

Building a Click Model From Idea to Implementation

Yiqun LIU

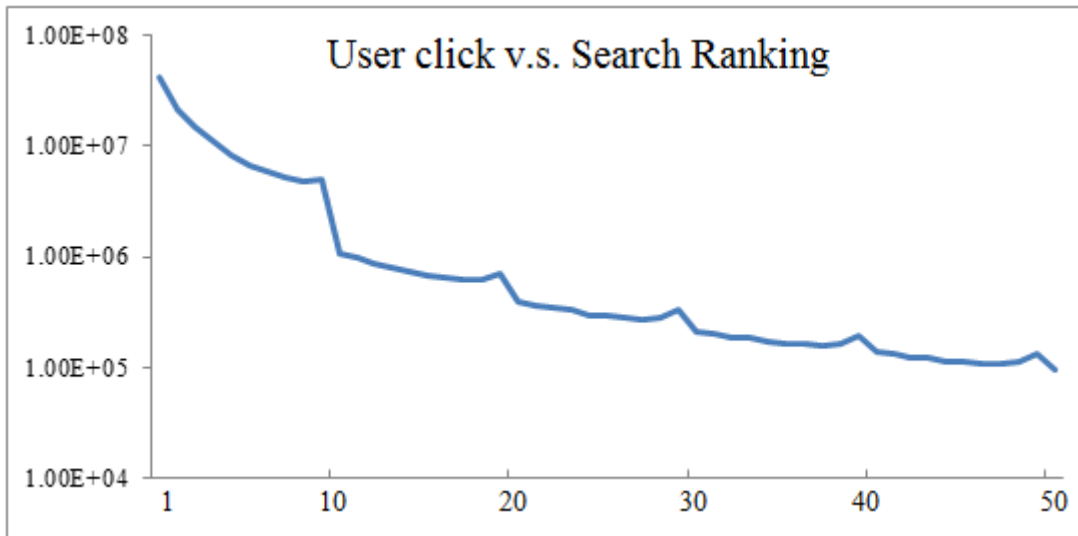
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User Behavior & Search Result Ranking

- **A simple solution: user click = relevance voting**
 - Works well for most navigational queries (e.g. SIGIR15)
- **Problem: position bias**
 - Users tend to click more on higher-ranked results



Result Examination: Click models

- **Examination Hypothesis (Richardson et al., 2007)**

$$C_i = 1 \rightarrow E_i = 1, R_i = 1$$

- **Estimating examination probabilities**

- Cascade model: $P(E_{i+1} = 1 | E_i = 1, C_i) = 1 - C_i$

- Dependent click model (DCM):

$$P(E_{i+1} = 1 | E_i = 1, C_i = 0) = 1$$

$$P(E_{i+1} = 1 | E_i = 1, C_i = 1) = \lambda_i$$

- User browsing model (UBM):

$$P(E_i = 1 | C_{1 \dots i-1}) = \lambda_{r_i, d_i}$$

- Other models: DBN, CCM, TCM...



From Idea to Implementation

- **Click model assumptions**

- **Ideal case (homogeneous results):** Position is the only factor that affects behavior
- Problem: results have different presentation styles
- **Ideal case (cascade assumption):** Results are examined from top to bottom
- Problem: results are often skipped or revisited

Research Questions

- ***Presentation bias problem:***
a click model incorporating vertical results
- ***Non-sequential examination problem:***
a click model incorporating revisiting behaviors

Heterogeneous Search Results

- Vertical results are everywhere (over 80% SERPs)

Organic
Result

Welcome to [SIGIR](#) | Home

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The Office of the Special Inspector General for Iraq Reconstruction (SIGIR), a temporary federal agency serving the American public as a watchdog for ...

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[Apple's latest store opening is one of 25 reasons the company needs to keep Beijing happy](#)

Quartz - 2 hours ago

Apple's new store in Hangzhou, which it opened with great fanfare over the weekend, is just one of five retail stores the company is opening in China ahead of...

[Marijuana in the App Store: Apple just says no to many pot apps](#)

Denver Post - 4 hours ago

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iTunes

Version: 12.0.1.26 Size: 116.8 MB

Update: 2014-10-17

OS: winxp,vista,win7,win8

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[kiazai.sogou.com](#) - 2014-10-23

[lash \(comics\) - Wikipedia, the free encyclopedia](#)



[en.wikipedia.org/wiki/Flash_\(comics\)](#) ▼

The Flash is a superhero from the DC Comics universe. Created by writer Gardner Fox and artist Harry Lampert, the original Flash first appeared in Flash ...

