Information Visualization for Knowledge Discovery

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Founding Director (1983-2000), Human-Computer Interaction Lab
Professor, Department of Computer Science
Member, Institute for Advanced Computer Studies

Interdisciplinary research community

- Computer Science & Info Studies
- Psych, Socio, Poli Sci & MITH

(www.cs.umd.edu/hcil)

Scientific Approach (~~beyond user friendly~~)

- Specify users and tasks
- Predict and measure
  - time to learn
  - speed of performance
  - rate of human errors
  - human retention over time
- Assess subjective satisfaction

  (Questionnaire for User Interface Satisfaction)
- Accommodate individual differences
- Consider social, organizational & cultural context

Design Issues

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

www.awl.com/DTUI

U.S. Library of Congress

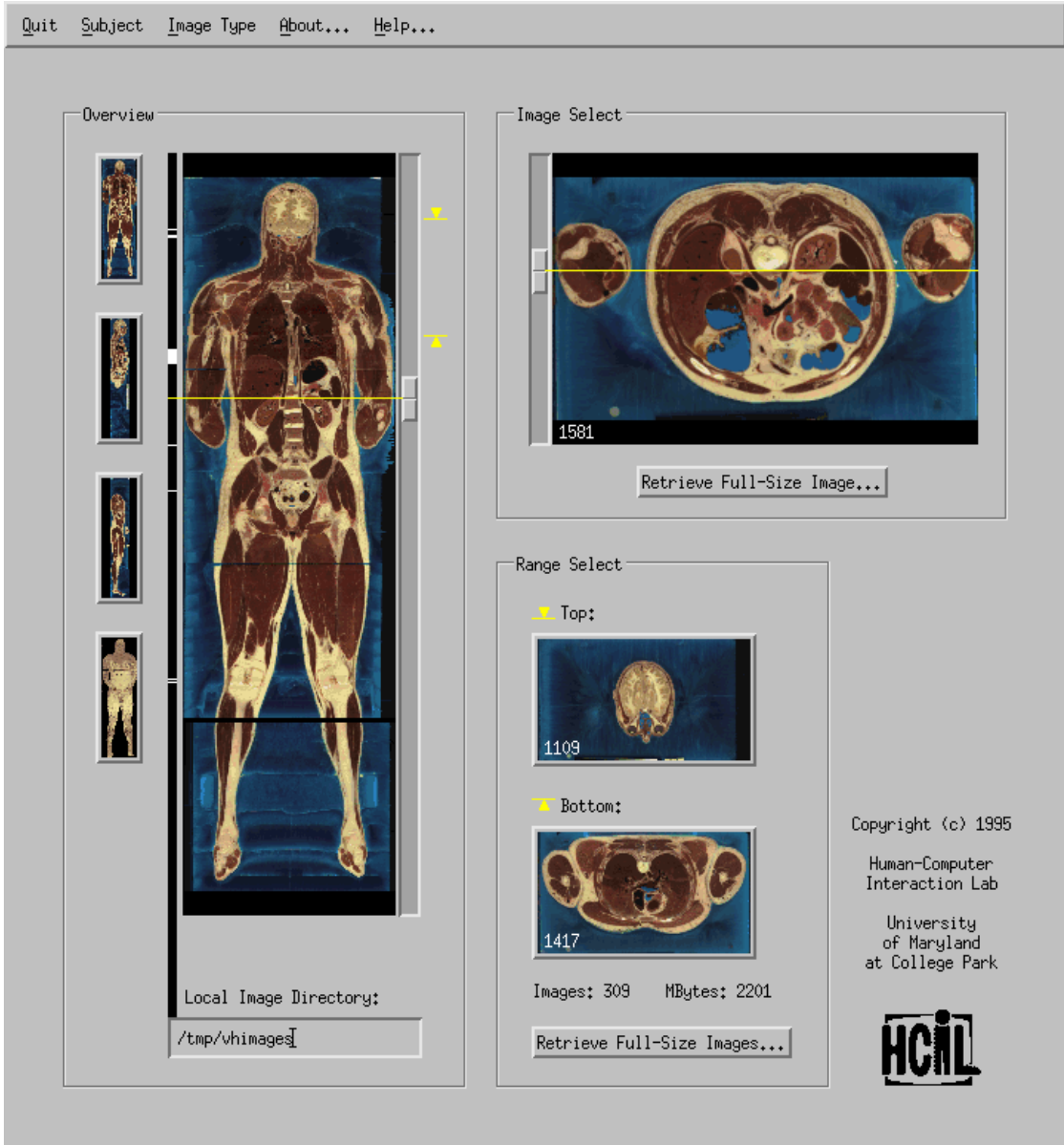
American Memory

Historical Collections for the National Digital Library

- Scholars, Journalists, Citizens
- Teachers, Students

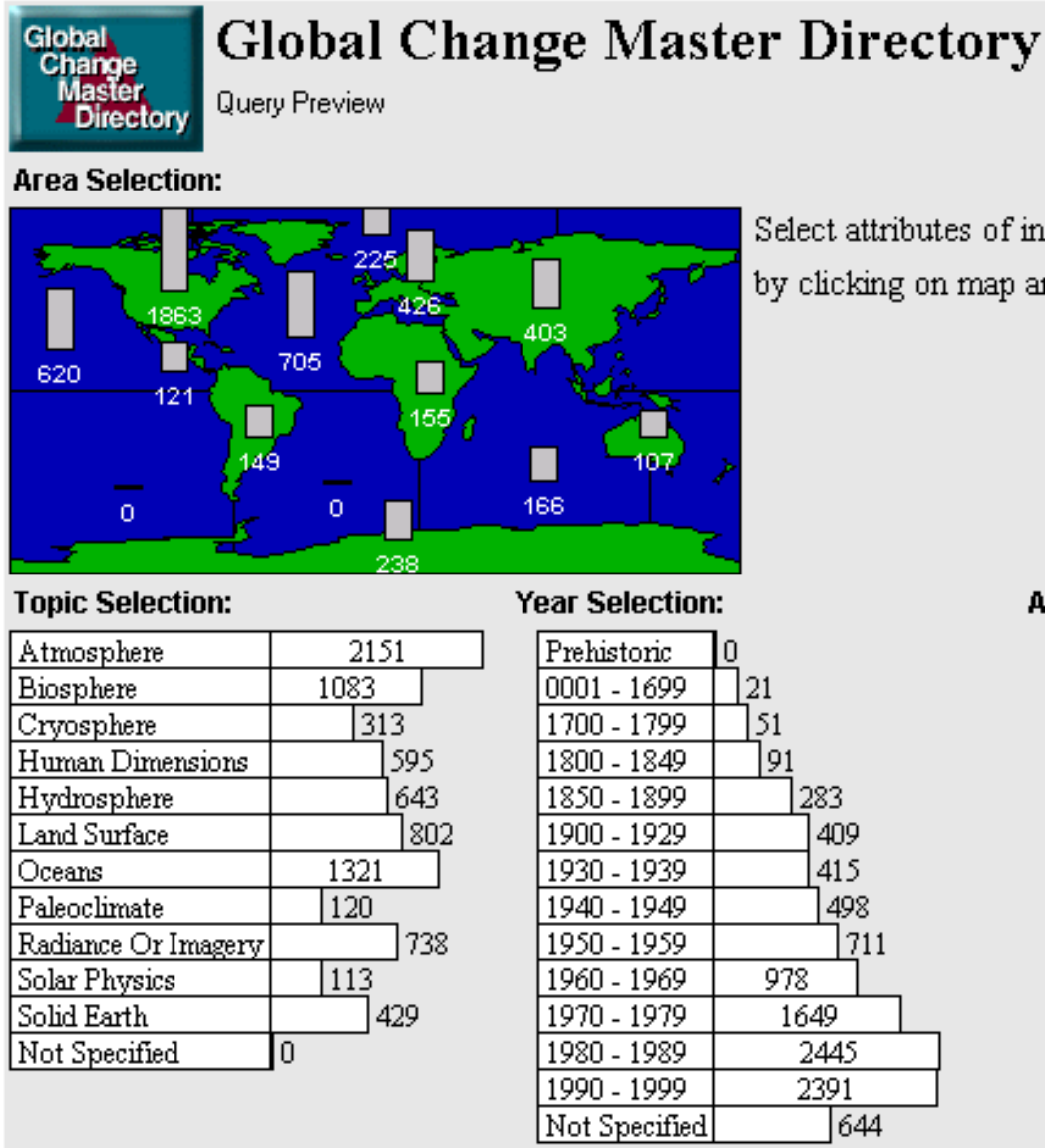
Visible Human Explorer (NLM)

- Doctors
- Surgeons
- Researchers
- Students



NASA Environmental Data

- Scientists
- Farmers
- Land planners
- Students



Bureau of the Census

- Economists, Policy makers, Journalists
- Teachers, Students

American FactFinder™

NSF Digital Government Initiative

Census,

NCHS,

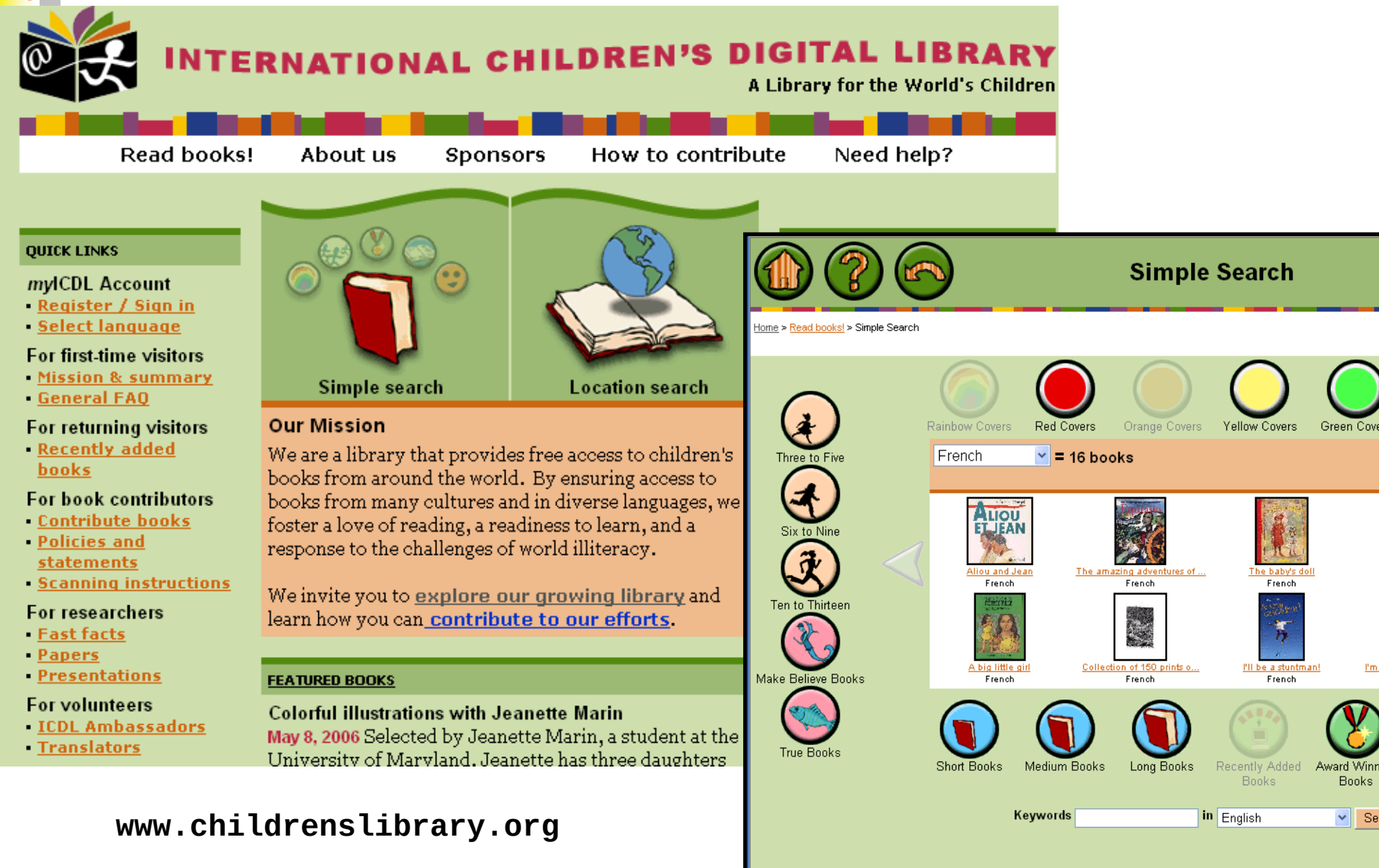
BLS, EIA, NASS, SSA

- Find what you need
- Understand what you Find

www.ils.unc.edu/govstat/

FEDSTATS

International Children’s Digital Library



www.childrenslibrary.org

Piccolo: Toolkit for 2D zoomable objects

Structured canvas of graphical objects in a hierarchical scenegraph

- Zooming animation
- Cameras, layers

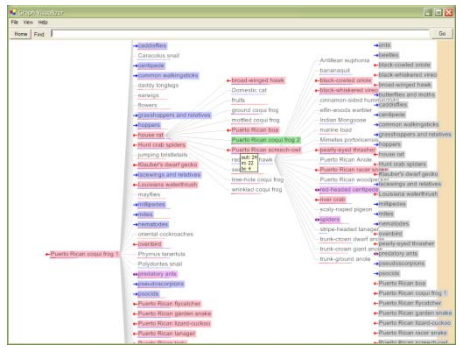
Open, Extensible & Efficient

Java, C#, PocketPC versions

www.cs.umd.edu/hcil/piccolo

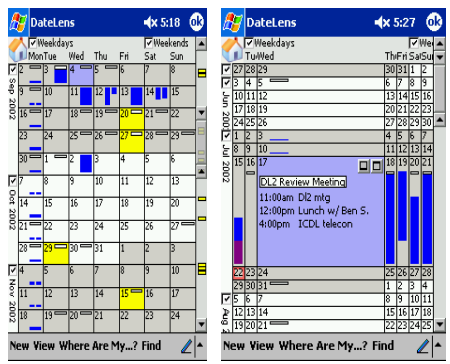
AppLens & Launch Tile

UMD, Microsoft Research



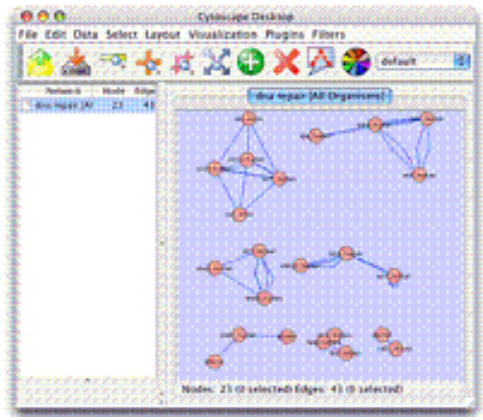
TreePlus

UMD



DateLens

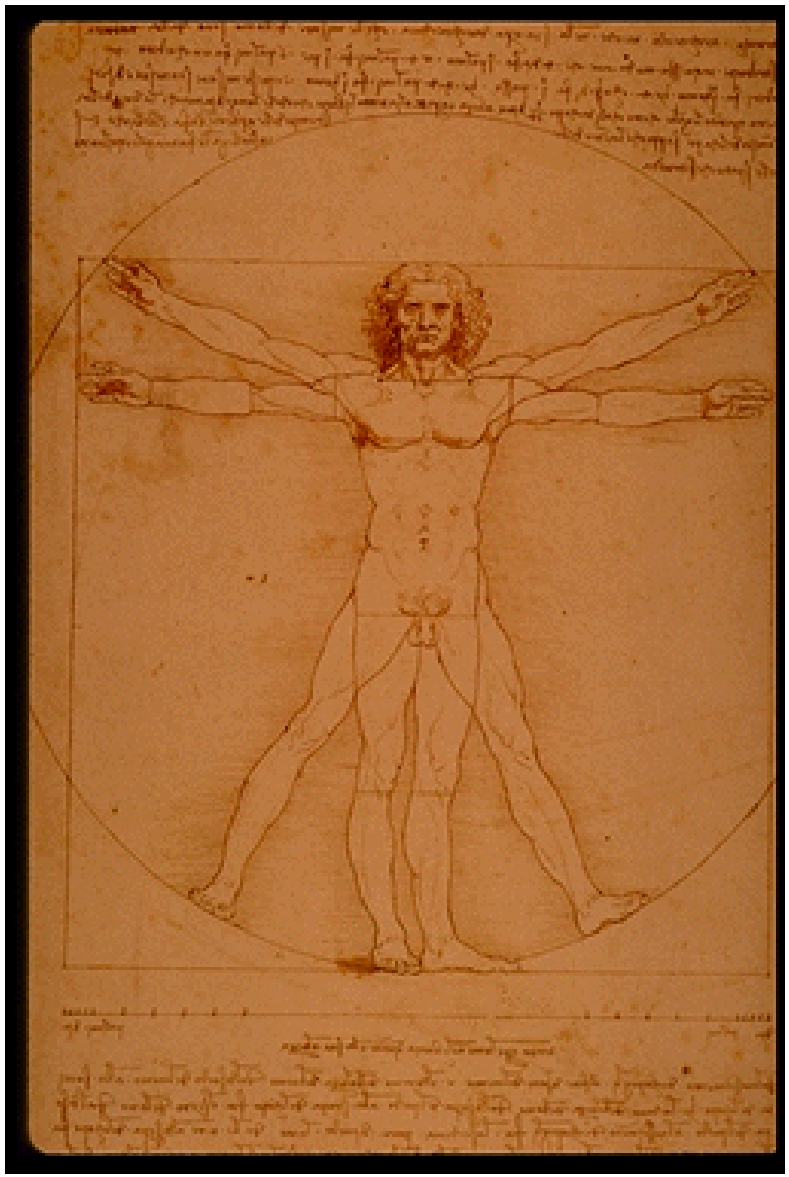
Windsor Interfaces, Inc.



