

Use of Click Data for Web Search

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Search Logs

🕒 Query logs recorded by search engines

Table 1: Samples of search engine clickthrough data

ID	Query	URL	Rank	Time
358	facebook	http://www.facebook.com	1	2008-01-01 07:17:12
358	facebook	http://en.wikipedia.org/wiki/Facebook	3	2008-01-01 07:19:18
3968	apple iphone	http://www.apple.com/iphone/	1	2008-01-01 07:20:36
...

🕒 Huge amount of data: e.g. 10TB/day at Bing

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1337 fiserv 2006-03-24 14:05:01 2 http://www.fiservinsurance.com
1337 fiserv 2006-03-24 14:05:01 3 http://www.fiservlendingsolutions.com
1337 integrated real estate 2006-03-27 14:52:29 1 http://www.integratedreal.com
1337 integrated real estate 2006-03-27 14:52:29 2 http://www.irisnet.net
1337 integrated loan services 2006-03-29 17:12:27 1 http://www.ils.com
1337 michael keaton date of birth 2006-04-03 22:05:48 1 http://www.imdb.com
1337 auto locator pennsylvania 2006-04-11 21:46:57 1 http://theautofinder.com
1337 auto locator 2006-04-11 21:47:57 1 http://www.auto-locator.com
1337 kentucky fried chicken 2006-04-25 16:07:14 1 http://www.kfc.com
1410 google 2006-05-01 21:40:54 1 http://www.google.com
2005 vrmu homepage 2006-03-01 00:46:55 2 http://www.vrmu.edu
2005 vrmu homepage 2006-03-01 00:48:28 1 http://www.vrmu.edu
2005 vrmu homepage 2006-03-01 00:48:28 1 http://www.vrmu.edu
2005 vrmu homepage 2006-03-01 21:03:03 1 http://www.vrmu.edu
2005 vrmu homepage 2006-03-01 21:04:35 1 http://www.vrmu.edu
2005 vrmu home page 2006-03-01 21:57:00 1 http://www.vrmu.edu
2005 vrmu home page 2006-03-01 22:21:57 1 http://www.vrmu.edu
2005 vrmu home page 2006-03-05 19:54:12 1 http://www.vrmu.edu
2005 vrmu homepage 2006-03-07 23:34:21 2 http://www.vrmu.edu
2005 vrmu homepage 2006-03-07 23:36:11 1 http://www.vrmu.edu
2005 vrmu webct 2006-03-07 23:47:49 1 https://western.checs.net:4443/wadmin/webct_logon.htm
2005 myspace.com 2006-03-09 23:12:40 1 http://www.morcey.net
2005 glitter graphics.com 2006-03-10 01:00:41 1 http://www.glitter-graphics.com
2005 google 2006-03-24 21:25:10 1 http://www.google.com
2005 ww.vibe.com 2006-03-26 21:21:51 7 http://www.vibe985.com
2005 vrmu.edu 2006-03-27 21:24:09 1 http://www.vrmu.edu
    
