Information Retrieval

Lecture 3: tfidf

[Reference] CS276: Information Retrieval and Web Search

This lecture

- Parametric and field searches
  - **Zones** in documents
- Scoring documents: **zone** weighting
  - Index support for scoring
- **Term** weighting

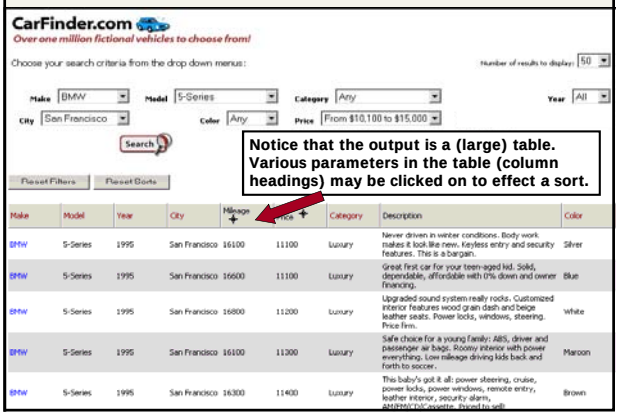
Parametric search

- Most documents have, in addition to text, some "meta-data" in fields e.g.,
  - Language = French
  - Format = pdf
  - Subject = Physics etc.
  - Date = Feb 2000

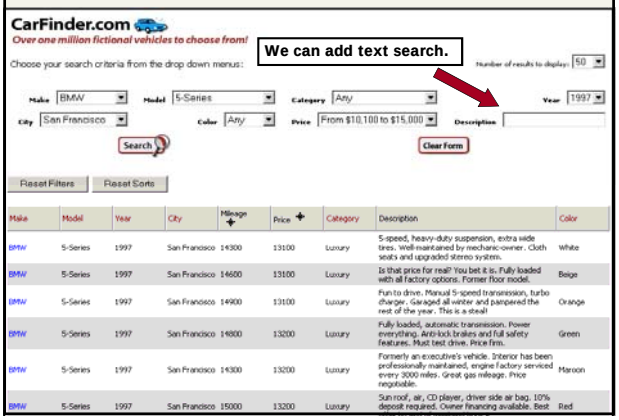
Fields → Format = pdf ← Values

- A parametric search interface allows the user to combine a full-text query with selections on these field values e.g.,
  - language, date range, etc.

Parametric search example



Parametric search example (con.)



Parametric / field search

- In these examples, we select field values
  - Values can be hierarchical, e.g.,
  - **Geography**: Continent → Country → State → City
- A paradigm for navigating through the document collection, e.g.,
  - "Aerospace companies in Brazil" can be arrived at first by selecting **Geography** then **Line of Business**, or vice versa
  - Filter docs in contention and run text searches scoped to subset

Index support for parametric search

- Must be able to support queries of the form
  - Find pdf documents that contain "stanford university"
  - A field selection (on doc format) and a phrase query
- Field selection
  - use inverted index of field values → docids
    - Organized by field name
    - Use compression etc. as before

Parametric index support

- Optional
  - provide richer search on field values – e.g., wildcards
    - Find books whose Author field contains ***s*trup***
- Range search
  - find docs authored between September and December
    - Inverted index doesn't work (as well)
    - Use techniques from database range search
    - See for instance www.bluerwhite.org/btree/ for a summary of B-trees
- Use query optimization heuristics as before

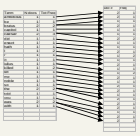
Field retrieval

- In some cases, must retrieve field values
  - E.g., ISBN numbers of books by ***s*trup***
- Maintain "forward" index
  - For each doc, those field values that are "retrievable"
  - Indexing control file specifies
    - which fields are retrievable (and can be updated)
  - Storing primary data here, not just an index

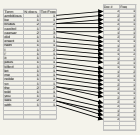
Zones

- A zone is an identified region within a doc
  - E.g., Title, Abstract, Bibliography
  - Generally culled from marked-up input or document metadata (e.g., powerpoint)
- Contents of a zone are free text
  - Not a "finite" vocabulary
- Indexes for each zone - allow queries like
  - ***sorting*** in **Title** AND ***smith*** in **Bibliography** AND ***recur**** in **Body**
- Not queries like "all papers whose authors cite themselves"

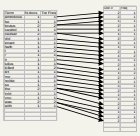
Zone indexes – simple view



Title



Author



Body

etc.

