CS317
Information Retrieval & Text Mining
Week 08

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Relevance Feedback & Query Expansion

Chapter No. 9

Agenda

- Problem of IR Systems
  - Recall /Precision
- Query Refinement
  - Global vs Local methods
- Global Methods
- Relevance Feedback
  - Direct / Indirect / Pseudo relevance feedback
- Relevance Feedback in Vector Space
  - Rocchio Algorithm

Agenda

- When Relevance Feedback work
- Relevance Feedback on Web
- Query Expansion
  - Global vs Local
  - Automatic thesaurus generation

Problem with IR Systems

- Same concept may be referred by different words (synonymy), it has an impact on the recall of most information retrieval systems.
  - Users often attempt to address this problem themselves by manually refining a query.
  - Query refinement / expansion
- The methods for tackling this problem split into two major classes:
  - Global Methods
  - Local Methods

Query Refinement: Global Methods

- Global methods are techniques for expanding or reformulating query terms independent of the query and results returned from the query.
- The changes in the query wording will cause the new query to match other semantically similar terms.
  - Query expansion/reformulation with a thesaurus or WordNet
  - Query expansion via automatic thesaurus generation
  - Techniques like spelling correction

Query Refinement: Local Methods

- Local methods adjust a query relative to the documents that initially appear to match the query.
  - Relevance feedback- involve users to get the feedback from the results return for a given query.
  - Pseudo relevance feedback, also known as Blind relevance feedback.
  - (Global) indirect relevance feedback.
- Relevance feedback is one of the most used and most successful approaches.

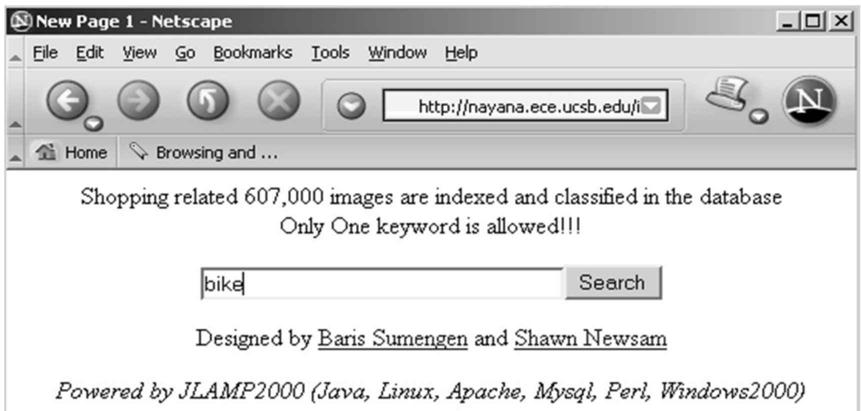
Relevance feedback

- The idea of relevance feedback (RF) is to involve the user in the retrieval process so as to improve the final result set.
  - The user issues a (short, simple) query
  - The system returns an initial set of retrieval results.
  - The user marks some returned documents as relevant or non-relevant.
  - The system computes a better representation of the information need based on the user feedback.
  - The system displays a revised set of retrieval results.

Sec. 9.1.1

Relevance Feedback: Example

- Image search engine http://nayana.ece.ucsb.edu/imsearch/imsearch.html



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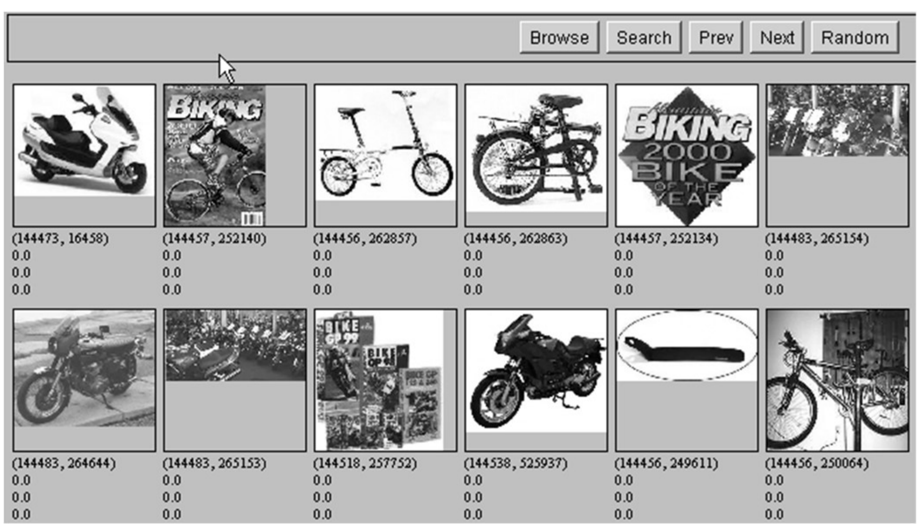
Results for Initial Query