```

Search sessions

Query sessions and analysis

Query-URL correlations:

- Query-to-pick
- Query-to-query
- Pick-to-pick

Examples of behavior analysis with search logs

- **Query-pick (click) analysis**
- **Session detection**
- **Classification**
 - $x_1, x_2, \dots, x_N \rightarrow y$
 - eg, whether the session has a commercial intent
- **Sequence labeling**
 - $x_1, x_2, \dots, x_N \rightarrow y_1, y_2, \dots, y_N$
 - eg, segment a search sequence into missions and goals
- **Prediction**
 - $x_1, x_2, \dots, x_{N-1} \rightarrow y_N$
- **Similarity**
 - $\text{Similarity}(S_1, S_2)$

Query-pick (click) analysis

- **Search Results for "CIKM"**

Search Result	# of clicks received
CIKM 2009 (1/2009)	49
Conference on Information and Knowledge Management (CIKM)	36
ACM CIKM 2007 - Lisbon Portugal	12
CIKM 2009 (1/2009)	50
Conference on Information and Knowledge Management (CIKM)	4

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Interpret Clicks: an Example

CIKM 2009 Home
 Tapa Valley Marriott Hotel & Spa, Tapa Valley, California October 26-30, 2009
 CIKM'09 Home

Conference on Information and Knowledge Management (CIKM)
 Provides an international forum for presentation and discussion of research on information and knowledge management, as well as recent advances in data and knowledge bases...

Conference on Information and Knowledge Management (CIKM'09)
 ACM Transactions, Tapa Valley, CA, 4-9 November 2009

ACM CIKM 2007 - Lisbon, Portugal
 News and announcements: Since 1992, CIKM has successfully brought together...

CIKM 2009 Home
 CIKM 2009 (The 18th ACM Conference on Information and Knowledge Management) will be held on November 24, 2009, Hong Kong. Since 1992, CIKM has successfully brought together...

Conference on Information and Knowledge Management (CIKM)
 CIKM Conference on Information and Knowledge Management The Conference on Information and Knowledge Management (CIKM) provides an international forum for presentation and...

CIKM 2004
 Identify emerging problems facing the development of future knowledge and information systems, and share their direction of research by studying and solving real-world...

CIKM
 International Conference on Information and Knowledge Management (CIKM) Home Page
 ACM, CIKM 2009, Tapa Valley, California, USA, November 4-9, 2009

- Clicks are good...
 - Are these two clicks equally "good"?
- Non-clicks may have excuses:
 - Not relevant
 - Not examined

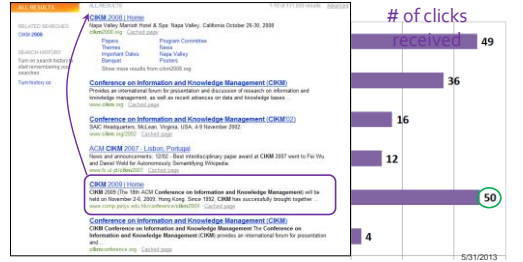


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Use of behavior data

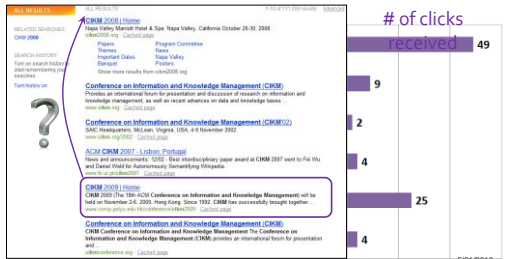
- Adapt ranking to user clicks?



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Non-trivial cases

- Tools needed for non-trivial cases



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Eye-tracking User Study



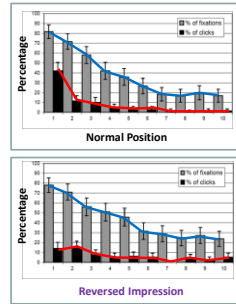
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Eye tracking for different web sites

Google user patterns



Click Position-bias



- Higher positions receive more user attention (eye fixation) and clicks than lower positions.
- This is true even in the extreme setting where the order of positions is reversed.
- “Clicks are informative but biased”.

[Joachims+07]

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Clicks as Relative Judgments for Rank Training

- “Clicked > Skipped Above” [Joachims, KDD02]

1	CIKM 2009 Tutorial CIKM 2009 Tutorial 5 Day, New York, October 26-30, 2009 Tutorial 5: Information Management Tutorial 6: Information Management Tutorial 7: Information Management Tutorial 8: Information Management
2	Confidence in Information and Knowledge Management (CIKM) Confidence in Information and Knowledge Management (CIKM) Confidence in Information and Knowledge Management (CIKM)
3	Confidence in Information and Knowledge Management (CIKM) Confidence in Information and Knowledge Management (CIKM) Confidence in Information and Knowledge Management (CIKM)
4	Confidence in Information and Knowledge Management (CIKM) Confidence in Information and Knowledge Management (CIKM) Confidence in Information and Knowledge Management (CIKM)
