Passage Retrieval & Re-ranking

Ling573
NLP Systems and Applications
May 5, 2011
Reranking with Deeper Processing

- Passage Reranking for Question Answering Using Syntactic Structures and Answer Types
  - Atkolga et al, 2011

- Reranking of retrieved passages
  - Integrates
    - Syntactic alignment
    - Answer type
    - Named Entity information
Motivation

- Issues in shallow passage approaches:
  - From Tellex et al.
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    - Retrieval match admits many possible answers
      - Need answer type to restrict
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    - Question implies particular relations
      - Use syntax to ensure
Motivation

- Issues in shallow passage approaches:
  - From Tellex et al.
    - Retrieval match admits many possible answers
    - Need answer type to restrict
    - Question implies particular relations
    - Use syntax to ensure
  - Joint strategy required
    - Checking syntactic parallelism when no answer, useless
  - Current approach incorporates all (plus NER)
Baseline Retrieval

- Bag-of-Words unigram retrieval (BOW)
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- Question analysis: QuAn
  - ngram retrieval, reformulation
Baseline Retrieval

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- Question analysis + Wordnet: QuAn-Wnet
  - Adds 10 synonyms of ngrams in QuAn
Baseline Retrieval

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- Question analysis: QuAn
  - ngram retrieval, reformulation

- Question analysis + Wordnet: QuAn-Wnet
  - Adds 10 synonyms of ngrams in QuAn

- Best performance: QuAn-Wnet (baseline)
Dependency Information

- Assume dependency parses of questions, passages
  - Passage = sentence
- Extract undirected dependency paths b/t words
Dependency Information

- Assume dependency parses of questions, passages
  - Passage = sentence
- Extract undirected dependency paths b/t words
- Find path pairs between words \((q_k,a_l),(q_r,a_s)\)
  - Where q/a words ‘match’
    - Word match if a) same root or b) synonyms
Dependency Information

- Assume dependency parses of questions, passages
  - Passage = sentence
- Extract undirected dependency paths b/t words
- Find path pairs between words \((q_k, a_l), (q_r, a_s)\)
  - Where q/a words ‘match’
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    - Later: require one pair to be question word/Answer term
- Train path ‘translation pair’ probabilities
Dependency Information

- Assume dependency parses of questions, passages
  - Passage = sentence
- Extract undirected dependency paths b/t words
- Find path pairs between words $(q_k, a_l), (q_r, a_s)$
  - Where q/a words ‘match’
    - Word match if a) same root or b) synonyms
    - Later: require one pair to be question word/Answer term
- Train path ‘translation pair’ probabilities
  - Use true Q/A pairs, $<\text{path}_q, \text{path}_a>$
  - GIZA++, IBM model 1
  - Yields $\Pr(\text{label}_a, \text{label}_q)$
Dependency Path Similarity
Dependency Path Similarity

Figure 2. Dependency trees for the sample question and sentence S1 in Figure 1 generated by Minipar. Some nodes are omitted due to lack of space.

<table>
<thead>
<tr>
<th>Question:</th>
<th>Path_ID</th>
<th>Node1</th>
<th>Path</th>
<th>Node2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Path_ID</td>
<td></td>
<td>Node1</td>
<td>Path</td>
</tr>
<tr>
<td></td>
<td>&lt;P_Q1&gt;</td>
<td>Wisconsin</td>
<td>&lt;subj&gt;</td>
<td>produce</td>
</tr>
<tr>
<td></td>
<td>&lt;P_Q2&gt;</td>
<td>produce</td>
<td>&lt;head, whn, prep, pcomp-n&gt;</td>
<td>cheese</td>
</tr>
<tr>
<td></td>
<td>&lt;P_Q3&gt;</td>
<td>nation</td>
<td>&lt;gen&gt;</td>
<td>cheese</td>
</tr>
<tr>
<td>S1:</td>
<td>&lt;P_S1&gt;</td>
<td>Wisconsin</td>
<td>&lt;pcomp-n, mod, i&gt;</td>
<td>produce</td>
</tr>
<tr>
<td></td>
<td>&lt;P_S2&gt;</td>
<td>produce</td>
<td>&lt;obj, mod, pcomp-n&gt;</td>
<td>cheese</td>
</tr>
<tr>
<td></td>
<td>&lt;P_S3&gt;</td>
<td>nation</td>
<td>&lt;gen&gt;</td>
<td>cheese</td>
</tr>
</tbody>
</table>
Similarity

- Dependency path matching
Similarity

- Dependency path matching
  - Some paths match exactly
  - Many paths have partial overlap or differ due to question/declarative contrasts
Similarity