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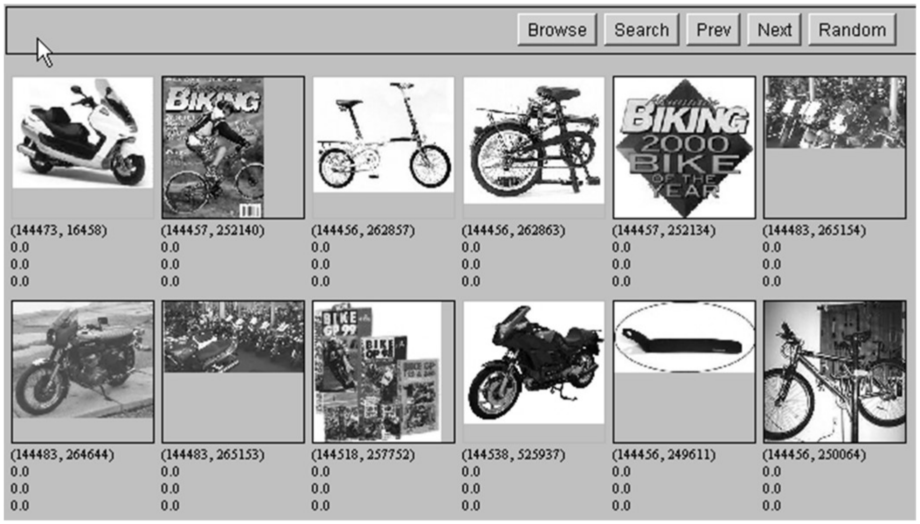
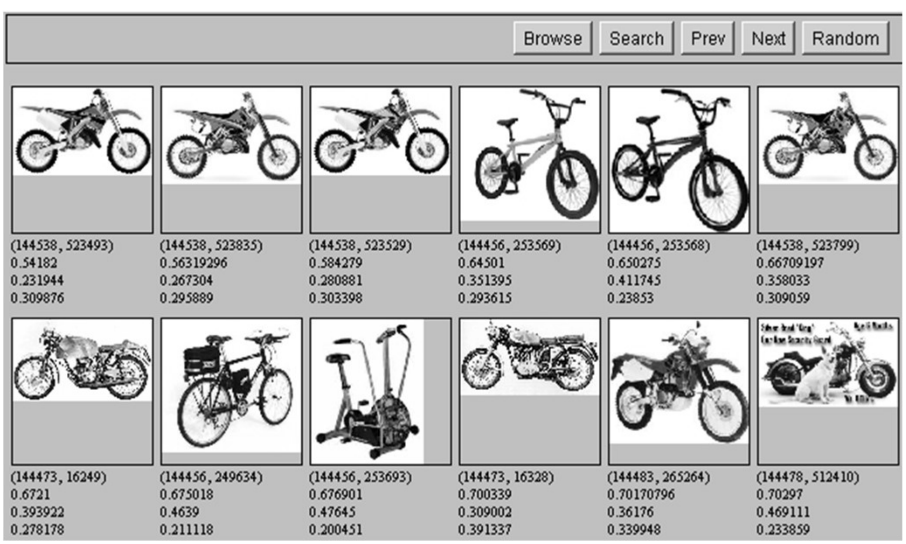
Relevance Feedback



Sec. 9.1.1

Results after Relevance Feedback



Example 2: Initial query/results

- Initial query: *New space satellite applications*

1. 0.539, 08/13/91, NASA Hasn't Scrapped Imaging Spectrometer
+ 2. 0.533, 07/09/91, NASA Scratches Environment Gear From Satellite Plan
+ 3. 0.528, 04/04/90, Science Panel Backs NASA Satellite Plan, But Urges Launches of Smaller Probes
4. 0.526, 09/09/91, A NASA Satellite Project Accomplishes Incredible Feat: Staying Within Budget
5. 0.525, 07/24/90, Scientist Who Exposed Global Warming Proposes Satellites for Climate Research
6. 0.524, 08/22/90, Report Provides Support for the Critics Of Using Big Satellites to Study Climate
7. 0.516, 04/13/87, Arianespace Receives Satellite Launch Pact From Telesat Canada
+ 8. 0.509, 12/02/87, Telecommunications Tale of Two Companies

- User then marks relevant documents with "+".