So we have a database now?

- **Not really**
- Databases do lots of things we don't need
  - Transactions
  - Recovery
    - our index is not the system of record; if it breaks, simply reconstruct from the original source
  - Indeed, **only indexes**
    - **we never have to store text in a search engine**
- **Focusing on** optimized indexes for text-oriented queries, not an SQL engine

Scoring and Ranking

Scoring

- Queries have all been Boolean:**Docs either match or not**
- Good：
  - Expert users with precise understanding of their needs and the corpus
  - Applications can consume 1000's of results
- Not good：
  - users with poor Boolean formulation of their needs
- Most users don't want to wade through 1000's of results
  - use of web search engines

- *Wish: to return in order the documents **most likely to be useful** to the searcher*
- **How can rank order** the docs
  - in the corpus with respect to a query?
- Assign a **score**
  - say in [0,1]
  - for each doc on each query
  - under web search

Linear zone combinations (线性组合)

- First generation of scoring methods
  - a **linear combination of Booleans**
  - E.g.,

Score = 0.6*<***sorting*** in Title> + 0.3*<***sorting*** in Abstract> + 0.05*<***sorting*** in Body> + 0.05*<***sorting*** in Boldface>

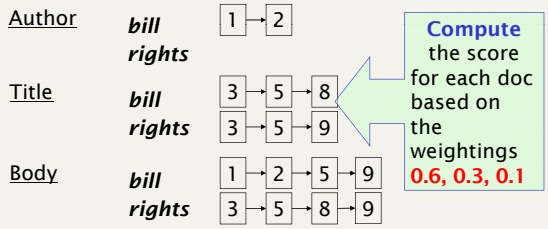
  - Each expression takes on a value in {0,1}.
    - such as **<*sorting* in Title>**
  - Then the overall score is in [0,1].

For this example the scores can only take on a finite set of values – what are they?

- the expressions between **< .... >**
  - could be ***any*** Boolean query
- Who generates the Score expression?
  - with weights *such as 0.6* etc.?
  - In uncommon cases: the user, in the UI
  - Most commonly: a **query parser**
    - that takes the user's Boolean query and runs it on the indexes for each zone

Exercise

- On the query: ***bill OR rights***
  - suppose : retrieve the following docs from the various zone indexes (索引区).

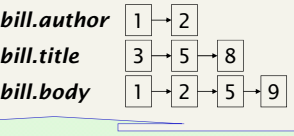


General idea

- Given a **weight vector**
  - whose components **sum up to 1**.
  - There is a weight for **each zone/field**.
- Given a Boolean query
  - assign a score to each doc by **adding up the weighted contributions** of the zones/fields.
- Typically
  - users want to see the ***K* highest-scoring** docs.

Index support for zone combinations

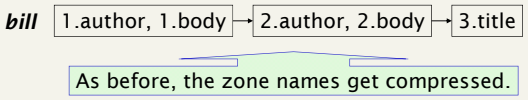
- In the simplest version
  - **a separate inverted index for each zone**
- Variant
  - have a **single index** with a separate dictionary entry for each term and zone
- E.g.,



compress zone names like author/title/body.

Zone combinations index

- The scheme is still wasteful:
  - each term is potentially replicated for each zone
- Slightly better scheme
  - **encode the zone in the postings**

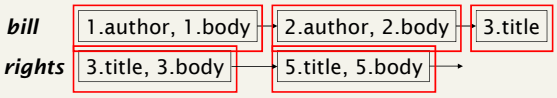


As before, the zone names get compressed.

- At query time
  - accumulate(积累) contributions **to the total score** of a document from the various postings.

