A Visual Interface for Multivariate Temporal Data: Finding Patterns of Events across Multiple Histories

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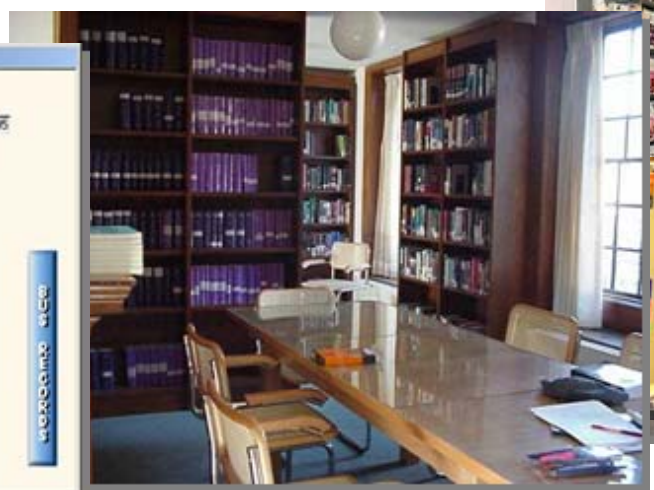
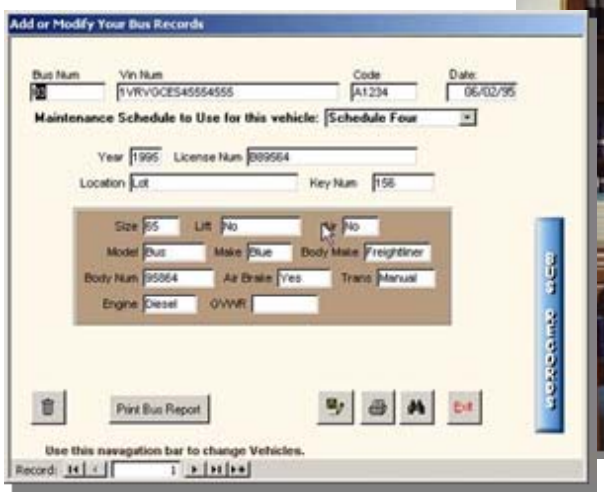
Time is Pervasive!

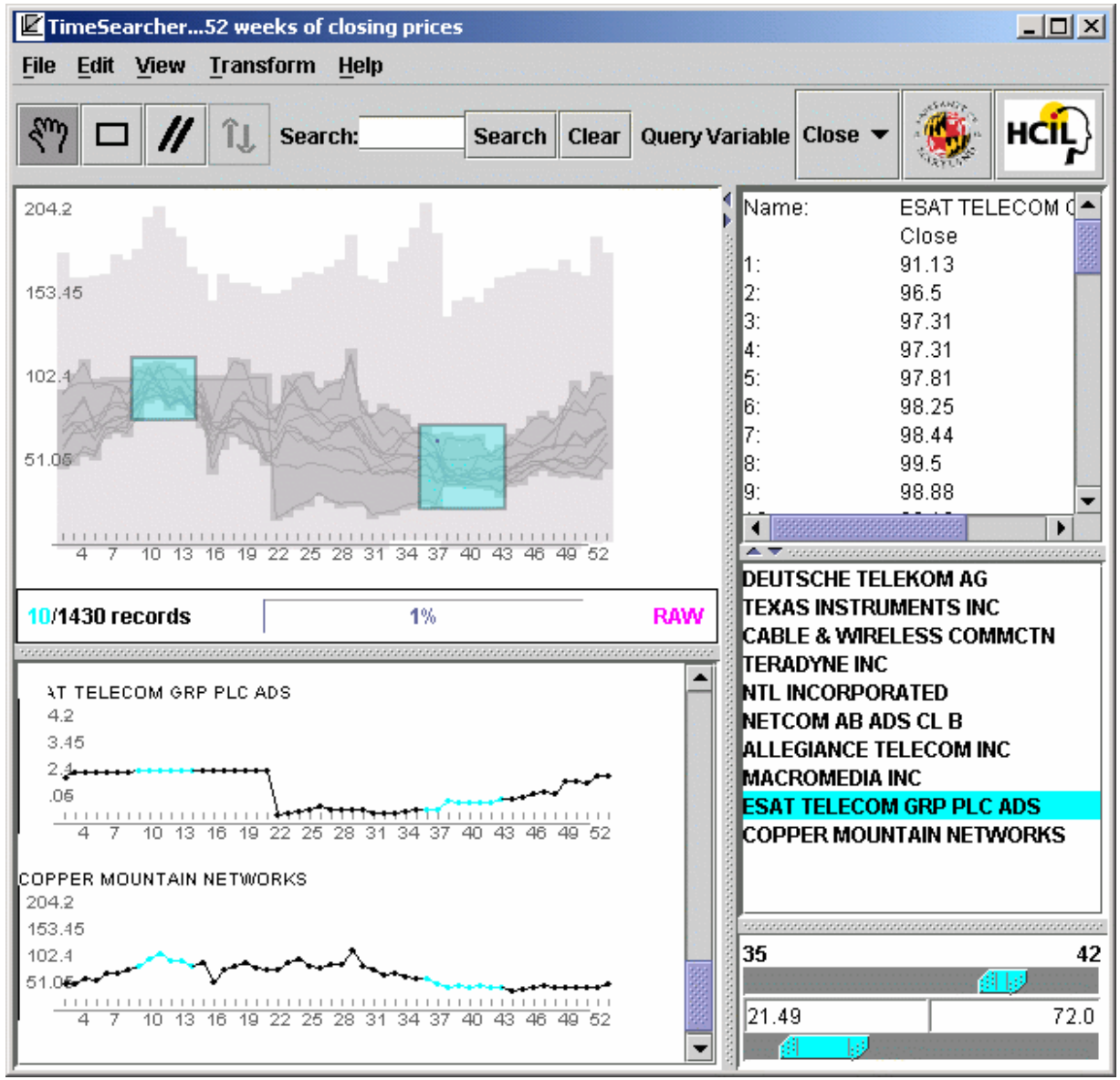
- Stock market trades
- Web log URLs
- Medical histories
- Crime/terror activities
- Maintenance records