5	Confidence in Information and Knowledge Management (CIKM) Confidence in Information and Knowledge Management (CIKM) Confidence in Information and Knowledge Management (CIKM)
6	Confidence in Information and Knowledge Management (CIKM) Confidence in Information and Knowledge Management (CIKM) Confidence in Information and Knowledge Management (CIKM)
7	CIKM 2009 CIKM 2009 Tutorial 5 Day, New York, October 26-30, 2009 Tutorial 5: Information Management Tutorial 6: Information Management Tutorial 7: Information Management Tutorial 8: Information Management
8	CIKM Confidence in Information and Knowledge Management (CIKM) Confidence in Information and Knowledge Management (CIKM) Confidence in Information and Knowledge Management (CIKM)

- Preference pairs:
#5>#2, #5>#3, #5>#4.
- Use Rank SVM to optimize the retrieval function.
- Limitation:
 - Confidence of judgments
 - Little implication to user modeling

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Additional relation for relative relevance judgments

click > skip above
last click > click above
click > click earlier
last click > click previous
click > no-click next

Web Search Ranking by Incorporating User Behavior Information Rank pages relevant for a query

•Eugene Agichtein, Eric Brill, Susan Dumais SIGIR 2006

• Web Search Ranking

- Content match
 - e.g., page terms, anchor text, term weights
 - Prior document quality
 - e.g., web topology, spam features
 - Hundreds of parameters
- Improve with implicit user feedback from click data

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Related Work

• Personalization

- Rerank results based on user's clickthrough and browsing history

• Collaborative filtering

- Amazon, DirectHit: rank by clickthrough

• General ranking

- Joachims et al. [KDD 2002], Radlinski et al. [KDD 2005]: tuning ranking functions with clickthrough

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Rich User Behavior Feature Space

• Observed and distributional features

- Aggregate observed values over all user interactions for each query and result pair
- Distributional features: deviations from the "expected" behavior for the query

• Represent user interactions as vectors in user behavior space

- **Presentation:** what a user sees *before* a click
- **Clickthrough:** frequency and timing of clicks
- **Browsing:** what users do *after* a click

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Ranking Features

<i>Presentation</i>	
ResultPosition	Position of the URL in Current ranking
QueryTitleOverlap	Fraction of query terms in result Title
<i>Clickthrough</i>	
DeliberationTime	Seconds between query and first click
ClickFrequency	Fraction of all clicks landing on page
ClickDeviation	Deviation from expected click frequency
<i>Browsing</i>	
DwellTime	Result page dwell time
DwellTimeDeviation	Deviation from expected dwell time for query

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More Presentation Features

<i>Query-text features</i>	
TitleOverlap	Words shared between query and title
SummaryOverlap	Words shared between query and snippet
QueryURLOverlap	Words shared between query and URL
QueryDomainOverlap	Words shared between query and URL domain
QueryLength	Number of tokens in query
QueryNextOverlap	Fraction of words shared with next query

More Clickthrough Features

<i>Clickthrough features</i>	
Position	Position of the URL in Current ranking
ClickFrequency	Number of clicks for this query, URL pair
ClickProbability	Probability of a click for this query and URL
ClickDeviation	Deviation from expected click probability
IsNextClicked	1 if clicked on next position, 0 otherwise
IsPreviousClicked	1 if clicked on previous position, 0 otherwise
IsClickAbove	1 if there is a click above, 0 otherwise
IsClickBelow	1 if there is click below, 0 otherwise

Browsing features

<i>Browsing features</i>	
TimeOnPage	Page dwell time
CumulativeTimeOnPage	Cumulative time for all subsequent pages after search
TimeOnDomain	Cumulative dwell time for this domain
