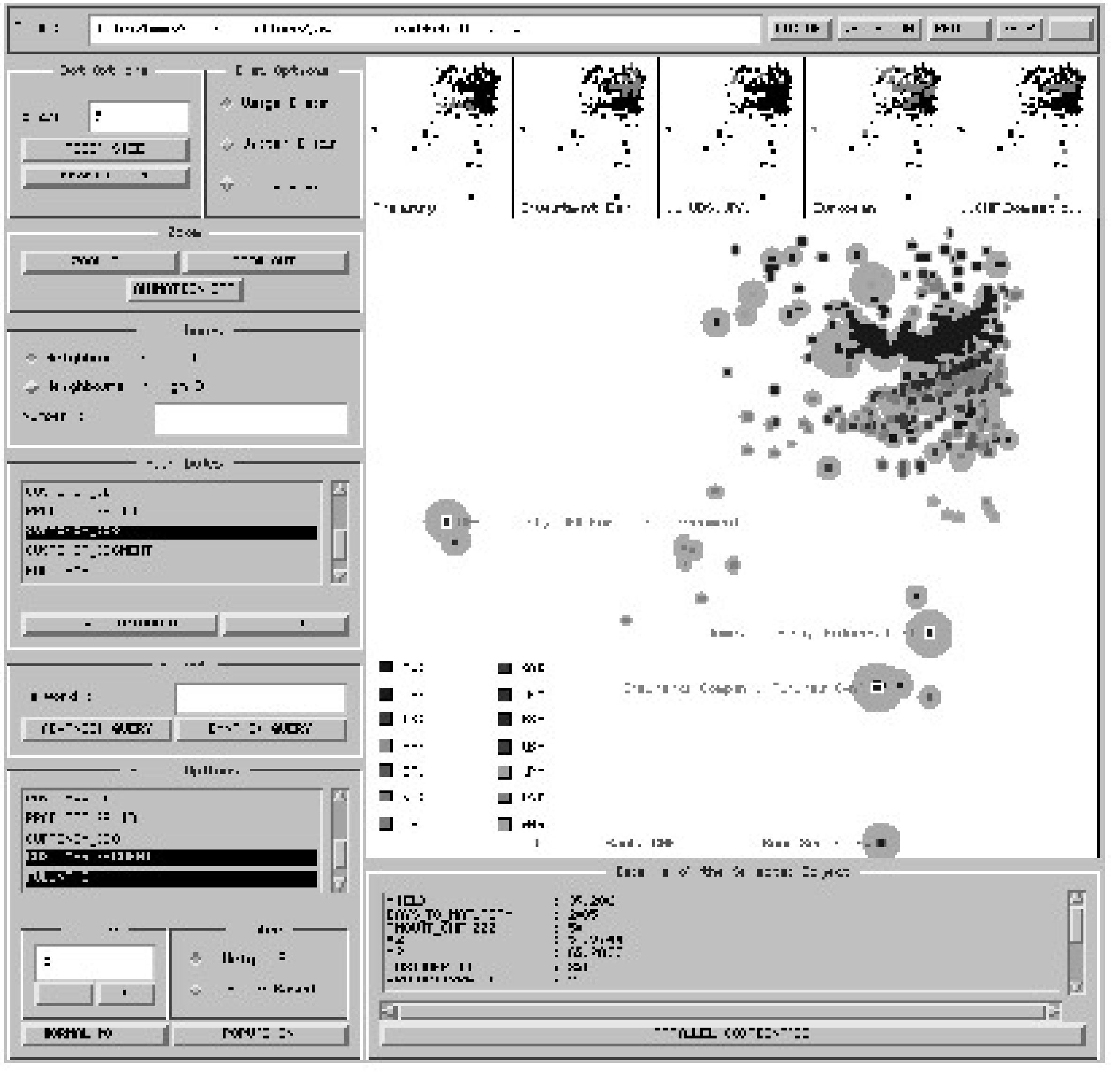
  totalForce += force(i,j)
- adjust velocity(i) using totalForce
- adjust position(i) using velocity(i)

# Energy over Time

- Sum of squared errors for each iteration



# A Bead Map



# Strengths and Weaknesses

- Cost
  - basic algorithm: $O(n^2)$ per iteration
  - approximate algorithm: $O(n)$ per iteration
- Position shows global relationships
  - neighbours in lowD but not in highD?
- All dimensions combined in position
  - not for exploring individual dimensions
- Limited scale: a thousand or two?

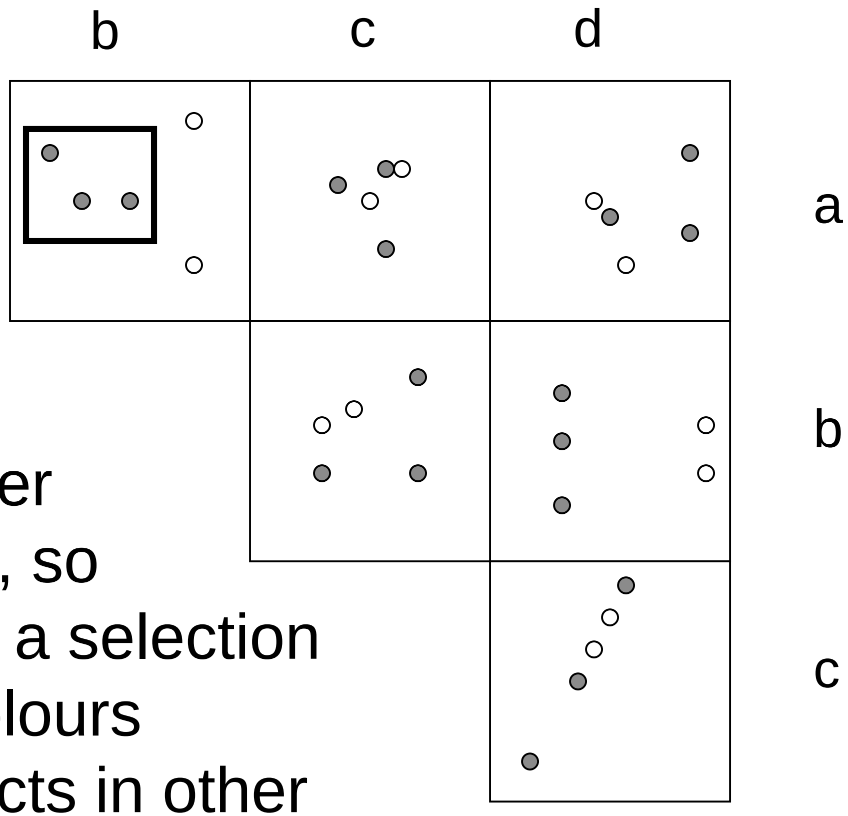
# Dimensional Reduction

- Widely applicable technique, but
  - can be computationally expensive
  - question of how good the metric is
  - putting parameters in users' hands
- Force-based models
  - show more of data set structure
- Kohonen maps (SOMs)
  - scale better to large numbers

