CSA4020

Multimedia Systems:

Adaptive Hypermedia Systems

Lecture 5:
Statistical Models
Of
Information Retrieval

Problems with Boolean Model

- Difficult to capture user information need and document content

  e.g., compare NL with SQL query for "retrieve documents that describe companies whose stock value has increased by 150% over the last 18 months"

- Difficult to rank output

- Difficult to control no. of docs retrieved

- Difficult to perform automatic relevance feedback

  user ranking vs relevance judgements vs "find more like this"

Blair & Maron’s 1985 study

- Tested Boolean Retrieval Model, STAIRS, to evaluate Precision and Recall
- Also wanted to test hypothesis that “terms” accurately predict information content of documents
- STAIRS indexed c. 40,000 legal documents
- Lawyer’s information request submitted to STAIRS by trained paralegals
- Results showed that although Precision was 80%, Recall was 20%
- Why might this be?

The Cosine Similarity Measure

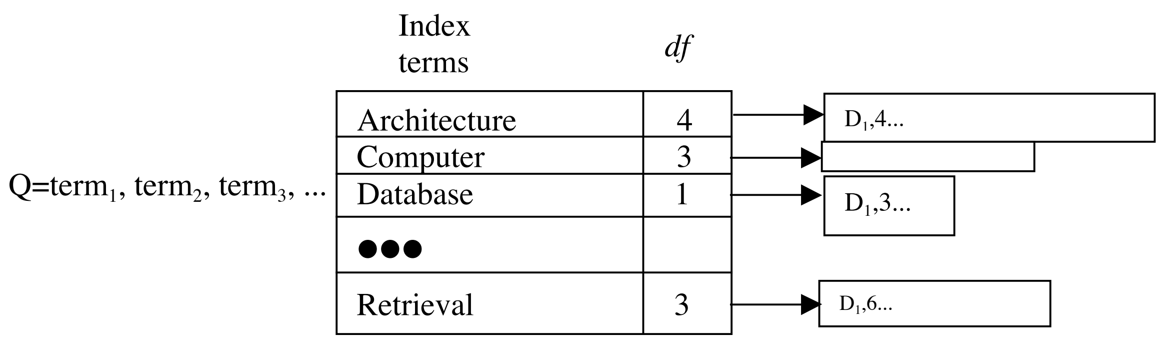
$$sim(Q,Dj) = \frac{\sum_{i=1}^{n} q_i \cdot w_{ij}}{\sqrt{\sum_{i=1}^{n} q_i^2 \cdot \sum_{i=1}^{n} w_{ij}^2}}$$

- Also allows us to visualise docs plotted into *n*-dimensional space
- Query can be plotted into same space
- Query’s nearest neighbours are most relevant documents...
- Can use same formula to find docs most similar to current doc...
- ... and to classify documents into categories (not too good...)

Implementation Issues

- Typically, vectors of docs in collection are stored in an inverted index file

  More efficient: access, updates, etc



Document and Query Term Weights

$$w_{i,j} = tf_{i,j} \Box idf_j$$

$tf_{i,j}$ = frequency of term j in document i

idf_j = inverse document frequency of term j

$$= \log_2 \frac{\text{number of documents}}{df_j}$$

df_j = document frequency of term j
= number of documents containing term j

- term weight will be high in a doc if it appears frequently in doc, but infrequently in collection
- If weights not specified in query, choose from either {0, 0.5} or {0,1}
- NL query can be treated as doc

Normalising term weights

- We don't want shorter documents to be considered more relevant than longer ones

- Assume the following:

  Longer docs contain more terms and/or more occurrences of the same terms than shorter docs, so:

  $freq_{i,j}$ = raw term freq of T_j in D_i

  $f_{i,j}$ = normalised frequency of T_j in D_i

  $\max_l freq_{l,j}$ = frequency of occurrence of most frequently occurring term in D_j

$$f_{i,j} = \frac{freq_{i,j}}{\max_l freq_{l,j}}$$

- $f_{i,j}$ will replace $tf_{i,j}$ to calculate $w_{i,j}$

Example (using simple w_{ij})

Assume *C* is 2048 documents

Vocabulary *n* is 3: oil, Mexico, refinery

Doc Frequency of terms is:

$DF_{oil} = 128$
$DF_{mexico} = 16$
$DF_{refinery} = 1024$

$$w_{ij} = tf_{ij} \times [\log_2(C) - \log_2(DF_i) + 1]$$

Assume doc exists with following:

$TF_{oil} = 4$
$TF_{Mexico} = 8$
$TF_{refinery} = 10$

$w_{oil} = 4 \times (\log_2(2048) - \log_2(128) + 1)$
$= 4 \times (11 - 7 + 1) = 20$

$w_{Mexico} = 8 \times (\log_2(2048) - \log_2(16) + 1)$
$= 8 \times (11 - 4 + 1) = 64$

$w_{refinery} = 10 \times (\log_2(2048) - \log_2(1024) + 1)$
$= 10 \times (11 - 10 + 1) = 20$

Benefits

- Can rank documents in order of relevance
- Can retrieve docs that *partially* match query
- Can use relevance feedback

Disadvantages

- Assumes *term independence* (but studies show that term dependence can hurt retrieval performance)
- No independent estimation of relevance: rank is dependent on other docs in collection

Probably most popular retrieval model after boolean