# Freshness Matters

## - In Flowers, Food, and Web Authority -

Andreas Sander

*Hot Topics in Information Retrieval, WS 10/11*

15th November 2010

# Overview

# Why do we need freshness in web authority rankings?

Freshness is all about links & pages which were created or changed recently.

Contrary to that: stale pages and links.


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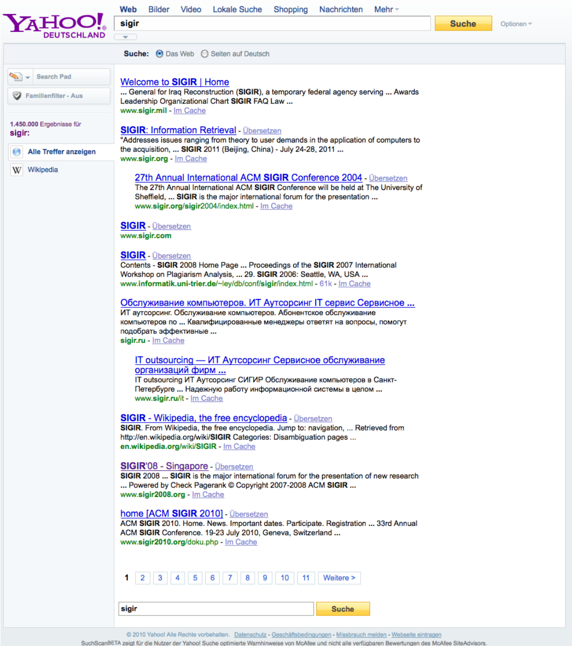
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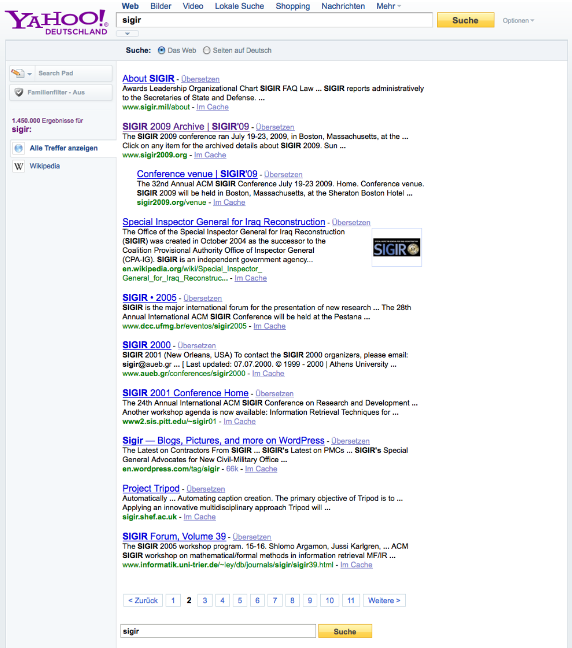
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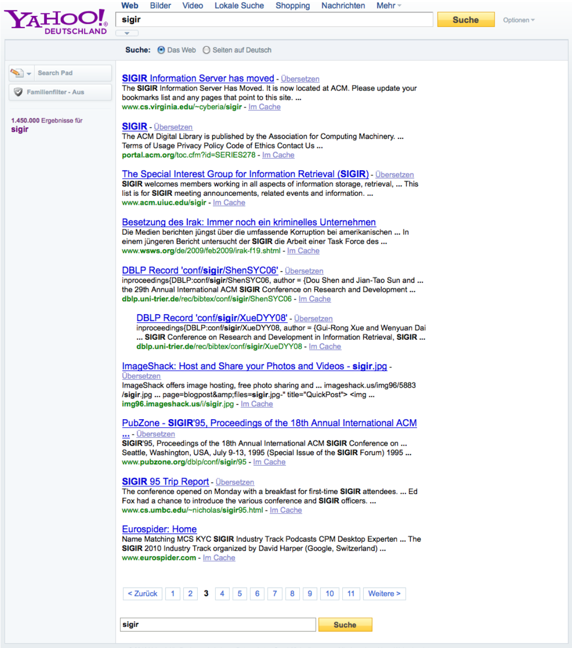

