Web to World

Predicting Transitions from Self-Diagnosis to the Pursuit of Local Medical Assistance in Web Search

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Microsoft Research
Pursuit of Insights about Consumer Experiences with Health Search

- Mining insights from large-scale logs
  - Query sequences & page accesses
  - Content distribution & dynamics
  - Insights, predictive models, services
Prior Study: Escalation of Concerns

- Large-scale crawl & log analysis, survey (TOIS 2009)
- Transition from common symptoms to rare diseases
e.g., \{headache, nausea, dizziness\} \rightarrow \text{rare illness}

- **Conclusions**
  - Escalations of concerns widespread
  - Web suffers from & amplifies biases of judgment
    - Base-rate neglect
    - Availability bias
Prior Study: Predicting Escalation

Predict transition from common symptoms to rare illness based on features of pages being viewed (SIGIR 2010)
New Work: Influence of Web on Seeking Healthcare Professionals

- Web search → more engagement with healthcare system (AMIA 2009)

- Survey of Microsoft employees (n=515):

  “Web content put you over the threshold for scheduling an appointment with a health professional, when you would likely have not sought professional medical attention if you had not reviewed Web content.”

→ 23.7% Yes!
Predict pursuit of *in-world healthcare resources*: 
*Healthcare Utilization Intention (HUI)*

- Querying for information on proximal physicians, specialists, healthcare centers
- e.g., “neurologist in seattle, wa”, “evergreen hospital”, “urgent care clinic”

Automated detection:
- Appropriate medical specialty for the symptom (e.g., *neurologist* for symptom: muscle twitches);
- medical resource (e.g., *hospital*, *physician*)
- five-digit US zipcode, US city & state name pair (e.g., *Redmond, Washington*)
Study of Web to World!

- Prediction of transition to HUI

Session with healthcare utilization intent (HUI):

- q1
- q2
- q3
- P
- q4
- q5

- chest pain
- heart pain
- cardiologist

Session without healthcare utilization intent (No HUI):

- q1
- q2
- q3
- P
- SESSION END
Methods

Analysis of Log Data

- Six mos. anonymized logs from MSN Toolbar (opt in)
- Extract search sessions using automated tools
- Sessions: start query and all queries and URLs
- Symptoms: chest pain, muscle twitches, abdominal pain
- Automatic extraction of sessions w/ symptom $\rightarrow$ HUI
- 700 HUI, 700 no-HUI sessions
Characteristics of Resource Pursuits

- Specific treatment location: 38%
- Specific physician: 21%
- Any treatment location: 19%
- Medical specialist: 13%
- Any physician: 5%

- Treatment center for condition: 4%
- [Physicians near 32713]
- [Endocrinologists in Chattanooga, TN]
- [Emergency clinic in Sacramento]
- [Back pain, Peoria, Illinois]
- [Dr. Smith, Everett]
- [Tacoma Urgent Care]
Characteristics of Resource Usage

- HUI queries toward end of sessions
  - 36% of sessions, HUI query was last query in session
  - Mean: HUI queries occur 75% of the way through session

- When additional queries follow, search activity is:
  - **Refine** query in pursuit of resource (46%)
  - **Explore** a medical condition (22%)
  - **Compare** different resources (e.g., two specialists) (14%)

- **Other**
  - Request next search results page (10%)
  - Shift topics (8%)
Prediction task

*Probability that user will next issue an initial HUI query given currently viewing page p.*

Three classes of features

- **Page:** Structure & content of current page.
- **Session:** Attributes of search interaction in current session.
- **User:** Aspects of users’ historic medical search interactions from the beginning of our log data to start of current session.
Page Features

\( \text{FracPageFirstSerious} \): Fraction page to first serious illness

\( \text{FracPageFirstBenign} \): Fraction page to first benign explanation

\( \text{NumSeriousInFirstPara} \): Number serious illness in first para.

\( \text{NumBenignInFirstPara} \): Number benign explanations in first para.

\( \text{NumNegMod} \): Number negative modifiers (e.g., don’t have)

\( \text{NumPosMod} \): Number positive modifiers (e.g., do have)

\( \text{NumTestimonials} \): Number testimonials (e.g., I was scared)

\( \text{UrlTrusted} \): Page from trusted source (e.g., medlineplus)?

\( \text{TrustedDomain} \): Page from trusted domain (e.g., .edu)?

\( \text{IsWebForum} \): Page from a Web forum?