Publication history · Fictional character ... · Powers and abilities · Writers

News
Vertical

Download
Vertical

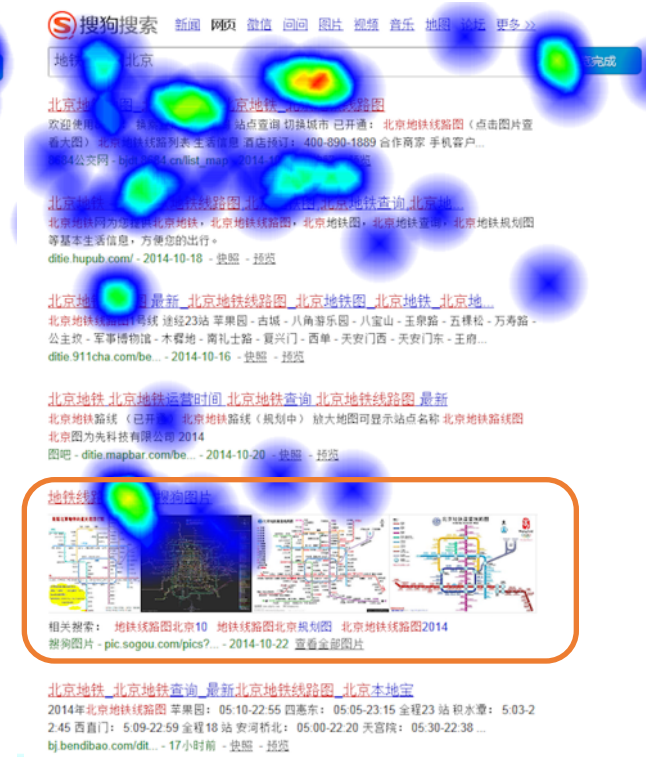
Encyclo-
pedia
Vertical

Textual
Vertical

Image
Vertical

- **Attractiveness Effect (Wang et al., 2013; Liu et al., 2015)**
 - Certain verticals draw much attention from users

Rank 5th



Vertical-aware Click Model

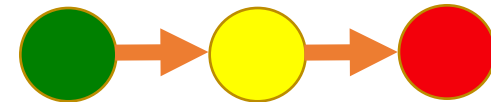
- **Cut-off Effect (Liu et al., 2015)**

- After users have viewed **on-topic** verticals, they are more likely to **decrease** their visual attention on **the organic results** which are **below** verticals.

Relevant Vertical	Textual	Encyclopedia	Image-only	Application-download	News
	Position = 3				
Organic	34.61%				
Vertical	30.13%	16.70%	8.44%	13.04%	22.61%
Diff	-12.95%	-51.74%*	-75.62%**	-62.32%**	-34.68%
	Position = 5				
Organic	25.27%				
Vertical	26.30%	19.27%	10.33%	6.21%	38.69%
Diff	4.09%	-23.76%	-59.10%*	-75.44%*	53.09%

Vertical-aware Click Model

- **Restart effect (Wang et al., 2013)**



- Most users (70%) will restart from the beginning to continue

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Vertical-aware Click Model

• Model Construction (based on UBM)

Original UBM

$$\left\{ \begin{array}{l} P(C_i = 1|E_i = 0) = 0 \\ P(C_i = 1|E_i = 1) = P(A_i = 1|E_i = 1) \\ P(E_i = 1|F = 0, C_{1:i-1}) = \gamma_{i,i-l_i} \\ P(A_i = 1|E_i = 1, F = 0) = \alpha_{q,i} \end{array} \right.$$

Users examine vertical results at first — $P(F = 1) = \phi_{t_v, l_v}$ Simplified case: difficult to quantify the effect when not all results are affected

Effect on Examination — $P(E_i = 1|F = 1, C_{1:i-1}) = \gamma_{i,i-l_i} + \theta_{q,i}$

Effect on Click-through — $P(A_i = 1|E_i = 1, F = 1) = \alpha_{q,i} + \beta_{q,i}$

Restart effect

$$\left\{ \begin{array}{l} P(B = 1|F = 0) = 0 \\ P(B = 1|F = 1) = \sigma_{t_v, l_v} \end{array} \right.$$

Vertical-aware Click Model

- **Experimental results**

- About 300,000 queries and 11,000,000 sessions collected from a major Chinese search engine

Click/skip perplexity

Perplexity	UBM	VCM	VCM Improvement
Text vertical	1.2266	1.2139	+5.58%
Multimedia vertical	1.3735	1.3071	+17.78%
Application vertical	1.1908	1.1601	+16.09%

Log-likelihood

	UBM	VCM	VCM Improvement
Text vertical	-2.9093	-2.7968	+11.90%
Multimedia vertical	-4.1142	-3.8638	+28.44%
Application vertical	-2.2671	-2.1427	+13.24%

Possible Future Directions

- **How to rank items within vertical blocks?**
 - An example vertical block composed of an image and several hyperlinks (e.g. news, Q&A portal results, etc.)
 - Position bias: only for the top result
 - Attractiveness effect: not so significant

[Result Title Here](#)

Title⁰

1

**Image**

[Subtopic Title Here](#)

Item1²

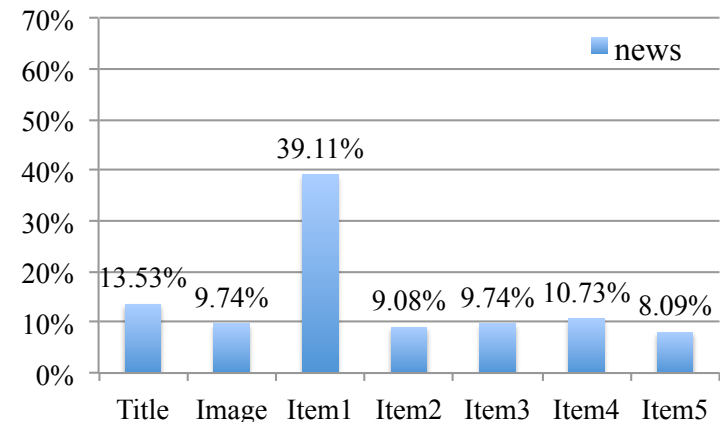
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Item2-5³