Cytoscape

Institute for Systems Biology
Memorial Sloan-Kettering
Institut Pasteur UCSD

Information Visualization

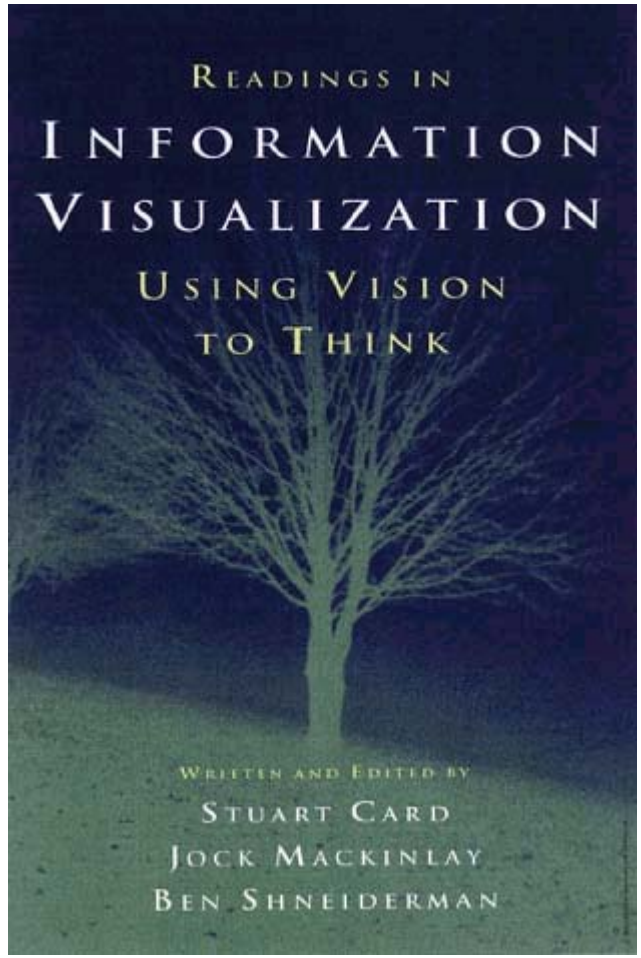


The eye…
the window of the soul,
is the principal means
by which the central sense
can most completely and
abundantly appreciate
the infinite works of nature.

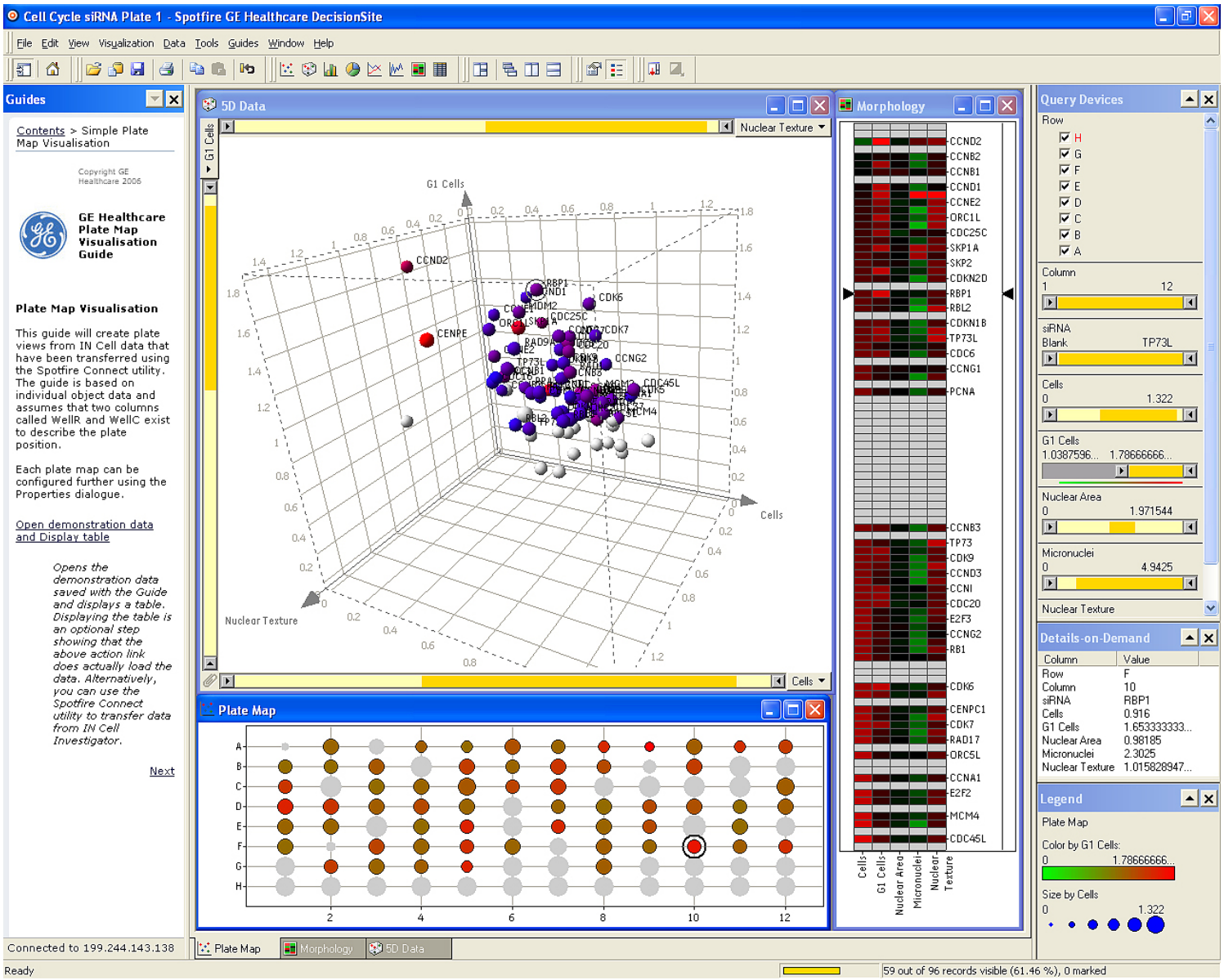
Leonardo da Vinci
(1452 - 1519)

Using Vision to Think

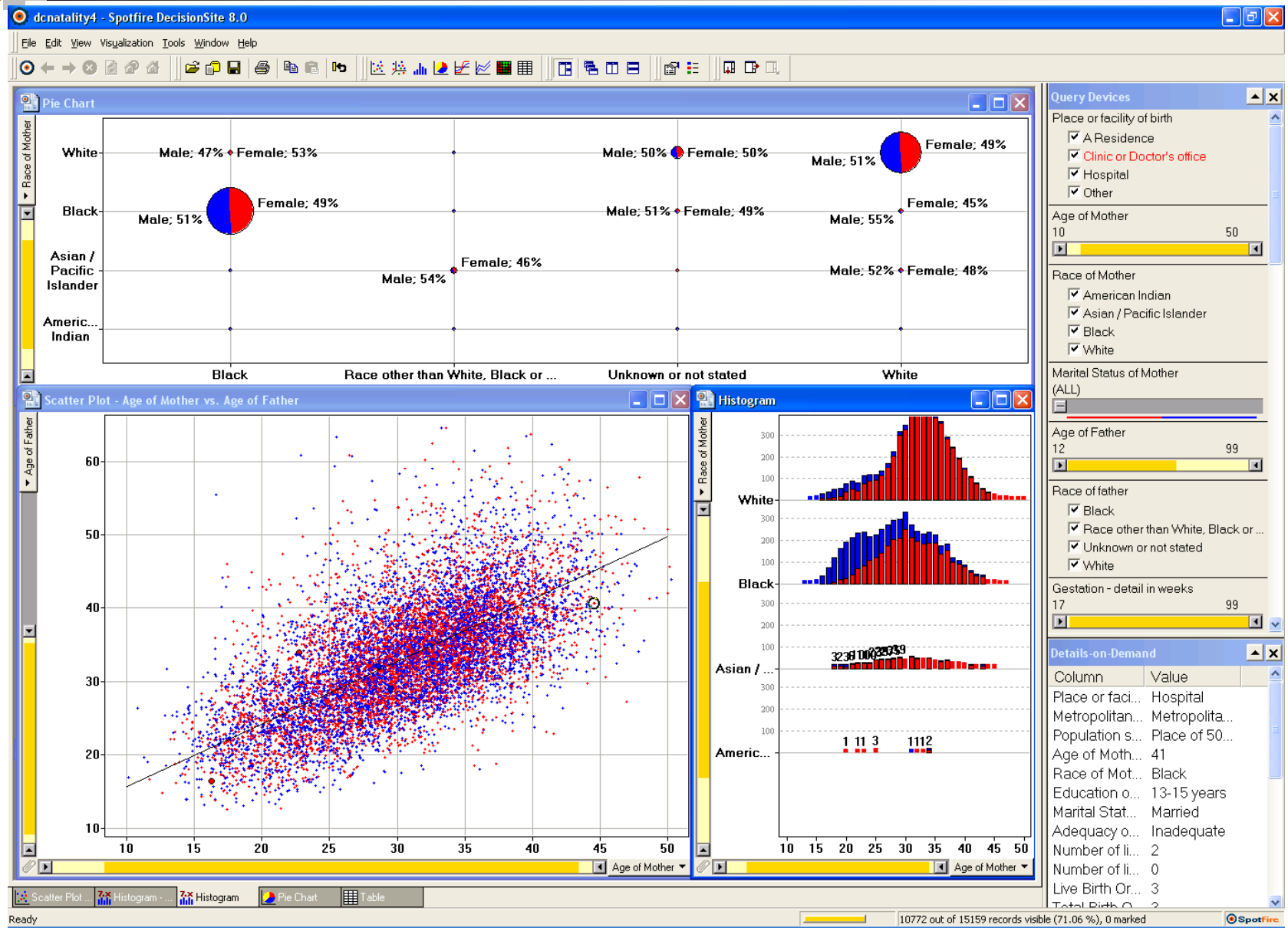
- **Visual bandwidth is enormous**
  - Human perceptual skills are remarkable
    - Trend, cluster, gap, outlier...
    - Color, size, shape, proximity...
  - Human image storage is fast and vast
- **Opportunities**
  - Spatial layouts & coordination
  - Information visualization
  - Scientific visualization & simulation
  - Telepresence & augmented reality
  - Virtual environments



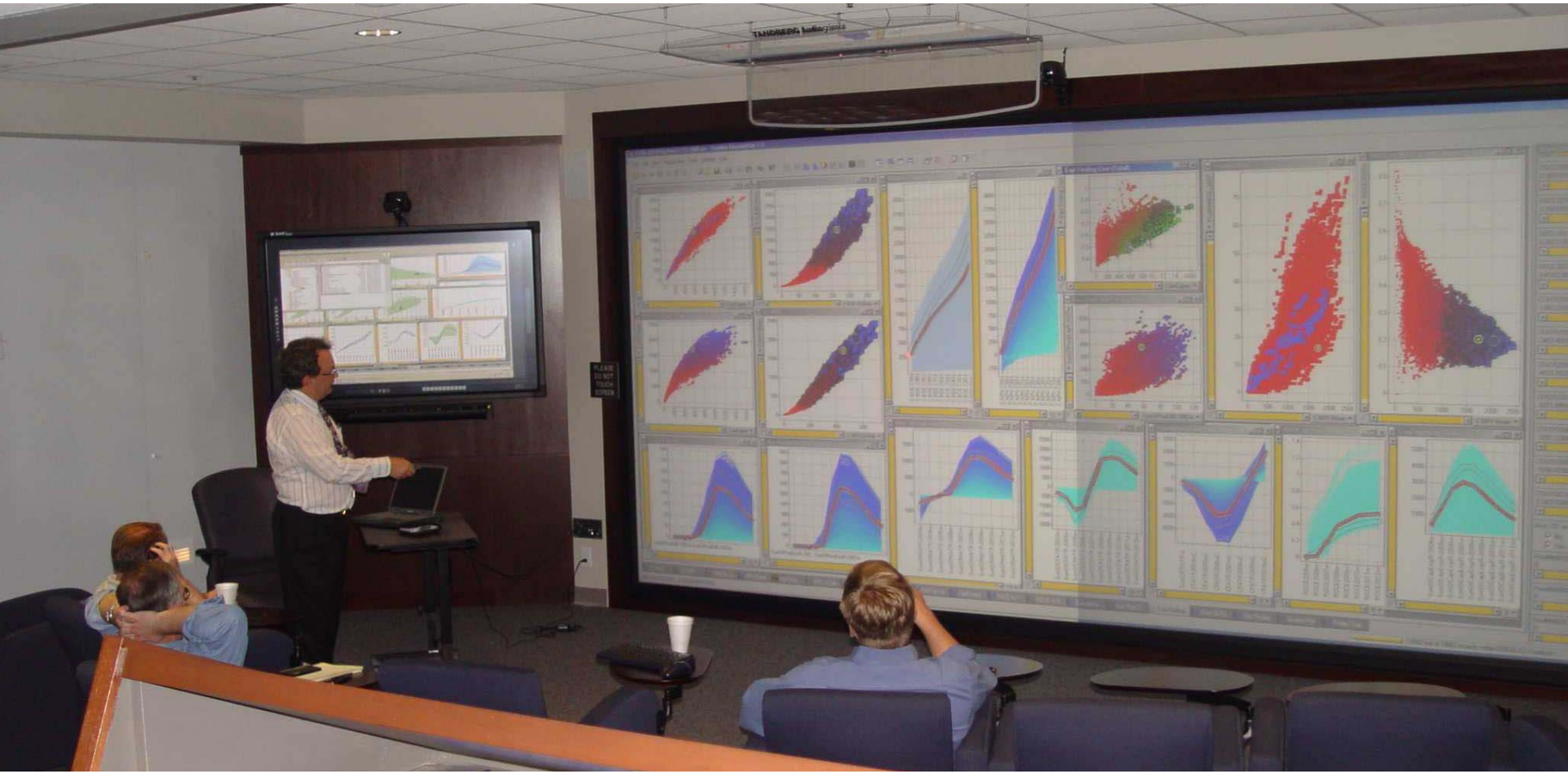
Spotfire: Retinol's role in embryos & vision



Spotfire: DC natality data



Spotfire



HCIL

Information Visualization: Mantra

- Overview, zoom & filter, details-on-demand
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Information Visualization: Data Types

SciViz

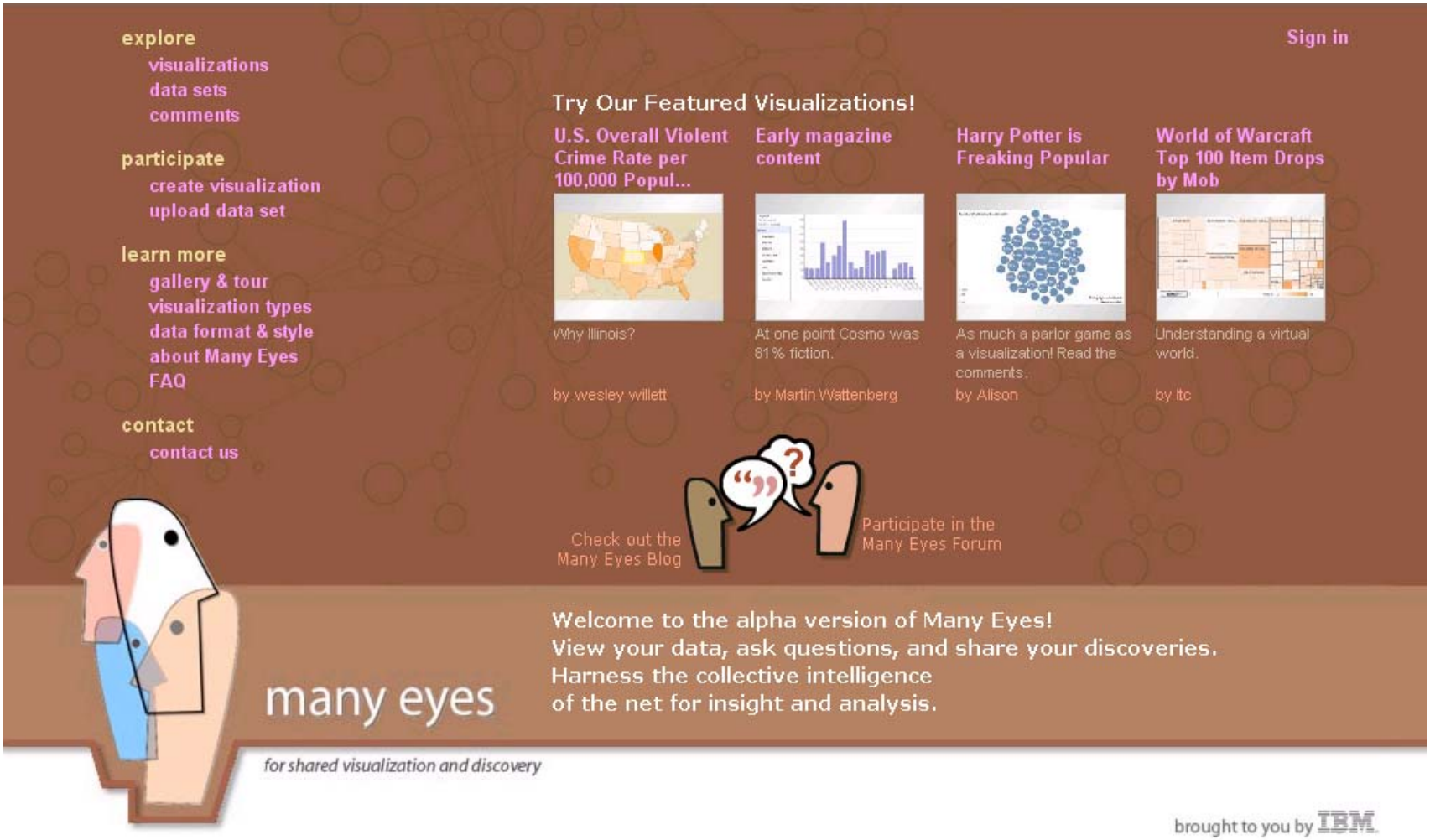
- **1-D Linear** — Document Lens, SeeSoft, Info Mural, Value Bars
- **2-D Map** — GIS, ArcView, PageMaker, Medical imagery
- **3-D World** — CAD, Medical, Molecules, Architecture