# Interaction Techniques

- Varied views, abstractions and interpretations
- User control and adaptive techniques
  - filtering
  - categorisation and clustering
  - zooming and semantic zooming
  - getting hidden detail
  - multiple views [Chapter 13]

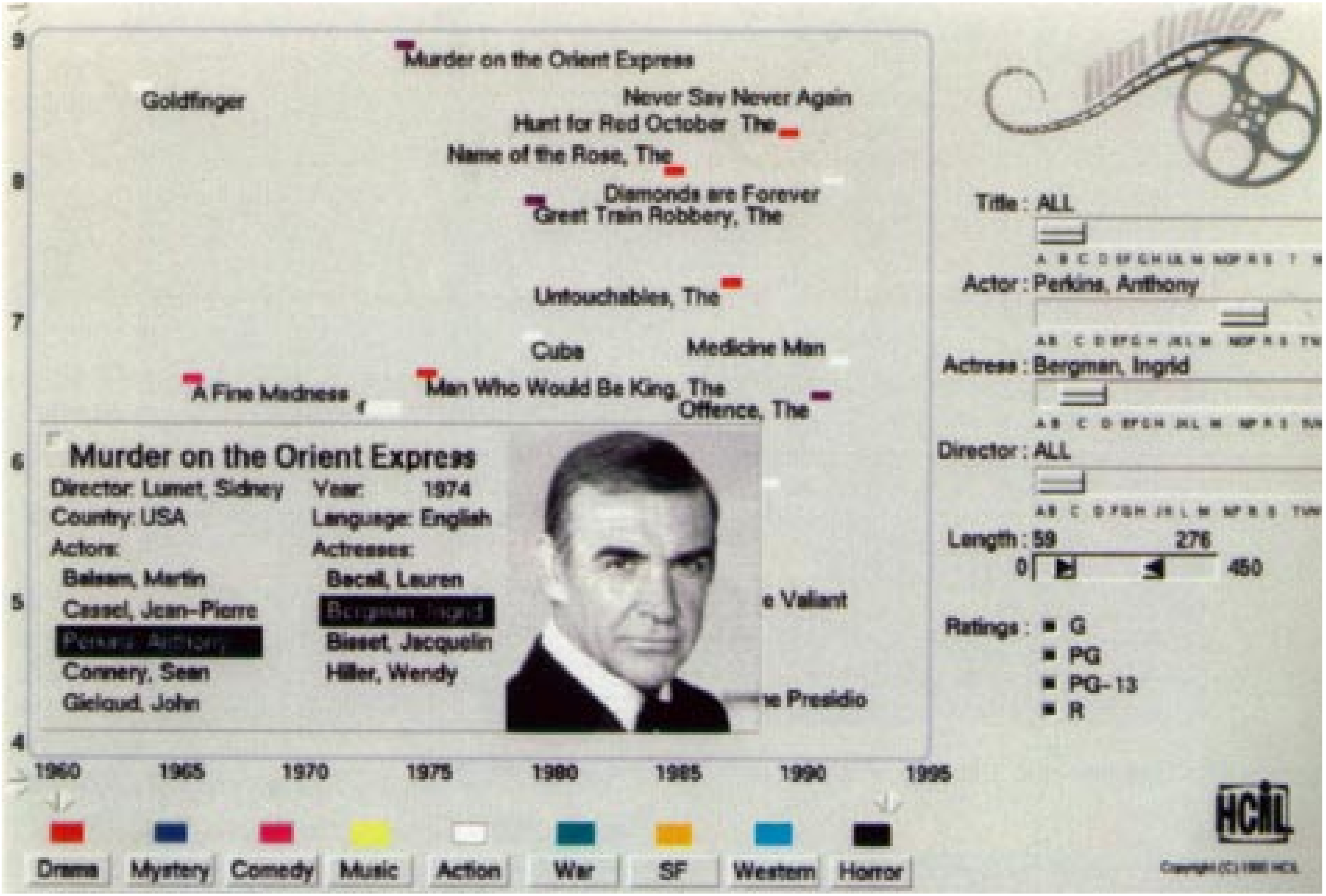
# Brushing and Linking



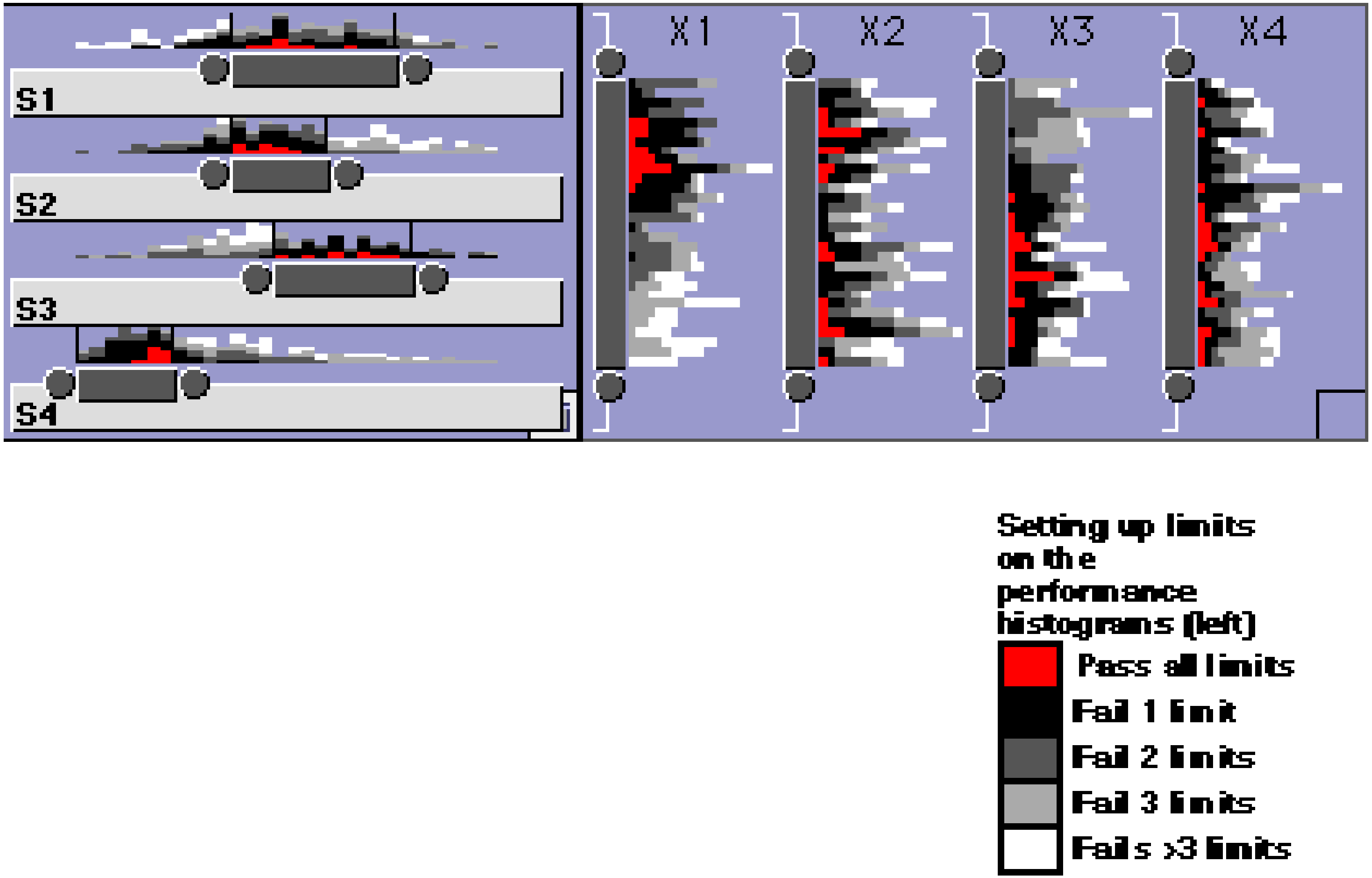

Linking together multiple views, so that ‘brushing’ a selection in one view colours matching objects in other views.

# Filtering

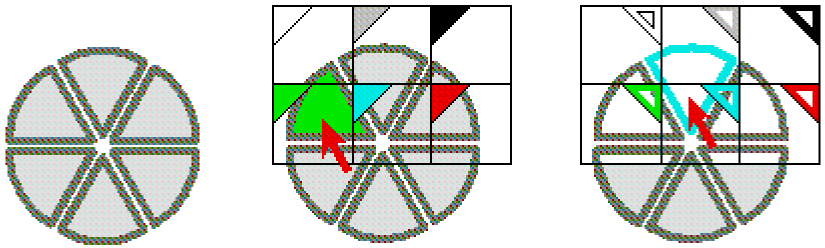
- Traditional query languages
  - often too static, difficult to understand
  - give absolute more than relative info
- ‘Dynamic queries’ and sliders
  - Ahlberg’s *Spotfire*: (www.ivee.com) [B4,B5]
  - Lisa Tweedie’s histograms & related tools
- Magic Lenses (Bier et al.)



Murder on the Orient Express
Goldfinger
Never Say Never Again
Hunt for Red October The
Name of the Rose, The
Diamonds are Forever
Great Train Robbery, The
Untouchables, The
Cuba
Medicine Man
A Fine Madness
