Practical Data Science – COSC2670

Textual Data: Query Suggestions for Search

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Outline

- Query suggestions and related searches
- Search engine query logs
- Approaches for search suggestions
  - Session-based
  - Click data
  - Statistical (relevance feedback)

Query Suggestions

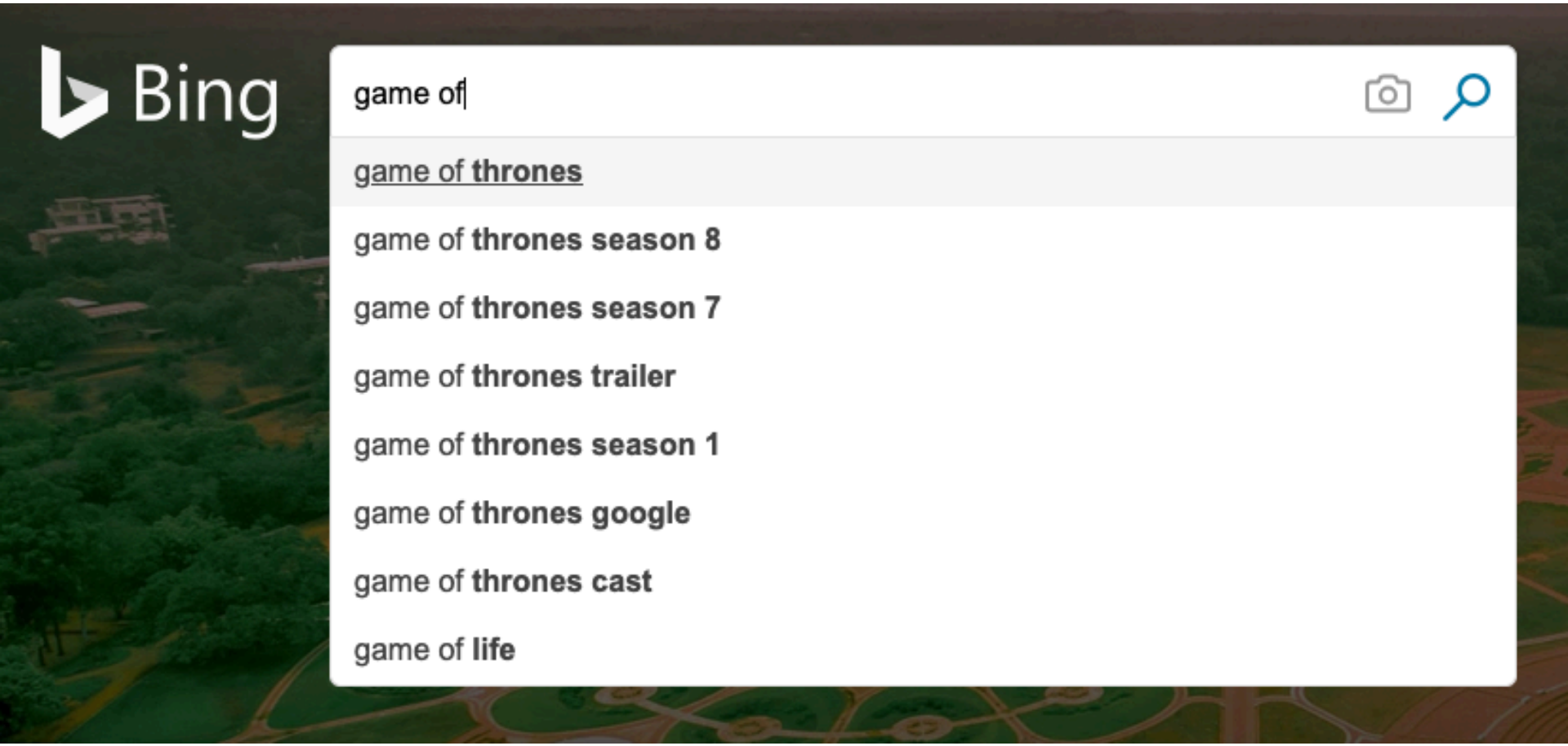
Game of …. ?