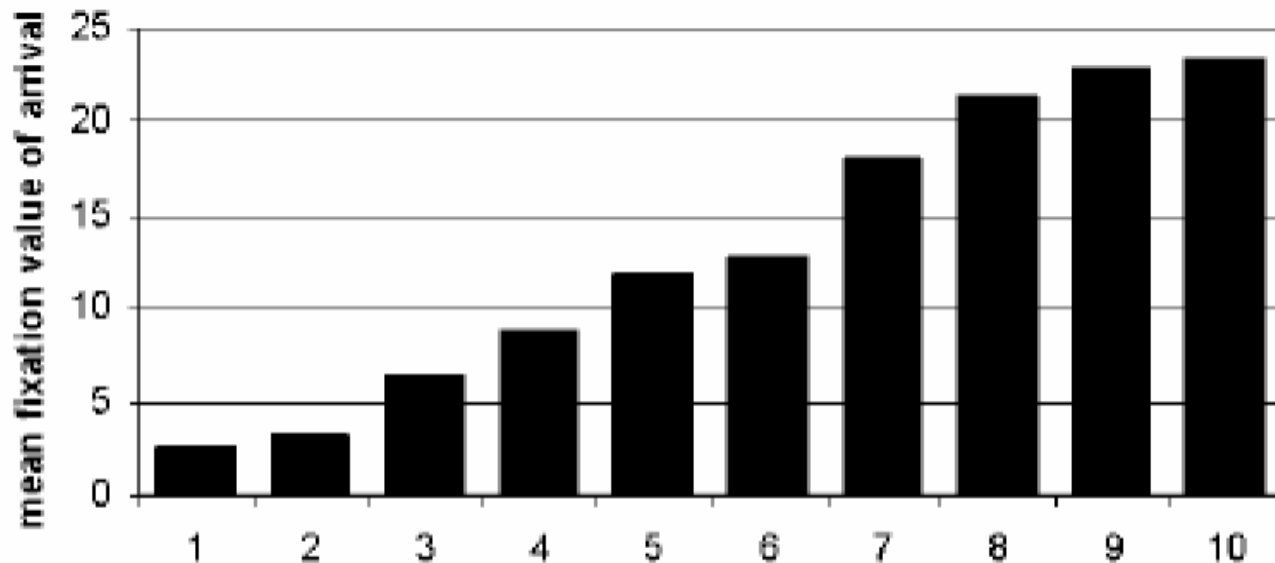


Research Questions

- *Presentation bias problem:*
a click model incorporating vertical results
- ***Non-sequential examination problem:***
a click model incorporating revisiting behaviors

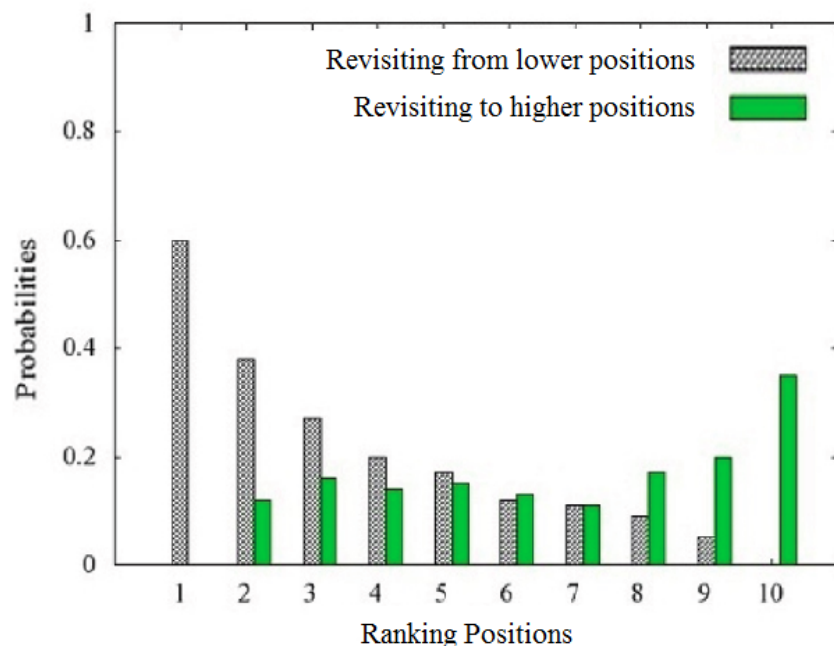
Sequential order of Examination/Clicking

- **Sequential examination happens a lot**
 - **Cascade assumption**: Users tend to examine results from top to bottom
 - Mean time of arrival v.s. result ranking position



Non-sequential Examination Problem

- **Revisiting behavior cannot be ignored**
 - Chinese search engine (Sogou): 27.9% sessions
 - Non-Chinese search engine (Yandex): 30.4% sessions



Query Frequency	Chinese	Yandex
[1,9]	0.239	0.597
[10,30]	0.235	0.593
[31,99]	0.228	0.592
[100,499]	0.256	0.594
[500,∞)	0.249	0.622

Label	Been Revisited	Never Been Revisited
bad	0.031	0.073
fair	0.075	0.151
good	0.310	0.364
excellent	0.513	0.399
perfect	0.071	0.013

