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CS47300: Web Information Search and Management

Query Expansion

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Material adapted from course created by
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Indiana Center for Database Systems™

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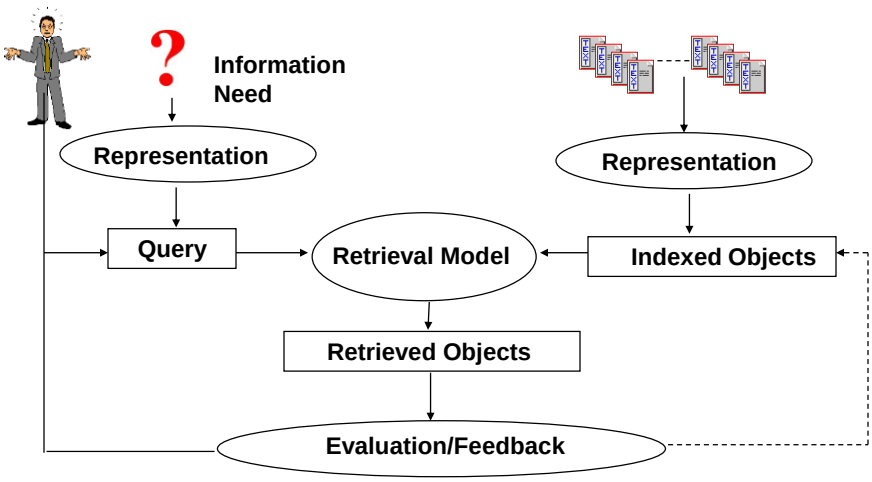
Retrieval Models



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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?

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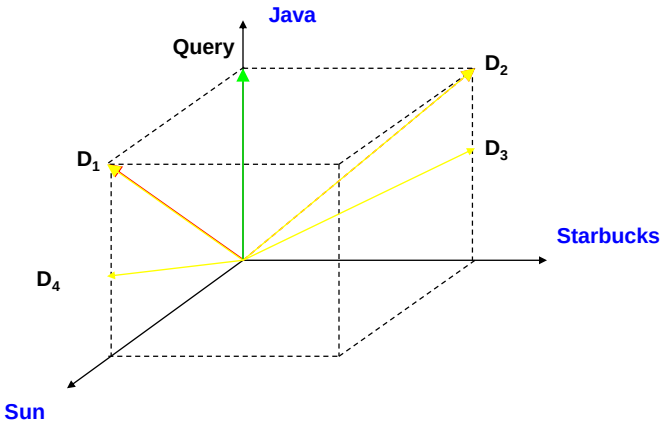
Query Expansion



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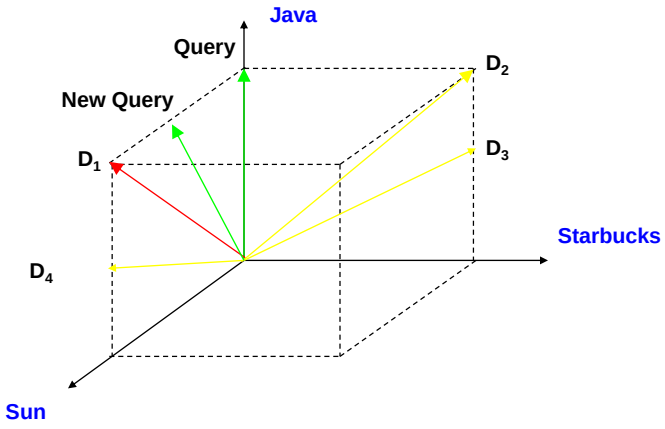
Query Expansion



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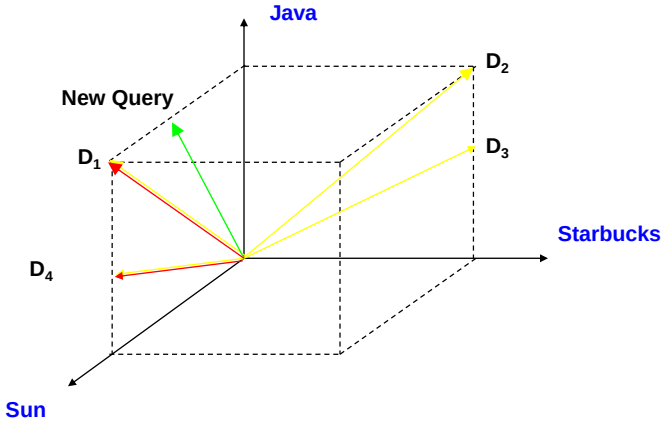
Query Expansion



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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

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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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Query Expansion via External Resources: Thesaurus

MeSH Heading	Neoplasms
Tree Number	C04
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; / etiol: 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
Entry Term	Tumors
Entry Term	Benign Neoplasms
Entry Term	Neoplasms, Benign

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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*