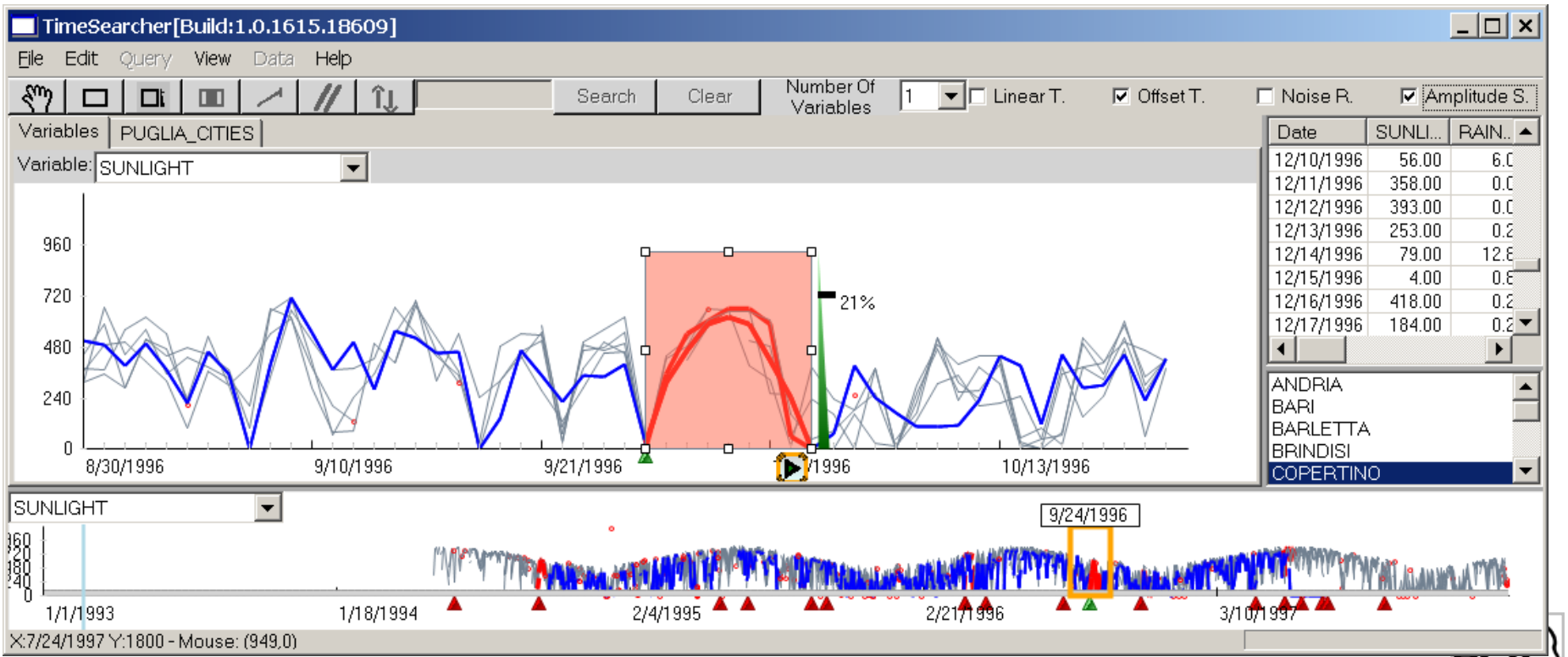
Temporal Data: TimeSearcher 1.3

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



Temporal Data: TimeSearcher 2.0

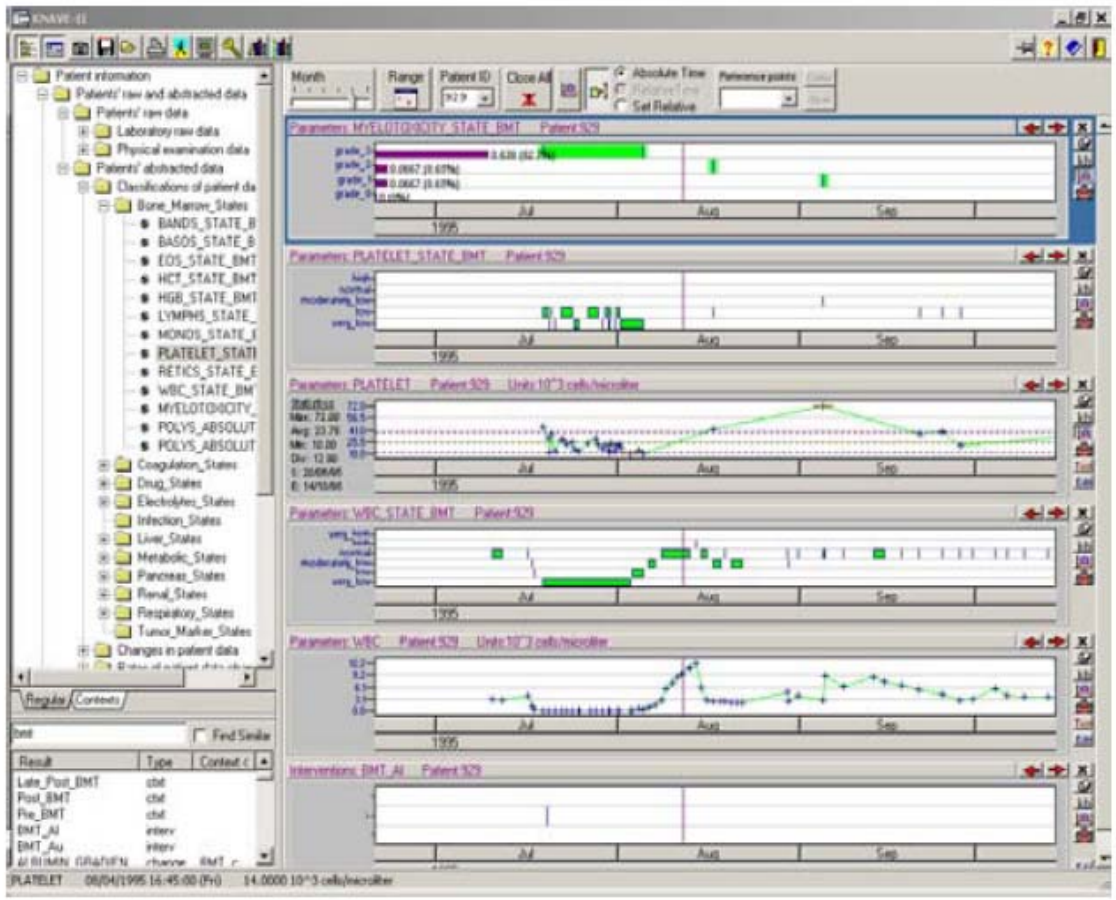
- Long Time series (>10,000 time points)
- Multiple variables
- Controlled precision in match
  (Linear, offset, noise, amplitude)