game of

game of **thrones**
game of **thrones season 8**
game of **thrones cast**
game of **thrones season 7**
game of **thrones season 8 release date**
game of **thrones season 1**
game of **thrones season 8 trailer**
game of **thrones episodes**
game of **thrones characters**
game of **thrones map**

Google Search I'm Feeling Lucky

Report inappropriate predictions

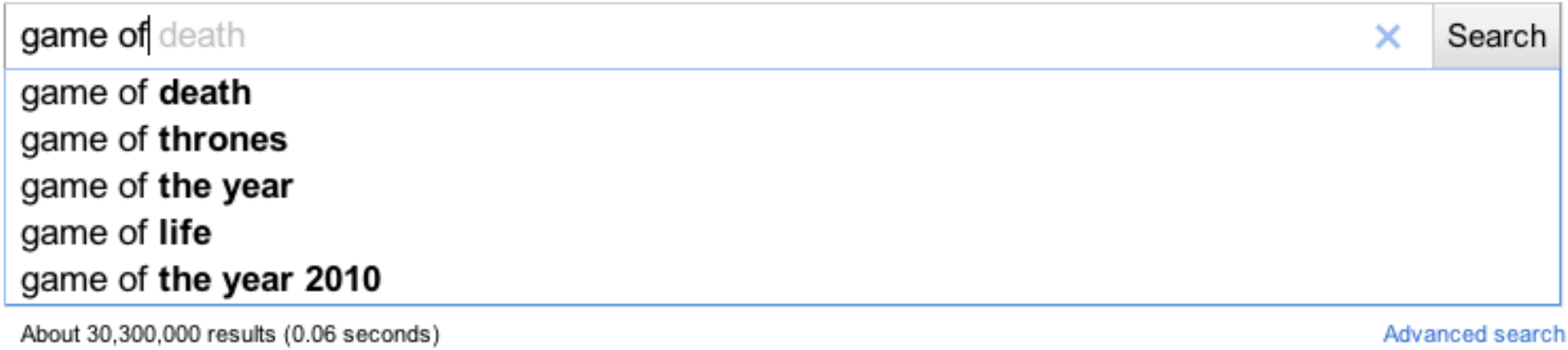

Bing
game of
game of thrones
game of thrones season 8
game of thrones season 7
game of thrones trailer
game of thrones season 1
game of thrones google
game of thrones cast
game of life