TimeOnShortUrl	Cumulative time on URL prefix, no parameters
IsFollowedLink	1 if followed link to result, 0 otherwise
IsExactUriMatch	0 if aggressive normalization used, 1 otherwise
IsRedirected	1 if initial URL same as final URL, 0 otherwise
IsPathFromSearch	1 if only followed links after query, 0 otherwise
ClicksFromSearch	Number of hops to reach page from query
AverageDwellTime	Average time on page for this query
DwellTimeDeviation	Deviation from average dwell time on page
CumulativeDeviation	Deviation from average cumulative dwell time
DomainDeviation	Deviation from average dwell time on domain

Training a User Behavior Model

- **Map user behavior features to relevance judgements**
- **RankNet: Burges et al., [ICML 2005]**
 - Neural Net based learning
 - Input: user behavior + relevance labels
 - Output: weights for behavior feature values
 - Used as testbed for all experiments

User Behavior Models for Ranking

- **Use interactions from previous instances of query**
 - General-purpose (not personalized)
 - Only available for queries with past user interactions
- **Models:**
 - Rerank, clickthrough only: reorder results by number of clicks
 - Rerank, predicted preferences (all user behavior features): reorder results by predicted preferences
 - Integrate directly into ranker: incorporate user interactions as features for the ranker

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Evaluation Metrics

- **Precision at K: fraction of relevant in top K**
 - **NDCG at K: norm. discounted cumulative gain**
 - Top-ranked results most important
- $$N_q = M_q \sum_{j=1}^K (2^{r(j)} - 1) / \log(1 + j)$$
- **MAP: mean average precision**
 - Average precision for each query: mean of the precision at K values computed after each relevant document was retrieved

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Datasets

- **8 weeks of user behavior data from anonymized opt-in client instrumentation**
- **Millions of unique queries and interaction traces**
- **Random sample of 3,000 queries**
 - Gathered independently of user behavior
 - 1,500 train, 500 validation, 1,000 test
- **Explicit relevance assessments for top 10 results for each query in sample**

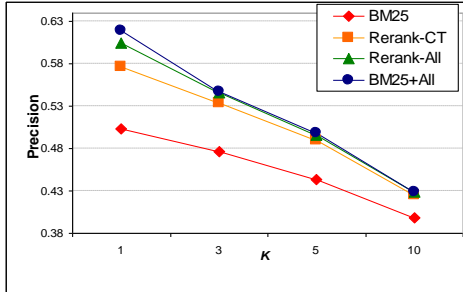
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Methods Compared

- **Content only: BM25F**
 - A variation of TF-IDF model
- **Full Search Engine: RN**
 - Hundreds of parameters for content match and document quality
 - Tuned with RankNet
- **Incorporating User Behavior**
 - Clickthrough: **Rerank-CT**
 - Full user behavior model predictions: **Rerank-All**
 - Integrate all user behavior features directly: **+All**

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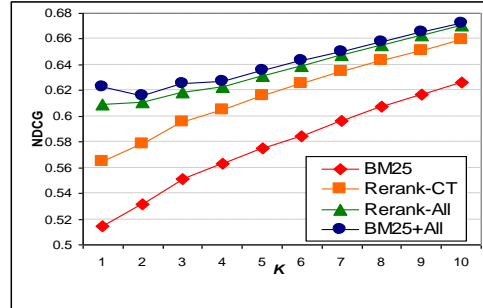
Content, User Behavior: Precision at K, queries with interactions



BM25 < Rerank-CT < Rerank-All < +All

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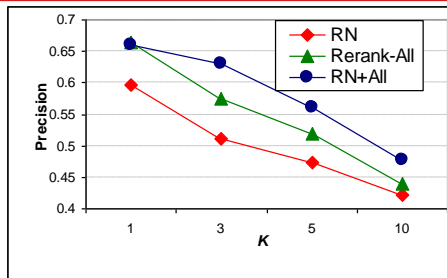
Content, User Behavior: NDCG



BM25 < Rerank-CT < Rerank-All < +All

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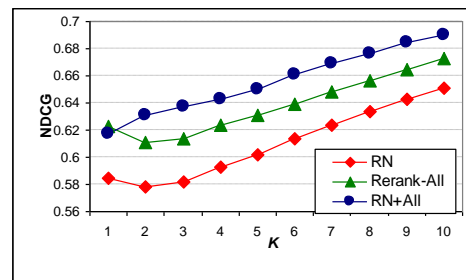
Impact: All Queries, Precision at K



< 50% of test queries w/ prior interactions
+0.06-0.12 precision over **all** test queries

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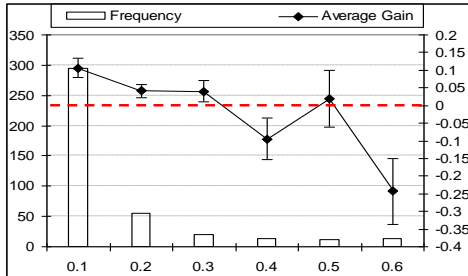
Impact: All Queries, NDCG



+0.03-0.05 NDCG over **all** test queries

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Which Queries Benefit Most



Most gains are for queries with poor ranking

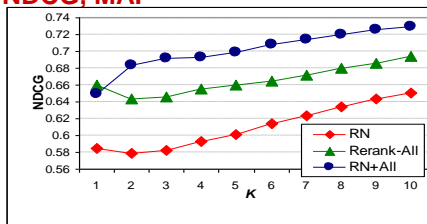
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Conclusions

- Incorporating user behavior into web search ranking dramatically improves relevance
- Providing rich user interaction features to ranker is the most effective strategy
- Large improvement shown for up to 50% of test queries

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Full Search Engine, User Behavior: NDCG, MAP



RN	0.270	
RN+ALL	0.321	0.052 (19.13%)
BM25	0.236	
BM25+ALL	0.292	0.056 (23.71%)

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