Introduction to Information Retrieval

http://informationretrieval.org

IIR 10: XML Retrieval

Hinrich Schütze, Christina Lioma

Institute for Natural Language Processing, University of Stuttgart

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Overview

Outline

IR and relational databases

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Some structured data sources containing text are best modeled as structured documents rather than relational data (Structured retrieval).

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Example

- Digital libraries: *give me a full-length article on fast fourier transforms*
- Patents: *give me patents whose claims mention RSA public key encryption and that cite US patent 4,405,829*
- Entity-tagged text: *give me articles about sightseeing tours of the Vatican and the Coliseum*

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Solution: adapt ranked retrieval to structured documents to address these problems.

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- structured IR $\rightarrow$ XML IR
- also applicable to other types of markup (HTML, SGML, ...)

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- Attributes can have child elements (e.g. title, verse)

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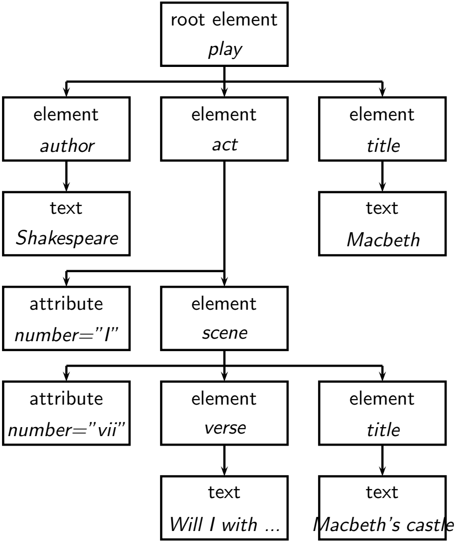
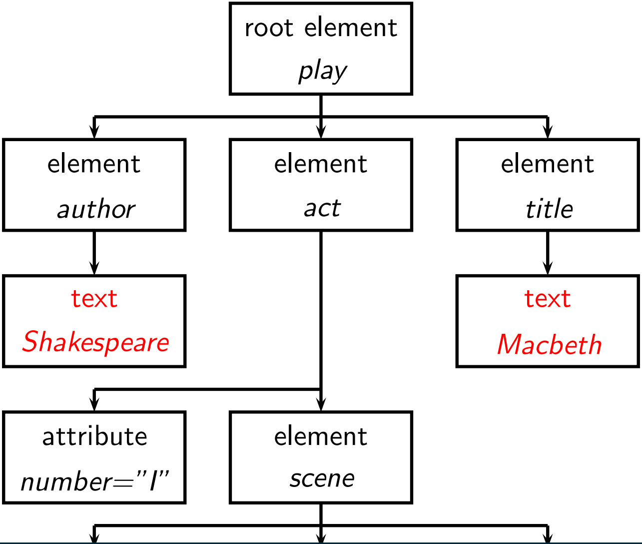


XML document

The leaf nodes consist of text



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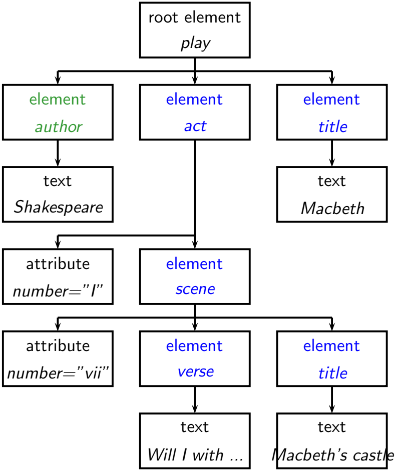
The *internal nodes* encode document structure or metadata functions



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- **Schema:** puts constraints on the structure of allowable XML documents. E.g. a schema for Shakespeare's plays: scenes can only occur as children of acts.
  - Two standards for schemas for XML documents are: XML DTD (document type definition) and XML Schema.

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  - But in this case, the title of the tragedy (higher node) is preferred.
  - Difficult to decide which level of the tree satisfies the query.