Non-sequential Examination Problem

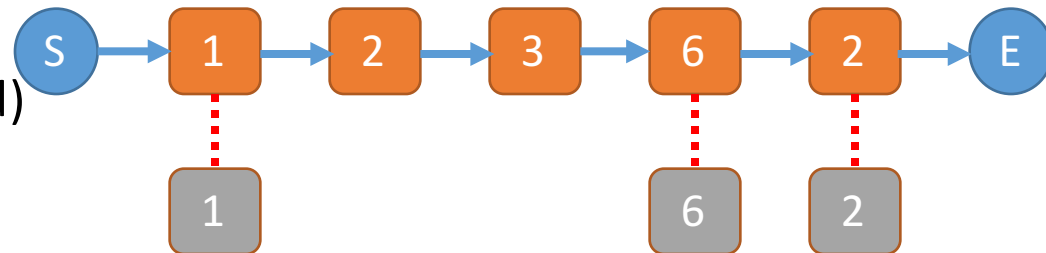
- **Depth-first strategy (cascade assumption)**
 - Users examine search result lists from top to bottom
 - Accepted by most existing click models



Examine
(unobserved)

Click
(observed)

Reorganize data with
cascade assumption



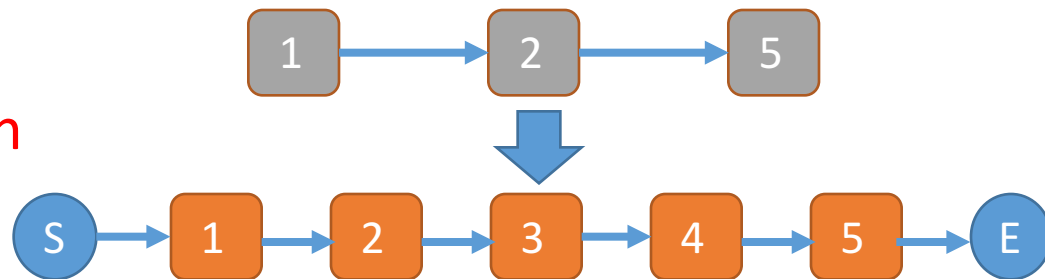
Problem#1: not the true **last click**

Problem#2: **sequential information** is missing

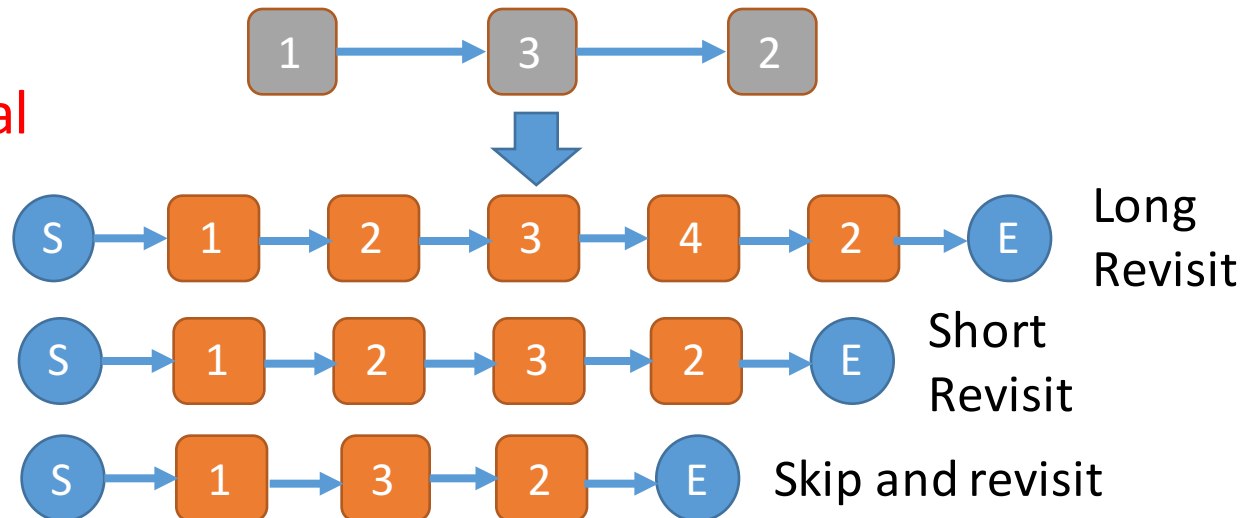
Non-sequential Examination Problem

- Why is it difficult to retain sequential information

Cascade assumption



Retaining Sequential Information



Non-sequential Examination Problem

- Any rules in users' non-sequential examination?
- How often do users change the direction of examination between clicks?

click

examine



Non-sequential Examination Problem

- Any rules in users' non-sequential examination?
- How far do users' eye gazes jump after examining the current clicked result?

