



Information Visualization for Medical Informatics: From Patient Histories to Clinical Research

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Professor, Dept of Computer Science &
Member, Institute for Advanced Computer Studies





Interdisciplinary research community

- Computer Science & Psychology
- Information Studies & Education

(www.cs.umd.edu/hcil)

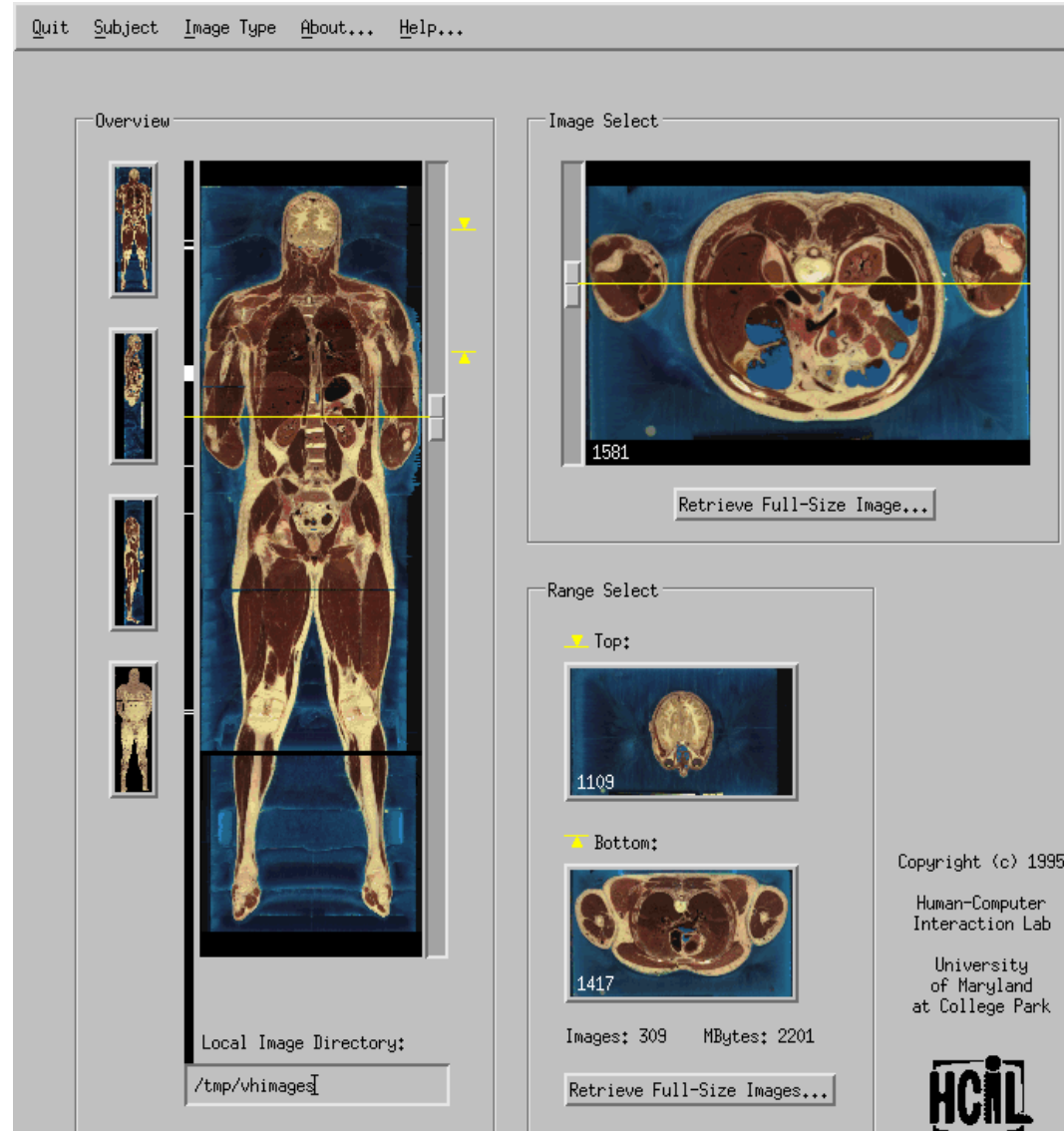
U.S. Library of Congress



- Scholars, Journalists, Citizens
- Teachers, Students

Visible Human Explorer (NLM)

- Doctors
- Surgeons
- Researchers
- Students



NASA Environmental Data

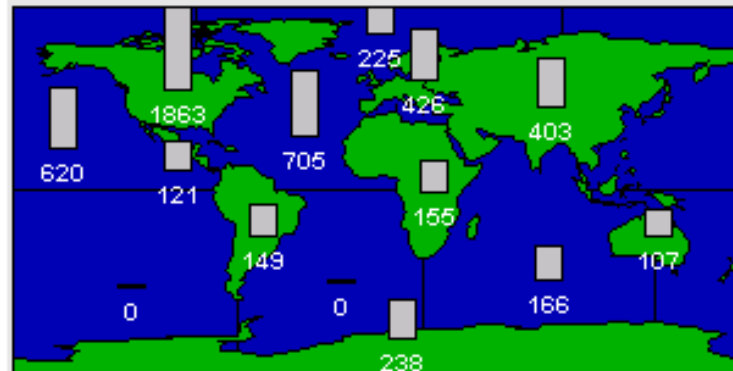
- Scientists
- Farmers
- Land planners
- Students



Global Change Master Directory

Query Preview

Area Selection:



Select attributes of in
by clicking on map and

Topic Selection:

Atmosphere	2151
Biosphere	1083
Cryosphere	313
Human Dimensions	595
Hydrosphere	643
Land Surface	802
Oceans	1321
Paleoclimate	120
Radiance Or Imagery	738
Solar Physics	113
Solid Earth	429
Not Specified	0

Year Selection:

Prehistoric	0
0001 - 1699	21
1700 - 1799	51
1800 - 1849	91
1850 - 1899	283
1900 - 1929	409
1930 - 1939	415
1940 - 1949	498
1950 - 1959	711
1960 - 1969	978
1970 - 1979	1649
1980 - 1989	2445
1990 - 1999	2391
Not Specified	644