www.cs.umd.edu/hcil/timesearcher

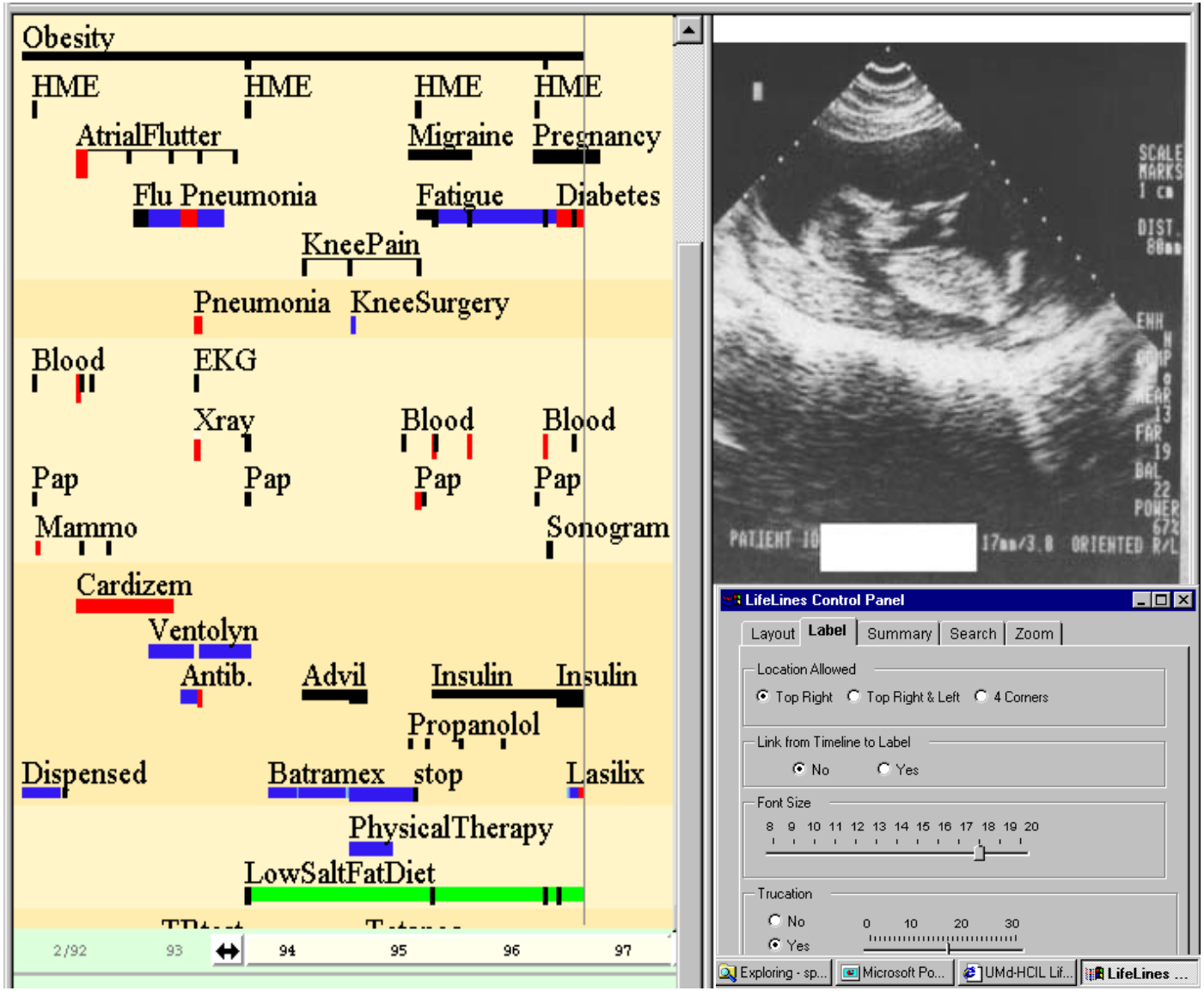
KNAVE: Clinical Patient Data

Distributed Knowledge-Based Abstraction, Visualization, and Exploration of Time-Oriented Clinical Data



(Shahar, 1998)

LifeLines: Visualizing Personal Histories



(Plaisant et al., CHI 1997)

Finding Patterns in Temporal Events

- Types of Time Data
  - Ordinal Values (e.g., TimeSearcher)
  - Categorical Events & Intervals (e.g., LifeLines)
  - Categorical Events

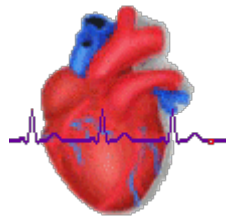
- Goal: Find Temporal Patterns
  Across Millions of Records
  - SQL makes it very difficult to specify
  - Temporal SQL helps only a little

Comparison with SQL

```
SELECT P.*
FROM Person P, Event E1, Event E2, Event E3, Event E4

WHERE P.PID = E1.PID
  AND P.PID = E2.PID
  AND P.PID = E3.PID
  AND P.PID = E4.PID
  AND E1.type = “Medication”
  AND E1.class = “Anti Depressant”
  AND E1.name = “Remeron"
  AND E2.type = “Medication”
  AND E2.class = “Anti Depressant”
  AND E2.name = “Remeron"
  AND E3.type = “Medication”
  AND E3.class = “Anti Depressant”
  AND E3.name = “Remeron"
  AND E2.value > E1.value
  AND E3.value >= E2.value
  AND E2.date > E1.date
  AND E3.date >= E2.date
  AND E4.type = “Visit”
  AND E4.class = “Hospital”
  AND E4.name = “Emergency"
  AND E4.value = "Heart Attack"
  AND E4.date >= E3.date
  AND 180 <= (E4.date – E3.date)
```

Temporal Patterns in Medical Histories



- Reality
  - Very large & complex data sets
  - Missing, uncertain, and redundant data
- Tasks
  - Alerts concerning patient status
  - Decision support for treatment decisions
  - Clinical research on outcomes
  - Identify groups of patients for testing