Man Who Would Be King, The
Offence, The
Murder on the Orient Express
Director: Lumet, Sidney
Year: 1974
Country: USA
Language: English
Actors:
Balsam, Martin
Cassel, Jean-Pierre
Perkins, Anthony
Connery, Sean
Gielgud, John
Actresses:
Bacall, Lauren
Bergman, Ingrid
Bisset, Jacqueline
Hiller, Wendy
Valiant
Presidio
9
8
7
6
5
4
1960
1965
1970
1975
1980
1985
1990
1995
Drama
Mystery
Comedy
Music
Action
War
SF
Western
Horror
Title : ALL
Actor : Perkins, Anthony
Actress : Bergman, Ingrid
Director : ALL
Length : 59 276
0 450
Ratings :
G
PG
PG-13
R
HCIL

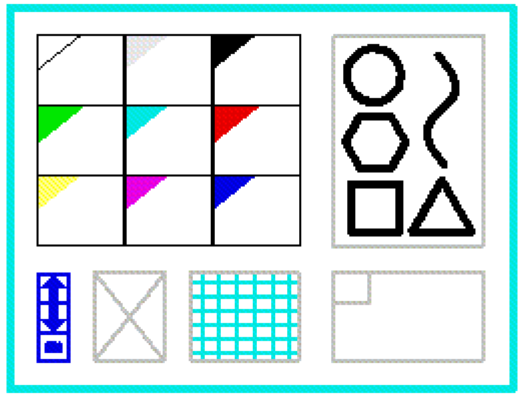

S1
S2
S3
S4
X1
X2
X3
X4
Setting up limits on the performance histograms (left)
Pass all limits
Fail 1 limit
Fail 2 limits
Fail 3 limits
Fails >3 limits

# Magic Lenses



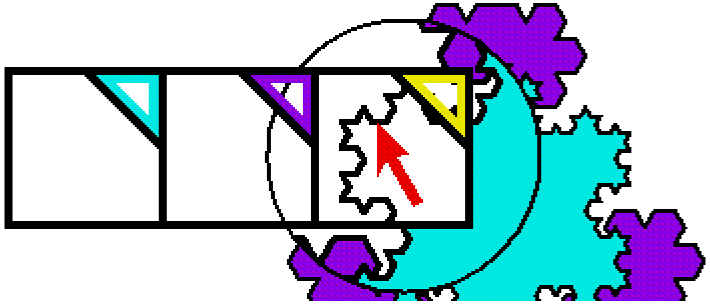
a b c

In (a), six wedge-shaped objects are positioned, and in (b) a palette of six ‘click-through’ fill colours is used to make one segment green. In (c), another wedge has its outline coloured blue by using an outline colour lens.