Bureau of the Census



- Economists, Policy makers, Journalists
- Teachers, Students

American FactFinderTM

NSF Digital Government Initiative

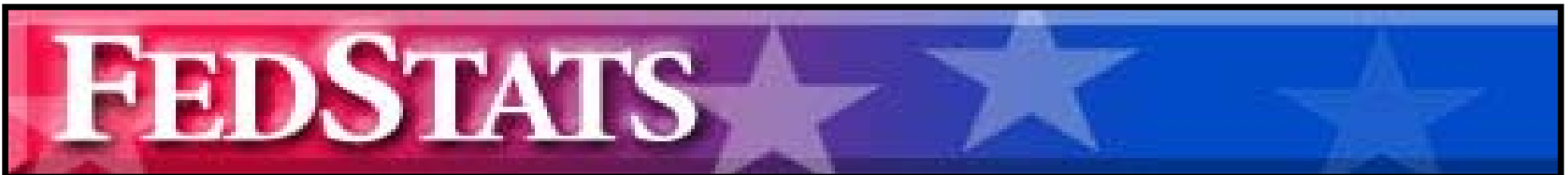


Census,
NCHS,
BLS, EIA,
NASS, SSA

- Find what you need
- Understand what you Find

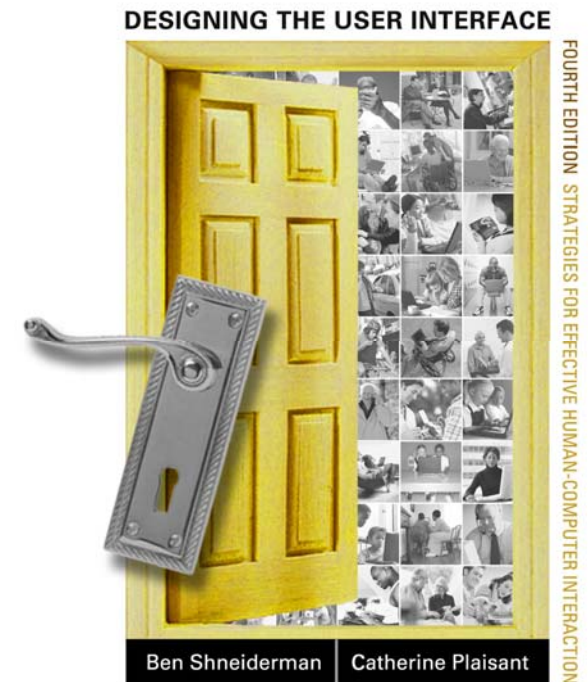


www.ils.unc.edu/govstat/



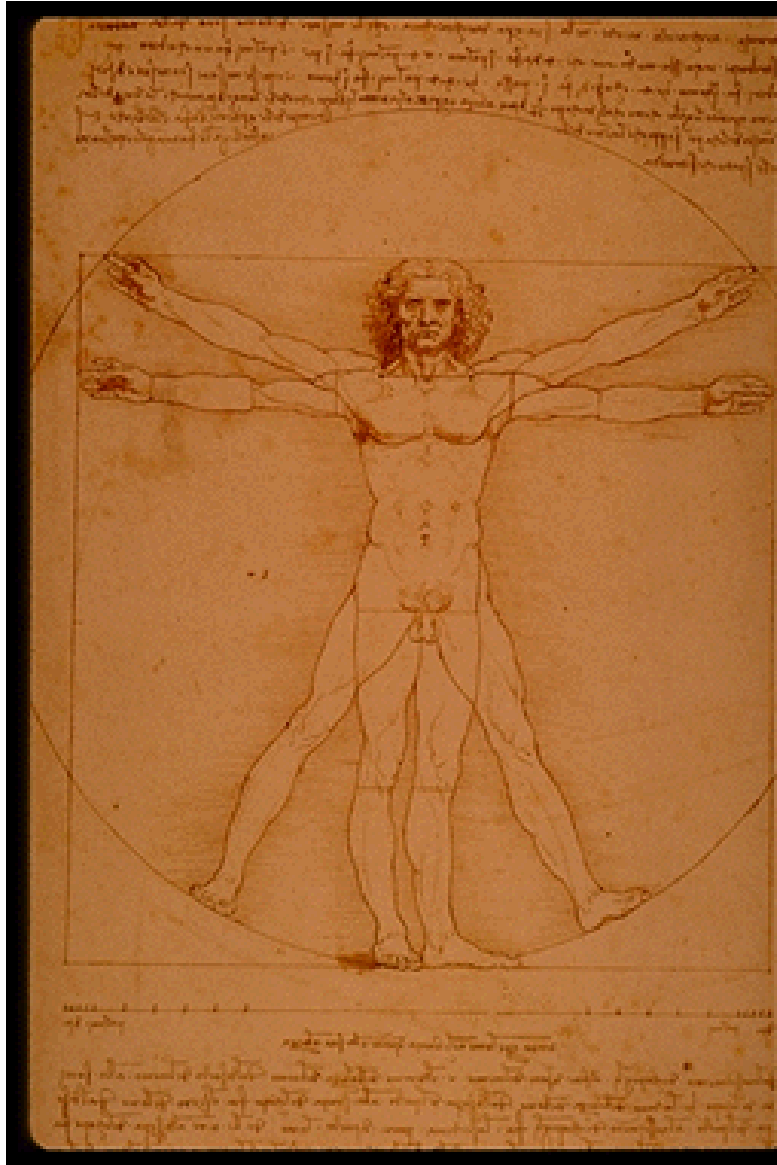
Design Issues

- 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

Information Visualization

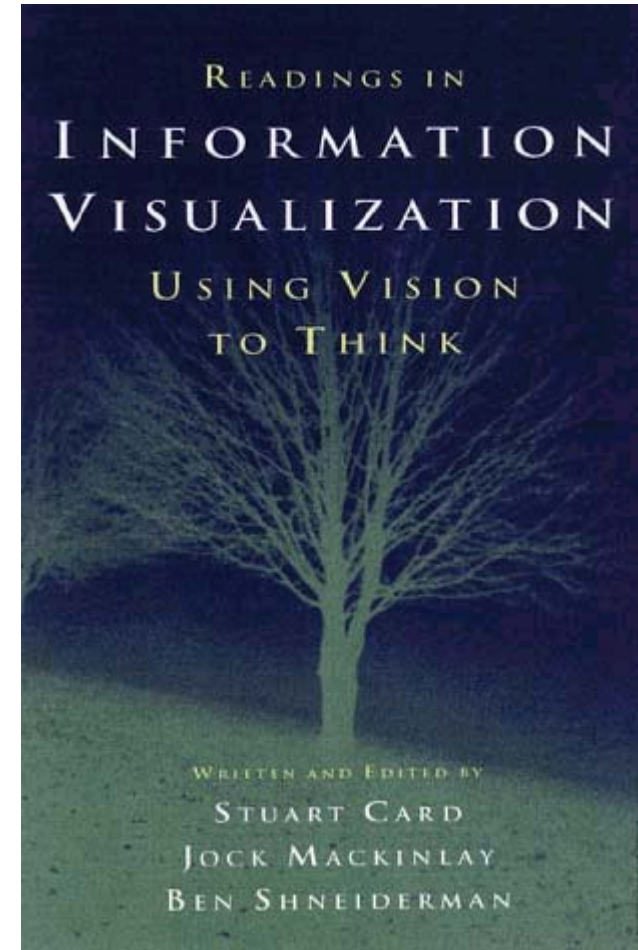


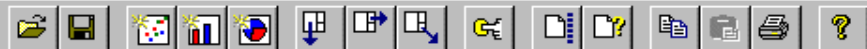
**The eye...
the window of the soul,
is the principal means
by which the central sense
can most completely and
abundantly appreciate
the infinite works of nature.**

***Leonardo da Vinci*
(1452 - 1519)**

Using Vision to Think

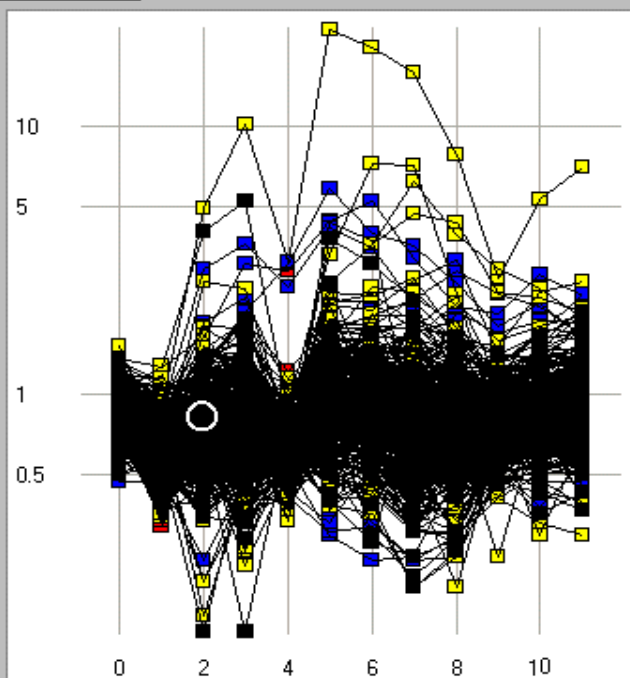
- **Visual bandwidth is enormous**
 - Human perceptual skills are remarkable
 - Trend, cluster, gap, outlier...
 - Color, size, shape, proximity...
 - Human image storage is fast and vast
- **Opportunities**
 - Spatial layouts & coordination
 - Information visualization
 - Scientific visualization &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