DuckDuckGo

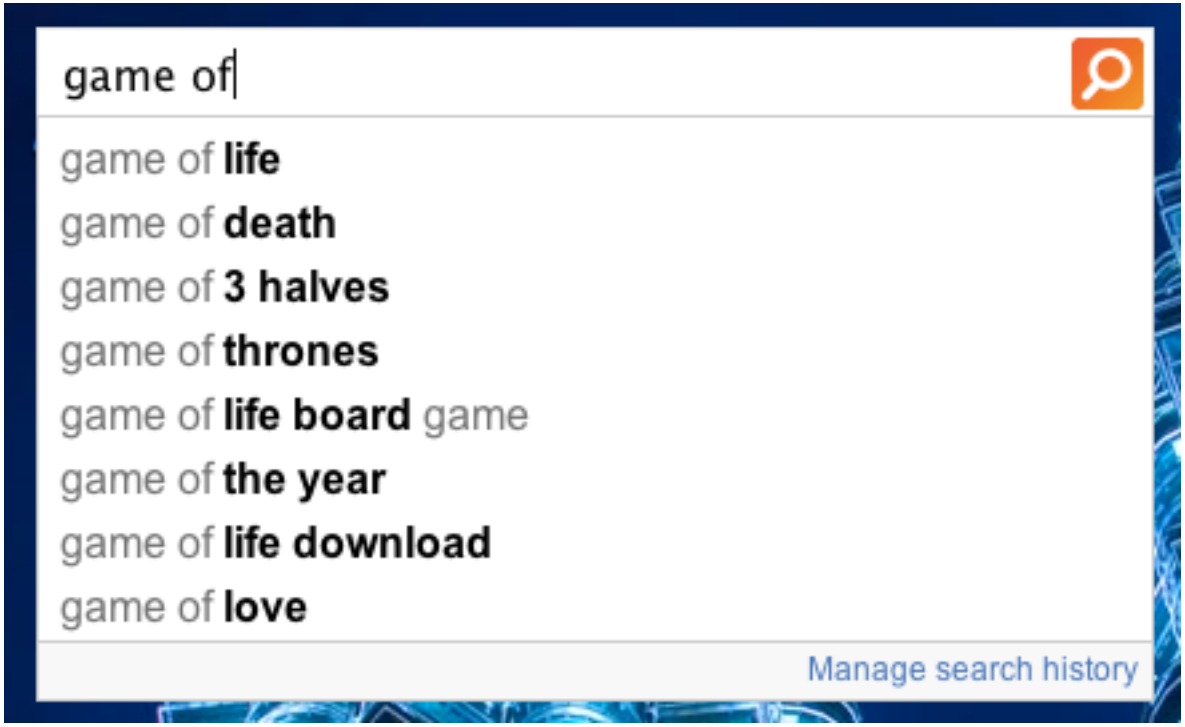
game of

- game of **thrones**
- game of **thrones season 8**
- game of **thrones cast**
- game of **thrones trailer**
- game of **thrones characters**
- game of **thrones map**
- game of **thrones wiki**
- game of **thrones books**

Google 2010


game of death
Search
game of **death**
game of **thrones**
game of **the year**
game of **life**
game of **the year 2010**
About 30,300,000 results (0.06 seconds)
Advanced search

Bing 2010


game of
game of life
game of death
game of 3 halves
game of thrones
game of life board game
game of the year
game of life download
game of love
Manage search history

Location-based Differences

Google

mcg

- mcg **capacity**
- mcg **stadium**
- mcg **facts**
- mcg **today**
- mcg **history**
- mcg **events**
- mcg **unit**
- mcg **dose**

Report inappropriate predictions

www.mcg.org.au › about-us › about-the-mcg

About the MCG - Melbourne Cricket Ground

The **MCG** is more than just a sports venue. It's a place where memories are made and childhood dreams come alive. Ask any Victorian and they'll be aware of ...

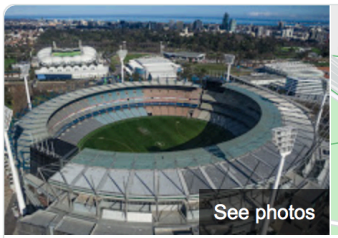
www.mcg.org.au › Tours

MCG Tours - Melbourne Cricket Ground

Go behind the scenes of one of the world's most iconic stadiums, the **MCG**. Located just minutes from the CBD, discover the secrets of the **Melbourne Cricket** ...

People also ask

- What is the meaning of MCG?
- What is the MCG made of?
- What is the size of the MCG?



Melbourne Cricket Ground

Website | Directions | Save

4.7 ★★★★½ 17,635 Google reviews

Ground in East Melbourne, Victoria

The Melbourne Cricket Ground, also known simply as "The G", is an Australian sports stadium located in Yarra Park, Melbourne, Victoria. Wikipedia

Address: Brunton Ave, Richmond VIC 3002

Capacity: 100,024

Opened: 1853

Owner: MCG Trust

Phone: (03) 9657 8888

Suggest an edit

Location-based Differences

mcg

- **mcgraw hill connect**
- **mcgregor**
- **mcgraw hill**
- **mcg to mg**
- **mcgill university**
- **mcg**
- **mcgriddle**
- **mcguffin**
- **mcgee and co**
- **mcgregor retired**

Google Search | I'm Feeling Lucky

Report inappropriate predictions

Related Searches

Game of Thrones
5 Apr 2011 ... A fan site dedicated to HBO's **Game of Thrones**, with News, Information and Comment.
www.**game-of-thrones**.co.uk/ - Cached - Similar

Variety Reviews - **Game of Thrones** - TV Reviews - - Review by Brian ...
10 Apr 2011 ... Westeros, a mythical land of seven kingdoms where dragons once lived is full of plotting, intrigue and fractious families on all sides, ...
www.variety.com/review/VE1117944992

Searches related to **game of thrones**

george rr martin	game of thrones **ccg**
game of thrones **hbo**	game of thrones **board** game
game of thrones **review**	game of thrones **rpg**
game of thrones **movie**	game of thrones **map**

