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1 Term Relationships and Grouping

1.1 Problems with Single-Term Indexing

- Single terms are either too specific or too broad.
- Single terms carry no context.
- Single terms are more ambiguous.

1.2 Generation of Complex Identifiers

- Manual content analysis and indexing.
- Automatic:
  - Linguistic analysis to generate linguistically related terms.
  - Term clustering based on term co-occurrence statistics.
  - Probabilistic analysis incorporating term-dependence information.
    Estimation of joint occurrence probabilities for pairs and triplets of words: Too expensive yet unreliable accuracy.

1.3 Automatic Term Classification

- Construct a term-document matrix from an existing document collection:

<table>
<thead>
<tr>
<th></th>
<th>$T_1$</th>
<th>$T_2$</th>
<th>...</th>
<th>$T_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D_1$</td>
<td>$d_{1,1}$</td>
<td>$d_{1,2}$</td>
<td>...</td>
<td>$d_{1,t}$</td>
</tr>
<tr>
<td>$D_2$</td>
<td>$d_{2,1}$</td>
<td>$d_{2,2}$</td>
<td>...</td>
<td>$d_{2,t}$</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>$D_n$</td>
<td>$d_{n,1}$</td>
<td>$d_{n,2}$</td>
<td>...</td>
<td>$d_{n,t}$</td>
</tr>
</tbody>
</table>

- Similar terms tend to be used in the same documents: Group terms together based on similarity among columns.
• Similar documents contain related terms: Group documents into document classes based on similarity between rows, and then group terms that cooccur frequently with a document class.

1.3.1 Problems

- Co-occurring terms not necessarily related: relation may be local to a collection of documents.
- Statistical methods may not be reliable (as reflected in low precision and recall).

1.4 Linguistic Methods

• Identification of syntactic classes and construct word phrases based on patterns of the syntactic marker (e.g., noun-noun, adjective-noun).
• Problems: Ambiguous words and syntactic structures, unreliable. Note syntactic structures can’t be simply lookup from a dictionary (contrarily to what the textbook said).
• Solution:
  - Develop good parsers and semantic analyzer
  - Use statistical methods to resolve ambiguity
  - Accept the fact that the automatic analysis can never be perfect.

1.5 Term Phrase Formation

• Term phrases provide more specific information than single terms.
• Simple phrase-formation process:
  1. Choose a phrase head — a term with a high document frequency or negative discrimination value.
  2. Add to the phrase head other medium or low frequency terms. Restriction can apply: must occur within the same sentence, same grammatical unit, or within a certain proximity.
  3. Elimination of function words.
• Restrictions in Step 2 can lead to more or fewer term phrases.
• Combine with linguistic analysis:
  - Term phrases must conform to certain syntactic pattern (e.g., noun-noun).
  - Term phrases must occur within the same sentence units (e.g., subject phrase, object phrase, verb phrase).
  - Augmented with domain-specific semantic analysis (e.g., to detect technical terms within a field).
  - Recognition of semantically identical but structurally different phrases during indexing. Alternatively, generation of semantically equivalent phrase structures from phrases specified in the query.
1.6 Thesaurus Group Generation  
- Thesaurus can be used to broaden the scope of a term.  
- Convert every terms within the same class to the name of class.  
- Stemming can be applied at the same time to reduce the size of the thesaurus.  
- Thesaurus are typically constructed manually for a particular domain (e.g., CACM Computing Review Classification).  

1.7 Thesaurus Group Generation Based on Term Co-occurrence  
- Given a term-document matrix for an existing document collection:

<table>
<thead>
<tr>
<th></th>
<th>$T_1$</th>
<th>$T_2$</th>
<th>...</th>
<th>$T_l$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D_1$</td>
<td>$d_{1,1}$</td>
<td>$d_{1,2}$</td>
<td>...</td>
<td>$d_{1,t}$</td>
</tr>
<tr>
<td>$D_2$</td>
<td>$d_{2,1}$</td>
<td>$d_{2,2}$</td>
<td>...</td>
<td>$d_{2,t}$</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>$D_n$</td>
<td>$d_{n,1}$</td>
<td>$d_{n,2}$</td>
<td>...</td>
<td>$d_{n,t}$</td>
</tr>
</tbody>
</table>

- Compute the similarity between terms $T_j$ and $T_j$:

$$sim(T_j, T_k) = \frac{\sum_{i=1}^{n} d_{i,j} \times d_{i,k}}{\sqrt{\sum_{i=1}^{n} d_{i,j}^2 \times \sum_{i=1}^{n} d_{i,k}^2}}$$

- Single-link classification: two words are put into the same group if their similarity exceeds a threshold.  
- Complete-link classification: the similarity of each pair of words with a group must exceed a threshold.  

1.8 Pseudo Classification  
- Given a sample collection, a sample set of queries with relevance judgement, if $D$ and $Q$ are judged to be relevant, two terms $T_j$ in $Q$ and $T_k$ in $D$ are put into the same group.  
- Such assignment will increase the similarity between $D$ and $Q$.  
- Similar principle used in relevance feedback.  
- Query driven: examines a small number of documents; unreliable to generalize from a few queries.