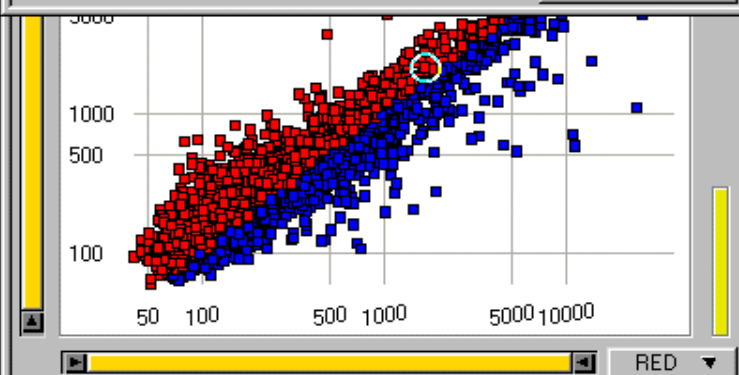


Scatter Plot

RGRATIO



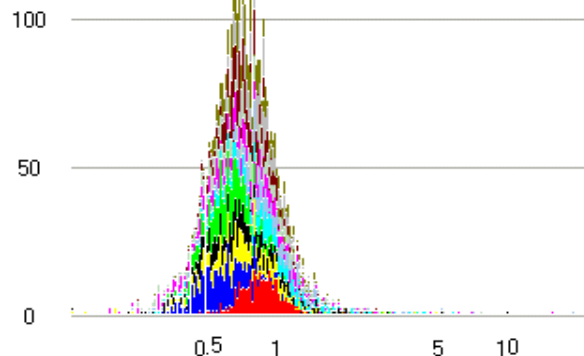
TIMEPOINT



RED

Histogram

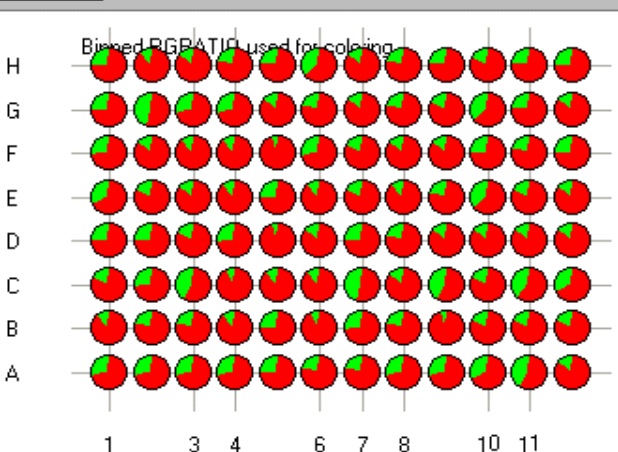
TIMEPOINT used for coloring



RGRATIO

Pie Chart

PROW



PCOL

Table

RED 42 38938

RGRAT 0.13 23

REGR -1.48 10.17

CORR -0.64 1

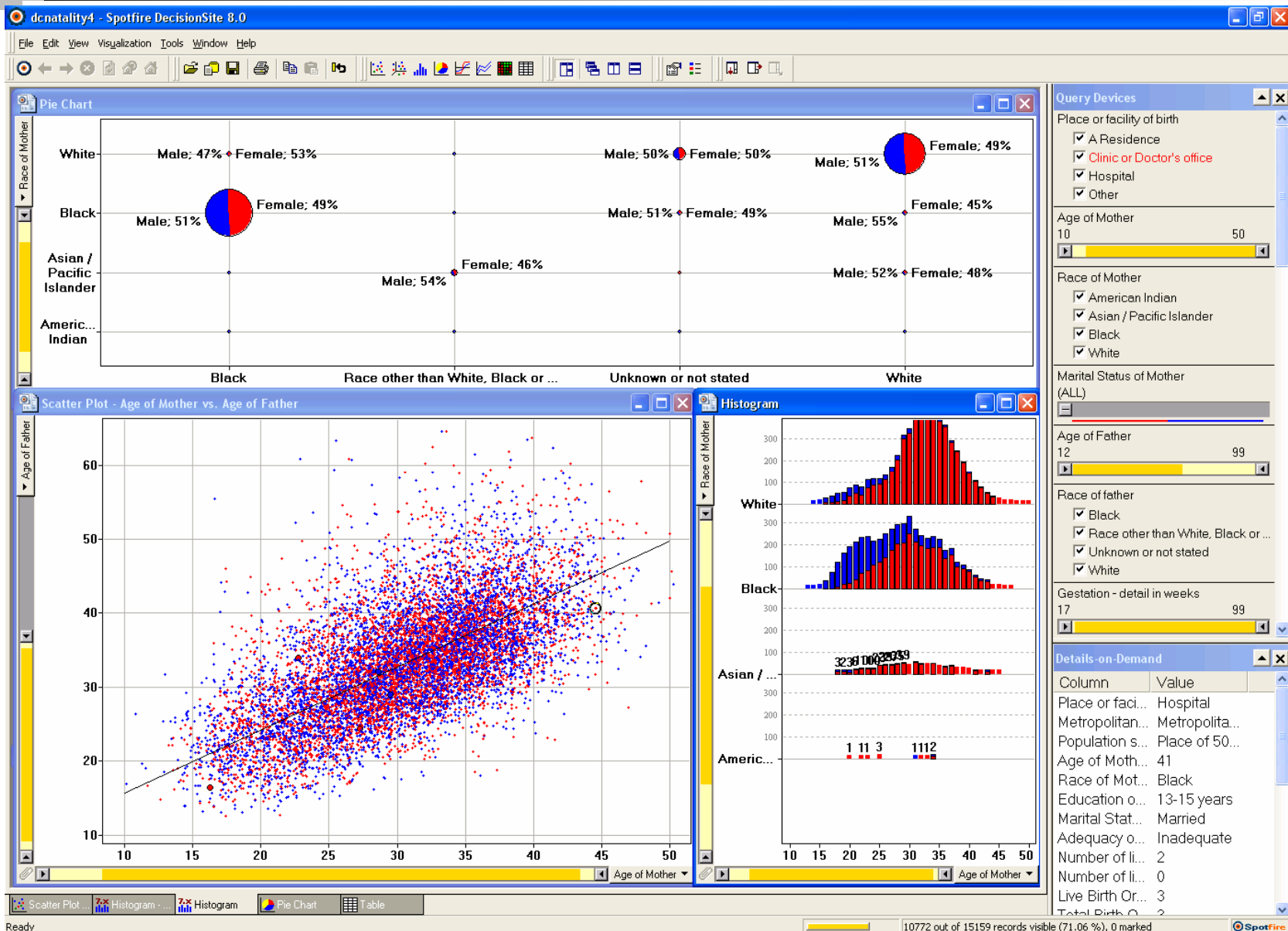
AROW
☒ 7
☒ 8
☒ 9
☒ 10

ACOL 1 51

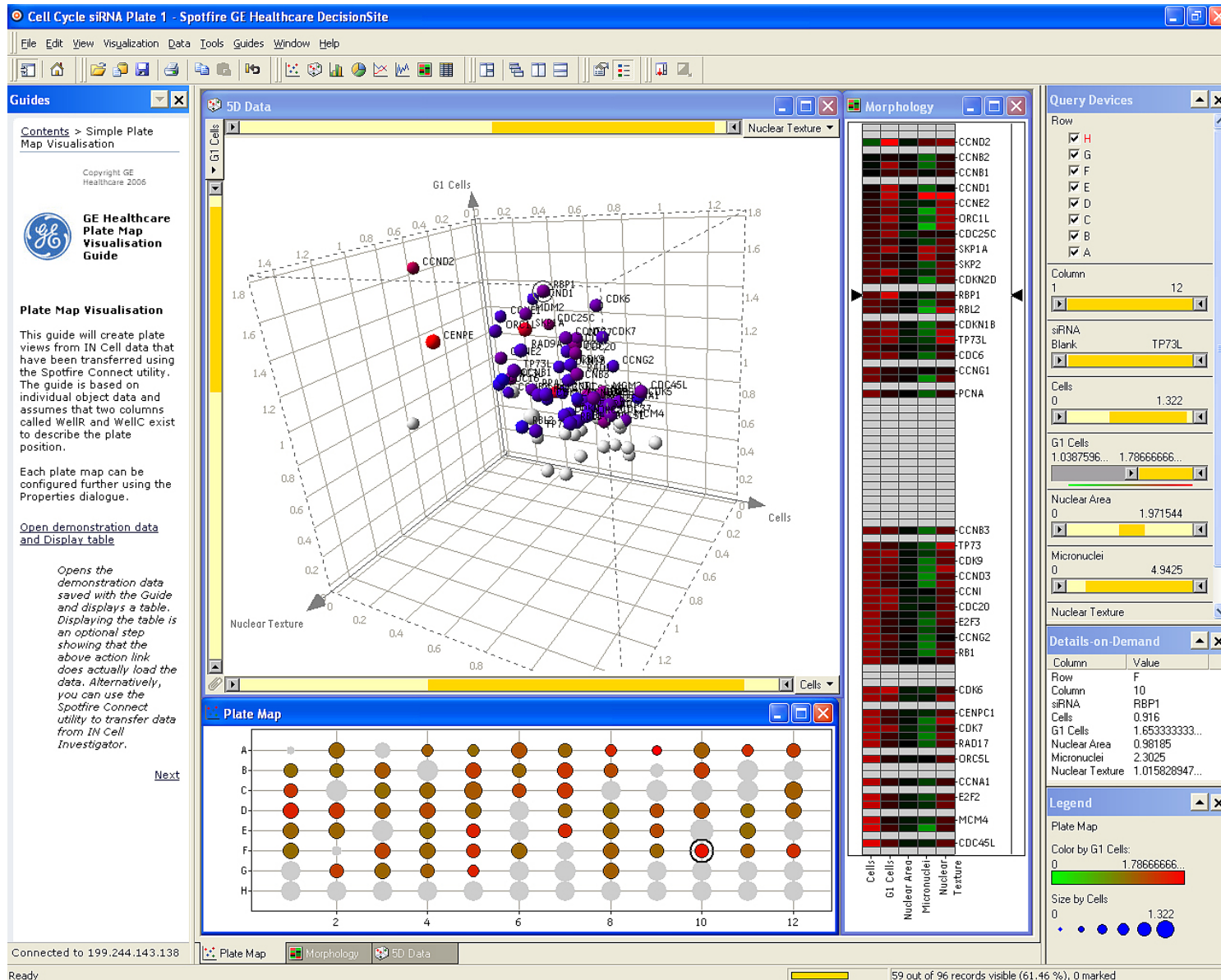
☒ 14
☒ 15
☒ 16

TIMEPOINT 2
 DESCRIPTION ESTs
 TYPE cDNA
 GENENAME R71468
 GREEN 2089
 RED 1706
 RGRATIO 0.82
 REGR 1.28
 CORR 0.95
 AROW 8
 ACOL 41
 PLAT 15
 PROW E
 PCOL 4

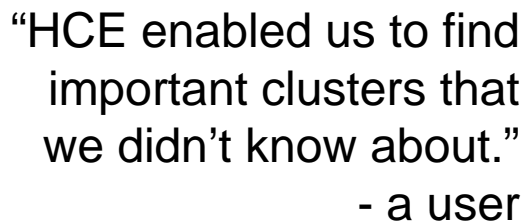
Spotfire: DC natality data



Spotfire: Retinol's role in embryos & vision

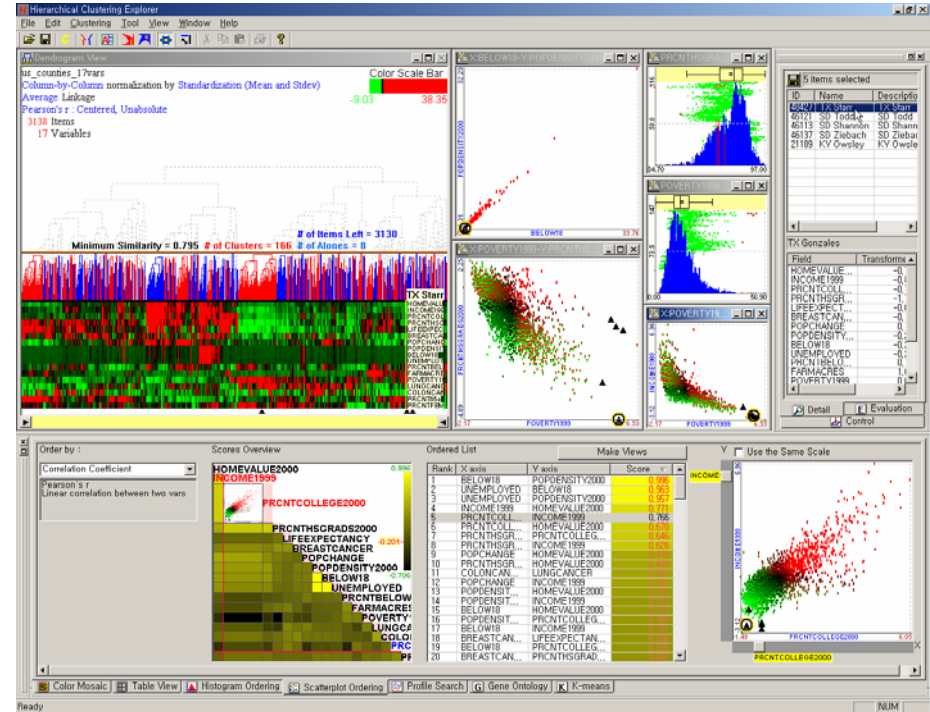






HCE Status

- In collaboration and sponsored by Eric Hoffman: Children's National Medical Center
- Categorical Variables: 4.0 beta, May 2005
- 60K lines of C++ codes, 58 Classes
- 2,000+ downloads since April 2002
- www.cs.umd.edu/hcil/hce



Information Visualization: Mantra

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

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, HCE
	• Temporal	Perspective Wall, LifeLines, Lifestreams, Project Managers, DataSpiral
	• Tree	Cone/Cam/Hyperbolic, TreeBrowser, Treemap
	• Network	Netmap, netViz, SeeNet, Multi-trees