Goooooooooogle

1 2 3 4 5 6 7 8 9 10 **Next**

Query Suggestions and Related Searches

- Provided by all major web search engines
- Currently the implementations look very similar
- Function as a kind of "*auto-complete*" feature
- Suggestions are *listed in a selection box*; related searches are embedded as *clickable links* in the results page
  - Both can be selected easily
- They are usually whole queries

Query Suggestion

- Suggested queries provided by search engines may differ based on various features
  - Location of user
  - Search history of user (if available)
  - Connection speed
  - Device being used (smartphone, tablet, computer, …)
  - Browsing or searching preferences (e.g. language settings)
- The suggestions that you and I see when we type in a query might be different

Why Provide Search Suggestions?

- Make life easier for the user
  - Less typing
  - Help to specify their information need
  - Disambiguate queries
  - Minimise spelling errors
- Make life easier for search engines
  - Reduces overall variability of queries entered
    - Efficiency benefits
    - Effectiveness benefits

Implementing Search Suggestions: Sources of Evidence

- There are three main sources of evidence that are used to generate query suggestions and related searches
  - Search sessions
  - Click data
  - Term statistics

Approach 1: Search Sessions

A Search Log

[16:34:02] Q: godzilla

[16:34:05] C (1): www.imdb.com/title/tt0831387/

[16:34:10] C (5): www.godzillamovie.com/

[16:36:39] Q: godzilla resurgence

[16:36:45] Q: shin gojira

[16:36:47] C (1): www.imdb.com/title/tt4262980/

[16:41:22] Q: python for data science

……

Search Logs

- Key items
  - Timestamps
  - Queries
  - Clicks (on answer items)
- Advantages
  - Provide direct evidence about searcher behaviour, in a natural setting
  - Once instrumentation is in place, gathering log data is relatively cheap
  - Can quickly accumulate large amounts of evidence

Search Logs: Complications

- Can be difficult to determine session boundaries
  - When does one search "task" end and another begin?
  - Non-linear search processes / tabbed browsing
- Amount of data can become a problem
  - 1k bytes/record x 10 records/query x 10 mil queries/day = 100 Gb/day
- What data can be collected
  - Privacy issues / Ethics considerations / Terms of service
- How to identify users
  - Cookies / IP address – but people might share a machine
  - Login / plugin – identifies users more reliably, but not all users will login/use plugin, so data will be limited

Search Logs: Complications…

- Key limitation: logs don't tell us **why** the user did something
- Instead, we need to make assumptions about what those observed actions mean
  - Did the user actually like the item that they clicked on?
  - Did they finish the search session because their information need was *resolved*, or because they were *frustrated* and gave up?

Session Data for Search Suggestions

- Given a query log ***L***, pre-process the log
  - Split into *sessions*
    - For example, based on an inactivity threshold (5 minutes) and a maximum session length (30 minutes)
  - For each query q_i in the log, count how often it has occurred with each other query q_j in the same session
- For a new user query q_{new}
  - Look up the query in the processed log data
  - Return the N most frequently co-occurring past user queries

Session Data for Search Suggestions…

- Query pairs and counts in 10,000,000 sessions
  - ….
  - <jaguar, jaguar wild cat> 3,251
  - <jaguar, jaguar car> 7,795
  - <jaguar, OSX jaguar> 1,406
  - <jaguar, movie jaguar > 341
  - <jaguar, jaguar drink> 2,599
  - …
- New query: *jaguar* → return:
  - jaguar car
  - jaguar wild cat
  - …

Session Data for Search Suggestions

- Query log pre-processing can be extremely resource intensive
  - But fortunately, can be done offline
  - Needs to be repeated periodically since search behaviour (and therefore trends) change over time
- After processing, the *suggestion* part can be implemented efficiently using a fast lookup data structure (such as a hash table, or a suffix array)