InfoViz

- **Multi-Var** — Parallel Coordinates, Spotfire, XGobi, Visage, Influence Explorer, TableLens, DEVise
- **Temporal** — Perspective Wall, LifeLines, Lifestreams, Project Managers, DataSpiral
- **Tree** — Cone/Cam/Hyperbolic, TreeBrowser, Treemap
- **Network** — Netmap, netViz, SeeNet, Butterfly, Multi-trees

(Online Library of Information Visualization Environments)
otal.umd.edu/Olive

ManyEyes: A web sharing platform



http://services.alphaworks.ibm.com/manyeyes/app

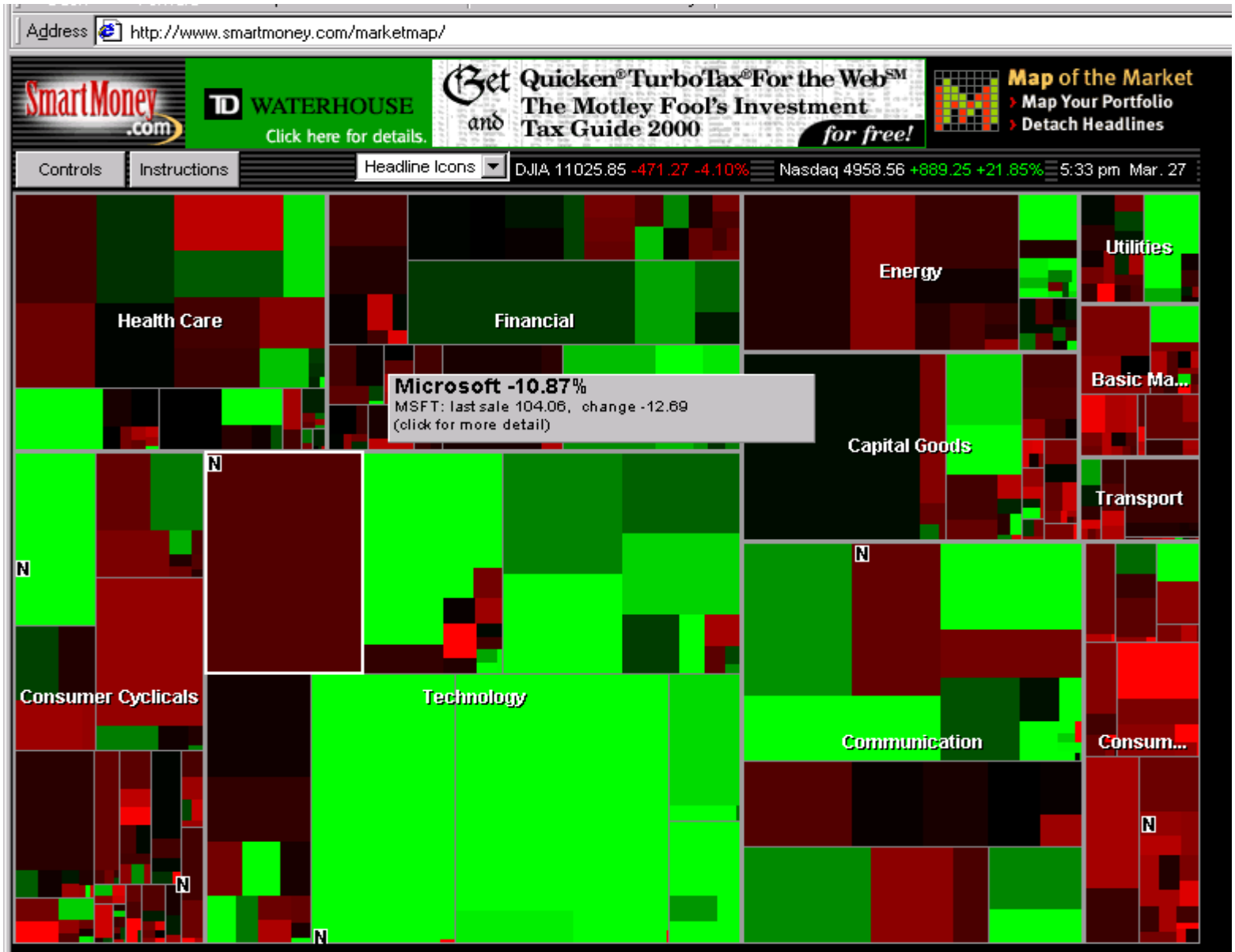
Treemap: view large trees with node values

- \+ Space filling
- \+ Space limited
- \+ Color coding
- \+ Size coding
- – Requires learning

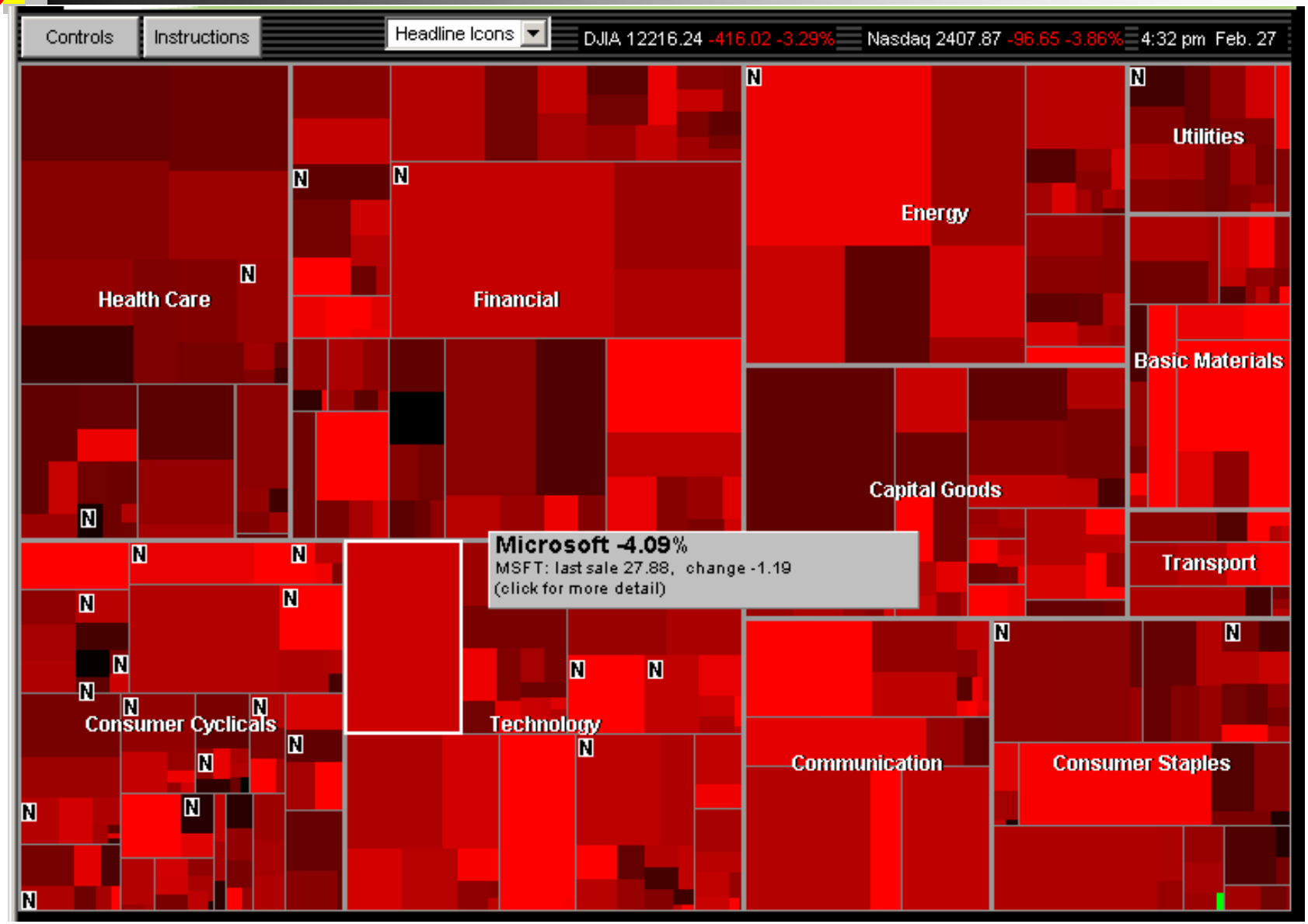
TreeViz (Mac, Johnson, 1992)
NBA-Tree(Sun, Turo, 1993)
Winsurfer (Teittinen, 1996)
Diskmapper (Windows, Micrologic)
SequoiaView, Panopticon,
HiveGroup, Solvern
Treemap4 (UMd, 2004)

(Shneiderman, *ACM Trans. on Graphics*, 1992 & 2003)

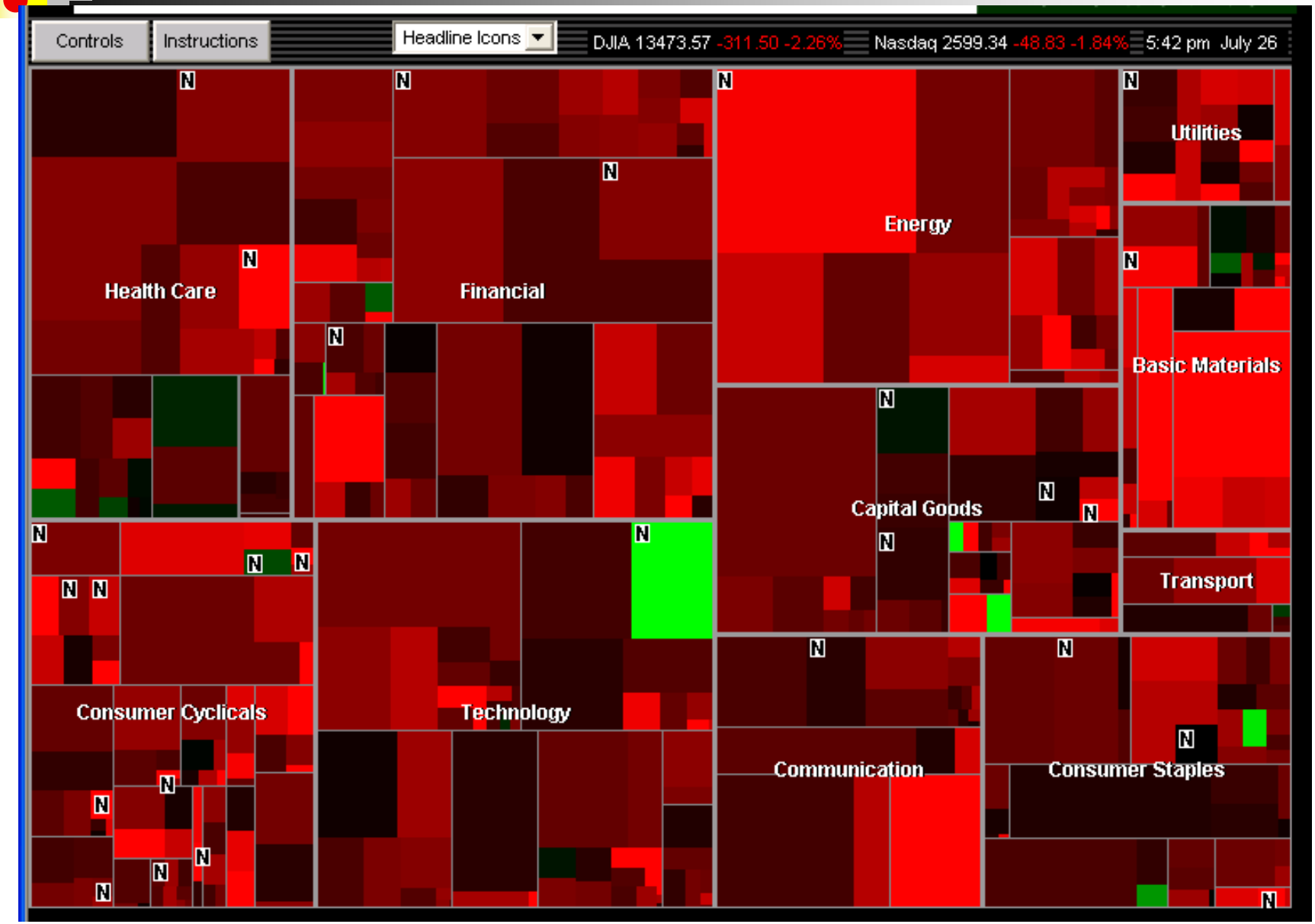
Treemap: Stock market, clustered by industry



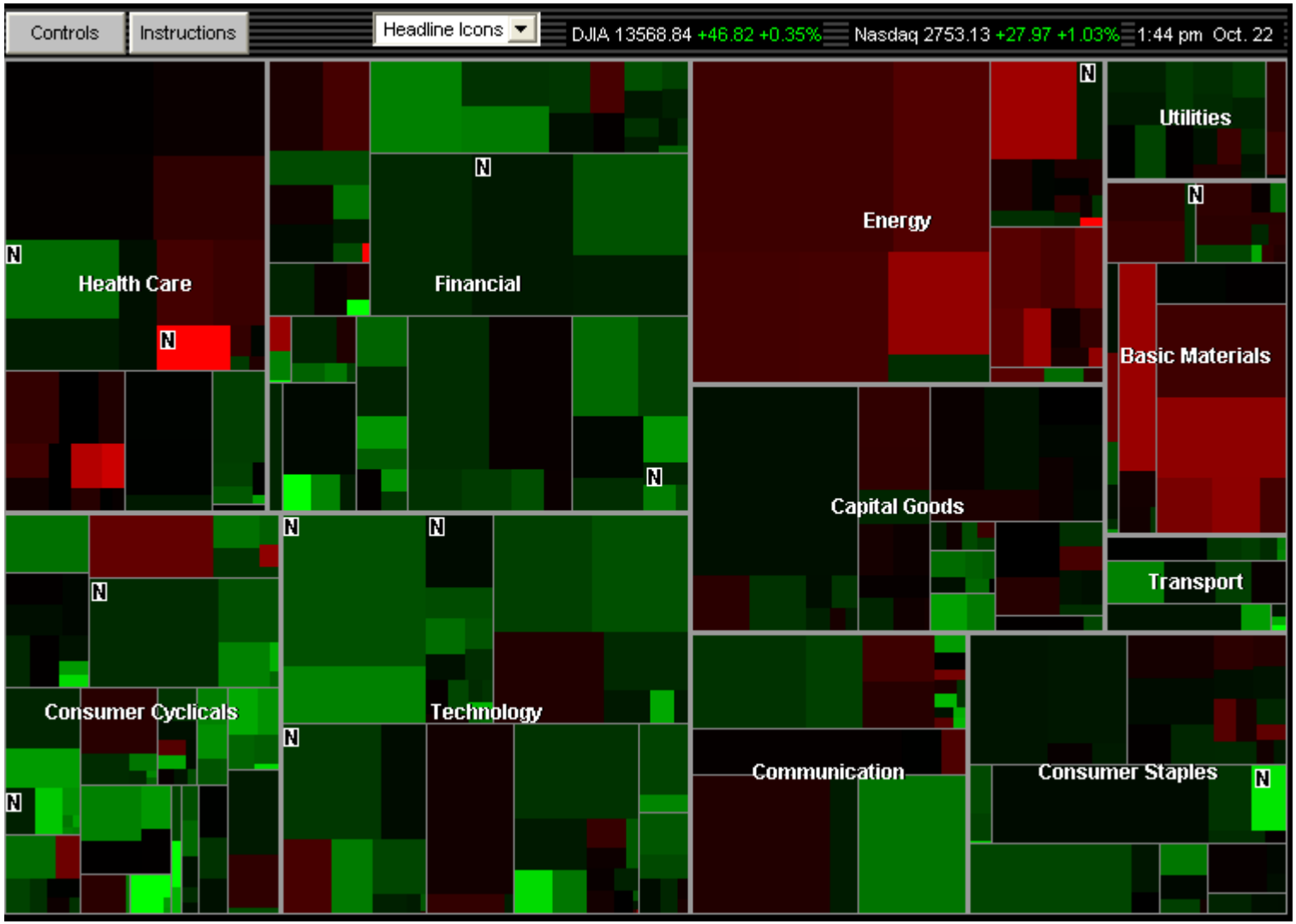
Market falls steeply Feb 27, 2007, with one exception