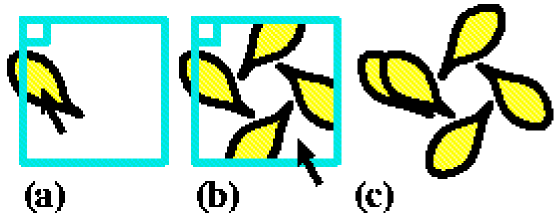


A sheet of magic lens widgets: fill colours, shape drawing, clipboard, snap grid, delete button, and a button to navigate to further widgets.

# Magic Lenses



An outline colour palette, over a magnifying lens, over a 'snowflake' shape. This is an example of stacking lenses so as to compose their functions. Here, the magnifier makes it easy to work on individual outlines within a complex shape.




In (a), a 'symmetry clipboard' lens is placed over a yellow 'tear' shape. The lens replicates the shape in a symmetrical pattern (b), and this pattern can be moved and pasted elsewhere (c).

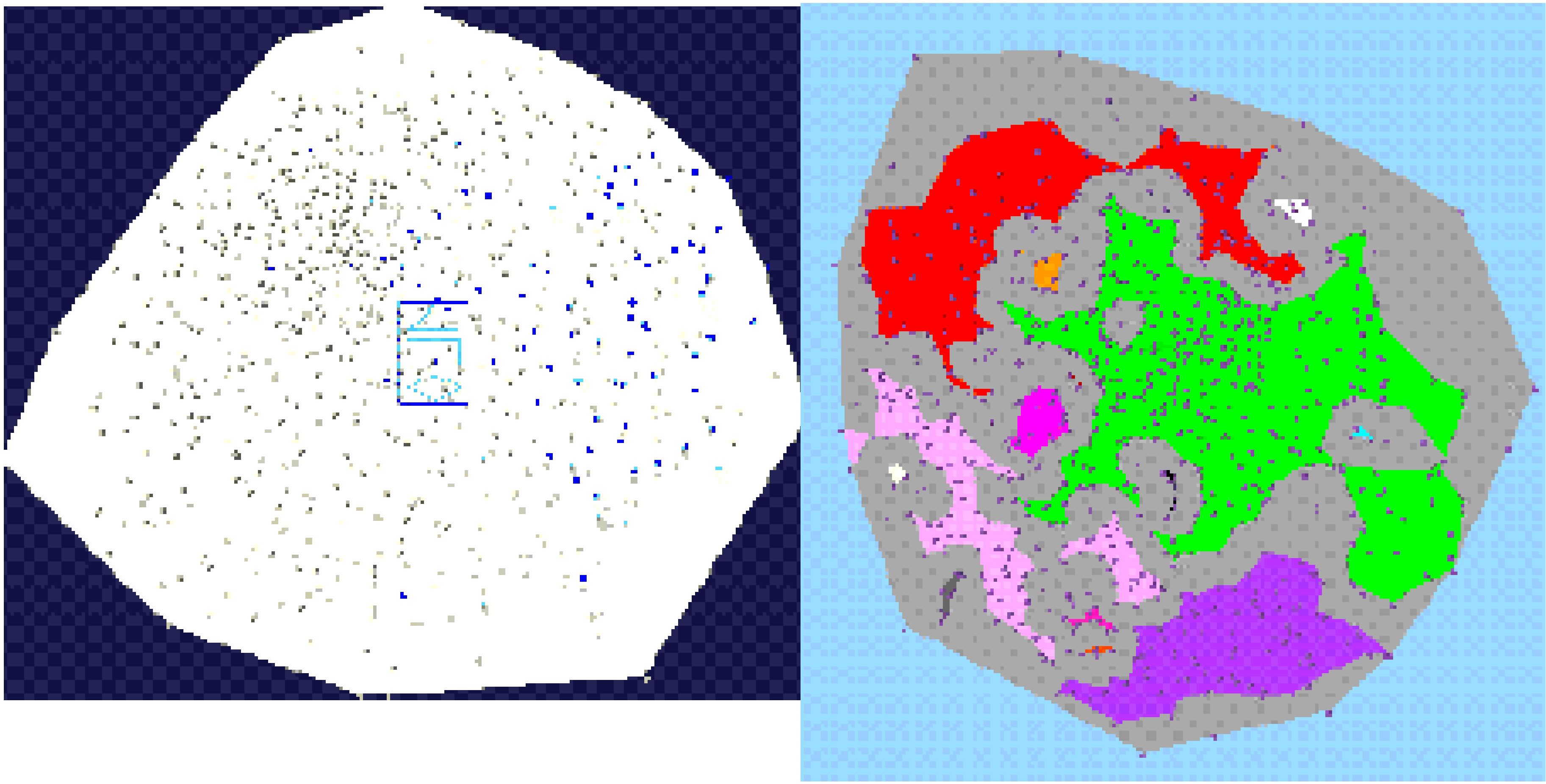
# Zooming — Pad++

- ‘Infinite’ detail potentially available
- Focus in on detail but retain overview
  - can see detail, and remember context
- Semantic Zoom
  - things don’t just get bigger, but adapt
- Recently added in a web browser
- Free from www.cs.umd.edu/hcil/pad++

# Categorisation

- Another kind of view or abstraction
  - e.g. subsets that share a property
  - or subsets that are relatively alike
- Can be done statically *a priori*
  - traditional cluster analysis, etc.
- Can then map to colour, shape, etc.
  - or make it an extra dimension