Approach 2: Click Data

Click Data for Search Suggestions

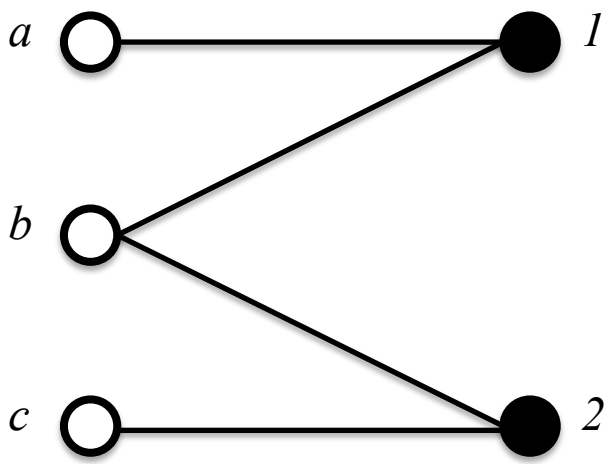
- In addition to finding direct relationships from query co-occurrences in a *search session*, can also use *click data* to try and identify new trends
- Intuition: if different queries lead to clicks on the same page, then those queries are related
- This approach uses a technique called *agglomerative clustering*

Agglomerative Clustering of Click Data: Setup

- Input: Search log $\boldsymbol{L}$, in the form of $(query, URL)$ pairs
- Output: A bipartite graph $\boldsymbol{G}$

1. Collect $\boldsymbol{Q}$, the set of unique queries in $\boldsymbol{L}$
2. Collect $\boldsymbol{U}$, the set of unique URLs in $\boldsymbol{L}$
3. For each of the queries in $\boldsymbol{Q}$, create a “white” vertex in $\boldsymbol{G}$
4. For each of the URLs in $\boldsymbol{U}$, create a “black” vertex in $\boldsymbol{G}$
5. For each URL (in $\boldsymbol{U}$) that was clicked in response to a query $\boldsymbol{q}$ (in $\boldsymbol{Q}$), draw an edge

Agglomerative Clustering of Click Data…

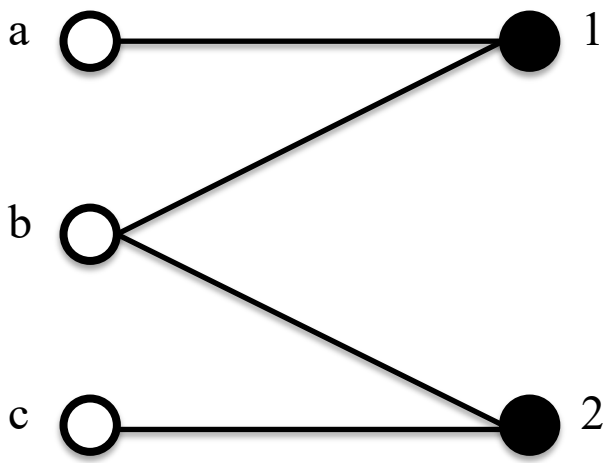


Measuring Similarity

- Let $N(x)$ be the set of vertices that neighbour a vertex *x* in a graph
  - For a black (white) vertex, the neighbours are the white (black) vertices that it is linked to
- Then the *similarity* of a vertex x with another vertex y can be measured based on the *Jaccard similarity* (or overlap) of their neighbours:

$$sim(x,y) = \begin{cases} \dfrac{N(x) \cap N(y)}{N(x) \cup N(y)}, & \text{if } \left|N(x) \cup N(y)\right| > 0 \\ 0, & \text{otherwise} \end{cases}$$

Agglomerative Clustering of Click Data…



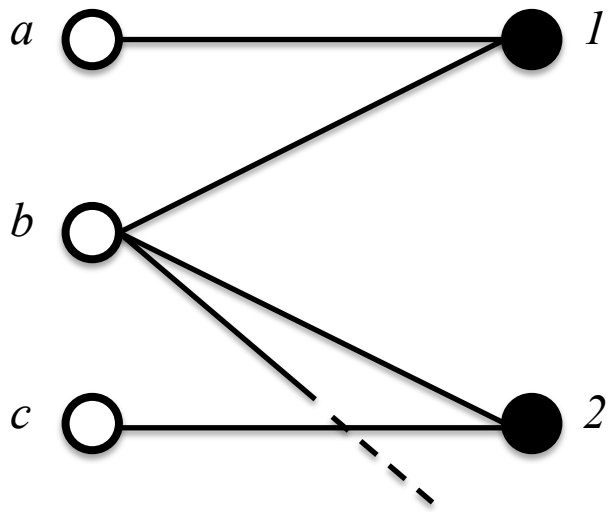
- *sim(a,b) = 1/2*
- *sim(a,c) = 0*
- *sim(b,c) = 1/2*

