



Finding Patterns of Events in Electronic Health Records Databases

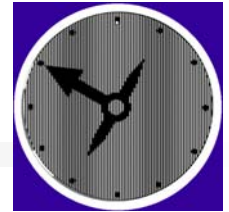
Stanley Lam, Catherine Plaisant, Ben Shneiderman

**with Patti Abbott (JHU), Nathaniel Ayewah,
Alex Quinn, Roman Stanchak, David Wang**

Human-Computer Interaction Lab &
Dept of Computer Science



Temporal Data is Pervasive!



- Health records
- Stock market trades
- Web log analysis
- Crime/terror activities
- Maintenance records



Add or Modify Your Bus Records

Bus Num: Vin Num: Code: Date:

Maintenance Schedule to Use for this vehicle:

Year: License Num:

Location: Key Num:

Size: Lift: Air:

Model: Make: Body Make:

Body Num: Air Brake: Trans:

Engine: OVRN:

Print Bus Report

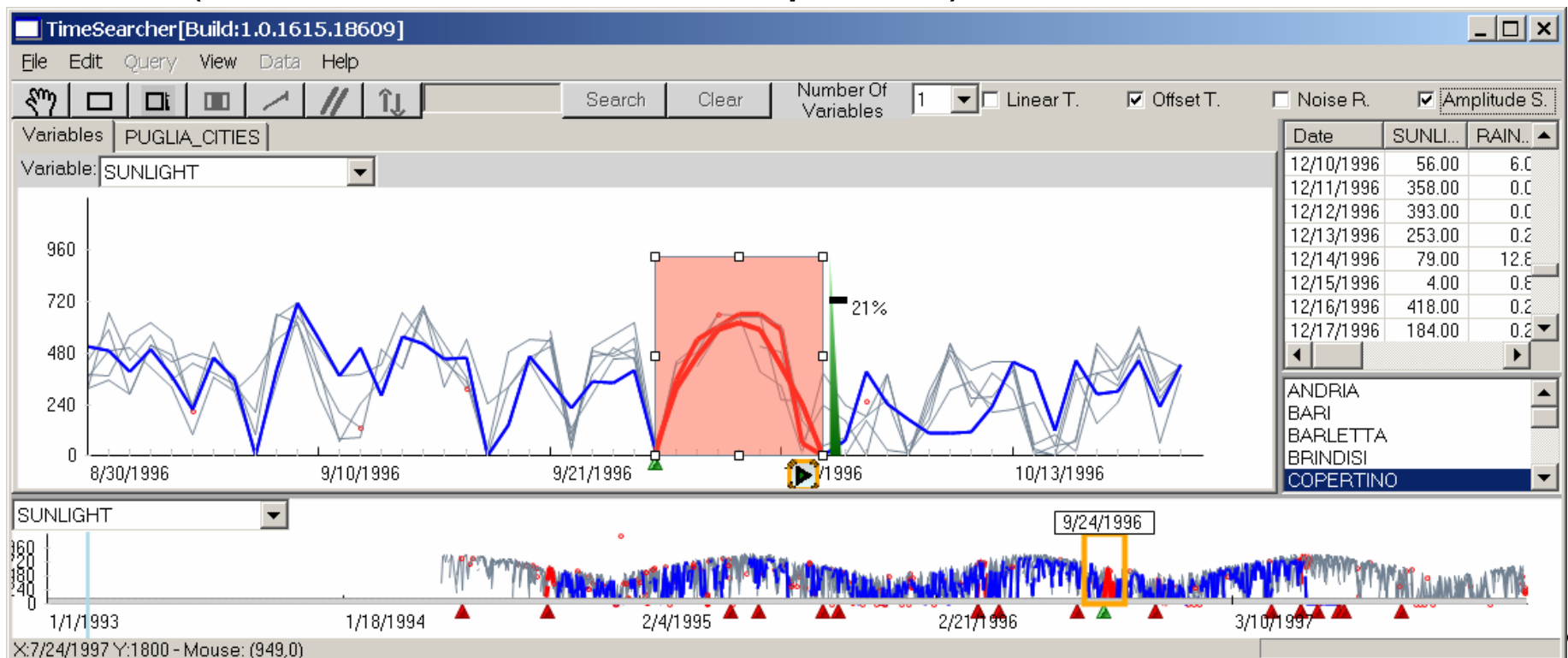
Use this navigation bar to change Vehicles.