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- In unstructured retrieval, usually straightforward: files on your desktop, email messages, web pages on the web etc.
- In structured retrieval, there are four main different approaches to defining the indexing unit.
  1. non-overlapping pseudodocuments
  2. top down
  3. bottom up
  4. all

XML indexing unit: approach 1

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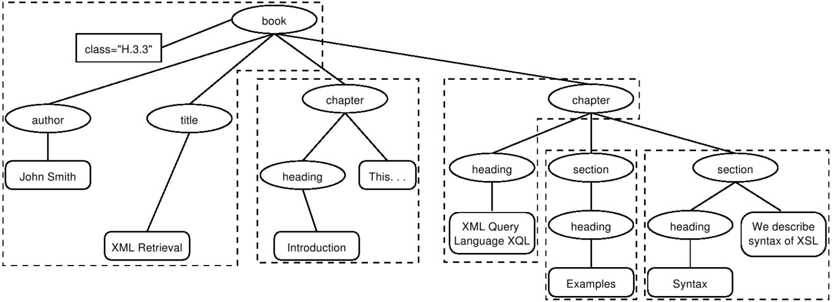

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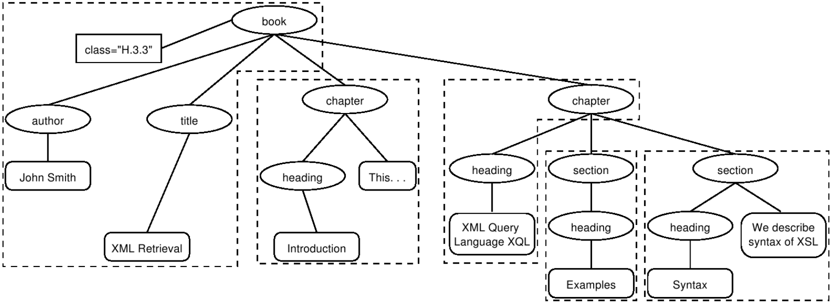

Indexing units: books, chapters, sections, but without overlap.
Disadvantage: pseudodocuments may not make sense to the user because they are not coherent units.

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Top down (2-stage process):

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This two-stage retrieval process often fails to return the best subelement because the relevance of a whole book is often not a good predictor of the relevance of small subelements within it.

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Instead of retrieving large units and identifying subelements (top down), we can search all leaves, select the most relevant ones and then extend them to larger units in postprocessing.
Similar problem as top down: the relevance of a leaf element is often not a good predictor of the relevance of elements it is contained in.

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For the query *Macbeth's castle* we would return all of the *play*, *act*, *scene* and *title* elements on the path between the root node and *Macbeth's castle*. The leaf node would then occur 4 times in the result set: 1 directly and 3 as part of other elements.

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We call elements that are contained within each other **nested elements**. Returning redundant nested elements in a list of returned hits is not very user-friendly.

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In most of these approaches, result sets will still contain nested elements.

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Highlighting

- Gain 1: enables users to scan medium-sized elements (e.g., a section); thus, if the section and the paragraph both occur in the results list, it is sufficient to show the section.
- Gain 2: paragraphs are presented in-context (i.e., their embedding section). This context may be helpful in interpreting the paragraph.

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Solution: compute idf for XML-context term pairs.

- sparse data problems (many XML-context pairs occur too rarely to reliably estimate df)
- compromise: consider the parent node x of the term and not the rest of the path from the root to x to distinguish contexts.

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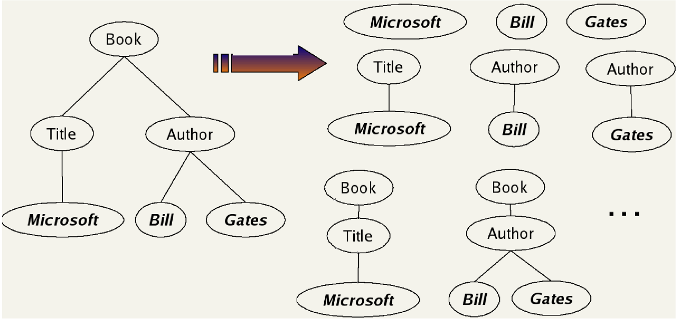
How: Map XML documents to lexicalised subtrees.