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

Treemap: view large trees with node values

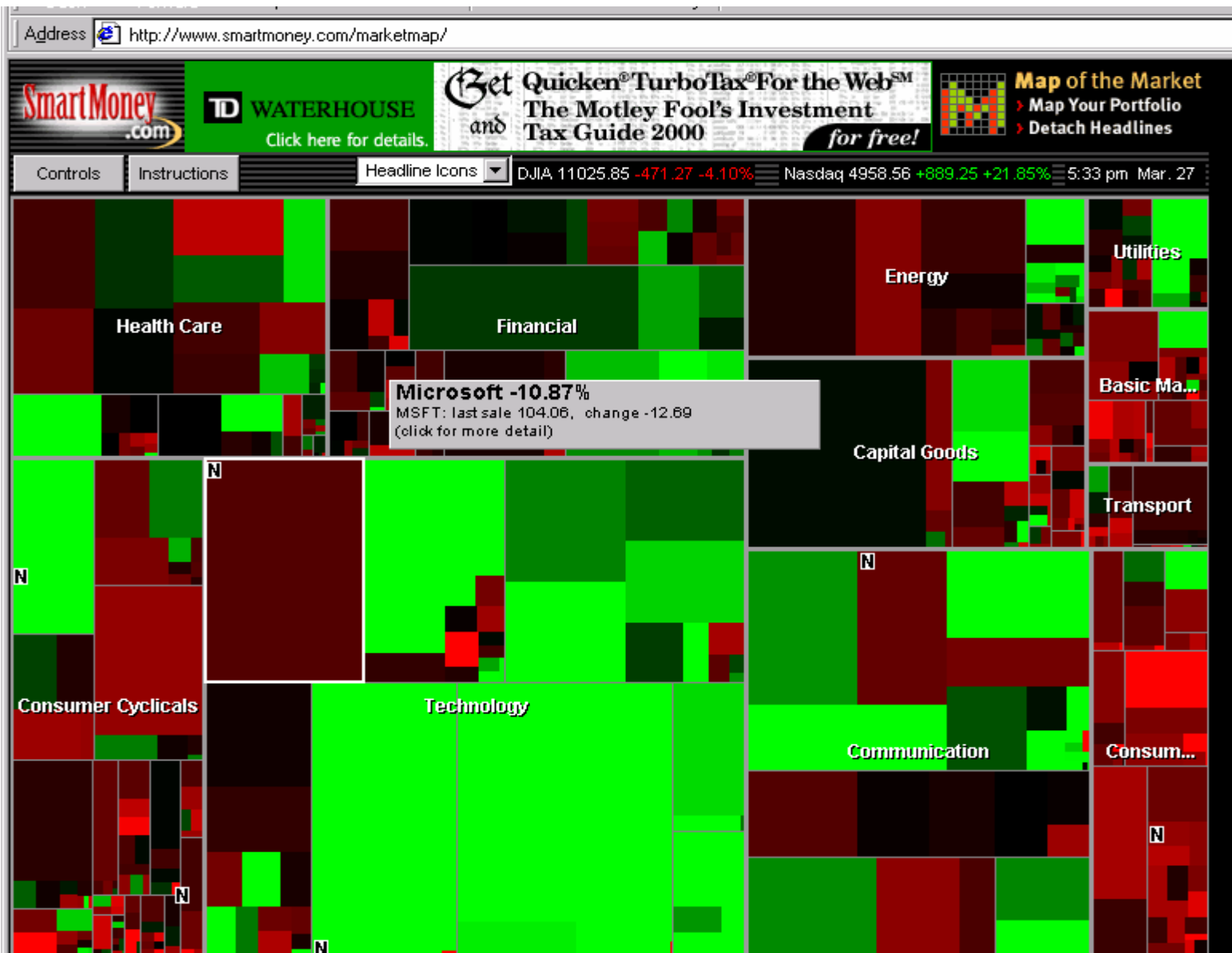
- + Space filling
- + Space limited
- + Color coding
- + Size coding
- Requires learning

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



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

Treemap: Stock market, clustered by industry





Treemap: Gene Ontology



Treemap: Product catalogs



[SHOP](#) | [ROASTING](#) | [FRESHNESS](#) | [TASTING](#) | [ABOUT US](#)

[COFFEE TASTING](#) | [COFFEE BREWING](#) | [TEA TASTING](#) | [TEA BREWING](#)

COFFEE SELECTOR

[CLICK HERE FOR HELP.](#)

THIS FIELD REPRESENTS THE FULL SPECTRUM OF PEET'S COFFEES.

CLICK ON A COFFEE TO ADD IT TO YOUR CART OR TO LEARN MORE.

LEGEND

GROUP = COFFEE TYPE

SIZE = PRICE

COLOR = BODY

Medium Very Full

CHECK A BOX TO VIEW...

☐ BEST SELLERS

☐ RECOMMENDED FOR ESPRESSO

Try our Holiday Gift Finder.

Peet's Blends

Decaffeinate

Top Blend
Premium coffees from Latin America and the Pacific blended to create full body, sparkling acidity, and spicy notes.
\$10.95 / lb (Click for more)

Americas

Africa and Arabia

The Pacific

Dark Roast

http://www.hivegroup.com/amazon_dyn.html - Microsoft Internet Explorer

The Hive Group

Audio & Video *Camera & Photo* *Computer Add-Ons*

Digital Cameras: All Digital Cameras

Amazon.com prices subject to change. Generated: Mon Oct 6 22:24:34 2003

HONEYCOMB LAYOUT

GROUP by: SIZE represents: COLOR represents:

Product Manufacturer Amazon.com - Our Price Amazon.com - Sales Rank

Filters:

1) Show Only Available Items

2) Average Customer Review:

3) Amazon.com - You Save %:

4) Amazon.com - You Save \$:

5) Amazon.com - Our Price:

6) Amazon.com - Sales Rank:

Nikon	Sony	Kodak	Panasonic
	\$1,016.95 \$799.99	\$499.99 \$282.9...	\$399.99 \$26... \$26...
		\$599... \$368.94	\$399.99 \$26... \$24...
		Olympus	Fujifilm
		\$349... \$34...	\$438... \$34...
		\$216... \$16...	\$269.94 \$226.99
		Yashica	Casio
		\$599.99	\$499.8...
			Minolta
			\$32...
			Canon Cameras US
			\$429.99 \$319... \$129...
			Samsung Optical
			\$299.9...
			Hewlett Packard
			\$369...
			RCA
			\$299.0...
			HP
			\$799.00
			Argus
			\$15...
			Vivitar
			Pretec
			\$199...
			Kyocera Optics, Inc.
			\$319...
			Ezonics
			\$199...
			** Other Brands (CLICK TO ZOOM IN) ** 1

Displaying: 94 of 94 Amazon Products Cell Labels: ☒ Price SEARCH:

Pentax Optio 555 5MP Digital Camera w/ 5x Optical Zoom

Pentax:
List Price: n/a
Our Price: **\$599.99**
You Save: n/a
Availability: Not yet released

Features:

- 5.0 MegaPixel CCD
- Ultra lightweight aluminum alloy body - Weighs only 7.2 oz
- Voice recording mode - audio capability that rivals stand alone audio recording devices
- Unlimited recording in Movie mode with sound

Average Customer Review: **0.00 Stars (0 Reviews)**
Sales Rank: **3,670**

[Click to View Options](#)

MERIT

MARINE CORPS EQUIPMENT READINESS INFORMATION TOOL

USMC BY TAMCN | USMC By MEF | 1 MEF | 2 MEF | 3 MEF | MARFORPAC | HAWAII | PREPOSITIONED | RPAS

[Home](#) | [Readiness by Commodity](#) | [Readiness by Functional Area](#) | [Feedback](#) | [Logout](#)

GROUP Functional Area | **SIZE** S rating - Current | **COLOR** MR rating - Current

FILTER BY PROBLEMS
TAMCNs with problems in every checked area will be displayed.

	Current	This Month	This Quarter	This Year
MR <85	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
S <90	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
R <85	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

FILTER BY ITEMS
Selected items will be shown.

- 00 - Unknown
- 10 - Radios
- 11 - Communications Support Equipment
- 13 - Air Command/Control Equipment
- 14 - Air Support Radar/IFF Equipment
- 16 - Electronic Equipment
- 17 - Ground Support Radar
- 18 - Tactical Remote Sensor Equipment
- 19 - Intelligence/Surveillance Equipment
- 20 - Generators
- 21 - Environmental Control Equipment
- 23 - Earthmoving Equipment
- 26 - Materials Handling Equipment
- 29 - Engineer Support
- 30 - Trucks
- 35 - Towed Motor Transport Equipment
- 40 - Tanks
- 41 - Assault Amphibious Vehicles
- 42 - Light Armored Vehicles
- 43 - Artillery
- 45 - Infantry Weapons
- 48 - Anti-Air/Armor Weapon Systems and
- 49 - Missile Systems
- 50 - High Density/Low Deadline
- 97 - Communications Security Equipment
- 98 - Assault Crafts
- 99 - Nuclear Biological Chemical Equip

View Deadlined Items for this TAMCN
Generate Control Chart for this TAMCN
Generate Historical View for this TAMCN
Show Tabular data for this TAMCN

Track this TAMCN
Zoom In on this group
Zoom Out to view all
Close Menu

B2460
Tractor, Full-Track, W/AngleBlade, T-5

	Last Week	This Month	This Quarter	This Year
MR:	101%	101%	100%	94%
S:	111%	113%	112%	110%
R:	91%	89%	89%	86%

Click mouse for reports and options.

Currently displaying: 186 of 186 items

Search by: TAMCN # | Search by: TAMCN Title

FILTER BY SEARCH CRITERIA
TAMCNs meeting search criteria will be shown.

EXCESS FILTER & LABEL
Isolate items without equipment

FILTER BY PACING ITEM
Pacing items will be shown.

Filter by MyMERIT Portfolio | Label by MyMERIT Portfolio

COMING SOON Feature Coming Soon



Treemap: WHC Emergency Room

(6304 patients in Jan2006)