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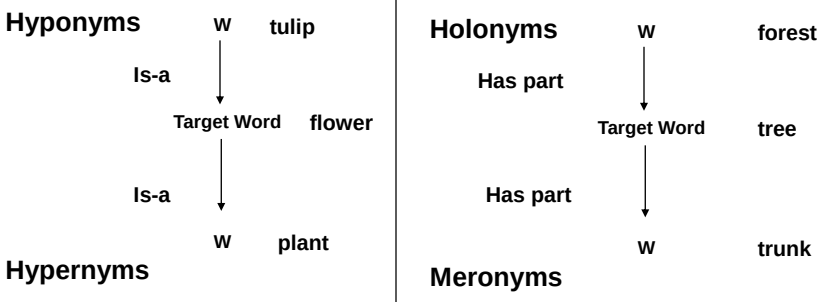
Query Expansion via External Resources: Semantic Network



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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)

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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

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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 is southern Indonesia; located in northern Java)

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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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Idea: Query Expansion

- Add terms to query to improve recall
  - And possibly precision
- Query Expansion via External Resources
  - Thesaurus
    - "Industrial Chemical Thesaurus", "Medical Subject Headings" (MeSH)
  - Semantic network
    - WordNet
- Relevance Feedback
  - Use user-specified "good documents" to get new terms
  - Blind/Pseudo Relevance Feedback

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Query Expansion via Relevance Feedback

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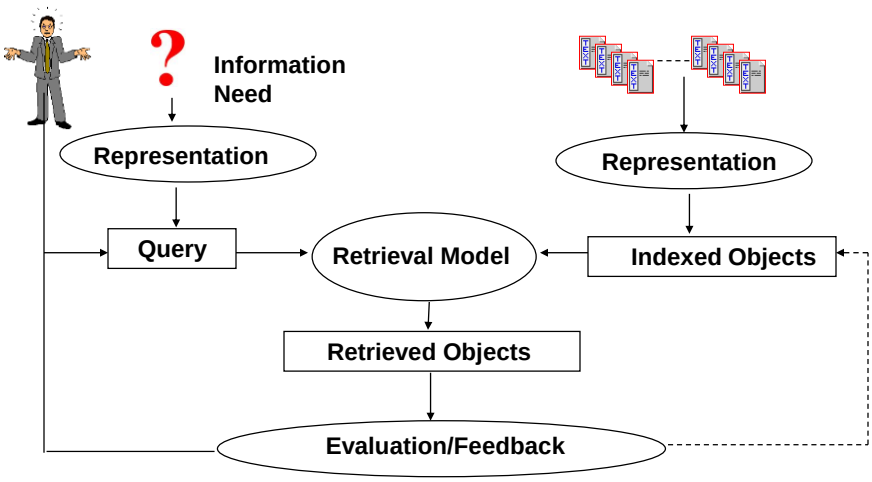
Retrieval Models



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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
```

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Query Expansion: Relevance Feedback

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

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Query Expansion: Relevance Feedback

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

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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*

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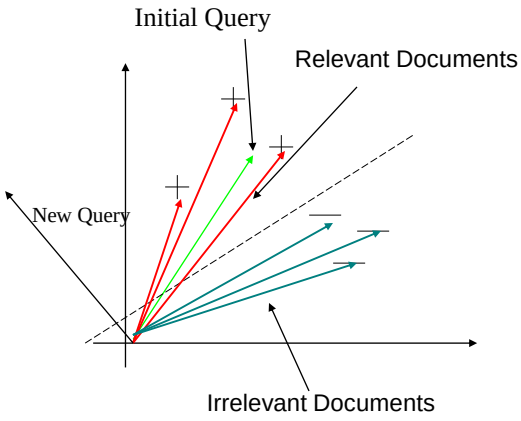
Relevance Feedback Vector Space Model

- Desirable weights for α and β



Try find α and β such that

$\vec{q}(\alpha,\beta)\cdot\overrightarrow{d_i} \geq 1$ for $\overrightarrow{d_i} \in R$

$\vec{q}(\alpha,\beta)\cdot\overrightarrow{d_i} \leq -1$ for $\overrightarrow{d_i} \in NR$

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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

$$\overrightarrow{q'} = \vec{q} + \alpha\frac{1}{|R|}\sum_{\overrightarrow{d_i}\in R}\overrightarrow{d_i} - \beta\frac{1}{|NR|}\sum_{\overrightarrow{d_i}\in NR}\overrightarrow{d_i} \quad \text{(Rocchio formula)}$$

Positive feedback for terms in relevant docs

Relevant documents

Irrelevant documents

Negative feedback for terms in irrelevant docs

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Relevance Feedback Vector Space Model

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

How do we set the desired weights?

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Relevance Feedback Vector Space Model

- Desirable weights for α and β
- Exhaustive search
- Heuristic choice

  α=0.5; β=0.25
- Learning method
  - Perceptron algorithm (Rocchio)
  - Support Vector Machine (SVM)
  - Regression
  - Neural network algorithm

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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?

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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

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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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Summary: Query Expansion

- Add terms to query to improve recall
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