Market falls 311 points July 26, 2007, with a few exceptions

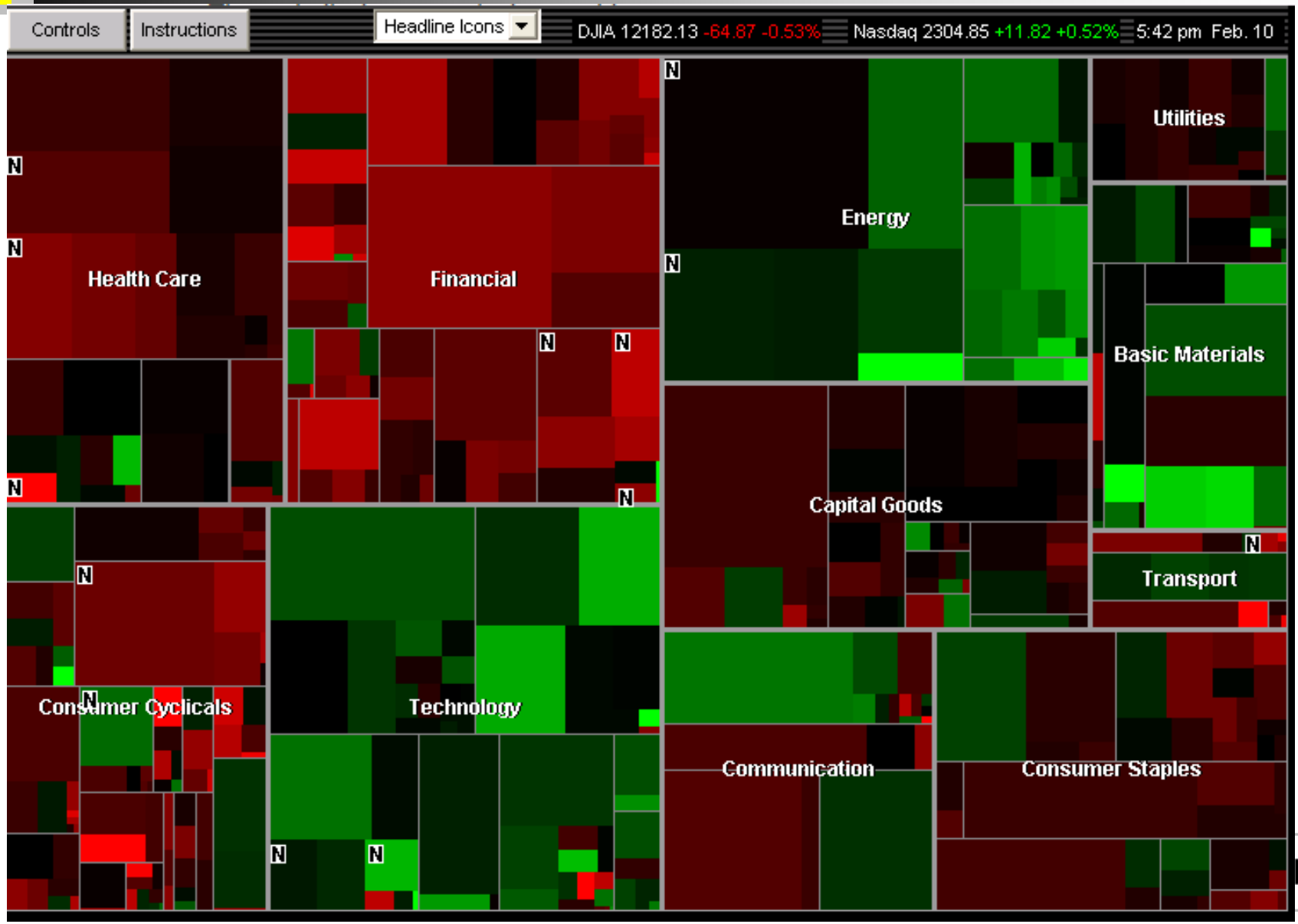


Market mixed, October 22, 2007,
Energy & Basic Material are down

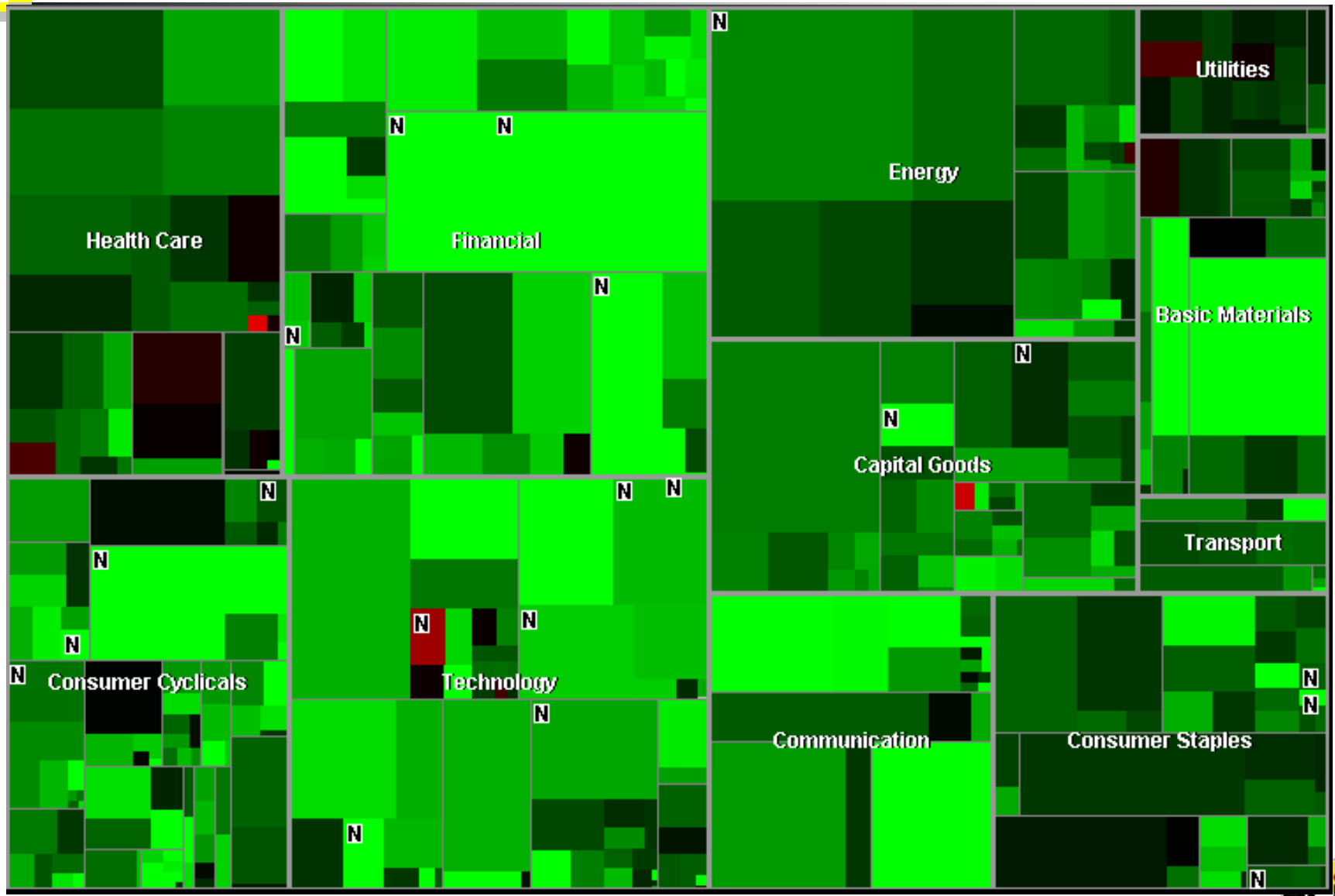


Market mixed, February 8, 2008

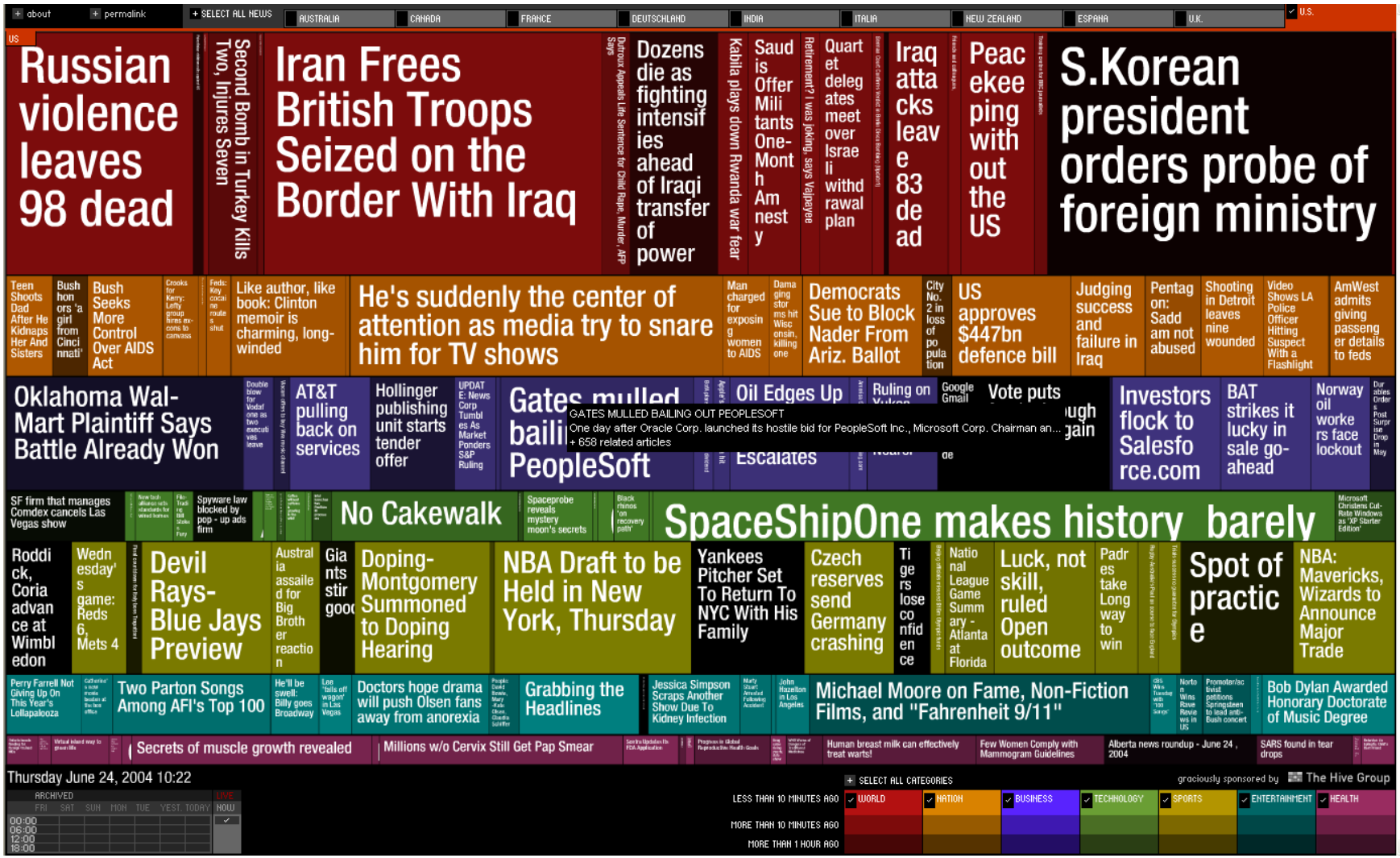
Energy & Technology up, Financial & Health Care down