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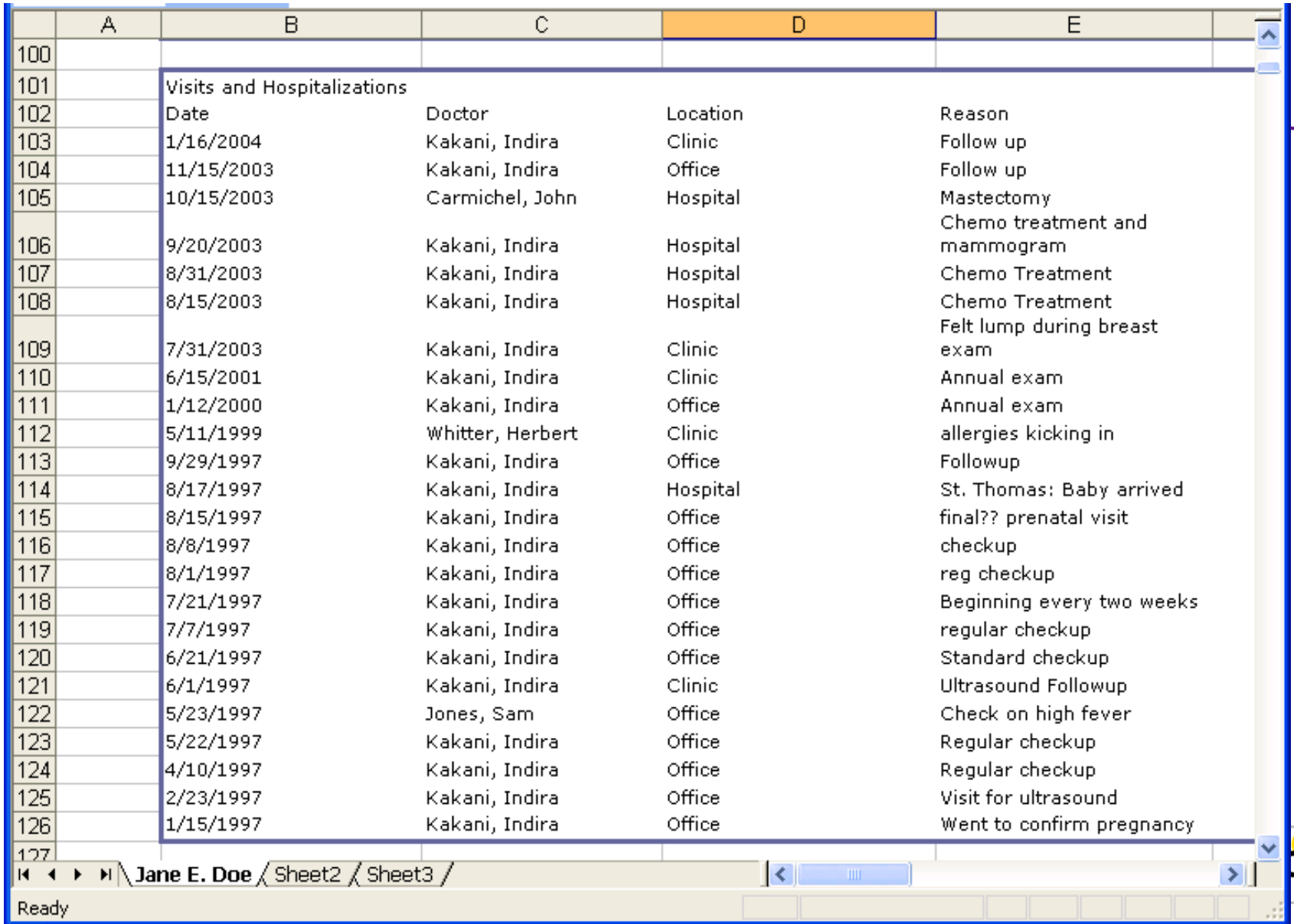
Temporal Patterns in Medical Histories



	A	B	C	D	E
100					
101		Visits and Hospitalizations			
102		Date	Doctor	Location	Reason
103		1/16/2004	Kakani, Indira	Clinic	Follow up
104		11/15/2003	Kakani, Indira	Office	Follow up
105		10/15/2003	Carmichel, John	Hospital	Mastectomy
106		9/20/2003	Kakani, Indira	Hospital	Chemo treatment and mammogram
107		8/31/2003	Kakani, Indira	Hospital	Chemo Treatment
108		8/15/2003	Kakani, Indira	Hospital	Chemo Treatment
109		7/31/2003	Kakani, Indira	Clinic	Felt lump during breast exam
110		6/15/2001	Kakani, Indira	Clinic	Annual exam
111		1/12/2000	Kakani, Indira	Office	Annual exam
112		5/11/1999	Whitter, Herbert	Clinic	allergies kicking in
113		9/29/1997	Kakani, Indira	Office	Followup
114		8/17/1997	Kakani, Indira	Hospital	St. Thomas: Baby arrived
115		8/15/1997	Kakani, Indira	Office	final?? prenatal visit
116		8/8/1997	Kakani, Indira	Office	checkup
117		8/1/1997	Kakani, Indira	Office	reg checkup
118		7/21/1997	Kakani, Indira	Office	Beginning every two weeks
119		7/7/1997	Kakani, Indira	Office	regular checkup
120		6/21/1997	Kakani, Indira	Office	Standard checkup
121		6/1/1997	Kakani, Indira	Clinic	Ultrasound Followup
122		5/23/1997	Jones, Sam	Office	Check on high fever
123		5/22/1997	Kakani, Indira	Office	Regular checkup
124		4/10/1997	Kakani, Indira	Office	Regular checkup
125		2/23/1997	Kakani, Indira	Office	Visit for ultrasound
126		1/15/1997	Kakani, Indira	Office	Went to confirm pregnancy
127					