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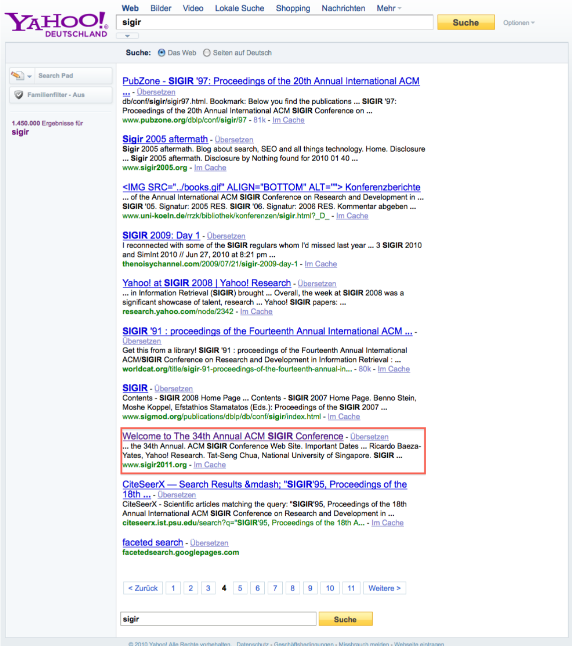
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It is a common strategy to estimate the page authority by accumulation of in-link (links pointing to the specific site) contributions (e.g. PageRank).

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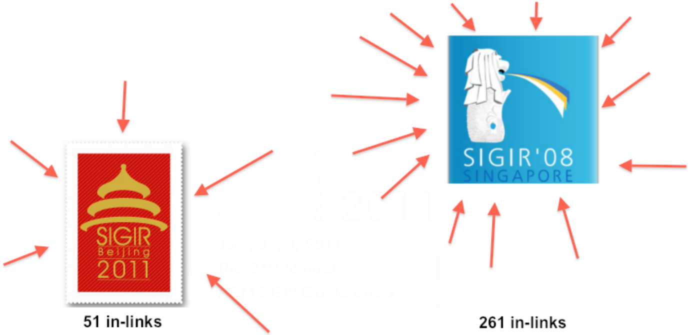

Millions of people (interested in web activities) change web link-structure and content day by day.


Figure: Various Web 2.0 Tools (Source: Flickr User pipeapple)

Millions of people (interested in web activities) change web link-structure and content day by day.

BUT

Web authority of a webpage is often computed based on a single website snapshot.


Figure: Various Web 2.0 Tools (Source: Flickr User pipeapple)

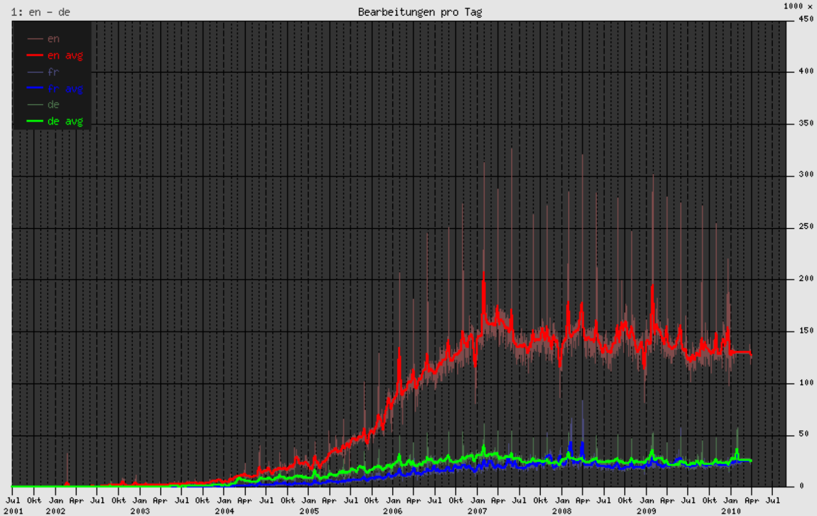


Figure: Wikipedia Statistic: Average Changes per Day (Source: Wikipedia)