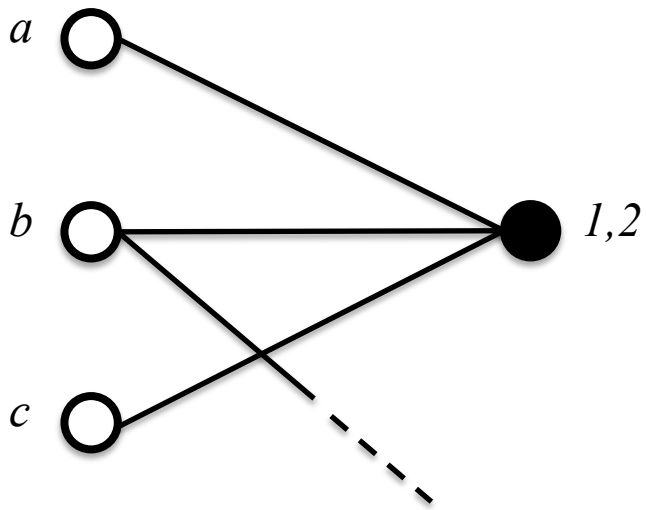
Agglomerative Clustering of Click Data: Processing

- Input: Bipartite graph ***G***
- Output: A new bipartite graph ***G'*** where each white (black) vertex in ***G'*** corresponds to one or more white (black) vertices of ***G***

1. Score all pairs of white vertices in ***G*** by ***sim(x,y)***
2. Merge the two white vertices for which ***sim(x,y)*** is largest
3. Score all pairs of black vertices in ***G*** by ***sim(x,y)***
4. Marge the two black vertices for which ***sim(x,y)*** is the largest
5. If (termination condition not met) return to 1.

Agglomerative Clustering of Click Data…





- Iterative clustering is able to uncover latent relationships
- Initially, $sim(a,c) = 0$
- After merging black nodes 1 and 2 (which have a similarity of 1/3), vertices a and c are actually shown to have something in common

Using Click Data for Query Suggestions

- For example, suppose some of the following queries initially didn't have any clicks directly in common, but shared some URLs through neighbours:
  - godzilla
  - shin gojira
  - kaiju movie 2016
  - kamata kun

- The queries appear unrelated from a string-similarity perspective, and didn't need to occur in the same search session, but can now be clustered
- Using the created clusters for query suggestions
  - For a new user query q_{new} that is submitted
    - Find the cluster that contains q_{new}
    - Return up to N members of the cluster