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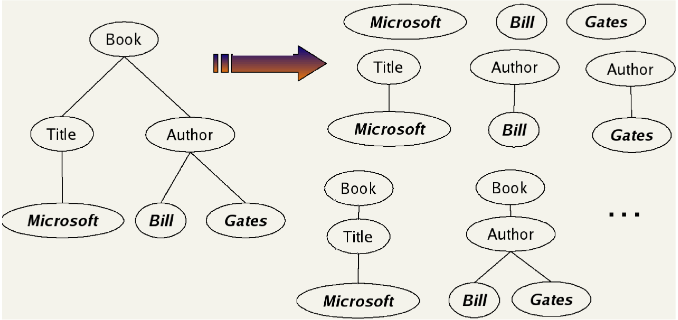

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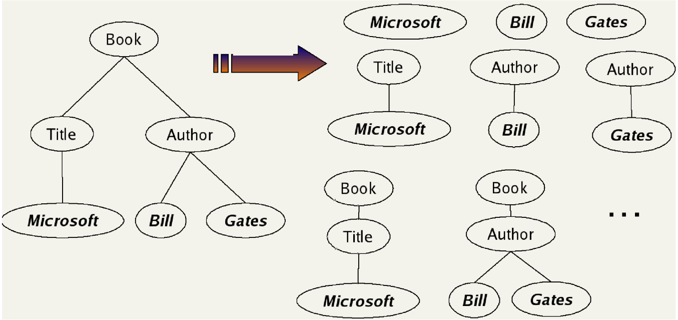

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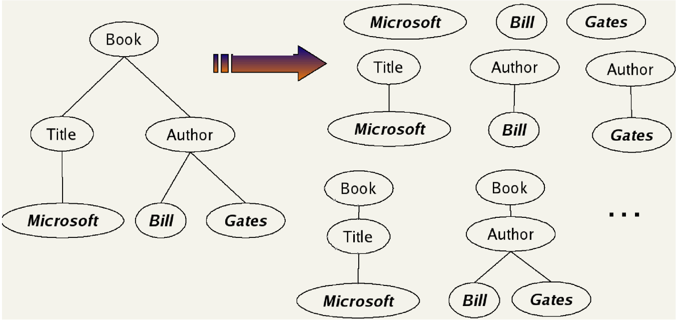
1. Take each text node (leaf) and break it into multiple nodes, one for each word. E.g. split *Bill Gates* into *Bill* and *Gates*.
2. Define the dimensions of the vector space to be lexicalized subtrees of documents – subtrees that contain at least one vocabulary term.



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Vector space formalism in unstructured VS. structured IR

The main difference is that the dimensions of vector space in unstructured retrieval are vocabulary terms whereas they are lexicalized subtrees in XML retrieval.

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Compromise: index all paths that end in a single vocabulary term, in other words, all XML-context term pairs. We call such an XML-context term pair a structural term and denote it by $\langle c, t \rangle$: a pair of XML-context c and vocabulary term t.

Context resemblance

A simple measure of the similarity of a path c_q in a query and a path c_d in a document is the following *context resemblance* function $\textsc{Cr}$:

$$\textsc{Cr}(c_q, c_d) = \begin{cases} \frac{1+|c_q|}{1+|c_d|} & \text{if } c_q \text{ matches } c_d \\ 0 & \text{if } c_q \text{ does not match } c_d \end{cases} \quad (1)$$

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c_q matches c_d iff we can transform c_q into c_d by inserting additional nodes.

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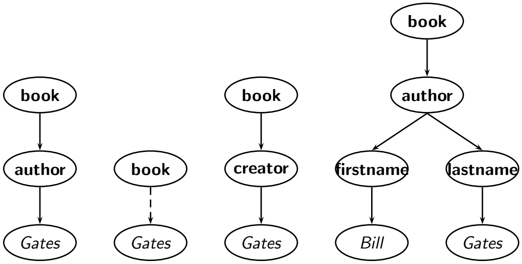

q_3 q_4 d_2 d_3

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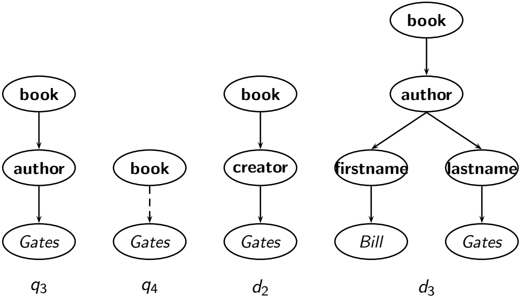