Expanded query after relevance feedback

- 2.074 new — 15.106 space
- 30.816 satellite — 5.660 application
- 5.991 nasa — 5.196 eos
- 4.196 launch — 3.972 aster
- 3.516 instrument — 3.446 arianespace
- 3.004 bundespost — 2.806 ss
- 2.790 rocket — 2.053 scientist
- 2.003 broadcast — 1.172 earth
- 0.836 oil — 0.646 measure

Results for expanded query

1. 0.513, 07/09/91, NASA Scratches Environment Gear From Satellite Plan
2. 0.500, 08/13/91, NASA Hasn't Scrapped Imaging Spectrometer (2)
3. 0.493, 08/07/89, When the Pentagon Launches a Secret Satellite, Space Sleuths Do Some Spy Work of Their Own (1)
4. 0.493, 07/31/89, NASA Uses 'Warm' Superconductors For Fast Circuit
5. 0.492, 12/02/87, Telecommunications Tale of Two Companies
6. 0.491, 07/09/91, Soviets May Adapt Parts of SS-20 Missile For Commercial Use (8)
7. 0.490, 07/12/88, Gaping Gap: Pentagon Lags in Race To Match the Soviets In Rocket Launchers
8. 0.490, 06/14/90, Rescue of Satellite By Space Agency To Cost $90 Million

Pseudo Relevance feedback

- Pseudo relevance feedback, also known as blind relevance feedback, provides a method for automatic local analysis.
- It automates the manual part of relevance feedback, so that the user gets improved retrieval performance without an extended interaction.
- This automatic technique mostly works. Evidence suggests that it tends to work better than global analysis.

Indirect Relevance feedback

- We can also use indirect sources of evidence rather than explicit feedback on relevance as the basis for relevance feedback. This is often called implicit (relevance) feedback.
- Implicit feedback is less reliable than explicit feedback, but is more useful than pseudo relevance feedback.
- Users are often reluctant to provide explicit feedback, it is easy to collect implicit feedback in large quantities for a high volume system, such as a web search engine.

Relevance Feedback in vector spaces

- We can modify the query based on relevance feedback and apply standard vector space model.
- Use only the docs that were marked.
- Relevance feedback can improve recall and precision
- Relevance feedback is *believed* to be most useful for increasing *recall* in situations where recall is important
  - Users can be expected to review results and to take time to iterate

Sec. 9.1.1

Key concept: Centroid

- The centroid is the center of mass of a set of points
- Recall that we represent documents as points in a high-dimensional space
- Definition: Centroid $$\vec{\mu}(C) = \frac{1}{|C|}\sum_{d \in C} \vec{d}$$

where C is a set of documents.

Rocchio Algorithm

- The Rocchio algorithm incorporates relevance feedback information into the vector space model.

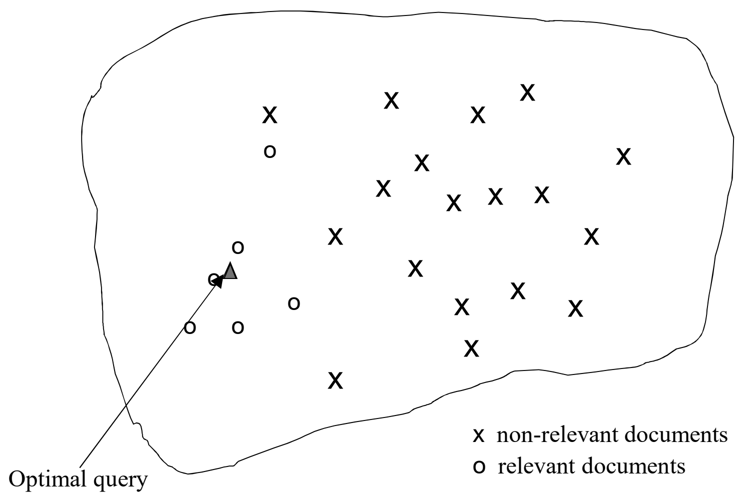
$$\vec{q}_{opt} = \arg\max_{\vec{q}} [\cos(\vec{q}, \vec{\mu}(C_r)) - \cos(\vec{q}, \vec{\mu}(C_{nr}))]$$