Market rises 319 points, November 13, 2007, with 5 exceptions

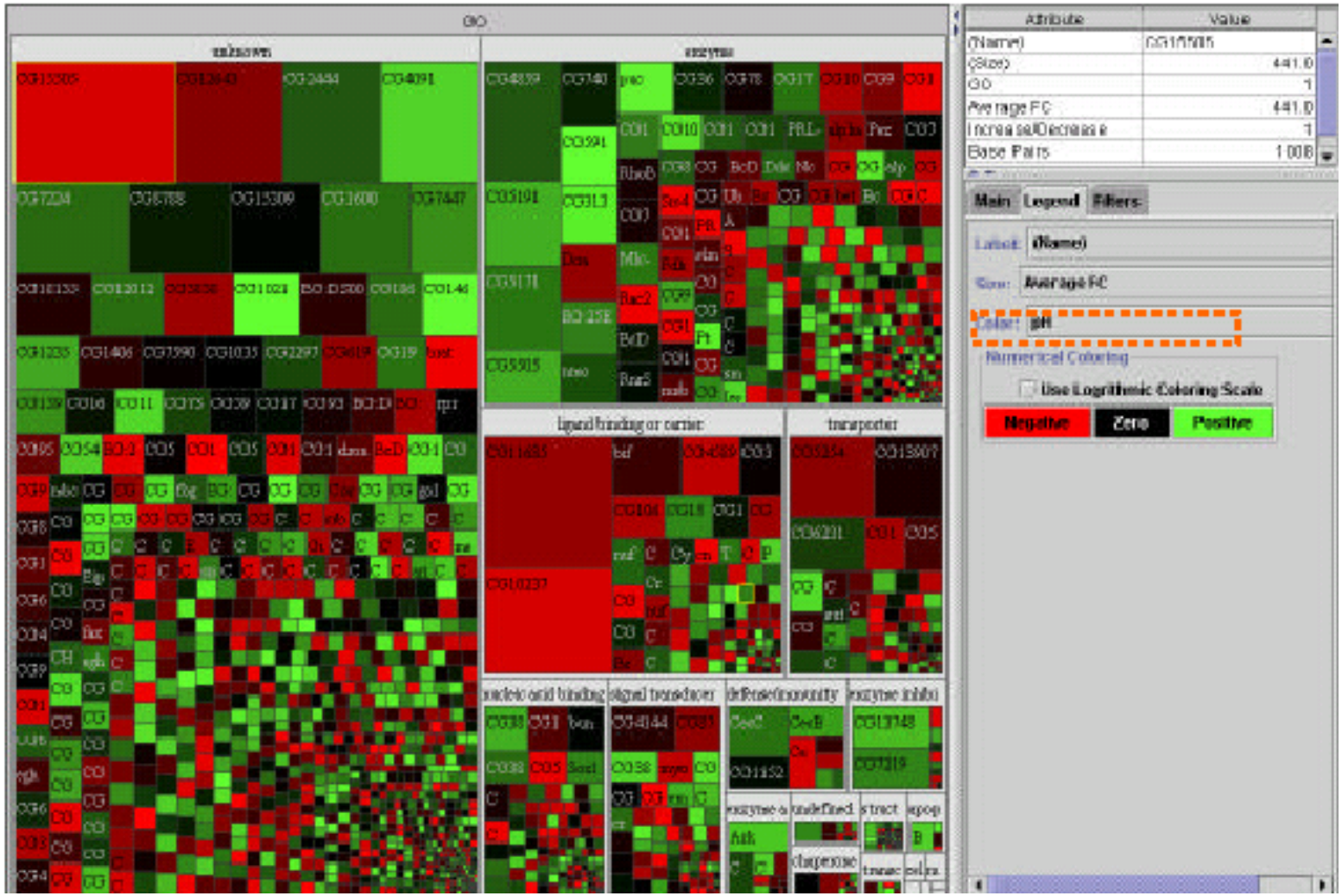


Treemap: Newsmap



www.hivegroup.com

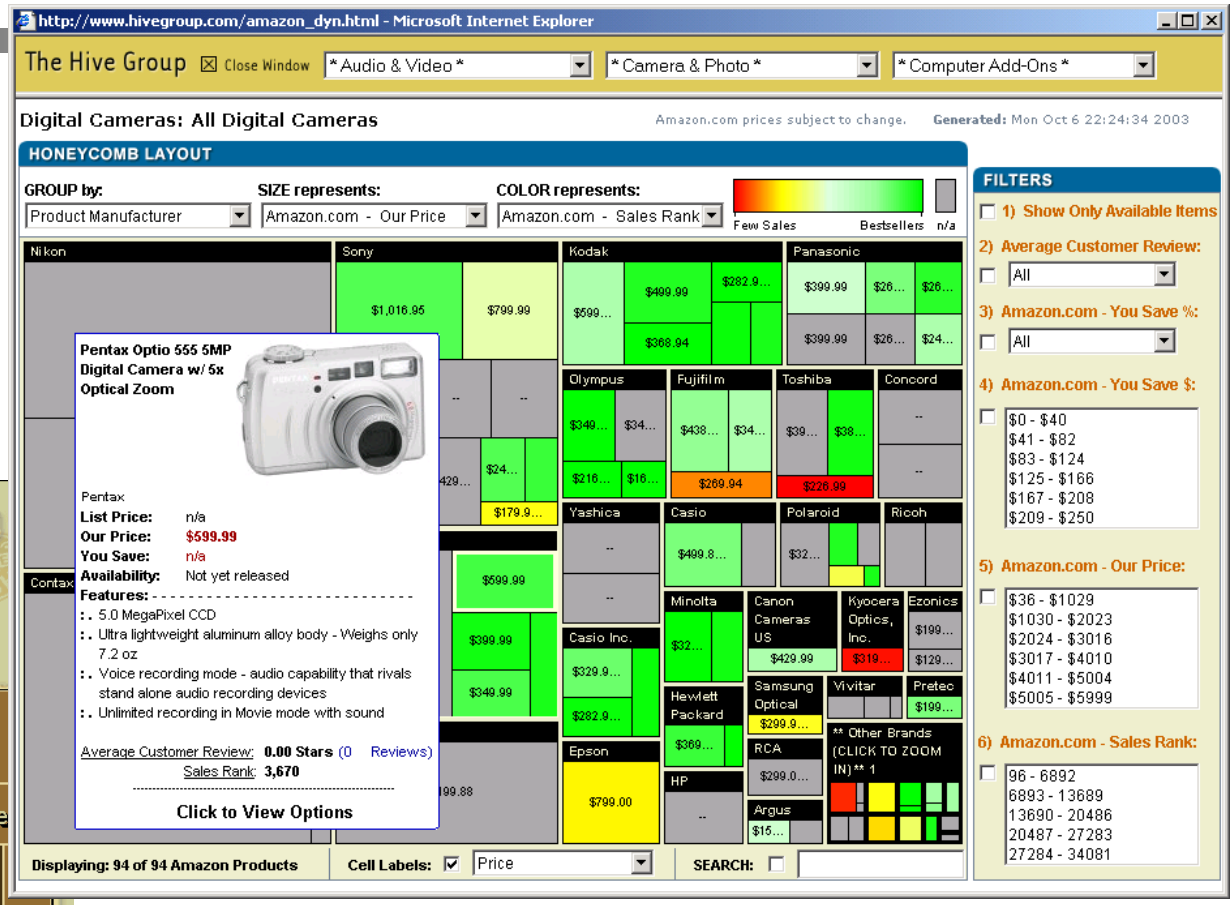
Treemap: Gene Ontology



http://www.cs.umd.edu/hcil/treemap/

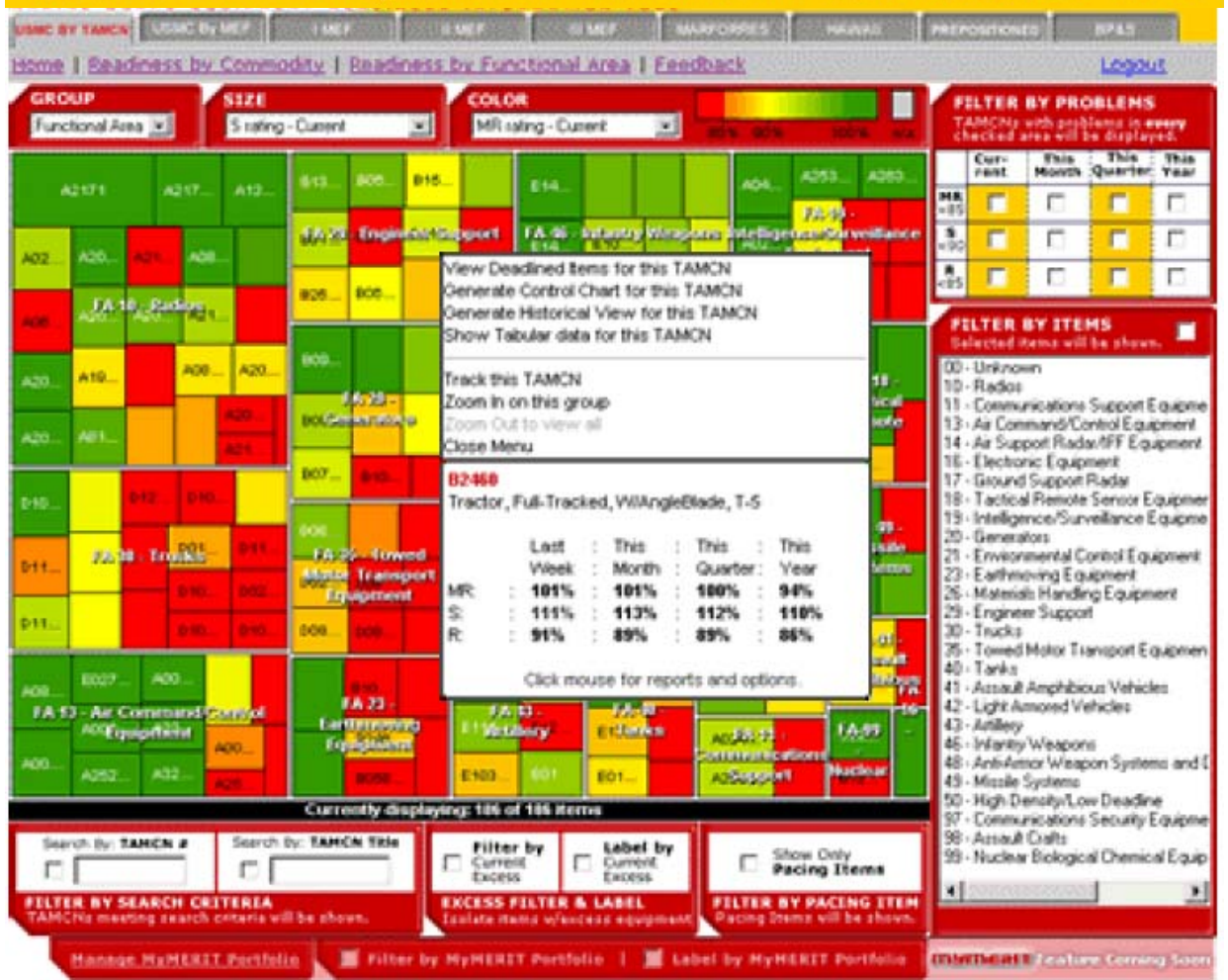
Treemap: Product catalogs

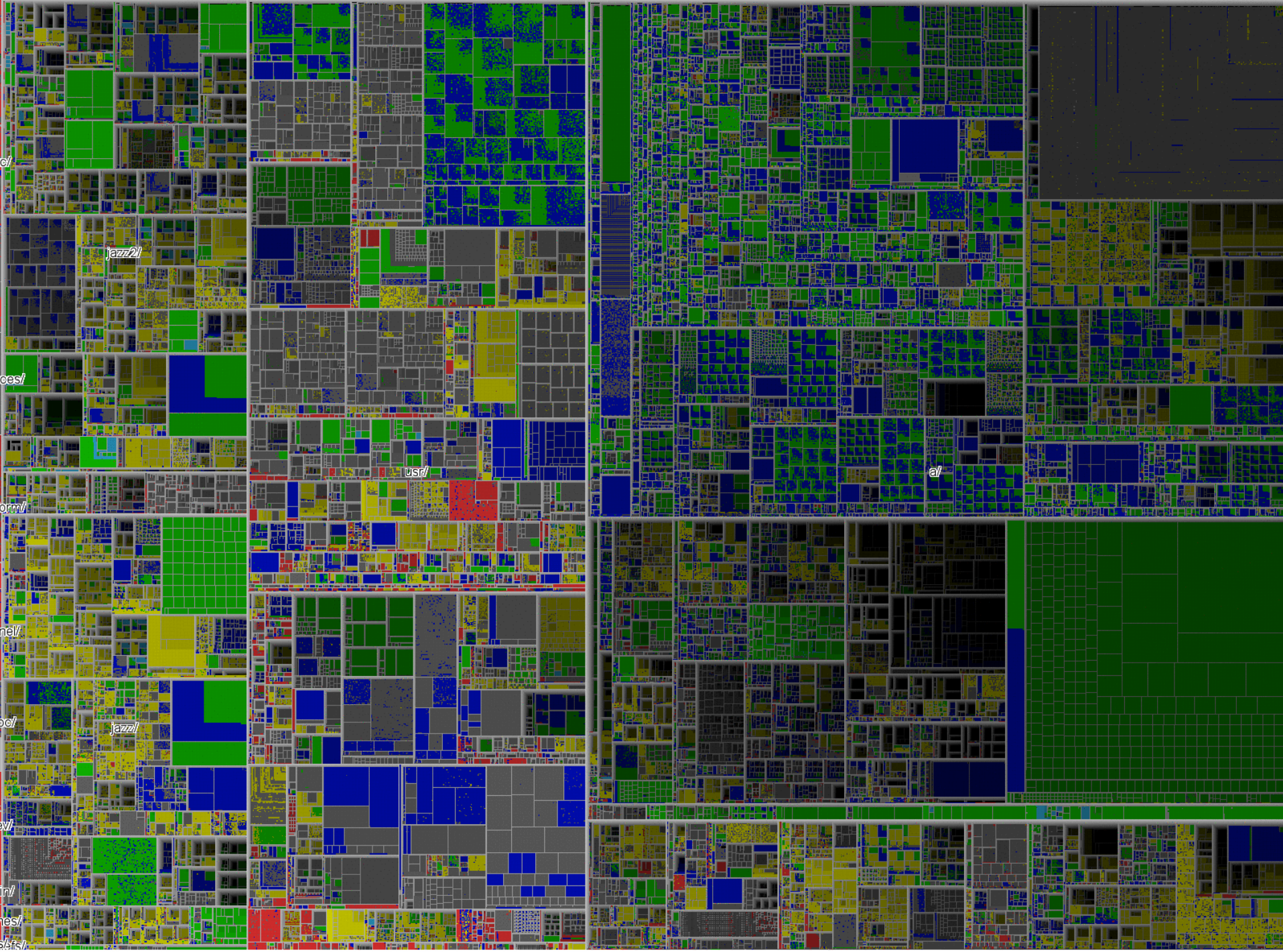
www.hivegroup.com



MERIT

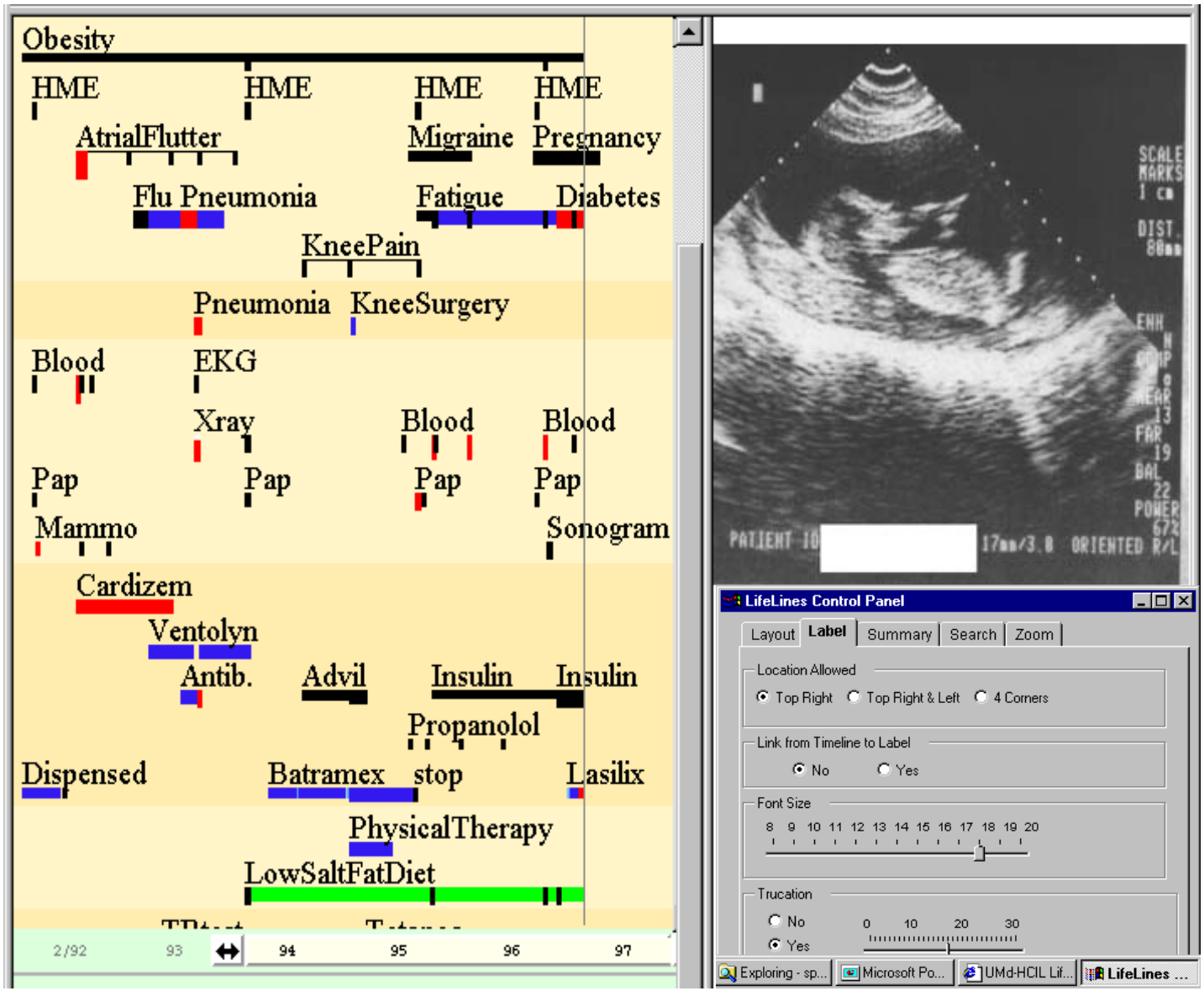
Marine Corps Equipment Readiness Information Tool



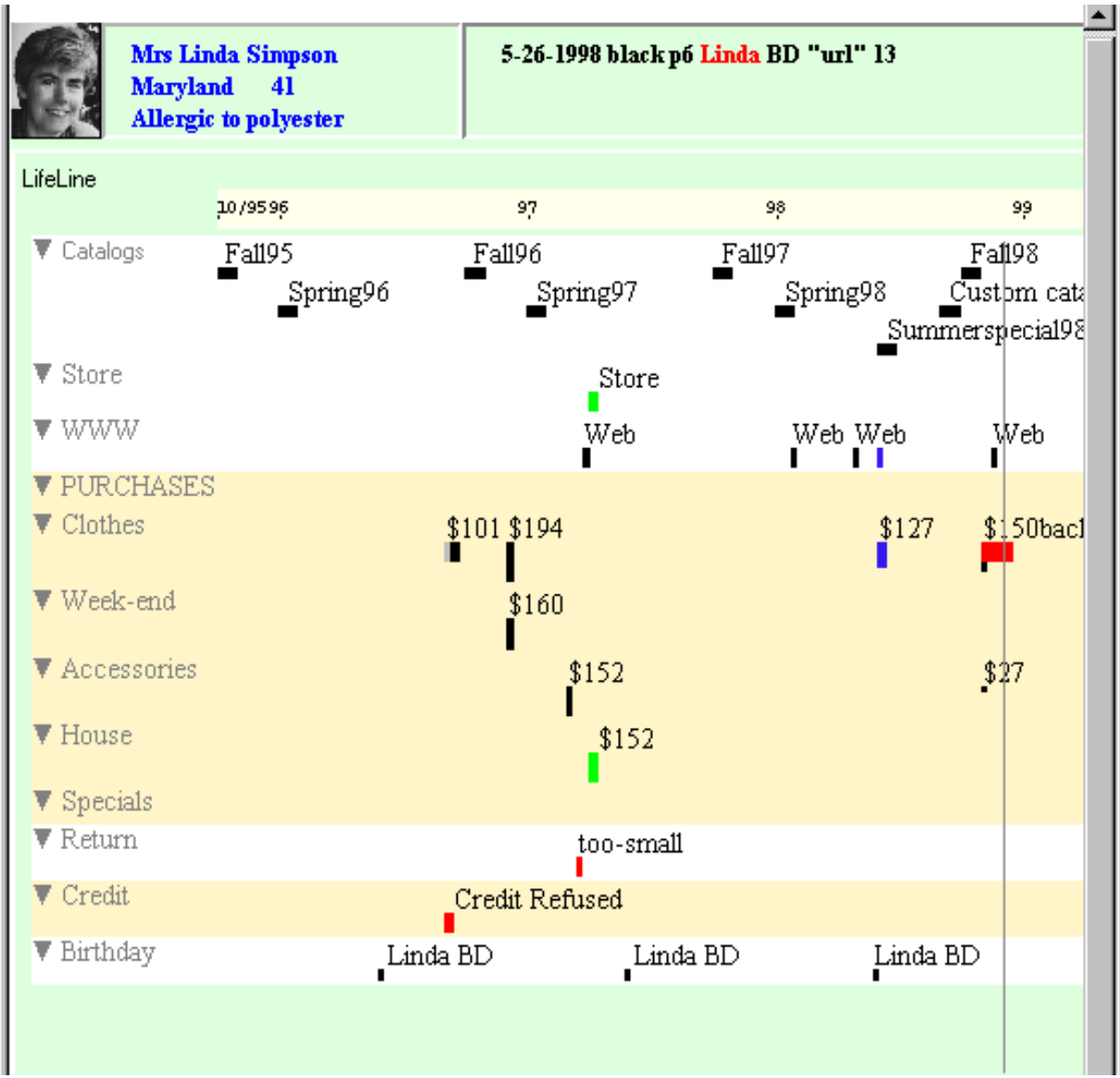


Speed: 5.917fps/0.169spf 971061 items .root.xml.gz/a/kronos/raid/ 'a/users/hsh/src/ .ld/build.sh