click

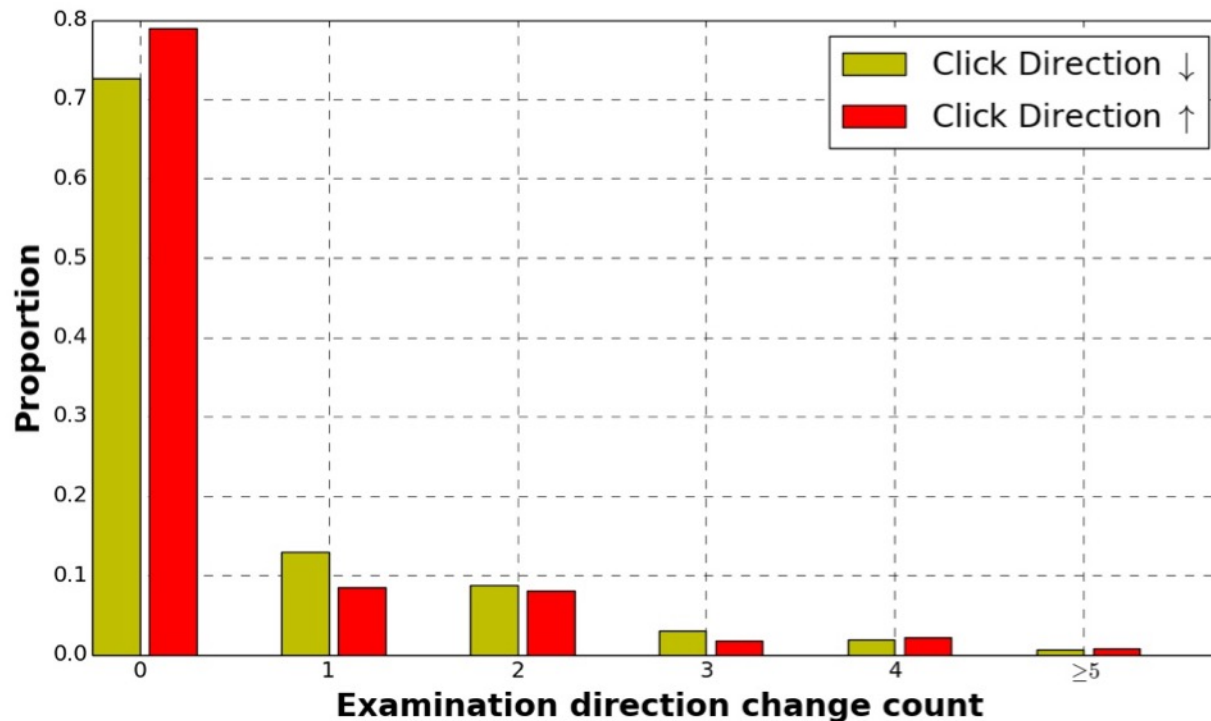
examine



Non-sequential Examination Problem

- **Locally Unidirectional Examination**

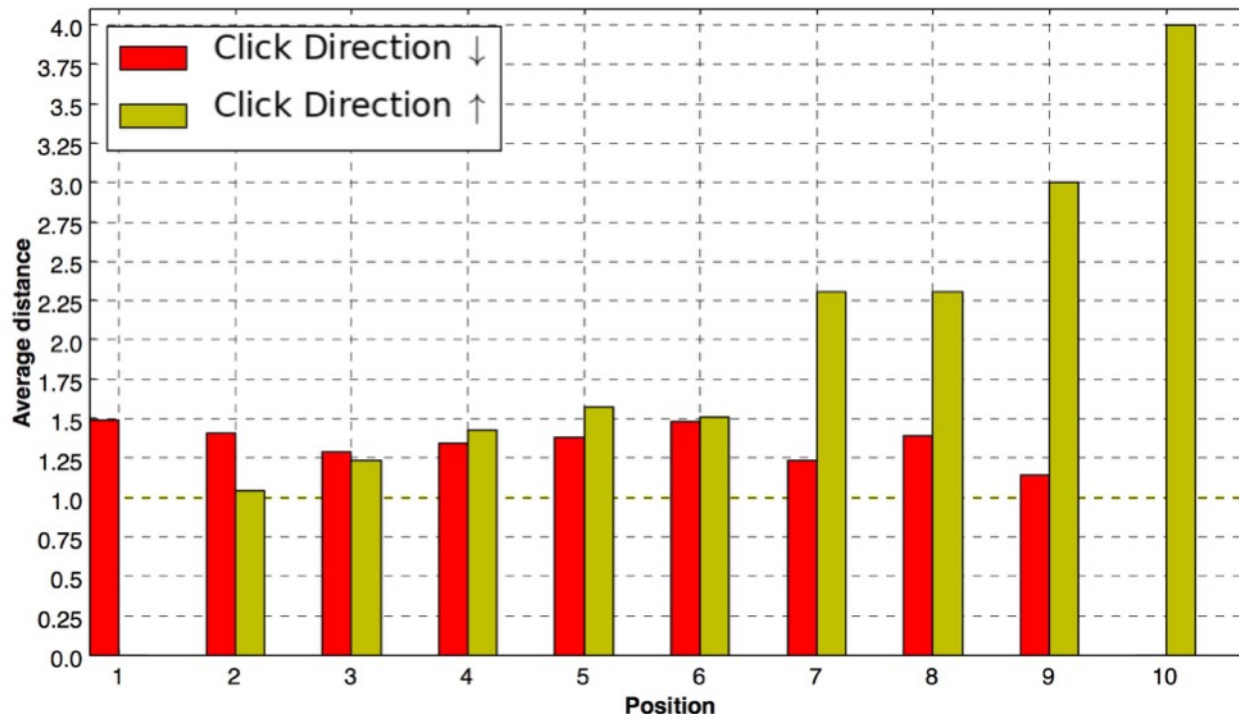
- Users tend to examine search results in a single direction without changes between clicks



