Idea: Query Expansion

- Users often start with short queries with ambiguous representations.
- Observation: Many people refine their queries by analyzing the results from initial queries, or consulting other resources (thesaurus).
  - By adding and removing terms.
  - By reweighting terms.
  - By adding other features (e.g., Boolean operators).
- Technique of query expansion:
  Can a better query be created automatically?
Query Expansion

Diagram showing the relationships between different data sets (D1, D2, D3, D4) with axes for Java, Starbucks, and Sun. The diagram illustrates how new queries can expand the scope of search or query results.
Idea: Query Expansion

- Add terms to query to improve recall
  - And possibly precision
- Initial intuition: Help users find synonyms for query terms
  - Later: Help users find good query terms
- Query Expansion via External Resources
  - Thesaurus
    - “Industrial Chemical Thesaurus”, “Medical Subject Headings” (MeSH)
  - Semantic network
    - WordNet
### Query Expansion via External Resources: Thesaurus

#### Word: Bank (Institution)
- coffer, countinghouse, credit union, depository, exchequer, fund, hoard, investment firm, repository, reserve, reservoir, safe, savings, stock, stockpile...

#### Word: Bank (Ground)
- beach, berry bank, caisse populaire, cay, cliff, coast, edge, embankment, lakefront, lakeshore, lakeside, ledge, levee, oceanfront, reef, riverfront, riverside, ...

#### Word: Java (Coffee)
- Jamocha, cafe, cafe noir, cappuccino, decaf, demitasse, dishwater, espresso...

#### Word: Refusal
- abnegation, ban, choice, cold shoulder*, declension, declination, defiance, disallowance, disapproval, disavowal, disclaimer...

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### MeSH Heading: Neoplasms

<table>
<thead>
<tr>
<th>MeSH Heading</th>
<th>Neoplasms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tree Number</td>
<td>C04</td>
</tr>
</tbody>
</table>

**Annotation**

avoid: too general; prefer specifics; policy: Manual section 24; / chem ind permitted but consider also CARCINOGENS; / class: consider also NEOPLASM STAGING (see note there) but "grading" = / pathol; / chol; consider also ONCOGENIC VIRUSES; / vet: Manual 24.6+ or TN 136....

**Scope Note**

New abnormal growth of tissue. Malignant neoplasms show a greater degree of anaplasia and have the properties of invasion and metastasis, compared to benign neoplasms.

**Entry Term**

- Cancer
- Tumors
- Benign Neoplasms
- Neoplasms, Benign
Query Expansion via External Resources: Semantic Network

- WordNet: a lexical thesaurus organized into 4 taxonomies by part of speech (George Millet et al.)
- Inspired by psycholinguistic theories of human lexical memory
- English nouns, verbs, adjectives and adverbs are organized into synonym sets, each representing one concept
- Multiple relations link the synonym sets
  - Hyponyms: \( Y \) is a hyponym of \( X \) if every \( Y \) is a (kind of) \( X \)
  - Hypernyms: \( Y \) is a hypernym of \( X \) if every \( X \) is a (kind of) \( Y \)
  - Meronyms: \( Y \) is a meronym of \( X \) if \( Y \) is a part of \( X \)
  - Holonyms: \( Y \) is a holonym of \( X \) if \( X \) is a part of \( Y \)
Query Expansion via External Resources: Semantic Network

• Three sense of the noun “Java”
  1. Java (an island in Indonesia south of Borneo; one of the world's most densely populated regions)
  2. java (a beverage consisting of an infusion of ground coffee beans) "he ordered a cup of java"
  3. Java (a simple platform-independent object-oriented programming language used for writing applets that are downloaded from the World Wide Web by a client and run on the client's machine)

Query Expansion via External Resources: Semantic Network

• The hypernym of Sense 3 of “Java”
  =>: (n) object-oriented programming language, object-oriented programming language
  =>: (n) programming language, programming language
  =>: (n) artificial language
  =>: (n) language, linguistic communication
  =>: (n) communication
  =>: (n) abstraction
  =>: (n) abstract entity
  =>: (n) entity
Query Expansion via External Resources: Semantic Network

- The meronym of Sense 1 of “Java”
  - =>: (n) Jakarta, Djakarta, capital of Indonesia (capital and largest city of Indonesia; located on the island of Java; founded by the Dutch in 17th century)
  - =>: (n) Bandung (a city in Indonesia; located on western Java (southeast of Jakarta); a resort known for its climate)
  - =>: (n) Semarang, Samarang (a port city in southern Indonesia; located in northern Java)