- Dependency path matching
  - Some paths match exactly
  - Many paths have partial overlap or differ due to question/declarative contrasts

- Approaches have employed
  - Exact match
  - Fuzzy match
  - Both can improve over baseline retrieval, fuzzy more
Dependency Path Similarity

- Cui et al scoring
- Sum over all possible paths in a QA candidate pair
Dependency Path Similarity

- Cui et al scoring
- Sum over all possible paths in a QA candidate pair

\[ \sum_{path_q, path_a \in Paths} scorePair(path_q, path_a) \]
Dependency Path Similarity

- Cui et al scoring
- Sum over all possible paths in a QA candidate pair

\[
\sum_{path_q, path_a \in \text{Paths}} \text{scorePair}(path_q, path_a)
\]

\[
\frac{1}{|path_a|} \prod \sum_{\text{Pr}(label_{a_j} \mid label_{q_i})}
\]
Dependency Path Similarity

- Atype-DP

- Restrict first q,a word pair to Qword, ACand
  - Where Acand has correct answer type by NER
Dependency Path Similarity

- Atype-DP
- Restrict first q,a word pair to Qword, ACand
  - Where Acand has correct answer type by NER
- Sum over all possible paths in a QA candidate pair
  - with best answer candidate
Dependency Path Similarity

- Atype-DP
- Restrict first q,a word pair to Qword, ACand
  - Where Acand has correct answer type by NER
- Sum over all possible paths in a QA candidate pair
  - with best answer candidate

\[
\max_i \sum_{path_q, path_a \in Paths_{ACand_i}} scorePair(path_q, path_a)
\]
Comparisons

- Atype-DP-IP
  - Interpolates DP score with original retrieval score
Comparisons

- Atype-DP-IP
  - Interpolates DP score with original retrieval score

- QuAn-Elim:
  - Acts a passage answer-type filter
  - Excludes any passage w/o correct answer type
Results

- Atype-DP-IP best

Table 2. Evaluation of Reranking Techniques. All results are averages from the testing datasets TREC 2000 and TREC 2001, evaluated on the top 100 retrieved passages.

<table>
<thead>
<tr>
<th>Model</th>
<th>MRR@1</th>
<th>MRR@5</th>
<th>MRR@10</th>
<th>MRR@20</th>
<th>MRR@50</th>
<th>MRR@100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q-BOW</td>
<td>0.168</td>
<td>0.266</td>
<td>0.286</td>
<td>0.293</td>
<td>0.299</td>
<td>0.301</td>
</tr>
<tr>
<td>QuAn-Wnet</td>
<td>0.193</td>
<td>0.289</td>
<td>0.308</td>
<td>0.319</td>
<td>0.324</td>
<td>0.325</td>
</tr>
<tr>
<td>Cui</td>
<td>0.202</td>
<td>0.307</td>
<td>0.325</td>
<td>0.335</td>
<td>0.339</td>
<td>0.341</td>
</tr>
<tr>
<td>Atype-DP</td>
<td>0.148</td>
<td>0.24</td>
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<td>0.273</td>
<td>0.279</td>
<td>0.28</td>
</tr>
<tr>
<td>Atype-DP-IP</td>
<td>0.261*</td>
<td>0.363*</td>
<td>0.38*</td>
<td>0.389*</td>
<td>0.393*</td>
<td>0.394*</td>
</tr>
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% Improvement over Cui

- Atype-DP-IP: +29.2
- Atype-DP: +18.24
- Q-BOW: +16.9
- QuAn-Wnet: +16.12

% Improvement over QuAn-Wnet

- Atype-DP-IP: +35.2
- Atype-DP: +25.6
- Q-BOW: +23.4
- QuAn-Wnet: +21.9
Results

- Atype-DP-IP best
- Raw dependency: ‘brittle’; NE failure backs off to IP

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% Improvement over Cui

- **+29.2**
- +18.24
- +16.9
- +16.12
- +15.9
- +15.54

% Improvement over QuAn-Wnet

- **+35.2**
- +25.6
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- +21.3
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Results

- Atype-DP-IP best
  - Raw dependency: ‘brittle’; NE failure backs off to IP
- QuAn-Elim: NOT significantly worse

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Units of Retrieval

- *Simple is Best: Experiments with Different Document Segmentation Strategies for Passage Retrieval*
  - Tiedemann and Mur, 2008

- Comparison of units for retrieval in QA
  - Documents
  - Paragraphs
  - Sentences
  - Semantically-based units (discourse segments)
  - Spans
Motivation

- Passage units necessary for QA
  - Focused sources for answers
  - Typically > 20 passage candidates yield poor QA