Jane E. Doe | Sheet2 | Sheet3

Ready

Finding Patterns in Temporal Events

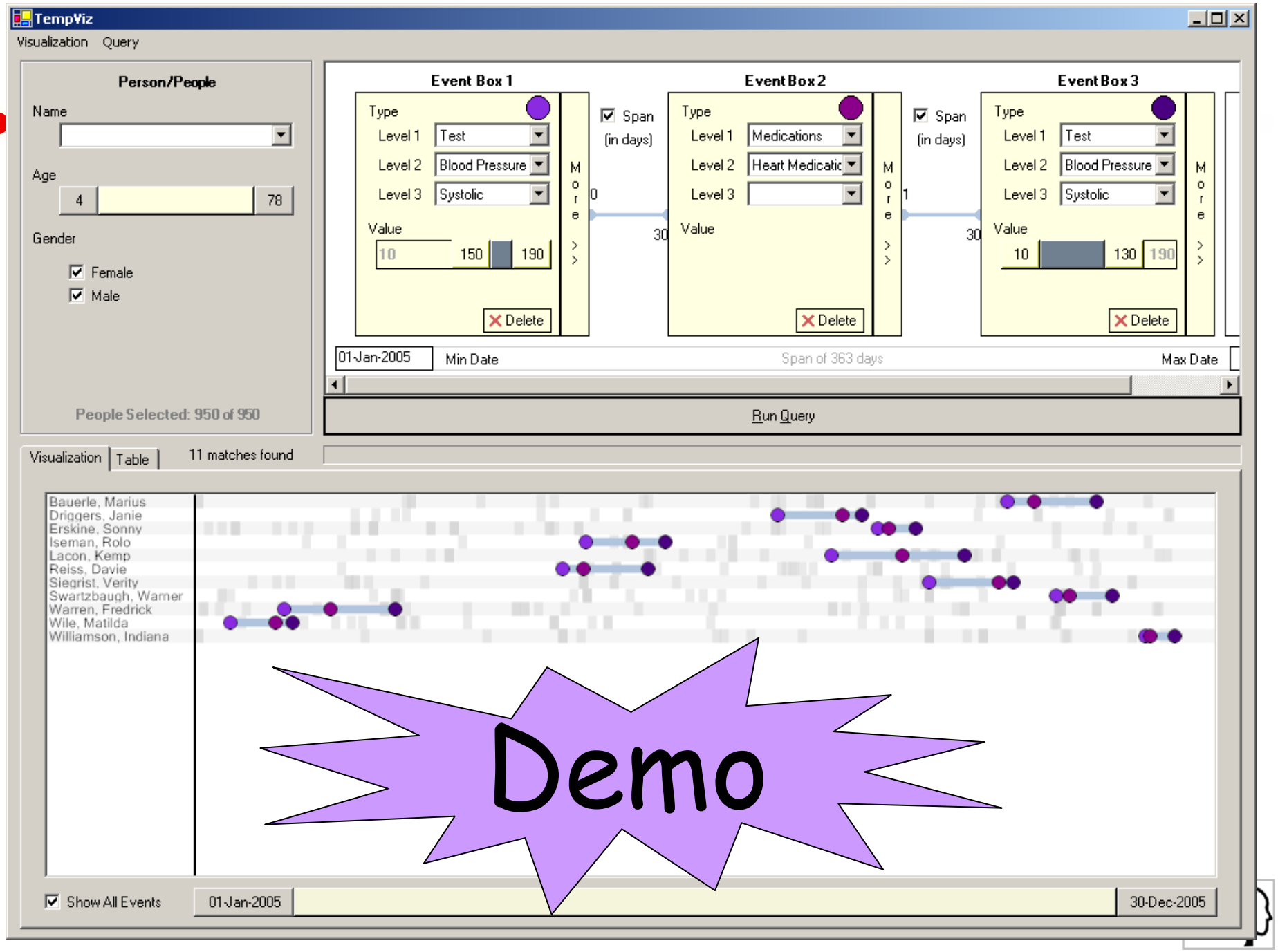
- Imagine simple table

P-ID	Age	Gender	Date	Source	Attribute	Value
174	73	M	5/6/2005	Test	WBC	12
183	67	F	5/7/2005	ER	Symptom	Chest Pain
183	67	F	5/8/2005	Test	WBC	23
174	73	M	5/12/2005	Medication	Tylenol	325mg
259	71	F	5/12/2005	Test	HDL	55
174	73	M	5/14/2005	Test	WBC	19

Finding Patterns in Temporal Events

- Imagine an even simpler table

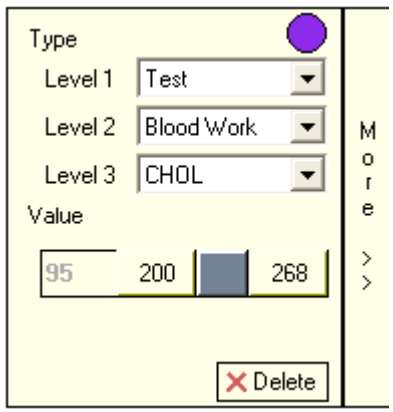
P-ID	Age	Gender	Date	Source	Attribute	Value
174	73	M	5/6/2005	Test	WBC	12
183	67	F	5/7/2005	Test	WBC	14
183	67	F	5/8/2005	Test	WBC	23
174	73	M	5/12/2005	Test	RBC	4
259	71	F	5/12/2005	Test	HDL	55
174	73	M	5/14/2005	Test	WBC	19


TempViz
Visualization
Query
Person/People
Name
Age
4
78
Gender
Female
Male
People Selected: 950 of 950
Event Box 1
Type
Level 1
Test
Level 2
Blood Pressure
Level 3
Systolic
Value
10
150
190
More >>
Delete
Span (in days)
0
30
Event Box 2
Type
Level 1
Medications
Level 2
Heart Medicatic
Level 3
Value
Delete
Span (in days)
1
30
Event Box 3
Type
Level 1
Test
Level 2
Blood Pressure
Level 3
Systolic
Value
10
130
190
Delete
01-Jan-2005
Min Date
Span of 363 days
Max Date
Run Query
Visualization
Table
11 matches found
Bauerle, Marius
Driggers, Janie
Erskine, Sonny
Iseman, Rolo
Lacon, Kemp
Reiss, Davie
Siegrist, Verity
Swartzbaugh, Warner
Warren, Fredrick
Wile, Matilda
Williamson, Indiana
Demo
Show All Events
01-Jan-2005
30-Dec-2005

Simple Search: Event (E)