Non-sequential Examination Problem

- **Non First-order Examination**

- Users may skip a few results and examine a result at some distance away from the current one after clicks

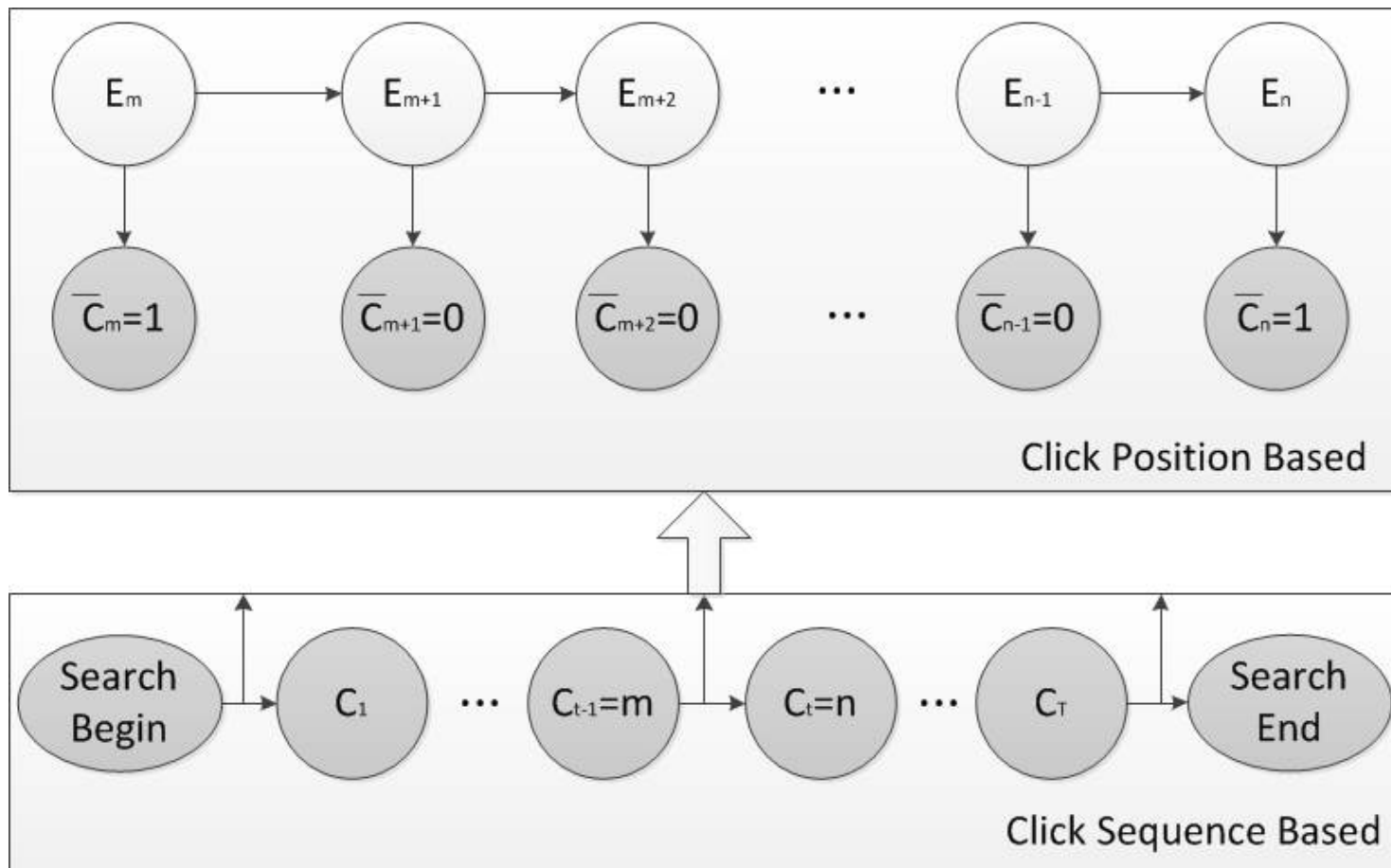


Non-sequential Examination Problem

- **Locally Unidirectional Examination Assumption**
 - Between adjacent clicks, user's examination direction is strictly consistent with click direction (\uparrow or \downarrow).
 - Compared with position based models: **Allow non-sequential click/examination sequence**
 - Compared with click sequence based models: **Reduce lots of examination sequences**
- **Non First-order Examination Assumption**
 - **Skipped results may not be examined**: Cascade model and DCM do not work, should try UBM