Group by Admissions/MF, size by service time, color by age

Treemap: WHC Emergency Room

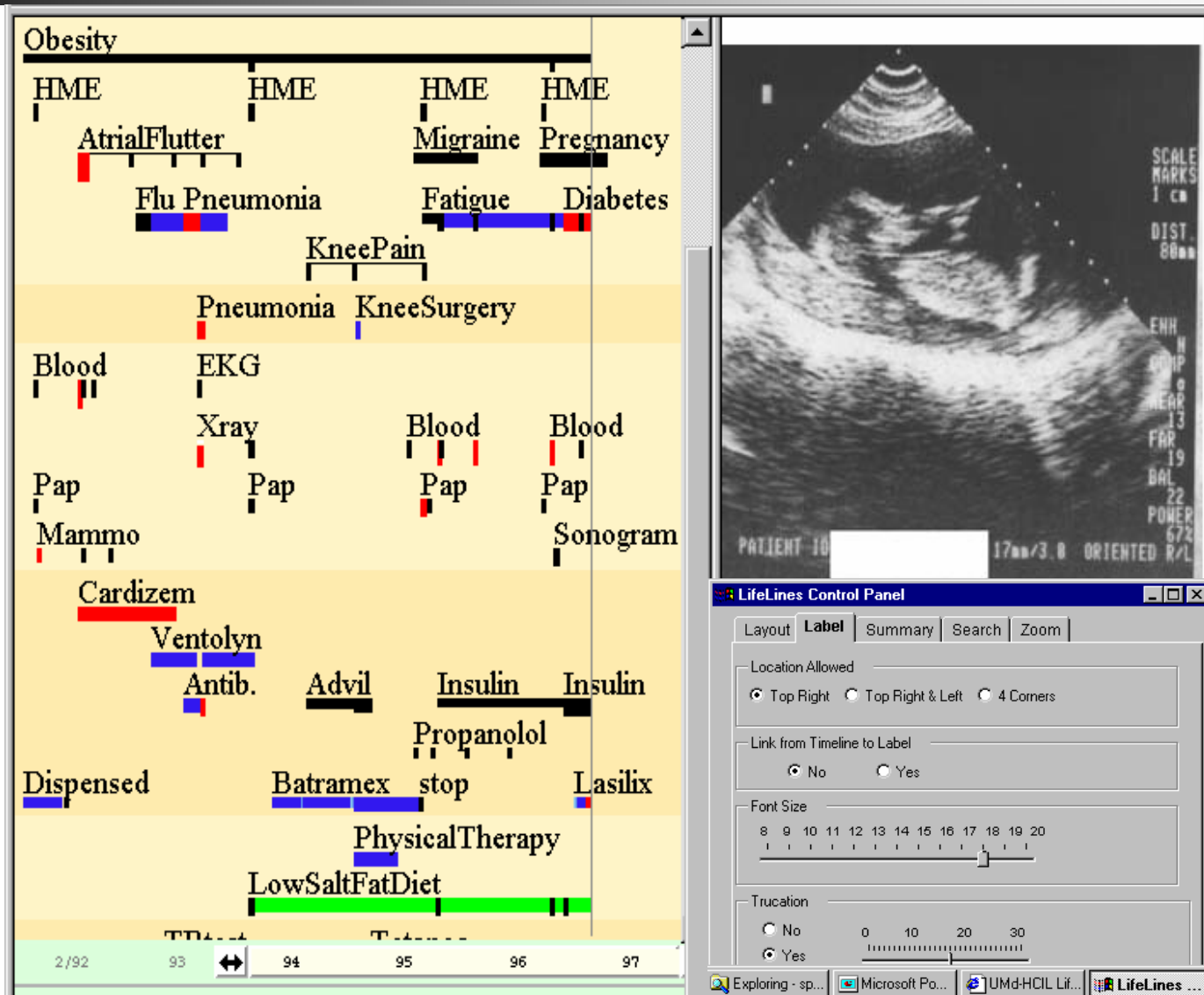
(6304 patients in Jan2006) (only those service time >12 hours)



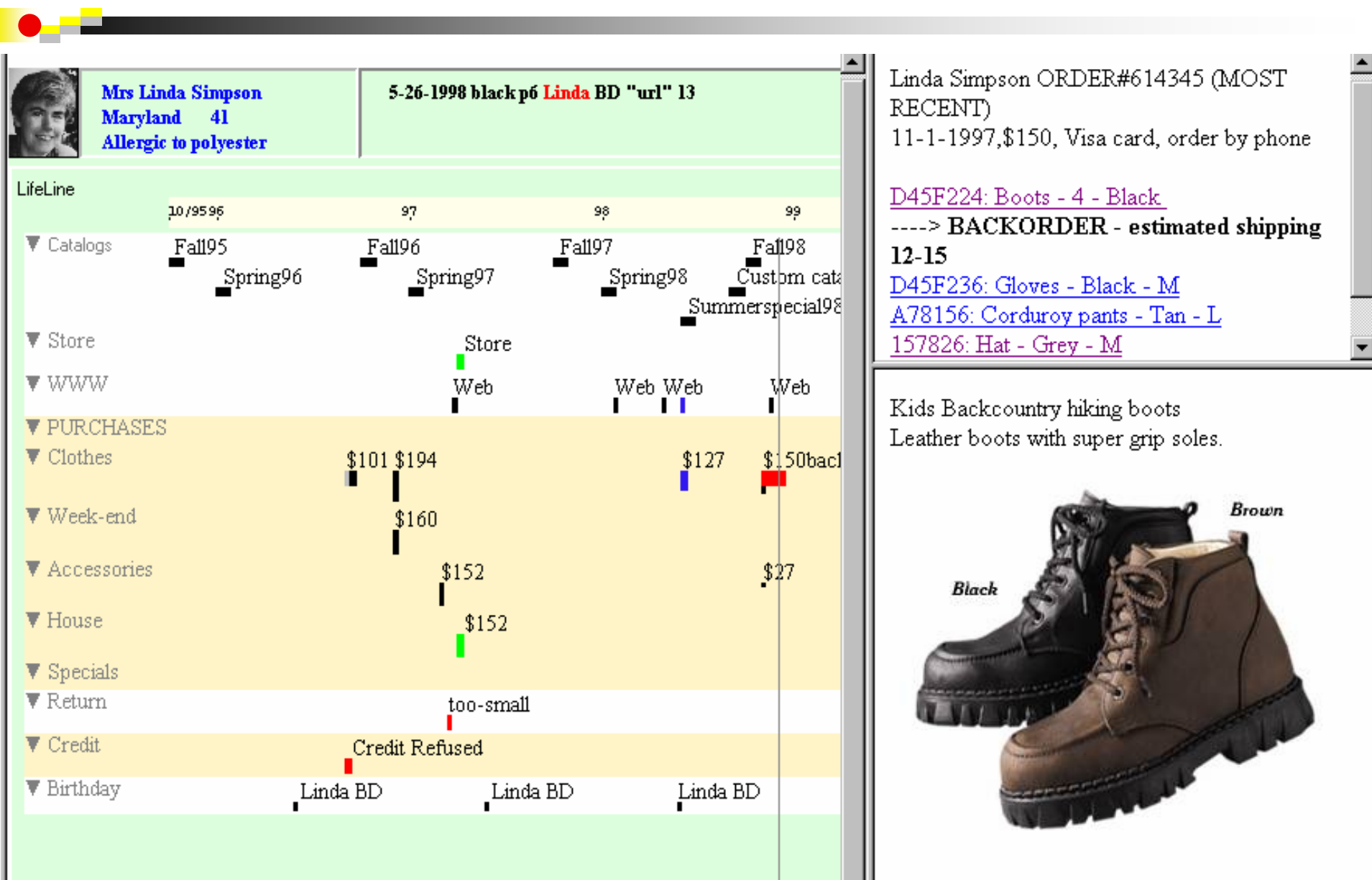
Group by Admissions/MF, size by service time, color by age