- No TimeSpan

Find patients who had cholesterol test above 200

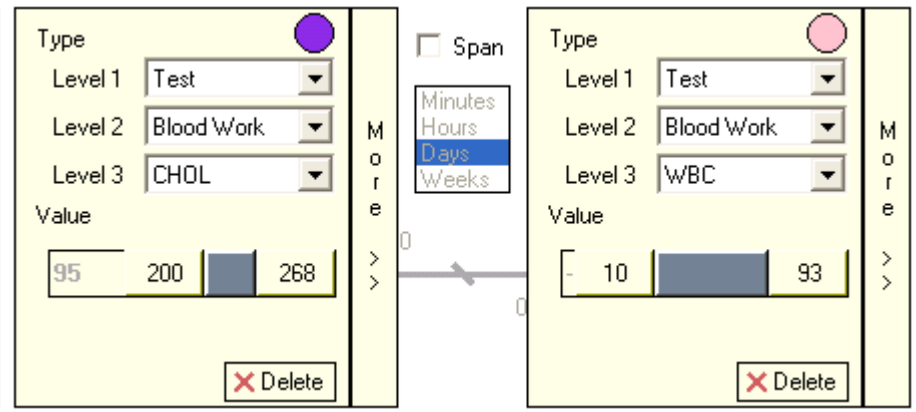


Simple Search: Two Events (E)

- No TimeSpan

Find patients who had cholesterol test above 200

And White Blood Cell above 10

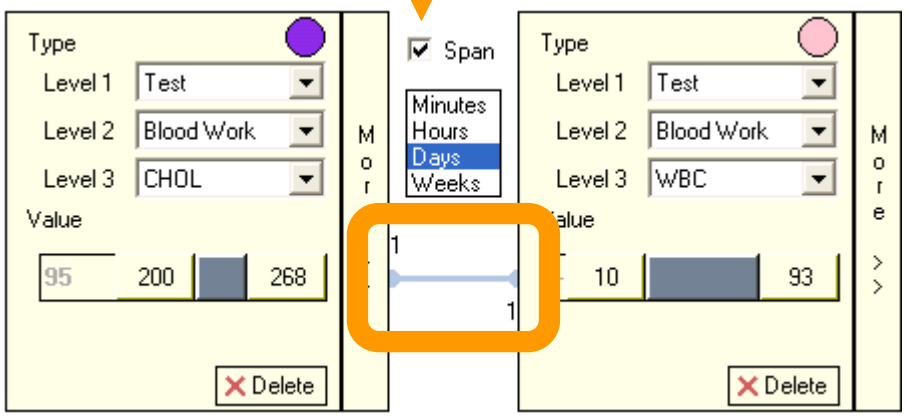


Events with Fixed Time (E-FT)

- Fixed TimeSpan length

Find patients who had cholesterol test above 200

And White Blood Cell above 10 exactly 1 day later

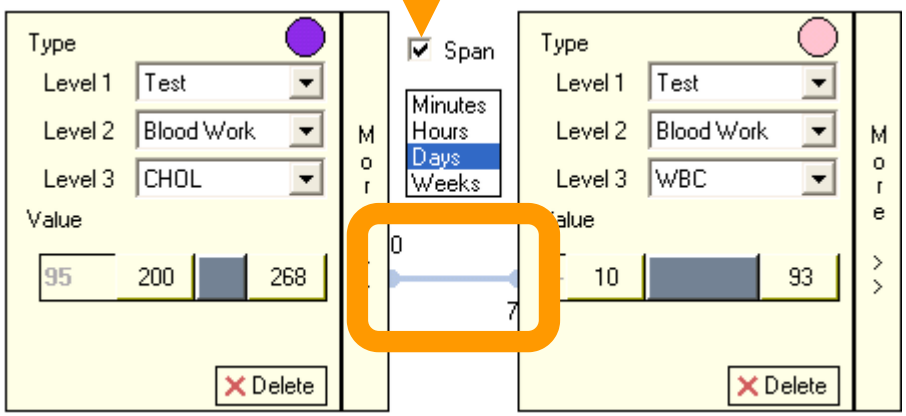


Events with Variable Time (E-VT)

- Variable TimeSpan length

Find patients who had cholesterol test above 200

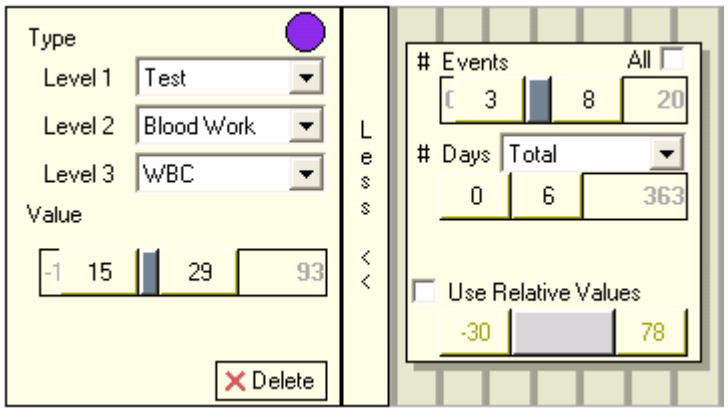
And White Blood Cell above 10 with 0 to 7 days later