Non-sequential Examination Problem

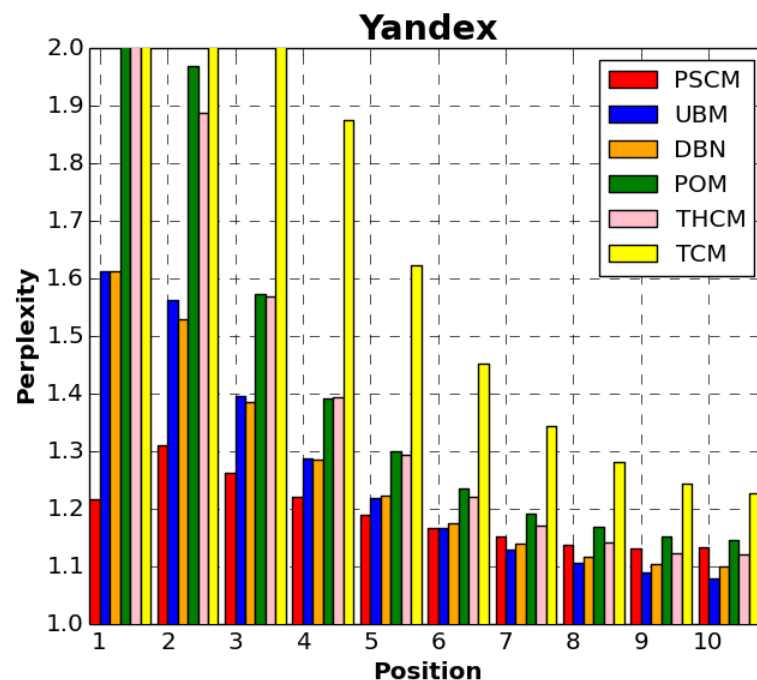
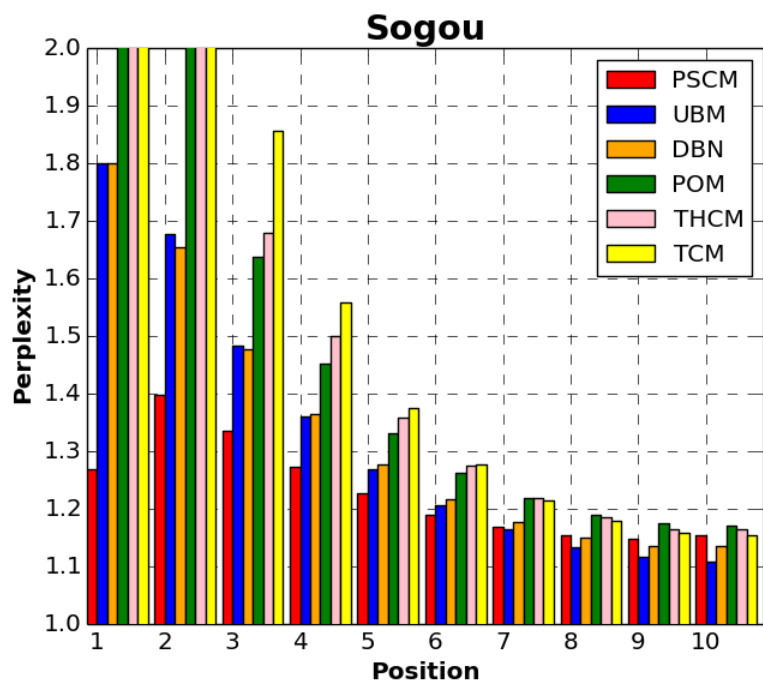
- Partially Sequential Click Model (PSCM)



Non-sequential Examination Problem

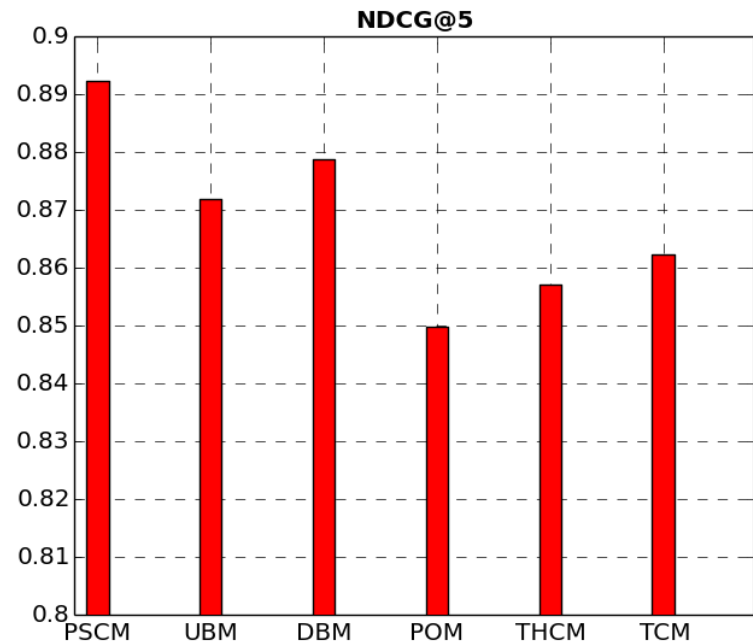
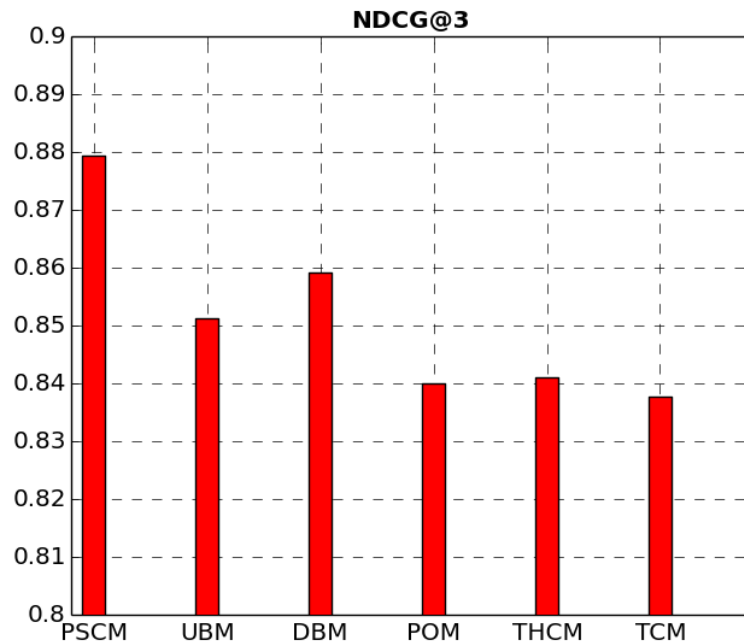
- **Experimental results: Perplexity**

