

Page Rank

What's the big deal?

Life before PageRank



Life after PageRank

I will use Google before asking dumb questions. www.mrburns.nl before asking dumb questions. I will use Google before asking dumb questions I will use Google before asking dumb questions. I will use Google before asking dumb questions.



Evolution of the web



Idea #I: Centralization



Idea #I: Centralization



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Archie (1990)







Veronica (1992)

Evolution of the web



Idea #2: Relevancy

Given a query, how do we know what to retrieve?

I.Web directories



2. More sophisticated indexing methods

Filename \longrightarrow Description \longrightarrow Content

The index size war



Evolution of the web



Idea #3: Ranking

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Page Rank How it works ...

Main idea

A page is important if it is pointed to by other important pages



The Algorithm

Given a web graph with n nodes, where the nodes are pages and edges are hyperlinks

- Assign each node an initial page rank
- repeat until convergence

calculate the page rank of each node (using the equation in the previous slide)

Example



	Iteration 0	Iteration I	Iteration 2	Page Rank
P	I/5	1/20	1/40	5
P ₂	I/5	5/20	3/40	4
P ₃	I/5	1/10	5/40	3
P ₄	I/5	5/20	15/40	2
P ₅	I/5	7/20	16/40	I

 $r_1(P_5) = 1/5 + 1/5 \times 1/4 + 1/5 \times 1/2 = 7/20$

Matrix representation

1/20		0	0	1/4 0	0	1/5
5/20		I	0	I/4 0	0	1/5
1/10	=	0	0	0 1/2	0	1/5
5/20		0	0	I/4 0	I	1/5
7/20		0		1/4 1/2	0	I/5

 $r^{(t+1)} = H$

Three Questions

 $r^{(t+1)} = H r^{(t)}$ Also known as the power method

- Does this converge?
- Does it converge to what we want?
- Are the results reasonable?

Does it converge?



	Iteration 0	Iteration I	Iteration 2	Iteration 3
P		0		0
P ₂	0	Ι	0	Ι

Does it converge to what we want?

$) \longrightarrow 2$

	Iteration 0	Iteration I	Iteration 2	Iteration 3
P		0	0	0
P ₂	0	I	0	0

Does it converge to what we want?



Page ranks to converge to 0.

Looks a lot like ...

 $\mathbf{r}^{(t+1)} = \mathbf{H} \mathbf{r}^{(t)}$

Markov Chains

Set of states X

Transition matrix P where $P_{ij} = P(X_t=j | X_{t-1}=i)$

 π specifying the probability of being at each state $x \in X$

Goal is to find π such that $\pi = P \pi$

Why is this analogy useful?

There exists a theory about Markov chains that says that for any start vector, the power method applied to a Markov transition matrix P will converge to a unique positive stationary vector as long as P is stochastic, irreducible and aperiodic.

Make H stochastic

 $S = H + a(I/n e^{T})$



0	1/5	/4	0	0
	1/5	/4	0	0
0	1/5	0	1/2	0
0	1/5	/4	0	
0	1/5	1/4	1/2	0

Make H aperiodic

A chain is periodic if there exists k > 1 such that the interval between two visits to some state s is always a multiple of k.



Make H irreducible

From any state, there is a non-zero probability of going from one state to another.





The Random Surfer Model: for each page, time spent \propto importance.

Are the results reasonable? $G = \alpha S + (1-\alpha) I/n ee^T$ G is stochastic, aperiodic and irreducible. $r^{(t+1)} = G r^{(t)}$

G is dense but computable using the sparse matrix H.

$$G = \alpha S + (I-\alpha) I/n ee^{T}$$

= $\alpha (H + I/nae^{T}) + (I-\alpha) I/n ee^{T}$
= $\alpha H + (\alpha a + (I-\alpha)e) I/n e^{T}$

Page Rank The problems

The Rich Gets Richer



(Cho et al, 04)

Google Bombs

Web Results 1 - 10 of about 969,000 for miserable failure. (0.06 seconds) Biography of President George W. Bush Biography of the president from the official White House web site. www.mikehouse gov/president/gowbio km1 - 29k Cached - Similar pages Past Presidents - Kids Only - Current News - President More results from www.wikehouse.gov.s Welcome to MichaelMoore com! Official step of godge of corporations, creator of the film Roger and Me and the television show The Awful Truth. Includes mailing list, message board, www.michaelmoore.com/ - 35k - Sep 1, 2005 - Cached - Similar pages BEC NEWS Americas : Miserable failure' links to Bush Web users manipulate a popular search engine so an unflattering description leads to the president's page. mesw bbc. co.uk/2/hu/americas/329443.stm - 31k - Cached - Similar pages Google's (and Inktomi's) Miserable Failure Mes alte. Origine as official George W. Bush biography form the US White House web site. Dismissed by Google as not a search for miserable failure on Google bings up the official George W. Web Search for miserable failure on Google bings up the official George W. Web Search for miserable failure on Google bings up the official George W. Search or your computer - Hide - About Search for miserable failure on Google bings up the official George W. Search or your computer - Hide - About Search for miserab	Google Web Image	s <u>Groups News Froogle</u> Local more	Advanced Search Preferences
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Jew Watch News
The most comprehensive and easiest to use website dedicated to both current and historical
Jewish news, organizations, goals and related information.

Google Bombs



Did you mean: french military defeats

No standard web pages containing all your search terms were found.

Your search - french military victories - did not match any documents.

Suggestions:

- Make sure all words are spelled correctly.
- Try different keywords.
- Try more general keywords.
- Try fewer keywords.

Also, you can try Google Answers for expert help with your search.

Google Home - Advertise with Us - Search S

These Weapons of Mass Destruction cannot be displayed

The weapons you are looking for are currently unavailable. The country might be experiencing technical difficulties, or you may need to adjust your weapons inspectors mandate.

Please try the following:

- Click the 🕞 Regime change button, or try again later.
- If you are George Bush and typed the country's name in the address bar, make sure that it is spelled correctly. (IRAQ).
- To check your weapons inspector settings, click the UN menu, and then click Weapons Inspector Options. On the Security Council tab, click Consensus. The settings should match those provided by your government or NATO.
- If the Security Council has enabled it, The United States of America can examine your country and automatically discover Weapons of Mass Destruction.
 If you would like to use the CIA to try and discover them, click <u>Detect weapons</u>
- Some countries require 128 thousand troops to liberate them. Click the Panic menu and then click About US foreign policy to determine what regime they will install.
- If you are an Old European Country trying to protect your interests, make sure your options are left wide open as long as possible. Click the **Tools** menu, and then click on

Link Farms



Link Farms

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(Wu and Davison, 05)

Take-home



Ranking is important.

Relationship between links and the importance of pages.

Why PageRank converges (to the right answer).

How link-based ranking methods can be manipulated.