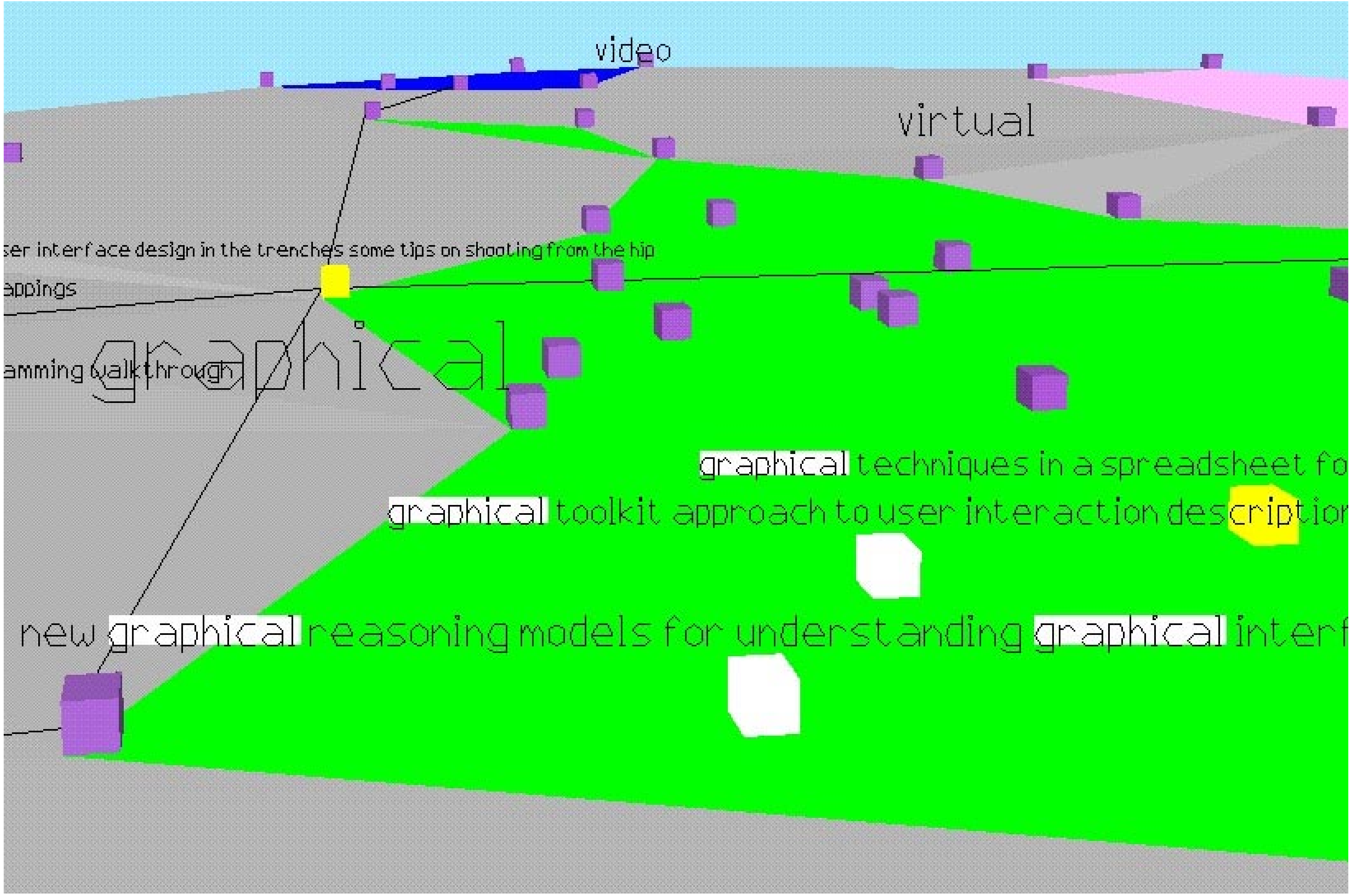
# Clusters in Bead



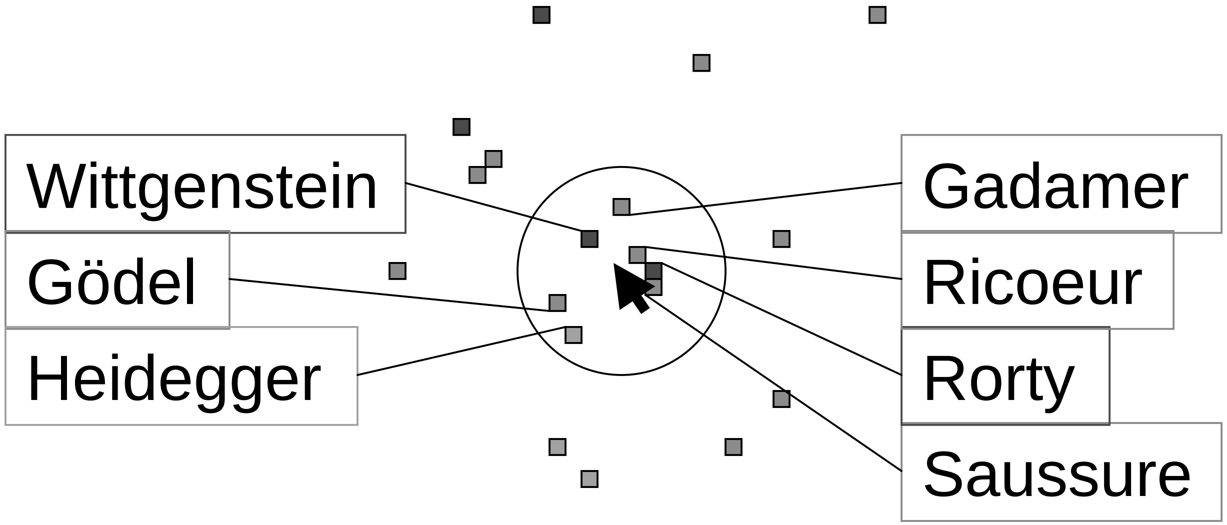
# Cluster Labels and Popups

- Cluster labelling
  – Find words that are common in a cluster?
  – Find words that are particularly local
    - higher local density than density over all set
- Dynamic pop-up detail
  – choose a few objects to be shown in detail
  – weight by importance e.g. search hits
  – keep sampling, biased by these weights