Approach 3: Term Statistics

Statistical Query Suggestions

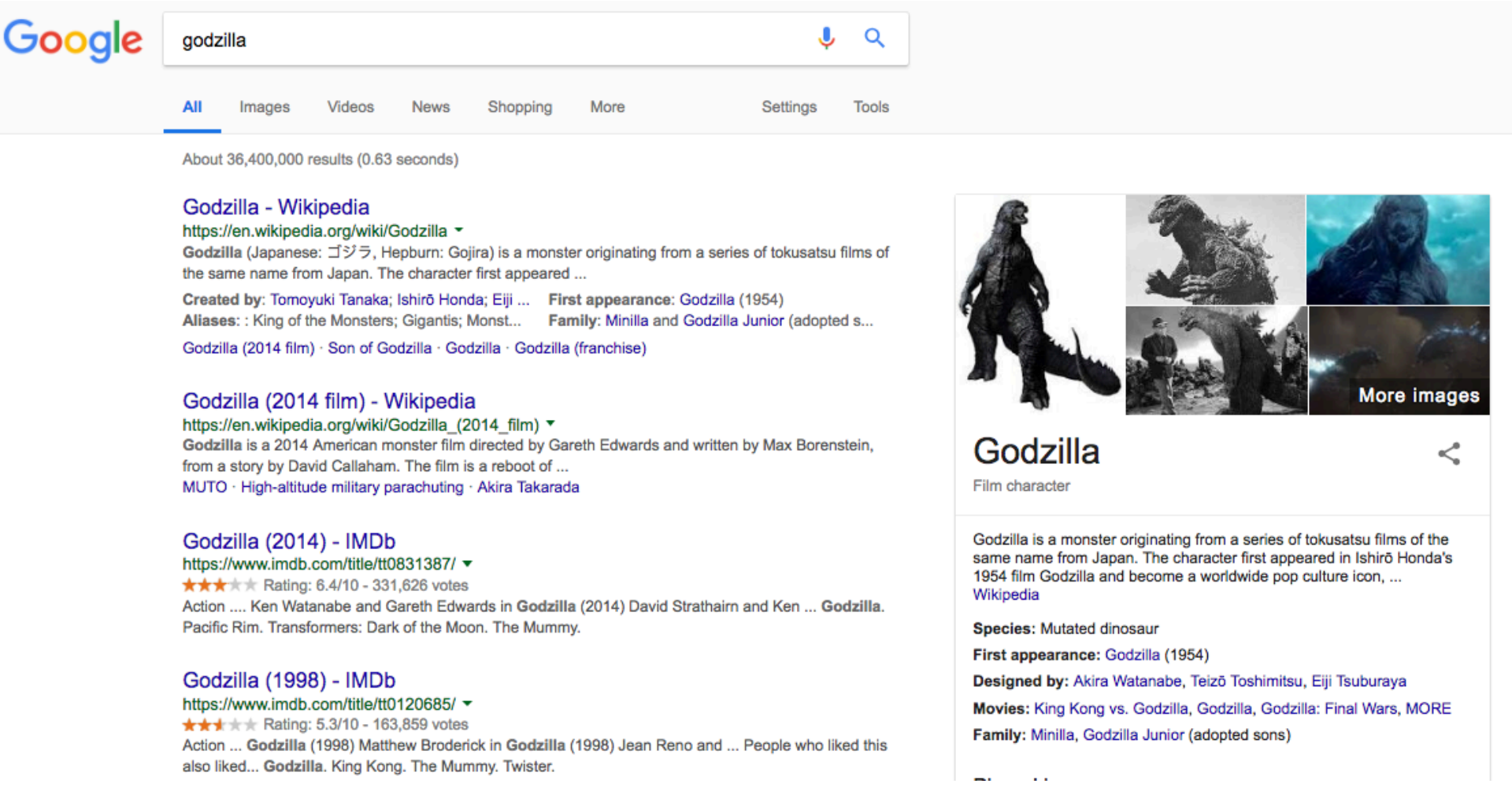
- When a query is submitted to a search engine, a *ranked list* of search results is returned
  - The ranking is based on the *expected relevance* of each resource to the user's query
  - Items that are higher in the ranking can be expected to be a better match than items that are lower in the list
- This observation can be exploited to identify related terms that might help to improve a query

Automatic Relevance Feedback

- Input: a user query q
- Output: a set of term suggestions s

1. Submit q to a search engine and obtain a *ranked list* of results
2. Assume that the top N results are relevant
   - Let the list of all *terms* occurring in these documents be a candidate set, C
3. Process set C, to count how often each unique term occurs
4. Select the R most frequently occurring *terms*, and return them as query suggestions