| # | Seite | Namensräume | Bearb. (30 T.) | Bearb. |
|---|---|---|---|---|
| 1 | Wikipedia:Vandalismusmeldung | 4 | 3891 | 3891 |
| 2 | Wikipedia:Auskunft | 4 | 3079 | 3079 |
| 3 | Wikipedia:Auskunft/alt6 | 4 | 2647 | 5143 |
| 4 | Wikipedia:Fragen zur Wikipedia | 4 | 2582 | 3660 |
| 5 | Wikipedia:Kandidaten für exzellente Bilder/Archiv2 | 4 | 1737 | 4843 |
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| 10 | Wikipedia:Importwünsche | 4 | 880 | 4524 |
| 11 | Wikipedia:Löschkandidaten/8. Juni 2009 | 4 | 849 | 850 |
| 12 | Wikipedia:Löschkandidaten/13. Juni 2009 | 4 | 842 | 842 |
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| 17 | Wikipedia:Löschkandidaten/11. Juni 2009 | 4 | 764 | 765 |
| 18 | Wikipedia:Administratoren/Anfragen | 4 | 747 | 3710 |
| 19 | Wikipedia:Löschkandidaten/23. Juni 2009 | 4 | 744 | 744 |
| 20 | Wikipedia:Persönliche Bekanntschaften/neue Einträge | 4 | 742 | 9519 |

Figure: Wikipedia Statistic: Top 20 Wikipedia Sites (Germany) with the most changes from 01.06.2009 to 30.06.2009 (Source: Wikipedia)


Figure: Picture from Flickr

# Overview

PageRank [Lawrence Page & Sergey Brin, 1998]

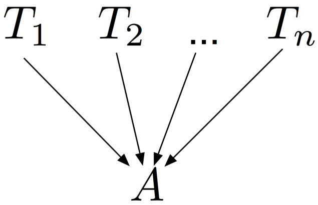
- is the most popular ranking algorithm.
- concept is based on a site's in-links (links pointing to the specific site).
- represents the probability that a random web-surfer model enters a page.

# Moves of the Random Web Surfer Model

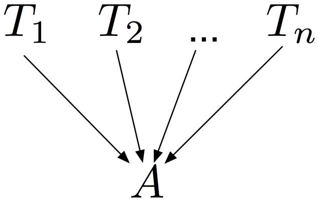
In every step the random web surfer model either follows an out-linked page **OR** does a random jump to any page.

# The PageRank Algorithm

Assuming n pages $T_1$, $T_2$, $\cdots$, $T_n$ link to a page A.



# The PageRank Algorithm




Assuming n pages $T_1$, $T_2$, $\cdots$, $T_n$ link to a page A.

Then

$$PR(A) = \frac{1-d}{N} + d \cdot \left(\frac{PR(T_1)}{C(T_1)} + \cdots + \frac{PR(T_n)}{C(T_n)}\right)$$

with

N: # of overall pages

d: damping factor ($0 \leq d \leq 1$) and

$C(T_i)$: # of out-links of $T_i$, $1 \leq i \leq n$.

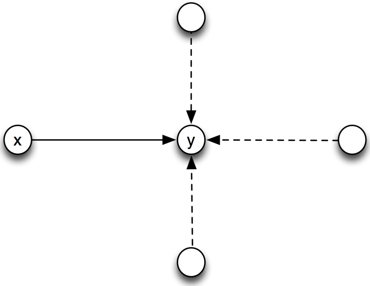
No freshness of links and pages is considered here!

T-Rank [K. Berberich et al, 2005]

- is build upon the PageRank idea & algorithm.
- extends PageRank algorithm with a bias for following an out-link and jumping to a new page to introduce freshness of pages and links.

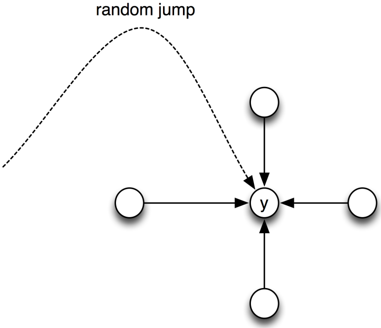
The probability that a random surfer is clicking at page x on an out-link to page y is a weighted combination of

- freshness of page y,
- freshness of the link from x to y and
- average freshness of all incoming links of y.



The probability that a random surfer takes a random jump to page y is a weighted combination of

- freshness of page y,
- activity of page y,
- average freshness of all incoming links of y and
- average activity of the pages that link to y.