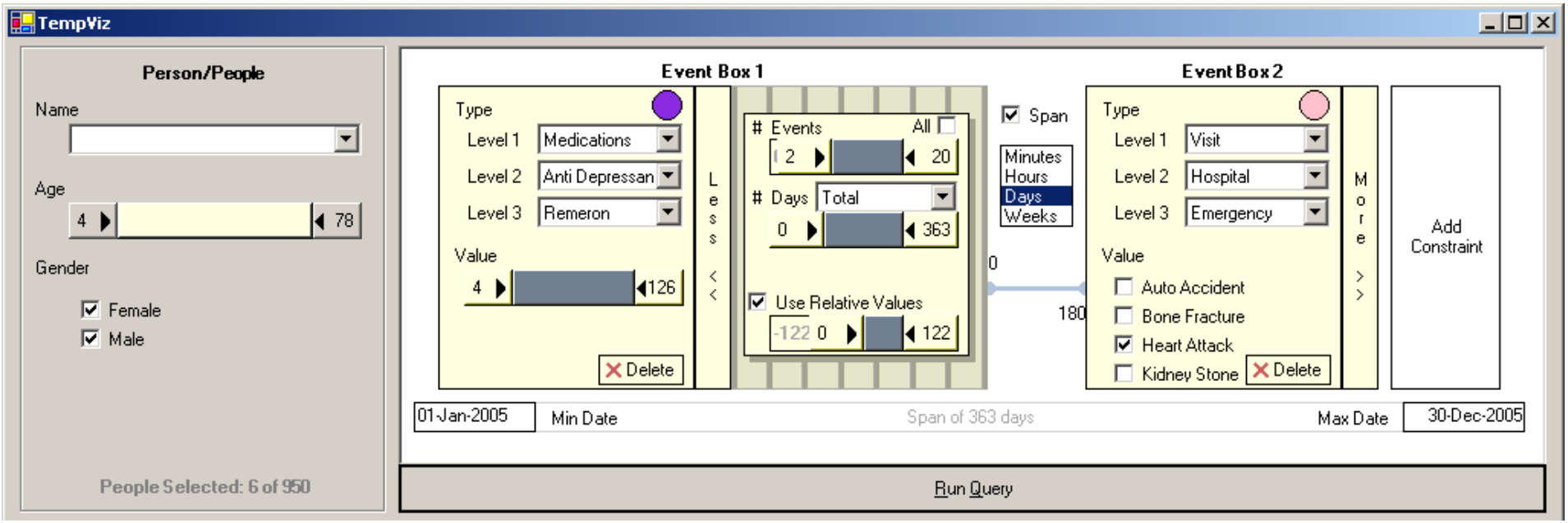
Trends with Event Sets E*WC

- Sets of Events behave as single Events
- Adds Window and Cardinality constraints

Find patients with 3-8 WBC tests at 15-29, during a 6 day period

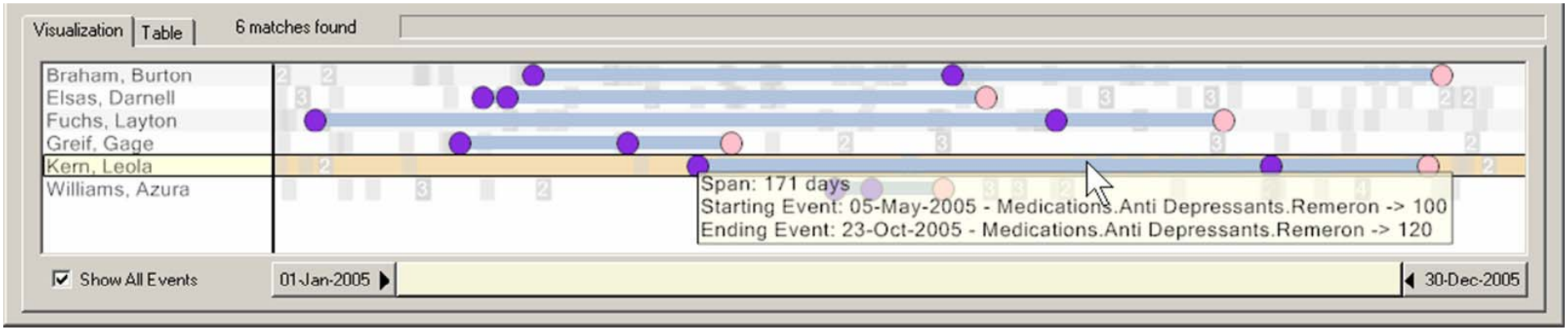


PatternFinder Interface



This pattern specificies any patient who received increasing dosages of Remeron followed by a heart attack within 180 days (along with the events constituting the temporal pattern match).

Result set visualization: ball & chain



The results show five matches of people who received increasing dosages of Remeron followed by a heart attack within 180 days.

Current work

Work with Washington Hospital Center
- Developing taxonomy of simple queries
- Designing interface to fit in Azyxxi
- Implementing simple searches

Lab value [HGB] is high, then decreases >1.5
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]

Diverse Applications

Maintenance log
  Replace battery, repair generator, repair starter,…

Web log analyis
  Browse books, Checkout, Help, Leave Website

Terror/criminal behavior
  Withdraw funds, buy weapon, purchase tickets…

TV viewing (in 30 min segments)
  NBC, ABC, ABC, ABC,CBS, CBS

Contributions: Queries for temporal events

- Taxonomy of queries
- Visual specification
- Visualization of results: ball & chain view

Contributions: Queries for temporal events

- Taxonomy of queries
- Visual specification
- Visualization of results: ball & chain view

- Reformulation of relational completeness
- Facilitate medical treatment & research

24th Annual Symposium
May 31-June 1, 2007

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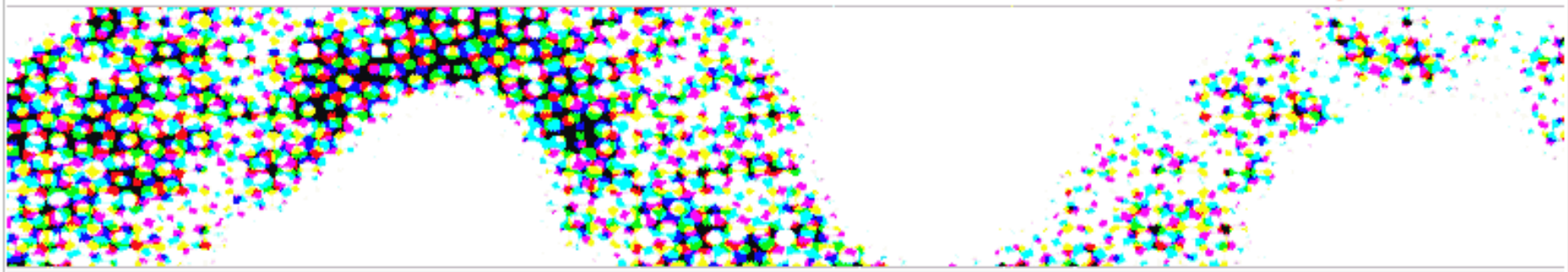
CC2007