# Cluster Labels and Popups



# Excentric Labelling



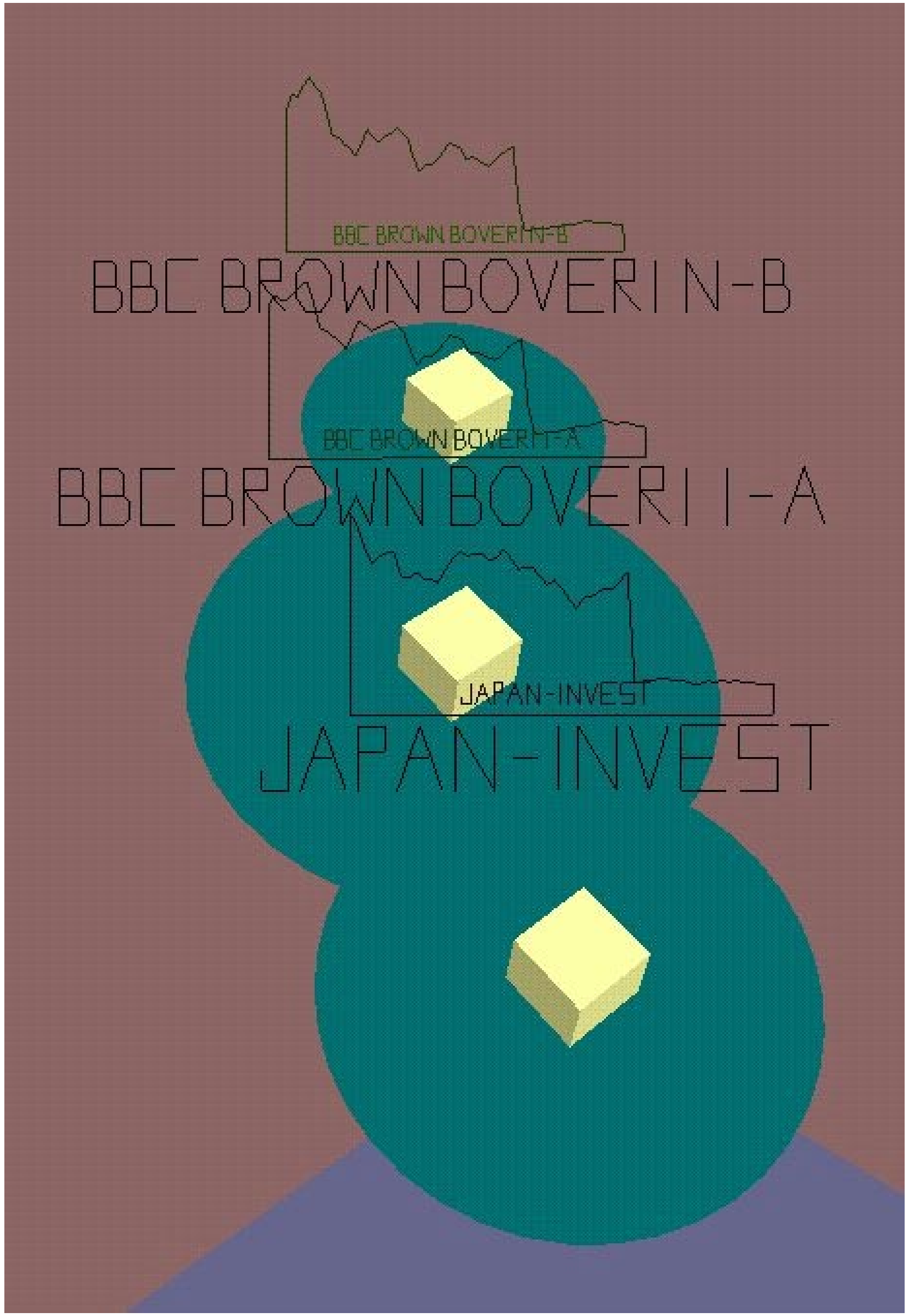

Labels pop up in the neighbourhood of the cursor, and are spread to avoid overlapping. When objects are too numerous, the total number is shown along with a subset of the labels.