LifeLines: Patient Histories



LifeLines: Customer Histories



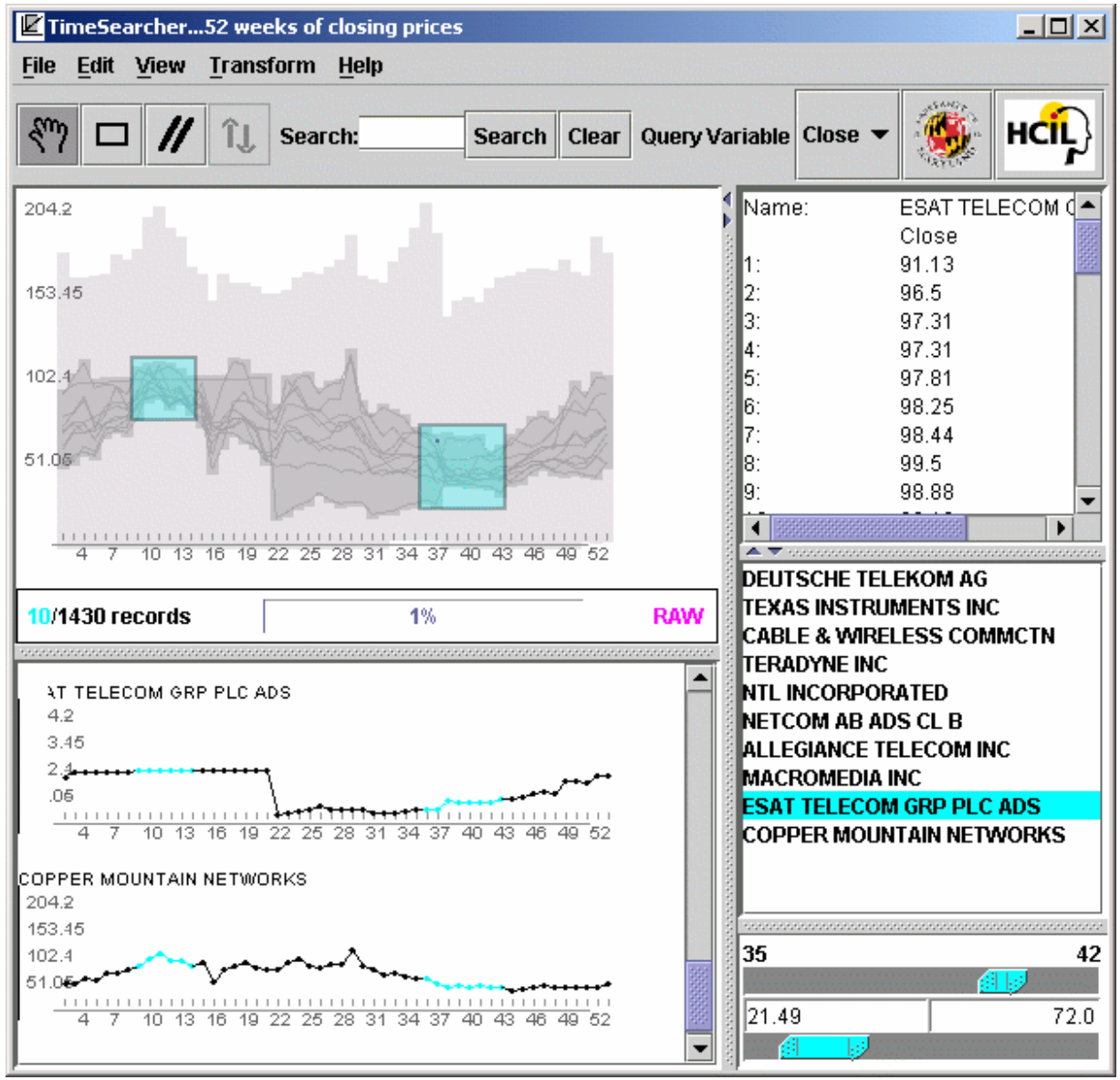
Linda Simpson ORDER#614345 (MOST RECENT)
11-1-1997,$150, Visa card, order by phone

D45F224: Boots - 4 - Black
----> **BACKORDER - estimated shipping 12-15**
D45F236: Gloves - Black - M
A78156: Corduroy pants - Tan - L
157826: Hat - Grey - M

Kids Backcountry hiking boots
Leather boots with super grip soles.

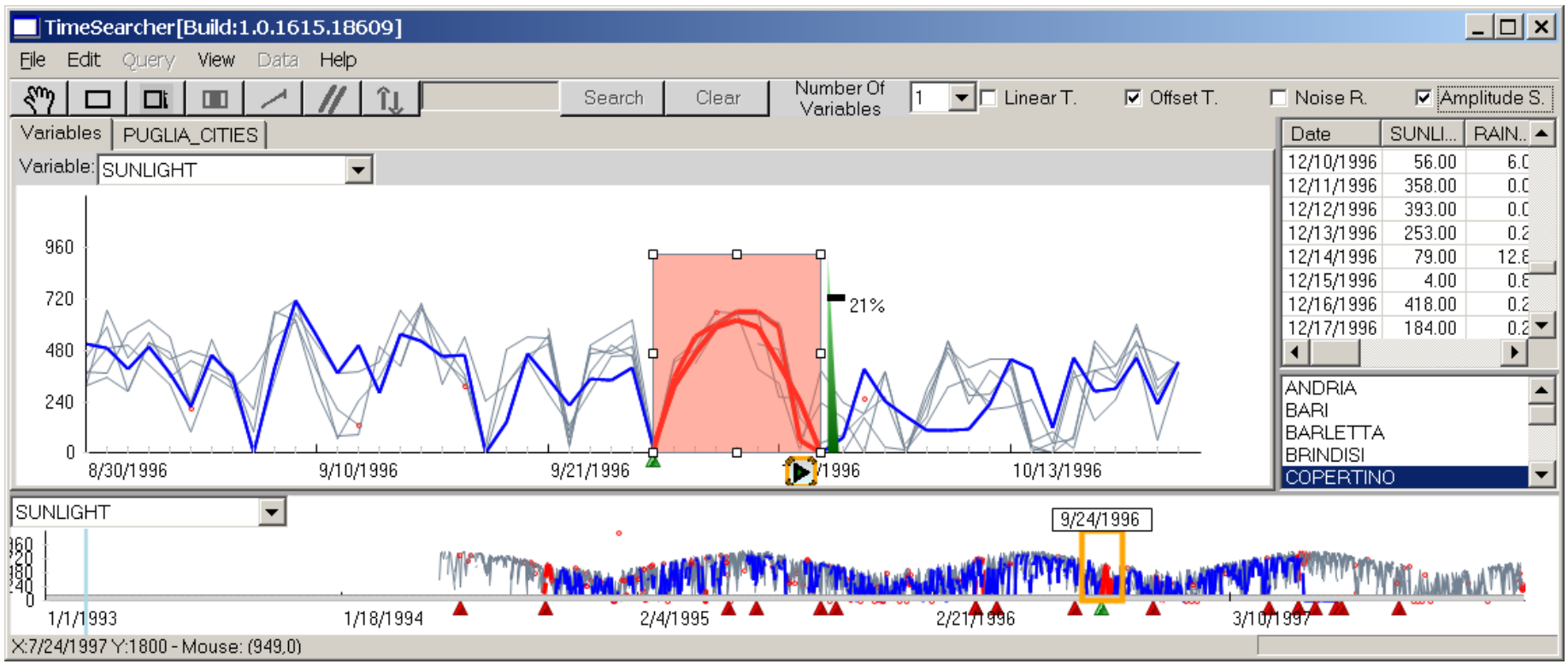
Temporal Data: TimeSearcher 1.3

- Time series
  - Stocks
  - Weather
  - Genes
- User-specified patterns
- Rapid search



Temporal Data: TimeSearcher 2.0

- **Long Time series (>10,000 time points)**
- **Multiple variables**
- **Controlled precision in match**
  (Linear, offset, noise, amplitude)

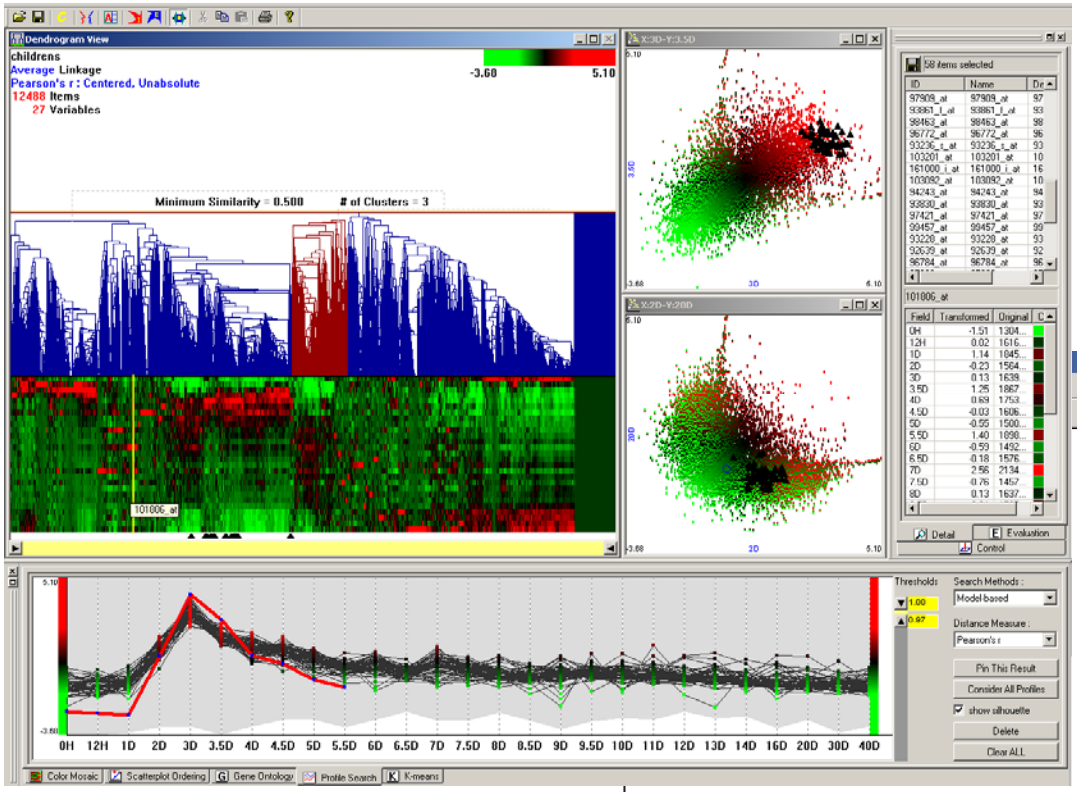


Goal: Find Features in Multi-Var Data

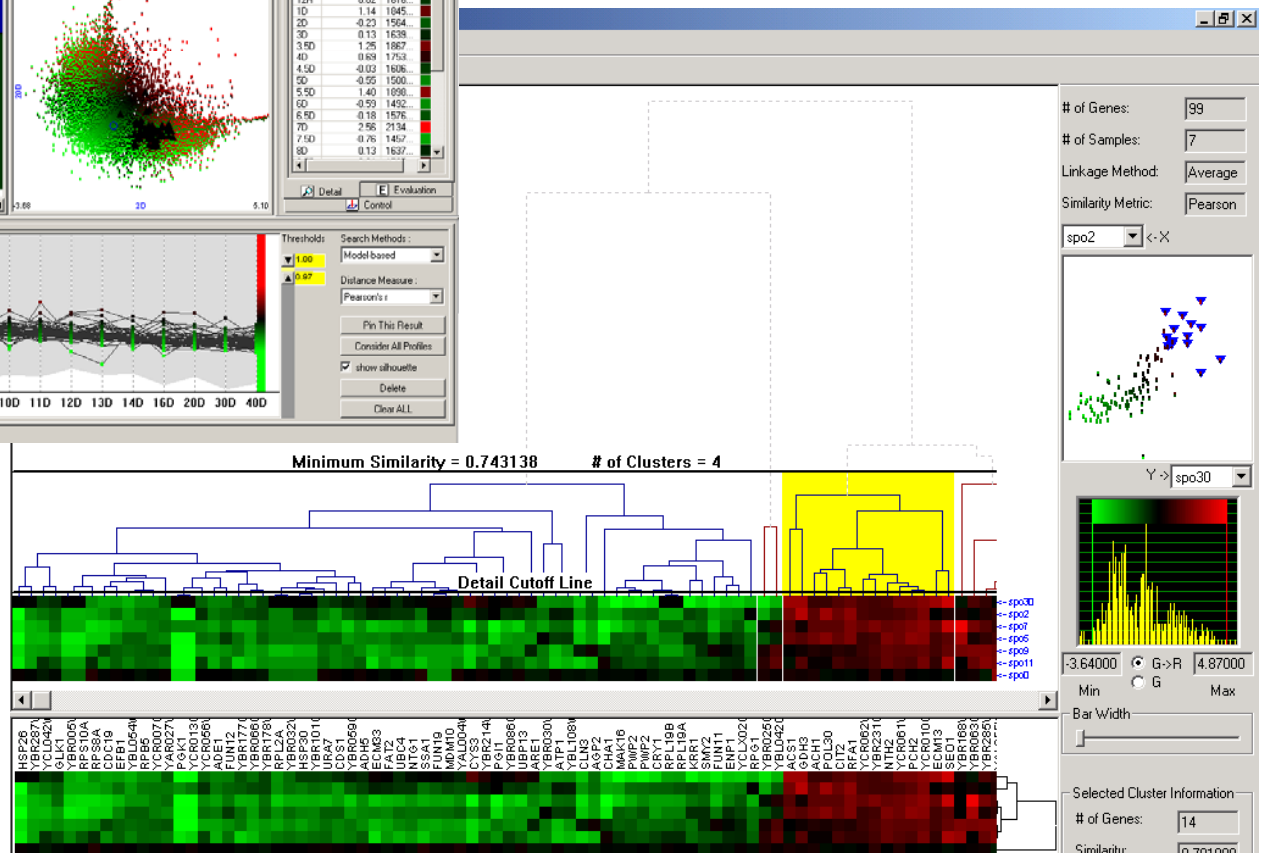
- Clear vision of what the data is
- Clear goal of what you are looking for

- Systematic strategy for examining all views
- Ranking of views to guide discovery
- Tools to record progress & annotate findings

Multi-V: Hierarchical Clustering Explorer



www.cs.umd.edu/hcil/hce/



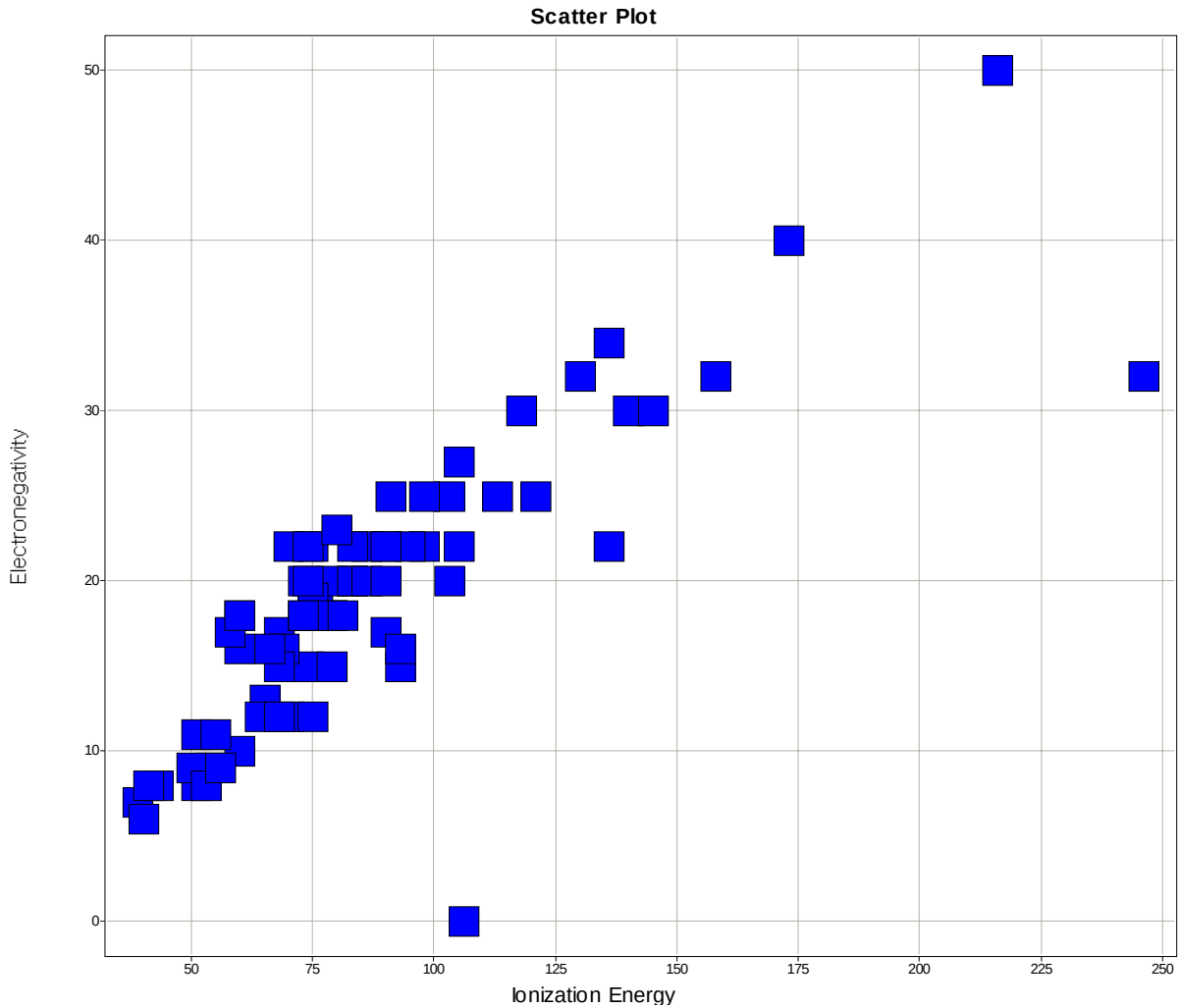
"HCE enabled us to find important clusters that we didn't know about."
- a user

Do you see anything interesting?