6th Creativity & Cognition Conference

Seeding Creativity: Tools, Media, and Environments

June 13-15, 2007, Washington, DC USA



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practice. Rigorous research is
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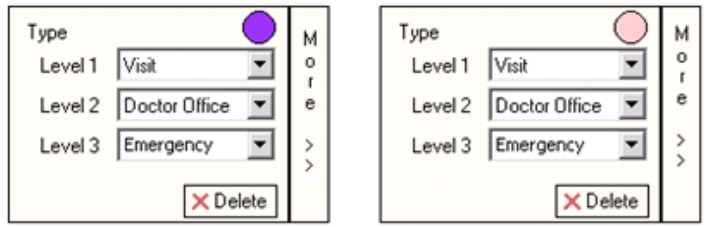
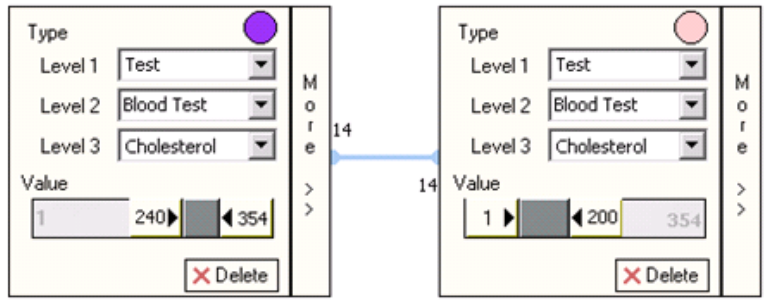
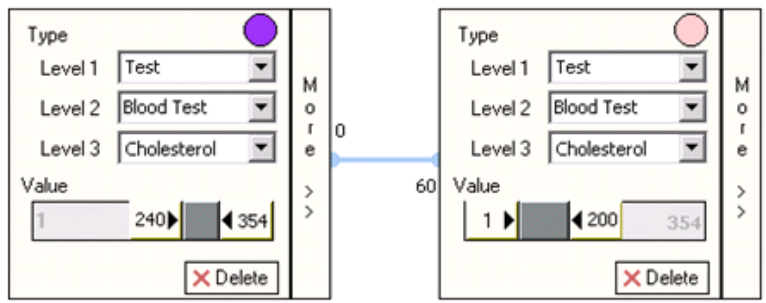
re two elegant evening receptions at
DC locations:
the National Academy of Sciences (June 13) and Corcoran Gallery of Art (June 14)

Important Dates

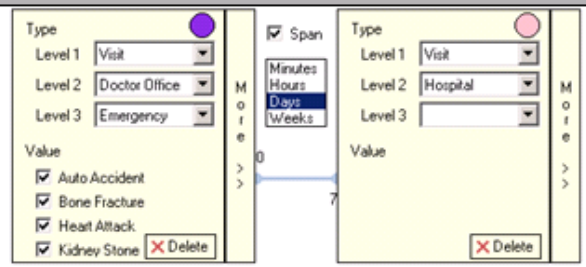
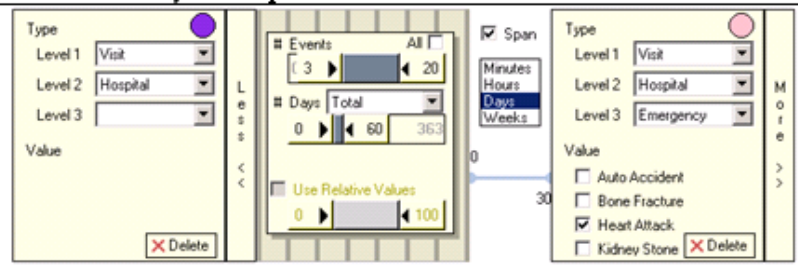
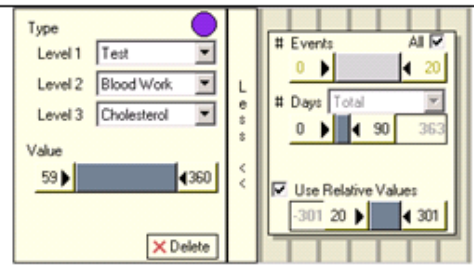
Papers Deadline:	December 15, 2006
Notification:	February 19, 2007
Revised papers:	March 19, 2007
Conference:	June 13-15, 2007

http://www.cs.umd.edu/hcil/CC2007/

Taxonomy Table (1 of 2)

Pattern	Restrictions	Example
E **Events Only**	**Event**: Specify all non-temporal attributes of one or more events. **TimeSpan**: No span. Left to right ordering implicitly denotes "any time later".	 Find patients who have had at least 2 emergency doctor visits.
E–FT **Fixed TimeSpans**	**Event**: Specify all non-temporal attributes of *two or more events.* **TimeSpan**: Relative TimeSpan of fixed size.	 Find patients whose cholesterol was above 240 but two weeks later was below 200.
E–VT **Variable TimeSpans**	**Events**: Same as E–FT. **TimeSpan**: Relative TimeSpan of variable size.	 Find patients whose cholesterol was above 240 but fell below 200 within 2 months.

Taxonomy Table (2 of 2)

Pattern	Restrictions	Example
E*–VT **Variable Events** **Variable TimeSpans**	**Event**: Specify a *subset* of non-temporal attributes of one or more events. **TimeSpan**: Same as E–VT	 Find patients who had an emergency doctor's visit followed by a hospitalization within a week.
E*WC–VT **Linked EventSet and Event**	**Event**: Specify a subset of non-temporal attributes of one or more event *sets*. The elements of an event set are defined by a relative time *window* during which all events in the set must occur, as well as *cardinality* - the number of events that must occur within the window. **TimeSpan**: Same as E–VT.	 Find patients who had 3 or more hospitalizations within two months followed by a heart attack hospitalization within a month.
***f*(E*WC)–VT** **EventSet**	**Event**: Same as E*WC–VT plus a functional condition that must hold across all members of the set. **TimeSpan**: Same as E–VT	 Find patients whose cholesterol increased by at least 20 points each reading for 3 months.

Current work

Query 1: Fixed patient values and fixed dates

Low HGB followed by higher HGB after 9/22/2006

Filter1: HGB < 150 Date < 9/22/2006

Filter2: HGB > 160 Date > 9/22/2006

Query 2: Fixed patient values and relative dates

Low HGB followed by higher HGB After the first reading.

Filter1: HGB < 150 Date < 9/22/2006

Filter2: HGB > 160 Date AFTER F1.Date

Query 3: Relative patient values and relative dates

Low HGB followed by HGB 5 points higher, After the first reading.

Filter1: HGB < 150 Date < 9/22/2006

Filter2: HGB > F1.HGB+5 Date AFTER F1.Date