# The T-Rank Algorithm

$$r(y) = (1-\varepsilon)\cdot s(y) + \sum_{(x,y)\in E} \varepsilon \cdot t(x,y)\cdot r(x)$$

with

$\varepsilon$: probability that a random surfer is clicking on an out-link

$(1-\varepsilon)$: probability that a random surfer makes a random jump to a page.

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$s(y)$: the random jump probability

$t(x,y)$: the transition probability

# The T-Rank Algorithm

- T-Rank is based on the fact that the users have a specific temporal focus of attention where the user is interested in.
- Freshness and activity computation is based on that temporal focus.

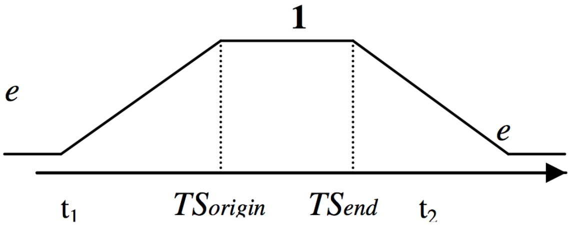



Figure: Temporal proximity window for a temporal interval

# The T-Rank Algorithm

T-Rank is based on a good approach, BUT:

Activities at different time points are not distinguished.

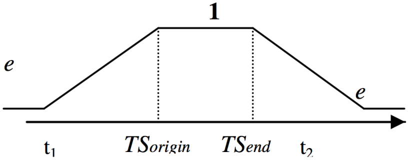



Figure: Temporal proximity window for a temporal interval

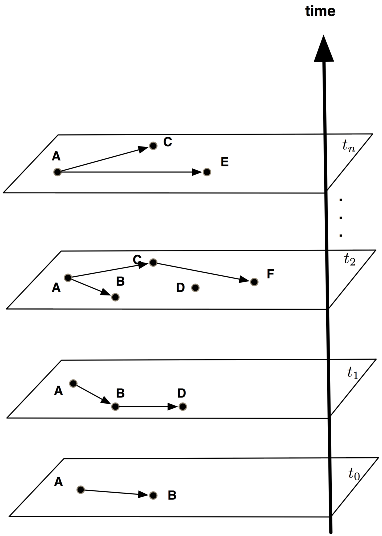
Instead, influence of activities on web freshness should decay over time.

# Overview

Probabilistic algorithm to estimate web page authority by considering two temporal aspects:

1. Web freshness
2. Multiple snapshots collected at different timepoints

   $t_0,\ t_1,\ \cdots, t_n.$



## Web Freshness

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- computation is based on temporal page profiles and temporal link profiles.

# The Web Freshness Computation

Computation of the in-link and page freshness at a certain time point $t_i$:

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$$InF(p)_{t_i} = \beta_1 e^{-\beta_2 \Delta t} InF(p)_{t_{i-1}} + \Delta InF(p)|_{t_{i-1}}^{t_i}$$

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How can we compute $\Delta InF(p)|_{t_{i-1}}^{t_i}$ and $\Delta PF(p)|_{t_{i-1}}^{t_i}$?

# In-Link Activites

| Link activity | | Infl. on $p$'s InF | Gain of $p$'s InF ($\omega_j$) |
|---|---|---|---|
| 1 | creation of link $l : q \rightarrow p$ | $\uparrow\uparrow\uparrow$ | 3 |
| 2 | update on link $l : q \rightarrow p$ (changed anchor) | $\uparrow\uparrow$ | 2 |
| 3 | update on link $l : q \rightarrow p$ (unchanged anchor) | $\uparrow$ | 1.5 |
| 4 | removal of link $l : q \rightarrow p$ | $\downarrow\downarrow$ | -0.5 |

# Computation of $\Delta InF(p)|_{t_{i-1}}^{t_i}$

$$\Delta InF_0(p)|_{t_{i-1}}^{t_i} = \sum_{l:q \to p} \sum_{j \in LA} \omega_j C_j(l)$$

with

$C_j(l)$ : # of the $j^{th}$ type of link activity on link l in $[t_{i-1}, t_i]$.