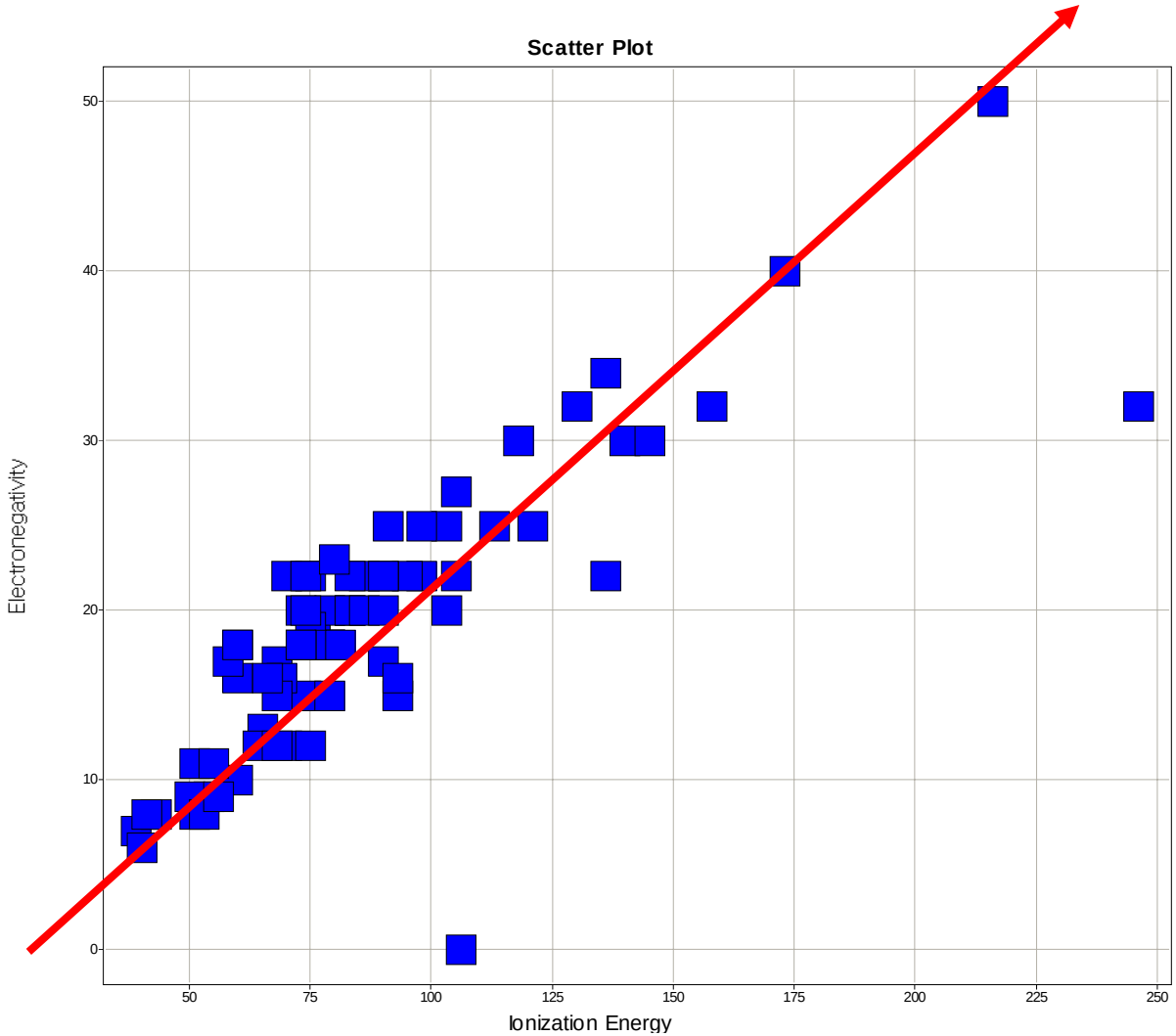
	A	B	C	D	E	F	G	H	I	J	K
1	Element	*P1	*P2	Atomic Num	Atomic Mas	Atomic Radi	Ionic Radius	Ionization E	Electronega	*C1	*C2
2	Ac	140	0	89	227	200	126	51	11	62	56
3	Ag	630	80	47	107	144	129	75	18	124	40
4	Al	750	160	13	27	143	67	60	16	28	25
5	Ar	1050	160	18	39	98	154	158	32	176	51
6	As	870	120	33	75	120	72	98	22	115	33
7	At	990	40	85	210	140	76	95	22	119	22
8	Au	630	40	79	197	144	99	91	25	131	22
9	B	750	200	5	10	85	41	83	20	101	8
10	Ba	80	40	56	137	222	149	51	8	46	56
11	Be	80	200	4	9	112	59	93	15	82	15
12	Bi	870	40	83	209	150	117	73	20	140	27
13	Br	990	120	35	79	114	182	118	30	161	44
14	C	810	200	6	12	77	30	113	25	82	1
15	Ca	80	120	20	40	197	114	60	10	70	51
16	Cd	690	80	48	112	151	109	90	17	113	43
17	Cl	990	160	17	35	100	167	130	32	173	47
18	Co	500	120	27	59	125	83	79	18	120	30
19	Cr	320	120	24	52	128	75	68	17	91	28
20	Cs	20	40	55	132	265	181	39	7	7	56
21	Cu	630	120	29	63	128	87	76	19	118	32
22	F	990	200	9	19	72	119	173	40	39	1
23	Fe	440	120	26	55	126	83	79	18	115	32
24	Fr	20	0	87	223	269	194	40	6	1	56
25	Ga	750	120	31	69	135	76	60	18	89	31
26	Ge	810	120	32	72	122	87	79	20	118	33
27	H	20	240	1	1	32	0	136	22	40	1
28	He	1050	240	2	4	31	93	246	32	1	1
29	Hf	200	40	72	178	159	85	70	12	95	44
30	Hg	690	40	80	200	151	116	103	20	147	27
31	I	990	80	53	126	133	206	105	27	153	44
32	In	750	80	49	114	167	94	58	17	93	42
33	Ir	500	40	77	192	136	82	90	22	116	25
34	K	20	120	19	39	227	152	43	8	37	56
35	Kr	1050	120	36	83	112	169	140	30	163	47

periodic

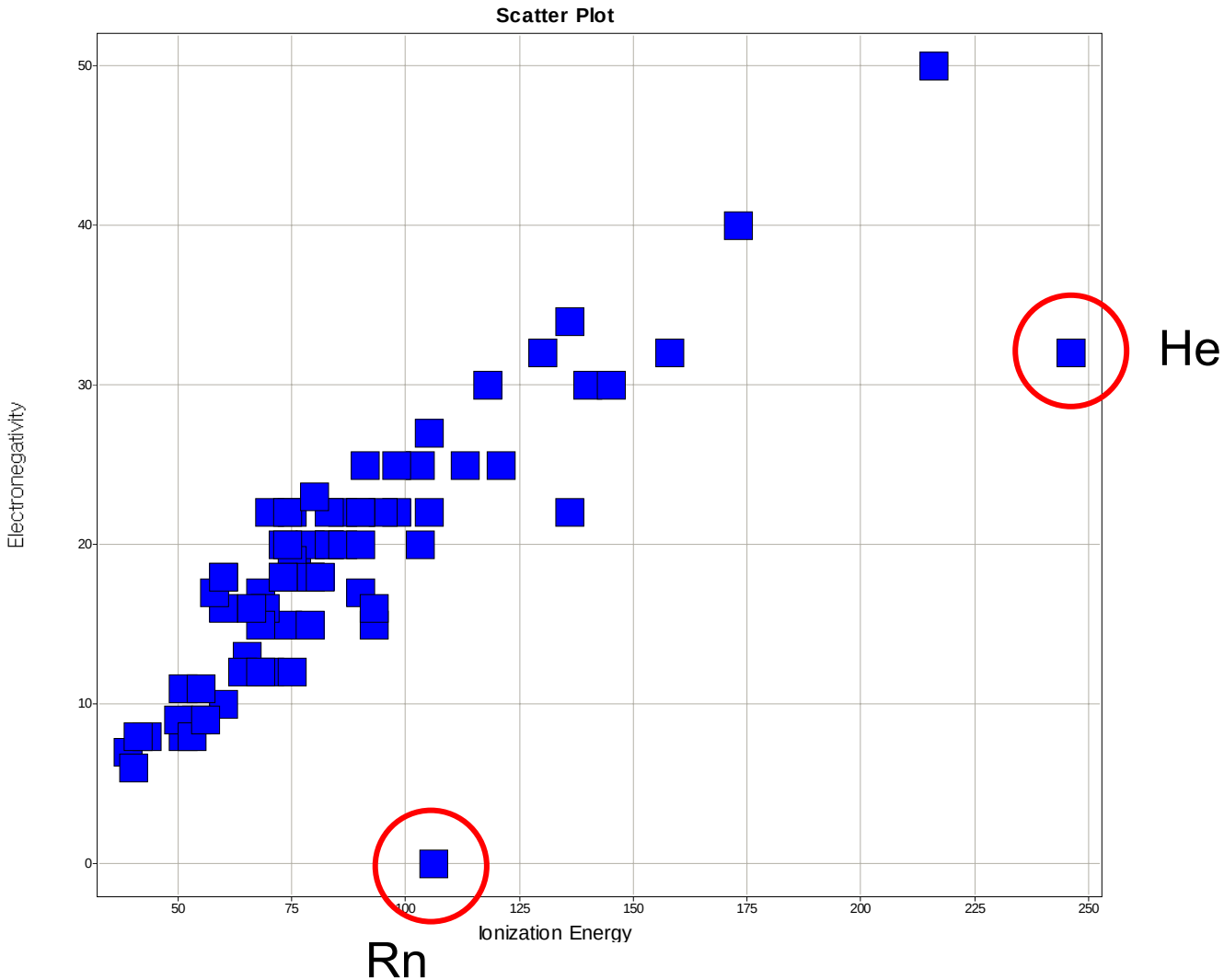
What features stand out?



Correlation…What else?



… and Outliers

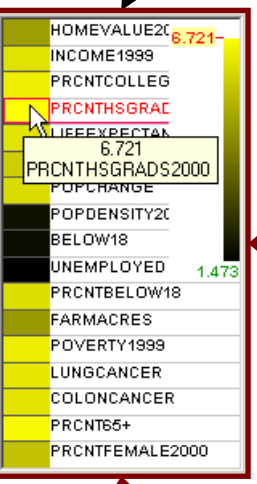


Demonstration

- US counties census data
  - 3138 counties
  - 14 dimensions : population density, poverty level, unemployment, etc.

Rank-by-Feature Framework: 1D

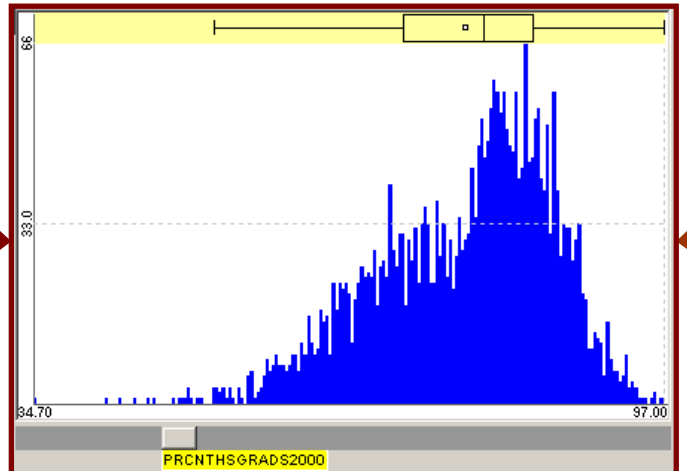
Ranking Criterion



Rank-by-Feature Prism

Score List

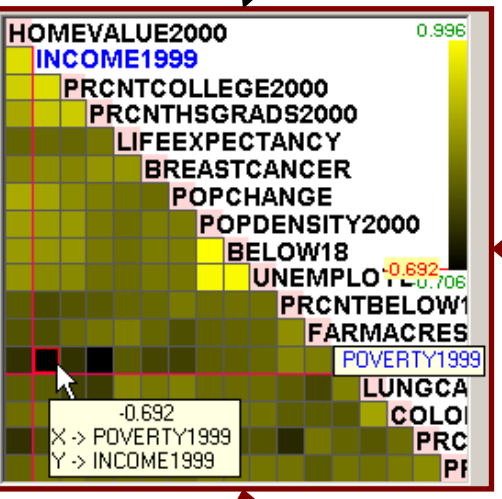
Rank	Column Name	S.	Min	Q1(25%)	Median	Q3(75
1	PRCNTHSG...	6,721	34,700	71,200	79,200	84,
2	PRCNT65+	6,580	1,800	12,100	14,400	17,
3	PRCNTCOL...	6,370	4,900	11,200	14,500	19,
4	POVERTY1999	6,350	0,000	9,500	13,000	17,
5	LUNGCANC...	6,208	10,700	50,200	60,300	69,
6	COLONCAN...	6,169	7,400	19,300	22,400	25,
7	LIFEEXPEC...	6,135	65,600	74,200	75,600	76,
8	INCOME1999	6,096	5213,000	15136,000	16946,000	18986,
9	PRCNTBEL...	6,019	9,600	23,700	25,300	27,
10	POPCHANGE	5,979	-10,400	-0,800	0,200	1,
11	BREASTCA...	5,710	0,000	20,579	23,713	26,
12	PRCNTFEM...	5,469	32,700	50,000	50,800	51,
13	HOMEVALU...	4,724	0,000	57900,000	75900,000	96900,
14	FARMACRES	4,607	0,000	82807,500	186881,000	367063,
15	POPDENSIT...	1,828	67,000	11223,500	24653,000	61775,
16	BELOW18	1,729	13,000	2821,500	6310,000	15510,
17	UNEMPLOY	1,473	3,000	237,000	559,000	1309,