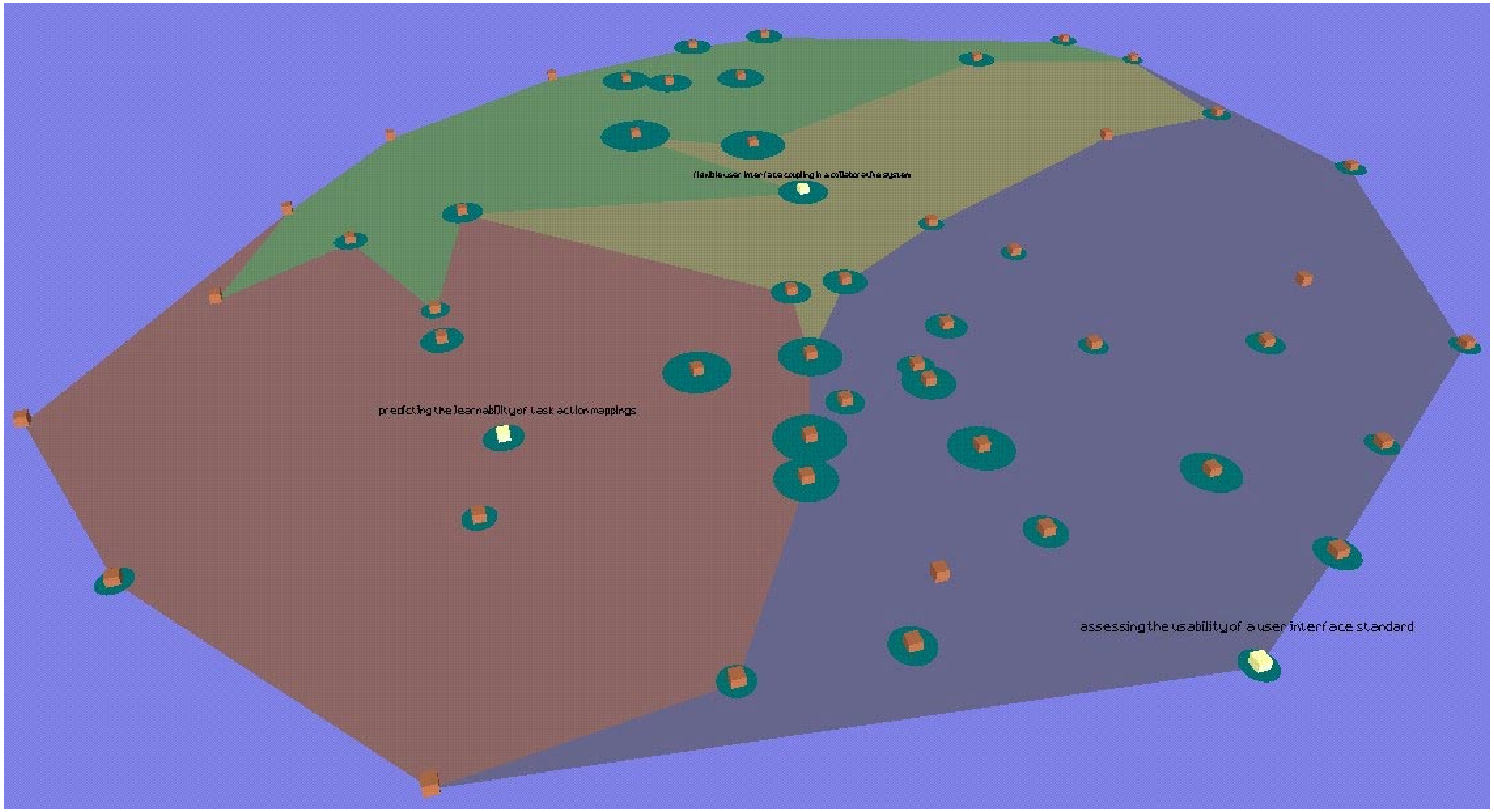
*Fekete and Plaisant, Proc. CHI 99, pp. 512-519*