\( \text{HasURACVerification} \): Verified by www.urac.org?

\( \text{HasHONVerification} \): Verified by www.healthonnet.org?

\( \text{HasSeekMedicalAdvice} \): Recommends medical consult.?

\( \text{ForHealthProfessionals} \): Content meant for health prof.?

\( \text{LengthInWords} \): Number of words

\( \text{SizeInKB} \): Size in kilobytes (text only)

\( \text{HasResources} \): Mentions external resources (e.g., doctor)?
Page Features

*AdsPresent*: Advertisements present on page?

*NumAdBlocks*: Number of advertising blocks

*SeriousThenBenign*: Serious illness for concern appears on the page before a benign explanation for that symptom?

*NumWordsToSerious*: Number words to first serious illness

*NumWordsToBenign*: Number words to first benign explanation

*NumWordsBetweenSeriousAndBenign*: Number words between first serious illness and first benign explanation

*SeriousInTitle*: Serious illness in page title?

*BenignInTitle*: Benign explanation in page title?

*SeriousInFirstPara*: Serious illness in first paragraph?

*BenignInFirstPara*: Benign explanation in first paragraph?

*SeriousAndBenignInFirstPara*: Serious/benign first para.?

*NoSeriousBenignInFirstPara*: No serious/benign first para.?

*NumSerious*: Number serious illnesses

*NumBenign*: Number benign explanations

*NumGraveConcerns*: Number grave concerns (e.g., fatal)
Session and User Features

*NumQueries*: Number queries

*AvgQueryLength*: Average query length (in tokens)

*NumEscQueries*: Number queries with escalations for concern

*NumNonEscQueries*: Number queries with benign explanation

*NumURLs*: Number (non-search engine result) pages

*AvgDwellTime*: Average dwell time on pages

*TotalDwellTime*: Total dwell time on pages

*AvgConcernSearchesPerDay*: Number concern queries per day

*AvgMedicalSessionsPerDay*: Number medical sessions per day

*NumUniqueSymptoms*: Number unique Merck symptoms

*NumEscalations*: Number previous queries for serious illnesses
Exploration of Key Features

- Explore page, session, user features

<table>
<thead>
<tr>
<th>Features</th>
<th>HUI</th>
<th>No HUI</th>
</tr>
</thead>
<tbody>
<tr>
<td>SeriousBeforeBenign (Page)</td>
<td>59%</td>
<td>48%</td>
</tr>
<tr>
<td>IsWebForum (Page)</td>
<td>14%</td>
<td>9%</td>
</tr>
<tr>
<td>NumQueries (Session)</td>
<td>4.9</td>
<td>2.9</td>
</tr>
<tr>
<td>AvgQueryLength (Session)</td>
<td>4.5</td>
<td>4.1</td>
</tr>
<tr>
<td>NumUniqueSymptoms (User)</td>
<td>3.6</td>
<td>2.2</td>
</tr>
<tr>
<td>NumResourceQueries (User)</td>
<td>5.5</td>
<td>2.0</td>
</tr>
</tbody>
</table>

- All differences are significant
Study of Predictive Model

Logistic regression with five-fold cross-validation

**Accuracy:**
- Page features = 59.3%
- Page + session = 68.9%
- Page + session + user = 77.7%
Prediction Findings

- Inspected feature weights
- Top features by evidential weight, relative to most predictive feature, *AvgDwellTime*:

<table>
<thead>
<tr>
<th>Feature</th>
<th>Class</th>
<th>Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>AvgDwellTime</em></td>
<td>Session</td>
<td>1.00</td>
</tr>
<tr>
<td><em>NumEscalations</em></td>
<td>User</td>
<td>0.71</td>
</tr>
<tr>
<td><em>HasResources</em></td>
<td>Page</td>
<td>0.60</td>
</tr>
<tr>
<td><em>NumResourceQueries</em></td>
<td>User</td>
<td>0.56</td>
</tr>
<tr>
<td><em>NumURLs</em></td>
<td>Session</td>
<td>0.47</td>
</tr>
</tbody>
</table>

Value of multiple classes of features in building predictive models
Summary

Web to world: Predicting *Health Utilization Intention* (HUI)

Predictive models of escalation to HUI given features of a page, session, user

Characterized resource seeking:
- Most HUIs are searches for specific locations or physicians
- Post-initial HUI query, users refine, explore, or compare