- Compared with UBM (Sogou: +30.1%, Yandex: +27.4%)
- Compared with DBN (Sogou: +31.6%, Yandex: +27.9%)



Non-sequential Examination Problem

- **Experimental results: relevance estimation**
 - Query-URL Relevance Generated from Click Models
 - Annotated by Sogou's professional assessors



Non-sequential Examination Problem

- Experimental results: user preference test
 - 200 queries and 22 human assessors
 - Which ranking lists is preferred by real users

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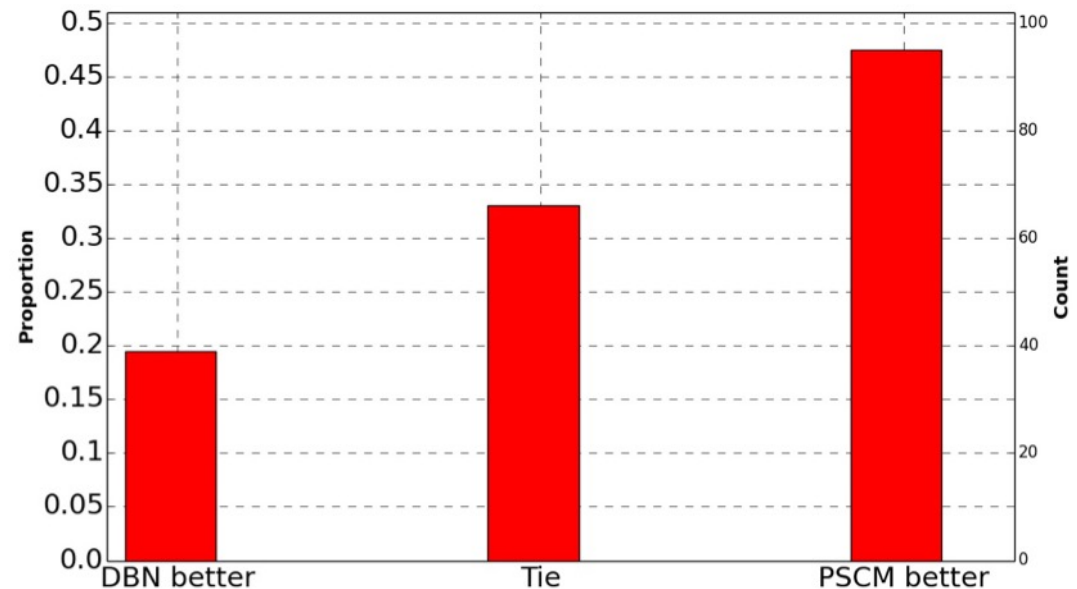
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羽球吧羽毛球网, 为球友提供羽毛球教学视频、最新羽毛球比赛直播视频、比赛规则、羽毛球知识, 分享打羽毛球经验; 羽球吧有你更精彩; 网址: www.yuqiuba.com。
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Take-Home Messages

- ***Presentation bias problem:***
a click model incorporating vertical results
 - **Attractiveness** effect; **Cut-off** effect: for organic results;
Restart effect: different examination sequence
- ***Non-sequential examination problem:***
a click model incorporating revisiting behaviors
 - Non-sequential examination happens a lot : **Locally unidirectional** and **non First-order** patterns



Reference

- (**Presentation bias problem**) Chao Wang, *Yiqun Liu*, Min Zhang, Shaoping Ma, Meihong Zheng, Jing Qian, Kuo Zhang. Incorporating Vertical Results into Search Click Models. **The 36th ACM SIGIR conference (SIGIR 2013)**
- (**Non-sequential examination problem**) Chao Wang, *Yiqun Liu*, Meng Wang, Ke Zhou, Jian-Yun Nie, Shaoping Ma, Incorporating Non-sequential Behavior into Click Models. **The 38th ACM SIGIR conference (SIGIR2015)**
- (**Vertical Examination problem**) Liu Zeyang, *Yiqun Liu*, Ke Zhou, Min Zhang, Shaoping Ma, Influence of Vertical Result in Web Search Examination. **The 38th ACM SIGIR conference (SIGIR2015)**
- **Codes are available on** <https://github.com/THUIR/PSCMModel>

Thank you



Dataset is available for academic use:

Eye fixations, mouse movement features,
clicks, relevance annotation, examination
feedback, ...

<http://www.thuir.cn/group/~YQLiu/>