- Retrieval fundamentally crucial

- Re-ranking passages is hard
  - Tellex et al experiments
    - Improvements for passage reranking, but
    - Still dramatically lower than oracle retrieval rates
<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Lucene MRR</th>
<th>% Inc.</th>
<th>Strict PRISE MRR</th>
<th>% Inc.</th>
<th>TREC % Inc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBM</td>
<td>0.326</td>
<td>49.20%</td>
<td>0.331</td>
<td>39.60%</td>
<td>44.3%</td>
</tr>
<tr>
<td>ISI</td>
<td>0.329</td>
<td>48.80%</td>
<td>0.287</td>
<td>41.80%</td>
<td>41.7%</td>
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<tr>
<td>SiteQ</td>
<td>0.323</td>
<td>48.00%</td>
<td>0.358</td>
<td>40.40%</td>
<td>56.1%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Algorithm</th>
<th># Incorrect</th>
<th>% Incorrect</th>
<th>MRR</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBM</td>
<td>31</td>
<td>7.18%</td>
<td>0.851</td>
</tr>
<tr>
<td>SiteQ</td>
<td>32</td>
<td>7.41%</td>
<td>0.859</td>
</tr>
<tr>
<td>ISI</td>
<td>37</td>
<td>8.56%</td>
<td>0.852</td>
</tr>
<tr>
<td>Alicante</td>
<td>39</td>
<td>9.03%</td>
<td>0.816</td>
</tr>
<tr>
<td>MultiText</td>
<td>44</td>
<td>10.19%</td>
<td>0.845</td>
</tr>
<tr>
<td>bm25</td>
<td>45</td>
<td>10.42%</td>
<td>0.810</td>
</tr>
<tr>
<td>MITRE</td>
<td>45</td>
<td>10.42%</td>
<td>0.800</td>
</tr>
<tr>
<td>stemmed MITRE</td>
<td>63</td>
<td>14.58%</td>
<td>0.762</td>
</tr>
</tbody>
</table>
Passages

• Some basic advantages for retrieval (vs documents)
  • Documents vary in
    • Length,
    • Topic term density,
    • Etc
      • across type

• Passages can be less variable
  • Effectively normalizing for length
What Makes a Passage?

- Sources of passage information
  - Manual:
    - Existing markup
      - E.g., Sections, Paragraphs
    - Issues: ?
      - Still highly variable:
        - Wikipedia vs Newswire
      - Potentially ambiguous:
        - blank lines separate ..... 
    - Not always available
What Makes a Passage?

- **Automatic:**
  - Semantically motivated document segmentation
    - Linguistic content
    - Lexical patterns and relations

- **Fixed length units:**
  - In words/chars or sentences/paragraphs
  - Overlapping?
  - Can be determined empirically

- All experiments use Zettair retrieval engine
Coreference Chains

- Coreference:
  - NPs that refer to same entity
    - Create an equivalence class
  - Chains of coreference suggest entity-based coherence

- Passage:
  - All sentences spanned by a coreference chain
  - Can create overlapping passages
  - Built with cluster-based ranking with own coref. System
    - System has F-measure of 54.5%
1. [Jim McClements en Susan Sandvig-Shobe] \_i 
   hebben een onrechtmatig argument gebruikt.

2. [De Nederlandse scheidsrechter] \_j 
   [Jacques de Koning] \_j 
   bevestigt dit.

3. [Kuipers] \_k 
   versloeg zondag in een rechtstreeks duel 
   [Shani Davis] \_m .

4. Toch werd \[hij\] \_k 
   in de rangschikking achter \[de Amerikaan\] \_m geklasseerd.

5. [De twee hoofdarbiters] \_i 
   verklaarden dat [Kuipers’] \_k
   voorste schaats niet op de grond stond.

Cluster i (1,5): [Jim McClements en Susan Sandvig-Shobe] 
[De twee hoofdarbiters]

Cluster j (2): [De Nederlandse scheidsrechter] 
[Jacques de Koning]

Cluster k (3-5): [Kuipers] [hij] [Kuipers’]

Cluster m (3,4): [Shani Davis] [de Amerikaan]
TextTiling (Hearst)

- Automatic topic, sub-topic segmentation
  - Computes similarity between neighboring text blocks
    - Based on tf-idf weighted cosine similarity
  - Compares similarity values
    - Hypothesizes topic shift at dips b/t peaks in similarity
- Produces linear topic segmentation
- Existing implementations
Window-based Segmentation

- Fixed width windows:
  - Based on words? Characters? Sentences?
    - Sentences required for downstream deep processing

- Overlap? No overlap?
  - No overlap is simple, but
    - Not guaranteed to line up with natural boundaries
      - Including document boundaries