Score accumulation

1 0.7
2 0.7
3 0.4
5 0.4



- **Seeks** the postings for the query ***bill*** *OR* ***rights***
- **Accumulate scores** for each doc
  - in a **linear merge** as before
- Note:
  - get both ***bill*** and ***rights*** in the Title field of doc 3
  - but score it no higher.
- Should give **more weight** to more hits?

```
ZoneScore(q1,q2)
    float scores[N]={0}
    constant g_zone[l]={w_zone1, w_zone2…,w_zonel}
    p1=postings(q1)
    p2=postings(q2)
    while p1!=NULL and p2!=NULL
    do if   docId(p1) == docId(p2)
       then scores[docId(p1)]=WeightedZone(p1,p2,g)
            p1=next(p1)
            p2=next(p2)
       else if   docId(p1)< docId(p2)
            then p1=next(p1)
            else p2=next(p2)
    return scores
```

Accumulate scores

Where do these weights come from?

- **Machine learned relevance**
- Given
  - A *test corpus*
  - A suite of *test queries*
  - A set of ***relevance judgments***
- **Learn** a set of weights
  - such that **relevance judgments matched**
- Be formulated as ordinal regression (有序回归)

Full text queries

- Just scored the Boolean query:
  bill** OR **rights
- Most users more likely to type
  bill rights or ***bill of rights***
  - How do interpret(理解) these *full text* queries?
  - **No** Boolean connectives (布尔连接词)
  - Of several query terms some may be missing in a doc
  - Only some query terms may occur in the title, etc.

- To use zone combinations for free text queries

- Need
  - A way of assigning a score
    - to a pair **<free text query, zone>**
  - Zero query terms in the zone
    - should **mean a zero score**
  - More query terms in the zone
    - should **mean a higher score**
  - Scores don't have to be Boolean
- Will look at some alternatives

Incidence matrices (关联矩阵) / Correlation matrices

- Recall:
  - Document (or a zone in it) is **binary vector** X in $\{0,1\}^v$
  - Query is a vector
- **Score**: Overlap (重叠) measure

$$|X \cap Y|$$

	Antony and Cleopatra	Julius Caesar	The Tempest	Hamlet	Othello	Macbeth
Antony	1	1	0	0	0	1
Brutus	1	1	0	1	0	0
Caesar	1	1	0	1	1	1
Calpurnia	0	1	0	0	0	0
Cleopatra	1	0	0	0	0	0
mercy	1	0	1	1	1	1
worser	1	0	1	1	1	0

Example

- On the query: ***ides of march*** (三月十五)
  - Shakespeare's(莎士比亚的) *Julius Caesar*(尤利乌斯 凯撒) has a score of 3
- All other Shakespeare plays have a score of 2
  - because they contain ***march*** or 1
- Thus: in a rank order (排名序列)
  - *Julius Caesar* would come **out tops**

Overlap matching

- What's wrong with the overlap measure?
- It doesn't consider:
  - Term frequency in document
  - Term scarcity in collection (document mention frequency)
    - ***of*** is more common than ***ides*** or ***march***
  - Length of documents
    - (And queries: score not normalized)

Overlap matching

- One can normalize in various ways:
  - Jaccard(杰卡德) coefficient(系数)

$$|X \cap Y| / |X \cup Y|$$

  - Cosine(余弦) measure

$$|X \cap Y| / \sqrt{|X| \times |Y|}$$

机器学习中的**相似性度量**方法:

1. **欧氏距离**
2. **曼哈顿距离**
3. **切比雪夫距离**
4. **闵可夫斯基距离**
5. **标准化欧氏距离**
6. **马氏距离**
7. **夹角余弦**
8. **汉明距离**
9. **杰卡德距离&**
   杰卡德相似系数
10. **相关系数&**
    相关距离
11. **信息熵**

Scoring: density-based(基于密度)

- Thus far
  - **position** and **overlap** of **terms** in a doc
    - title, author etc.
- Obvious next idea
  - if a document talks about a **topic** *more,*
  - then it is a **better match**
- This applies even when we only have **a single query term**.
- Document **relevant** if it has **a lot of** the **terms**
- This leads to the idea of **term weighting**.