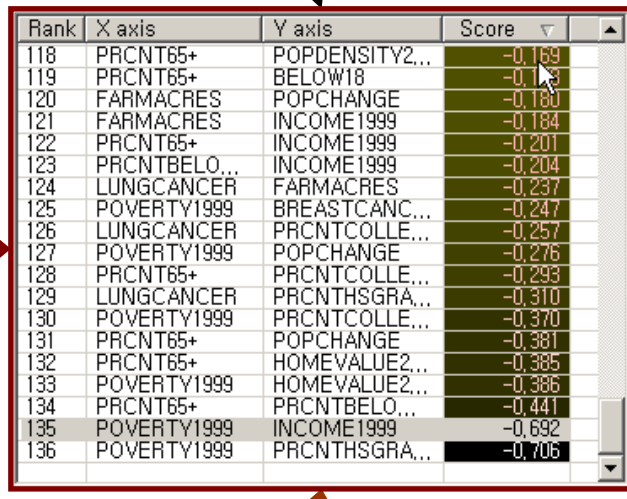
Manual Projection Browser

Rank-by-Feature Framework: 2D

Ranking Criterion

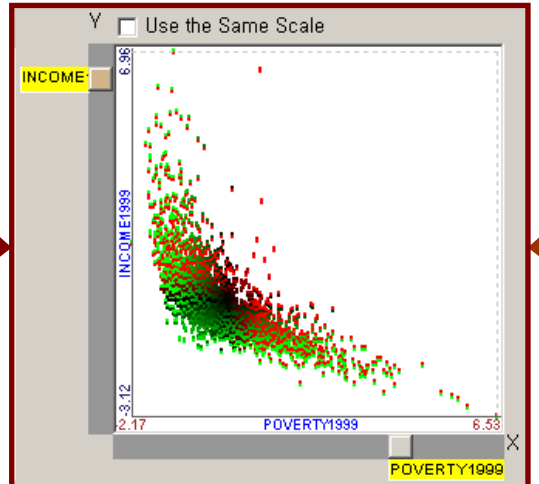


Rank-by-Feature Prism



Rank	X axis	Y axis	Score
118	PRCNT65+	POPDENSITY2...	-0,169
119	PRCNT65+	BELOW18	-0,[illegible]
120	FARMACRES	POPCHANGE	-0,180
121	FARMACRES	INCOME1999	-0,184
122	PRCNT65+	INCOME1999	-0,201
123	PRCNTBELO...	INCOME1999	-0,204
124	LUNGCANCER	FARMACRES	-0,237
125	POVERTY1999	BREASTCANC...	-0,247
126	LUNGCANCER	PRCNTCOLLE...	-0,257
127	POVERTY1999	POPCHANGE	-0,276
128	PRCNT65+	PRCNTCOLLE...	-0,293
129	LUNGCANCER	PRCNTHSGRA...	-0,310
130	POVERTY1999	PRCNTCOLLE...	-0,370
131	PRCNT65+	POPCHANGE	-0,381
132	PRCNT65+	HOMEVALUE2...	-0,385
133	POVERTY1999	HOMEVALUE2...	-0,386
134	PRCNT65+	PRCNTBELO...	-0,441
135	POVERTY1999	INCOME1999	-0,692
136	POVERTY1999	PRCNTHSGRA...	-0,706

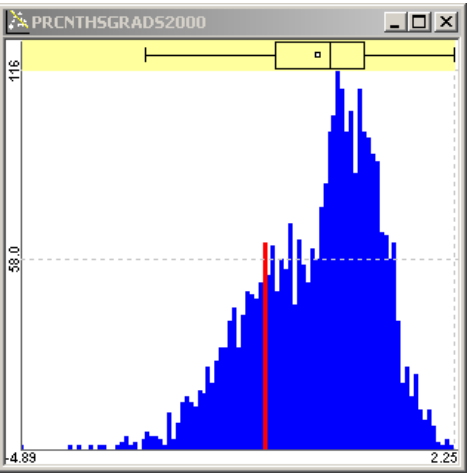
Score List

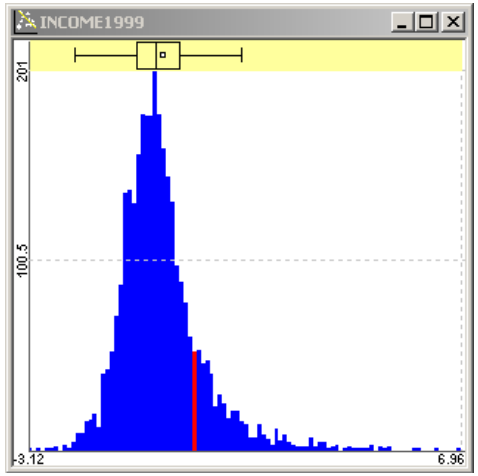


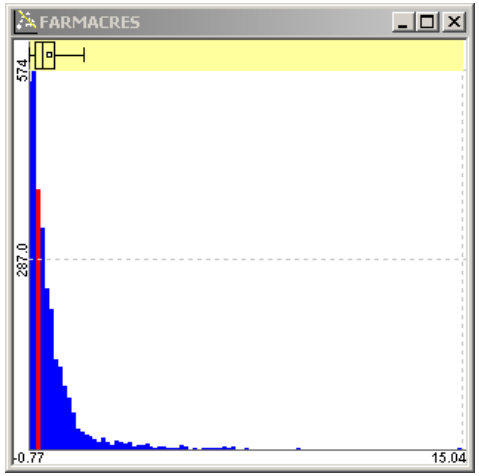
Manual Projection Browser

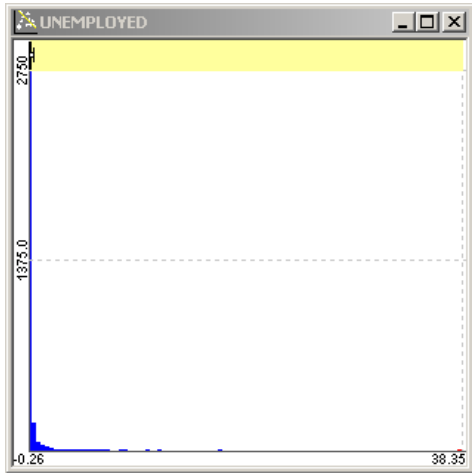
A Ranking Example

3138 U.S. counties with 17 attributes

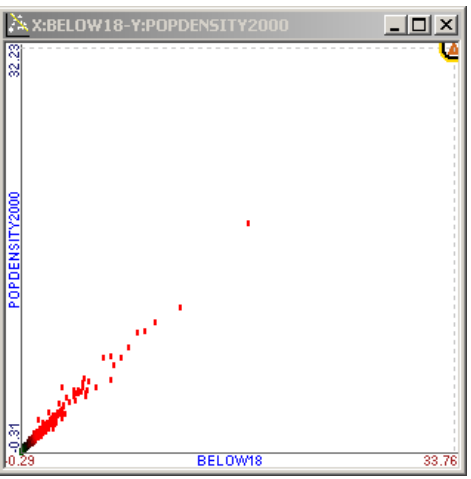


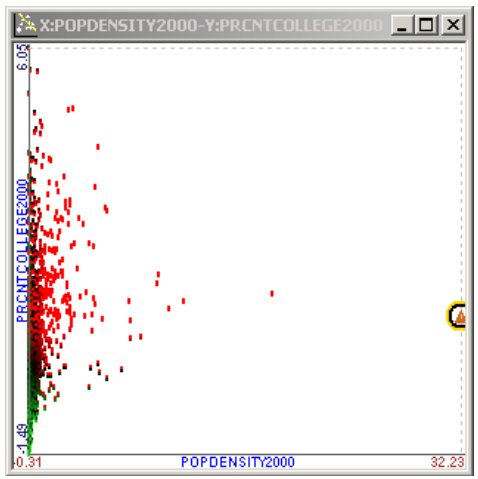


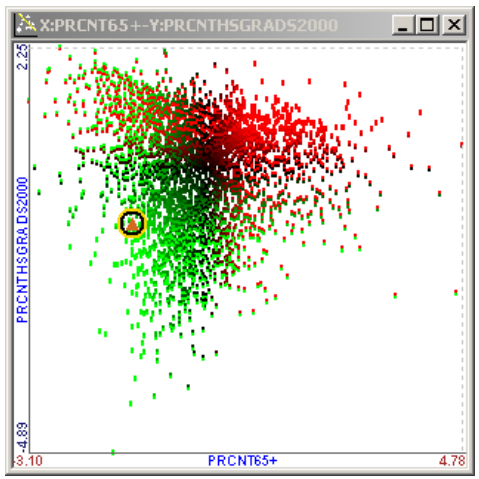


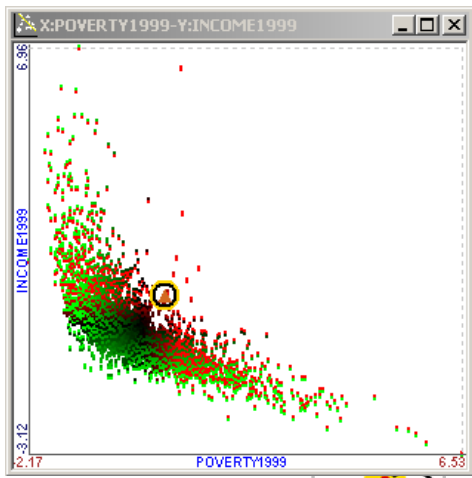


Ranking Criterion: Uniformity (entropy) (6.7, 6.1, 4.5, 1.5)









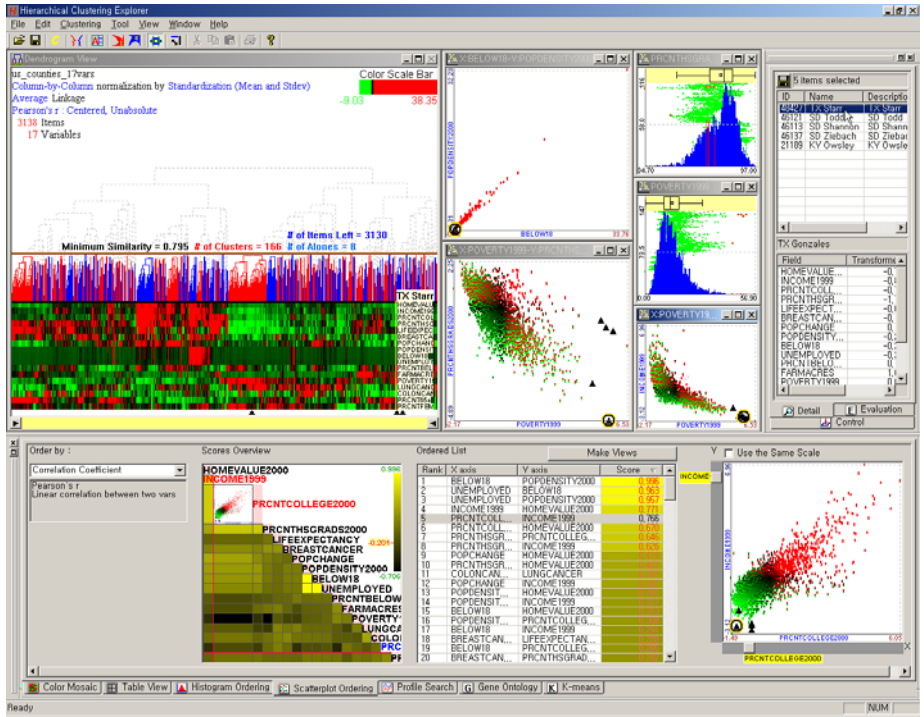
Ranking Criterion: Pearson correlation (0.996, 0.31, 0.01, -0.69)

HCE Status

- In collaboration and sponsored by Eric Hoffman: Children's National Medical Center
- Phd work of Jinwook Seo

- 72K lines of C++ codes
- 4,000+ downloads since April 2002

- www.cs.umd.edu/hcil/hce



Evaluation Methods

Ethnographic Observational Situated

- Multi-Dimensional
- In-depth
- Long-term
- Case studies

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Domain Experts
Doing Their Own Work
for Weeks & Months

Evaluation Methods

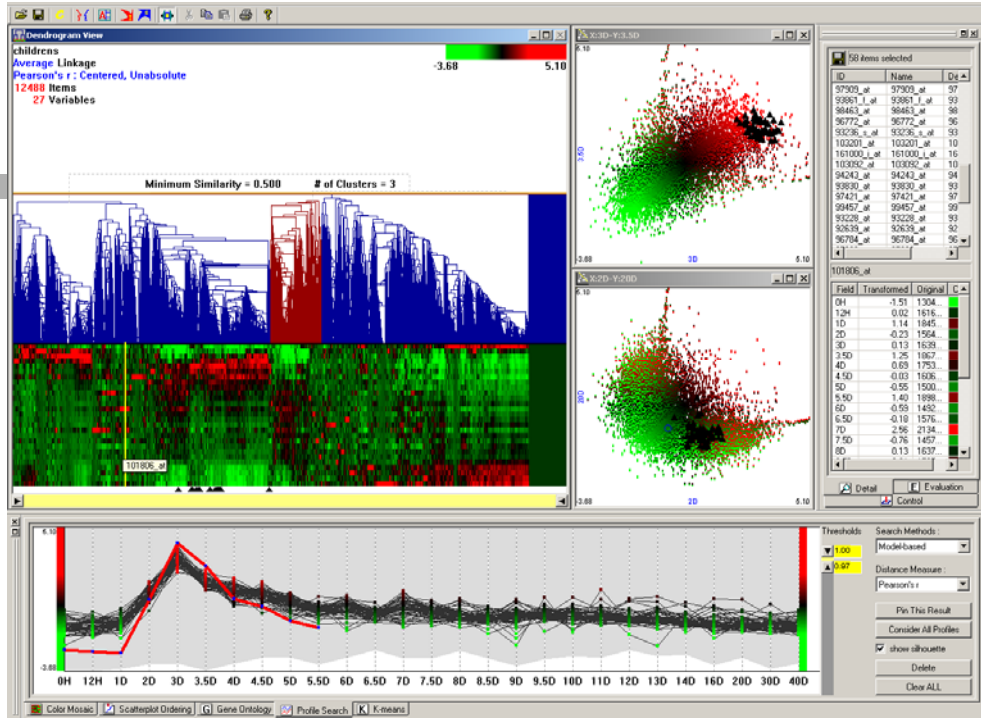
Ethnographic Observational Situated

- Multi-Dimensional
- In-depth
- Long-term
- Case studies

MILCs

Shneiderman & Plaisant, *BeLIV workshop*, 2006

MILC example

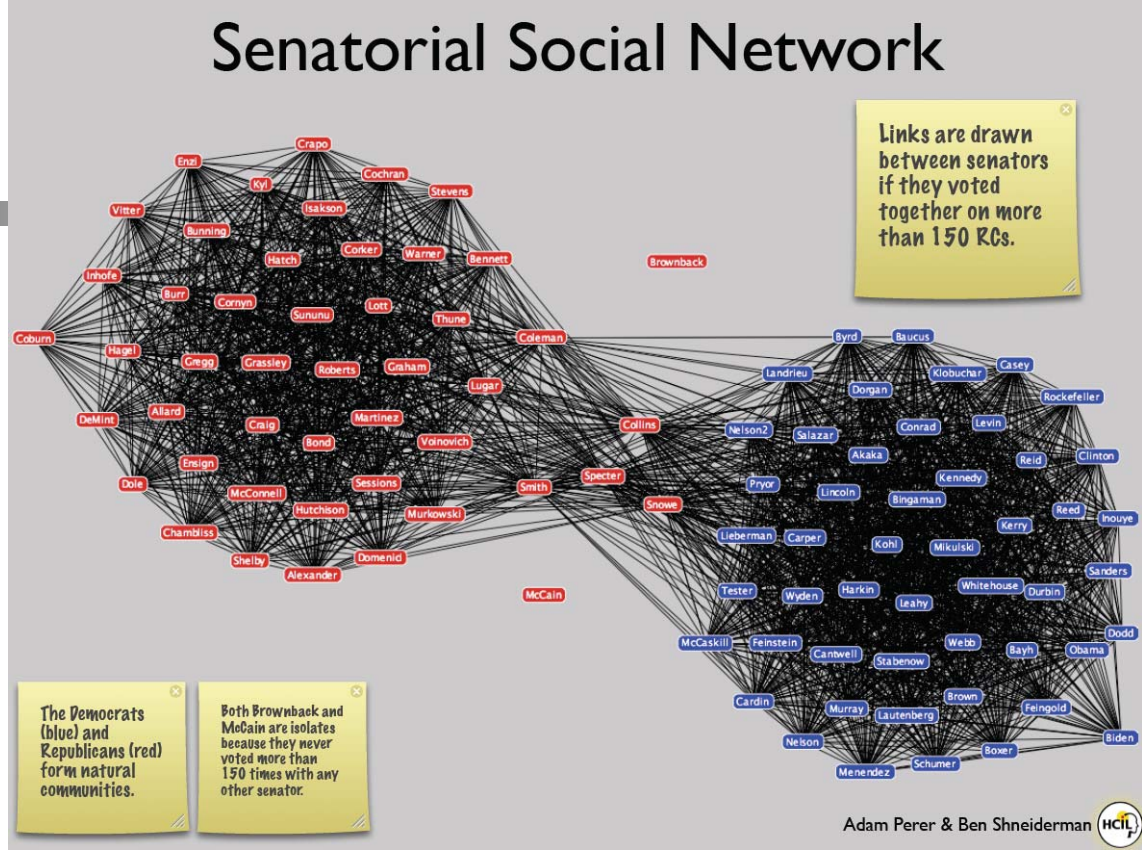


- Evaluate Hierarchical Clustering Explorer
- Focused on rank-by-feature framework
- 3 case studies, 4-8 weeks (molecular biologist, statistician, meteorologist)
- 57 email surveys
- Identified problems early, gave strong positive feedback about benefits of rank-by-feature

Seo & Shneiderman, *IEEE TVCG* 12,3, 2006

MILC example

- Evaluate SocialAction



- Focused on integrating statistics & visualization
- 4 case studies, 4-8 weeks (journalist, bibliometrician, terrorist analyst, organizational analyst)
- Identified desired features, gave strong positive feedback about benefits of integration

Perer & Shneiderman, 2007

Case Study Methodology

1) Interview (1 hr)
2) Training (2 hr)
3) Early Use (2-4 weeks)
4) Mature Use (2-4 weeks)
5) Outcome (1 hr)

Take Away Message

Rank-by-Feature Framework

- Decomposition of complex problems into multiple simpler problems wins
- Ranking guides discovery
- Systematic strategies

www.cs.umd.edu/hcil/hce

HCIL

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