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$\text{CR}(c_{q_4}, c_{d_2}) = 3/4 = 0.75.$

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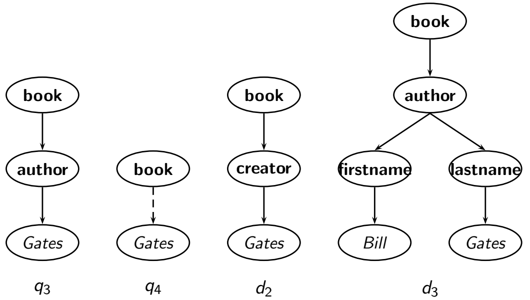

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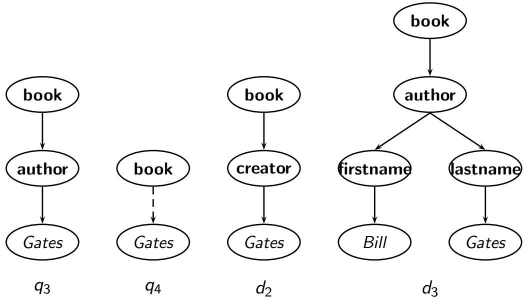
$\mathrm{CR}(c_{q_4}, c_{d_2}) = 3/4 = 0.75$. The value of $\mathrm{CR}(c_q, c_d)$ is 1.0 if q and d are identical.

Context resemblance exercise



$$\mathrm{CR}(c_q, c_d) = \begin{cases} \frac{1+|c_q|}{1+|c_d|} & \text{if } c_q \text{ matches } c_d \\ 0 & \text{if } c_q \text{ does not match } c_d \end{cases}$$

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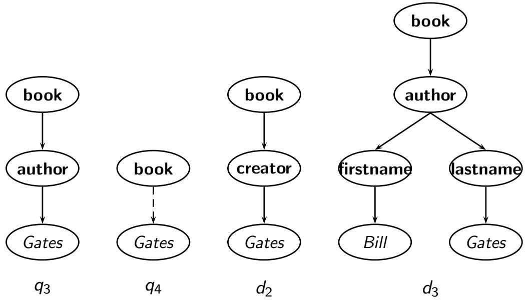

$$\mathrm{CR}(c_q, c_d) = \begin{cases} \frac{1+|c_q|}{1+|c_d|} & \text{if } c_q \text{ matches } c_d \\ 0 & \text{if } c_q \text{ does not match } c_d \end{cases}$$

$\mathrm{CR}(c_{q_4}, c_{d_3}) = ?$
$\mathrm{CR}(c_{q_4}, c_{d_3}) = 3/5 = 0.6.$

Document similarity measure

The final score for a document is computed as a variant of the cosine measure, which we call SimNoMerge.

$\textsc{SimNoMerge}(q, d) =$

$$\sum_{c_k \in B} \sum_{c_l \in B} \textsc{Cr}(c_k, c_l) \sum_{t \in V} \text{weight}(q, t, c_k) \frac{\text{weight}(d, t, c_l)}{\sqrt{\sum_{c \in B, t \in V} \text{weight}^2(d, t, c)}}$$

- V is the vocabulary of non-structural terms
- B is the set of all XML contexts
- $\text{weight}(q, t, c)$, $\text{weight}(d, t, c)$ are the weights of term t in XML context c in query q and document d, resp. (standard weighting e.g. $\text{idf}_t \cdot \text{wf}_{t,d}$, where idf_t depends on which elements we use to compute df_t.)

$\textsc{SimNoMerge}(q, d)$ is not a true cosine measure since its value can be larger than 1.0.