Query Expansion via External Resources: Semantic Network

- User select synonym sets for some query terms
  - Add to query all synonyms in synset
  - Add to query all hypernyms (“… is a kind of X”) up to depth n
  - May add hyponyms, meronym etc
- Query expansions with WordNet has not been consistently useful
  - What to expand? To what kind of detail?
  - Not query-specific, difficult to disambiguate the senses
  - some positive results reported using conservative set of synonyms close to limited query terms
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- Query Expansion via External Resources
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  - Semantic network
    - WordNet
- Relevance Feedback
  - Use user-specified “good documents” to get new terms
  - Blind/Pseudo Relevance Feedback

Query Expansion:
Relevance Feedback

Query: iran iraq war

Initial Retrieval Result

1. 0.643 07/11/88, Japan Aid to Buy Gear For Ships in Persian Gulf
2. 0.582 08/21/90, Iraq's Not-So-Tough Army
3. 0.569 09/10/90, Societe Generale Iran Pact
4. 0.566 08/11/88, South Korea Estimates Iran-Iraq Building Orders
5. 0.562 01/02/92, International: Iran Seeks Aid for War Damage
6. 0.541 12/09/86, Army Suspends Firings Of TOWs Due to Problems
New query representation:

10.82 Iran 9.54 iraq 6.53 war
2.3 army 3.3 perisan 1.2 aid
1.5 gulf 1.8 raegan 1.02 ship
1.61 troop 1.2 military 1.1 damage

Updated Query

Refined Retrieval Result

+1 0.547 08/21/90, Iraq's Not-So-Tough Army
+2 0.529 01/02/92, International: Iran Seeks Aid for War Damage
3 0.515 07/11/88, Japan Aid to Buy Gear For Ships in Persian Gulf
4 0.511 09/10/90, Societe Generale Iran Pact
5 0.509 08/11/88, South Korea Estimates Iran-Iraq Building Orders
+ 6. 0.498 06/05/87, Reagan to Urge Allies at Venice Summit To Endorse Cease-Fire in Iran-Iraq War
Relevance Feedback Vector Space Model

- Two types of words are likely to be included in the expanded query
  - Topic specific words: good representative words
  - General words: introduce ambiguity into the query, may lead to degradation of the retrieval performance
  - Utilize both positive and negative documents to distinguish representative words

Relevance Feedback Vector Space Model

- **Goal**: Move new query close to relevant documents and far away from irrelevant documents
- **Approach**: New query is a weighted average of original query, and relevant and non-relevant document vectors

\[
\vec{q}' = \vec{q} + \alpha \frac{1}{|R|} \sum_{\vec{d}_i \in R} \vec{d}_i - \beta \frac{1}{|NR|} \sum_{\vec{d}_i \in NR} \vec{d}_i \quad \text{(Rocchio formula)}
\]
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q' = \hat{q} + \alpha \frac{1}{|R|} \sum_{d_i \in R} d_i - \beta \frac{1}{|NR|} \sum_{d_i \in NR} d_i
\]  
(Rocchio formula)

How do we set the desired weights?

Relevance Feedback Vector Space Model

- Desirable weights for \( \alpha \) and \( \beta \)
- Exhaustive search
- Heuristic choice
  - \( \alpha = 0.5; \beta = 0.25 \)
- Learning method
  - Perceptron algorithm (Rocchio)
  - Support Vector Machine (SVM)
  - Regression
  - Neural network algorithm
Relevance Feedback Vector Space Model

- Desirable weights for $\alpha$ and $\beta$

Try find $\alpha$ and $\beta$ such that

$$\tilde{q}(\alpha, \beta) \cdot \tilde{d}_i \geq 1 \text{ for } \tilde{d}_i \in R$$

$$\tilde{q}(\alpha, \beta) \cdot \tilde{d}_i \leq -1 \text{ for } \tilde{d}_i \in NR$$

Blind (Pseudo) Relevance Feedback

- What if users only mark some relevant documents?
  - Use bottom documents as negative documents

- What if users only mark some irrelevant documents?
  - Use top documents in initial ranked lists and queries as positive documents

- What if users do not provide any relevance judgments?
  - Use top documents in initial ranked lists as positive documents; bottom documents as negative documents

- What about implicit feedback?
  - Use reading time, scrolling and other interaction?
Blind (Pseudo) Relevance Feedback

Approaches

• Pseudo-relevance feedback
  – Assume top N (e.g., 20) documents in initial list are relevant
  – Assume bottom N’ (e.g., 200-300) in initial list are irrelevant
  – Calculate weights of term according to some criterion (e.g., Rocchio)
  – Select top M (e.g., 10) terms

• Local context analysis
  – Similar approach to pseudo-relevance feedback
  – But use passages instead of documents for initial retrieval; use different term weight selection algorithms

Relevance Feedback Summary

• Relevance feedback can be very effective
• Effectiveness depends on the number of judged documents (positive documents more important)
• An area of active research (many open questions)
• Effectiveness also depends on the quality of initial retrieval results (what about bad initial results?)
• Need to do retrieval process twice
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