LifeLines: Patient Histories

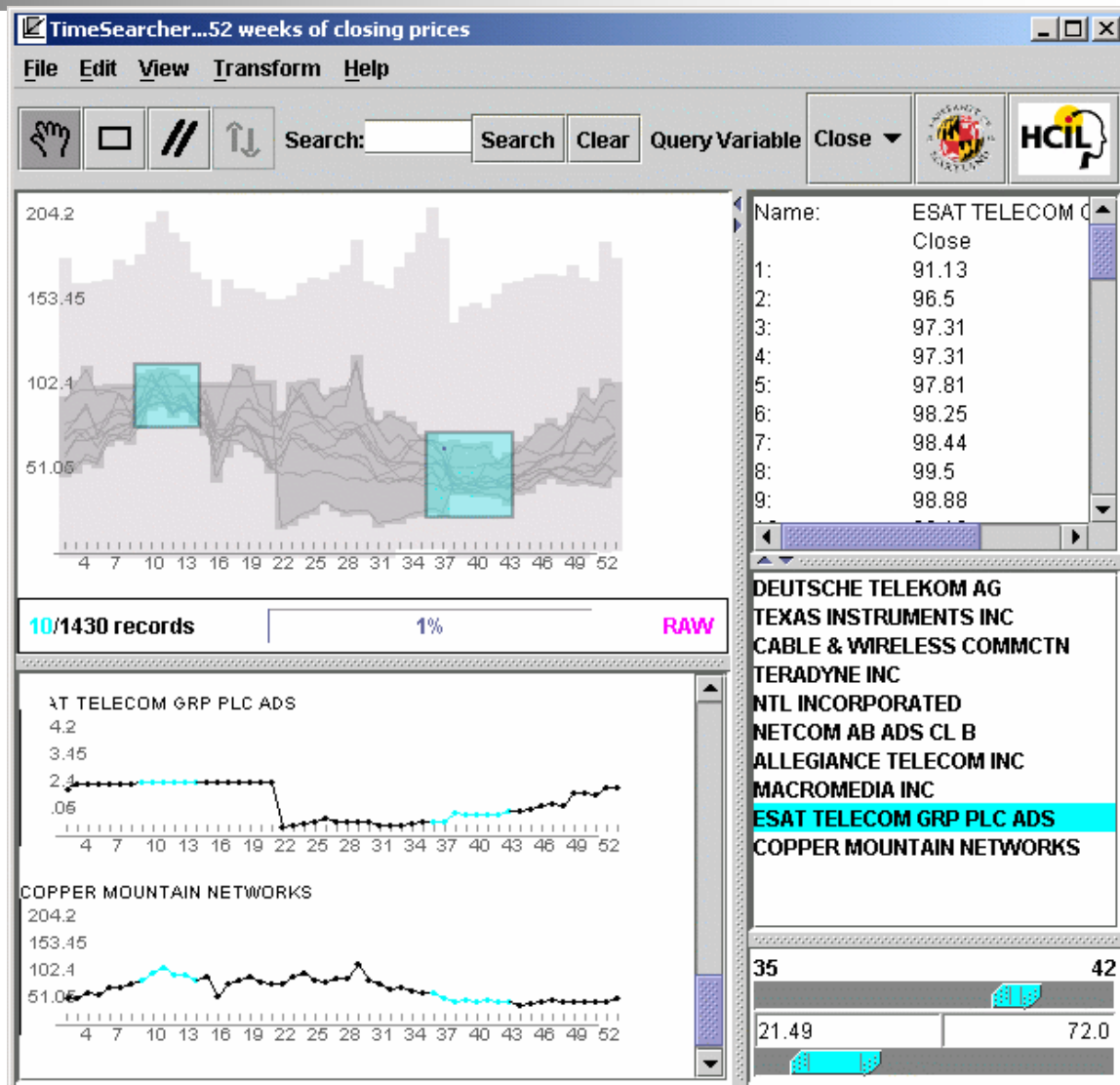


LifeLines: Customer Histories



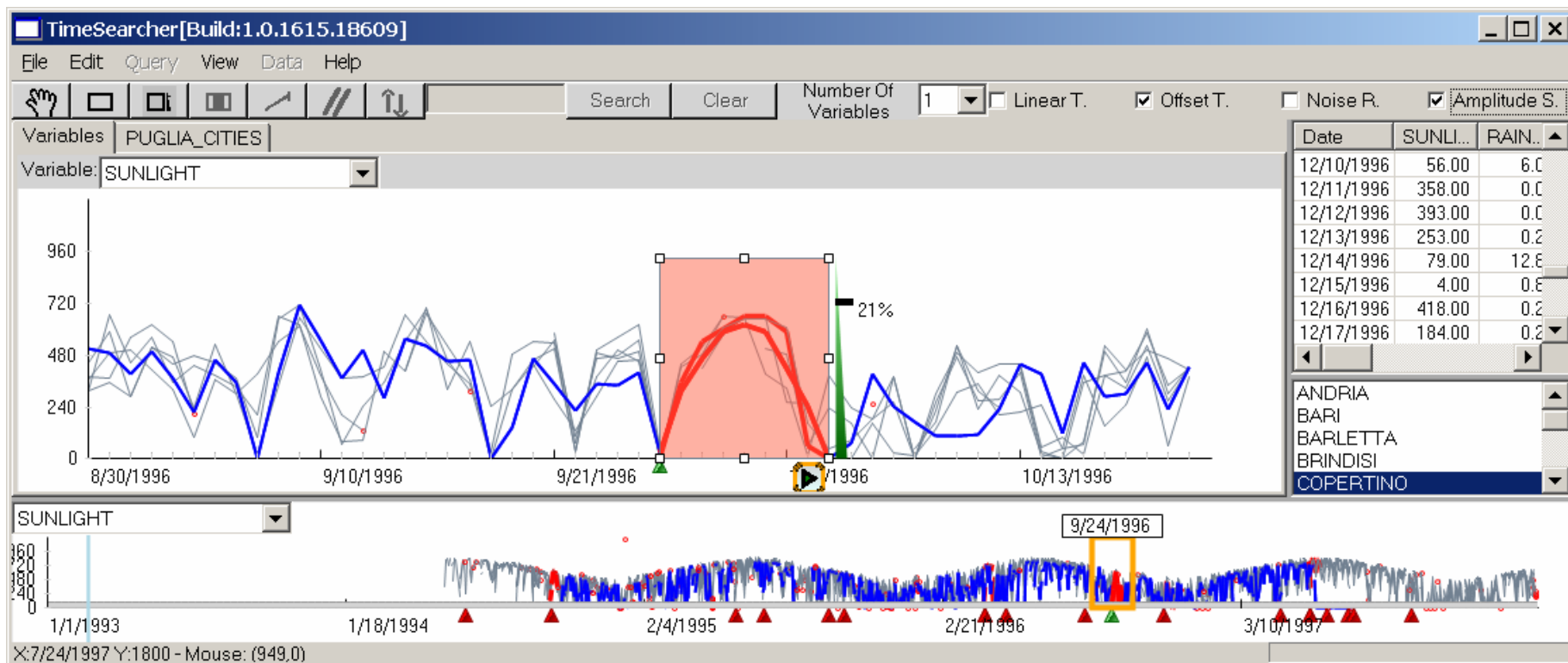
Temporal Data: TimeSearcher 1.3

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



Temporal Data (Real): TimeSearcher 2.0

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



Temporal Data (Categorical): PatternFinder

Patternfinder 2.0

File Data

Person/People

Name:

Age:

Gender: ☒ Female ☒ Male

People Selected: 4 of 552

Event Box 1

Type: ☐ ☒

Level 1: Test

Level 2: Blood Work

Level 3: WBC

Value:

☒ Span

Minutes
Hours
Days
Weeks

☒ Delete

Event Box 2

Type: ☐ ☒

Level 1: Test

Level 2: Blood Work

Level 3: WBC

Value:

☒ Delete

Add Constraint

05-Sep-2005 Min Date Span of 36 days Max Date 11-Oct-2005

Current Query: (05-Sep-2005,05-Sep-2005)
Test.Blood Work.WBC NumericalQueryControls.Range[10,93] (simple)
TimeSpan Days [2,14]

Run Query

Visualization Table 6 matches found

Busk, Rosie Dickinson, Marilyn Napier, Pamela	
Tue, Doreen	

Span: 2 days
Starting Event: 03-Oct-2005 - Test.Blood Work.WBC -> 12.35
Ending Event: 05-Oct-2005 - Test.Blood Work.WBC -> 15.80

☒ Show All Events 05-Sep-2005 11-Oct-2005

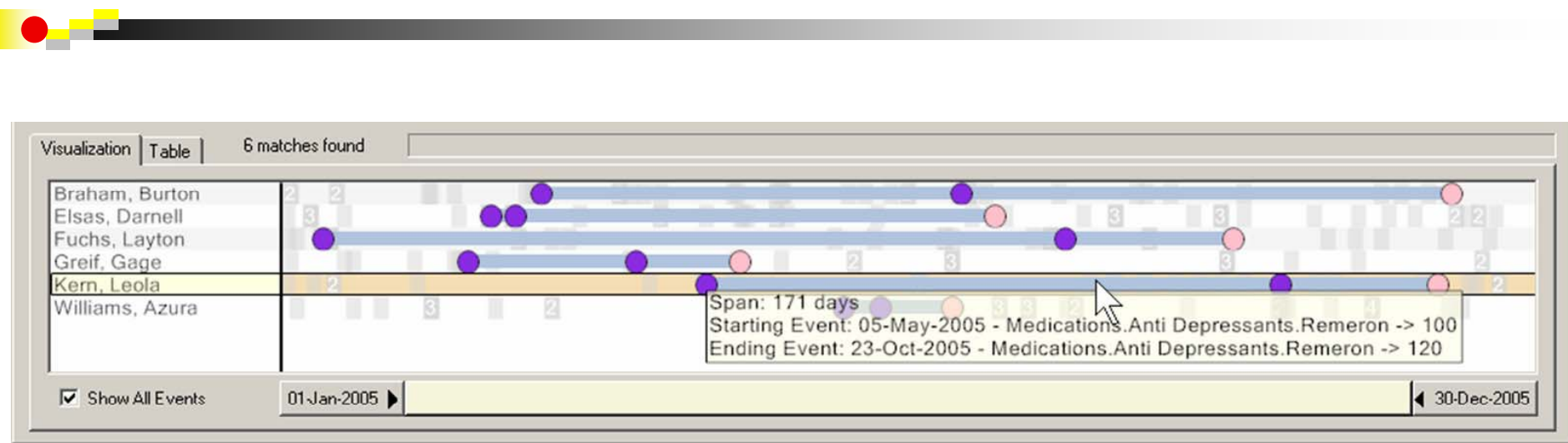
PatternFinder Interface

The screenshot displays the TempViz PatternFinder interface, which is used for defining temporal queries. The interface is divided into several sections:

- Person/People:** Contains filters for Name (a dropdown menu), Age (a range from 4 to 78), and Gender (checkboxes for Female and Male, both checked). It also shows "People Selected: 6 of 950".
- Event Box 1:** Contains a Type section with Level 1 set to "Medications", Level 2 to "Anti Depressan", and Level 3 to "Remeron". The Value section shows a range from 4 to 126. A "Delete" button is present. The # Events section shows a range from 2 to 20. The # Days section shows a range from 0 to 363. The "Use Relative Values" checkbox is checked, with a range from -122 to 122.
- Event Box 2:** Contains a Type section with Level 1 set to "Visit", Level 2 to "Hospital", and Level 3 to "Emergency". The Value section shows a range from 0 to 180. A "Delete" button is present. The # Events section shows a range from 0 to 20. The # Days section shows a range from 0 to 363. The "Use Relative Values" checkbox is checked, with a range from -122 to 122.
- Span:** A checkbox labeled "Span" is checked. A dropdown menu shows "Minutes", "Hours", "Days" (selected), and "Weeks".
- Min Date:** 01-Jan-2005
- Max Date:** 30-Dec-2005
- Span of:** 363 days
- Run Query:** A button at the bottom right.

Patients with increasing dosages of Remeron followed by a heart attack within 180 days

Result set visualization: ball & chain



Five matches!

Patients with increasing dosages of Remeron followed by a heart attack within 180 days

Current work

Washington Hospital Center & Partners HealthCare

- Developing taxonomy of simple queries based on interviews with physicians
- Designing interface to fit in Azyxxi
- Implementing simple searches:
 - Lab value [HGB] increases by 50% in 10 days
 - Lab value [Platelets] is high in a patient on heparin, then decreases > 20%
 - Patient seen at ER & discharged, then returns to ER within 14 days
 - Patient seen at ER & discharged, then returns to ER within 14 days & condition = [dead]

Patient History Search: WHC- PatternFinder

Pattern Search

Available Fields

- MRN
- Age
- Sex
- Lab_ObservationDtTm
- AbnormalFlags
- Observation
- Value
- Units
- Dx
- Dsp

Filter 1

Add > Observation EQUAL TO HGB
 < Remove
 Value... >
 Date Time Lab_ObservationDtTm

Filter 2

Add > Observation EQUAL TO HGB
 Value INCREASE GREATER THAN (REL. %) .50
 < Remove
 Value... >
 Date Time Lab_ObservationDtTm
 Temporal... > Lab_ObservationDtTm WITHIN (REL) 10 DAYS

Filter 3

Add > Observation EQUAL TO HGB
 Value DECREASE GREATER THAN (REL. %) .30
 < Remove
 Value... >
 Date Time Lab_ObservationDtTm
 Temporal... > Lab_ObservationDtTm WITHIN (REL) 10 DAYS

Quit Set Identity View SQL Reset Search

MRN	Age	Sex	Lab_ObservationDtTm	AbnormalFlags	Observation	Value	L
3528155	57	M	2/22/2007 5:35 PM	C	HGB	5.2	G
3528155	57	M	2/23/2007 9:24 AM	L	HGB	9.1	G
3528155	57	M	2/24/2007 5:14 PM	C	HGB	5.2	G
9319394	51	F	2/19/2007 12:53 PM	L	HGB	6.8	G
9319394	51	F	2/19/2007 11:25 PM	L	HGB	10.5	G
9319394	51	F	2/27/2007 2:47 AM	L	HGB	7	G
9319394	51	F	2/20/2007 6:57 AM	L	HGB	10.7	G
9319394	51	F	2/19/2007 11:31 AM	L	HGB	6.4	G
10455134	70	F	12/20/2006 10:49 AM	C	HGB	4.2	G
10455134	70	F	12/21/2006 8:47 PM	I	HGB	8.9	G

