Sim•TwentyFive: An Interactive Visualization System for Data-Driven Decision Support

David Kale
University of Southern California
Virtual PICU
Children’s Hospital LA
dkale@chla.usc.edu

Brendan Stubbs
Department of Computer Science
Amar Das
Stanford Center for Biomedical Informatics Research
Pediatric intensive (critical) care
PICU observational time series

- High-dimensional (~100’s variables), sparse
- Episodic (begins at admission, ends at discharge)
- Large number of individual patients
- **Manually entered or verified by clinical staff**

![HR and RR time series](image)
Typical EHR ICU interface

* Not real patient data; screenshot from advertisement
The paper flowsheet’s legacy

Image from Health Care Renewal blog
http://hcrenewal.blogspot.com/2012/01/anecdotal-complaint-about-icu-ehr.html
Interactivity: Google search

- Add "hobbit ticket" section to my Google News homepage
- Hobbit tickets go on sale Wednesday
  - NBCNews.com (blog) - 11 hours ago
  - If you've been impatiently combing the Internet for every last bit of news about Peter Jackson's "The Hobbit: An Unexpected Journey" which hits theaters Dec.

- Hobbit tickets go on sale Nov. 7
  - Pittsburgh Post Gazette (blog) - 9 hours ago
  - "The Hobbit: Tickets On Sale Wednesday, First 48 FPS Theaters ..." /FILM (blog) - 9 hours ago
  - all 93 news sources »

- Hobbit tickets on sale from midnight
  - Stuff.co.nz - 6 hours ago
  - Wellington's Embassy Theatre will be selling tickets to the Hobbit from midnight tonight due to the level of expressed interest. The Embassy Theatre posted on its ...

- New Pictures, TV Spot for The Hobbit: An Unexpected Journey
  - ComingSoon.net - 11 hours ago
  - This Wednesday, November 7, you'll be able to buy your tickets for the first part in Peter Jackson's new trilogy The Hobbit: An Unexpected Journey. Tickets will ...

- 'The Hobbit' and 'Lord of the Rings' marathon: where you can see it ...
  - The Grand Rapids Press - MLive.com - 16 hours ago
  - GRAND RAPIDS, MI — Mark your calendars, Middle Earthers: Tickets for "The Hobbit: An Unexpected Journey" go on sale nationwide at noon Wednesday, Nov.
Transparency: Netflix recommendations

Witty Workplace TV Comedies

Independent Dramas Featuring a Strong Female Lead

Winter's Bone

In this unflinching noir drama, a resilient teen goes on the trail of her missing, drug-dealing father when his absence threatens the family's safety. More Info

Starring: Jennifer Lawrence, John Hawkes

Based on your interest in: No Country for Old Men, Fargo and Adaptation.

Our best guess for

Not interested

+ Instant Queue
The areas of the blue, red, & black wedges are each measured from the centre as the common vertex. The blue wedges measured from the centre of the circle represent area for deaths from Preventable or Mitigable Zymotic diseases; the red wedges measured from the centre the deaths from wounds; & the black wedges measured from the centre the deaths from all other causes. The black line across the red triangle in Nov. 1854 marks the boundary of the deaths from all other causes during the month. In October 1854, & April 1855 the black area coincides with the red; in January & February 1856 the blue coincides with the black. The entire areas may be compared by following the blue, the red & the black lines enclosing them.
Data visualization goals

Reduce the cognitive burden of querying, exploring, analyzing and comparing current patient to similar past patient episodes

- Enable perceptual inference
- Enhance patterns
- Encode information in a manipulation medium
Objectives

Interactivity
Ability to search, filter, refine, sort, query, etc.

Responsiveness (i.e., fast)
Amazon (2006): 100ms speedup ==> 1% revenue increase

Transparency
Clinical users (heck, everybody) hates black boxes

Emphasize visual exploration, not prediction
Make searching EHR data as easy as searching web

“Bootstrap” experience with “similar patients”
Complement “reasoning by anecdote/analogy” approach
Related work

- **SweetINFO**
- **Patientslikeme.com**
- **Tufte**
- **Lifelines2**
Distribution of diagnostic categories across clusters: Respiratory

See Marlin, Kale, Wetzel, and Khemani, ACM IHI 2012
Distribution of diagnostic categories across clusters: Neurologic

See Marlin, Kale, Wetzel, and Khemani, ACM IHI 2012
Derived similarity scores
Sim 25: design decisions

- Flexibility
- Consistency
- Responsiveness
- Parsimony

Hypothesis Generation Cycle

Visual Querying
Sim 25: implementation

- Web/HTML5
- D3/SVG
- JSON/AJAX
Sim 25: functionality

- Query any patient.
- Sort by categorical or continuous attributes.
- Select by individual (any line or circle) or category.
- Scale similarity axis by rank, relative or absolute similarity.
Sim 25: functionality

- Optimize aspect ratios of line graphs individually or collectively.
- Superimpose aggregate (entire population mean +/- one standard deviation).
Sim 25: implementation

- Web/HTML5
- D3/SVG
- JSON/AJAX
## Sim 25: results

<table>
<thead>
<tr>
<th>Question</th>
<th>Response counts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strongly Disagree</strong></td>
<td><strong>Disagree</strong></td>
</tr>
<tr>
<td>Information is presented in a clear and logical manner.</td>
<td>0</td>
</tr>
<tr>
<td>The interface is intuitive and easy to use.</td>
<td>0</td>
</tr>
<tr>
<td>In my experience, Sim•TwentyFive is better than current EMR patient data visualizations.</td>
<td>0</td>
</tr>
<tr>
<td>Sim•TwentyFive will be useful for learning about a given query patient from similar patients.</td>
<td>0</td>
</tr>
<tr>
<td>Sim•TwentyFive will be useful for physician education and treatment planning.</td>
<td>0</td>
</tr>
</tbody>
</table>
Future work

• Increase flexibility of query specification.
• Support dynamic similarity scoring based on input criteria.
• Host on a secure CHLA environment and include more detailed patient information.
• Apply rule-based domain expert knowledge against the query patient's attributes to indicate abnormalities and/or normal ranges.
• Arrange physiologic variables in an ontologically-meaningful layout.
• Integrate with traditional clinical interfaces
Closing remarks

- **Data Driven Documents** ([http://d3js.org/](http://d3js.org/))
- Share data and collaborate!
- Designers (UX, UI, etc.) are worth their weight in gold (see April 2012 Reuters article)
- **Meaningful Use of Complex Medical Data** annual symposium ([http://mucmd.org](http://mucmd.org))
- Diana Maclean: tomorrow, 9:30am, Will. B

- Email me: **dkale@chla.usc.edu**
Thanks to our extended team!

Randall Wetzel, M.D.
Roby Khemani, M.D., MSCI
Paul Vee, MBA
Ricky Nguyen, MS
Sheryl John, MS
Francisco Cai, MS
Yael Peled
Nesbert Hidalgo

Dan Crichton, M.S.
Chris Mattmann, Ph.D.
Andrew Hart, M.S.

Benjamin Marlin, Ph.D.

Christian Shelton, Ph.D.
Busra Celikkaya

Jeffrey Heer, Ph.D.
Diana Maclean

Yan Liu, Ph.D.