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$$\Delta InF(p)|_{t_{i-1}}^{t_i} = \lambda_{InF}\, \Delta InF_0(p)|_{t_{i-1}}^{t_i} + (1-\lambda_{InF}) \sum_{l:q\to p} m_{qp}\, \Delta InF(q)|_{t_{i-1}}^{t_i}$$

with

$C_j(l)$ : # of the $j^{th}$ type of link activity on link l in $[t_{i-1}, t_i]$.
$m_{qp}$ : one-step transition probability from q to p with $\sum m_{q*} = 1$

# Page Activities

$\omega_j^{'}$

| Page activity | | Infl. on $q$'s PF | Gain of $q$'s PF |
|---|---|---|---|
| 1 | creation of page $q$ | $\uparrow\uparrow\uparrow$ | 3 |
| 2 | update on page $q$ | $\uparrow$ | 1.5 |
| 3 | removal of page $q$ | $\downarrow\downarrow$ | -0.5 |

# Computation of $\Delta PF(q)|_{t_{i-1}}^{t_i}$

$$\Delta PF_0(q)|_{t_{i-1}}^{t_i} = \sum_{j \in PA} \omega_j^{'} C_j^{'}(q)$$

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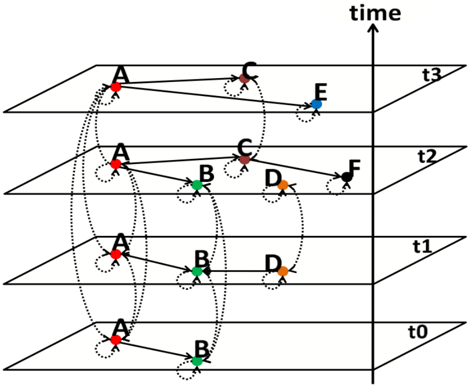
with

$C_j^{'}(q)$ : # of the $j^{th}$ type of page activity on page q in $[t_{i-1}, t_i]$.
$m_{qp}^{'}$ : Inverted one-step transition probability from q to p with $\sum m_{*p} = 1$

How to use web freshness to control authority propagation in an archival link graph?



# Extended Temporal Random Surfer Model

The difference between PageRank's surfer model and this model is:

- The extended model has specific temporal intent
- The extended model can choose a snapshot for targeted page (based on the temporal intent).
- The extended model prefers fresh web resources.

# Moves of the Surfer

A move of the extended surfer model takes the following steps:

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A move of the extended surfer model takes the following steps:

1. Follow an out-linked page **OR** do a random jump to any page at the same timepoint. (see PageRank surfer model)
2. After reaching target page, choose the snapshot based on the temporal intent.

# Goal

Use a semi-Markov process for page authority estimation.

Long-run proportion of time that the Markov process is in state i is given by:

$$A(i) = \frac{\pi_i \mu_i}{\sum_{j=1}^{N} \pi_j \mu_j}, \; i = 1, 2, \cdots, N$$

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with

$\pi_i$ : probability that markov process reaches state i

$\mu_i$ : mean time process is remaining at state i.

# Computation of $\pi_{p,i}$

How to compute the probability $\pi_{p,i}$ that a web surfer reaches page p at snapshot $t_i$?

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$$P_{t_j}(Follow|q) = (1-d) \qquad P_{t_j}(Jump|q) = d$$

$$P_{t_j}(p|q, Follow) = F_{t_j}(p,q) \qquad P_{t_j}(p|q, Jump) = \frac{1}{N_{t_j}}$$

with

$F_{t_j}(p,q)$ : web surfer's preference for following out-linked pages

$N_{t_j}$ : total # of pages at $t_j$

# Computation of $\pi_{p,i}$

Due to the fact, that fresh web resources are likely to attract surfer's attention, we define:

$$F_{t_j}(p,q) = \frac{PF_{t_j}(p)}{\sum\limits_{p':q \rightarrow p'} PF_{t_j}(p')}$$

# Computation of $\pi_{p,i}$

Probability that a surfer reaches page p at $t_i$ from page p at $t_j$ is

$$P_{t_i|t_j}(p) = \frac{\omega(t_i,t_j)}{\sum\limits_{V_k : p \in V_k, t_k \in T_i} \omega(t_i,t_k)}$$