MRN = 9319394

MRN = 10455134

MRN: 10455134
 Age: 70
 Sex: F
 Lab_ObservationDtTm: 12/20/2006 10:49:00 AM
 AbnormalFlags: C
 Observation: HGB
 Value: 4.2
 Units: Gm/dl
 Dx: Septicemia Nos
 Dsp: A
 Filter: 1

MRN = 19431942

MRN = 21153722

☒ Show Identifier
☒ Show LifeLines View
☒ Show Ball-and-Chain View

Search Engine Optimization



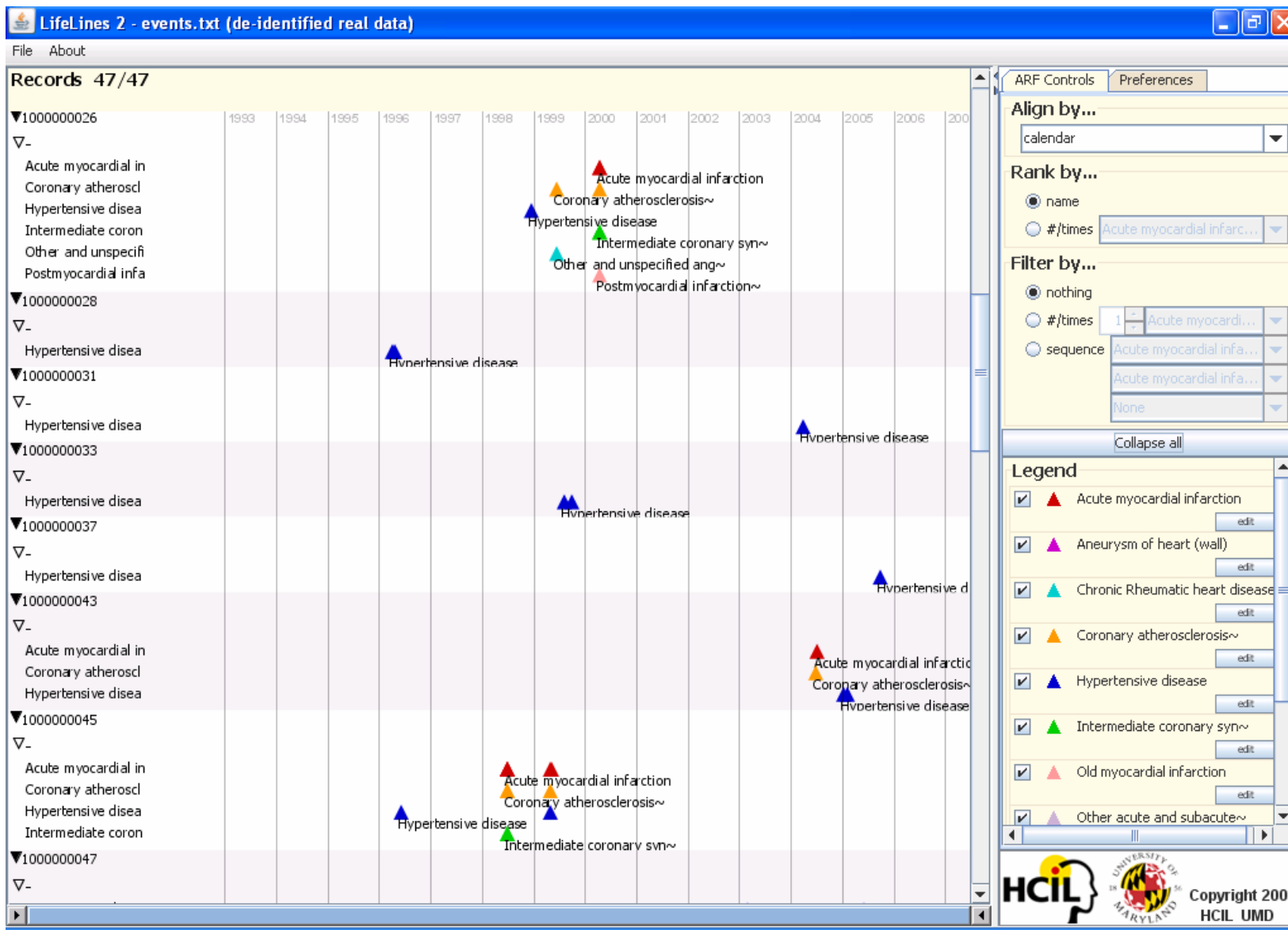
Multiple self-joins are poorly handled in SQL Server
Very slow execution times

→ Add hand-written code in .NET to produce
dramatic speed up in execution

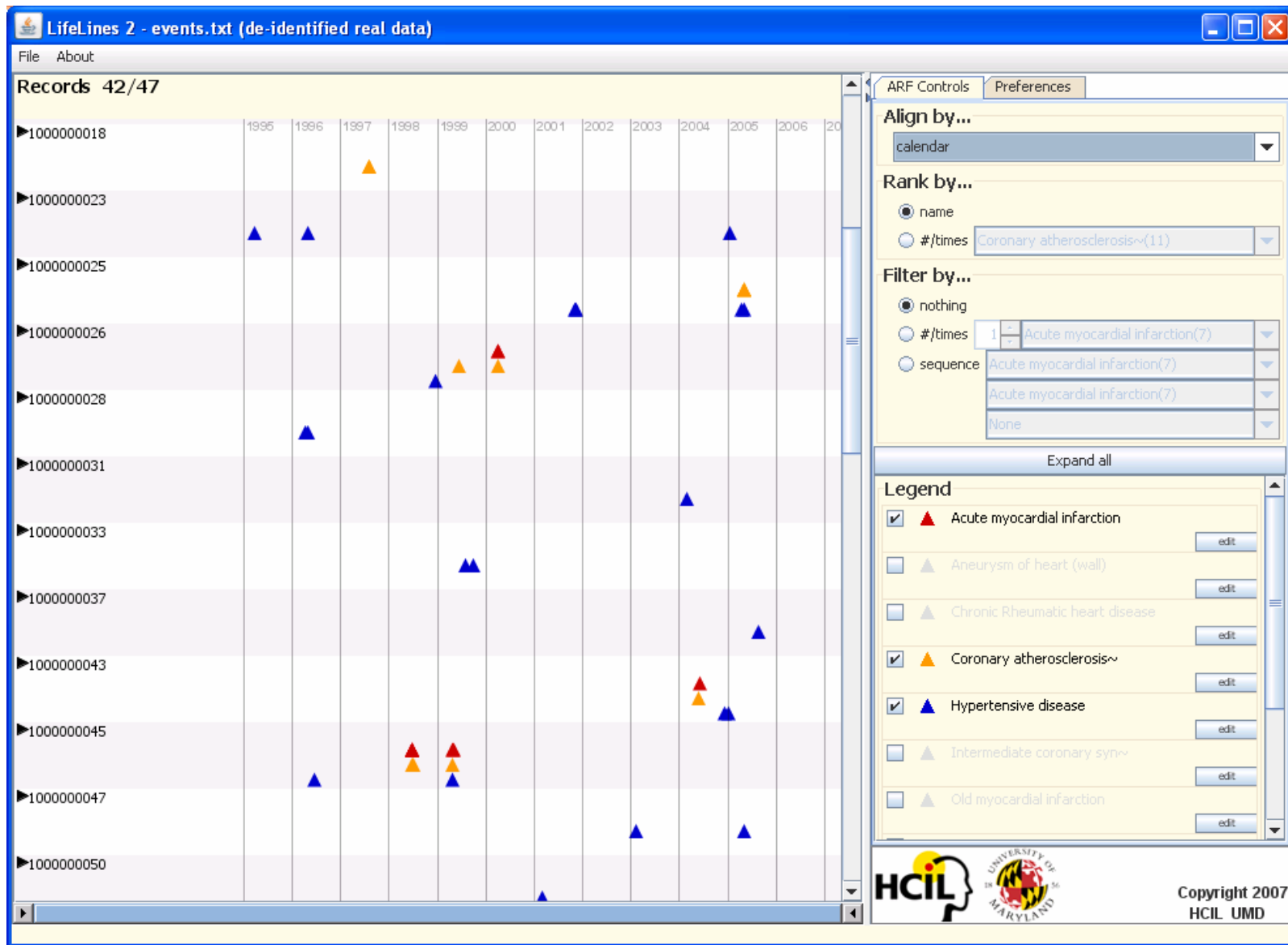
LifeLines2: Align-Rank-Filter

- Multiple records simultaneously visible
- Align by sentinel events
- Rank by frequency
- Filter by events