- The optimal query vector for separating relevant and non-relevant documents (with cosine sim.):

$$\vec{Q}_{opt} = \frac{1}{|C_r|}\sum_{\vec{d}_j \in C_r} \vec{d}_j - \frac{1}{N - |C_r|}\sum_{\vec{d}_j \notin C_r} \vec{d}_j$$

- Q_{opt} = optimal query; C_r = set of rel. doc vectors; N = collection size; C_{nr} = set of non-rel. doc
- Unrealistic: we don’t know relevant documents.

The Theoretically Best Query



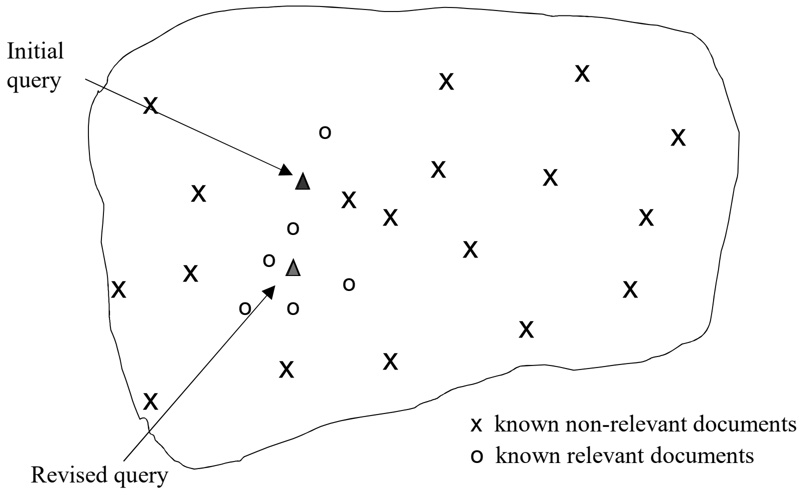
Rocchio 1971 Algorithm (SMART)

- Used in practice:

$$\vec{q}_m = \alpha\vec{q}_0 + \beta\frac{1}{|D_r|}\sum_{\vec{d}_j \in D_r}\vec{d}_j - \gamma\frac{1}{|D_{nr}|}\sum_{\vec{d}_j \in D_{nr}}\vec{d}_j$$

- q_m = modified query vector; q_0 = original query vector; α,β,γ: weights (hand-chosen or set empirically); D_r = set of known relevant doc vectors; D_{nr} = set of known irrelevant doc vectors
- New query moves toward relevant documents and away from irrelevant documents
- Tradeoff α vs. β/γ : If we have a lot of judged documents, we want a higher β/γ.
- Term weight can go negative
  - Negative term weights are ignored

Relevance feedback on initial query



Relevance Feedback: Assumptions

- A1: User has sufficient knowledge for initial query.
- A2: Relevance prototypes are “well-behaved”.
  - Term distribution in relevant documents will be similar
  - Term distribution in non-relevant documents will be different from those in relevant documents
    - Either: All relevant documents are tightly clustered around a single prototype.
    - Or: There are different prototypes, but they have significant vocabulary overlap.
    - Similarities between relevant and irrelevant documents are small

Sec. 9.1.3

Violation of A1

- User does not have sufficient initial knowledge.
- Examples:
  - Misspellings (Brittany Speers).
  - Cross-language information retrieval (hígado).
  - Mismatch of searcher’s vocabulary vs. collection vocabulary
    - Cosmonaut/astronaut

Sec. 9.1.3

Violation of A2

- There are several relevance prototypes.
- Examples:
  - Burma/Myanmar
  - Contradictory government policies
  - Pop stars that worked at Burger King
- Often: instances of a general concept
- Good editorial content can address problem
  - Report on contradictory government policies