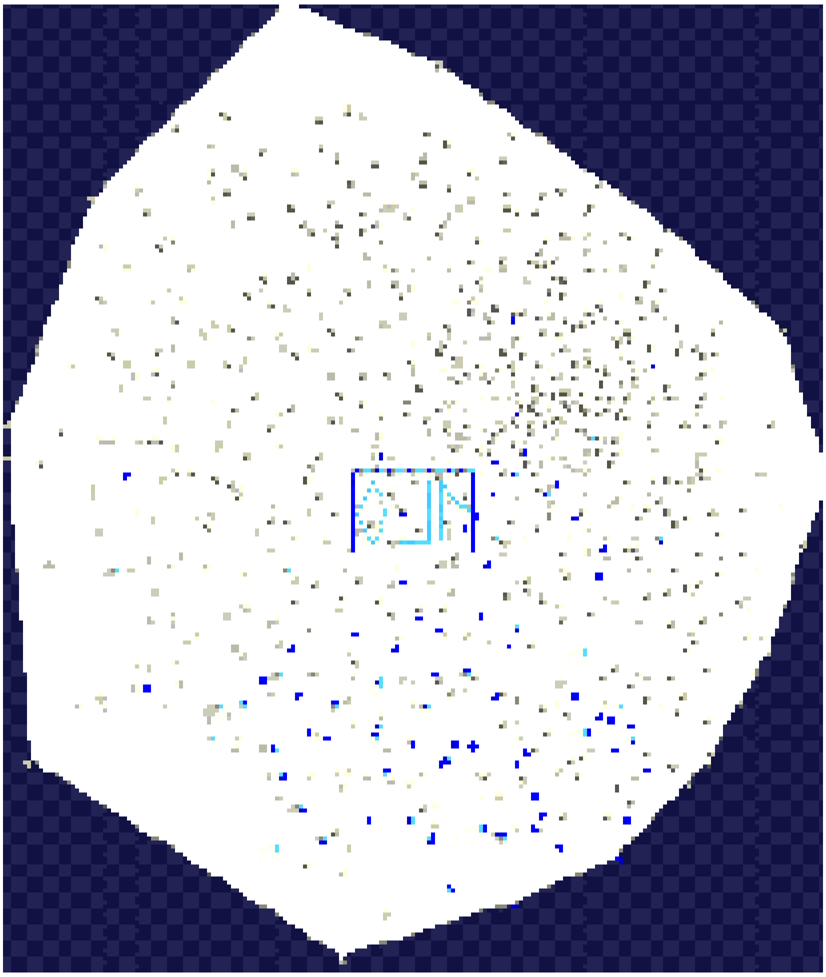
*http://www.cs.umd.edu.hcil/excentric*

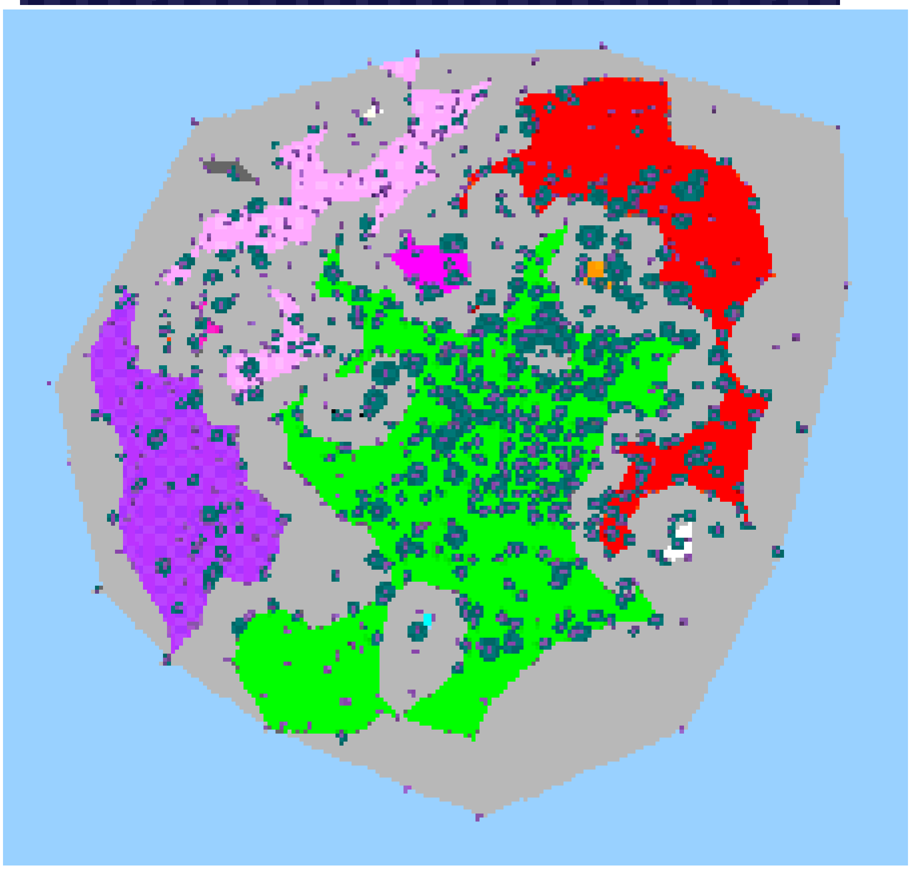
# Subjective Categorisation

- Categories are usually objective
  - e.g. clusters made independent of use
- Labels in Bead also used history
  - words weighted by frequency of use
- Usage discs
  - ‘edit wear and read wear’ idea again
  - radius proportional to use
  - easy to do this in 2D also


BBC BROWN BOVERI N-B
BBC BROWN BOVERI N-B
BBC BROWN BOVERI I-A
BBC BROWN BOVERI I-A
JAPAN-INVEST
JAPAN-INVEST


flexible user interface coupling in a collaborative system
predicting the learnability of task action mappings
assessing the usability of a user interface standard





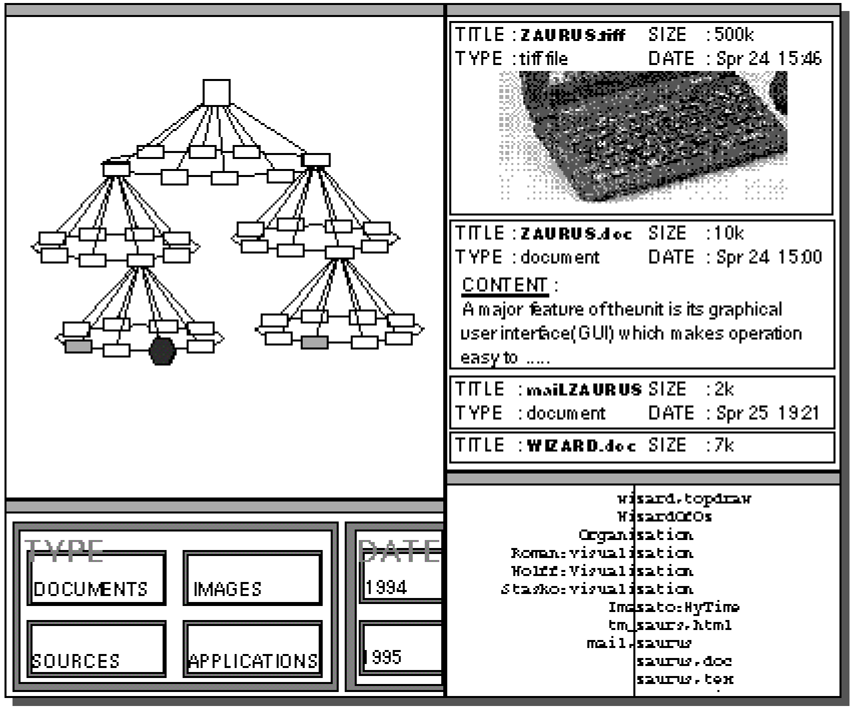
# Subjective Categorisation

- Try to find what people *really* do
  - variation between people, jobs, etc.
- Maybe can’t do this beforehand
  - so use ongoing activity and adapt to fit
  - hot topic nowadays: *adaptive systems*
- Privacy issues: you are being watched
  - telephones, credit cards, ATMs...

# Multiple Views

- Linking and brushing just one example
- Getting different views of the same data
  - no one view is going to suit every use
  - can combine filters, 2D views, 3D views, categorisations, distortions...
  - what happens in one view affects the others

# Masui’s file hierarchy viewer



# Software Architecture Tip

- Build one central model e.g. MVC
  - same model controls many views
  - any change to model? All views notified
  - use same protocol for all views
- Interaction via each view
  - translate view-specific interaction into model's protocol
  - easy to add or remove views

# Interaction as Interpretation

- Emphasise a useful subset
  - zooming, filtering
- Extract useful abstraction or metadata
  - clustering and categorisation
- But who determines what is useful?
  - user control, adaptation with use
- Offer multiple views/interpretations

# Review

- Perceptual issues vitally important
  - 2D better for abstract data
  - avoid naïve use of colour
  - beware of mathematical ‘convenience’
  - over time, link fine-grained activities
- Link related interpretations
  - over space: multiple views
  - over time: wear, usage, paths

# Review

- MultiD data and dimensional reduction
  - algorithms: computation v. richness
  - display: show reduced version in 2D
    - but offer access via each original dimension too
- Interaction
  - filtering, zooming, categorisation
  - dynamism, adaptation, linked views

# Future Trends

- Integration into everyday programs
  - small InfoVis widgets inside other tools
- Multiple views and tools
- Multiple data types interwoven
  - different choice as to what ‘similar’ means
- Adaptation and dynamism
  - with individual’s use, with individuals’ use

# Further Reading

- *How Maps Work*, Alan MacEachren
  - ideas are general to InfoVis & cartography
- *Readings in Information Visualization*, Card, MacKinlay & Shneiderman
- *Envisioning Information*, Edward Tufte
  - 'information design' for graphs, charts, etc.
- Proc. IEEE InfoVis, ACM CHI and UIST
- http://www.otal.umd.edu/Olive/

# Contact Information

http://www.dcs.gla.ac.uk/~matthew

matthew@dcs.gla.ac.uk

…or see you at the banquet.