- Overlap -> Sliding window
Evaluation

- Indexing and retrieval in Zettair system
  - CLEF Dutch QA track

- Computes
  - Lenient MRR measure
    - Too few participants to assume pooling exhaustive
  - Redundancy: Average # relevant passage per query
  - Coverage: Proportion of Qs w/ at least one relpass
  - MAP

- Focus on MRR for prediction of end-to-end QA
Baselines

- Existing markup:
  - Documents, paragraphs, sentences
- MRR-IR; MRR-QA (top 5); CLEF: end-to-end score
- Surprisingly good sentence results in top-5 and CLEF
- Sensitive to exact retrieval weighting

<table>
<thead>
<tr>
<th></th>
<th>#sent</th>
<th>cov</th>
<th>red</th>
<th>MRR IR</th>
<th>MRR QA</th>
<th>MRR CLEF</th>
</tr>
</thead>
<tbody>
<tr>
<td>sent</td>
<td>16,737</td>
<td>0.784</td>
<td>2.95</td>
<td>0.490</td>
<td>0.487</td>
<td>0.430</td>
</tr>
<tr>
<td>par</td>
<td>80,046</td>
<td>0.842</td>
<td>4.17</td>
<td>0.565</td>
<td>0.483</td>
<td>0.416</td>
</tr>
<tr>
<td>doc</td>
<td>618,865</td>
<td>0.877</td>
<td>6.13</td>
<td>0.666</td>
<td>0.457</td>
<td>0.387</td>
</tr>
</tbody>
</table>
Semantic Passages

- **Contrast:**
  - Sentence/coref: Sentences in coref. chains -> too long
    - Bounded length
  - Paragraphs and coref chains (bounded)
  - TextTiling (CPAN) – Best: beats baseline

<table>
<thead>
<tr>
<th></th>
<th>#sent</th>
<th>IR</th>
<th>QA</th>
<th>CLEF</th>
</tr>
</thead>
<tbody>
<tr>
<td>sent/coref</td>
<td>490,968</td>
<td>0.604</td>
<td>0.469</td>
<td>0.405</td>
</tr>
<tr>
<td>sent/coref (200-1000)</td>
<td>76,865</td>
<td>0.535</td>
<td>0.462</td>
<td>0.395</td>
</tr>
<tr>
<td>par+coref (200-1000)</td>
<td>82,378</td>
<td>0.560</td>
<td>0.493</td>
<td>0.426</td>
</tr>
<tr>
<td>par+coref (200-400)</td>
<td>67,580</td>
<td>0.555</td>
<td>0.489</td>
<td>0.422</td>
</tr>
<tr>
<td>TextTiling</td>
<td>107,879</td>
<td>0.586</td>
<td>△ 0.503</td>
<td>0.434</td>
</tr>
</tbody>
</table>
Fixed Size Windows

- Different lengths: non-overlapping
- 2-, 4-sentence units improve over semantic units

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<thead>
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<th>#sent</th>
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<th>QA</th>
<th>CLEF</th>
</tr>
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<tbody>
<tr>
<td>2 sentences</td>
<td>33468</td>
<td>0.545</td>
<td>△ 0.506</td>
</tr>
<tr>
<td>3 sentences</td>
<td>50190</td>
<td>0.554</td>
<td>0.504</td>
</tr>
<tr>
<td>4 sentences</td>
<td>66800</td>
<td>0.581</td>
<td>△ 0.512</td>
</tr>
<tr>
<td>5 sentences</td>
<td>83575</td>
<td>0.588</td>
<td>0.493</td>
</tr>
<tr>
<td>6 sentences</td>
<td>100110</td>
<td>0.583</td>
<td>0.489</td>
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Sliding Windows

- Fixed length windows, overlapping
- Best MRR-QA values
  - Small units with overlap
  - Other settings weaker

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<td>29095</td>
<td>0.548</td>
<td>0.516</td>
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<tr>
<td>3 sent (sliding)</td>
<td>36415</td>
<td>0.549</td>
<td>0.484</td>
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<tr>
<td>4 sent (sliding)</td>
<td>41565</td>
<td>0.546</td>
<td>0.476</td>
</tr>
<tr>
<td>5 sent (sliding)</td>
<td>45737</td>
<td>0.534</td>
<td>0.465</td>
</tr>
<tr>
<td>6 sent (sliding)</td>
<td>49091</td>
<td>0.528</td>
<td>0.454</td>
</tr>
</tbody>
</table>
Observations

- Competing retrieval demands:
  - IR performance
    - vs
  - QA performance

- MRR at 5 favors:
  - Small, fixed width units
    - Advantageous for downstream processing too
  - Any benefit of more sophisticated segments
    - Outweighed by increased processing