Analyzing Query Reformulation & Search Abandonment in Web Search

Efthimis N. Efthimiadis
University of Washington
efthimis@uw.edu
Work presented here is in collaboration with Jeff Huang (UW) and Sofia Stamou (UPatras)

Related Publications:


• Huang, J. and Efthimiadis, E.N. Search Abandonment in Web Search Logs. Submitted for publication.


University of Geneva, March 18, 2010
Agenda

A. Search Interaction: overview
B. Reformulations
   1. Classifier
   2. Study
   3. Findings
C. Abandonment
   1. Classifier
   2. Study
   3. Findings
D. User Study
E. Future work
Research on Search Interaction: QF & models

e.g., Bates, Belkin, Fidel, …
Ingwersen, Tenopir, …
Hartley, Borlund, Toms, …
Efthimiadis…
& many others
REFORMULATIONS
Query Reformulations are...

a modification of a previous query made by computers or users used to retrieve different search results in a web search engine

We study these cases
Query Types

- New Query
- Same Query
- Query Reformulation
We ask:

Which reformulation strategies work?

How do we classify these reformulation strategies?

How are users doing query reformulation?
More examples...

Word Reorder → Reorder Word

Stemming → Stemmed

Word Substitution → Term Replacement

Spelling Correction → Spelling Correctoin

Remove Words → Remove
## Prior Reformulation Taxonomies

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>word reorder</strong></td>
<td>syntactic variant</td>
<td>word order</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SPL, PUN</td>
<td></td>
<td>word splitting, word merging</td>
</tr>
<tr>
<td><strong>whitespace and</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>punctuation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>remove words</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>add words</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>url stripping</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>stemming</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>acronym</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>substring</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>abbreviation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>word substitution</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>spelling correction</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* not detected</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* not in data</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

University of Geneva, March 18, 2010
A Rule-Based Classifier

First automated reformulation strategy classifier

Based on heuristics,

– Reformulation types are intuitive, no machine learning

Primary Goal: High Precision
Secondary Goal: Adequate Recall

High precision enables accurate comparison between properties of reformulation types

University of Geneva, March 18, 2010
Architecture

Query Logs
user1, query string1, timestamp, rank, url
user1, query string2, timestamp, rank, url
user1, query string3, timestamp, rank, url
user2, query string1, timestamp, rank, url
user3, query string1, timestamp, rank, url
user3, query string2, timestamp, rank, url

Classifier

Reformulation
Acronym
Stemming
etc...

New Queries

Same Queries
# 36M Queries from AOL Query Logs

<table>
<thead>
<tr>
<th>UserId</th>
<th>Query</th>
<th>Timestamp</th>
<th>ClickRank</th>
<th>ClickUrl</th>
</tr>
</thead>
<tbody>
<tr>
<td>16348</td>
<td>lucille roberts</td>
<td>5/3/2006 8:01</td>
<td>1</td>
<td><a href="http://www.lucilleroberts.com">http://www.lucilleroberts.com</a></td>
</tr>
<tr>
<td>16348</td>
<td>tmobile</td>
<td>5/22/2006 14:06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16348</td>
<td>welime</td>
<td>5/30/2006 14:58</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16348</td>
<td>we lime</td>
<td>5/30/2006 14:59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16348</td>
<td>back2basics</td>
<td>5/30/2006 15:07</td>
<td>6</td>
<td><a href="http://back2basics.mypicgallery.com">http://back2basics.mypicgallery.com</a></td>
</tr>
<tr>
<td>16348</td>
<td>nycaribbeanvibes</td>
<td>5/30/2006 15:15</td>
<td>2</td>
<td><a href="http://nycaribbeanvibes.photosite.com">http://nycaribbeanvibes.photosite.com</a></td>
</tr>
<tr>
<td>16473</td>
<td>slipknot masks</td>
<td>3/2/2006 0:20</td>
<td>1</td>
<td><a href="http://www.hauntmasters.com">http://www.hauntmasters.com</a></td>
</tr>
<tr>
<td>16473</td>
<td>aol maps</td>
<td>3/2/2006 22:08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16473</td>
<td>southeast missouri basketball</td>
<td>3/2/2006 22:11</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Comparitive Evaluation