Record:

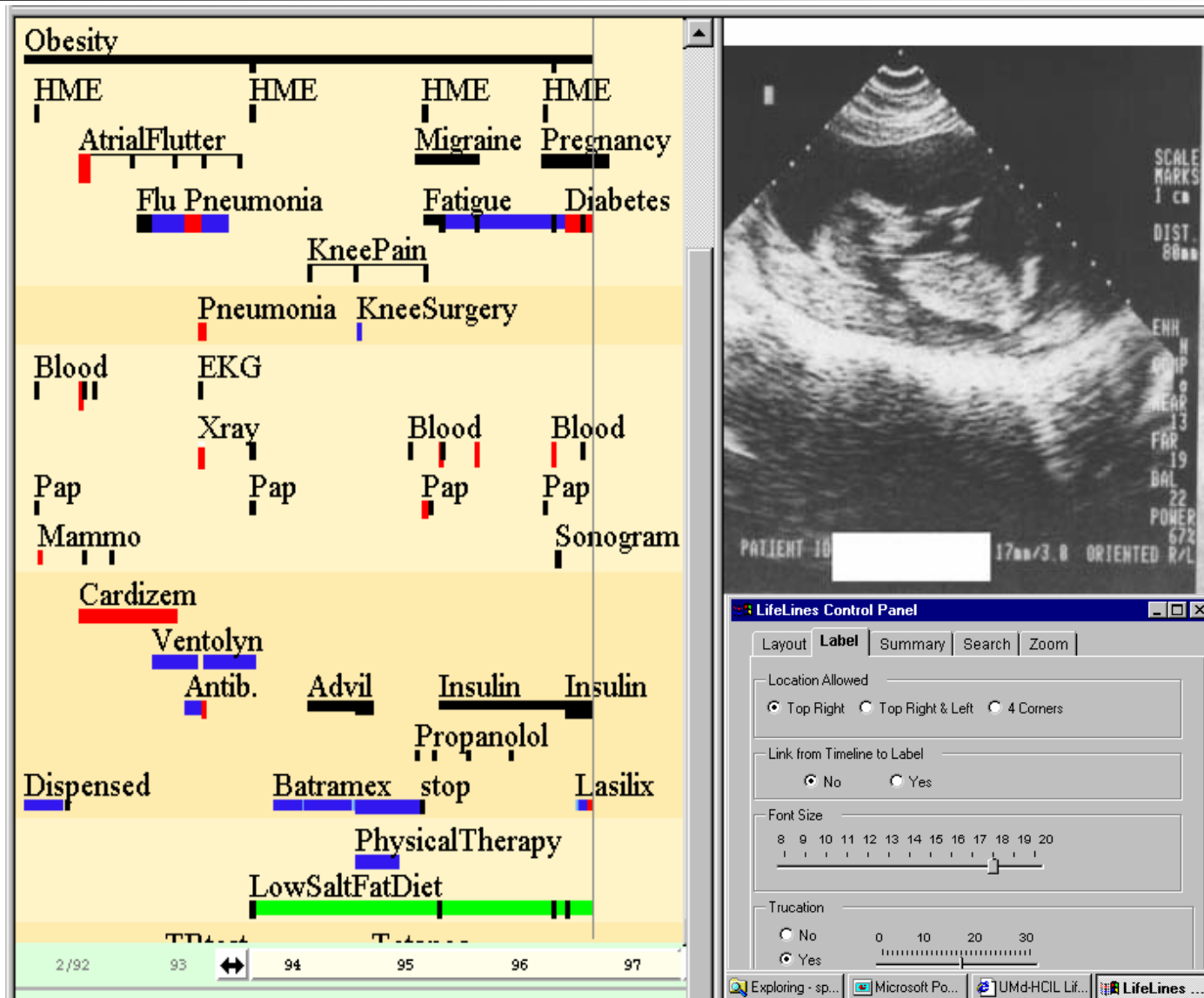


Temporal Data: TimeSearcher 2.0

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



LifeLines: Visualizing Personal Histories

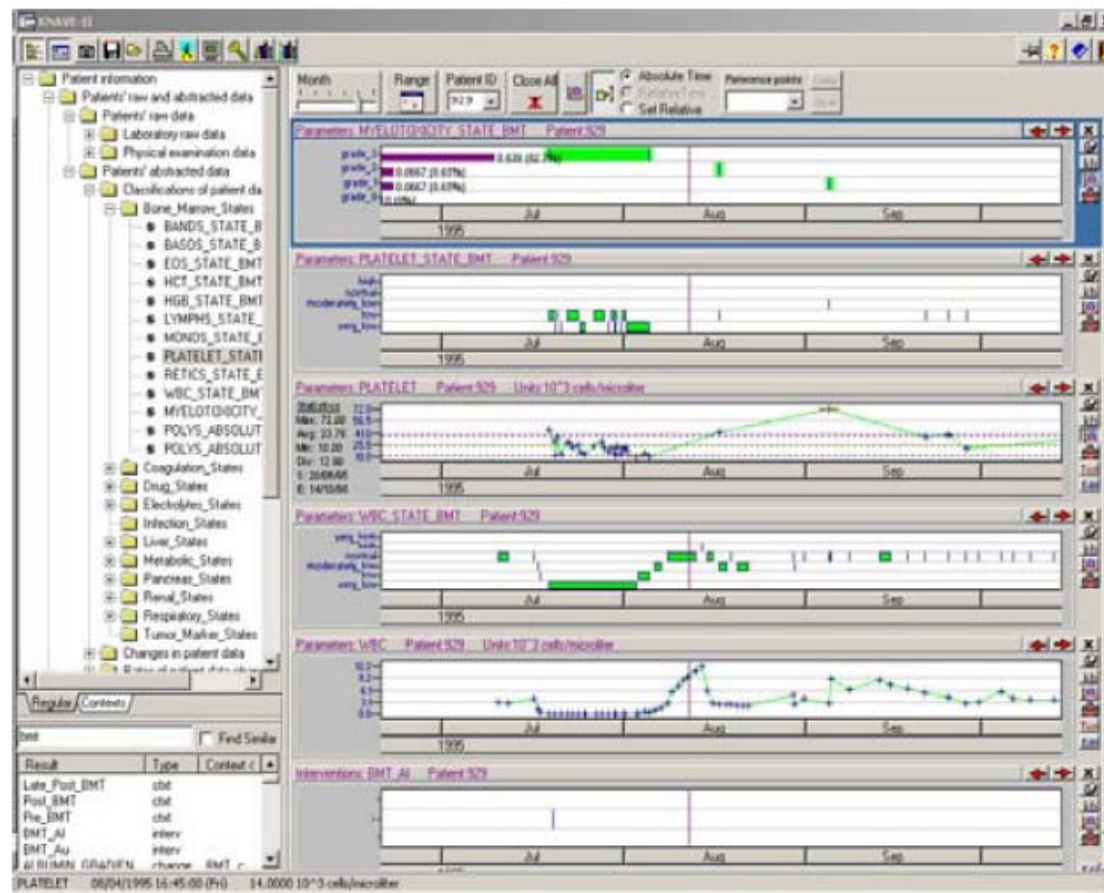


(Plaisant et al., CHI 1997)

www.cs.umd.edu/hcil/timesearcher

KNAVE: Clinical Patient Data

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



(Shahar, 1998)

Finding Patterns in Temporal Events

- Types of Time Data
 - Numerical Values (e.g., TimeSearcher)
 - Categorical Events & Intervals (e.g., LifeLines)
 - Categorical Events
- Goal: Find Temporal Patterns
across Millions of Records
 - SQL makes it difficult to specify