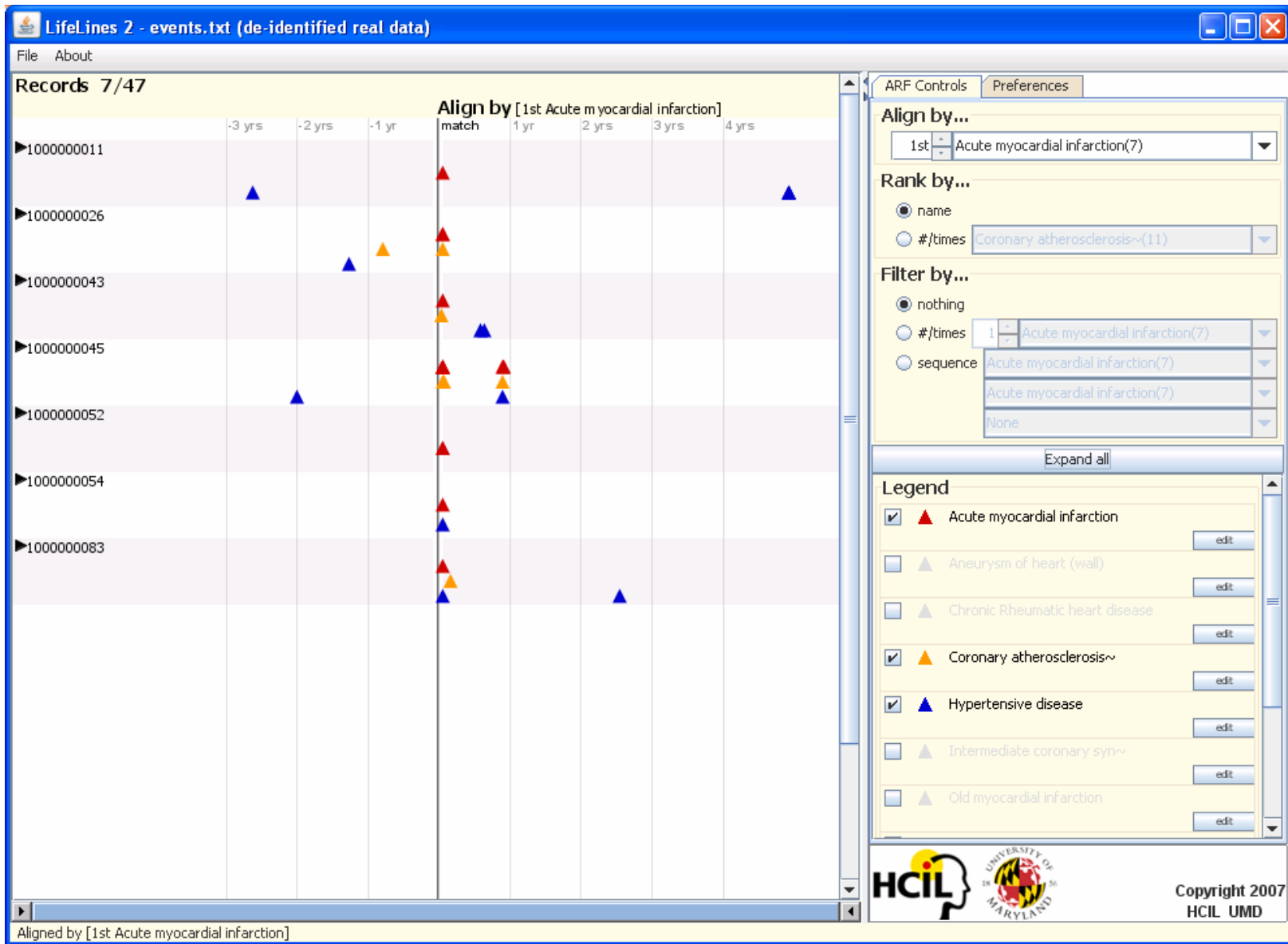
LifeLines2: Align-Rank-Filter



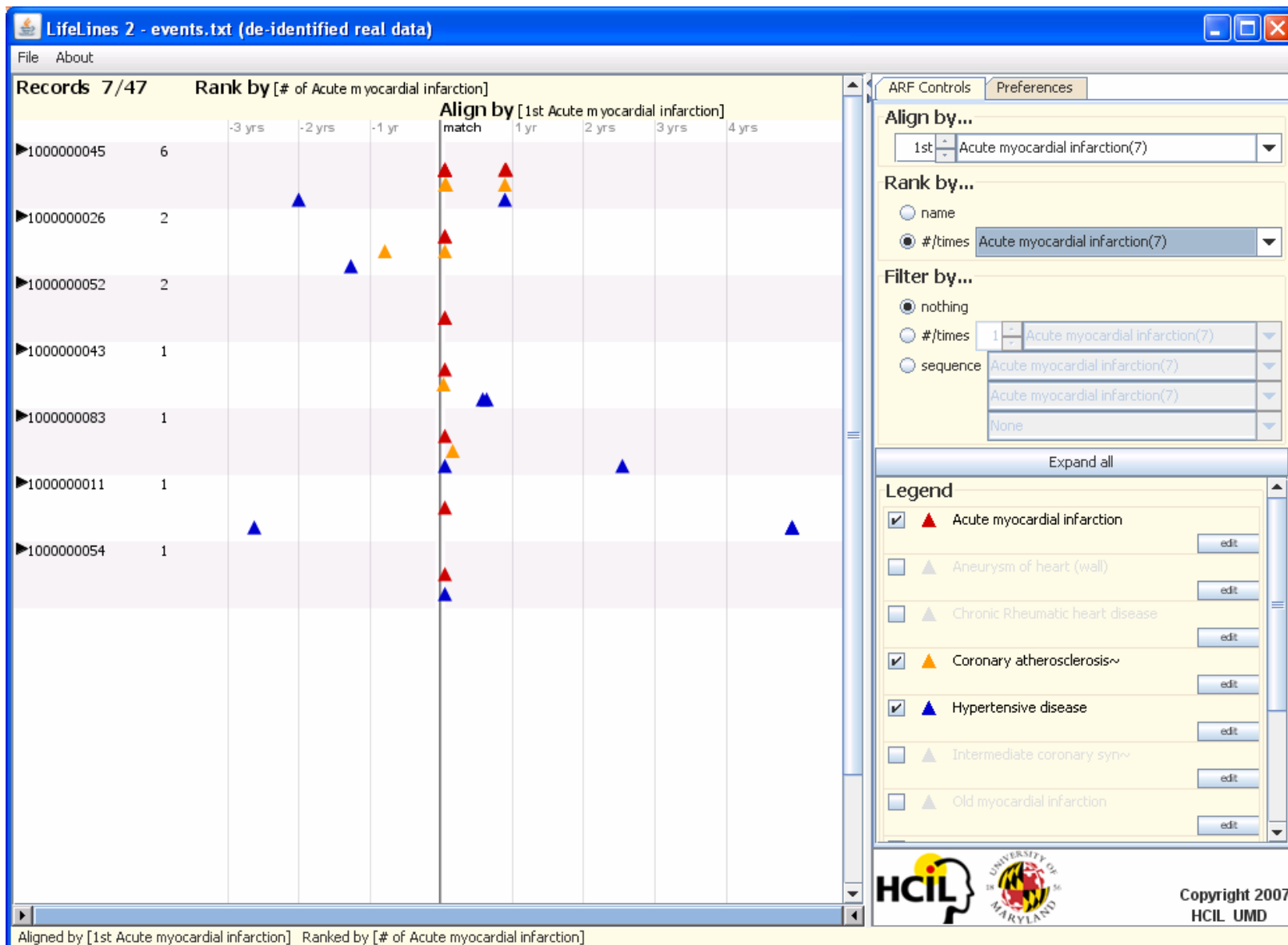
LifeLines2: Align-Rank-Filter



LifeLines2: Align-Rank-Filter



LifeLines2: Align-Rank-Filter



Goal: Empowering Knowledgeable Users

- Interactive visualizations to enable
 - Influential discoveries
 - Bold decisions
- Users can detect
 - Patterns
 - Clusters
 - Relationships
 - Gaps
 - Outliers
 - Anomalies
- Even in the presence of
 - Missing, uncertain, deceptive data

Current Tools for Exploratory Search



- Information abundant displays
- Multiple coordinated windows
- Dynamic queries for filtering
 - Rapid incremental and reversible actions
- Easy data import/export
- Powerful annotation and collaboration
- History-keeping for reversibility & repetition

Next Generation Advances

Support systematic exploration

1) Incorporate

- Statistical tools
- Data mining methods

2) Accommodate diverse data types

3) Integrate into organizational workflow

- Social creativity harnesses diverse skills
- Organizational learning promotes quality

Health & Wellness Technologies

- More people are familiar with technologies
 - Low cost makes them widely available
 - Social shift to take great personal responsibility for personal health care, fitness & wellness
- Personal medical devices & medical records

However:

- Lack of interface commonality inhibits growth
- Lack of file standardization prevents collaboration

Surveys: www.cs.umd.edu/hcil/iHealth/

Class Projects: www.cs.umd.edu/class/spring2004/cmsc434/



Improve & Standardize Home Medical Devices

Monitors

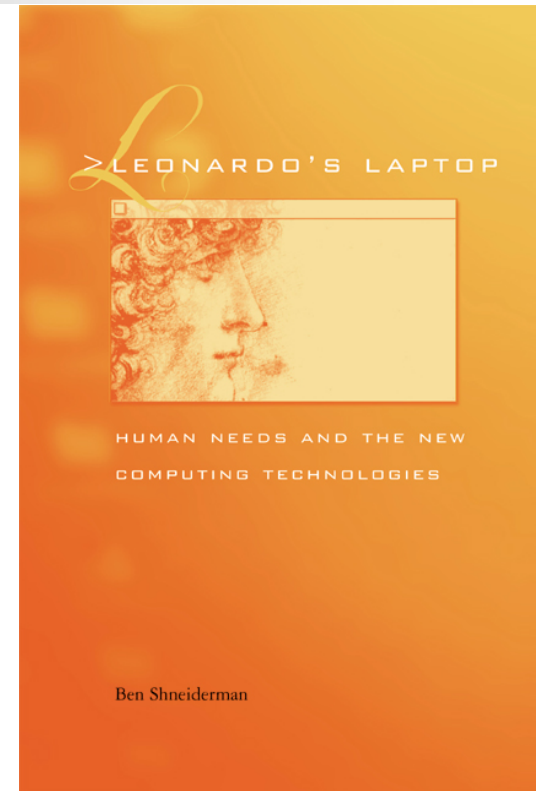
- Glucose
- Bathroom scale
- Thermometer
- Blood pressure
- Breath
- Fat

Issues

- Ease of use
- Accuracy
- Interpretation
- Logging
- Annotation
- Save/Send
- Visualize

Leonardo's Laptop

- **E-learning:** The new education
- **E-business:** The new commerce
- **E-healthcare:** The new medicine
- **E-government:** The new politics
- Mega-creativity
- Grander Goals & The Next Leonardo





25th Annual Symposium

May 29-30, 2008

www.cs.umd.edu/hcil



For More Information

- Visit the HCIL website for 350 papers & info on videos
www.cs.umd.edu/hcil
- Conferences & resources: www.infovis.org
- See Chapter 14 on Info Visualization
Shneiderman, B. and Plaisant, C., *Designing the User Interface: Strategies for Effective Human-Computer Interaction: Fourth Edition* (April 2004) www.awl.com/DTUI
- Edited Collections:
Card, S., Mackinlay, J., and Shneiderman, B. (1999)
Readings in Information Visualization: Using Vision to Think
Bederson, B. and Shneiderman, B. (2003)
The Craft of Information Visualization: Readings and Reflections

For More Information

- **Treemaps**
 - **HiveGroup:** www.hivegroup.com
 - **Smartmoney:** www.smartmoney.com/marketmap
 - **HCIL Treemap 4.0:** www.cs.umd.edu/hcil/treemap
- **Spotfire:** www.spotfire.com
- **TimeSearcher :** www.cs.umd.edu/hcil/treemap
- **Hierarchical Clustering Explorer:**
www.cs.umd.edu/hcil/hce