<table>
<thead>
<tr>
<th></th>
<th>Precision</th>
<th>Recall</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Present Study</strong></td>
<td>98.2%</td>
<td>61.3%</td>
<td>89.1%</td>
</tr>
<tr>
<td><strong>He et al.</strong></td>
<td>60%</td>
<td>98%</td>
<td></td>
</tr>
<tr>
<td><strong>Jones et al.</strong></td>
<td></td>
<td></td>
<td>87.3%</td>
</tr>
<tr>
<td><strong>Murray et al.</strong></td>
<td>97.3%</td>
<td>76%</td>
<td></td>
</tr>
<tr>
<td><strong>Radlinski et al.</strong></td>
<td>96.5%</td>
<td></td>
<td>92.3%</td>
</tr>
</tbody>
</table>

Unscientific because:
- Different data sources
- Different ways of counting (i.e. include same queries or not?)
FINDINGS
Comparing click pattern frequencies between reformulations types

Query Reformulation Type

- new
- form acronym
- remove words
- substring
- word reorder
- add words
- word substitution
- url stripping
- abbreviation
- superstring
- stemming
- whitespace / punctuation
- same
- spelling correction
- expand acronym
Comparing click pattern frequencies between reformulations types

- Spelling correction, & Expand acronym, have high ratios, i.e., people use these reformulations

compare the ratio of SkipSkip to SkipClick to see whether a user is more likely to click if the initial action is Skip
Comparing click pattern frequencies between reformulations types

Some reformulations are performed to improve the result set, while others redo the result set.

Different reformulations are “effective” depending on the initial action, i.e. the action performed after the initial query.
Comparing websites clicked between reformulation types

- url stripping
- form acronym
- whitespace / punctuation
- word reorder
- abbreviation
- stemming
- same
- expand acronym
- substring
- superstring
- spelling correction
- remove words
- add words
- word substitution
- new

Same
Different

University of Geneva, March 18, 2010
Comparing **time between queries** (secs) and **rank change** between reformulations types

<table>
<thead>
<tr>
<th>Reformulation Type</th>
<th>Median Time (s) between Queries</th>
<th>Mean Rank Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>word substitution</td>
<td>73</td>
<td>+4.04</td>
</tr>
<tr>
<td>add words</td>
<td>63</td>
<td>+3.19</td>
</tr>
<tr>
<td>substring</td>
<td>33</td>
<td>+3.15</td>
</tr>
<tr>
<td>remove words</td>
<td>68</td>
<td>+3.02</td>
</tr>
<tr>
<td>word reorder</td>
<td>85</td>
<td>+2.86</td>
</tr>
<tr>
<td>expand acronym</td>
<td>42</td>
<td>+2.02</td>
</tr>
<tr>
<td>stemming</td>
<td>33</td>
<td>+2.00</td>
</tr>
<tr>
<td><strong>new</strong></td>
<td>2,417</td>
<td>+1.91</td>
</tr>
<tr>
<td>abbreviation</td>
<td>35</td>
<td>+1.39</td>
</tr>
<tr>
<td>superstring</td>
<td>53</td>
<td>+1.10</td>
</tr>
<tr>
<td>spelling correction</td>
<td>22</td>
<td>+1.03</td>
</tr>
<tr>
<td>form acronym</td>
<td>103</td>
<td>+.64</td>
</tr>
<tr>
<td>whitespace &amp; punctuation</td>
<td>27</td>
<td>+.54</td>
</tr>
<tr>
<td>url stripping</td>
<td>57</td>
<td>+.29</td>
</tr>
<tr>
<td><strong>same</strong></td>
<td>1</td>
<td>-1.83</td>
</tr>
</tbody>
</table>

**Positive rank change** = successful reformulation
Future Work

**Multi-reformulation**

- Seattle pizza
- Seattle sausage pizza
- Sausage pizza
- Netbook eee pc
- Eee pc netbook deals

Using instances of **sequential reformulations** to detect **multi-reformulations**

**Abandonment**

Search abandonment **redefined** in terms of reformulation:

- Initial query
- Reformulations
- Session end

*NoClick* (timeout or new query)
Applications

• UIs supporting Reformulations
• Query session boundary detection
• Intelligent query assistance
• Personalized Search
Summary

• We created a **taxonomy** of query reformulation strategies and a rule-based **classifier** to classify reformulations from the AOL query logs, where characteristics for each reformulation strategy was measured.

• **Different** reformulations are **useful** depending on the initial action.

• Some reformulations **re-rank** clicked results higher while others **generate new** results.
Thank You!

Questions?

Efthimis N. Efthimiadis
University of Washington
efthimis@uw.edu