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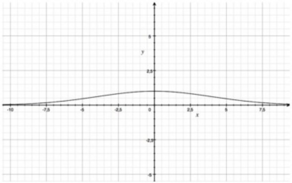
with

$\omega(t_i, t_k)$ : weight that represents the influence between the snapshots at $t_i$ and $t_k$ (modeled with kernels)

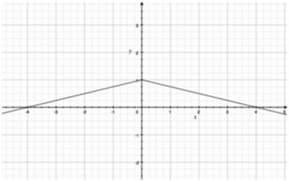
$V_j$: set of pages at time point $t_j$

$T_i$ : set of snapshots which can directly distribute authority to $t_i$ within one step (depending on window size $|T|$).

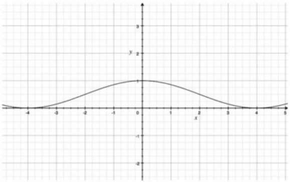
**Kernels for |T|=4**



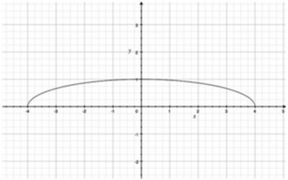
Gaussian Kernel



Triangle Kernel



Cosine Kernel



Circle Kernel

# Computation of $\pi_{p,i}$

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Probability that a web surfer reaches page p at snapshot $t_i$:

$$\pi_{p,i} = \sum_{t_j \in T_i} P_{t_i|t_j}(p) \sum_{q:q \to p|t_j} P_{t_j}(Follow|q) P_{t_j}(p|q, Follow) \pi_{q,j}$$

with

$T_i$ : set of snapshots which can directly distribute authority to $t_i$ within one step (depending on window size $|T|$).

## Computation of $\pi_{p,i}$

Probability that a web surfer reaches page p at snapshot $t_i$:

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$$+ \sum_{t_j \in T_i} P_{t_i|t_j}(p) \sum_{q|t_j} P_{t_j}(Jump|q) P_{t_j}(p|q, Jump) \pi_{q,j}$$

with

$T_i$ : set of snapshots which can directly distribute authority to $t_i$ within one step (depending on window size $|T|$).

# Computation of $\mu_{p,i}$

How to compute the average staying time $\mu_{p,i}$ that a web surfer surfs on page p at snapshot $t_i$?

# Computation of $\mu_{p,i}$

- Pages with more in-link activity are likely to attract a surfer to spend time browsing it.
- Using in-link freshness to model the time of a surfer staying on a web page.

## Computation of $\mu_{p,i}$

$$\mu_{p,i} = \sum_{t_j \in T'_{t_i}} \omega'(t_i, t_j) InF(p)_{t_j}$$

with

$T'_{t_i}$: Set of snapshots included in the sliding window centered on $t_i$

$\omega'(t_i, t_j) = \frac{1}{|T'_{t_i}|}$ for any $t_j \in T'_{t_i}$

$$\sum_{t_j \in T'_{t_i}} \omega'(t_i, t_j) = 1$$

# Final Computation

$$A(p,i) = \frac{\pi_{p,i}\mu_{p,i}}{\sum_{j=1}^{n}\sum_{q \in V_j} \pi_{q,j}\mu_{q,j}}$$

with

n: # of snapshots

$V_j$: set of pages at time point $t_j$

# T-Fresh & Attributes

## T-Fresh(kernel, window, snapshot)

kernel: The kernel controlling authority propagation among different web snapshots

window: The window size used in calculating average in-link freshness for estimating staying time

snapshot: The number of month spanned over the temporal graph.

# Overview

# Experimental Setup

- Used archival web pages in the .ie domain (collected from January 200 to December 2007)

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- Corpus contained 158 million web pages and 12 billion temporal links

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- Time period of interest was April 2007.

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- For each query 84.6 URLs on average were judged according to freshness and relevance by human editors.