Step 1: Run Initial Query



Step 2: Extract Terms From Top Documents

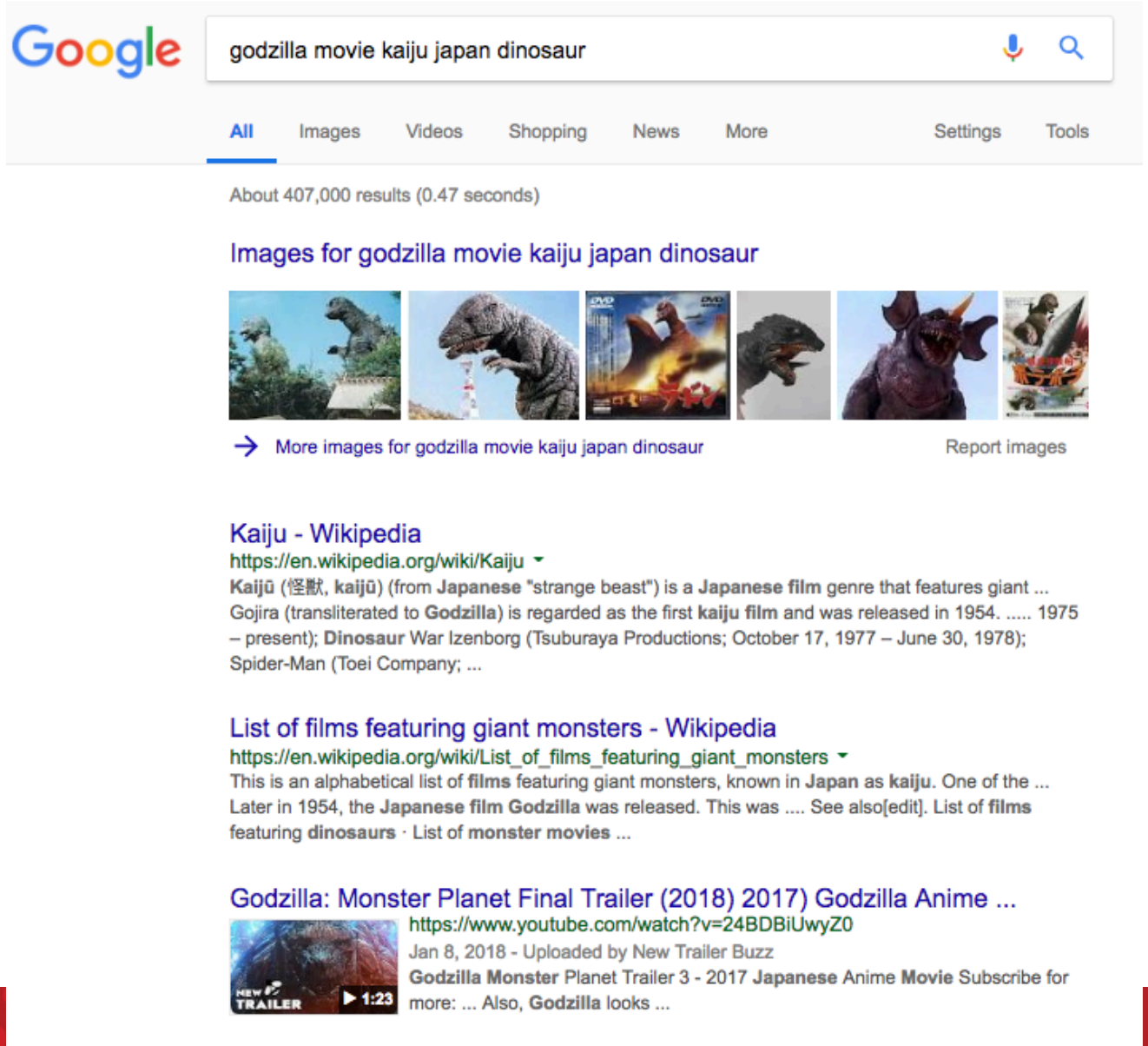
godzilla, dinosaur,
kaiju,
japan,
toho, monster,
movie, 1964,
ghidora,
…

Step 3: Count Term Occurrences And Sort

59: godzilla
23: dinosaur
41: kaiju
31: japan
11: toho
5: monster
74: movie
2: 1964
6: ghidora
…

74: movie
59: godzilla
41: kaiju
31: japan
23: dinosaur

Step 4: Run Expanded Query



Summary

- Query suggestions can useful for both users and search systems
- Query logs are a key source of information about searcher behaviour
- Query suggestions can be made based on
  - Query co-occurrence data in a *search session*
  - Agglomerative clustering of *click data*
  - Automatic relevance feedback based on *term statistics*

References

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- D. Beeferman and A. Berger. *Agglomerative clustering of a search engine query log.* ACM SIGKDD International Conference on Knowledge Discovery and Data Mining, pp 407--416, 2000.
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Data
Science

Thanks!