SimNoMerge algorithm

```
ScoreDocumentsWithSimNoMerge(q, B, V, N, normalizer)
for n ← 1 to N
do score[n] ← 0
for each ⟨c_q, t⟩ ∈ q
do w_q ← Weight(q, t, c_q)
    for each c ∈ B
    do if Cr(c_q, c) > 0
          then postings ← GetPostings(⟨c, t⟩)
               for each posting ∈ postings
               do x ← Cr(c_q, c) ∗ w_q ∗ weight(posting)
                  score[docID(posting)]+ = x
for n ← 1 to N
do score[n] ← score[n]/normalizer[n]
return score
```

Outline

Initiative for the Evaluation of XML Retrieval (INEX)

INEX: standard benchmark evaluation (yearly) that has produced test collections (documents, sets of queries, and relevance judgments).

Based on IEEE journal collection (since 2006 INEX uses the much larger English Wikipedia as a test collection).

The relevance of documents is judged by human assessors.

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INEX 2002 collection statistics

12,107	number of documents
494 MB	size
1995–2002	time of publication of articles
1,532	average number of XML nodes per document
6.9	average depth of a node
30	number of CAS topics
30	number of CO topics

INEX topics

Two types:

1. content-only or **CO topics**: regular keyword queries as in unstructured information retrieval
2. content-and-structure or **CAS topics**: have structural constraints in addition to keywords

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2. content-and-structure or **CAS topics**: have structural constraints in addition to keywords

Since CAS queries have both structural and content criteria, relevance assessments are more complicated than in unstructured retrieval.

INEX relevance assessments

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Evaluates whether the element retrieved is "structurally" correct, i.e., neither too low nor too high in the tree.

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Component coverage

Evaluates whether the element retrieved is "structurally" correct, i.e., neither too low nor too high in the tree.

We distinguish four cases:

1. Exact coverage (E): The information sought is the main topic of the component and the component is a meaningful unit of information.
2. Too small (S): The information sought is the main topic of the component, but the component is not a meaningful (self-contained) unit of information.
3. Too large (L): The information sought is present in the component, but is not the main topic.
4. No coverage (N): The information sought is not a topic of the component.

INEX relevance assessments

The **topical relevance** dimension also has four levels: highly relevant (3), fairly relevant (2), marginally relevant (1) and nonrelevant (0).

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Combining the relevance dimensions

Components are judged on both dimensions and the judgments are then combined into a digit-letter code, e.g. 2S is a fairly relevant component that is too small. In theory, there are 16 combinations of coverage and relevance, but many cannot occur. For example, a nonrelevant component cannot have exact coverage, so the combination 3N is not possible.

INEX relevance assessments

The relevance-coverage combinations are quantized as follows:

$$\mathbf{Q}(rel, cov) = \begin{cases} 1.00 & \text{if} \quad (rel, cov) = 3E \\ 0.75 & \text{if} \quad (rel, cov) \in \{2E, 3L\} \\ 0.50 & \text{if} \quad (rel, cov) \in \{1E, 2L, 2S\} \\ 0.25 & \text{if} \quad (rel, cov) \in \{1S, 1L\} \\ 0.00 & \text{if} \quad (rel, cov) = 0N \end{cases}$$

This evaluation scheme takes account of the fact that binary relevance judgments, which are standard in unstructured IR, are not appropriate for XML retrieval. The quantization function $\mathbf{Q}$ does not impose a binary choice relevant/nonrelevant and instead allows us to grade the component as partially relevant.

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This evaluation scheme takes account of the fact that binary relevance judgments, which are standard in unstructured IR, are not appropriate for XML retrieval. The quantization function **Q** does not impose a binary choice relevant/nonrelevant and instead allows us to grade the component as partially relevant. The number of relevant components in a retrieved set A of components can then be computed as:

$$\#(\text{relevant items retrieved}) = \sum_{c \in A} \mathbf{Q}(rel(c), cov(c))$$

INEX evaluation measures

As an approximation, the standard definitions of precision and recall can be applied to this modified definition of relevant items retrieved, with some subtleties because we sum graded as opposed to binary relevance assessments.

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Overlap is not accounted for. Accentuated by the problem of multiple nested elements occurring in a search result.

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Recent INEX focus: develop algorithms and evaluation measures that return non-redundant results lists and evaluate them properly.

Recap

- Structured or XML IR: effort to port unstructured (standard) IR know-how onto a scenario that uses structured (DB-like) data
- Specialised applications (e.g. patents, digital libraries)
- A decade old, unsolved problem
- http://inex.is.informatik.uni-duisburg.de/