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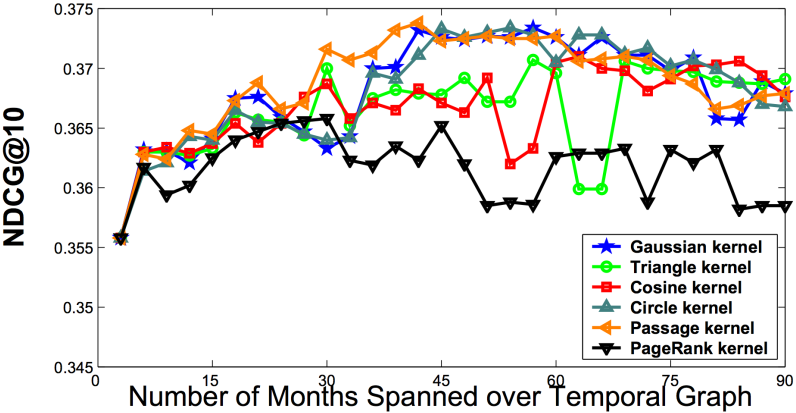
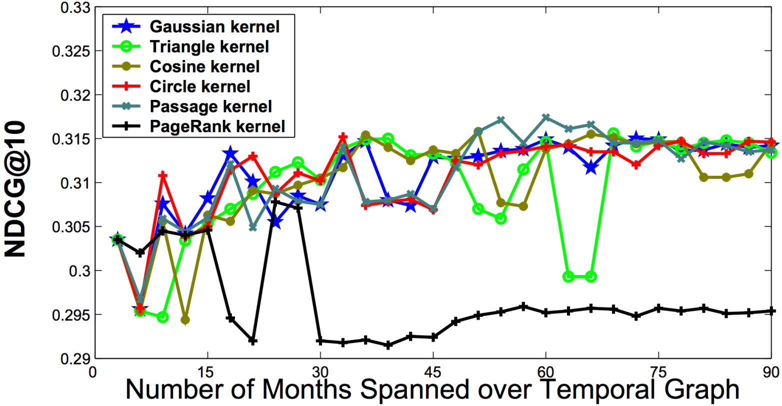
- For each query 84.6 URLs on average were judged according to freshness and relevance by human editors.
- For judging about ranking qualities two metrics were used: the Normalized Discounted Cumulative Gain (NDCG) and Precision@k.

# Experimental Results




(a) Relevance performance: NDCG@10




(b) Freshness performance: NDCG@10

| Relevance | | | | |
|---|---|---|---|---|
| Method | P@10 | NDCG@3 | NDCG@5 | NDCG@10 |
| BM25 | 0.4695 | 0.2478 | 0.2740 | 0.3344 |
| PageRank | 0.4894 | 0.2589 | 0.2840 | 0.3457 |
| BuzzRank | 0.4770 | 0.2770 | 0.2980 | 0.3460 |
| TemporalRank | 0.4841 | 0.2706 | 0.2875 | 0.3524 |
| TimedPageRank | 0.5031 | 0.2830 | 0.3063 | 0.3587 |
| T-Random | 0.4904 | 0.2690 | 0.2877 | 0.3495 |
| T-rank | 0.4875 | 0.2669 | 0.2870 | 0.3496 |
| T-Fresh(1,1,30) | **0.5051** | **0.3229** | **0.3347** | **0.3729** |
| **Freshness** | | | | |
| Method | P@10 | NDCG@3 | NDCG@5 | NDCG@10 |
| BM25 | 0.3138 | 0.2137 | 0.2379 | 0.2805 |
| PageRank | 0.3325 | 0.1946 | 0.2345 | 0.2838 |
| BuzzRank | 0.3327 | 0.2043 | 0.2234 | 0.2797 |
| TemporalRank | **0.3473** | 0.2312 | 0.2510 | 0.2992 |
| TimedPageRank | 0.3398 | **0.2443** | 0.2514 | 0.2972 |
| T-Random | 0.3316 | 0.2054 | 0.2403 | 0.2879 |
| T-rank | 0.3356 | 0.2269 | 0.2498 | 0.2950 |
| T-Fresh(1,1,30) | 0.3412 | 0.2411 | **0.2662** | **0.3076** |

# Future Work

Sensitivity of web activity detection accuracy.

Try as best as possible to find a way to close the gap caused by some pages having archival copies and some without in the searching process.

# Strengths and Weakness of the Paper

| Good | Bad |
|---|---|
| Nice background informations<br><br>Good explanations of the ideas | Wrong formulas<br><br>Improvable detailed explanations |

Thank you for your attention!