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)
```

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

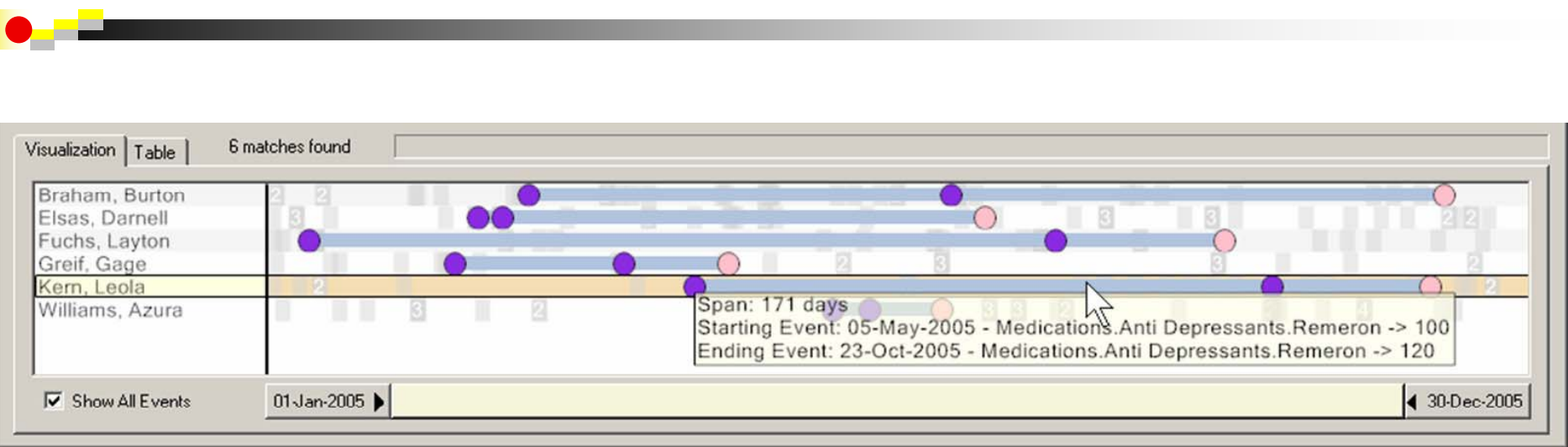
PatternFinder Interface

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

- Person/People:** This section on the left allows for filtering the dataset. It includes a 'Name' dropdown, an 'Age' range selector (set from 4 to 78), and 'Gender' checkboxes for 'Female' and 'Male'. At the bottom, it indicates 'People Selected: 6 of 950'.
- Event Box 1:** This box defines the first event in the pattern. It has a 'Type' section with three levels: Level 1 is 'Medications', Level 2 is 'Anti Depressan', and Level 3 is 'Remeron'. The 'Value' section shows a range from 4 to 126. The '# Events' section shows a range from 2 to 20. The '# Days' section shows a range from 0 to 363. There is a 'Use Relative Values' checkbox which is checked, with a range from -122 to 122. A 'Delete' button is at the bottom.
- Event Box 2:** This box defines the second event. It has a 'Type' section with three levels: Level 1 is 'Visit', Level 2 is 'Hospital', and Level 3 is 'Emergency'. The 'Value' section shows a list of conditions: 'Auto Accident', 'Bone Fracture', 'Heart Attack' (which is checked), and 'Kidney Stone'. There is a 'Delete' button next to the 'Kidney Stone' option.
- Temporal Constraints:** Between the two event boxes, there is a 'Span' section with a 'Span' checkbox checked and a unit selector set to 'Days'. A blue line with arrows indicates a span of 180 days between the two events.
- Time Range:** At the bottom, there is a 'Min Date' field set to '01-Jan-2005' and a 'Max Date' field set to '30-Dec-2005'. A 'Run Query' button is located at the bottom center.

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

Sentinel Events : LifeTimes



Diverse Applications



Stock Market Trading

Buy, sell, put, call

Web log analysis

Browse books, checkout, help, leave website

Crime/terror activities

Withdraw funds, buy weapon, purchase tickets...

Maintenance records

Replace battery, repair generator, repair starter,...

Take Away Messages



Queries for temporal events are possible!

- Visual specification
- Rapid execution
- Visualization of results: ball & chain view
- Goal:
Facilitate medical treatment & research

Thanks to:

Washington Hospital Center & Partners HealthCare