Sec. 9.1.4

Excite Relevance Feedback

Spink et al. 2000

- Only about 4% of query sessions from a user used relevance feedback option
  - Expressed as "More like this" link next to each result
- But about 70% of users only looked at first page of results and didn't pursue things further
  - So 4% is about 1/8 of people extending search
- Relevance feedback improved results about 2/3 of the time

Relevance Feedback: Problems

- Long queries are inefficient for typical IR engine.
  - Long response times for user.
  - High cost for retrieval system.
  - Partial solution:
    - Only reweight certain prominent terms
      - Perhaps top 20 by term frequency
- Users are often reluctant to provide explicit feedback
- It's often harder to understand why a particular document was retrieved after apply relevance feedback

Relevance feedback summary

- Relevance feedback has been shown to be very effective at improving relevance of results.
- Its successful use requires queries for which the set of relevant documents is medium to large.
- Full relevance feedback is often onerous for the user, and its implementation is not very efficient in most IR systems.

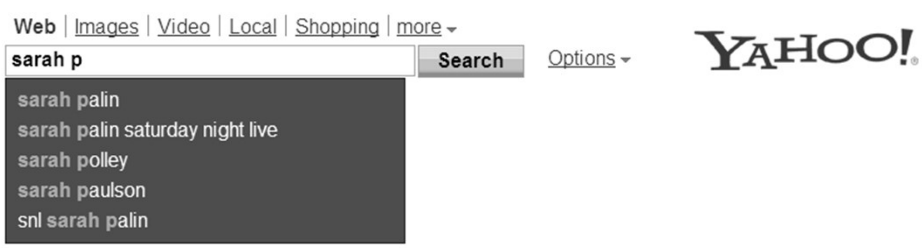
Relevance feedback summary

- Other use of relevance feedback
  - Following a changing information need (e.g., names of car models of interest change over time)
  - Maintaining an information filter (e.g., for a news feed).
  - Active learning (deciding which examples it is most useful to know the class of to reduce annotation costs).

Query Expansion

- In relevance feedback, users give additional input (relevant/non-relevant) on documents, which is used to reweight terms in the documents
- In query expansion, users give additional input (good/bad search term) on words or phrases
- Query expansion help in extending user queries with related terms in order to solve the lexical gap problem in Information Retrieval

Query assist



Would you expect such a feature to increase the query volume at a search engine?

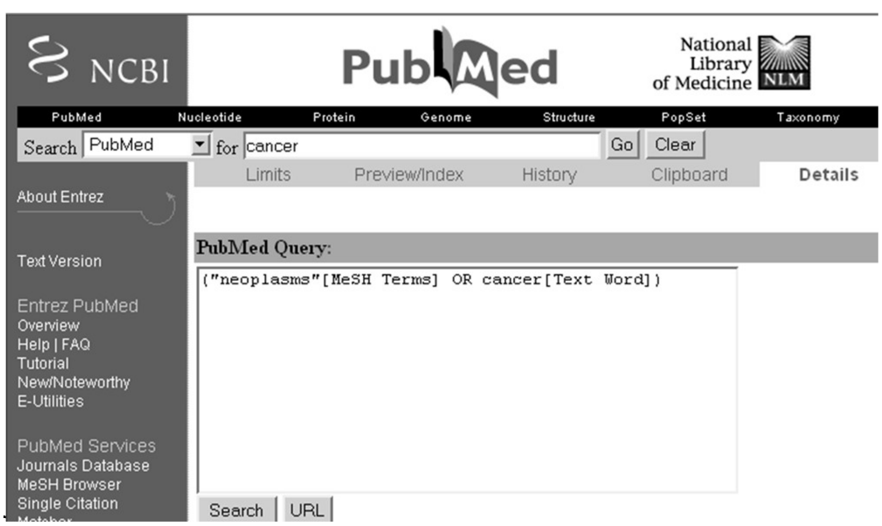
Sec. 9.2.2

How do we augment the user query?

- Manual thesaurus
  - E.g. MedLine: physician, syn: doc, doctor, MD, medico
  - Can be query rather than just synonyms
- Global Analysis: (static; of all documents in collection)
  - Automatically derived thesaurus
  - Refinements based on query log mining
- Local Analysis: (dynamic)
  - Analysis of documents in result set

Sec. 9.2.2

Example of manual thesaurus



Conclusion

- Relevance Feedback is an important part of learning the query intent from a user.